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TERRESTRIAL SERVICE ENVIRONMENTS FOR SELECTED GEOGRAPHIC LOCATIONS

Final Report

R. E. Thomas
D. C. Carmichael

June 24, 1976

Work Performed Under Contract No. NAS-7-100-954328

Battelle Columbus Laboratories
Columbus, Ohio

MASTER

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Division of Solar Energy

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FINAL REPORT

on

TERRESTRIAL SERVICE ENVIRONMENTS FOR SELECTED GEOGRAPHIC LOCATIONS

to

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY

for the

ENCAPSULATION TASK OF THE
LOW-COST SILICON SOLAR ARRAY PROJECT

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This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract NAS7-100 for the U.S. Energy Research and Development Administration, Division of Solar Energy.

The JPL Low-Cost Silicon Solar Array Project is funded by ERDA and forms part of the ERDA Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays.

June 24, 1976

R. E. Thomas and D. C. Carmichael

JPL Contract No. 954328

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ABSTRACT

This report contains results obtained from analyses of climatic, precipitation, air pollution, and other environmental data for the years 1965–1974 at nine widely different geographic locations in the United States. In addition to descriptive and diurnal statistics for 24 individual climatic variables, "environmental cell" statistics were computed to obtain the frequencies, durations, and transitions for the simultaneous occurrence of various combinations of environmental variables. Results are presented for the simultaneous occurrence of specific levels of air temperature, relative humidity, wind speed, and insolation, in addition to representative results obtained for other combinations of variables.

The results characterize the environmental conditions to which terrestrial solar arrays would be exposed over a 20-year lifetime, and serve to identify environmental factors and levels that can be used in testing candidate encapsulation materials and systems for such terrestrial exposures. An innovative methodology was applied to obtain these results for combinations of environmental variables. Because of its generality and demonstrated feasibility, it is concluded that the methodology also has broad applications to other testing programs.

ACKNOWLEDGMENTS

The results presented in this report have been obtained through a team effort. The Battelle-Columbus team consisted of D. C. Carmichael (Program Manager) and R. E. Thomas (Principal Investigator), with major contributions being made by R. W. Cote and J. B. Miller (statistical data processing), J. L. Gemma (20-year forecasts), P. R. Sticksel (air-pollution data), S. G. Talbert and T. A. Klausing (solar-radiation data), R. C. Behn (meteorology), and R. D. Igou (information systems). Guidance on material properties was provided by F. A. Sliemers (polymers), R. B. Bennett (glass and ceramics), and G. B. Gaines (electronic materials and devices). The interactions with individuals representing the Jet Propulsion Laboratory were always vigorous and constructive. W. F. Carroll was especially insistent on developing improved methodology. C. C. Gonzalez and M. A. Salama were equally insistent on obtaining and processing the best available data, and H. G. Maxwell focused on the practical utility of the output.

The results would have been demonstrably different if any of these individuals had been omitted from the team.

PREFACE

This work was performed by Battelle's Columbus Laboratories between October 1975 and June 1976 as part of the Encapsulation Task of the Low-Cost Silicon Solar Array Project, which is managed by the Jet Propulsion Laboratory for the ERDA Division of Solar Energy. The portion of the development effort reported herein is designated as Study 2 – Environmental Definitions and Requirements. It is part of JPL Contract No. 954328 being conducted by Battelle to evaluate potential encapsulation materials and systems for protection of photovoltaic solar arrays for a period of 20 years in terrestrial environments.

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TERRESTRIAL SERVICE ENVIRONMENTS FOR SELECTED GEOGRAPHIC LOCATIONS

SUMMARY AND CONCLUSIONS

The two primary objectives of this study were:

(1) To determine the frequency and duration of climatic and other environmental conditions that terrestrial solar arrays would be expected to experience over a 20-year lifetime at various geographic locations

(2) To identify environmental factors and levels that can be used in testing candidate encapsulation materials and systems for such terrestrial exposures.

To accomplish these objectives it was necessary to develop an innovative methodology based on "cells" that represent **combinations** of environmental variables, and to obtain results on selected cells, representing possible test conditions, by analyzing historical environmental data for each geographic location.

To accomplish the first objective, the developed methodology yields answers to the following basic questions:

- How often does a particular environmental condition occur?
- When the condition occurs, how long does it last?
- What condition is likely to occur next?

These questions were answered by using historical data and associating each environmental condition with a particular cell. A computer-based counting procedure was used to determine the frequency and duration of each cell and to identify the transitions that occur from cell to cell. These historical counts were then projected to obtain expected 20-year frequencies and estimated exposure times.

The methodology was implemented by means of the Statistical Package for the Social Sciences (SPSS), a widely available computer software package that is well suited for computer processing of large data bases.

The methodology developed was applied to historical data for the 10-year period 1965-1974 for nine geographic locations representing widely different environmental conditions in the United States:

- Albuquerque, New Mexico
- Bismarck, North Dakota
- Boston, Massachusetts
- Brownsville, Texas
- Cleveland, Ohio
- Fairbanks, Alaska
- Los Angeles, California
- Miami, Florida
- Phoenix, Arizona.

Climatic data (air temperature, relative humidity, wind speed, precipitation, etc.), insolation data (total horizontal), and air-pollution data (SO_2, CO_2, total oxidants, etc.) were merged, whenever possible, to give sets of measured values at actual corresponding times at 3-hour intervals. Over 7×10^6 measurements were processed in making the analyses in this study.

The merged data for the geographic locations were used to generate 10-year descriptive statistics, diurnal statistics at 3-hour intervals, and statistics of weather events, in addition to the statistics related to the cell frequencies, durations, and transitions for selected combinations of environmental variables. Representative results on the following combinations of variables are included in this report:

- Air temperature, relative humidity, wind speed, and total insolation
- Air temperature and weather event (fog, rain, snow, etc.)
- Air pollutant (SO_2, NO_2, total oxidants) and weather event (fog, drizzle, rain, etc.).

To demonstrate feasibility, the methodology was applied to several additional combinations of variables. The results for the combinations listed below are available at JPL in the form of computer listings. Because of their excessive volume these listings are not included in the present report.

- Wind speed, wind direction, and weather event (fog, rain, snow, etc.)
- Air temperature, relative humidity, wind speed, and computed values of direct insolation
- Air temperature, total insolation, and weather event (fog, rain, snow, etc.)
- Air temperature, relative humidity, and air pollution (CO, SO_2, NO_2, total oxidants, and soiling index).

The cell methodology was also applied to the second objective to identify test conditions that can be used to evaluate candidate encapsulation materials and systems. The methodology was developed to provide procedures by which test conditions can be selected and evaluated using historical environmental data for each geographic location of interest. These procedures result in weighting factors that can be applied to experimentally determined degradation rates to obtain values for the expected total degradation for each location. In general, different weights, and hence different values, are obtained for the expected total degradation at each location. An example involving five test cells, is given for Albuquerque, Bismarck, Miami, and Phoenix.

It is to be noted that environmental characterizations are limited by the historical data available. For most geographic locations, for example, it was found that (1) virtually no solar spectral data in the ultraviolet range are available; (2) total horizontal insolation data, if available, are frequently of questionable validity; and (3) air-pollution data are usually intermittent and since they are taken at sites where high concentrations are expected, they are not representative of suburban and rural areas. However, it was found that available historical data can serve as an effective basis for planning and analyzing laboratory tests and field tests of encapsulation materials and arrays.

It is concluded that the cell methodology derived in this effort should be applied to provide for other sites a factual basis for experimental evaluations of encapsulation materials and systems. It is recommended that the procedures for evaluating test conditions should be extended in several ways: (1) develop corresponding procedures for evaluating cyclic tests, (2) extend the approach into the area of accelerated testing, and (3) develop criteria for "optimizing" the tests for a given set of geographic locations.

Thus, the developed cell methodology, based on combinations of environmental variables, yields necessary engineering information that cannot be obtained from conventional one-variable data summaries. Under suitable additional assumptions, the methodology also provides an effective way to relate historical environmental data at a given location to proposed test conditions. This cell-methodology approach incorporating combinations of variables is believed to have broad application to testing programs for solar-array encapsulants and other materials and components.

INTRODUCTION

The study for which the final results are presented here was conducted in support of the Low-Cost Silicon Solar Array (LSSA) Project sponsored by the Energy Research and Development Administration (ERDA), Division of Solar Energy, and managed by the Jet Propulsion Laboratory (JPL). *The 1985 objectives of the LSSA Project are to develop the technology and manufacturing capability to produce 500,000 kW/year of photovoltaic arrays at a cost of less than $500/kW, with an efficiency of greater than 10 percent and a service life of 20 years.* One of the tasks (Task III) of this five-task project is concerned with the development of the encapsulation systems for terrestrial photovoltaic arrays. Within Task III, four interrelated studies are being conducted by Battelle's Columbus Laboratories:

Study 1: Review of World Experience and Properties of Materials for Encapsulation of Terrestrial Solar-Cell Arrays. *Available data defining the state of the art of encapsulation system materials and processes were collected and analyzed to provide a credible basis for defining Task III materials evaluation and development efforts.*

Study 2: Definition of Terrestrial Service Environments and Test Conditions for Encapsulation Materials. *Environmental conditions to which a terrestrial solar array will be exposed over a 20-year lifetime were characterized to aid definition of a realistic test program for encapsulation system materials.*

Study 3: Evaluation of Test Methods and Material Properties and Processes for Encapsulants. *Techniques for meeting property-data, materials, and environmental requirements defined in Studies 1 and 2 will be validated and materials property evaluations will be undertaken.*

Study 4: Development of Accelerated and Abbreviated Testing Methods for Predicting Performance of Encapsulation Materials Over a 20-Year Lifetime. *Detailed methodology and test plans for conducting accelerated aging evaluations will be developed.*

This report presents the final results on Study 2 which was conducted over the period from October, 1975, to June, 1976. A separate report has been issued on Study 1, and reports will be prepared for the other studies as they are completed.

Objectives

This study had two primary objectives:

(1) To determine the frequency and duration of climatic and other environmental conditions that terrestrial solar arrays would be expected to experience over a 20-year lifetime at specified geographic locations

(2) To identify environmental factors and levels (test conditions) that can be used to evaluate candidate encapsulation materials and systems for such terrestrial exposures.

The effort focused on accomplishing these objectives using data for nine geographic locations, representing widely different environmental conditions in the United States: Albuquerque, New Mexico; Bismarck, North Dakota; Boston, Massachusetts; Brownsville, Texas; Cleveland, Ohio; Fairbanks, Alaska; Los Angeles, California; Miami, Florida; and Phoenix, Arizona. All methods and data-processing procedures developed in this effort are demonstrated using actual climate, insolation, and air-pollution data for some or all of these nine geographic locations.

This effort also included the identification of available data pertaining to "miscellaneous hazards", such as storms, tornadoes, etc. For these hazards, geographical distributions for the continental United States are used rather than the nine selected geographical locations listed above.

Organization of This Report

The subsequent portions of this Introduction discuss the needs for improved environmental characterizations and for test conditions based on these actual environments, the approaches used in this study to answer both of these needs, and the geographic locations selected for this work. These are followed by introductory sections on various aspects of the data-processing procedures that were used.

Following these introductory discussions, **the results of the various data analyses are presented in the next major section of the report, Technical Discussions and Results on Characterization of Terrestrial Service Environments.** This major section is organized into a section on insolation and other data limitations, an extensive results section presenting *comparative descriptive and diurnal statistics* for the nine locations, and extensive results sections presenting the methodology and the resulting statistics on the simultaneous occurrence of selected *combinations of environmental variables.*

In the first of the major results sections, the tables related to *descriptive statistics* give the following information for each of the nine geographic locations:

Geographic location, latitude, longitude, and elevation (Table 1)

Ten-year descriptive statistics for 1965-1974 (Table 2):

Air temperature

Dew point temperature

Relative humidity

Station pressure

Insolation.

Weather event occurrences for 1965-1974 (Table 3), includ:

Thunderstorms	Snow
Tornadoes	Snow showers
Rain	Sleet
Rain showers	Fog
Drizzle	Haze
Freezing drizzle	Dust.

Occurrences of opaque sky cover for 1965-1974 (Table 4):

Clear
Scattered
Broken
Overcast.

Examples of the *diurnal statistics* for the nine geographic locations are then presented which show the following information on climatic variables at 3-hour intervals for June and December for the years 1965–1974:

Diurnal statistics at 3-hour intervals (Tables 5-8):

Air temperature
Relative humidity
Wind speed
Horizontal insolation.

(Appendix A, Part 2 presents the complete diurnal statistics for each of the months of the year, including weather-event diurnal statistics for each of the sites.)

In the sections on *combinations of variables*, results for each of the geographic locations are presented on the simultaneous occurrence of given levels of the following combinations of variables:

Occurrences of (expected exposure hours to) all levels of air temperature, relative humidity, wind speed, and insolation for all sites (Tables 10a through 10i)

Occurrences of high air temperatures at various levels of relative humidity, wind speed, and insolation (Table 11)

Occurrences of high humidity and freezing temperatures at various levels of insolation and wind speed (Table 12)

Occurrences of various weather events such as fog, rain, snow, etc. at various air temperatures (Table 13)

Air temperatures during occurrences of (abrasive) snow pellets, blowing dust, or sand (Table 14)

Air temperatures during periods of no precipitation or other weather event (Table 15)

Occurrences of various levels of air pollutants (SO_2, NO_2, total oxidants, etc.) and simultaneous weather events such as fog, drizzle, rain, etc. (Table 18).

These combinations are examples extracted from the complete results of the analyses that are currently in use at the Jet Propulsion Laboratory for the study of encapsulation materials and systems.

Following the extensive section on Characterization of Terrestrial Service Environments, the subsequent major section of the report describes the methodology developed in the study to *select and relate experimental test conditions to actual environmental conditions for specific geographic locations.* A numerical application of the method is presented to illustrate the procedure.

Subsequent sections of the report include a discussion of available *ultraviolet radiation data* and brief discussions of several other environmental hazards, including:

Tropical storms	Blizzards
Thunderstorms	Chinooks
Lightning	Earthquakes
Tornadoes	Fungi.

Following the references, the report contains nine appendixes containing detailed information relating to terrestrial service environments and test conditions. Detailed climatological descriptions of each geographic location are given in Appendix A. Appendix A, Part 1, contains a general description of the climate of each of the nine geographic locations and Appendix A, Part 2, contains the complete diurnal statistics obtained for each of the nine geographic locations. Other appendixes include additional information on the following:

Ultraviolet Radiation (Appendix B)
Data Sources (Appendix C)
Forecasting (Appendix D)
Data Management (Appendix E)
Meteorological Definitions (Appendix F)
Derivation of Test Methodology Theory (Appendix G)
Conversion Factors (Appendix H)
Glossary (Appendix I).

Need for Improved Definitions of Environmental Conditions

Improved quantitative definitions of climatic and other environmental conditions are needed for a wide variety of solar-energy applications. Within the Low-Cost Silicon Solar Array Project, such applications include the selection of encapsulating materials to protect photovoltaic arrays against environmental abuses, the evaluation and prediction of failure mechanisms and degradation rates resulting from service environments, the determination of expected useful lifetimes for solar arrays under various environments, and the selection of geographic locations for installations of solar arrays.

The primary deficiency in conventional data summaries stems from the fact that each variable is summarized independently of all other variables. Thus, average values for temperature, for instance, are usually reported on a monthly, seasonal, or annual basis, with no indication of simultaneously occurring values for air temperature, wind speed, and insolation. Yet the simultaneous values of these three variables may be required, for example, to estimate the surface temperature of an encapsulation system. Some two-variable combinations are also frequently of interest. For example, it may be useful to know the air temperature that exists when different forms of precipitation occur.

These kinds of considerations yield the conclusion that it is necessary to process environmental data in terms of combinations of simultaneously occurring values of several different variables. Such a combination serves to define a particular environmental "condition". Thus, the combination of simultaneously occurring values of 20 C for air temperature, 70 percent for relative humidity, 2 meters/second for wind speed, and 500 watts/square meter for insolation denotes a specific environmental condition. The methodology used in this report makes extensive use of the concept of an environmental condition.

Need for Test Conditions Based on Terrestrial Service Environments

Current test procedures typically subject the system under test to temperature cycling between extreme temperatures, together with intensive exposures to high humidities and other abuses, such as simulated hail. If the test system survives such abuses, the survival is sometimes taken as evidence that the test system would have survived the less abusive terrestrial service environments. However, such evidence is frequently not compelling. In particular, the poor correlations often observed between field experience and laboratory tests suggest the weakness of such evidence. Moreover, even if the system degrades under abusive testing, it is frequently not clear whether such degradation should disqualify the system for service use. The intense level of abusiveness used in the test may occur rarely, if at all, in the service environment. Thus, it is possible that the system could easily survive 20 years of actual service in spite of the degradation observed from extremely abusive tests. Such tests could yield overly conservative designs and result in excessive costs.

Considerations of this type have led to a recognition of the need for better test procedures that can serve to indicate whether an encapsulation system, for example, could be expected to have a minimum service life of at least 20 years under the environmental exposure associated with a specific geographic location.

Approach for Obtaining Improved Definitions of Terrestrial Service Environments

In the approach used in this study, improved definitions of terrestrial service environments are obtained by defining environmental conditions to consist of the simultaneous occurrence of several environmental variables, such as air temperature, relative humidity, wind speed, and insolation. The simultaneous values of these variables are then grouped into relatively small ranges, called cells, so that each cell represents a particular environmental condition. A computer-based counting procedure is then applied to historical data for nine geographic locations to answer the following kinds of questions:

- How often does a particular environmental condition occur?
- How long does the condition last, once it occurs?
- What condition occurs next?

The approach is implemented using widely available statistical software. Much of this report consists of selected examples of the kinds of environmental information that can be generated using this cell methodology.

Approach for Obtaining Test Conditions Based on Terrestrial Service Environments

Under additional assumptions, the cell approach is further developed to provide procedures by which selected cells, representing possible test conditions, can be evaluated by means of historical environmental data for each geographic location, These developments are included in the section on Results and Technical Discussion of the Methodology for the Selection of Test Conditions for Aging Experiments. The procedures result in weighting factors, generally different for each location, that in time may be applied to experimentally determined degradation rates to obtain bounds for the amount of degradation that may be expected to occur at each location over a specified time period.

Selection of Geographic Locations

The nine geographic locations were selected for use in this study by representatives of the Jet Propulsion Laboratory and Battelle's Columbus Laboratories. (The number of locations was fixed by the contract.) The objective was to select locations that would be geographically and climatically representative of large areas; and exclude uniquely abusive locations of limited area. It was desired that some locations represent possibly abusive environmental extremes and some locations represent regions that would be particularly advantageous for solar-array installations. In every case the existence of suitable data at the location was a prerequisite for inclusion in the study. The nine locations and some primary characteristics associated with each are listed below.

Albuquerque, New Mexico	Semiarid, high altitude, high insolation, dust
Bismarck, North Dakota	Moderate humidity, large seasonal temperature variations
Boston/Blue Hill, Massachusetts	Humid, seacoast climate, fog
Brownsville, Texas	Hot climate, high insolation
Cleveland, Ohio	Pollution, high humidity, heavy snow, climatic mixtures
Fairbanks, Alaska	Low average temperature, large diurnal temperature variation, low rainfall
Los Angeles, California	Pollution, moderate seasonal variation, varied local conditions
Miami, Florida	Semitropical, marine, high humidity, moderate insolation, high rainfall, high average temperature
Phoenix, Arizona	Semiarid, some pollution, high insolation, moderate altitude, high temperature.

Although each location is labeled by the name of the principal city of the area, it must be understood that the label merely serves to identify a general geographic and climatic region centered around the city. For example, to obtain approximate simultaneous occurrences of climatic and insolation data, the climatic data from Boston were merged with the insolation data from Blue Hill, Massachusetts, which is located approximately 19 km (12 miles) from the Boston weather station. In general, climatic data are usually taken at airports, and consequently, are not always "representative" of the associated communities. Wide climatic variations are known to occur, for example, in the Los Angeles area. These local variations are not reflected by the climatic conditions at the Los Angeles International Airport. Air-pollution data also pose special problems. These data are typically taken at various locations within a community, not at airports, and often where relatively high pollution levels are expected; consequently, they are not "representative" of the levels that exist in the community.

Although there exist various such limitations in the available data, which are indicated in the text, the goal of the study was to make the best use of those data that are available. Members of the project team have attempted to do that, and explicitly caution the reader to exercise care in interpreting the results.

It should be noted in particular that the results are not to be closely linked with a geographic label. The primary intent of this effort consists of developing improved methodologies for obtaining quantitative descriptions of terrestrial service requirements and for obtaining a sound and factual basis for identifying corresponding test conditions. The intent does not consist of characterizing the environment of particular cities nor in making relative comparisons of their suitability for solar installations. *When sites are to be selected for major solar installations, it will be necessary to obtain climatic and solar data in the exact local site under consideration. As indicated, the objective of this study is not to provide such localized studies; however, the methodology developed should be of considerable use when such studies are made.*

Data Processing Procedures

Computer and Statistical Procedures

The methodology developed in this effort is implemented by means of the Statistical Package for the Social Sciences (SPSS), a widely available computer software package that is well suited for computer processing of large data bases. The intent was to use available software, together with standard instructions, to avoid the development of new software. Because of the simplicity of the counting procedures used in the methodology, it is expected that other computer software packages may also be used, especially those that have general-purpose sort and merge routines.

Reduction of Data and Availability of Results

The gathering of climatic, air-pollution, and hazard data can quickly yield overwhelming amounts of data. At times it has been necessary to resist the assumption that better methods, better characterizations of the environment, and better test conditions would automatically develop, provided more and more data were gathered. In fact, it would appear that almost the opposite is true; the main problem really consists of reducing the amount of data to be processed to a bare minimum without losing the desired information. The analysis of large quantities of data can easily give rise to still larger quantities of data. As discussed later, some of the calculations believed useful are, nevertheless, too voluminous to be presented in a report of reasonable length. These are described briefly but are not included in this report. The complete results, in both computer data-tape and printout forms, are in use at the Jet Propulsion Laboratory for evaluative studies of encapsulation materials.

Long-Range Predictions

The reader is also cautioned that this effort is primarily concerned with relatively long-range environmental characterizations. In particular, the effort is concerned with identifying test conditions, based on past historical data that, in turn, can indicate whether a solar-array system can be expected to have a minimum service life of 20 years. In many respects it is easier to predict general climatic events over a 20-year period than it is to predict climatic events for the next month. Moreover, in the results described below, the prediction problem is further simplified to one of predicting the *number* of occurrences over a long period of time. The exact month, day, or hour, for example, for such an occurrence is not predicted. That is, the focus is placed on the number of occurrences and their duration, not their timing.

It may be noted that the climatic variables considered in this report are not expressed as functions of time. Time-series methods are most useful for identifying the time trend and cyclic behavior of a single, continuous, climatic variable, such as temperature. However, when several variables must be tested simultaneously, time series methods require the determination of auto-correlations and cross-correlations, together with strong assumptions that are extremely difficult to validate. The assumptions are particularly troublesome when both continuous and discrete variables, such as temperature and rainfall, are simultaneously involved. For these reasons, the methods of time series analysis were judged to be inappropriate for this effort. Instead, it seemed necessary to use simple methods, relatively free of assumptions, that are based primarily on "counting" procedures. This conclusion was reached early in the effort when it was determined that counting procedures could yield answers to the basic questions: How often does a particular condition occur? How long does it last? What condition occurs next?

International System of Units

The International System of Units, designated by SI, is used in this report in compliance with the National Aeronautics and Space Administration Policy Directive NPD 2220.4 dated September 14, 1970. Temperatures are reported in degrees Celsius. To obtain the SI Kelvin units, add 273.15 to the temperatures given in this report. Statistical computations were performed using original units. The results were then transformed, if necessary, to SI units and rounded. Means, standard deviations, etc., are generally reported to one digit more than that given by the raw data. Conversion factors between English and SI units were obtained from NASA SP-7012. For convenience, English units are frequently given in parentheses in this report. Some useful conversion factors are given in Appendix H.

TECHNICAL DISCUSSIONS AND RESULTS ON CHARACTERIZATION OF TERRESTRIAL SERVICE ENVIRONMENTS

This major results section of the report begins with a concise summary of the current status of insolation data and a brief discussion of other data limitations relating to the results of this study. The environmental characterizations determined in the study, and the methods which were developed for obtaining them, are then presented and discussed in extensive sections on statistical descriptions and comparisons of terrestrial environments for selected geographic locations, and occurrences of combinations of environmental variables for selected geographic locations. The first of the major results sections contains descriptive statistics on climate, including precipitation and other weather-events, and diurnal statistics for individual variables for the nine selected locations. The next of these major sections contains a discussion of the developed environmental-cell approach and subsequent sections present results characterizing the simultaneous occurrences of selected combinations of variables for the nine locations.

It should be noted that the particular concern of the Encapsulation Task of the LSSA project with regard to insolation is the effect of the radiation on the operating temperatures of arrays and the effect on the aging behavior of the encapsulation materials. Ultraviolet radiation data are, of course, particularly important to the aging of materials and are discussed in some detail later in this report and in one of the appendices. Extensive studies are being made at Sandia Laboratories (Albuquerque, New Mexico) and elsewhere that are concerned with detailed analyses of amounts of solar radiation, particularly as these data relate to performance of solar-energy systems.

Description of Available Data

The Current Status of Insolation Data

Eighty-six weather stations in the United States measure and record insolation.(1) Nineteen National Weather Service (NWS) stations produce hourly and daily pyranomic measures of hemispheric solar radiation. Forty-one NWS stations and 29 cooperating stations produce daily measures only. Three NWS and two cooperative stations record normal incidence measures using pyrheliometers. These measures are taken at solar noon, and at solar angles corresponding to air masses of 2, 3, 4, and 5 under clear weather conditions. Since 1950 the climatic and insolation measurements have been published monthly in the Climatological Data - National Summary, and are available on tape or punched cards from the National Climatic Center (NCC), Asheville, North Carolina. Most of the pyranometer stations have records of less than 20 years; only seven stations have been in operation for over 30 years.(2) Albuquerque, New Mexico, and Tuscon, Arizona are the only southwestern locations for which measured values of both total and normal incidence insolation are available.(3) The only long-term (1947-1956) insolation measurements taken on nonhorizontal surfaces were taken at Blue Hill, Massachusetts.(4) The NCC has published turbidity measurements taken with sun photometers at 50 EPA-supported stations in the United States.(5) A 15 percent decrease in direct insolation on clear days at Washington, D.C., between 1920 and 1970 has been attributed to increased turbidity associated with industrialization.(6)

Radiation climatology is plagued by a variety of problems. The most notable involves the Parson's black used with old-style Eppley pyranometers. After 1956 the black absorber gradually changed to a gray-green color on a large number of instruments. By 1966 the problem became serious, with reported errors of ±5 percent to ±30 percent. In September, 1972, the NWS requested the NCC to stop publishing these data. The rehabilitation of these data has been the subject of much

discussion. As a result, several groups have recommended that these data be rehabilitated for all U. S. stations to an accuracy of at least 5 percent over a 10-year period.[7] The rehabilitation is in progress. The publication date estimated for the corrected data is early 1977.[8]

Additional problems in radiation climatology include the following:

(1) The Eppley normal incidence pyrheliometer has a view of approximately 6 degrees, whereas the sun intercepts an angle of approximately 1/2 degree. This means that cirrus clouds in the field of view can yield highly erroneous results.[9,10]

(2) The International Pyrheliometer Scale (IPS) is a relative, rather than absolute scale, and systematic errors of approximately -2.2 percent have been associated with IPS measures.[11,12]

(3) The presence of UV radiation (300 to 400 nm) in the solar spectrum is of great significance because of the potential degradation of material properties (see section on Ultraviolet Exposure). However, except for measurements at a few sites (Washington, D.C.; Rockville, Maryland; Los Angeles, California), measured spectral variations for a variety of azimuth angles, altitudes, and atmospheric conditions are extremely limited.[13]

(4) Procedures have been developed for converting insolation to tilted surfaces using average daily total radiation on horizontal surfaces. Because tilted-surface data are not available for the locations of this study (excepting the vertical surfaces at Blue Hill) the accuracy of these procedures cannot be determined.[4]

The research community generally suggests that improved measurement accuracy is essential to achieve the required understanding of radiation climatology. However, it often appears difficult to justify measurement goals of high accuracy for climatological quantities that are known to vary by several orders of magnitude, primarily because of highly variable cloud cover.[2] The research community seeks to identify very small "signals" in the presence of large amounts of "noise". This is necessary to obtain improved understanding of underlying physical processes. In contrast, the engineering community generally suggests that current accuracies are sufficient for engineering design and energy-conversion technologies. Rather than improved accuracy, the primary engineering need is stated to be an expanded network of stations that report daily total insolation within ±10 percent.[4] These stations would be augmented by a few highly instrumented stations that measure total and diffuse insolation on a horizontal surface, together with total radiation on selected vertical and tilted surfaces.

Other Data Limitations

A major limitation in the data available for this study results from the fact that, beginning in 1965, routine climate data have generally been taken at 3-hourly intervals in the United States. By taking measurements once every 3 hours, it is clear that some climatic events may be missed altogether and that gradient information, related to time rates of change of climatic variables is poorly captured, if at all, by such measurements. On the other hand, for long-term climatic exposures, averages, standard deviations, and other statistics related to climatic variables may be adequately estimated for a given location using 3-hourly data. To test the adequacy of 3-hourly data, monthly and annual averages were examined early in the effort at one geographic location (Columbus, Ohio) by comparing the means and standard deviations obtained from pre-1965 climate data, measured at hourly

intervals, with the corresponding means and standard deviations obtained from using every third measurement. The results showed minimal loss of information for the mean values of continuous climatic variables, such as air temperature, relative humidity, dew-point temperature, etc. The standard errors of the means based on 3-hourly data were increased, as expected, by a factor approximately equal to $\sqrt{3}$, relative to the standard errors based on hourly data. It was concluded that 3-hourly data are adequate for describing long-term average exposures. However, the usefulness of the resulting information is limited for estimation of rates of change and of frequencies of occurrence of weather events.

Because insolation measurements are made at hourly intervals, it follows that merging the climate and insolation data taken at corresponding times results in a loss of two-thirds of the insolation measurements. This loss was accepted in order to gain information on combinations of insolation measurements with measurements of other climatic variables. Some of the lost insolation information can be approximately recovered by interpolation among the averages associated with 3-hourly measurements to obtain estimates of insolation at intervening times. This procedure is expected to be useful in connection with the diurnal statistics presented in Appendix A-Part 2. As noted for climatic variables, rate-of-change information obtainable from insolation measurements corresponding to 3-hourly intervals is marginal. Nevertheless, the long-term averages based on 3-hourly measurements are expected to be useful for the purposes of this study with regard to the operating temperature and aging behavior of encapsulation materials.

There are, of course, some other limitations in the data used in this effort. In particular, it must be noted that climate data are generally taken at airports, and airports are not likely to represent the local climate of the surrounding urban or rural areas. It should also be noted that the air pollution data were taken intermittently, often over relatively short time intervals. Also of significance is the fact that the overall accuracy and precision of the measurements cannot be directly assessed. Such assessments are effectively prevented by several factors: the volume of the data (*over 7×10^6 measurements were processed in making the analyses of this report*), the geographic distribution of the data sources, the obviously subjective elements involved in recording many weather events, and the continual evolution of instrumentation and measurement practices. In spite of these recognized difficulties, the objective was to make the best possible use of the available data in order to obtain useful information on expected service environments, particularly with regard to the frequency and duration of combinations of variables.

Statistical Descriptions and Comparisons of Terrestrial Environments for Selected Geographic Locations

This portion of the report presents statistical tables derived from analyses performed on data for the nine geographic locations selected to be geographically and climatically representative of large areas. In addition to showing examples of the results obtained from these analyses, the tables permit contain comparisons to be made among the locations. Three kinds of statistical results are presented:

(1) General descriptive statistics (average, standard deviation, maximum, minimum)

(2) Frequencies of occurrence of various weather events (fog, rain, snow, etc.)

(3) Diurnal statistics (averages at 3-hour intervals, by month).

Descriptive Statistics

The descriptive statistics presented in the tables in this section are based on climatic measurements taken at 3-hour intervals over the 10-year period 1965-1974. The data are generally useful for basic information on each location and for making comparisons among geographic locations for design and experimental studies. More detailed statistics are given in Appendix A, Part 2.

The geographic locations selected for use in this study are listed in Table 1. The geographic locations shown in Column 1 are collective labels for three kinds of data: (1) climatic data taken at an airport, (2) air quality data taken at selected sites within selected localities, and (3) hazard data (tornadoes, hail, etc.) that are reported over more extensive geographic regions surrounding the localities. The code labels shown in Column 2 are used throughout this document.

The climatic data for these geographic locations were obtained for the weather stations having the 5-digit station identifiers shown in Column 3. The climatic data were obtained from the National Climatic Center in a standard tape format described in the Tape Reference Manual, Airways Surface Observations, TDF 14[14]. The insolation data, together with the latitudes, longitudes, and elevations, were obtained from the Reference Manual - Solar Radiation - Hourly 280[15]. The elevations of the pyranometers were chosen as a convenient, consistent set of elevation measurements relevant to solar-energy applications. Although such elevations are shown to exist for all nine geographic locations, complete insolation data are not available for Cleveland, Fairbanks, Los Angeles, or Phoenix during the period 1965-1974.

Selected climatic statistics for the nine geographic locations for the years 1965-1974 are given in Table 2. The table shows, for example, that the 10-year arithmetic average air temperature ranged between -2.9 C (26.8F) for Fairbanks to 24.1 C (75.4 F) for Miami. The average dew-point temperatures are -9.8 C (14.4 F) and 18.8 C (65.8 F) for Fairbanks and Miami, respectively. The average relative humidity varies between 38 percent for Phoenix and 76 percent for Brownsville. The average atmospheric air pressure varies between 83.8 kN/m^2 (24.7 in. Hg) for Albuquerque and 101.7 kN/m^2 (30.0 in. Hg) for Miami.

TABLE 1. SELECTED GEOGRAPHIC LOCATIONS AND THEIR LATITUDE, LONGITUDE, AND ELEVATION

Geographic Location[a]	Code[b]	WBAN[c]	Latitude[d]	Longitude[d]	Elevation[e], m
Albuquerque, New Mexico	ABQ	23050	35°03′	106°37′	1624
Bismarck, North Dakota	BIS	24011	46°46′	100°45′	511
Boston, Massachusetts	BOS	94701	42°21′	71°04′	48
Brownsville, Texas	BRO	12919	25°54′	97°26′	15
Cleveland, Ohio	CLE	14820	41°24′	81°51′	265
Fairbanks, Alaska	FAI	26411	64°49′	147°52′	138
Los Angeles, California	LAX	23174	33°56′	118°23′	38
Miami, Florida	MIA	12839	25°48′	80°16′	12
Phoenix, Arizona	PHX	23183	33°26′	112°01′	347

(a) A geographic location is a collective label for climatic data (usually taken at a local airport), air-quality data (taken at selected sites within selected localities), and hazard data (reported over more extensive geographic regions surrounding the locality).
(b) These codes are used throughout this document.
(c) These WBAN numbers are codes assigned by the United States Weather Bureau.
(d) Although not SI units, degrees and minutes, instead of radians, may be officially used for angular measure. (16)
(e) Elevation corresponds to the height of the pyranometer above mean sea level.

TABLE 2. SELECTED CLIMATIC STATISTICS FOR NINE GEOGRAPHIC LOCATIONS BASED ON OBSERVATIONS AT 3-HOUR INTERVALS FOR YEARS 1965-1974

Statistic [b,c,d]	Geographic Location[a]								
	ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
Air Temperature, C									
Average	13.1	5.1	10.3	22.7	9.9	- 2.9	16.6	24.1	22.0
Standard Deviation	10.4	13.8	9.8	6.4	10.7	17.2	4.2	4.5	10.3
Minimum	-26.1	-40.6	-20.0	- 2.2	-25.0	-50.0	1.1	1.7	- 5.0
Maximum	40.6	42.2	36.1	37.2	34.4	34.4	37.8	34.4	46.7
Dew Point Temperature, C									
Average	- 1.8	- 1.3	3.8	17.8	4.4	- 9.8	10.6	18.8	4.3
Standard Deviation	8.7	11.7	10.4	6.2	10.2	15.7	5.8	4.9	7.6
Minimum	-32.8	-44.4	-35.0	-12.8	-30.6	-55.0	-25.0	-10.6	-25.6
Maximum	18.9	25.0	23.3	28.3	24.4	17.2	21.7	29.4	24.4
Relative Humidity, percent									
Average	42.5	67.1	66.6	76.0	70.6	62.3	70.8	73.4	38.0
Standard Deviation	22.2	19.1	18.7	15.7	15.1	17.8	18.2	13.9	22.1
Minimum	2.0	8.0	13.0	9.0	18.0	14.0	3.0	19.0	3.0
Maximum	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Station Pressure, kN/m^2									
Average	83.8	95.5	101.5	101.4	98.8	99.4	101.2	101.7	97.4
Standard Deviation	0.5	0.8	0.9	0.5	0.7	1.1	0.4	0.4	0.5
Minimum	81.8	91.6	96.3	96.5	94.9	95.5	99.6	98.4	95.7
Maximum	85.6	100.9	104.5	104.2	101.4	103.6	102.8	103.1	99.4
Insolation, W/m^2									
Average	428	329	270	374	—	—	—	360	408
Standard Deviation	330	280	266	328	—	—	—	303	296
Maximum	1243	1154	1119	1260	—	—	—	1341	1018

(a) See Table 1 for definitions of location codes ABQ, ..., PHX.
(b) The minimum and maximum values are the absolute (not average) minimum and maximum values recorded over the 10-year period.
(c) See Appendix G for conversion to English units.
(d) The insolation data for PHX are based on the period January 1965 through June 1967. In some instances it may be possible to use sunshine data or insolation data for other time periods for CLE, FAI, and LAX, which were not available for 1965-1974.

Each average shown in Table 2 is based on approximately 29,216 measurements taken every 3 hours for the 10-year period (eight observations per day, 3,652 days per 10 years). As would be expected, considerable variation occurs about each of these averages. Consequently, the averages are useful only where a single overall annual measure is desired. The standard deviations shown in Table 2 are measures of variability about the computed averages. Small standard deviations indicate small variability.

Under idealized assumptions it can sometimes be asserted that approximately two-thirds of the observations will be within one standard deviation of the mean and approximately 95 percent of the observations will be within two standard deviations of the mean. However, such conclusions are considered hazardous for weather-related variables. Instead, it is recommended that the standard deviations reported in Table 2 be used primarily to make relative comparisons among the locations. For example, Table 2 shows that the largest variabilities for air temperature and dew point temperature occur at Fairbanks, and are 17.2 C (31.0 F) and 15.7 C (28.3 F), respectively.

For relative humidity, Table 2 shows that for these nine locations the greatest variability (22.2 percent) occurs at Albuquerque and the least variability (13.9 percent) occurs at Miami. The atmospheric pressure shows little variation at any location. The maximum and minimum variabilities occur at Fairbanks, 1.1 kN/m^2 (0.32 in. Hg), and at Los Angeles and Miami, 0.4 kN/m^2 (0.1 in. Hg).

The minimum and maximum values shown in Table 2 are the extreme values (not averages) that were reported among the approximately 29,216 observations taken at 3-hour intervals during 1965-1974. The maximum air temperature occurs at Phoenix, 46.7 C (116 F) and the minimum air temperature is shown at Fairbanks, -50 C (-58 F). The minimum relative humidity and minimum station pressure are 2 percent and 81.8 kN/m^2 (24.2 in. Hg), respectively, both occurring at Albuquerque.

Insolation is customarily measured in langleys per hour (ly/hr), where a langley denotes 1 gram-calorie per square centimeter. The insolation values shown in Table 2 are expressed in watts per square meter, obtained by multiplying langleys/hour by 11.62. The reader is cautioned that watts per square meter suggests that insolation is an instantaneous measure when, in fact, it is an integrated quantity.

The insolation values shown in Table 2 are the 10-year averages of nonzero, daytime measurements taken at 3-hour intervals that correspond approximately to the 3-hour measurement times for the climatic variables routinely measured at weather stations. Appendix F gives definitions of meteorological terms, together with methods of measurement and observation.

Precipitation and Other Weather-Event Statistics

The occurrence of various weather events constitutes an important environmental factor that must often be considered at various geographic locations. The total number of exposures to fog, rain, snow, etc., is reported in this portion of the report for each of the nine geographic locations. Definitions of some meteorological terms are given in Appendix F.

The numbers of observations of various weather events recorded at 3-hour intervals over the 10-year period 1965-1974 are given in Table 3. The total number of observations over this period is approximately equal to 29,216. The table shows, for example, that Miami was subjected to thunderstorm activity for 462 of the 29,216 observations. The overall relative frequency of thunderstorm activity is given by 462/29,216, so that approximately 1.6 percent of the observations show thunderstorm activity. Because 462 denotes the total number of observations of thunderstorm activity over a 10-year period, it follows that the expected number of observations per year of thunderstorm activity is equal to 46.2 observations. The definition of a thunderstorm is given in Appendix F.

It should be noted that care is required in interpreting the frequencies shown in this table. For example, a single rain that lasted for more than 3 hours would give rise to at least two observations of rain activity; one observation at the beginning and one observation at the end of the 3-hour period. That is, one rain can give rise to more than one observation in the table. Also, more than one rain could occur in a 3-hour period; rain, followed by clearing, followed by rain 3 hours later. Thus, the frequencies shown in the table do not reflect the number of occurrences of the weather event. Instead, the frequencies represent the number of recording times at which the weather event was observed to be occurring.

The following illustrate the types of information that can be extracted from Table 3:

(1) Among these nine geographic locations, only Miami was subjected to a reported heavy thunderstorm and two tornadoes in the period 1965-1974.

(2) In the categories of light, moderate, and heavy rain, Boston had the largest total number of rain observations: 1,455 + 159 + 40 = 1,654. At the opposite extreme, Phoenix had 179 and Albuquerque had 185 rain observations over the 10-year period.

(3) No occurrences of either moderate or heavy freezing rain were recorded at any of these locations during 1965-1974.

(4) The largest numbers of occurrences of drizzle were recorded for Boston (558) and for Brownsville (509).

(5) For the combined snow, ice, sleet, and hail categories, Fairbanks shows a total of 3,877 observations; a total of 2,920 is shown for Bismarck. In the same categories, Phoenix recorded one light snow and Brownsville recorded two observations of light sleet.

(6) For combined fog categories, Boston shows the largest number (3,474), followed by Cleveland (3,250), and Fairbanks (2,555). At the opposite extreme, Phoenix has the smallest number (81), followed by Albuquerque (187).

(7) The largest number of observations of blowing dust and dust occurs for Phoenix (61), followed by Albuquerque (40) and Bismarck (13).

(8) The largest number of observations for the categories of smoke, haze, and smoke and (plus) haze occurs for Los Angeles (10,057), following by Cleveland (5,635), and Boston (3,154). No occurrences are shown for Albuquerque.

TABLE 3. NUMBERS OF OBSERVATIONS[a] OF PRECIPITATION AND OTHER SELECTED WEATHER EVENTS OBSERVED AT 3-HOUR INTERVALS BY GEOGRAPHIC LOCATION FOR YEARS 1965-1974

Weather Event	Number of Observations at Each Geographic Location[b]								
	ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
Thunderstorm	194	182	61	131	127	20	12	462	105
Heavy Thunderstorm								1	
Tornado								2	
Squall			1						
Light Rain	178	556	1455	648	1182	930	431	665	167
Moderate Rain	6	16	159	41	26	15	62	33	12
Heavy Rain	1	3	40	8	1		12	9	
Light Rain Showers	487	553	728	375	1143	418	226	735	470
Moderate Rain Showers	29	17	46	62	40	4	15	57	21
Heavy Rain Showers	4	16	26	31	3	1	6	34	7
Light Freezing Rain	1	27	37		22	8			
Moderate Freezing Rain									
Heavy Freezing Rain									
Light Drizzle	4	184	556	504	414	51	129	8	3
Moderate Drizzle			1	5					
Heavy Drizzle			1						
Light Freezing Drizzle		53	28	1	30	30			
Moderate Freezing Drizzle					1	2			
Heavy Freezing Drizzle									
Light Snow	202	2540	799		945	3413			1
Moderate Snow	12	29	46		31	12			
Heavy Snow	4	3	9		7				
Light Snow Pellets	6	2	8		10	4			
Moderate Snow Pellets									
Heavy Snow Pellets									
Ice Crystals	2	163	30		86	335			
Light Snow Showers	56	164	147		1440	111			
Moderate Snow Showers					12				
Heavy Snow Showers	1		1		1				
Light Sleet	1	16	63	2	14	2			
Moderate Sleet		2							
Heavy Sleet			2						
Hail		1			1				1
Fog	173	1061	3139	1658	2558	869	1475	190	59
Ice Fog		11				1646			
Ground Fog	14	133	335	758	692	40	249	225	22
Blowing Dust	37	12		6			5		50
Blowing Sand									
Smoke		5	607	14	591	164	568	692	13
Haze		32	1487	1037	3333	3	273	168	5
Smoke and Haze		1	1060	13	1711	1	9216	198	106
Dust	3	1		20	1	1	8		11
Blowing Snow	15	200	32		163	26			
Blowing Spray									

(a) Total number of observations at 3-hour intervals over this 10-year period is approximately equal to 29,216.
(b) See Table 1 for definition of location codes ABQ, ..., PHX. See Appendix F for some meteorological definitions.

(9) Bismarck and Cleveland show the largest number of observations of blowing snow, with 200 and 163, respectively.

(10) As might be expected from the definitions of Appendix F, blowing spray is not shown for any of the nine locations during the period 1965-1974.

Table 4 shows the percentage of the opaque sky cover for the approximately 29,216 observations taken at each of the nine geographic locations for the years 1965-1974. A cloud layer that obscures a fraction of the sky or obscures higher cloud layers is said to be opaque. The table indicates, for example, that 56.6 percent of the observations taken at Phoenix showed opaque sky covers of less than 10 percent. Such a sky condition is said to be clear. As indicated by the left column of the table, scattered clouds are associated with fractions of opaque sky covers ranging between 10 and 50 percent, broken clouds with percentages between 60 and 90 percent, and overcast skies with 100 percent.

In general, the table shows that the largest percentages of observations occur at the extreme sky conditions corresponding to clear or overcast. Conversely, the least likely fraction of opaque sky cover occurs in the range 50 (scattered) to 60 percent (broken). The only exception occurs at Brownsville where the least likely occurrence is 4.7 percent for a 90 percent (broken) opaque sky cover.

The most frequent observations of overcast skies occur for Cleveland (43.5 percent), followed by Boston (33.2 percent), and Bismarck (28.8 percent). The least frequent observations of overcast skies occur for Phoenix (7.7 percent) and Albuquerque (9.5 percent). A comparison between the frequencies of occurrences for clear and overcast skies shows that Bismarck, Boston, and Brownsville are nearly as likely to have clear skies as overcast skies; Phoenix and Albuquerque are more likely to have clear skies, whereas Cleveland and Fairbanks are more likely to have overcast skies.

Diurnal Statistics

In this portion of the report, selected diurnal statistics for the months of June and December are presented in order to make comparisons among the nine geographic locations. The complete results for all months and all locations are given in Appendix A, Part 2: Tables A-1 through A-18.

Table 5 shows the average diurnal air temperature by geographic location for June and December for the years 1965-1974. Column 2 of the table is labeled Hour Index. This index denotes the eight measurement times per day that result from taking 3-hour measurements. The index is used because the time of day at which the observations are made varies from one geographic location to another. For Bismarck and Brownsville, the observations are taken at midnight, 3 a.m., 6 a.m., etc. Thus, the hour index, 1, 2, ..., 8, for these two locations denotes corresponding observation times beginning at midnight local standard time. For Albuquerque, Fairbanks, and Phoenix, the observation times occur two hours later, so that the hour index, 1, 2, ..., 8, for these three locations corresponds to 3-hour observation times beginning at 2 a.m. For the other four locations, the hour index begins at 1 a.m.

TABLE 4. OCCURRENCE OF OPAQUE SKY COVER BY GEOGRAPHIC LOCATION BASED ON OBSERVATIONS AT 3-HOUR INTERVALS FOR YEARS 1965-1974

Description of Opaque-Sky-Cover Condition		Occurrence of Given Sky-Cover Condition at Each Geographic Location[a], percent of total observations[b]								
Cloud Type	Opaque Sky Cover, percent	ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
Clear	Less than 10	44.6	25.0	29.1	23.9	18.2	14.9	35.2	14.8	56.6
Scattered	10	7.7	8.6	6.3	6.1	5.6	6.3	7.9	7.8	7.4
	20	7.4	7.3	6.5	6.7	5.6	7.7	6.6	9.5	5.9
	30	6.6	6.4	5.3	7.9	5.2	7.8	5.2	11.1	4.9
	40	4.4	5.3	3.7	6.1	4.1	6.0	3.6	8.6	3.5
	50	3.1	3.1	2.3	4.8	3.1	4.3	2.5	6.5	2.7
Broken	60	3.5	3.3	2.6	5.1	3.0	5.3	2.4	6.2	2.4
	70	3.9	3.6	3.1	5.0	3.4	6.3	2.8	7.7	2.9
	80	4.4	4.6	3.7	5.4	4.4	7.0	3.1	8.7	2.7
	90	4.8	4.2	4.3	4.7	3.9	7.2	4.1	8.7	3.3
Overcast	100	9.5	28.8	33.2	24.4	43.5	27.2	26.5	10.5	7.7
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(a) See Table 1 for definition of location codes ABQ, ..., PHX; all data are based on surface observations taken at airports.
(b) Total number of observations is approximately 29,216.

TABLE 5. AVERAGE DIURNAL AIR TEMPERATURE AT 3-HOUR INTERVALS FOR JUNE AND DECEMBER FOR YEARS 1965-1974 BY GEOGRAPHIC LOCATION

Month	Hour Index[a]	Air Temperature, C								
		ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
June	1	17.5	14.2	17.1	25.2	17.0	11.1	16.3	25.1	25.2
	2	15.4	12.5	16.1	24.5	16.0	11.4	16.0	24.5	22.2
	3	20.7	12.3	17.8	24.0	17.7	15.0	17.1	24.9	27.5
	4	26.4	17.7	21.1	28.6	21.9	18.5	19.9	28.2	33.5
	5	29.8	21.4	22.3	30.6	23.7	19.9	20.9	28.9	37.1
	6	29.4	23.0	22.2	30.8	23.6	19.9	20.2	28.2	37.9
	7	24.5	22.3	20.1	38.8	22.0	18.2	17.6	26.8	34.2
	8	20.8	17.5	18.2	26.0	18.7	14.0	16.7	25.8	29.5
December	1	- 1.9	-10.6	0.6	15.7	0.2	-21.9	11.3	18.9	7.1
	2	- 3.0	-11.1	0.2	15.2	- 0.2	-21.6	10.0	18.1	5.9
	3	- 3.0	-11.6	0.0	14.7	- 0.5	-22.1	9.6	17.6	5.4
	4	3.0	-10.9	1.5	17.0	0.3	-21.6	14.5	21.5	13.0
	5	6.5	- 7.5	3.2	21.1	1.7	-21.2	17.1	24.0	17.0
	6	4.9	- 5.6	2.9	21.7	1.8	-21.7	15.6	23.8	16.8
	7	1.1	- 8.0	1.8	18.6	1.0	-21.7	13.3	21.4	11.9
	8	- 0.6	- 9.9	1.0	16.3	0.5	-22.0	12.4	19.9	9.0

(a) The hour index corresponds to the eight observation times during a day. For BIS and BRO these eight observation times occur at 0, 3, 6, 9, 12, 15, 18, and 21 hours, local standard time; at BOS, CLE, LAX, and MIA, the observation times occur at 1, 4, 7, 10, 13, 16, 19, and 22 hours; and at ABQ, FAI, and PHX, the observation times occur at 2, 5, 8, 11, 14, 17, 20, and 23 hours.

Table 5 shows that the average air temperature is 17.5 C (63.5 F) for a June month in Albuquerque at an hour index of 1 (2 a.m.). This average is based on 300 observations of air temperature made at 2 a.m. during the June months in the 10-year period 1965-1974: (10 June months/10 years) · (30 days/June month) · (one observation at 2 a.m./day). The corresponding average air temperature for Albuquerque at 2 a.m. in a December month is -1.9 C (28.6 F). This average is based on 310 observations, reflecting the fact that a December month has 31 days.

An examination of the results shown in Table 5 yields the following observations:

(1) At 2 a.m., the average air temperature for a June day varies between a minimum at Fairbanks of 11.1 C (52 F) to a maximum at Brownsville and Phoenix of 25.2 C (77 F). The corresponding average air temperature for a December day varies between a minimum of -21.9 C (-7.4 F) at Fairbanks at 2 a.m. and a maximum of 18.9 C (66 F) at Miami at 1 a.m. The variability of the air temperature about these average values may be measured in terms of standard deviations which are given in Appendix A, Part 2.

(2) The maximum average air temperature for a day in June is 37.9 C (100.2 F) for Phoenix at 5 p.m.; the minimum average air temperature for a day in December is -22.1 C (-7.8 F) for Fairbanks at 8 a.m.

(3) The difference between the average maximum and average minimum air temperatures for a June day in Phoenix is 37.9 - 22.2 = 15.7 C (28.3 F). This difference is larger than for any other location, with Albuquerque showing a June difference of 29.8 - 15.4 = 14.4 C (25.9 F) and Bismark showing a June difference of 23.0 - 12.3 = 10.7 C (19.3 F). The smallest June difference occurs for Miami: 28.9 - 24.5 = 4.4 C (7.9F). The corresponding differences for December days range between 11.6 C (20.9 F) for Phoenix and 0.9 C (1.6 F) for Fairbanks.

These average diurnal temperature measurements may be used to obtain a wide variety of useful estimates. The average daily temperature, for example, for a June month may be estimated as follows for Albuquerque. The area under a temperature-versus-time curve is first estimated using Simpson's rule:

$$[17.5 + 4\,(15.4) + 2\,(20.7) + \ldots + 4\,(20.8) + 17.5] = 553 \text{ (deg) (hour)},$$

and division by 24 hours then yields 23.0 C for the average daily temperature. This computed value may be compared with 23.8 C, based on 30 years of data, as given by Court [39]. Similar calculations can be made to estimate average daytime temperature, average nighttime temperature, etc.

Table 6 shows the average diurnal relative humidity by geographic location for the days in June and December for the years 1965-1974. An examination of this table yields the following observations:

TABLE 6. AVERAGE DIURNAL RELATIVE HUMIDITY AT 3-HOUR INTERVALS FOR JUNE AND DECEMBER FOR YEARS 1965-1974 BY GEOGRAPHIC LOCATION

Month	Hour Index[a]	Relative Humidity, percent								
		ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
June	1	40.1	79.3	77.4	86.2	78.1	69.0	83.4	84.2	30.0
	2	45.8	84.2	80.8	88.3	81.6	69.9	84.4	86.8	36.0
	3	36.2	85.2	74.0	89.5	77.9	58.3	80.5	86.5	26.5
	4	23.8	67.3	63.3	69.8	64.5	45.3	68.7	71.0	18.1
	5	17.0	54.3	60.1	60.7	58.5	39.8	64.8	67.2	14.1
	6	17.9	48.5	60.6	59.5	57.6	40.0	67.5	69.7	12.7
	7	25.4	50.2	67.9	67.2	61.6	46.4	77.2	75.5	16.0
	8	32.8	67.7	74.6	82.4	73.1	61.1	81.6	80.5	22.6
December	1	65.7	78.3	69.5	84.4	74.5	66.2	66.8	78.4	67.3
	2	69.6	78.2	71.4	85.1	75.3	65.9	67.9	81.3	71.0
	3	70.3	78.4	72.3	85.5	75.9	65.9	66.5	82.9	72.3
	4	51.0	77.8	66.3	80.2	75.2	66.0	53.4	68.2	48.3
	5	39.8	70.6	62.1	63.8	71.4	65.5	48.8	58.5	35.8
	6	43.1	66.4	63.1	60.1	70.8	65.9	57.9	58.4	35.7
	7	54.8	73.8	66.4	73.1	73.4	66.0	66.4	68.8	51.8
	8	61.0	77.7	68.2	82.1	74.9	66.3	66.5	75.0	61.5

(a) The hour index corresponds to the eight observation times during a day. For BIS and BRO these eight observation times occur at 0, 3, 6, 9, 12, 15, 18, and 21 hours, local standard time; at BOS, CLE, LAX, and MIA, the observation times occur at 1, 4, 7, 10, 13, 16, 19, and 22 hours; and at ABQ, FAI, and PHX, the observation times occur at 2, 5, 8, 11, 14, 17, 20, and 23 hours.

(1) For a June day, the minimum average relative humidity (12.7 percent) occurs at Phoenix at 5 p.m.; the maximum average relative humidity for a June day occurs at Brownsville (89.5 percent) at 6 a.m.

(2) The minimum and maximum average relative humidities for a December day are 35.7 and 85.5 percent, occurring at Phoenix at 5 p.m. and at Brownsville at 6 a.m.

Table 7 shows the average diurnal wind speed by geographic location for the days in June and December for the years 1965-1974. The minimum and maximum average wind speeds for days in June are 2.4 m/s (5.4 mph) and 7.4 m/s (17.6 mph) and occur at Los Angeles at 4 a.m. and at Brownsville at 3 p.m. The corresponding results for days in December are 1.5 m/s (3.4 mph) for Fairbanks from 11 a.m. through 8 p.m. and 6.7 m/s (15 mph) for Brownsville at 3 p.m.

Table 8 shows the average June and December diurnal solar radiation based on observations at 3-hour intervals for six of the nine geographic locations. Insolation data are not available for Cleveland, Fairbanks, or Los Angeles for the years 1965-1974. Only 30 months of data are available for Phoenix (1965 through June, 1967). Thus, the averages shown in Table 8 for Phoenix are based on 90 and 62 observations for the days of June and December, respectively.

The insolation values reported in Table 8 are for total radiation (direct plus diffuse) as measured by a pyrometer. Although such data are measured at hourly intervals, only the 3-hourly measurements are used in this study since they correspond approximately to the measurement times of the other climatic data available. Examination of Table 8 shows that among the five locations reporting insolation measurements, the maximum average for a June day occurs at Albuquerque with 921 W/m^2 (79.2 ly/hr), followed by Phoenix, 803 W/m^2 (69.1 ly/hr), both occurring at 11 a.m. For December days, the average maximum occurs at Miami with 523 W/m^2 (45.0 ly/hr) at 1 p.m., followed by Brownsville with 471 W/m^2 (40.5 ly/hr) at 12 noon.

TABLE 7. AVERAGE DIURNAL WIND SPEED AT 3-HOUR INTERVALS FOR JUNE AND DECEMBER FOR YEARS 1965-1974 BY GEOGRAPHIC LOCATIONS

Month	Hour Index[a]	Wind Speed, m/s								
		ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
June	1	4.3	3.2	4.3	3.9	3.3	2.8	2.6	2.9	2.7
	2	3.7	3.1	4.1	3.4	3.2	2.5	2.4	2.6	2.8
	3	3.9	3.3	4.5	3.2	3.8	2.9	2.8	2.9	3.4
	4	4.1	4.7	5.1	6.2	4.6	3.7	4.1	4.3	3.3
	5	5.3	5.8	5.9	6.9	5.3	4.2	5.7	5.1	4.2
	6	6.1	6.1	5.9	7.4	5.1	4.1	6.0	5.1	5.0
	7	5.4	5.6	5.1	6.9	3.9	3.6	4.5	4.0	4.0
	8	5.0	3.7	4.6	4.7	3.4	3.0	3.1	3.5	2.9
December	1	3.7	3.4	5.9	3.7	5.1	1.7	2.8	3.5	2.7
	2	3.5	3.6	5.8	3.7	5.1	1.7	2.7	3.3	2.7
	3	3.4	3.5	6.0	3.8	5.1	1.7	3.0	3.2	2.6
	4	4.0	3.9	6.4	5.0	5.5	1.5	3.5	5.2	3.1
	5	4.4	4.9	6.4	6.5	5.9	1.5	4.1	5.8	3.1
	6	4.0	5.3	6.2	6.7	5.6	1.5	4.7	5.5	2.9
	7	3.7	4.0	6.2	4.8	5.1	1.5	3.3	3.9	2.1
	8	3.6	3.6	6.0	3.9	5.2	1.6	2.9	3.6	2.5

(a) The hour index corresponds to the eight observation times during a day. For BIS and BRO these eight observation times occur at 0, 3, 6, 9, 12, 15, 18, and 21 hours, local standard time; at BOS, CLE, LAX, and MIA the observation times occur at 1, 4, 7, 10, 13, 16, 19, and 22 hours; and at ABQ, FAI, and PHX the observation times occur at 2, 5, 8, 11, 14, 17, 20, and 23 hours.

TABLE 8. AVERAGE DIURNAL TOTAL HORIZONTAL SOLAR RADIATION AT 3-HOUR INTERVALS FOR JUNE AND DECEMBER FOR YEARS 1965-1974 BY GEOGRAPHIC LOCATION

Month	Hour Index[a]	Solar Radiation, W/m^2								
		ABQ	BIS	BOS	BRO	CLE[b]	FAI[b]	LAX[b]	MIA	PHX[c]
June	1	0	0	0	0				0	0
	2	1	0	6	0				0	0
	3	464	105	328	31				145	417
	4	973	529	636	537				585	857
	5	892	754	625	872				630	849
	6	387	629	318	706				333	359
	7	1	230	7	168				18	0
	8	0	0	0	0				0	0
December	1	0	0	0	0				0	0
	2	0	0	0	0				0	0
	3	72	0	7	0				3	26
	4	448	55	213	199				411	396
	5	397	264	210	473				583	369
	6	37	151	7	325				245	30
	7	0	0	0	3				0	0
	8	0	0	0	0				0	0

(a) The hour index corresponds to the eight observation times during a day. For BIS and BRO these eight observation times occur at 0, 3, 6, 9, 12, 15, 18, and 21 hours, local standard time; at BOS, CLE, LAX, and MIA, the observation times occur at 1, 4, 7, 10, 13, 16, 19, and 22 hours; and at ABQ, FAI, and PHX, the observation times occur at 2, 5, 8, 11, 14, 17, 20, and 23 hours.

(b) Solar radiation data not available for CLE, FAI, or LAX for the entire period 1965-1974.

(c) The June results for PHX are based on limited data available only for years 1965-1967 for a total of 90 observations for each hour index; the December results for PHX are based on the years 1965-1966 for a total of 62 observations for each hour index. (The other sites for which there are data available involve approximately 300 observations for June and 310 observations for December for the period 1965-1974.)

Source: Appendix A – Part 2.

Occurrences of Combinations of Environmental Variables for Selected Geographic Locations

As noted earlier in this report, a general deficiency in conventional data summaries stems from the fact that each variable is typically summarized independently of all other variables. The preceding descriptive statistics, weather–event statistics, and the diurnal statistics are all summaries of this type. These summaries are, of course, useful and necessary. However, more refined testing and design calculations require information concerning the simultaneous occurrence of the values of several environmental variables. Such combinations of variables are generally labeled "Environmental Cell Statistics" in this report. This section describes the methodology developed for the analysis and presentation of data on combinations of variables, and several following sections present the results of some of the specific combinations which were analyzed.

Description of "Environmental Cell Statistics"

General Description. An environmental cell represents a specified interval of values for each environmental variable involved in a simultaneous combination of variables. A three-variable environmental cell representing temperature, relative humidity, and insolation is defined, for example, by a temperature interval of 20 to 32 C, a relative-humidity interval of 30 to 49 percent, and an insolation interval of 400 to 800 W/m^2. With three environmental variables, the cells may be conveniently represented by a geometric cube.

A cube consisting of 36 environmental cells is shown in Figure 1. These cells are obtained by partitioning the ranges of temperature, relative humidity, and insolation into 4, 3, and 3, intervals, respectively. At any given time the values of a particular combination of temperature, relative humidity, and insolation can be considered to define the coordinates of a point which lies in exactly one of the 36 environmental cells. As the values of these environmental variables change over time, the point moves from cell to cell and generates a trajectory within the cube. By noting the location of the point every 3 hours, the following questions concerning frequency, duration, and transition can be answered:

Frequency: How often does a particular environmental condition occur in a specified time period?

Duration: When a particular environmental condition occurs, how long does it last?

Transition: Given that a particular environmental condition has occurred, what environmental condition is likely to occur next?

The frequency question is answered by counting the number of times the 3-hourly point falls within a particular cell; the duration question is answered by counting the number of successive 3-hourly observations for which the point remains in a specified cell; the transition question is answered by keeping track of the sequence of cells as the point moves from cell to cell. Each of these answers is approximate because in the time interval between the 3-hourly observations, the point may repeatedly move in and out of the cell.

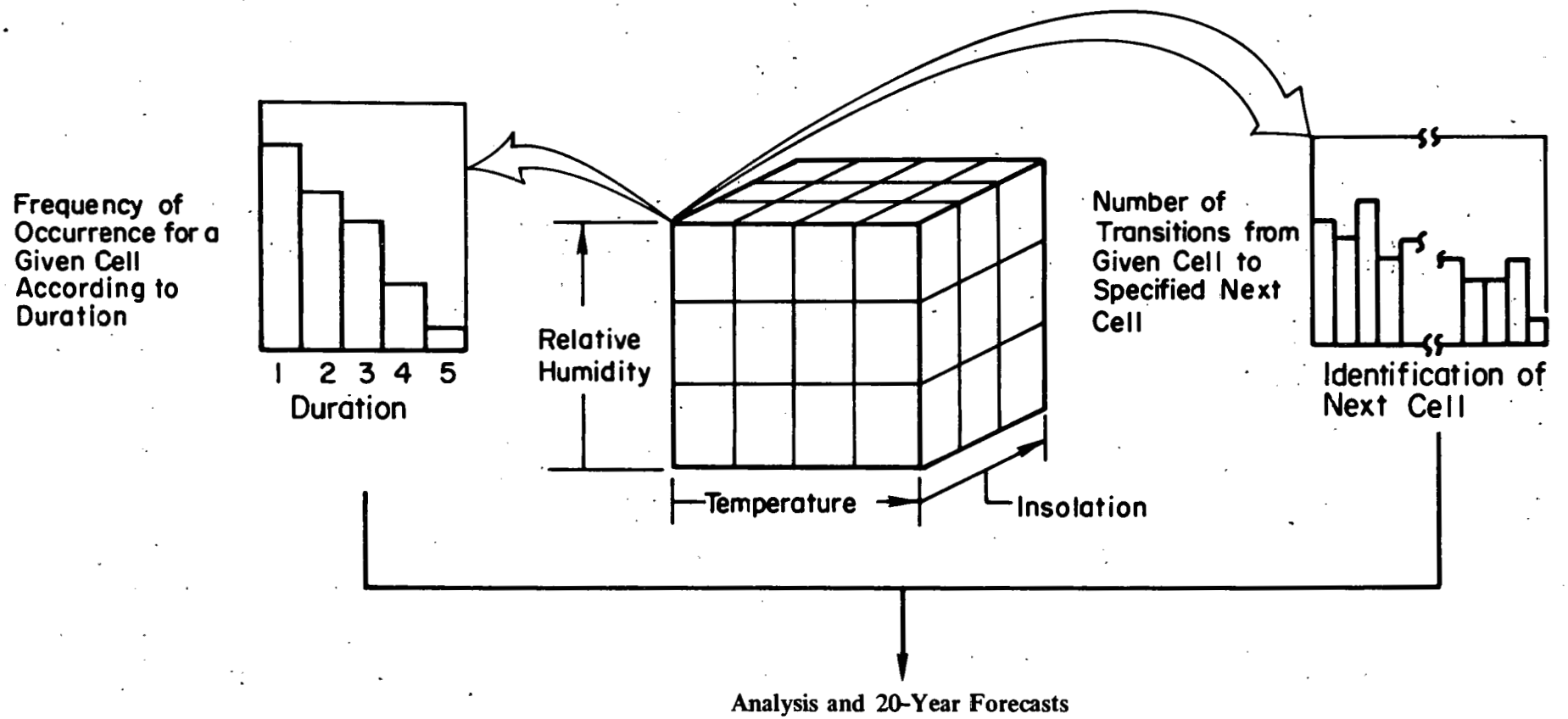


FIGURE 1. SCHEMATIC REPRESENTATIONS OF ENVIRONMENTAL CELL STATISTICS

A frequency and duration histogram for the particular cell having the emerging arrows is also displayed in Figure 1. The left-most bar of the histogram shows the number of times the environmental point entered the cell and remained in the cell for a duration of exactly one observation. The second bar shows the number of times the point entered the cell and remained in the cell for two successive observations, etc. The total number of occurrences of the cell during the historical time period is obtained by summing the products of the frequency and duration values.

The sketch on the right side of the figure shows a transition histogram. The horizontal scale consists of labels representing every possible cell in the cube. The vertical scale denotes the number of times a transition is made from the specified cell to each of the possible remaining cells.

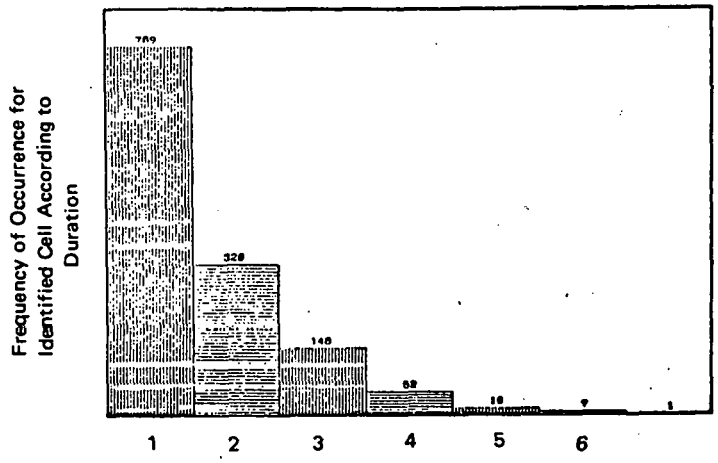
Frequency and Duration Histograms. Actual examples of histograms that indicate the frequency of occurrence of various durations for selected cells are presented in Figure 2. These illustrative examples were generated using data for Albuquerque. The upper histogram pertains to a four-variable cell involving air temperatures in the range 1 to 20 C, relative humidity 0 to 30 percent, wind speeds 2.32 to 6.43 m/s, and insolation 0 to 400 W/m^2. The lower histogram pertains to a three-variable cell involving wind speed, wind direction, and precipitation. In the interest of brevity additional histograms are not presented. Such histograms may be routinely obtained by means of current software for computer graphics.

Transition From Cell to Cell. The transitions from cell to cell constitute the most fundamental, and most voluminous, computed output obtained from this effort. The cell-to-cell transitions are explained in more detail by means of the following example. Suppose that the first measurement time (midnight) for 1965 shows that the air temperature is 5 C (41 F), relative humidity is 65 percent, wind speed is 4 m/s, and insolation is zero. As shown in Table 9 (which is further discussed later), these measurements fall into class intervals that have coded values of 6, 2, 1, and zero for temperature, relative humidity, wind speed, and insolation, respectively. In direct correspondence with these interval code numbers, this cell is assigned the cell code number 6210. Suppose that 3 hours later, the temperature has dropped to 1 C (34 F), the relative humidity has increased to 70 percent, and the wind speed has decreased to 1 m/s. Table 9 shows that these new measured values fall in the cell having the code number 5300. In this case a transition is said to have occurred between Cell 6210 and Cell 5300. Suppose that the next two sets of measurements yield Cells 5300 and 5311. For these four sets of measurements, the transition list now appears as follows: 6210, 5300, 5300, 5311, where the cell 5300 is seen to have a "duration" of 2 successive 3-hourly measurements before making a transition to Cell 5311.

Continuing in this way, it can be seen that the 3-hourly measurements for a given geographic location can be used to obtain the list of successive cell code numbers for the 10-year period 1965–1974. Such a computer-generated list consists of approximately 29,216 cell codes. The sequence of codes in this list can then be examined by computer to determine how many times Cell 5300, for example, occurs exactly once, exactly twice (as above), exactly three times, etc., before making a transition to a cell having a different code number. This aggregated information gives the basis for the frequency and duration histograms illustrated above.

Simultaneous Conditions for Cell 3010

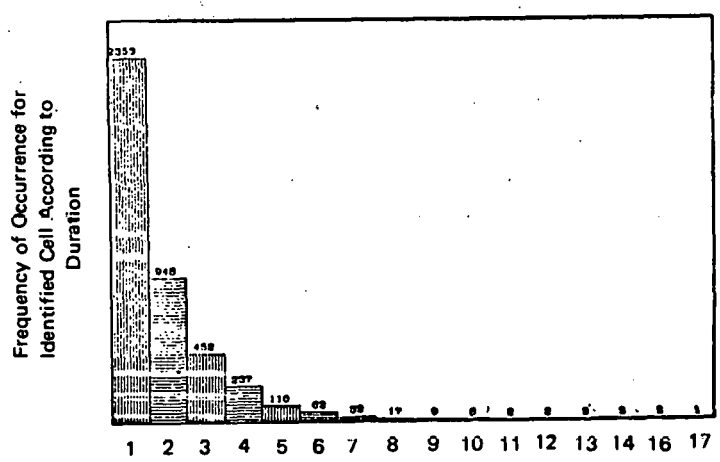
Dry Bulb Temp	1 to 20 deg C
Relative Humidity	0 to 20 percent
Wind Speed	2.32 to 6.43 m/s
Solar Radiation	0 to 400 W/sq m



(a) Example of Frequency and Duration Histogram for Four-Variable Cell for Albuquerque, New Mexico

Simultaneous Conditions for Cell 110

Wind Speed	2.32 to 6.43 m/s
Wind Direction	Northerly
Rain Occurrence	None



(b) Example of Frequency and Duration Histogram for Three-Variable Cell for Albuquerque, New Mexico

FIGURE 2. EXAMPLES OF HISTOGRAMS SHOWING THE FREQUENCY OF OCCURRENCE OF A GIVEN CELL ACCORDING TO DURATION

TABLE 9. CLASS INTERVALS USED IN GENERATING DATA ON COMBINATIONS OF CLIMATIC VARIABLES

Environmental Variable[a]	Code[b]	Class Interval[c][d] SI Units	English Units
Temperature T, C (F)	0	-/-40	(-/-40)
	1	-40/-30	(-40/-22)
	2	-30/-4	(-22/24)
	3	-4/-2	(24/28)
	4	-2/2	(28/36)
	5	2/4	(36/40)
	6	4/20	(40/68)
	7	20/32	(68/90)
	8	32/40	(90/104)
	9	40/+	(104/+)
Relative Humidity RH, percent	0	0/29	0/29
	1	30/49	30/49
	2	50/69	50/69
	3	70/79	70/79
	4	80/89	80/89
	5	90/100	90/100
Wind Speed WS, m/s (mph)	0	0/2	(0/4.5)
	1	2/6	(4.5/13)
	2	6/12	(13/27)
	3	12/+	(27/+)
Insolation INS, W/m^2 (ly/hr)	0	0/400	(0/34)
	1	400/800	(34/69)
	2	800/1000	(69/86)
	3	1000/1100	(86/95)
	4	1100/1400	(95/120)

(a) English units are shown in parentheses.
(b) The codes given convenient designations of particular combinations of the levels of the variables. For example, the ordered code 4213 represents a combination of variables with midpoint values of 0 C, 60 percent, 4 m/s, and 1050 W/m^2 for temperature, relative humidity, wind speed, and insolation, respectively.
(c) The upper class boundary is included in the class interval.
(d) Class intervals for air pollution are indicated later (Table 18).

The following tabulation gives a brief example of computer output that pertains to transitions from cell to cell:

Number of Occurrences in 10 Years	Initial Cell Code Number	Next Cell Code Number
4	2011	3011
1	2012	3000
2	2012	3011
1	2012	3012
3	2020	2010
1	2020	2020
6	2020	2110

The first row indicates that during the 10-year period, there were four transitions that occurred between Cell 2011 and Cell 3011; one transition occurred between Cell 2012 and Cell 3000; etc. Rows 5 and 7 show that Cell 2020 made twice as many transitions to Cell 2110 as it did to Cell 2010.

The complete transition information is available on tape and printout at JPL for use in continuing studies of encapsulation systems. The frequency of occurrence for each duration and the total frequency of occurrence for each cell are easily obtained from this transition information. Of special interest to future studies would be the determination of the number of successive observations in a 10-year period, for example, in which insolation measurements failed to reach a prescribed level, or wind speed remained below a level of interest, or temperature remained above some level, or any combination of these conditions persisted for a specified time.

Twenty-Year Forecasts of Exposure Hours. The environmental cell statistics are used to generate 20-year forecasts of the expected number of exposure hours, E, for each cell as follows:

$$E = NK(T/H),$$

where N denotes the observed number of occurrences of the cell of interest in the historical time period H, T denotes the forecast time period, and K denotes the time interval between measurements. For each of the climate variables, H = 10 years and K = 3 hours, so that a 20-year forecast is obtained by multiplying N by a forecast factor (20/10) (3) = 6. For air-pollution data, the historical time period varies considerably so each forecast factor must be individually generated.

Because of the large fluctuations which characteristically occur in values of climate, insolation, and air-pollution variables, the expected forecast generated by the above simple method is likely to be a poor estimate of the actual number of occurrences in 20 years. For this reason, it is desirable to provide an upper limit to the forecase in order to better quantify how often a cell might occur because of chance fluctuations. The Poisson distribution provides a simple method for obtaining such an upper limit. This method was investigated and a procedure is given in Appendix D for obtaining these upper limits at an approximate 95 percent confidence level. The statistical properties of the Poisson distribution are given in most standard textbooks.[17, 18] Applications to meteorology and climatology are numerous.[19–21]

Implementation of the Environmental Cell Analysis

The environmental cell analyses for the nine geographic locations were implemented using the CDC-computer version of the Statistical Package for the Social Sciences (SPSS), a widely available software package. The following outline shows the steps of the general procedures used in analyzing the data treated in this report. The same procedures are recommended for future analyses that may be performed for additional geographic locations.

(1) Obtain climatic, insolation, and air pollution data tapes for the desired geographic locations and historical time periods.

(2) Examine and edit the data tapes for illegal data in the various fields.

(3) For each location, generate a merged data tape in which the climate, insolation, and air pollution variables are matched at specific times throughout the historical time period (for example, at 3-hour intervals over the historical time period).

(4) Generate descriptive statistics, including the means, standard deviations, minimums and maximums for each variable and for each time period (monthly, seasonal, annual) of interest.

(5) Generate diurnal statistics (by time of day) for each variable of interest, including the mean, standard deviation, minimum, and maximum.

(6) Generate weather-event statistics by counting the number of occurrences, such as occurrences of fog, rain, snow, sleet, etc.

(7) Identify those combinations of variables that are of interest, such as simultaneously occurring values of air temperature, insolation, and wind speed.

(8) For each variable in a combination of variables, partition the range (maximum minus minimum) into a set of non-overlapping class intervals, such as those listed in Table 9.

(9) Assign code numbers to each class interval of each variable so that each combination of variables is represented by a unique cell code number; for example, the codes in Table 9 show that simultaneously occurring values of 10 C for temperature, 40 percent for relative humidity, 8 m/s for wind speed, and 900 W/m^2 for insolation would "occupy" a cell having a code number of 6122.

(10) Use appropriate computer software to determine which cell is occupied by the measured values recorded for the first measurement time of the historical period, which cell is occupied at the second measurement time, etc., and thereby generate an ordered listing of the occupied cells for the entire historical time period. This list is called a list of "cell transitions".

(11) With appropriate aggregation software use the list of cell transitions to obtain histograms of the form shown in Figure 2. That is, for each cell determine the number of times the cell is occupied exactly once, exactly twice, etc., before a transition occurs to a different cell. The frequency of occurrence for each duration for each cell is then plotted as shown in Figure 2, where, for example, Cell 3010 experiences 709 occurrences of duration 1, 326 occurrences of duration 2, 146 occurrences of duration 3, etc.

(12) For each cell compute the total number N of measurement times the cell was occupied during the historical time period of H years. This number N is equal to the sum of the products of the frequencies and durations obtained from histograms as illustrated in the preceding step.

(13) Estimate the exposure hours for the conditions of each cell by NK, where K denotes the number of hours between successive measurement times.

(14) Forecast the expected number of exposure hours for a future period of T years to be given by E = NK(T/H), and obtain an upper limit to this estimate from the procedure of Appendix D.

Several comments are appropriate regarding the choice of the class intervals in Step (8):

- The class intervals need not be of equal size. In Table 9 it is seen, for example, that relatively small class intervals of 2C were chosen for temperatures near freezing. This was done in order to permit more detailed analyses related to freeze-thaw cycles. The class intervals for wind speed are shown to be successively increasing in size. This was done to reflect a general dependency between solar panel surface temperature and wind speed (relatively high sensitivity at low wind speed; relatively low sensitivity at high wind speed). The class interval sizes are shown in Table 9 to be relatively small at high values of relative humidity and insolation. This was done to permit more refined analyses to be made under those environmental conditions expected to be associated with possibly high degradation rates of material characteristics.

- It is not necessary to have the same number of class intervals for each variable. Table 9 shows, for example, 10, 6, 4, and 5 class intervals for temperature, relative humidity, wind speed, and insolation, respectively.

- The total number of cells resulting from the class intervals must not be too large for convenient use and computer storage, nor be too few to permit sufficiently detailed analyses. The total number of cells obtained from the class intervals of Table 9 is seen to be (10) (6) (4) (5) = 1200 cells. Before analyses are made, it is generally not known how many of these cells will be occupied by historically occurring simultaneous values of the variables. General experience shows that many cells will not be occupied. This is reflected by the large number of blank cells shown in the tables of results which follow.

- In some instances the choice of suitable class intervals becomes a matter of trial and error. Considerable difficulty was experienced, for example, in defining class intervals for the air pollution data. Wide variations in pollution levels between geographic locations made it difficult to identify a single set of class intervals that would be suitable across all locations.

The above procedures were applied to the selected combinations of variables listed below and to geographic locations for which appropriate data were available. The combinations selected were based on several criteria: to provide illustrative examples, to test the practical feasibility of the method, and to obtain useful information for engineering purposes.

Combination of Variables	Locations
Air temperature, relative humidity, wind speed, and total insolation	Albuquerque, Bismarck, Boston, Brownsville, Miami
Air temperature, relative humidity, and wind speed (appropriate insolation data not available)	Cleveland, Fairbanks, Los Angeles, Phoenix
Air temperature, and weather event (fog, rain, snow, etc.)	All nine locations
Air pollutant (SO_2, NO_2, total oxidants), and weather event (fog, drizzle, rain, etc.)	Boston, Cleveland, Los Angeles, Phoenix
Wind speed, wind direction, and weather event (fog, rain, snow, etc.)	All nine locations
Air temperature, relative humidity, wind speed, and computed values of normal insolation	Albuquerque
Air temperature, total insolation, and weather event (fog, rain, snow, etc.)	Albuquerque, Bismarck, Boston, Brownsville, Miami
Air temperature, relative humidity, and air pollution (CO, SO_2, NO_2, HC, total oxidants, and soiling index)	Boston, Cleveland, Los Angeles, Phoenix

A large amount of output resulted from these calculations. From these results, only selected examples are given in the tables which follow. These tables are intended to illustrate the kinds of information obtained by this approach.

Occurrences of Combined Conditions of Temperature/Relative Humidity/Wind Speed/Insolation

The class intervals used to define the combinations of temperature, relative humidity, wind speed, and insolation used in the cell statistics were given in Table 9. English equivalents are shown in parentheses. The ten levels of temperature are coded as 0 through 9. Similarly, it is

seen that relative humidity, wind speed, and insolation have 6, 4, and 5 levels, respectively. The number of possible combinations of these four variables is thus given by (10) (6) (4) (5) = 1200.

As indicated previously, the data for each combination of variables consist of measurements taken once every 3 hours. The environmental conditions that exist between these successive 3-hour measurements are not recorded on the merged data tape. In order to estimate the number of hours spent under various environmental conditions, some assumptions must be made concerning the conditions that exist during the 3-hour intervals between measurements. The simplest assumption, and the one made in this report, is that any measured environmental condition identifies a particular cell and that cell lasts at least 3 hours; that is, any cell persists until the next measurement time, when a transition to the same or different cell may occur. Thus, if a particular cell is found to occur 50 times in 10 years, then a total exposure time of 150 hours is obtained for the conditions represented by that cell because it is assumed that each occurrence lasts 3 hours. It is also assumed in this report that trends may be neglected. Thus, the expected exposure time for a future 20-year period for the conditions of this cell is found to be 300 hours because the projected period (20 years) is twice the duration of the historical period (10 years). The net result of these assumptions is the following: the expected number of exposure hours for a 20-year forecast period is obtained by multiplying the observed number of occurrences in the 10-year period by 6. It may be noted that the assumption of the 3-hour persistence does not generally hold for a given condition. Some environmental variables will certainly change by a measureable amount over a 3-hour time interval. However, whether the change is sufficiently large to cause a transition to a different cell is not readily know. It depends, for example, on the size of the class intervals used to define the cell; the location of the "point" representing the environmental condition within the cell; etc. In other words, some variations in the environmental conditions can occur without violating the assumption that no transition from the cell occurs over the 3-hour period. Large variations, of course, will cause undetected transitions.

Results and Discussions

Tables 10(a) through 10(i) show the expected number of exposure hours for a 20-year forecast period for combinations of air temperature, relative humidity, wind speed, and insolation for the nine geographic locations considered in this report. These results are particularly applicable to design and evaluations of encapsulation systems and arrays. It is to be noted that calculations of of actual array service temperatures are based on simultaneous values of air temperature, insolation, and air speed.

For example, the main body of Table 10(a) for Albuquerque shows that 1152 hours of exposure may be expected in this time period with insolation between 0 and 400 W/m^2, air temperature between 20 and 32 C, relative humidity between 0 and 29 percent, and wind speed between 0 and 2 m/s. The actual number of occurrences of this cell for the period 1965–1974 is given by 1152/6 or 192 occurrences. From Table D-1 of Appendix D, a 95 percent Poisson upper limit for the number of occurrences is found to be 433. Under the assumption that each occurrence lasts 3 hours, an upper limit for the expected number of exposure hours under these conditions is given by 3 x (433) or 1299 hours. Similar calculations may be made for any of the entries in the main body of Table 10.

For convenience the entries of the main body of Table 10 have been summed in a variety of ways. The summation table immediately below the main body consists of the totals obtained by summing over the insolation intervals. This procedure yields the distribution of exposure hours by wind speed, relative humidity, and temperature. For Albuquerque, for example, the table

shows 2904 exposure hours for a temperature between 20 and 32 C, wind speed between 20 and 32 C, wind speed between 0 and 2 m/s, and relative humidity between 0 and 29 percent. This number is obtained by adding 1152, 762, 810, 156, and 24 across the 5 insolation intervals. The bottom row of the Table gives a summation over air temperatures. These totals show the distribution of exposure hours according to relative humidity for each interval of wind speed.

The summation tables shown at the right side of Table 10 are obtained by summing across columns. The summation table immediately to the right of the main body is obtained by summing over wind speed. The resulting table shows the distribution of exposure hours by air temperature and relative humidity for each category of insolation. For Albuquerque, the table shows 10,506 hours of exposure at a temperature between 20 and 32 C, relative humidity between 0 and 29 percent, and insolation between 0 and 400 W/m^2. The right-most column of the table is obtained by summing across relative humidity and wind speed. The resulting column gives the distribution of exposure hours by temperature for each interval of insolation.

The 2-way lower-right table is obtained by summing the main-body entries over insolation and wind speed. The resulting table gives the distribution of exposure hours by air temperature and relative humidity. The table shows 23,964 exposure hours for Albuquerque for temperatures between 20 and 32 C and relative humidities between 0 and 29 percent. The row and column sums of this table yield the distributions for air temperature alone, and relative humidity alone. For Albuquerque the table shows 43,836 exposure hours for temperatures between 20 and 32 C, and 57,564 exposure hours for relative humidities between 0 and 29 percent. The total of all entries is shown to be 171,066 exposure hours.

A blank entry in Table 10 indicates that no occurrence of the corresponding combination of variables was shown in the data base for the 10-year period 1965–1974. When an entire row or column was blank, the row or column of blanks (zeros) was not included in the table.

For Cleveland, Fairbanks, and Los Angeles only the (lower) summation tables are presented because insolation data for these locations were not available for the entire period, 1965–1974.

Some special comments are required for the low category of insolation, 0 to 400 W/m^2. The following rule was used to interpret blank values for insolation measurements as reported on the data tape. If the time of day was between 6:00 p.m. and 6:00 a.m. local time, then a blank insolation value was set equal to 0.0 W/m^2 to represent a nighttime value of insolation; for daytime values between 6:00 a.m. and 6:00 p.m. a blank value for insolation was interpreted to mean "missing data", and was deleted from subsequent calculations. For each geographic location, the amount of missing data can be assessed by comparing the lower-right grand total with 175,296, the maximum number of exposure hours for the 20-year forecast period. An approximate correction for the missing data can be obtained by inflating the entries of the main body of Table 10 by the ratio of 175,296 to the grand total shown for each geographic location.

Table 11 shows the expected number of exposure hours for combinations of relative humidity, wind speed, and insolation at high air temperatures (those above 32 C, or 90 F) for a period of 20 years for those five locations for which insolation data were available for 1965–1974. The table shows, for example, that Bismarck is expected to experience 120 hours of exposure in the next 20 years to a combination of temperatures over 32 C, relative humidity between 30 and 49 percent, wind speed between 2 and 6 m/s, and insolation between 0 and 400 W/m^2. This combination of hours may be symbolically expressed as follows: T (32+), RH (30/49), WS (2/6), and INS (0/400), where T, RH, WS, and INS denote temperature, relative humidity, wind speed, and

TABLE 10. EXPECTED NUMBER OF EXPOSURE HOURS[a] FOR COMBINATIONS OF AIR TEMPERATURE, RELATIVE HUMIDITY, WIND SPEED, AND INSOLATION FOR 20-YEAR FORECAST PERIOD

TABLE 10(a). ALBUQUERQUE, NEW MEXICO

Expected Exposure Time in 20 Years for Combinations of Wind Speed vs. Relative Humidity vs. Insolation vs. Air Temperature, hours

Insolation, W/m²	Air Temperature, C	Wind Speed, m/s: 0/2						2/6						6/12						12/+						Totals for Relative Humidity vs. Insolation vs. Temperature						Totals for Temperature vs. Insolation
	Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
0/400	-30/-4		216	660	468	420	246	48	672	1668	888	744	312		108	270	60	54	18		18	12	12	12		48	1014	2610	1428	1230	576	6906
	-4/-2	36	276	636	396	294	156	60	570	1368	678	498	228	12	90	222	96	18	12		18	66	12			108	954	2292	1182	810	396	5742
	-2/2	162	1212	1956	804	738	258	516	2556	4140	1698	828	444	120	468	858	180	96	30		30	72	6	6		798	4266	7026	2688	1668	732	17178
	2/4	246	786	732	294	150	60	462	2004	1770	744	516	210	102	372	432	168	30	12		30	18				810	3192	2952	1206	896	282	9138
	4/20	3414	4176	3276	1368	1176	498	12180	11982	8496	2952	2436	930	2958	3006	2352	774	288	42	78	210	150		6	6	18630	19374	14274	5094	3906	1476	62754
	20/32	1152	1110	702	66			6702	4944	2280	222	30		2532	1830	660	12			120	108	36				10506	7992	3678	300	30		22506
	32/40	66						384						114	6					12						576	6					582
400/800	-30/-4		12	18	12			12	42	72	42	18	12	6	6	18						6				18	60	114	54	18	12	276
	-4/-2	6	78	30	6	6	6	12	60	54		12	18	18	36											36	174	84	6	18	24	342
	-2/2	72	150	138	24	6	6	60	492	276	54		5	66	96	48					6					198	744	462	78	6	12	1500
	2/4	36	228	102	6	6		126	492	222	18	12		66	96	24	6				6	12				228	822	360	30	18		1458
	4/20	1542	1668	588	108	24	6	3612	3372	960	162	42	5	1152	864	168	18	6		84	66	6				6390	5970	1722	288	72	12	14454
	20/32	762	564	402	30			3198	1728	570	48			1560	390	48				120	6	6				5640	2688	1026	78			9432
	32/40	84						678	12					288						6						1056	12					1068
	40/+													6												6						6
800/1000	-2/2	6	6					24	6	12		6		24												54	12	12		6		84
	2/4	12	6	12				12	12		6		5	18	6						6					42	30	12	6		6	96
	4/20	342	174	54				1332	540	120	6			606	54					42						2322	768	174	6			3270
	20/32	810	714	126				3888	2112	186	6			876	228	18				54	12					5628	3066	330	6			9030
	32/40	192						888	6					156						12						1248	6					1254
1000/1100	4/20	24	18	6				342	48	6				150	6					12						528	72	12				612
	20/32	156	114	12				1254	366	60				384	18					48						1842	498	12				2412
	32/40	18						366						18												402						402
1100/1400	4/20	6						54	6					24												84	6					90
	20/32	24	30					252	72	6				72												348	102	6				456
	32/40							18																		18						18

Totals for Wind Speed vs. Relative Humidity vs. Temperature

Air Temperature, C	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	Totals for Temperature Levels
-30/-4		228	678	480	420	246	60	714	1740	930	762	324	6	114	288	60	54	18		18	18	12	12		66	1074	2724	1482	1248	588	7182
-4/-2	42	354	666	402	300	162	72	630	1422	678	510	246	30	126	222	96	18	12		18	66	12			144	1128	2376	1188	828	420	6084
-2/2	240	1368	2094	828	744	264	500	3054	4428	1752	834	450	210	564	906	180	96	30		36	72	6	6		1050	5022	7500	2766	1680	744	18762
2/4	294	1020	846	300	156	60	500	2508	1992	768	528	216	186	474	456	174	30	12		42	30				1080	4044	3324	1242	714	288	10692
4/20	5328	6036	3924	1476	1200	504	17520	15948	9582	3120	2478	936	4890	3930	2520	792	294	42	216	276	156		6	6	27954	26190	16182	5388	3978	1488	81180
20/32	2904	2532	1242	96			15294	9222	3102	276	30		5424	2466	726	12			342	126	42				23964	14346	5112	384	30		43836
32/40	360						2334	18					576	6					30						3300	24					3324
40/+													6												6						6
Total	9168	11538	9450	3582	2820	1236	36480	32094	22266	7524	5142	2172	11328	7680	5118	1314	492	114	588	516	384	30	24	6	57564	51828	37218	12450	8478	3528	171066

Totals for Temperature vs. Relative Humidity

(a) See text for description of assumption and procedure used for calculating expected number of hours. (Blanks are zeros, as described in the text.)

TABLE 10(b). BISMARCK, NORTH DAKOTA

Insolation, W/m²	Air Temperature, C	Expected Exposure Time in 20 Years for Combinations of Wind Speed vs. Relative Humidity vs. Insolation vs. Air Temperature, hours: Wind Speed, m/s 0/2						2/6						6/12						12/+						Totals for Relative Humidity vs. Insolation vs. Temperature						Totals for Temperature vs. Insolation
	Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
0/400	-40/-30		6	144	150	66	36		18	126	54	6	12			18	6										24	288	210	72	48	642
	-30/-4	6	48	1974	2544	2676	1626		216	6066	4506	3750	1093		144	3018	1758	924	114		24	102	120	48	18	6	432	11160	8928	7398	2856	30780
	-4/-2		12	198	516	750	390		48	564	1068	1008	450		42	462	480	300	78			24	6	6	6		102	1248	2070	2064	924	6408
	-2/2		48	852	1272	1662	138	12	180	2196	2514	2730	935		96	1050	1134	1122	270		18	84	54	48	18	12	342	4182	4974	5562	1962	17034
	2/4		36	438	654	648	240	12	198	1278	1284	948	324	6	132	618	648	348	144		12	18	18	6		18	378	2352	2604	1950	708	8010
	4/20	66	900	2730	2496	4008	3572	540	3678	7152	4674	5562	4033	588	2226	3234	1578	1734	1062	36	66	84	24	6	12	1230	6870	13200	8772	11310	9084	50466
	20/32	108	402	438	210	90	36	1008	2574	1914	672	306	72	546	1530	798	234	54	30		12		6	6		1662	4518	3150	1122	456	138	11046
	32/40	24	24					246	120					84	42											354	186					540
400/800	-40/-30									6																		6				6
	-30/-4		54	312	102	48			96	924	294	72	13		96	576	126	24			6	36					252	1848	522	144	18	2784
	-4/-2			18	24	12			30	168	60	42			24	108	36		6			6					54	300	120	54	6	534
	-2/2		12	54	36	6		6	42	330	126	48	12		66	270	138	30								6	120	654	300	84	12	1176
	2/4		18	54	12	18	6	6	42	318	90	18	6	6	66	150	72	6								12	126	522	174	42	12	888
	4/20	72	360	666	300	66	18	384	1698	2010	582	180	60	426	1764	1428	246	66	12	54	48	18				936	3870	4122	1128	312	90	10458
	20/32	126	252	384	42	6		756	1812	1452	234	48		678	1224	624	60	18		36	18					1596	3306	2460	336	72		7770
	32/40	12	18					216	126	6				204	114											432	258	6				696
	40/+													6												6						6
800/1000	-30/-4			12	6				18	60	18				12	42											30	114	24			168
	-4/-2								6	12						6											6	18				24
	-2/2		6	12				12	12	18				6	6	36	12				12					18	36	66	12			132
	2/4		6					6		12		6			24	18										6	30	30		6		72
	4/20		66	30				144	522	216	18	12		204	462	150	6			18	6					366	1056	396	24	12		1854
	20/32	48	276	78				342	1398	450	12			432	1002	252					6					822	2682	780	12			4296
	32/40		6					114	60					42	84	6										156	150	6				312
1000/1100	-4/-2										6				6		6										6		12			18
	2/4		6							6																	6	6				12
	4/20		6					6	108	42				24	108	18										30	222	60				312
	20/32		12	18				6	108	48				36	96	12	18									42	216	78	18			354
1100/1400	-2/2									6																		6				6
	20/32								12																		12					12
		Totals for Wind Speed vs. Relative Humidity vs. Temperature																								Totals for Temperature vs. Relative Humidity						Totals for Temperature Levels
	-40/-30		6	144	150	66	36		18	132	54	6	12			18	6										24	294	210	72	48	648
	-30/-4	6	102	2298	2652	2724	1625		330	7050	4818	3822	1116		252	3636	1884	948	114		30	138	120	48	18	6	714	13122	9474	7542	2874	33732
	-4/-2		12	216	540	762	393		84	744	1134	1050	450		72	576	522	300	84			30	6	6	6		168	1566	2202	2118	930	6984
	-2/2		66	918	1308	1668	738	30	234	2550	2640	2778	948	6	168	1356	1284	1152	270		30	84	54	48	18	36	498	4908	5286	5646	1974	18348
	2/4		66	492	666	666	246	24	240	1614	1374	972	330	12	222	786	720	354	144		12	18	18	6		36	540	2910	2778	1998	720	8982
	4/20	138	1332	3426	2796	4074	3990	1074	6006	9420	5274	5754	4098	1242	4560	4830	1830	1800	1074	108	120	102	24	6	12	2562	12018	17778	9924	11634	9174	63090
	20/32	282	942	918	252	96	36	2112	5904	3864	918	354	72	1692	3852	1686	312	72	30	36	36		6	6		4122	10734	6468	1488	528	138	23478
	32/40	36	48					576	306	6				330	240	6										942	594	12				1548
	40/+													6												6						6
Total		462	2574	3412	8364	10056	7062	3816	13122	25380	16212	14736	7026	3288	9366	12894	6558	4626	1716	144	228	372	228	120	54	7710	25290	47058	31362	29538	15858	156816

TABLE 10(c). BOSTON, MASSACHUSETTS

Expected Exposure Time in 20 Years for Combinations of Wind Speed vs. Relative Humidity vs. Insolation vs. Air Temperature, hours

Insolation, W/m²	Air Temperature, C	Wind Speed, m/s: 0/2						2/6						6/12						12/+						Totals for Relative Humidity vs. Insolation vs. Temperature						Totals for Temperature vs. Insolation
	Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
0/400	-30/-4	6	144	108	42	36	6	96	1344	2130	456	480	108	204	2616	2274	252	240	78	12	192	48	12	30	18	318	4296	4560	762	786	210	10932
	-4/-2	6	36	126	54	30	36	24	612	1374	366	360	156	72	750	1128	174	180	156		36	96	6	6	6	102	1434	2724	600	576	354	5790
	-2/2	6	90	396	306	282	222	96	1704	4740	2292	2040	1620	84	1800	3054	1038	1032	1086	6	108	60	12	78	168	192	3702	8250	3648	3432	3096	22320
	2/4		66	144	204	162	96	54	822	2286	1632	1428	858	48	750	1560	564	600	336	6	24	24	12	48	78	108	1662	4014	2412	2238	1368	11802
	4/20	12	144	1320	1344	1692	2196	366	3708	12354	9270	11376	10428	468	3336	5898	2784	3126	3012	24	108	78	48	138	126	870	7296	19350	13445	16332	15762	73056
	20/32	6	18	324	324	396	66	78	1578	4614	3360	2568	942	126	1098	2196	1086	648	132		6	6	12	6		210	2700	7140	4782	3618	1140	19590
	32/40								108					12	72	12										12	180	12				204
400/800	-30/-4		6					12	138	60				36	336	120					6	6				48	486	186				720
	-4/-2							18	30	42	6			12	162	54					6	6				30	198	102	6			336
	-2/2		24	24	6			54	282	150	30	6	6	18	354	210	18	6			12	6				72	672	390	54	12	6	1206
	2/4		18			12		12	144	84	30	18		6	282	138	12				12	6				18	456	228	42	30		774
	4/20	30	72	168	66	42	6	222	1578	2466	870	444	114	216	1524	1422	300	78	24	24	42	36				492	3216	4092	1236	564	144	9744
	20/32		90	180	54	6	6	34	1764	2832	696	168		162	1002	1110	270	12		6		6				252	2856	4128	1020	186	6	8448
	32/40		6					6	120	12					54	12										6	180	24				210
800/1000	-30/-4								6						12												18					18
	-4/-2														6	6											6	6				12
	-2/2									6				6	36	6										6	36	12				54
	2/4							6	12					6	24	6										12	36	6				54
	4/20		12		6			120	372	384	72	84	13	156	354	330	96	24	6		6					276	744	714	174	108	24	2040
	20/32		36	24				150	1098	720	48	6		66	468	276	24	12			6					216	1608	1020	72	18		2934
	32/40								24	6					42	6											66	12				78
1000/1100	4/20								6																		6					6
	20/32								6																		6					6
1100/1400	2/4														6												6					6

Totals for Wind Speed vs. Relative Humidity vs. Temperature

Air Temperature, C	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	Totals for Temperature vs. Relative Humidity: 0/29	30/49	50/69	70/79	80/89	90/+	Totals for Temperature Levels
-30/-4	6	150	108	42	36	6	108	1488	2190	456	480	108	240	2964	2394	252	240	78	12	198	54	12	30	18	366	4800	4746	762	786	210	11670
-4/-2	6	36	126	54	30	36	42	642	1416	372	360	156	84	918	1188	174	180	156		42	132	6	6	6	132	1638	2832	606	576	354	6138
-2/2	6	114	420	312	282	222	150	1986	4896	2322	2046	1626	108	2190	3270	1056	1038	1086	6	120	56	12	78	168	270	4410	8652	3702	3444	3102	23580
2/4		84	144	204	174	96	72	978	2370	1662	1446	858	60	1062	1704	576	600	336	6	36	30	12	48	78	138	2160	4248	2454	2268	1368	12636
4/20	42	228	1188	1416	1734	2202	708	5664	15204	10212	11904	10560	840	5214	7650	3180	3228	3042	48	156	114	48	138	126	1638	11262	24156	14856	17004	15930	84846
20/32	6	144	528	378	402	72	312	4446	8166	4104	2742	942	354	2568	3582	1380	672	132	6	12	12	12	6		678	7170	12288	5874	3822	1146	30978
32/40		6					6	252	18				12	168	30										18	426	48				492
Total	66	762	2514	2406	2658	2610	1398	15456	34260	19128	18978	14250	1698	15084	19818	6618	5958	4830	78	564	378	102	306	396	3240	31866	56670	28254	27900	22110	170340

TABLE 10(d). BROWNSVILLE, TEXAS

Expected Exposure Time in 20 Years for Combinations of Wind Speed vs. Relative Humidity vs. Insolation vs. Air Temperature, hours

Insolation, W/m²	Air Temperature, C	Wind Speed, m/s: 0/2						2/6						6/12						12/+						Totals for Relative Humidity vs. Insolation vs. Temperature						Totals for Temperature vs. Insolation
	Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
0/400	-2/2			6	18	36	12		6	30	48	24	18			18	6	126	102								6	54	72	186	132	450
	2/4			24	36	54	36		12	132	138	78	78		36	72	36	72	42								48	228	210	204	156	846
	4/20		36	366	918	2748	4032	66	882	3732	3522	6564	8382	48	540	1530	1122	1596	1968			12		6		114	1458	5640	5562	10914	14382	38070
	20/32	6	12	108	528	4536	7338	42	264	4854	9420	19314	11388	30	240	6450	5778	5706	1668			66	60	30	18	78	516	11478	15786	29586	20412	77856
	32/40			12					12	30						12											12	54				66
400/800	2/4								12	6		6			6	6	12										18	12	12	6		48
	4/20	24	60	30	42	12	24	78	396	516	222	162	72	126	438	372	78	36	18			6				228	894	924	342	210	114	2712
	20/32	18	42	270	300	102	12	108	1158	6012	2826	738	72	156	1092	8262	2202	186	24		36	288	72			282	2328	14832	5400	1026	108	23976
	32/40		6	12				12	282	324				18	534	792	6					6				30	822	1134	6			1992
800/1000	4/20		18					42	72	72	12			30	96	60	12				12					72	198	132	24			426
	20/32		42	42				30	492	1356	90	24		60	444	2538	96	6	6	6		78				96	978	4014	186	30	6	5310
	32/40		6					6	294	348					612	702						18				6	912	1068				1986
1000/1100	4/20		6					12	24					6	18	6										18	48	6				72
	20/32	12	6	24	6			18	180	402	36	12		6	186	852	12					30				36	372	1308	54	12		1782
	32/40			6					150	114				6	372	366						12				6	522	498				1026
1100/1400	20/32		12					6	48	222	6			6	84	294	12									12	144	516	18			690
	32/40								66	60					150	168											216	228				444

Totals for Wind Speed vs. Relative Humidity vs. Temperature

	-2/2			5	18	36	12		6	30	48	24	18			18	6	126	102								6	54	72	186	132	450
	2/4			24	36	54	36		24	138	138	84	78		42	78	48	72	42								66	240	222	210	156	894
	4/20	24	120	395	960	2760	4056	198	1374	4320	3756	6726	8454	210	1092	1968	1212	1632	1986		12	18		6		432	2598	6702	5928	11124	14496	41280
	20/32	36	114	444	834	4638	7350	204	2142	12846	12378	20088	11460	258	2046	18396	8100	5898	1698	6	36	462	132	30	18	504	4338	32148	21444	30654	20526	109614
	32/40		12	33				18	804	876				24	1668	2040	6					36				42	2484	2982	6			5514
Total		60	246	903	1848	7488	11454	420	4350	18210	16320	26922	20010	492	4843	22500	9372	7728	3823	6	48	516	132	36	18	978	9492	42126	27672	42174	35310	157752

Totals for Temperature vs. Relative Humidity

Totals for Temperature Levels

TABLE 10(e). CLEVELAND, OHIO

Wind Speed, m/s	Expected Exposure Time in 20 Years for Combinations of Wind Speed vs. Relative Humidity vs. Air Temperature, hours																								Totals for Relative Humidity vs. Temperature						Totals for Temperature Levels
	0/2						2/6						6/12						12/+												
Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
Air Temperature, C																															
-30/-4		18	414	528	384	162		318	5088	3318	1914	408		180	2700	1278	672	114			18	12	6			516	8220	5136	2976	684	17532
-4/-2		6	288	312	264	102		144	2382	1596	1140	258		54	1074	600	294	144			12	12		6		204	3756	2520	1698	510	8688
-2/2		90	606	696	798	438		558	5034	4350	4092	1734		246	2388	1428	1146	294			24	30	6	12		894	8052	6504	6042	2478	23970
2/4		36	342	414	288	174	6	426	2298	2184	1560	774		204	1032	732	414	162	6		24	6	6		6	672	3596	3336	2268	1110	11088
4/20	30	570	2352	2730	4680	3972	216	4836	15042	11274	12072	7854	120	1980	5202	2592	2478	1110	42	132	48	24		366	7428	22728	16644	19254	12936	79356
20/32	6	564	1590	912	582	306	156	4386	11772	5034	2850	942	24	1296	2850	570	204	60	36	18					186	6282	16230	6516	3636	1308	34158
32/40		18					6	60	54					30	18										6	108	72				186
Total	36	1302	5592	5592	6996	5154	384	10728	41670	27756	23628	11970	144	3990	15264	7200	5208	1884	84	228	108	42	18		564	16104	62754	40656	35874	19026	174978

TABLE 10(f). FAIRBANKS, ALASKA

Wind Speed, m/s	0/2						2/6						6/12						12/+												
Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
Air Temperature, C																															
-/-40		12	3702	66		18			138	6		12														12	3840	72		30	3954
-40/-30		858	2796	5046	564	282		192	348	504	84	24			6											1050	3150	5550	648	306	10704
-30/-4	66	4824	15882	7302	6726	2582	48	4506	8700	3432	2568	660		630	468	90	66	18	6	12	6		6	114	9966	25052	10830	9360	3666	58998
-4/-2	6	192	948	936	684	270		534	1362	780	516	156		108	84	54	6	12			6			6	834	2394	1776	1206	438	6654
-2/2	12	606	2052	1356	1242	162	18	1560	3474	1494	1044	468		156	276	114	84	24						30	2322	5802	2964	2370	1254	14742
2/4	6	564	840	678	792	192	12	1074	1416	624	420	126	24	126	150	78	48	12							42	1764	2406	1380	1260	330	7182
4/20	798	3966	6534	3870	4506	1116	2268	11514	11088	4554	4566	1680	708	1518	648	234	318	168	6	6					3774	17004	18276	8658	9390	3564	60666
20/32	420	1398	354	12			1644	3414	606				300	336	72										2364	5148	1032	12			8556
32/40	6						6																		12						12
Total	1314	12420	33108	19266	14514	6222	3996	22794	27132	11394	9198	3126	1032	2874	1704	570	522	234		12	18	12		6	6342	38100	61952	31242	24234	9588	171468

TABLE 10(g). LOS ANGELES, CALIFORNIA

Wind Speed, m/s	0/2						2/6						6/12						12/+												
Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
Air Temperature, C																															
-2/2		12	12																							12	12				24
2/4		60	36	6	18		12	84	66	6															12	144	102	12	18		288
4/20	888	2766	5214	7308	13986	10308	2952	7392	19062	23742	27600	11525	522	1194	3864	1800	846	612	6	24	84			6	4368	11376	28224	32850	42432	22452	141702
20/32	546	420	894	750	780	54	2454	2610	12270	6474	1644	63	306	318	2562	900	18								3306	3348	15726	8124	2442	114	33060
32/40	48						168																		216						216
Total	1482	3258	6156	8064	14784	10362	5586	10086	31398	30222	29244	11585	828	1512	6426	2700	864	612	6	24	84			6	7902	14880	44064	40986	44892	22566	175290

Note: For these three geographic locations, insolation data were not included because sufficient data were not available for the period 1965–1974.

TABLE 10(h). MIAMI, FLORIDA

Expected Exposure Time in 20 Years for Combinations of Wind Speed vs. Relative Humidity vs. Insolation vs. Air Temperature, hours

Insolation, W/m²	Air Temperature, °C	0/2						2/6						6/12						12/+						Totals for Relative Humidity vs. Insolation vs. Temperature						Totals for Temperature vs. Insolation
	Wind Speed, m/s																															
	Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
0/400	-2/2				6					12	18		6															12	24		6	42
	2/4				12	6				18	48	24				18												36	60	30		126
	4/20	6	66	708	1110	2202	2274	60	666	3822	3330	4230	2898	24	156	798	438	252	132			6		12		90	888	5334	4878	6696	5304	23190
	20/32		60	1236	5220	9702	8568	54	1110	18744	22344	16728	8682		414	5244	2892	1326	774			12	6	24	66	54	1584	25236	30462	27780	18090	103206
	32/40								6						12												18					18
400/800	4/20		18	78	24	12	6	48	414	792	162	72	18	48	270	312	30	6								96	702	1182	216	90	24	2310
	20/32	6	102	858	594	162	24	54	1554	12234	3792	732	102	30	918	5922	1398	168	6	6	6		6			90	2580	19020	5784	1068	132	28674
	32/40			6					112	66					36	12											48	84				132
800/1000	4/20		6					18	72	30	6			18	84	30										36	162	60	6			264
	20/32	6	30	144	36			24	552	3240	534	42	6		354	1200	102	12								30	936	4584	672	54	6	6282
	32/40								6	30					6	6											12	36				48
1000/1100	4/20		6						24						18												48					48
	20/32			18					78	744	30	12	6		84	144	18										162	906	48	12	6	1134
	32/40			6					12	12																	12	18				30
1100/1400	4/20								6																		6					6
	20/32		6					5	18	252	24					90	6									6	24	342	30			402

Totals for Wind Speed vs. Relative Humidity vs. Temperature

																																Totals for Temperature Levels
	-2/2				6					12	18		6															12	24		6	42
	2/4				12	6				18	48	24				18												36	60	30		126
	4/20	6	96	786	1134	2214	2280	125	1182	4644	3498	4302	2916	90	528	1140	468	258	132			5		12		222	1806	6576	5100	6786	5328	25818
	20/32	12	198	2256	5850	9864	8592	138	3312	35214	26724	17514	8796	30	1770	12600	4416	1506	780	6	18	6		30	66	180	5286	50088	36996	28914	18234	139698
	32/40			12					36	108					54	18											90	138				228
Total		18	294	3054	7002	12084	10872	264	4530	39996	30288	21840	11718	120	2352	13776	4884	1764	912	6	24	6	42	66		402	7182	56850	42180	35730	23568	165912

TABLE 10(i). PHOENIX, ARIZONA

Insolation, W/m²	Air Temperature, C	Wind Speed, m/s: 0/2						2/6						6/12						12/+						Totals for Relative Humidity vs. Insolation vs. Temperature						Totals for Temperature vs. Insolation
	Relative Humidity, percent	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	
	-30/-4				24																								24			24
	-4/-2			24	24	24	24																					24	24	24	24	96
	-2/2		48	408	360	840	672		96	456	456	312	24														144	864	816	1152	696	3672
0/400	2/4		240	888	576	720	600	72	192	792	456	576	264													72	432	1680	1032	1296	864	5376
	4/20	3888	10104	7896	3024	3024	1416	4656	12024	9312	3432	3888	2136	288	312	144	96	120	72						24	8232	22440	17352	6552	7032	3648	65256
	20/32	6000	4944	1896	432	240	264	11304	7920	4656	1296	576	504	864	384	168	120	24		24	24					18192	13272	6720	1848	840	768	41640
	32/40	1320	456					6312	1944	24				336	168						24					7968	2592	24				10584
	40/+	96						1056						120												1272						1272
	2/4			24																								24				24
	4/20	1032	1896	1128	72	24		2304	2664	936	240	120		240	120	48	24									3576	4680	2112	336	144		10848
400/800	20/32	2904	888	216	48			6528	2472	360	48			432			24									9864	3360	576	120			13920
	32/40	984	624					3648	1824					264	48											4896	2496					7392
	40/+	72						500						24												696						696
	4/20	120	240	48				192	360	72				72	24	24										384	624	144				1152
800/1000	20/32	1464	144					3340	384	48				408	24											5712	552	48				6312
	32/40	792	120					3360	240					144	24											4296	384					4680
	40/+	48						528																		576						576
1000/1100	4/20							24						24												48						48
	20/32							120																		120						120

Totals for Wind Speed vs. Relative Humidity vs. Temperature

Air Temperature, C	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	0/29	30/49	50/69	70/79	80/89	90/+	Totals for Temperature vs. Relative Humidity: 0/29	30/49	50/69	70/79	80/89	90/+	Totals for Temperature Levels
-30/-4				24																								24			24
-4/-2			24	24	24	24																					24	24	24	24	96
-2/2		48	408	360	840	672		96	456	456	312	24														144	864	816	1152	696	3672
2/4		240	912	576	720	600	72	192	792	456	576	264														432	1704	1032	1296	864	5400
4/20	4440	12240	9072	3096	3048	1416	7776	15048	10320	3672	4008	2136	624	456	216	120	120	72						24	12240	27744	19608	6888	7176	3648	77304
20/32	10368	5976	2112	480	240	264	21792	10776	5064	1344	576	504	1704	408	168	144	24		24	24					33888	17184	7344	1968	840	768	61992
32/40	3096	1200					13320	4008	24				744	240						24					17160	5472	24				22656
40/+	216						2184						144												2544						2544
Total	18120	19704	12528	4560	4872	2976	44544	30120	15656	5928	5472	2928	3216	1104	384	264	144	72	24	48				24	65904	50976	29568	10752	10488	6000	173688

Expected exposure times for PHX were computed by multiplying the observed number of occurrences in 2.5 years (January 1965 through June 1967) by 24 (3 hours between measurements x 2) forecast years/2.5 historical years).

TABLE 11. EXPECTED NUMBER OF EXPOSURE HOURS[a] AT HIGH AIR TEMPERATURES FOR COMBINATIONS OF RELATIVE HUMIDITY, WIND SPEED, AND INSOLATION FOR A PERIOD OF 20 YEARS BY GEOGRAPHIC LOCATION

		Exposure Hours Above 32 C (90 F)																
Relative Humidity, percent		Below 30				30/49				50/69				70/79				
Wind Speed, m/s		0/2	2/6	6/12	12/+	0/2	2/6	6/12	12/+	0/2	2/6	6/12	12/+	0/2	2/6	6/12	12/+	Total
Insolation	Location[b]																	
0/400	ABQ	66	384	114	12			6										582
	BIS	24	246	84		24	120	42										540
	BOS			12			108	72				12						204
	BRO						12			12	30	12						66
	MIA						6	12										18
400/800	ABQ	84	678	294		6	12											1074
	BIS	12	216	204		18	126	114			6							696
	BOS		6			6	120	54			12	12						210
	BRO		12	18		6	282	534		12	324	792	6			6		1992
	MIA						12	36		6	66	12						132
800/1000	ABQ	192	888	156	12		6											1254
	BIS		114	42		6	60	84				6						312
	BOS						24	42			6	6						78
	BRO		6			6	294	612			348	702	18					1986
	MIA						6	6			30	6						48
1000/1100	ABQ	18	366	18														402
	BIS																	
	BOS																	
	BRO			6			150	372		6	114	366	12					1026
	MIA						12			6	12							30
1100/1400	ABQ		18															18
	BIS																	
	BOS																	
	BRO						66	150			60	168						444
	MIA		6			6	18				252	90			24	6		402

(a) Exposure hours are computed under the assumption that each observed environmental condition persists for the 3-hour interval that occurs between measurements. Thus, an environmental condition that is observed 100 times in 10 years yields an expected number of observations equal to 200 in 20 years with an expected exposure time of 600 hours over the 20-year period. The total number of hours in a 20-year period is approximately equal to 175,320 hours.

(b) See Table 1 for explanation of symbols ABQ, . . ., PHX.

Note: Blanks are zeros. There were no occurrences of relative humidity over 79 percent for temperatures above 32 C.

Source: Table 10.

insolation, respectively. The largest entry in the table is 792 hours for Brownsville in the cell defined by T (32+), RH (50/69), WS (6/12), and INS (400/800). The marginal totals on the right side of the table show that the largest number of exposure hours for each insolation level across locations occurs for INS (400/800) with a total of 1074+ ... + 132 = 4110 hours. It is clear that considerable information is obtained by adding the entires of this table in a variety of ways.

Such information is useful for the design of aging tests for encapsulation materials. The amount of time expected to be spent at temperatures above 32 C (90 F) can be obtained for any location, and the expected number of hours in which the relative humidity is simultaneously at a high level can also be obtained. In general, the results show that little time is expected to be spent under combined high levels of these variables. No occurrences are shown, for example, for the combination involving relative humidities above 80 percent with temperatures above 32 C (90 F). For tests representing maximum encapsulation temperatures the entries can be summed over high levels of temperature and insolation combined with low levels of wind speed.

The expected numbers of exposure hours for combinations of relative humidities over 80 percent, temperatures between -2 and 2 C and various wind speeds are shown in Table 12. This table was constructed to determine the number of exposure hours for the three-variable combination of T, RH, and WS near the freezing point at high relative humidity, since such freeze-thaw conditions may be abusive to solar arrays.

Normal-Insolation Cells

The cell methodology was also applied to computed normal insolation values. The transformation from horizontal to normal incidence was made using Boes' regression relations[22]:

$$\text{Normal Incident Radiation} = \begin{cases} 0.0 & \text{if } PP \leqslant 0.30 \\ 1.79\ PP - 0.55 & \text{if } 0.30 < PP \leqslant 0.85 \\ 1.00 & \text{if } PP > 0.85 \end{cases},$$

where PP denotes the ratio of the total horizontal insolation to the extraterrestrial insolation. This general relation is obtained by combining similar relations obtained from data taken at Albuquerque, Blue Hill, and Omaha, and is recommended by Boes for those applications that involve long time intervals or comparisons among different geographic locations.

To obtain the cell statistics, the normal insolation values for Albuquerque were computed at 3-hour intervals using Boes' formula and were then combined with the corresponding 3-hourly measurements of temperature, relative humidity, and wind speed to form a four-variable environmental cell. The class interval sizes shown in Table 9 were used.

As expected, the results obtained are similar to those obtained for the corresponding four-variable cell involving total horizontal insolation. Consequently, the results are not presented here but are available for use in the LSSA Project. It is concluded that the methodology can be effectively implemented to obtain cell frequencies, duration, and transitions for combinations of variables that include computed values of normal insolation.

TABLE 12. EXPECTED NUMBER OF EXPOSURE HOURS[a] FOR A PERIOD OF 20 YEARS WITH HUMIDITY EXCEEDING 80 PERCENT AND AIR TEMPERATURE NEAR FREEZING (-2/2 C) ACCORDING TO WIND SPEED[b]

	Exposure Hours With Humidity Over 80 Percent and Air Temperature Between -2 and +2 C				
Wind Speed, m/s:	0/2	2/6	6/12	12/+	Total
Geographic Location[b]					
ABQ	1008	1284	126	6	2424
BIS	2406	3726	1422	66	7620
BOS	504	3672	2124	246	6546
BRO	48	42	228		318
MIA		6			6
PHX	1512	336			1848

(a) Expected exposure hours are computed by applying a multiplying factor to the observed number of occurrences. The factor is equal to the product of 3 (number of hours between measurements) and the ratio of the forecast time period (20 years) to be the historical time period. A factor of 6 is obtained for ABQ through MIA (based on a historical time period of 10 years) and a factor of 24 is obtained for PHX (based on a historical time period of 2.5 years). Blanks are zeros.

(b) Source: Table 10.

Occurrences of Combined Conditions of Weather Events (Precipitation, etc.) and Air Temperature

Table 13 shows the expected number of exposure hours for weather events at various air temperatures. The weather events shown in this table are grouped to yield fewer categories than shown in Table 3. The category labeled Rain includes light, moderate, and heavy rain; Drizzle includes light, moderate, and heavy drizzle, etc. The table shows, for example, that at temperatures between -2 and 2 C, Albuquerque can expect 228 exposure hours of fog, 12 hours of drizzle, etc., over a period of 20 years. This table was constructed partly to identify the weather events that would be expected to occur near the freezing point where freeze-thaw damage might occur, and partly to identify weather events that might occur at high air temperatures and thereby aggravate chemical attack on array materials.

Table 14 shows the expected number of exposure hours for snow pellets or ice crystals and for blowing dust or sand in combination with air temperatures. The largest entry occurs at Fairbanks with 804 exposure hours of snow pellets expected over a 20-year period. The most exposure hours for blowing dust or sand at high temperatures is shown for Phoenix, with 300 hours. The information shown in this table was obtained in order to better identify the temperatures at which abrasion detrimental to solar arrays might occur.

The expected number of exposure hours for normal weather conditions by air temperature is shown in Table 15. Normal weather conditions are taken to be those weather conditions for which none of the weather events listed in Table 3 are observed. Thus, normal conditions exclude the occurrence of fog, rain, hail, thunderstorms, etc., but include the entire range of temperatures, relative humidity, cloud cover, etc. These conditions are predominant conditions and are essential to characterize the weather condition that prevails most of the time. Results shown in Table 15 can be used in a variety of ways. For example, the expected number of exposure hours without the occurrence of any weather event can be expressed as a percentage of the total of 175,296 hours in a 20-year period. For each geographic location, the percentages of the time with weather events present are given in the tabulation which follows (on page 61).

TABLE 13. EXPECTED NUMBER OF EXPOSURE HOURS[a] TO PRECIPITATION AND OTHER WEATHER EVENTS ACCORDING TO AIR TEMPERATURES FOR A PERIOD OF 20 YEARS BY GEOGRAPHIC LOCATION

Air Temperature Interval, C		Number of Exposure Hours at Each Geographic Location[b]								
		ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
-/-40	Fog						3570			
	Snow or Blowing Snow						12			
	Snow Pellets						366			
-40/-30	Fog		42				3894			
	Rain						6			
	Snow or Blowing Snow		18				822			
	Snow Shower						12			
	Freezing Drizzle						12			
	Snow Pellets		150				804			
	Smoke or Haze						6			
-30/-4	Fog	156	1086	18		108	432			
	Thunderstorm						6			
	Snow or Blowing Snow	306	10980	960		1776	15390			
	Snow Shower	30	294	204		4464	156			
	Freezing Drizzle		114	42		6	138			
	Freezing Rain		36	12			18			
	Snow Pellets		630			36	588			
	Sleet		18	12						
	Blowing Dust or Sand		6							
	Smoke or Haze		36	396		2358	24			
-4/-2	Fog	102	456	66		132	72			
	Snow or Blowing Snow	312	1512	816		936	1590			
	Snow Shower	42	138	96		1434	96			
	Freezing Drizzle		54	48		24	30			
	Freezing Rain		54	42		24	6			
	Sleet			12		6	12			
	Blowing Dust or Sand	6								
	Smoke or Haze		6	288		1134				
-2/2	Fog	228	864	528	24	1512	210			24
	Drizzle	12	204	456	114	366	24			
	Rain	60	294	996	90	600	240			6
	Rain Shower	18	90	36		120	6			6
	Thunderstorm	6				12				
	Snow or Blowing Snow	654	2736	2622		2082	2052			
	Snow Shower	180	468	444		1884	354			
	Freezing Drizzle		150	54	6	90	6			
	Freezing Rain	6	36	120		54	24			
	Snow Pellets	18	12	36		18	12			
	Sleet	6	78	306	12	60				
	Blowing Dust or Sand	6								
	Smoke or Haze		48	1608		4038			6	12

TABLE 13. (CONTINUED)

Air Temperature Interval, C		Number of Exposure Hours at Each Geographic Location[b]								
		ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
2/4	Fog	48	276	540	48	570	126	6		18
	Drizzle	6	264	342	78	222	42			
	Rain	204	570	1344	42	834	402			36
	Rain Shower	132	174	126		360	96			12
	Thunderstorm					6				
	Snow or Blowing Snow	54	144	198		138	78			6
	Snow Shower	84	60	42		192	42			
	Snow Pellets	18		6		30	6			
	Sleet		6	54						
	Blowing Dust or Sand	6	6							
	Smoke or Haze		42	720		1992	6		12	30
4/20	Fog	54	1008	4878	5928	4386	270	4290	738	216
	Drizzle	6	492	1758	2454	1086	144	366	36	6
	Rain	786	2250	6582	2532	3774	4800	2790	726	960
	Rain Shower	1758	2268	3186	264	3834	2262	1308	210	1740
	Thunderstorm	528	708	208	120	300	90	36	24	48
	Snow or Blowing Snow		12	30			6			
	Snow Shower	6	6	30						
	Snow Pellets						6			
	Hail		6			6				
	Sleet		6							
	Blowing Dust or Sand	72	36					18		36
	Smoke or Haze	18	60	7308	1050	12540	684	47310	2244	594
20/32	Fog		48	564	3780	624			474	
	Drizzle		12	24	192	12			6	
	Rain	18	6	108	1374	66	12		3156	60
	Rain Shower	498	240	540	1920	618	48	36	3264	702
	Thunderstorm	606	372	120	654	174	24	24	2712	402
	Tornado								12	
	Hail									6
	Blowing Dust or Sand	126	24		36			12		168
	Smoke or Haze		42	8358	5196	11694	288	13068	4068	150
32/40	Rain Shower	6			6				6	66
	Thunderstorm	12	6							108
	Blowing Dust or Sand									96
	Smoke or Haze			246	258	60		12	18	18
40/+	Smoke or Haze									6

(a) Exposure hours are computed under the assumption that each observed environmental condition persists for the 3-hour interval that occurs between measurements. Thus, an environmental condition that is observed 100 times in 10 years yields an expected number of observations equal to 200 in 20 years with an expected exposure time of 600 hours over the 20-year period. The total number of hours in a 20-year period is approximately 175,320. Blanks are zeros.

(b) See Table 1 for explanation of symbols ABQ, . . ., PHX.

TABLE 14. EXPECTED NUMBER OF EXPOSURE HOURS[a] TO SNOW PELLETS OR TO BLOWING DUST OR SAND[b] ACCORDING TO AIR TEMPERATURE FOR A PERIOD OF 20 YEARS BY GEOGRAPHIC LOCATION

Air Temperature Interval, C	Exposure Hours to Snow Pellets (or to Blowing Dust or Sand)[b] at Each Geographic Location[c]								
	ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
-/-40						366			
-40/-30		150				804			
-30/-4		630(6)			36	588			
-4/-2	(6)								
-2/2	18(6)	12	36		18	12			
2/4	18(6)	(6)	6		30	6			
4/20	(72)	(36)				6	(18)		(36)
20/32	(126)	(24)		(36)			(12)		(168)
32/40									(96)
40/+									

(a) Exposure hours are computed under the assumption that each observed environmental condition persists for the 3-hour interval that occurs between measurements. Thus, an environmental condition that is observed 100 times in 10 years yields an expected number of observations equal to 200 in 20 years with an expected exposure time of 600 hours over the 20-year period. The total number of hours in a 20-year period is approximately 175,320. Blanks are zeros.

(b) Expected exposure hours to blowing dust or sand are shown in parenthesis; all other entries refer to exposure hours to snow pellets.

(c) See Table 1 for explanation of symbols ABQ, . . ., PHX.

Source: Table 13.

TABLE 15. EXPECTED NUMBER OF EXPOSURE HOURS[a] WITHOUT PRECIPITATION AND OTHER SELECTED WEATHER EVENTS[b] ACCORDING TO AIR TEMPERATURE FOR A PERIOD OF 20 YEARS BY GEOGRAPHIC LOCATION

Air Temperature Interval, C	Number of Exposure Hours at Each Geographic Location[c]								
	ABQ	BIS	BOS	BRO	CLE	FAI	LAX	MIA	PHX
-/-40		6				156			
-40/-35		684				5148			
-30/-4	6870	29988	10578		8784	42264			18
-4/-2	5754	6510	5076	12	4998	4848			132
-2/2	17994	16518	17574	414	13134	11814	24	36	2430
2/4	10404	8556	9774	1008	6744	6384	282	114	3894
4/20	79794	58182	62934	37344	53430	52554	85590	23046	68748
20/32	43836	22848	21582	104808	20970	8202	19920	134154	62934
32/40	3372	1548	252	5532	126	12	204	216	27312
40/+	6	6							4290

(a) Exposure hours are computed under the assumption that each observed environmental condition persists for the 3-hour interval that occurs between measurements. Thus, an environmental condition that is observed 100 times in 10 years yields an expected number of observations equal to 200 in 20 years with an expected exposure time of 600 hours over the 20-year period. The total number of hours in a 20-year period is approximately 175,320. Blanks are zeros.

(b) This condition is taken to be that for which none of the weather events listed in Table 3 are observed. Thus, the condition excludes the occurrence of fog, rain, hail, thunderstorms, etc.

(c) See Table 1 for explanation of symbols ABQ, . . ., PHX.

Geographic Location	Percentages of Time With and Without the Presence of Any Weather Event	
	Present	Absent
ABQ	4	96
BIS	17	83
BOS	27	73
BRO	15	85
CLE	38	62
FAI	25	75
LAX	40	60
MIA	10	90
PHX	3	97

These results show, for instance, that Los Angeles experiences some kind of weather event 40 percent of the time. From Table 3, it can be seen that most of these weather events are smoke and haze (9216), fog (1475), or smoke (568). The minimum-percentage occurrences of weather events are shown for Phoenix (3 percent) and Albuquerque (4 percent). These weather events consist primarily of light rain showers (see Table 3).

Occurrences of Combined Conditions of Air Pollution and Climate Variables

Air pollution measurements were combined with climate measurements to form environmental cell statistics. The following special problems were encountered with the air-pollution data:

(1) Widely differing amounts of pollution data are available for the various locations.

(2) The pollution data are taken at differing intermittent time intervals at each location so that matching the pollution measurement times with the climate measurement times is difficult.

(3) Various pollutants are measured at each location, but there are relatively few common pollutants that are measured at every location.

(4) Widely varying distributions of measured values for each pollutant made it difficult to define suitable cell intervals that would be valid across all locations.

(5) Some pollutants are measured daily, weekly, or at other times that cannot be directly related to the 3-hourly climatic measurements.

Thirty-six analyses involving pollution cell statistics were generated. The analyses yield the frequency, duration, and transition statistics for each measured pollutant.

Table 16 shows the number of months of 3-hourly pollution measurements obtained for each location for the period 1965–1974. For existing data, the average number of months of data for this period is found to be approximately 35, with a maximum of 98. As noted earlier, extreme caution must be exercised in projecting climate data from a historical base of 10 years to a forecast period of 20 years. The situation is even more severe with air-pollution data for several reasons: (1) the air-pollution data are more limited than climate data; (2) increased industrialization tends to increase pollution levels over time; and (3) regulations prohibiting pollution tend to decrease pollution levels over time. Clearly, 20-year forecasts of pollution levels are to be regarded with skepticism. Nevertheless, it seems appropriate to apply the environmental-cell approach using combinations of air-pollution and climate measurements to provide at least a guideline for material evaluations. Analyses were run for Boston, Cleveland, Los Angeles, and Phoenix using available pollutant measurements in combination with weather events and in combination with temperature and relative humidity. Where data at more than one site within a geographic location were available, that site having the most data was used. These analyses were made primarily to assess the usefulness of the methodology. Some limited results are shown next.

The mean values obtained for air pollutants for four geographic locations are given in Table 17. The locations were chosen to reflect different climatic regions and types of air pollution. For example, the air pollution in Los Angeles represents photochemical smog, while that in Cleveland represents industrial air pollution. The pollutants were selected mainly on the availability of data within three hourly intervals for at least the major fraction of a year. They were also selected on the basis of some potential interaction with solar cell encapsulants. The pollutants are measured in parts per million except for soiling index which is measured in terms of a "coefficient of haze", COHS/1000 linear feet. The coefficient of haze is proportional to the amount of material collected by the passage of 1000 linear feet of air through a filter. As noted earlier, these averages are based on varying amounts of data taken during the period 1965–1974.

Table 18 shows the observed number of occurrences for sulfur dioxide, SO_2, nitrogen dioxide, NO_2, and total oxidants according to weather event for the 10-year period 1965–1974 by geographic location. It is important to note the number of months of observations shown for each pollutant-location combination. Although not recommended, a 20-year forecast of the expected number of exposure hours could be obtained by multiplying the number of occurrences shown in the table by 3 (240/M), where 240 denotes the number of months in 20 years, M denotes the number of months of historical data, and 3 denotes the time interval between measurements in hours.

In general, the calculation of the environmental-cells statistics is found to be far from routine in analyzing combinations of air-pollution measurements with climatic measurements. This stems primarily from the widely scattered, often intractable distributions of the air-pollution data. As more and better pollution data are obtained, the basic simplicity of the environmental-cell approach is likely to be recovered. When it is essential to determine the frequency of occurrence of combinations of air-pollution measurements with climate and insolation measurements, the analyses performed to date demonstrate the feasibility of the cell approach.

TABLE 16. APPROXIMATE NUMBER OF MONTHS OF AVAILABLE 3-HOURLY POLLUTION MEASUREMENTS BY GEOGRAPHIC LOCATION FOR 1965–1974

Geographic Location[a]	Number of Months of Measurements Available for Each Pollutant[b]									
	CH_4	CO	HC	NO	NO_2	NO_x	O_3	SIX	SO_2	TOX
ABQ		32					9	72		26
BIS								26		
BOS		94					91		98	
BRO	10	11	10	11	7		17		18	
CLE		87					81		82	
FAI		24								
LAX		16	14	17	17			8	7	
MIA		11	11	8	8	8	11		8	
PHX		75	64		58			15	66	74

(a) See Table 1 for explanation of symbols ABQ, . . ., PHX.

(b) Symbol definitions: CH_4, methane; CO, carbon monoxide; HC, hydrocarbons; NO, nitrogen oxide; NO_2, nitrogen dioxide; NO_x, nitrogen oxides; O_3, ozone; SIX, soiling index; SO_2, sulfur dioxide; TOX, total oxidants.

TABLE 17. MEAN VALUES FOR SELECTED AIR POLLUTANTS ACCORDING TO GEOGRAPHIC LOCATION BASED ON VARYING MEASUREMENT PERIODS DURING 1965-1974

Geographic Location[a]	Mean Values[b] for Given Air Pollutants[c]							
	CO	HC	HO	NO_2	O_3	SIX	SO_2	TOX
BOS	5.6				0.01		0.02	
CLE	2.1				0.01	0.69	0.03	
LAX	3.2	4.8	0.03	0.03		0.45	0.00	0.04
PHX	4.0	1.8		0.02		36.8	0.01	0.02

(a) See Table 1 for explanation of symbols BOS, . . ., PHX.
(b) All pollutants are given in parts per million except soiling index which is measured in COHS per 1000 linear feet (see text).
(c) Symbol definitions: CO, carbon monoxide; HC, hydrocarbons; HO, hydrogen oxide; NO_2, nitrogen dioxide; O_3, ozone; SIX, soiling index; SO_2, sulfur dioxide; TOX, total oxidants.

TABLE 18. OBSERVED NUMBER OF OCCURRENCES FOR SELECTED AIR POLLUTANTS AND WEATHER EVENTS FOR VARYING MEASUREMENT PERIODS DURING 1965-1974 ACCORDING TO GEOGRAPHIC LOCATION

		Number of Occurrences of Given Levels of SO_2 at Each Location				Number of Occurrences of Given Levels of NO_2 at Each Location		Number of Occurrences of Given Levels of Total Oxidants
	Location[a]:	CLE	BOS	LAX	PHX	LAX	PHX	PHX
	Months[b]:	82	98	7	66	17	58	74
Weather	Level[c]							
No precipitation	2	518	2510	324	1442	1600	5588	10,060
	3	647	1530	6	186	19	264	163
	4				21			
Fog	2	48	140	16		128	11	11
	3	60	101		1	8		
Drizzle	2	10	60	1		11	1	1
	3	3	28					
Rain	2	25	167	11	2	30	46	52
	3	20	82				1	
Rain Shower	2	37	88	6	5	10	85	136
	3	25	23					
Thunderstorm	2	2	9			1	18	36
	3	2	1					
Hail	2	1						

(a) See Table 1 for explanation of symbols ABQ, . . ., PHX.
(b) Length of measurement period in months. See Table 16.
(c) Levels 2, 3, and 4 for SO_2 denote the intervals (0.00058, 0.0241), (0.0241, 1.0), (1.0, +) ppm, respectively; levels 2 and 3 for NO_2 denote (0.012, 0.110), (0.110, 1.0) ppm, respectively; and levels 2 and 3 for total oxidants denote (0.01, 0.10), (0.10, 1.0) ppm, respectively.
Note: Blanks are zeros.

RESULTS AND TECHNICAL DISCUSSION OF THE METHODOLOGY FOR THE SELECTION OF TEST CONDITIONS FOR AGING EXPERIMENTS

This portion of the report is concerned with the development of test conditions based upon environmental data for the nine locations. The environmental parameters and levels which result from this information are intended for analytical studies and for use in the design and specification of laboratory tests for evaluating the effects of various terrestrial service exposures on encapsulation materials and systems. The method described below represents an initial effort to obtain test conditions based on historical data. Limited computer runs on environmental data have shown that the method is feasible and is easily implemented. However, as described below, the interpretations of the "weights" obtained from the method are not simple. It is expected that the approach can be further developed to yield improved simplicity and better identification of appropriate tests, either for an individual geographic location, or across several different geographic locations.

The approach which was developed in this study and is presented here involves an extension of the environmental-cell methodology described previously. The extended methodology is believed to have broad application in the development of environmental tests. This methodology is described below and its use is illustrated for the identification of environmental stress levels that can be used as a factual basis for the design of laboratory experiments. **It is expected, of course, that the data developed in this study will be useful in many other applications.**

It should be noted that the term "stress" as used in this report is not restricted to the concept of mechanical stress. Instead, the term is used to indicate the general level of severity of environmental conditions, with abusive or severe conditions associated with "high" stress. It is also required that a high degradation rate be associated with high stress. In this way degradation rates become useful indicators of the severities of generalized stresses.

The tests of principal importance for this application are aging tests in which the primary objective consists of measuring the time rates of degradation for various material and system characteristics of interest. The tests are envisioned to be performed under conditions that would closely approximate the conditions experienced in terrestrial applications. That is, the tests illustrated here are not "accelerated" tests in which the environmental conditions (stress) are increased beyond those ever encountered in the real environment. The conditions are those that would be used in controlled laboratory aging tests in which sensitive techniques are used for early detection of degradation. With the methodology proposed below, certain historical data are necessary and are used both in the selection of the test conditions and in the analysis of the resulting data on the degradation rates that result from these tests. With further modifications it is expected that this methodology may also be useful in the design of accelerated tests.

The following assumptions are made:

(1) It is desired to perform unaccelerated laboratory tests which will indicate whether a solar-array material or device will survive 20 years in a terrestrial service environment at any of several specified geographic locations.

(2) Historical environmental data such as those from this study are available for the location of interest on measured values of variables believed to be relevant to the lifetime of the system.

(3) It is possible for the experimenter to state for a specific material and degradation mode whether the environmental stress on the specimen is increased or decreased as each test variable is increased or decreased.

(4) Several tests are to be run, with each test consisting of several variables set at specified levels.

The assumption of unaccelerated laboratory testing is made for several reasons. In accelerated testing, the test conditions are deliberately chosen to "stress" the system at levels higher than the stress levels expected under actual service environments. Such overstressing is expected to yield higher degradation rates for important material or performance characteristics. Because the degradation rates are higher, measurable degradations may occur relatively early during the test. Hopefully, by extrapolation from higher stress levels to normal stress levels, it may be possible to predict degradation rates at normal stress levels, and hence predict the lifetimes that would result under various criteria of failure. The necessity for accelerated testing stems from the fact that is is impractical to test a system under normal operating conditions for 20 years in order to determine whether the system has an expected life of 20 years. The primary hazard in accelerated testing is the possibility that the dominant degradation mechanism is changed by operating the system at higher-than-normal stresses; the system fails early but for the srong reasons.

It may also be noted that in accelerated testing, the historical data available at each geographic location are not easily related to the test conditions because the test conditions are deliberately chosen to be more severe than those historically encountered. In contrast, in unaccelerated testing, the historical data at each geographic location are directly relevant in defining test conditions. That such data are available is the requirement of Assumption (2).

Assumption (3) is a strong assumption. If the experimenter cannot state the direction of increasing stress for each test variable, he may have the option of running some preliminary tests to determine the direction of increasing stress. In some cases, it should be noted that the direction of increasing stress may depend on the range of the variable involved. Increasing temperatures above 40 C may be associated with increasing stress for one degradation mechanism, whereas temperatures below -20 C may also be associated with an increasing stress associated with a different degradation mechanism. Thus, the direction of increasing stress may depend on the range of the variable. In such a case, two different tests would be required.

It is implicit in Assumption (3) that if the stress on the specimen increases as either variable A increases or B increases, then the stress will also increase if variables A and B are increased together. If Assumption (3) can be met, then the appropriateness of a proposed set of test conditions can be partially evaluated before the tests are run.

Assumption (4) is made explicit simply to highlight the fact that more than one test is expected to be developed under the recommended procedure, with each test consisting of several variables set at specified levels.

Finally, it should be noted that for any two distinct stress levels, the higher stress level may be regarded as accelerated relative to the lower stress level, even though the lower stress level does not represent a normal stress condition.

General Features of the Proposed Methodology

The proposed methodology involves two steps. First, a "nested" set of tests is identified, and then these tests are evaluated using historical data. The following tests form an example of a nested set of five tests, where temperature, relative humidity, and insolation are denoted by T, RH, and INS, respectively.

Test	T, C	RH, percent	INS, W/m^2
1	40	100	1000
2	30	70	800
3	0	70	500
4	-10	50	100
5	-20	30	0

The rows of the tabulation show the test conditions associated with each specific test. By examining the columns, it is seen that the values of each variable increase or decrease monotonically. When this monotone constraint holds for each variable, the tests and the test conditions are said to be nested. If, for example, the relative humidity in Test 3 had been set at 80 percent, then the relative humidity would show both an increase and decrease across the five tests, and, consequently, the tests would no longer be nested. The two successive values of 70 percent for the relative humidity for Tests 2 and 3 indicate that a variable may remain at the same level from test-to-test and still be acceptable for inclusion in a nested set of tests.

Now suppose, for the above test conditions, that for a given material and degradation mode the stress on the specimen increases if temperature, relative humidity, or insolation are increased, either individually or jointly. Then the test conditions for Test 1, Test 2, etc., are ranked in order of decreasing stress in the tabulation. This means that the degradation rates corresponding to Test 1, 2, etc., are also ranked in order of decreasing magnitude.

To obtain a set of test conditions suitable for the evaluation method, it is required that the nesting of the tests be accomplished in the direction of decreasing stress, beginning with Test 1. Thus, the conditions for Test 2 must be less stressful and be nested within the conditions of Test 1 by the monotone relations. Similar relations must hold between Tests 2 and 3, Tests 3 and 4, etc. One of the reasons for the nesting requirement is the fact that if the test conditions for two tests are not nested, then it will generally not be clear which test is the more stressful, even though Assumption (3) holds. Thus, with nesting, the test conditions establish an unambiguous ranking for the stress condition of each test. As illustrated later, the nesting also permits specific portions of the historical data to be associated with each test.

The procedure for introducing the historical data is as follows. For each test the historical data for a given time period at a given location are examined to estimate the fraction $\Delta\tau_1$ of the total exposure time that is spent under conditions that are less stressful than in Test 1, but are not less stressful than in Test 2. Thus, $\Delta\tau_1$, represents the fraction of the historical time period spent under stress levels "nested between" those of Test 1 and Test 2. Corresponding exposure fractions $\Delta\tau_2$ and $\Delta\tau_3$ are determined using the conditions of Tests 2 and 3, Tests 3 and 4, etc. The nesting condition guarantees that each environmental condition will be associated with exactly one of these exposure fractions, so that the resulting fractions will sum to 1.0. These fractions may be used as weights for the five

degradation rates $\dot{x}_i$, $i = 1, \ldots, 5$ experimentally obtained from each of the five tests. The symbol x denotes a material property or performance characteristic for the encapsulation material or system under consideration. The weighted degradation rates, in turn, provide an upper bound for the amount of degradation Δx to be expected in a specified time period, T_h. The bound is expressed mathematically as follows:

$$\Delta x \leqslant (\Delta\tau_1 \cdot \dot{x}_1 + \ldots + \Delta\tau_5 \cdot \dot{x}_5) \cdot T_h \quad .$$

In words: the amount of degradation Δx, expected in the time period T_h, is less than the sum of the products, $\Delta\tau_1 \cdot x_1$, where each product represents the amount of degradation attributed to each degradation rate $\dot{x}_1$ and the total time $\Delta\tau_1$ over which that degradation rate is found to hold at a geographic location of interest. The validity of this equation depends on several important assumptions: (1) the amounts of degradation that result from exposure hours in each environmental cell are additive; (2) the order in which the transitions are made from cell-to-cell are irrelevant to the amount of degradation that results; (3) within each cell the degradation amounts are cumulative; and (4) for the forecast time period the future will mimic the historical past. The procedure is illustrated by applying it to data associated with four geographic locations.

These upper bounds cannot be numerically evaluated until experiments have been run to determine the degradation rates for each test. Once these degradation rates are experimentally determined, the numerical bounds may be obtained using the above expressions for each geographic location. Suppose that Δx^* denotes the largest amount of degradation that can be tolerated for characteristic x over a lifetime of $T_h = 20$ years. If the upper bound, computed from the above expression, is found to be less than Δx^* for a given location, then the experimental and historical evidence would support an expected lifetime for characteristic x in excess of 20 years. Analogous calculations, not shown above, can yield lower (instead of upper) bounds for the amount of degradation in time period T_h. If the numerical evaluation of these lower bounds were found to be larger than Δx^* for some geographic locations, then it would be concluded that a 20-year life for characteristic x could not be achieved at these locations.

It may be noted that if Test 1 were the only test performed, then the upper bound would be given by the simple expression: $\Delta x \leqslant \dot{x}_1 \cdot T_h$. *In this way it can be seen that effect of running additional tests at lower stress levels is to reduce the weight applied to the highest degradation rate,* $\dot{x}_1$.

Test Condition Evaluation at Four Geographic Locations

The proposed procedure for evaluating test conditions is applied below to Albuquerque, Bismarck, Miami, and Phoenix using the four-variable cells based on temperature, relative humidity, wind speed, and insolation. A nested set of test conditions evaluated by this procedure is shown in the following tabulation:

Test Number	Test Conditions T	RH	WS	INS	Fractional Exposure Times Between Conditions of Test 1 and Test 2, etc., $\Delta\tau$ ABQ	BIS	MIS	PHX
1	40	100	2	1400				
					0.05	0.09	0.13	0.22
2	32	89	2	1100				
					0.33	0.34	0.79	0.41
3	20	79	2	800				
					0.59	0.51	0.08	0.37
4	4	69	6	400				
					0.03	0.06	0.00	0.00
5	-4	49	12	0				
					0.00	0.00	0.00	0.00
				Total	1.00	1.00	1.00	1.00

The nesting of the test conditions shown in this tabulation is based on the assumption that increases in stress are associated with increases in temperature, relative humidity, and insolation, and with decreases in wind speed. The class boundaries for these tests correspond to selected cell boundaries given in Table 9. Computer runs were made to determine the fraction at exposure times associated with each geographic location for the conditions shown for each test. The 3-hourly climatic and insolation data for the 10-year period 1965-1974 were used to obtain these results. In this tabulation, for instance, the number 0.05 for Albuquerque indicates that 5 percent of the historical time period was spent under stress conditions "nested between" those of Test 1 and Test 2; 33 percent of the time was spent under stress conditions "nested between" those of Test 2 and Test 3, etc.

The reader is cautioned that the above table does **not** indicate that Albuquerque spends 5 percent of the time with T between 32 and 40 C, RH between 89 and 100 percent, WS at 2 m/s, and INS between 1100 and 1400 W/m^2. As defined above, the stress conditions that are "nested between" those of Test 1 and Test 2 consist of those conditions that are "less stressful" than those of Test 1 but are "more stressful" than those of Test 2. To further clarify the meaning of these relations, consider the above Table. Under the preceding assumptions concerning the direction of increasing stress, the following conditions are less stressful than those of Test 2: T less than 32 C, RH less than 89 percent; WS greater than 2 m/s, and INS less than 1100 W/m^2. If **one** or more of these conditions does not hold, then a given combination of conditions is taken to be more stressful than that of Test 2. In particular, this means that if T exceeds 32 C, then a given combination of conditions is taken to be more stressful than that of Test 2 **regardless of the values of RH, WS, and INS.** For example, the combined conditions of T = 36 C, RH = 49 percent, WS = 6 m/s, and INS = 400 W/m^2 are taken to be more stressful than those of Test 2 because the temperature exceeds 32 C. However, this same combination of conditions is seen to be less stressful than that of Test 1, and consequently, is taken to be "nested between" the conditions of Test 1 and Test 2 even though RH does not fall between 89 and 100 percent, WS is not equal to 2 m/s, and INS does not fall between 1100 and 1400 W/m^2.

Thus, the above table shows that Albuquerque spends 5 percent of the time under conditions with T less than 40 C, RH less than 100 percent, WS greater than 2 m/s, and INS less than 1400 W/m^2, and simultaneously, either T exceeds 32 C, or RH exceeds 89 percent, or WS is less than 2 m/s, or INS exceeds 1100 W/m^2. Such sets of conditions are admittedly complex, but appear to be unavoidable when a simple ranking for an environmental stress is to be related to a combination of several environmental variables.

The tabulated results show that each geographic location assigns a different weight to the degradation rate that would be obtained from each test. For example, for Test 2 the assigned weights are seen to vary between 0.33 for Albuquerque to 0.79 for Miami. Note that no location assigns any weight to Test 5. This would be expected for Miami and Phoenix because of the low temperature condition associated with Test 5. In addition, to 2 decimal places, neither Albuquerque nor Bismarck assigns any weight to Test 5. This suggests that Test 5 should not be run. The largest weight assigned to any test is 0.79 assigned by Miami to Test 2. Phoenix also assigns more weight to Test 2 than to any other tests, and assigns more weight to Test 1 than does any other location.

These weights can also serve to yield upper limits for the amount of degradation Δx to be expected in a time period T_h for a characteristic x whose five degradation rates would be separately obtained by running each of the five tests. With the degradation rates denoted by $\dot{x}_1, \ldots, \dot{x}_5$ for Test 1, . . . , Test 5, respectively, the following relations hold:

Geographic Location	Upper Bound for Amount of Degradation, Δx
Albuquerque	$\Delta x \leqslant (0.05\ \dot{x}_1 + 0.33\ \dot{x}_2 + 0.59\ \dot{x}_3 + 0.03\ \dot{x}_4)\ T_h$
Bismarck	$\Delta x \leqslant (0.09\ \dot{x}_1 + 0.34\ \dot{x}_2 + 0.51\ \dot{x}_3 + 0.06\ \dot{x}_4)\ T_h$
Miami	$\Delta x \leqslant (0.13\ \dot{x}_1 + 0.79\ \dot{x}_2 + 0.08\ \dot{x}_3)\ T_h$
Phoenix	$\Delta x \leqslant (0.22\ \dot{x}_1 + 0.41\ \dot{x}_2 + 0.37\ \dot{x}_3)\ T_h$

Figure 3 shows plots of the tabulated fractional exposure times. For each geographic location the figure shows "profiles" for the weights assigned to each test. Because the total areas associated with the profiles are equal, the profiles show the distribution of weight across the proposed tests. Roughly, each profile shows the ability of each test to represent the historical data at each location. It is clear that by changing the test conditions, new weights and new profiles would be generated. These profiles, in turn, would aid in making the final choice of the test conditions.

The methodology is summarized as follows:

(1) Identify a nested set of proposed test conditions, with Test 1 denoting a high-stress test that exceeds, by small amounts, the historical stress encountered at all geographic locations.

(2) Use historical data for each geographic location to obtain the fractional exposure times, the $\Delta\tau$ weights, for each proposed test.

(3) Compute the upper bounds for the amounts of degradation to be expected, generate profiles, eliminate unwarranted tests, and iterate the above procedure using different proposed test conditions to minimize dissatisfactions, and thereby obtain a final set of suitable test conditions.

(4) Implement the final set of test conditions.

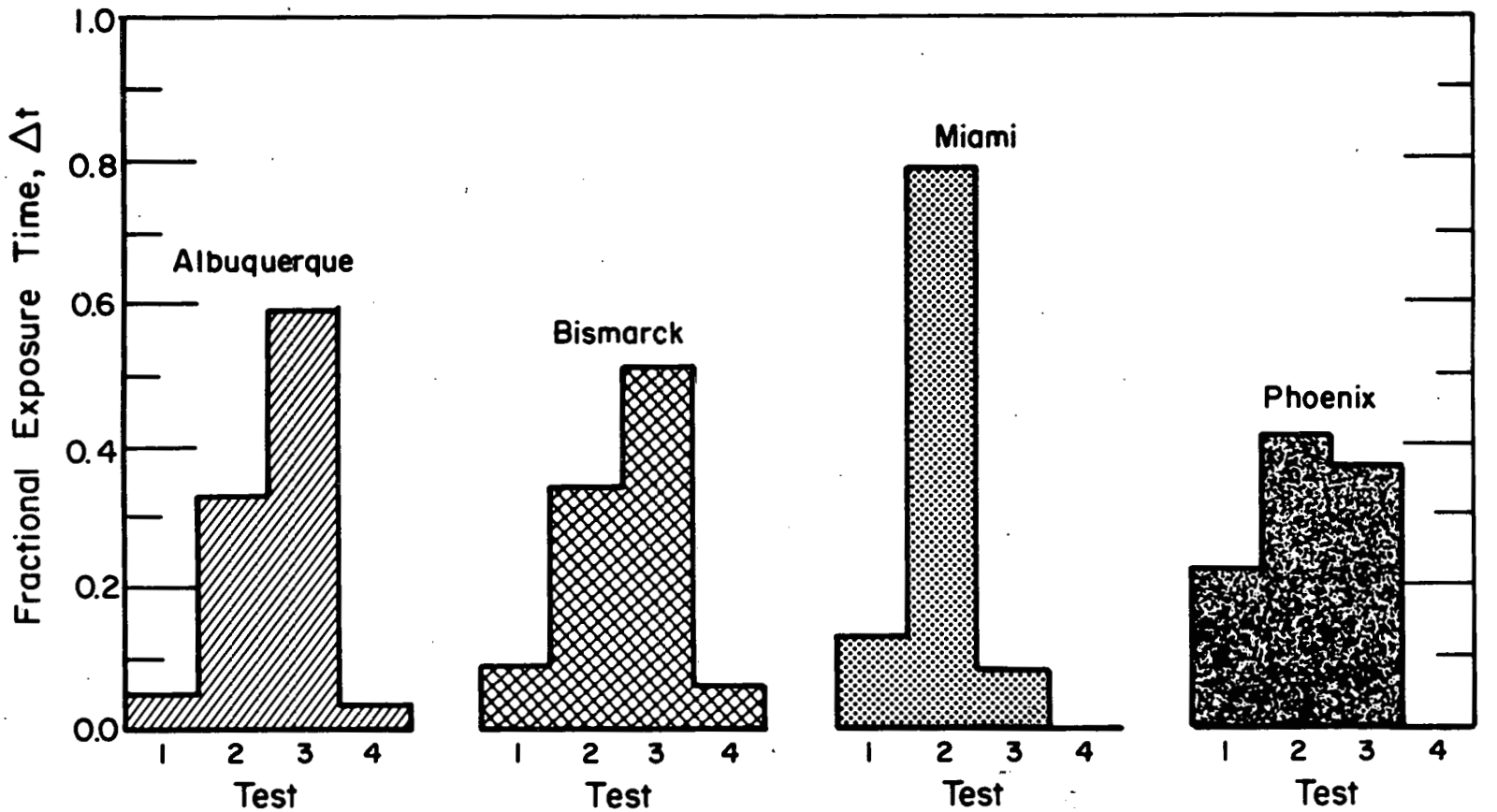


FIGURE 3. FRACTIONAL EXPOSURE TIME AS A FUNCTION OF TEST CONDITION BY GEOGRAPHIC LOCATION

ULTRAVIOLET EXPOSURE

Ultraviolet radiation, between 290 and 400 nm, is expected to be a primary source of degradation for solar-array materials exposed to terrestrial environments. For this reason, efforts have been directed towards identifying the total amount of ultraviolet radiation that might be expected to occur over a period of 20 years at each of the nine geographic locations. To be of maximum utility, the expected amount of ultraviolet radiation would be expressed as a function of several variables: latitude and elevation of the geographic location; average climatic conditions, including insolation levels, turbidity, sky cover, precipitation, etc.; geography of the local terrain, including features that may generate dust, fog, water vapor, etc.; and industrialization, including smog, smoke, and haze.

Only widely scattered ultraviolet data were located, and almost none were directly relevant to the nine geographic locations of this study. For this reason the following account contains only brief descriptions of the ultraviolet data obtained, together with additional data sources that were identified. The remaining material obtained from this effort consists primarily of a variety of theoretical formulations. Although potentially useful, these formulations remain of marginal value until more and better data on ultraviolet radiation and related atmospheric parameters become available. Descriptions of these formulations are included in Appendix B.

Masters and Wolfe[23] report that the terrestrial energy distribution of the solar spectrum consists of approximately 5 percent of the total energy between 290 and 380 nm (ultraviolet), approximately 43 percent between 380 and 750 nm (visible), and the remaining 52 percent between 750 and 2500 nm (infrared). Ultraviolet radiation is the most important spectral component in the area of photodegradation because of its high quantum energy. Degradation of polymers and organic coatings can sometimes result from selective absorption of energy in given wavelengths.

Several polymers together with the wavelengths that are the most readily absorbed are listed in Table 19.[24-27] Absorption of energy in a given wavelength does not necessarily mean that the wavelength in question is the most degrading.[28] The amount of degradation is also a function of the intensity of the radiation.

TABLE 19. ABSORPTION WAVELENGTH IN ULTRAVIOLET REGION FOR SEVERAL POLYMERS[24-27]

Polymer	Wavelength Peak, nm
Polyesters (various formulations)	325.0
Polystyrene	318.5
Polyethylene	300.0
Polypropylene	370.0
Polyvinyl chloride	320.0
Polyvinyl acetate	<280.0
Polycarbonate	285-305 and 330-360
Cellulose acetate butyrate	295-298
Styrene acrylonitrile	290-325

Approximately 10 percent of the energy of the extraterrestrial solar spectrum is contained in the ultraviolet range.[29] This percentage is reduced by passage of the radiation through the atmosphere. Over a period of several years, the percentage UV was found to vary between 1 and 7 percent of the total spectral energy in sunlight at Stamford, Connecticut.[30] The percentage was found to vary widely depending on the time of day, season of the year, and sky conditions.

In the excellent report by Masters and Wolfe[23] an extensive discussion of the spectral distribution, insolation, and instrumentation is attributed to a work edited by Robinson[31].

Zone, degrees	Zone, steradians	Observed Fraction Less Than 320 nm
0-10	0.10	0.039
10-20	0.28	0.101
20-30	0.46	0.147
30-40	0.63	0.173
40-50	0.77	0.180
50-60	0.90	0.158
60-70	0.99	0.112
70-80	1.06	0.060
80-90	1.09	0.030

Differing amounts of ultraviolet radiation are received from different portions of the sky. For wavelengths less than 320 nm the above tabulation shows some observed fractions of the solar radiation received from successive 10-degree zones of the sky measured from the horizontal.[32,33]

Ultraviolet Radiation Data for Washington, D.C., and Rockville, Maryland

The Smithsonian Radiation Biology Laboratory in Rockville, Maryland, has published spectral solar-radiation data taken in two locations in the continental U. S. during the time period from 1968 to 1973.[34] The two locations were in Washington, D.C. (38.9° N. Latitude and 77.0° W. Longitude), and in Rockville, Maryland, about 15 miles northwest of Washington, D.C. The two locations represent an urban and a nearby surburban area. At each location, daily radiation data on horizontal surfaces were recorded for each of six spectral bands, together with the total radiation. These data were examined by comparing the portion of the ultraviolet spectral band below 400 nm with the total insolation.

Figures 4 and 5 show scatter plots based on the Smithsonian data for the measured ultraviolet radiation as a function of total insolation for Washington, D. C., and Rockville, Maryland, respectively. The individual data points are monthly averages and represent all of the available data (September 1968 to November 1972 for Washington, D. C., and June 1970 to December 1973 for Rockville). The straight lines drawn through the data represent least-squares lines calculated by linear regression. The plots show wide scatter for both locations, with relatively less scatter for surburban Rockville than for urban Washington. The slopes of the regression lines are shown to be approximately 3 percent for Washington and 5 percent for Rockville.

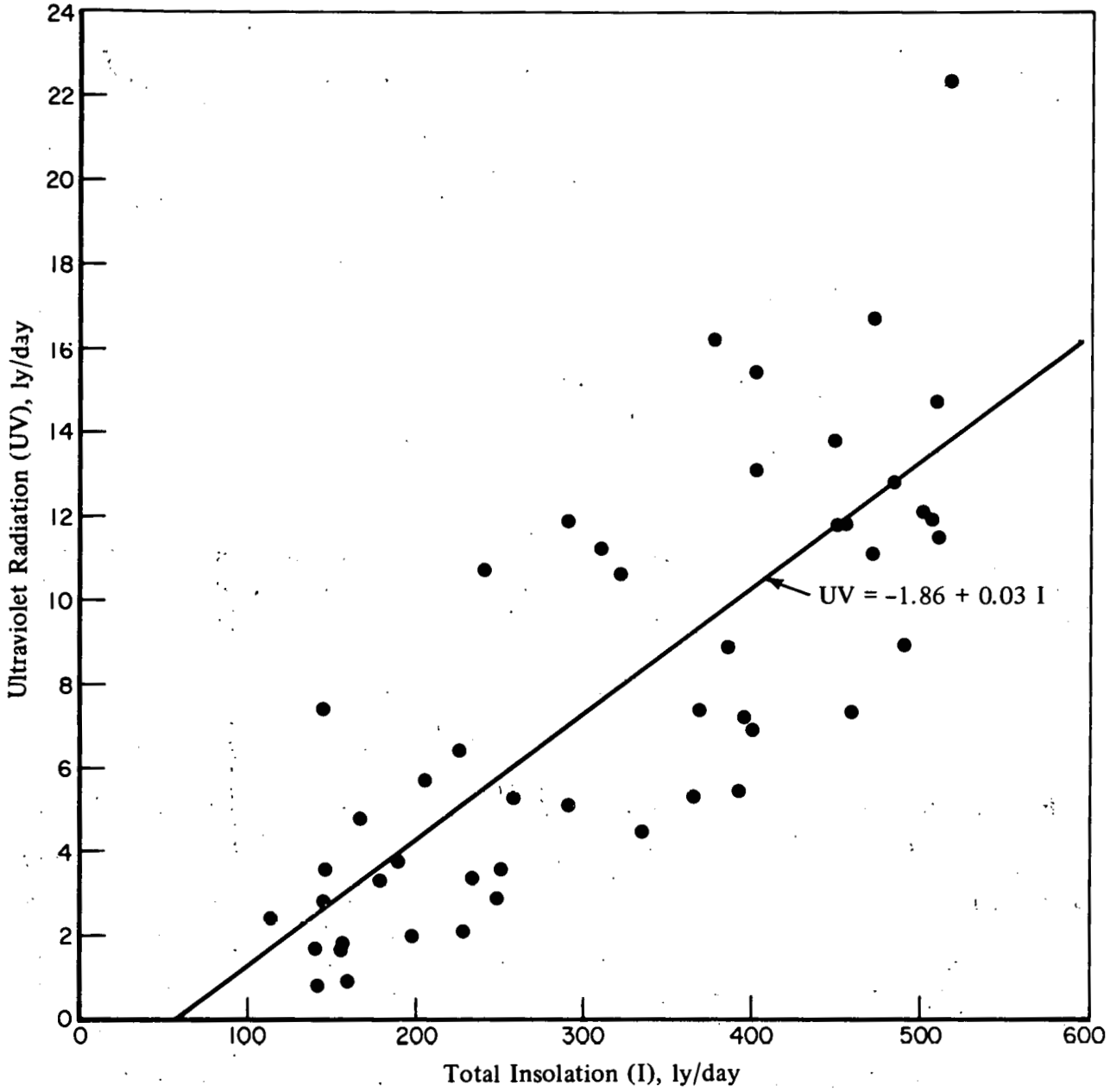


FIGURE 4. MONTHLY AVERAGE ULTRAVIOLET RADIATION (LESS THAN 400 nm) VERSUS MONTHLY AVERAGE TOTAL INSOLATION FOR WASHINGTON, D.C., SEPTEMBER 1968–NOVEMBER 1972[34]

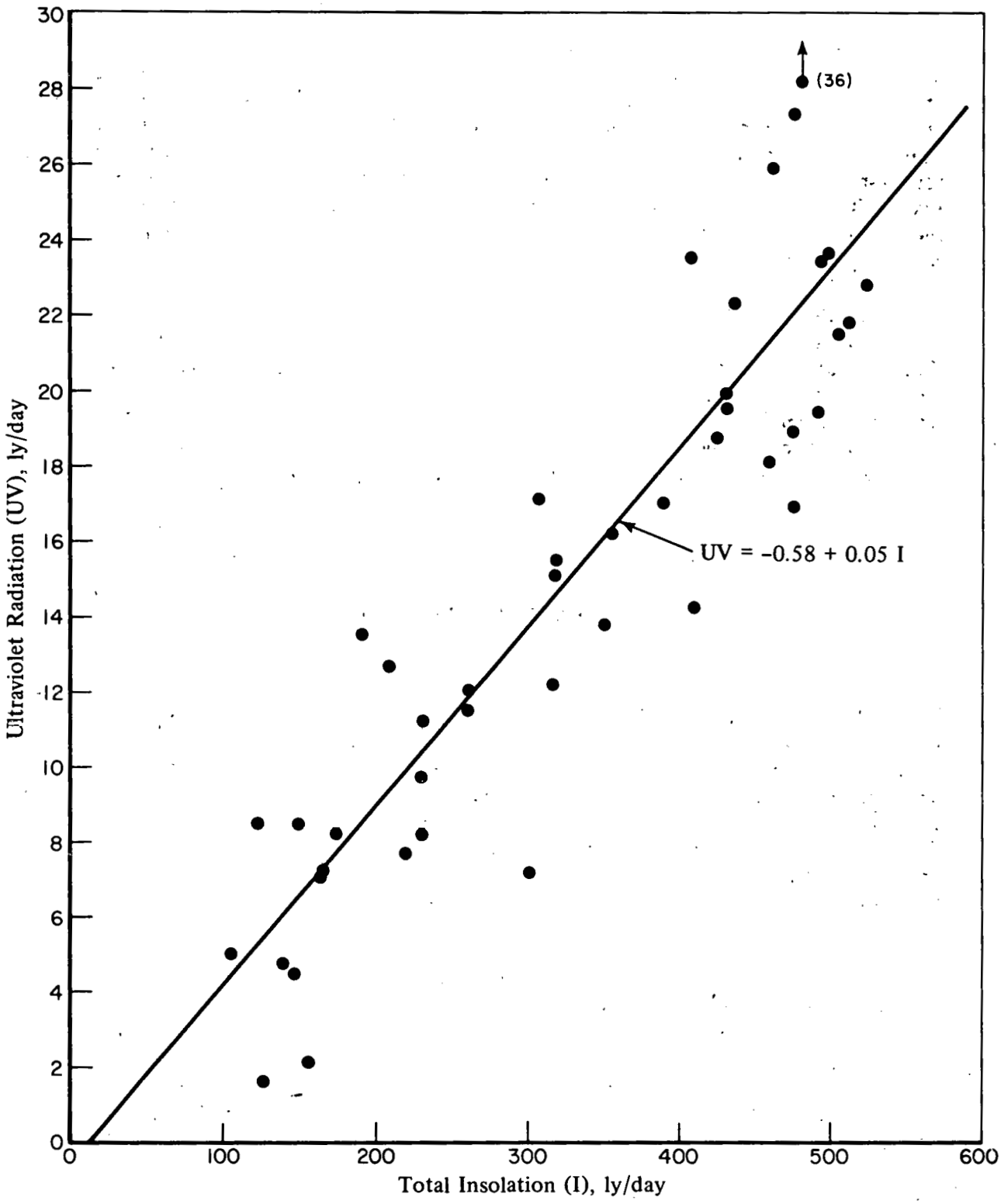


FIGURE 5. MONTHLY AVERAGE ULTRAVIOLET RADIATION (LESS THAN 400 nm) VERSUS MONTHLY AVERAGE TOTAL INSOLATION FOR ROCKVILLE, MD., JUNE 1970–DECEMBER 1973[34]

Similar plots were made for other subsets of the data. For example, plots were made of the daily total ultraviolet radiation versus the daily total insolation for selected months for Rockville and Washington. The results showed relatively high correlations within a month but widely different relations from month to month. The percentage ultraviolet as a function of total insolation using monthly averages varied from 1.2 to 8.4 percent for Rockville and from 0.5 to 5.4 percent for Washington. The average percentages were 4.6 and 2.5 for Rockville and Washington, respectively. Other plots also showed wide variations in the ultraviolet percentages from year to year for these two locations. *This indicates that data must be collected over long time periods to obtain accurate predictions for long-term exposures.*

The ratios of the cumulated monthly average ultraviolet radiation to the cumulated total monthly average insolation for Rockville and Washington are plotted in Figure 6. The cumulation starts at the beginning of each time series. The ratios are seen to stablize at approximately 4.6 percent for Rockville and at 2.5 percent for Washington, D.C. This method of expressing the ultraviolet component of total insolation appears to suppress much of the variability inherent in other methods of presentation. The stable values exposed by this method may represent reasonable estimates of the percentage of the total insolation that is represented by the ultraviolet component for long-term exposures.

Ultraviolet Radiation Data From the National Cancer Institute

The National Cancer Institute has published data from an ultraviolet-radiation study conducted in 10 locations during the 1974 calendar year.(35) Specially constructed dosimeters were used to record the cumulative ultraviolet radiation, with spectral weighting being given to the 290 to 330-nm band, which is the tanning band for human skin. The unique weighting (nonlinearity) of this narrow-band instrument means that the radiation "counts" measured by the dosimeters cannot be compared directly with other ultraviolet data encompassing broader spectral-band widths. However, significant correlations were found between ultraviolet radiation counts and variables such as latitude, elevation, and sky cover at the 10 locations. This suggests that similar correlations may hold for the more conventional measurements of ultraviolet radiation.

Figure 7 shows annual ultraviolet dosimeter count versus degrees North Latitude for 10 locations. A linear regression analysis for these data was found to have an R^2 coefficient of 0.68. When both altitude and sky cover are taken into account, together with latitude, a multiple regression analysis yields an R^2 coefficient of 0.97, and thereby indicates a strong functional relationship.

It is not known whether correlations of this magnitude can be achieved with ultraviolet data for the wider 290 to 400-nm band. However, the above results would indicate that this correlation method should be attempted when ultraviolet data become available for a sufficient number of cities. Obviously, the measuring instrumentation used at each test location must be quite accurate if good correlations are to be obtained.

Ultraviolet Radiation Data for Phoenix, Arizona

Ultraviolet measurements were made in the Phoenix, Arizona, area in 1967-1968 by Desert Sunshine Exposure Tests, Inc.(36) The middle curve in Figure 8 shows the percentage of total

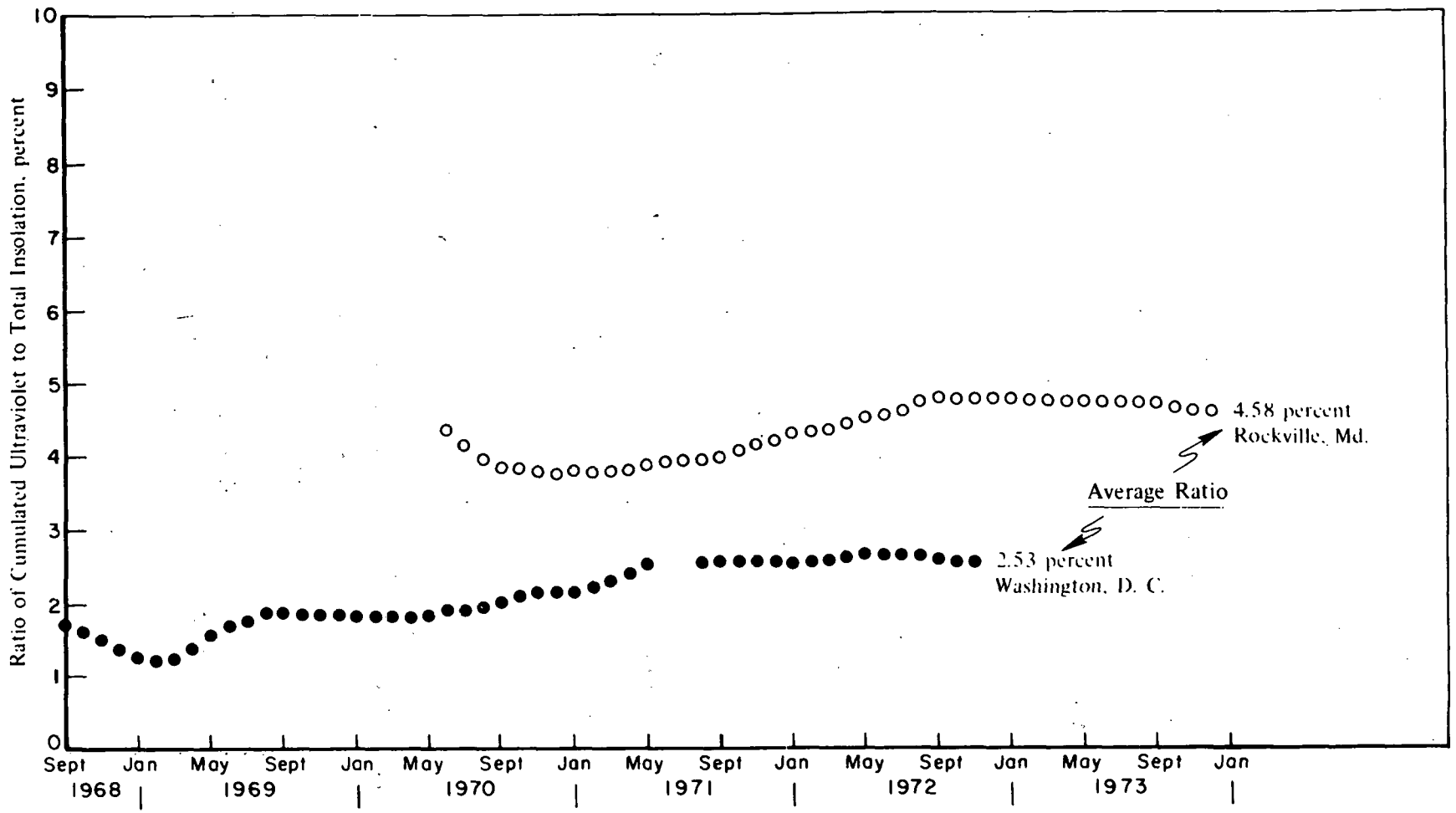


FIGURE 6. RATIO OF CUMULATED ULTRAVIOLET RADIATION TO CUMULATED TOTAL INSOLATION, IN PERCENT, FOR ROCKVILLE, MD., AND WASHINGTON, D. C., 1968 – 1973[34]

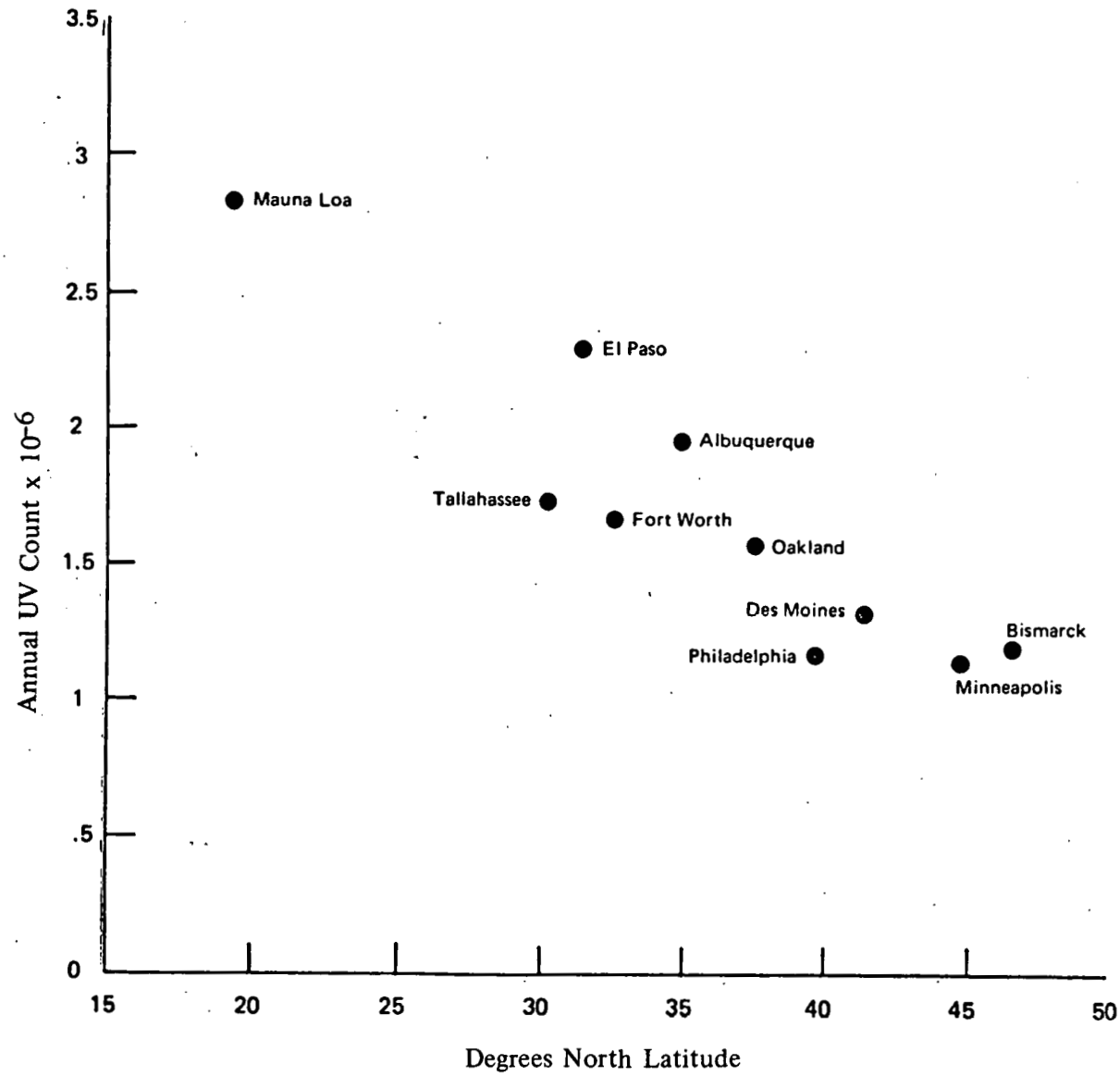


FIGURE 7. ANNUAL ULTRAVIOLET DOSIMETER COUNT AS A FUNCTION OF LATITUDE AND LOCATION[35]

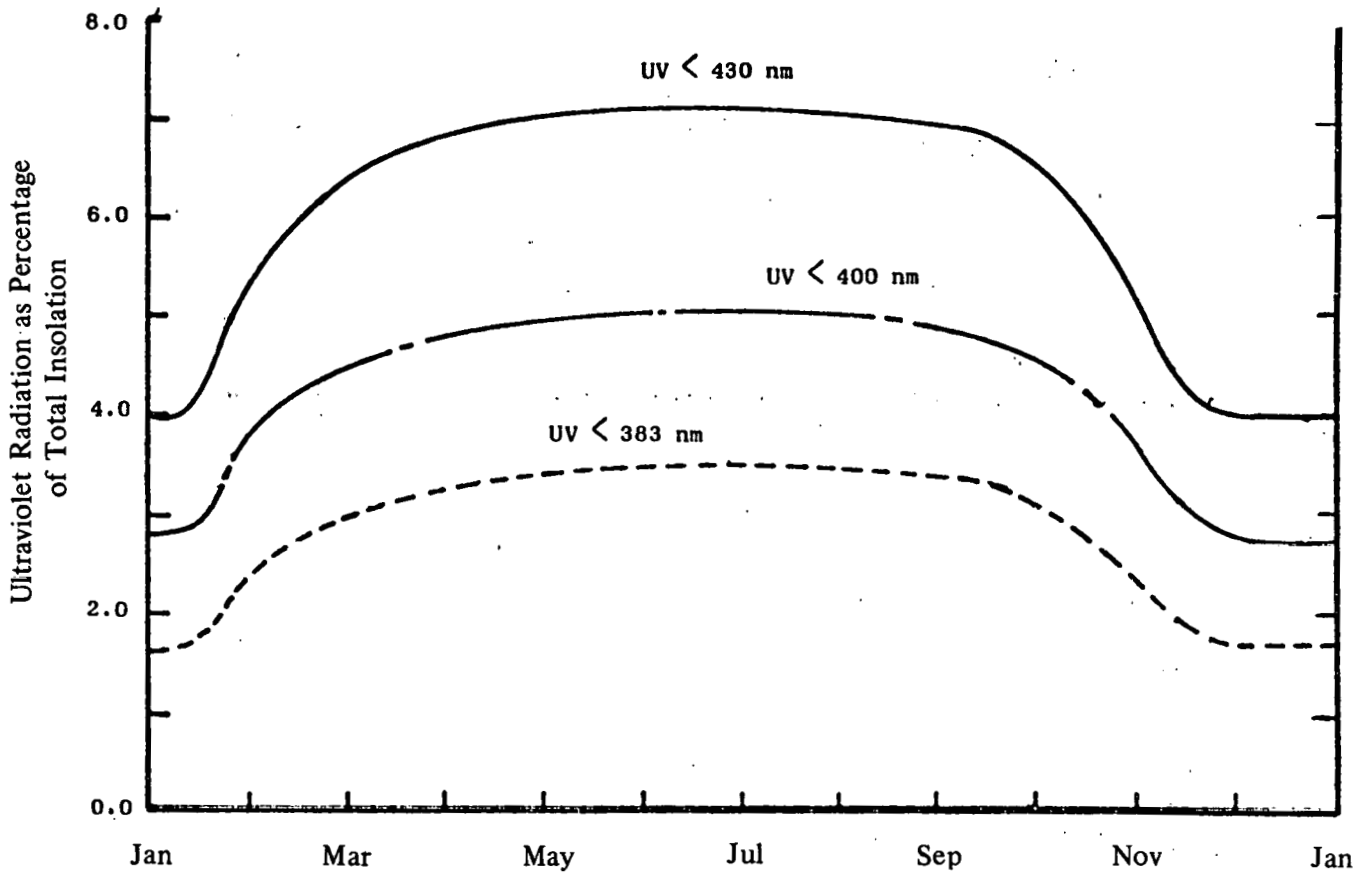


FIGURE 8. ULTRAVIOLET RADIATION BELOW SPECIFIED WAVELENGTH AS A FUNCTION OF MONTH OF YEAR FOR PHOENIX, ARIZONA, OBTAINED BY DESERT SUNSHINE, 1967–1968[36]

insolation below 400 nm as a function of month of the year. The data involved in this figure are based on the "best (most clear) day" in each month. The percentage of ultraviolet below 400 nm reaches a maximum value of approximately 5 percent of the total insolation during the "best day" in the summer months. This percentage correlates well with the Rockville, Maryland, data discussed earlier.

Ultraviolet Radiation for Los Angeles

Another data source for urban area ultraviolet radiation is the radiation study conducted in October, 1965, in downtown Los Angeles and on nearby Mt. Wilson (5700 feet).[37] This study involved measurements of UV in downtown Los Angeles and on top of Mt. Wilson for 5 typical days in October. The smog level at the downtown location varied from "light" to "moderately heavy" during these 5 days, whereas on Mt. Wilson, the sky was "clear" to "very clear".

The total solar radiation in downtown Los Angeles, as a function of true solar time, for each of the 5 days is shown in Figure 9. From these data, the total solar flux for each day was determined by planimeter measurements. Table 20 shows the average incoming 300 to 380-nm radiation at 30-minute intervals for each of the 5 days at both locations. These total daily values were compared, and it was determined that for downtown Los Angeles the ultraviolet radiation between 300 and 380 nm averaged 3.4 percent of the total radiation for the 5 days. The range was from 3.1 percent on a day with moderate-to-heavy smog to 3.8 percent on a day with little smog. The 3.4 percent average is somewhat higher than expected, and would be still higher (approximately 4.9 percent) if the band width were extended to 400 nm rather than 380 nm. Differences in instrumentation and the relatively small number of days sampled may account for the levels being somewhat higher than expected for downtown Los Angeles.

The ultraviolet radiation at Mt. Wilson is approximately 40 percent greater than that in downtown Los Angeles[37], but no information on total radiation was given for Mt. Wilson, and therefore the percentage of ultraviolet could not be determined.

Another source of UV data for the Los Angeles area was obtained from the Los Angeles Reactive Pollutant Program (LARPP).[38] This study involved extensive data gathering at six locations (Mt. Disappointment, L. A. International Airport, L. A. Air Pollution Building, El Monte, Upland, and San Bernardino) over a 46-day period from September 11, 1973, to November 20, 1973. The data are available on magnetic computer tapes.[38]

Although UV radiation levels were recorded at the six locations at 10-minute intervals during most of the testing period, the total solar-radiation levels were recorded only at two locations (1657 Gramercy Avenue in Torrance and 924 N. Garey Avenue in Pomona) which were different from the six UV data stations. On the basis of large differences noted between UV data recorded in Rockville, Maryland, and Washington, D.C., which were described earlier, it was concluded that total solar insolation recorded at one location could not be compared with UV data taken at another location, even if the Los Angeles locations were only 5 miles apart. It is unfortunate that more total insolation measurements were not obtained because, in addition to UV data, many other atmospheric conditions were recorded in these tests, including air temperature, relative humidity, dust, SO_2, ozone, etc.

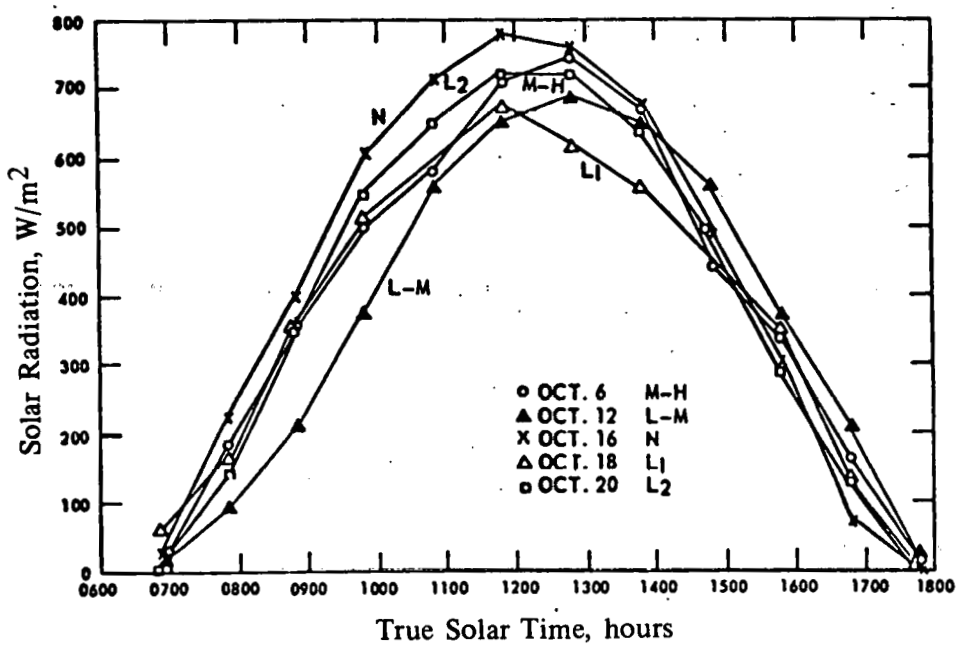


FIGURE 9. AVERAGE SOLAR RADIATION MEASURED WITH A PYRANOMETER FOR 1-HOUR INTERVALS IN LOS ANGELES, CALIFORNIA[37]

TABLE 20. AVERAGE INCOMING 300 TO 380-nm RADIATION (W/m^2) FOR 30-MINUTE INTERVALS, WIDE-BAND FILTER[37]

Midpoint of Time Interval (True Solar Time)	Mt. Wilson					Downtown Los Angeles				
	Oct 6	Oct 12	Oct 16	Oct 18	Oct 20	Oct 6	Oct 12	Oct 16	Oct 18	Oct 20
0715	6.47					4.44		4.67	10.3	
0745	10.9	9.80	9.46	10.2	9.08	6.87	5.31	7.21	7.29	7.33
0815	15.8	14.4	14.0	14.5	14.5	9.38	6.83	11.9	10.5	11.3
0845	20.7	19.1	18.7	18.3	18.1	11.8	8.28	16.4	13.0	15.0
0915	24.4	23.7	23.3	22.8	22.8	14.6	9.94	20.3	17.1	18.6
0945	28.1	26.1	25.1	27.0	26.8	14.3	12.2	24.5	21.0	21.5
1015	32.5	30.9	30.2	30.3	30.3	15.4	15.5	27.5	24.5	23.0
1045	36.7	34.6	33.9	32.6	33.0	16.5	18.2	29.9	26.2	24.0
1115	37.9	36.3	35.8	34.4	34.8	22.1	20.2	31.9	26.0	28.1
1145	38.1	36.7	36.0	35.0	34.6	25.2	20.6	31.7	23.5	27.9
1215	38.7	37.5	36.1	34.7	34.4	26.7	22.7	30.7	20.4	29.4
1245	38.3	37.0	35.5	34.0	33.1	27.0	25.4	30.8	19.3	26.6
1315	36.6	34.8	33.8	32.0	30.7	25.9	23.8	29.3	19.9	24.4
1345	29.0	29.9	29.2	30.0	27.4	20.1	22.9	26.7	17.6	19.7
1415	30.4	27.4	26.5	26.0	23.4	22.6	20.1	23.3	15.4	18.7
1445	19.6	24.5	23.0	21.8	19.3	16.8	16.8	19.6	14.6	15.6
1515	19.9	19.5	18.5	18.5	17.1	13.1	12.6	14.2	12.1	12.1
1545	15.1	14.7	13.6	12.5	11.3	10.7	9.62	9.23	8.76	8.51

General Status of Ultraviolet Radiation Data

In summary, these findings show that routine systematic measurements of ultraviolet radiation are not currently made in the United States and the existing ultraviolet data have resulted primarily from intermittent ad hoc measurements taken at scattered geographic locations as a result of specific research studies. Consequently, the amount of ultraviolet radiation received at a given geographic location in the United States is poorly known and is virtually impossible to estimate accurately. Although recent pyrheliometers integrate the entire solar spectrum, variations in the ultraviolet portion of the spectrum are not well identified and measured because the ultraviolet portion constitutes a small and variable fraction of the total spectrum.[23]

Thus, existing UV data are inadequate for precise design and development of solar energy systems. Until more extensive data and more accurate correlations are available, it is suggested that long-term ultraviolet exposure of horizontal surfaces be assumed to be between 3 and 5 percent of the total insolation received by that surface, depending on whether the surface is in an urban-type (hazy-sky) location or in a surburban-type (clear-sky) location, respectively.

MISCELLANEOUS HAZARDS

This section of the report is concerned with some of the special hazards associated with terrestrial environments. In some instances, the hazards may be characterized as devastating and occurring essentially without warning. These hazards include earthquakes, tornadoes, and lightning. Cumulative chemical attacks due to intermittent exposures to pollution, fungi, or migratory birds are examples of hazards that may occur slowly and predictably over time.

In general, there are three approaches to deal with each miscellaneous hazard associated with a specified location:

(1) Design a robust system that will withstand the hazard

(2) Design a system that will permit effective repair and maintenance procedures when, and if, the hazard occurs

(3) Accept the hazard and the risk of losing the capital investment.

Each hazard poses its own special problems so that the choice among these three alternatives is not easily made. The purpose of the information that follows is to identify some of the hazards that must be taken into consideration before such choices are made.

Court's Climate of the United States

The miscellaneous hazards due to effects of climate are put into perspective only by gaining some familiarity with the general climate of the United States. An excellent 150-page general survey is given by Court in the work edited by Bryson and Hare.(39) This survey includes approximately 160 references, as well as brief, informative climatic tables for 77 geographic locations. No other source of such concise, well-balanced, general information has been found. The following partial listing is made to indicate the scope of the treatment. In general, the information on each topic is displayed on a map of the United States.

Air Movement

- Average annual percentage of frequencies of wind direction, 1951-1960
- Average annual wind speeds, 1951-1960

Moisture

- Mean annual turbidity
- Average percentage of hours with visibility less than 5 km, 1948-1958, by seasons
- Mean annual number of days with fog, through 1960
- Mean annual moisture content of atmosphere up to 325 millibars over 50 stations, 1946-1956
- Average monthly dew point: January
- Average monthly dew point: June

Mean annual total precipitation

Mean number of days with precipitation of 0.25 mm or more, 1931-1960

Months of dominant concentration of precipitation

Snowbelts around the Great Lakes

Average annual date of first snowfall, 1 cm or more, 1950-1960

Average annual date of last snowfall, 1 cm or more, 1950-1960

Mean number of days with freezing precipitation

Storms

Percentage of total precipitation, June-October, attributed to tropical cyclones, 1931-1960

Mean number of days with thunderstorms

Hour (local standard time) of maximum frequency of thunderstorms, June-August

Locations of 960 lightning fatalities, 1959-1965

Mean annual number of days with hail, 1901-1960

Mean annual incidence of large hail (719 mm) per 26,000 km^2, 1955-1967

Mean annual incidence of tornadoes per 26,000 km^2, 1955-1967

Evaporation

Normal monthly distribution of runoff on 20 representative streams, 1931-1960

Average annual evaporation from lakes, 1946-1955

Percentage of months with severe or extreme drought

Heat

Mean annual total duration of sunshine, 1931-1960

Annual mean daily insolation, 1950-1964

Mean daily insolation, 1950-1964, by season

Coldest temperature with probability $\leqslant 1$ percent

Hottest temperature with probability $\leqslant 1$ percent

Mean monthly temperatures, 1931-1960

Mean interdiurnal variability of minimum and maximum temperatures in January and July, 1957-1961

Freeze-free period, 1921-1950

Climates

Longest duration (days) of temperature $\leqslant 32$ F in ten winters, 1950-51 to 1959-60

Mean annual frequency of cold-wet conditions, 1948-1953

Average temperature humidity index, 1951-1955

Normal annual total heating degree days, 1931-1960

Region with more than 700 cooling degree days, 1931-1960

Estimated probability that a wet day follows a wet day, 1951-1960.

The text material that accompanies these maps is clear and carefully written. Much of the information in the descriptions that follow is taken from Court's work.

Tropical Storms

Between 1961 and 1970, the Atlantic coast was hit by 14 tropical storms that killed 583 people and caused millions of dollars in damage. During the hurricane season, June to November, 15 percent of the total precipitation along the Gulf and Atlantic coasts is due to tropical storms.

Thunderstorms

Summer rainfall over much of the United States is associated with thunderstorms. Between 1953 and 1962, the mean annual number of days with thunderstorms exceeds 100 in southwest Florida. Approximately half of the United States has more than 40 thunderstorms per year. Some data suggest that the number of days with thunder increases with the elevation of the reporting station. This may be due to the increased range over which thunder can be heard.

Kansas and Oklahoma experience the longest and most severe thunderstorms. In summer, thunderstorms usually occur in the afternoon over most of the United States. However, in the Great Plains, they occur around midnight.

Lightning

Annual deaths due to lightning have exceeded 2.5 per million people in Vermont, Maryland, Arkansas, Wyoming, and New Mexico. On an annual basis, lightning strikes an average of ten times per square kilometer in Iowa.

Hail

In the United States, hail occurs most frequently in "Hail Alley", which includes portions of Texas, Oklahoma, Arkansas, Missouri, Kansas, Colorado, Nebraska, Wyoming, and South Dakota.

Hail ranges from stones the size of tiny pellets to stones the size of oranges. The hailstones begin as frozen rain or snow pellets in thunderstorm clouds. In upward air currents, supercooled water is encountered, and the size and weight are increased until the air currents of the cloud can no longer support the hailstones. A "cell" consists of an updraft of warm air that carries water vapor which condenses to form a cloud.

Recent research suggests that most hail is formed in a "supercell" storm. Such a storm has a single large cell in its cloud mass. This contrasts with the usual multicell storm that consists of several cells in various degrees of formation and decay. It is believed that the supercell storm yields more hail because the hail embryos move up the outer portions of the cloud first and then traverse horizontally into the supercooled water. This allows more time for growth of the small stones even though they move at speeds up to 63 m/s (140 mph).

Through 1975, approximately $11 million has been spent in hail research experiments designed primarily to reduce the size of hailstones by seeding the clouds with silver iodide.(40)

A map of the contiguous United States showing the average annual incidence of large hail exceeding 19 mm (3/4 inch) is given in the World Survey of Climatology.(39) For the central portions of the United States, this survey also includes a map showing the average annual number of days with hail for the period 1901-1960. The largest annual number is 6 days/year for certain regions in Colorado, Nebraska, and Wyoming, in the heartland of Hail Alley. Finally, it should be noted that hail generally falls in relatively narrow swaths of 0.8 km (1/2 mile) by 3.2 km (2 miles), although wide variations have also been reported. In general, because of the narrow swaths, the recording of hail at regular weather stations is uncommon. Many occurrences of hail would not be reported were it not for insurance claims against crop losses. Consequently, the sources of data on the occurrences of hail are far from ideal.

Tornadoes

Tornadoes occur more frequently in the central portions of the United States than anywhere else in the world. They are the most violent of all meteorological phenomena. Between 1953 and 1970, approximately 116 people per year were killed by tornadoes. The frequency of occurrence of tornadoes is lowest in winter in the Gulf Coast area. The frequency increases during spring and the center of maximum occurrence moves northwest.

A map of the United States showing the average annual incidence of tornadoes per 26,000 km^2 (10,000 square miles) is included in the World Survey of Climatology.(39)

Blizzards

Ordinary blizzards consist of cold temperatures, below -7 C (20 F) and strong winds, above 15 m/s (35 mph), accompanied by blowing or drifting snow. Severe blizzards consist of heavy snow at temperatures below -12 C (10 F) and wind speeds exceeding 20 m/s (45 mph). They result from the flow of Arctic air that moves southward at 20 to 30 m/s (45 to 65 mph) across the northern plains and upper Mississippi Valley in winter. Temperatures can drop as much as 25 or 30 C (75 or 85 F) in 24 hours.

Chinooks

Chinooks consist of very warm, dry air that flows just east of the Rocky Mountains through Montana, eastern Wyoming, and Colorado to northwestern New Mexico. From 1906 to 1968, a total of 76 chinooks occurred at Boulder, Colorado. When a chinook reaches ground level, the temperature increases 10 to 30 C (50 to 85 F), the humidity decreases, and snow quickly evaporates. In some instances, the chinook air rises and falls alternately with local winds at intervals of a few minutes or hours. This causes wide temperature excursions.

Earthquakes

A seismic-risk map for earthquakes occurring in the United States prior to 1948 is presented in Figure 10.[41] The zones vary from 0, indicating no damage, to 3, indicating major damage.

A more recent seismic-risk map based on earthquakes occurring in the United States prior to 1969 is presented in Figure 11.[41] In addition to the Zone 3 region shown for California and Nevada, the map shows other Zone 3 regions. One region occurs in the State of Washington; a third region occurs in southern Montana, eastern Idaho, northwest Wyoming and Utah; a fourth region occurs in eastern Arkansas, western Tennessee and Kentucky, northern Illinois and Indiana; and a fifth region lies in the State of South Carolina. Small Zone 3 regions also occur in the northeast United States – in eastern Massachusetts, northern Maine, and western New York State.

Biological Deterioration

A cursory survey of the literature relating to biological contamination and/or deterioration of glass and polymeric surfaces reveals no information or data which relate specifically to solar collectors. This is expected because, first, the biological deterioration of organic coatings or glass surfaces is a very subtle phenomenon, and second, only limited experience is available for the physical life expectancy of solar-collector surfaces.

There are, however, considerable data available concerning the growth of microorganisms, particularly fungi on glass surfaces such as optical instruments, camera lenses, binoculars, gun sights, etc. There are numerous reports of surface etching of glass by fungi identified as *aureobasidium pulluluns, monilia sitophola, aspergillus niger,* and *penicillium frequentens.*

Most of the investigations of biological deterioration on optical surfaces conclude that the fungus growth becomes established primarily as the result of either (1) sealants used to mount the optics or (2) the deposition of airborne organic debris on the surface. The latter is considered the more common cause for support of fungal growth. It is most likely that similar favorable substances could become associated with solar-collector surfaces which will be exposed to a variety of atmospheric conditions. The metabolic products, many of which consist of enzymes and organic acids, frequently react with the optical-glass surfaces. The result may be a clouding of the glass surface or, frequently, an etching or crazing of the surface. It is entirely conceivable that under optimum microenvironmental conditions for microbial growth, an impairment of light transmission could result.

The large number of organic coatings which may be found useful as cover sealants or as adhesives for solar collectors may also provide a similar reactive surface for fungal growth. Extensive investigations have been made of the microbial defacement of organic coatings. The same physical phenomena associated with microbial attack of optical surfaces, such as surface debris and airborne organic matter, obviously will occur with polymeric coatings. Further, there are extensive literature and data concerning the susceptibility of a wide spectrum of coating compounds to fungal degradation.

Early tests showed negligible effects of high humidity and fungus growth on common commercial types of insulating materials made from organic and inorganic filled polymers.[42] This is attributed to the more rapid deterioration resulting from absorption of water and condensation.

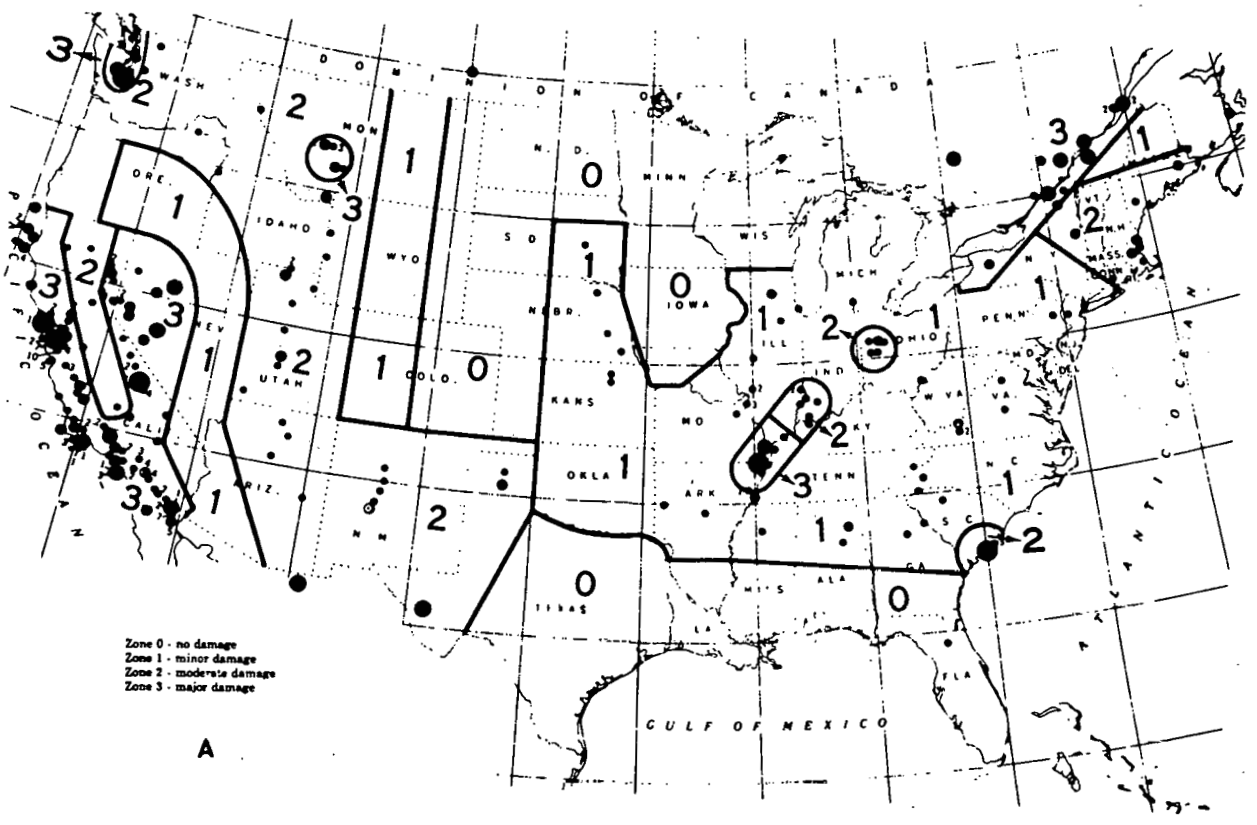


FIGURE 10. SEISMIC-RISK MAP BASED ON ACTUAL EARTHQUAKES OCCURRING IN THE UNITED STATES PRIOR TO 1948[41]

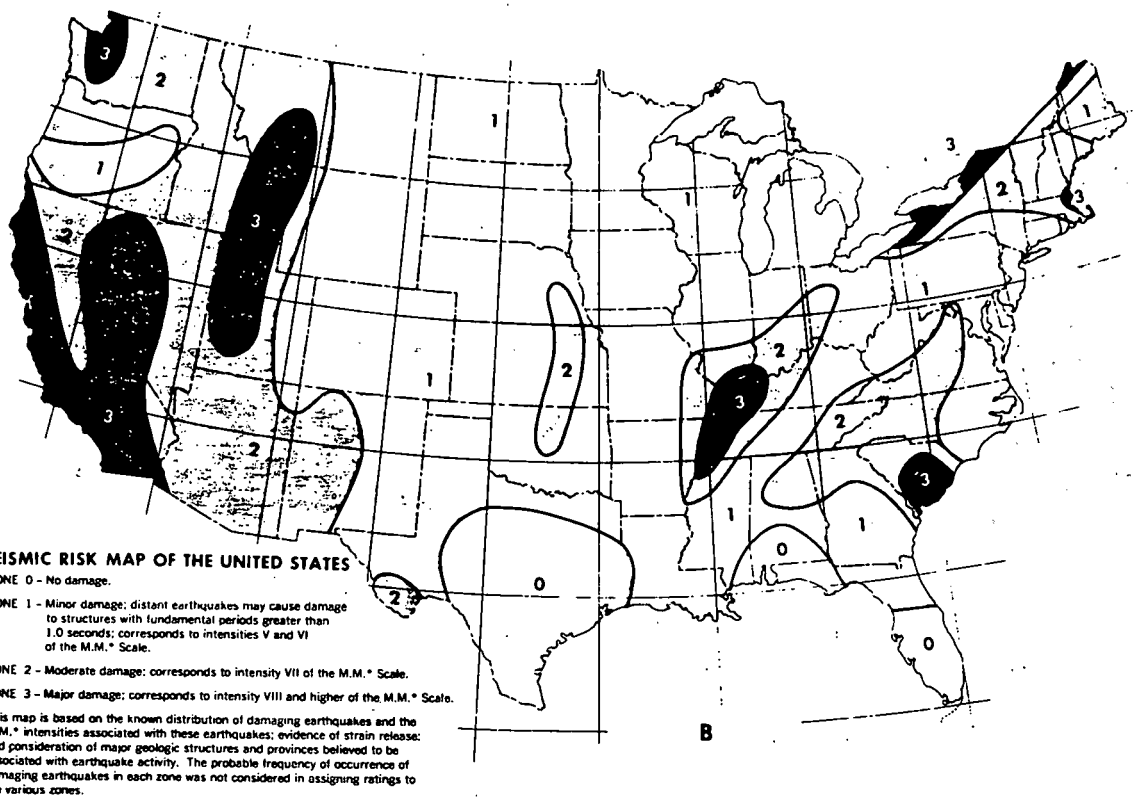


FIGURE 11. SEISMIC-RISK MAP BASED ON ACTUAL EARTHQUAKE OCCURRENCES IN THE UNITED STATES PRIOR TO 1969[41]

Subsequent studies were made of the effects of moisture and fungi on the mechanical and electrical properties of polymer materials[43], and on the surface and leakage resistance of hookup wire[44]. A tropical exposure site in the Panama Canal Zone has been used to evaluate the MPF (Moisture-Fungus-Proofed) treatment.[45] This treatment consisted of adding a fungicide to varnish or lacquer and then using this solution to coat radio and radar equipment.

Polymers with low-moisture-absorbing characteristics are less hospitable to the growth or organisms. Among the "pure" polymers that support fungus growth are cellulose nitrate, melamine formaldehyde, and vinyl acetate. Some modified polymers support fungal growth and some do not. Some phthalates support fungal growth. Plasticizers of the long-chain fatty-ester type, such as stearates, sebacates, aleates, and ricinoleates should be avoided, if possible.[46] Early studies by the Naval Research Laboratory yielded some results for plasticizers (see Table 21).[47]

The microorganisms known to be associated with biological deterioration are ubiquitous. Further, many of the fungal species have wide tolerance ranges both for moisture and temperature. Because of the anticipated long-time exposure of solar collecting surfaces and the potential range of environmental conditions to which they can be subjected throughout the continental United States, it would be highly advisable that careful consideration be given the potential for biological deterioration. The mycological aspects as well as the applicability of antimicrobial agents should be thoroughly investigated in close concert with any R&D program concerned with solar-collector coating or encapsulation.

TABLE 21. EXTENT OF FUNGAL GROWTH FOR VARIOUS PLASTICIZERS

Plasticizer	Extent of Fungal Growth
Caster oil	++++
Glyceryl laurates	++++
Sorbitol laurate	++++
Triethanolamine dicapyrlate	++++
Dibutyl sebacate	+++
Dibutyl phthalate	–
Diethyl phthalate	--
Tricresyl phosphate	+
Di-(o-xenyl) monophenyl phosphate	--
Butylphthalylbutyl glycolate	+
Ethylene glycol monoethyl ether laurate	++++
Triethylene glycol di-2-ethyl benzoate	–
Tetraethylene glycol distearate	++++
Silicone oil	--

*Key:

- – no growth on sample
- + growth discernible with 20X magnification, not visible to naked eye
- ++ sparse growth but easily visible
- +++ moderate growth
- ++++ heavy growth.

Source: Reference (47).

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NEW TECHNOLOGY STATEMENT

The following new technology item resulting from this study is being reported to NASA pursuant to the new technology provisions of the contract:

Title: Climate and Other Environmental Data for Various Locations in the United States for Use in Weathering Tests

Reported by: R. E. Thomas and D. C. Carmichael

Date: To be issued.

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APPENDIX A

CLIMATOLOGICAL DATA FOR EACH OF NINE SELECTED GEOGRAPHIC LOCATIONS

Part 1 General Descriptions of Climate for Nine Selected Locations

Part 2 Diurnal Climatic Statistics for Each of the Nine Selected Locations at 3-Hour Intervals by Month for the Years 1965-1974

APPENDIX A

Part 1. General Descriptions of Climate for Nine Selected Locations

Albuquerque, New Mexico
Bismarck, North Dakota
Boston, Massachusetts
Brownsville, Texas
Cleveland, Ohio
Fairbanks, Alaska
Los Angeles, California
Miami, Florida
Phoenix, Arizona

APPENDIX A

CLIMATOLOGICAL DATA FOR EACH OF NINE SELECTED GEOGRAPHIC LOCATIONS

Part 1. General Descriptions of Climate for Nine Selected Locations

This part of Appendix A consists of general descriptions of the climate for the 9 geographic locations listed below:

Albuquerque, New Mexico
Bismarck, North Dakota
Boston, Massachusetts
Brownsville, Texas
Cleveland, Ohio
Fairbanks, Alaska
Los Angeles, California
Miami, Florida
Phoenix, Arizona.

Albuquerque, New Mexico

State Climate. New Mexico has a mild, arid or semiarid, continental climate characterized by light precipitation totals, abundant sunshine, low relative humidities, and a relatively large annual and diurnal temperature range. Location and topography play major roles in determining the climate of New Mexico. This is particularly true for any specific locality. (A-1, pp 794-795)

Local Climate. Albuquerque is located in the Central Highlands of New Mexico at latitude 35°N and longitude 107° W. The climate is arid continental, with a predominance of clear, sunny weather. Almost half of the annual moisture is the result of thundershowers in the late summer months. Winters are generally very dry, with most of the precipitation in the form of light snow. In the mountains east of the city, precipitation is considerably heavier, and snow cover is normal during the winter months. During the late winter and spring months, there are occasional windy and dusty days. The weather station is at the Municipal Airport, Kirtland Air Force Base, which is 1600 m (5300 ft) above sea level and about 3 km (2 mi) from the Rio Grande River. A deep arroyo over 1.5 km (1 mi) wide borders the airport. (A-1, p 2; and A-3)

Temperature. There are large diurnal, daily, monthly, and annual variations in temperature at Albuquerque. On a typical January day during the years 1941-1970, the mean temperature ranged from -4 C (24 F) to 8 C (47 F); on a typical July day, the mean temperature ranged from 18 C (65 F) to 33 C (92 F). The diurnal statistics in Part 2 of this appendix for Albuquerque are seen to yield the following mean temperatures for the years 1965-1974: for a typical January day, -3.5 C (26 F) at 8 a.m.

to 6.4 C (44 F) at 5 p.m.; for a typical July day, 19.1 C (66 F) at 5 a.m. to 31.5 C (89 F) at 2 p.m. Reference A-3 shows that during 15 years of record keeping, the highest temperature was 41 C (105 F) in 1974; the lowest was -27 C (-17 F) in 1971. In comparison with the diurnal statistics in Part 2 of this appendix, the highest and lowest temperatures are seen to be 41.1 C (106 F) in July at 11 p.m. and -26.1 C (-15 F) in January at 8 a.m. The differences of 0.1 C and 0.9 C are believed to be minor and probably due to rounding errors. During 14 years of record keeping, the temperature was 32 C (90 F) or above on an average of 62 days per year; freezing temperatures were recorded on an average of 120 days per year; however, temperatures of -18 C (0 F) or lower occurred only 1 day per year, on the average.(A-3)

Precipitation. On the basis of records for the period 1931-1960 at the airport, the normal yearly rainfall is only 20 cm (8 in.). Prolonged rainy spells are practically unknown. July and August are the rainiest months because of frequent, intense, summer thunderstorms. Maximum rainfall in 24 hours, based on 32 years of record keeping, was 5 cm (2 in.) in 1955. In the mountains east of the city, precipitation is considerably heavier. At Tijeras Ranger Station, about 24 km (15 mi) east of Albuquerque, the average annual rainfall is around 38 cm (15 in.). Winter is the driest season. A considerable portion of the meager winter precipitation falls in the form of snow, but there are normally only 4 days a year when as much as 2.5 cm (1 in.) of snow occurs. Snow rarely remains on the ground in the valley for more than 24 hours but in the nearby mountains, snow cover is normal from the middle of December until early spring. During 32 years of record keeping at the airport, the average yearly snowfall was 25 cm (10 in.) and the maximum in 24 hours was 36 cm (14 in.) in 1958. (A-1, p 803; A-3)

Winds, Storms, and Floods. Widespread floods are not a threat but heavy summer thunderstorms frequently cause local flash floods and minor damage to culverts, roadways, and private property. These storms are also sometimes accompanied by hail. (A-1, pp 795-96) On the basis of records spanning 35 years at the airport, thunderstorms occur 43 days out of the year, on the average. Over the period of these records, the average wind speed was 15 km/h (9 mph), and the fastest mile of wind was 145 km/h (90 mph) in 1943. There are, on the average, only 46 days during the year when the maximum wind speed reaches 52 km/h (32 mph). Tornadoes rarely occur in the vicinity of Albuquerque.(A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 58 percent of the time, from 4 to 7 tenths of the sky 16 percent of the time, and 8 tenths or more of the sky 26 percent of the time. (A-2, p 15) During 23 years of record keeping, the average daily solar radiation ranged from 3140 Wh/m^2 (270 ly*) in December to 8470 Wh/m^2 (729 ly) in June. (A-1, p 803)

Air Pollution. Visibility is greater than 32 km (20 mi) 95 percent of the time. (A-2, p 15), but during the late winter and spring months there are occasional dust storms.(A-3) The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Bismarck, North Dakota

State Climate. North Dakota is typically plains country located near the center of the North American Continent. The climate is continental in nature, with wide diurnal variations in temperature.

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*Langleys.

Snowfall is often heavy, and spring flooding of rivers and tributaries is the usual aftermath. (A-1, pp 811-812)

Local Climate. Bismarck is located in south-central North Dakota, near the center of the North American landmass at latitude 47°N and longitude 101°W. It is on the east bank of the Missouri River in a shallow basin, almost entirely surrounded by low-lying hills. Climate of the area is semiarid, typically continental in character. During summer, relative humidity is generally low, with few hot days. Winters are quite cold and long. Temperature range from summer to winter is very great. Most summer precipitation occurs during thunderstorms. Snow has been reported in all months except July and August. The weather station is at the Municipal Airport, which is 500 m (1650 ft) above sea level and 5 km (3 mi) east of the river. (A-2, p 2; A-3)

Temperature. There are large diurnal, daily, monthly, and annual variations in temperature at Bismarck. On a typical January day during the years 1941-1970, the temperature ranged from -19 C (-3 F) to -7 C (19 F); on a typical July day, the temperature ranged from 14 C (58 F) to 32 C (90 F). For the years 1965-1974, the diurnal statistics in Part 2 of this appendix yield the following corresponding temperatures for typical days: in January, -16.2 C (3 F) at 6 a.m. to -10.9 C (12 F) at 3 p.m.; in July 14.4 C (58 F) at 6 a.m. to 27.7 C (82 F) at 3 p.m.. During 15 years of record keeping at the airport, the highest temperature was 43 C (109 F) in 1973. Part 2 of this appendix shows a maximum temperature of 42.2 C (108 F) in July at 3 p.m.. During the same period, the temperature was 32 C (90 F) or above on an average of 22 days per year; freezing temperatures were recorded on an average of 187 days per year; temperatures of -18 C (0 F) or lower occurred 50 days per year, on the average. On 7 days of the year, on the average, the maximum temperature will be below -18 C (0 F). Temperatures of -34 C (-30 F) or lower can be expected in about 7 out of 10 years, and -40 C (-40 F) or lower can be expected about 1 year in 10.(A-3)

Precipitation. During the period 1931-1960, the average yearly rainfall at the municipal airport was 38 cm (15 in.). Over 75 percent of this amount falls during the months from April through September. Most summer precipitation occurs during thunderstorms in late afternoon or evening. Maximum precipitation in 24 hours was 10 cm (4 in.) in 1914. On the basis of 18 years of record keeping, the normal yearly snowfall is 94 cm (37 in.). A trace or more of snow falls on 74 days of the year, and snow has been reported in all months except July and August. Maximum monthly snowfall was 79 cm (31 in.) in 1896. (A-1, p 818; A-3)

Winds, Storms, and Floods. Thunderstorms occur on an average of 31 days during the year, accompanied by hail on two or three of the days. A severely damaging hailstorm is experienced about once every 10 years. Major rainstorms of sufficient magnitude to cause more than local flooding (without snowmelt) are extremely rare. The Missouri River is now controlled by Garrison Dam, 60 miles northwest of Bismarck, thus eliminating the threat of serious floods which have occurred in past years. On the basis of 35 years of record keeping, the fastest mile of wind was 116 km/h (72 mph), in 1946. Five tornadoes occurred in the Bismarck area during the period 1924-1974, one of which resulted in widespread and serious loss.(A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 32 percent of the time, from 4 to 7 tenths of the sky 15 percent of the time, and 8 tenths or more of the sky 54 percent of the time. (A-2, p 15)

Air Pollution. The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Boston, Massachusetts

State Climate. Climatic characteristics of Massachusetts include changeability of weather on both a short and long time scale, large daily and annual ranges of temperature, equal distribution of precipitation throughout the year, and considerable climatic diversity from place to place. (A-1, p 175)

Local Climate. Boston is on the Atlantic coast at latitude 42°N and longitude 71°W. The climate of the area is made up of variable and changeable weather elements, with frequent fluctuations from fair to cloudy or stormy conditions. In winter, the severity of cold waves is often reduced by the ocean nearby. The freeze-free period varies by as much as 2 months in different locations in and around Boston. There is no dry season. During the summer, much of the rainfall comes from showers and thunderstorms. During the rest of the year, rain and snow are produced by low-pressure storm systems and coastal storms. High winds also frequently occur, especially in winter. The Boston weather station is at Logan International Airport, which is adjacent to Boston Harbor at an elevation of 5 m (15 ft) above sea level. About 19 km (12 mi) south is another weather station, Blue Hill Observatory. It is located 13 km (8 mi) southwest of Boston Harbor at an elevation of 194 m (635 ft) above sea level. The altitude of the Observatory and its proximity to Massachusetts Bay play major roles in determining the climate of Blue Hill. It has lower temperatures, more precipitation, higher winds, more frequent occurrence of fog, and longer periods of snow cover than do other nearby locations at lower elevations.(A-3)

Temperature. There are large diurnal, daily, monthly, and annual variations in temperature at Boston, although the proximity of the ocean is a moderating factor affecting temperature extremes. On a typical January day during the years 1941-1970, the temperature ranged from -5 C (23 F) to 2 C (36 F); on a typical July day, the temperature ranged from 18 C (65 F) to 27 C (81 F). For the years 1965-1974, the diurnal statistics in Part 2 of this appendix yield a range of -3.6 C (26 F) to 0.2 C (32 F) for a typical January day and a range of 19.4 C (67 F) to 25.8 C (78 F) for a typical July day. During 10 years of record keeping at Logan International Airport, the highest temperature was 37 C (99 F) in 1973. The highest temperature shown in Part 2 of this appendix is 36.1 C (97 F) for May at noon.

During the same period, the temperature was 32 C (90 F) or above on an average of 11 days per year; freezing temperatures were recorded on an average of 100 days per year; however, temperatures of -18 C (0 F) or lower occurred only 1 day per year, on the average. The temperature differential between the airport and Blue Hill is typically about 2 C (3 F). (A-1, p 183; A-3)

Precipitation. Boston has no dry season. Total precipitation is fairly evenly distributed throughout the year. Much of the rainfall from June to September comes from showers and thunderstorms. During the rest of the year, low-pressure systems pass more or less regularly and produce precipitation on an average of roughly 1 day in 3. Coastal storms or "northeasters" are prolific producers of rain or snow. On the basis of records for the period 1931-1960, the average yearly rainfall is 109 cm (43 in.) at Logan International Airport and 122 cm (48 in.) at Blue Hill. Maximum precipitation in 24 hours was

25 cm (10 in.) at Blue Hill in 1955. Measurable snowfall occurrences average 35 to 40 per season. On the basis of 33 years of record keeping, the average yearly snowfall at Logan International Airport is 107 cm (42 in.) and the maximum in 24 hours was 48 cm (19 in.) in 1958. On the basis of 83 years of record keeping, the average yearly snowfall at Blue Hill is 155 cm (61 in.) and the maximum in 24 hours was 69 cm (27 in.) in 1960. (A-1, p 183; A-3)

Winds, Storms, and Floods. On the basis of records spanning 39 years at Logan International Airport, thunderstorms occur 20 days per year, on the average. Winds of 51 km/h (32 mph) or higher may be expected on at least 1 day in every month of the year; gales are both more common and more severe in winter. The fastest mile of wind recorded at Logan Airport during the period 1958-1968 was 105 km/h (65 mph). The fastest mile at Blue Hill during the period 1960-1968 was 148 km/h (92 mph). Maximum wind speeds in earlier years for 5-minute periods reached 195 km/h (121 mph) in 1938 with peak gusts up to 299 km/h (186 mph). Destruction from tropical storms occurred 10 times during the period 1901-1955. (A-1, p 183; A-1, Appendix; A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 31 percent of the time, from 4 to 7 tenths of the sky 17 percent of the time, and 8 tenths or more of the sky 52 percent of the time. (A-2, p 15) During 21 years of record keeping, the average daily solar radiation ranged from 1390 Wh/m^2 (120 ly) in December to 5980 Wh/m^2 (515 ly) in June. Solar radiation at Blue Hill is typically 6 percent greater. (A-1, p 183)

Air Pollution. Smoke sources are largely confined to a circular area of radius 19 km (12 mi) centered at the airport. (A-2, p 16) Air pollution is also increased by cars driven by Metropolitan Boston's population of roughly 3 million. The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Brownsville, Texas

State Climate. Texas has diverse meteorological and climatological conditions. Continental, marine, and mountain types of climates are found in Texas. While the changes in climate across the State are considerable, they are nevertheless gradual. (A-1, p 878)

Local Climate. Brownsville is located in the extreme southern tip of Texas at latitude 26°N and longitude 97°W. The Gulf of Mexico is about 18 miles to the east, and more than half of the land toward the coast is made up of tidal marshlands. Despite its proximity to the Gulf, the area is semiarid due to lack of rainfall. The weather station is at Rio Grande Valley International Airport, which is located at a bend of the Rio Grande River about 29 km (18 mi) west of and 5 m (16 ft) higher than the Gulf coast. (A-2, p 2; A-3)

Temperature. The temperature at Brownsville usually varies over a relatively small range. On a typical January day during the years 1941-1970, the temperature ranged from 11 C (51 F) to 21 C (70 F); on a typical July day, the temperature ranged from 24 C (76 F) to 34 C (93 F). For the years

1965-1974, Part 2 of this appendix yields a range of 12.7 C (55 F) at 6 a.m. to 19.1 C (66 F) at 3 p.m. for a typical January day and a range of 24.3 C (76 F) at 6 a.m. to 32.4 C (90 F) at 3 p.m. for a typical July day. The highest temperature recorded at Brownsville is 40 C (104 F) in 1947; the lowest is -11 C (12 F) in 1899. The corresponding maximum and minimum temperatures shown in Part 2 of this appendix for the years 1965-1974 are found to be 37.2 C (99 F) and -2.2 C (28 F), respectively. During 8 years of record keeping, the temperature was 32 C (90 F) or above on an average of 104 days per year; freezing temperatures were recorded on an average of 2 days per year. Frequently, an entire winter will pass without a temperature as low as the freezing point.(A-3) Brownsville had 65 consecutive hours of subfreezing temperatures in 1951, and 64 consecutive hours in 1962; in the intervening period, no severe freezes occurred. (A-1, pp 880-84)

Precipitation. On the basis of records for the period 1931-1960 at Rio Grande International airport, the normal yearly rainfall is about 69 cm (27 in.). Most of the precipitation comes in the form of thunderstorm activity, and often a single thunderstorm will account for the entire month's rainfall. Some extreme rainfalls, for example, over 76 cm (30 in.) in September 1886, have occurred when hurricanes were in the vicinity. Only a trace of snow has been recorded in Brownsville since Weather Bureau records began. However, local newspaper records show that 15 cm (6 in.) of snow blanketed the area in 1895. Glaze is also rare, but in 1951 a record ice accretion of 4 cm (1.5 in.) was reported. (A-1, p 907; A-3)

Winds, Storms, and Floods. On the basis of records spanning 32 years, thunderstorms occur 24 days out of the year, on the average. Brownsville is also vulnerable to hurricanes. The probability is 2 percent that winds will exceed 200 km/h (124 mph) in any one year in an 80-km (50 mi) segment of the coastline east of Brownsville. The probability is 8 percent that winds will exceed 117 km/h (73 mph) in any one year in the same segment. During hurricane Beulah in 1967, a wind of 219 km/h (136 mph) was recorded at Port Brownsville. Record-breaking floods in low areas also resulted from this and other intense tropical storms. These storms can drop rainfall of up to 50 cm (20 in.) within a few hours. Destruction from tropical storms occurred 15 times during the period 1901-1955. Tornadoes, spawned by thunderstorms and hurricanes, are also a threat. The greatest number of tornadoes to be sighted in Texas during one year was 232 in 1967. Near and along the immediate coast, the hazard of hurricane tides carry the threat of great destructive power. (A-1, pp 881-82; A-1, Appendix; A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 25 percent of the time, from 4 to 7 tenths of the sky 32 percent of the time, and 8 tenths or more of the sky 43 percent of the time. (A-2, p 15) During 15 years of record keeping, the average daily solar radiation ranged from 2950 Wh/m^2 (254 ly) in December to 7320 Wh/m^2 (630 ly) in July. (A-1, p 907)

Air Pollution. Owing to the sea-breeze circulation off of the Gulf of Mexico, air pollution is not a problem in Brownsville. (A-1, p 885) Smoke is not a factor in this area. (A-4, p 2) Visibility is greater than 10 km (6 mi) 93 percent of the time. (A-4, p 15) The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Cleveland, Ohio

State Climate. The climate of Ohio is remarkably varied. It is essentially continental in nature, characterized by moderate extremes of heat and cold and of wetness and dryness. (A-1, pp 300-301)

Local Climate. Cleveland is on the south shore of Lake Erie at latitude 41°N and longitude 82°W. It has a continental climate, which is modified by the lake. Otherwise, local topography is of minor importance as a determining factor in the weather. The surrounding terrain is mostly level except for a ridge on the southeastern edge of the city. The weather station is at Cleveland Hopkins International Airport, which is 240 m (790 ft) above sea level and about 8 km (5 mi) south of and 61 m (200 ft) higher than the shoreline of Lake Erie, where the official weather records have been maintained since 1941. Prior to that time, the station was located in downtown Cleveland. Comparative records show that temperatures at the two sites have differed by as much as 7 C (12 F). Precipitation differences between the two locations are slight.(A-3)

Temperature. There are large diurnal, daily, monthly, and annual variations in temperature at Cleveland. On a typical January day during the years 1941-1970, the temperature ranged from -7 C (20 F) to 1 C (33 F); on a typical July day, the temperature ranged from 16 C (61 F) to 28 C (82 F). For the years 1965-1974 Part 2 of this appendix yields a range of -3.9 C (25 F) at 1 a.m. to -1.6 C (29 F) at 4 p.m. for a typical January day and a range of 17.6 C (64 F) at 4 a.m. to 25.6 C (78 F) at 1 p.m. for a typical July day. During 17 years of record keeping at the airport, the highest temperature was 39 C (103 F), in 1941. For the years 1965-1974, Part 2 of this appendix shows a maximum temperature of 34.4 C (94 F) for the months of June and July at 4 p.m. During 16 years of record keeping at the same location, the temperature was 32 C (90 F) or above on an average of 20 days per year; freezing temperatures were recorded on an average of 119 days per year; however, temperatures of -18 C (0 F) or lower occurred only 4 days per year, on the average. The lowest temperature on record is -27 C (-17 F), observed in 1873 (A-1, p 309, A-3); the lowest temperature for 1965-1974 is shown in Part 2 of this appendix to be -25 C (-13 F) at 7 a.m. for a January day.

Precipitation. On the basis of records for the period 1931-1960 at Cleveland Hopkins Airport, the normal yearly rainfall is about 81 cm (32 in.), which is evenly distributed throughout the year. During summer thunderstorms, maximum rainfalls have reached 13 cm (5 in.) in 24 hours. Much heavier rainfalls have occurred in the elevated sections of the eastern suburbs. On the basis of 16 years of record keeping, the normal yearly snowfall is 132 cm (52 in.). There is a marked tendency for northeastern counties to receive snowfall amounts substantially in excess of those measured elsewhere in Ohio. The maximum snowfall in 24 hours ever recorded in Cleveland was 43 cm (17 in.) in 1913. Although the area is subject to frequent snows, the persistence of snow cover is seldom great, because the temperature rarely remains below freezing for any considerable length of time. (A-1, pp 301 and 309; A-3)

Winds, Storms, and Floods. Damaging windstorms are mostly associated with heavy thunderstorms or line squalls. On the basis of records spanning 33 years, the average number of thunderstorms per year is 36. The fastest mile of wind recorded at different sites since 1870 was 125 km/h (78 mph) in 1940. Severe thunderstorms frequently cause local flash flooding. Although tornadoes are fairly common in Ohio (three or four may be expected to strike each year), only five have occurred within Cleveland city limits since records began in 1870. Several additional tornadoes have occurred in the Cleveland suburbs during this period. (A-1, p 301; A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 24 percent of the time, from 4 to 7 tenths of the sky 18 percent of the time, and 8 tenths or more of the sky 58 percent of the time. (A-2, p 15)

Air Pollution. The primary source of smoke is the industrial area located in the Cuyahoga River flats near the center of Cleveland.[A-3] Other smoke sources are railroads passing through the city. (A-2, p 16) Cars driven by the metropolitan population of 800,000 also contribute heavily to air pollution. The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Fairbanks, Alaska

State Climate. Continental, marine, mountain, and arctic types of climates are found in Alaska. Terrain and oceanography are responsible for unusual wind conditions in some localities. There are wide seasonal and geographic variations in solar radiation and temperature. Snowfall makes up a large portion of the total annual precipitation. (A-1, pp 482-483)

Local Climate. Fairbanks is located in the Tanana Valley of interior Alaska at latitude 65°N and longitude 148°W. Well sheltered from maritime influences by mountain ranges on practically all sides, the area has a definite continental climate. Because of the high latitude, days are long in summer and short in winter. Furthermore, the surrounding upland areas tend to aid the settling of cold air into the Tanana Valley lowlands. As a result, subzero temperatures occur regularly during the winter months and snow cover is persistent. Average cloudiness is low the year around, and wind speeds are especially low in winter. The weather station is at Fairbanks International Airport, which is 130 m (430 ft) above sea level and within 1 mile of both the Tanana and the Chena rivers. (A-2, p 2; A-3)

Temperature. There are large diurnal, daily, monthly, and annual variations in temperature at Fairbanks. On a typical January day during the years 1941-1970, the temperature ranged from -30 C (-22 F) to -19 C (-2 F); on a typical July day, the temperature ranged from 10 C (50 F) to 22 C (72 F). For the years 1965-1974, Part 2 of this appendix shows a range of -29.2 C (-21 F) at 8 a.m. to -26.6 C (-16 F) at 2 p.m. for a typical January day and a range of 12.3 C (54 F) to 20.7 C (69 F) for a typical July day. The lowest and highest temperatures on record are -54 C (-66 F) in 1934 and 37 C (99 F) in 1919.[A-3] For the years 1965-1974, Part 2 of this appendix shows that the lowest and highest temperatures are -50 C (-58 F) for a January day and 11.1 C (52 F) for a July day. During 11 years of record keeping, the temperature was 32 C (90 F) or above an average of 52 days per year; freezing temperatures were recorded an average of 225 days per year; and temperatures of -18 C (0 F) or lower occurred 122 days per year, on the average.

Precipitation. Snowfall makes up a large portion of the total annual precipitation. On the basis of records for the period 1931-1960, the average yearly rainfall is 28 cm (11 in.). On the basis of 16 years of record keeping, the average yearly snowfall is 168 cm (66 in.). During 33 years of record keeping, the maximum rainfall in 24 hours was about 8 cm (3 in.) in 1967, and the maximum snowfall in 24 hours was 51 cm (20 in.) in 1966. (A-1, p 492; A-3)

Winds, Storms, and Floods. On the basis of records spanning 23 years, thunderstorms occur 5 days out of the year, on the average. Over the period of these records, the average wind speed was 2.2 m/sec (5 mph) and the fastest mile of wind was 17.8 m/sec (40 mph) in 1974. Wind speeds are particularly low during the winter months.(A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1956-1960, clouds cover 3 tenths or less of the sky 24 percent of the time, from 4 to 7 tenths of the sky 16 percent of the time, and 8 tenths or more of the sky 60 percent of the time. (A-2, p 15) During 30 years of record keeping, the average daily solar radiation ranged from 70 Wh/m^2 (6 ly) in December to 5940 Wh/m^2 (511 ly) in June. (A-1, p 492)

Air Pollution. During the winter months, extremely low temperatures are frequently accompanied by ice fog and smoke conditions.(A-3) The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Los Angeles, California

State Climate. California has a variety of climates, often within short distances. Maritime, continental, and transitional climates are found within the State. Temperature and precipitation patterns vary by locality, but summer is a dry period over most of the State. (A-1, pp 538-542)

Local Climate. Los Angeles is located on the southern coast of California at latitude 34°N and longitude 118°W. The primary influence on the climate is the Pacific Ocean to the west, but mountain ranges along the north and east side of the coastal basin act as a buffer to the more extreme conditions of the interior. Pronounced differences in temperature, humidity, cloudiness, fog, sunshine, and rainfall occur over fairly short distances on the coastal plains and the adjoining foothills because of the local topography and the decreased marine effect further inland. Average wind speeds are rather low.(A-3) One weather station is at Los Angeles International Airport, which lies in the coastal plain 5 km (3 mi) east of and 30 m (100 ft) above the Pacific Ocean. (A-2, p 2) Another station is located in the Los Angeles civic center, 23 km (14 mi) east-northeast of and 82 m (270 ft) above the ocean.(A-3)

Temperature. The temperature at Los Angeles usually varies over a relatively small range. On a typical January day during the years 1931-1960, the airport temperature ranged from 7 C (45 F) to 18 C (64 F); on a typical July day, it ranged from 17 C (62 F) to 24 C (76 F). For the years 1965-1974, Part 2 of this appendix shows a range of 9.6 C (49 F) at 7 a.m. to 16.6 C (62 F) at 1 p.m. for a typical January day and a range of 17.6 C (64 F) at 4 a.m. to 22.7 C (73 F) at 1 p.m. for a typical July day. During 16 years of record keeping, the highest temperature was 43 C (110 F) in 1963. For the years 1965-1974, Part 2 of this appendix shows a maximum temperature of 37.8 C (100 F) occurring for days in September and November.Over a 15-year period, the temperature was 32 C (90 F) or above on an average of 5 days per year, and temperatures of -18 C (0 F) or lower did not occur. (A-1, p 577)

Precipitation. Rainfall comes mainly in the winter with nearly 85 percent of the annual total occurring from November through March, while summers are practically rainless. There is a marked variability in monthly and seasonal totals. On the basis of records for the period 1941-1970, the average yearly rainfall is 30 cm (12 in.) at Los Angeles International Airport and 36 cm (14 in.) at the civic center.(A-3) Farther inland, at Riverside, the average yearly rainfall is only 28 cm (11 in.), on the basis of 70 years of records. Annual rainfall at the airport is somewhat less than that recorded on the Palos Verdes Hills rising to an elevation of nearly 450 m (1500 ft) on a peninsula 19 km (12 mi) to the south, and on the Hollywood Hills and Santa Monica Mountains which extend east-west 19 km (12 mi) north of the airport with peaks reaching to nearly 600 m (2000 ft). Only traces of snow have fallen in Los Angeles and vicinity, the snow melting as it fell.(A-3)

Winds, Storms, and Floods. On the basis of records (possibly incomplete) for the period 1941-1964 at the civic center, thunderstorms occur 6 days out of the year, on the average. Thunderstorms do not occur often near the coast (3 days out of the year, on the average, in 27 years at the airport) but they are observed more frequently over the coastal ranges that border the area. Destructive flash floods occasionally develop in and below some mountain canyons. On the basis of records spanning 24 years at the civic center, the average wind speed is about 10 km/h (6 mph). At the airport, the average wind speed is about the same. Over a period of 34 years, the peak gust at the civic center was 79 km/h (49 mph) in 1946. Over a period of 25 years, the peak gust at the airport was 100 km/h (62 mph), in 1952. In fall, winter, and early spring, occasional foehn-like (Santa Ana) winds come from the northeast over ridges and through passes in the coastal mountains. These winds reach speeds of 56 to 80 km/h (35 to 50 mph) in north and east sections of the city, with higher speeds in outlying areas to the north and east, but rarely reach coastal portions of the city.(A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 58 percent of the time, from 4 to 7 tenths of the sky 13 percent of the time, and 8 tenths or more of the sky 29 percent of the time. (A-2, p 15) During 18 years of record keeping at the same site, the average daily solar radiation ranged from 2780 Wh/m^2 (239 ly) in December to 7460 Wh/m^2 (642 ly) in July. Corresponding radiation data for the civic center differ from these figures by less than 3 percent. (A-1, p 577)

Air Pollution. At times, lack of air movement, combined with a frequent and persistent temperature inversion, is associated with concentrations of air pollution in the Los Angeles coastal basin and some adjacent areas.(A-3) The main source area of smoke from industrial operations is from 16 to 24 km (10 to 15 mi) wide and around 40 km (25 mi) long; it is centered along a line extending from Torrance to El Monte. Visibility restrictions due to smoke are rarely localized but, when occurring, are usually widespread throughout the Los Angeles basin. Dense, widespread smoke hardly ever occurs by itself but is usually associated with haze or fog. (A-2, p 2) "Smog" from the high density of cars in the area is a recurring source of pollution. Occasional "Santa Ana" winds carry dust at speeds up to 80 km/h (50 mph) to north and east sections but rarely reach coastal portions of the city.(A-3) The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Miami, Florida

State Climate. Florida has climatic conditions that range from a zone of transition between temperate and subtropical conditions in the extreme northern interior portion to the tropical conditions found on the Florida Keys. Sunshine is abundant, while the annual and diurnal temperature range is relatively narrow. (A-1, p 45)

Local Climate. Miami is located in the southern tip of Florida at latitude 26°N and longitude 80°W. To the east of the city lies Biscayne Bay. East of that lies the island of Miami Beach, a mile or less wide and about 10 miles long, and beyond Miami Beach is the Atlantic Ocean. The surrounding countryside is level and sparsely wooded. The climate of Miami is essentially subtropical marine. Summers are long and warm, with abundant rainfall, and winters are mild and dry. The weather station is at Miami International Airport, which is 16 km (10 mi) west of and 2.5 m (8 ft) above the Atlantic Ocean. (A-2, p 2; A-3)

Temperature. The temperature at Miami usually varies over a relatively small range. On a typical January day during the years 1941-1970, the temperature at Miami International Airport ranged from 14 C (58 F) to 24 C (76 F); on a typical July day, the temperature ranged from 24 C (75 F) to 32 C (89 F). For the years 1965-1974, Part 2 of this appendix shows a range or 17.5 C (64 F) at 7 a.m. to 23.5 C (74 F) at 1 and 3 p.m. for a typical January day, and a range of 25.4 C (78 F) at 4 a.m. to 30.1 C (86 F) at 1 p.m. for a typical July day. The average daily range of temperature is only 18 C (10 F) at Miami Beach, while well inland the average daily range is about 32 C (18 F). During 34 years of record keeping at the airport, the highest temperature was 38 C (100 F) in 1942; the lowest was -2 C (28 F) in 1940. For the years 1965-1974, Part 2 of this appendix shows a maximum temperature of 34.4 C (94 F) for a day in August and a minimum temperature of 1.7 C (35 F) for days in December and January. During 10 years of records at the airport, the temperature was 32 C (90 F) or above an average of 33 days per year; freezing conditions did not occur. Freezing temperatures occur occasionally in the farming districts southwest, west, and northwest of the city, but almost never near the ocean.(A-3)

Precipitation. On the basis of records for the period 1941-1970 at Miami International Airport, the normal yearly rainfall is about 152 cm (60 in.). However, the cooperative station on Miami Beach, at the water's edge, has a normal yearly rainfall of about 117 cm (46 in.). The distribution of rainfall within the year is quite uneven; rainfall is light from November through April and relatively heavy in other months. Overcast, drizzly days are rare. The start and end of the rainy season varies considerably from year to year. In the summer, there is nearly a 50-50 chance that some rain will fall on any given day. Most of the summer rain is derived from local showers or thundershowers. No snow has ever been reported in the area. (A-1, pp 47 and 50; A-2, p 2; A-3)

Winds, Storms, and Floods. Hail and high local winds of short duration, capable of inflicting serious property damage, occur occasionally in connection with thunderstorms. On the basis of records spanning 25 years at Miami International Airport, thunderstorms occur 75 days out of the year, on the average. In any given year, there is a one-in-six chance of a hurricane hitting Miami, and a 5 percent chance of winds exceeding 200 km/h (124 mph). Destruction from tropical storms occurred 20 times during the period 1901-1955. Destructive tornadoes are very rare. Although funnel clouds occasionally touch the ground, significant damage is seldom reported. The only deaths ever reported in the Miami area from tornadoes occurred in 1925. (A-1, p 47; A-1, Appendix; A-3)

Sunshine. On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or more of the sky 22 percent of the time, from 4 to 7 tenths of the sky 40 percent of the time, and 8 tenths or more of the sky 38 percent of the time. (A-2, p 15) During 20 years of record keeping, the average daily solar radiation ranged from 3700 Wh/m^2 (319 ly) in December to 6650 Wh/m^2 (572 ly) in April. (A-1, p 62)

Air Pollution. Atmospheric instability and easterly trade winds greatly reduce the general pollution problem. However, these meteorological deterrents to pollution are becoming offset by population increases. (A-1, p 49) Smoke pollution is generally slight, but muck fires during the winter and early spring occasionally produce pollution that cuts visibility to less than 11 km (7 mi). (A-3, p 2) Visibility is greater than 10 km (6 mi) 96 percent of the time in Miami. (A-2, p 15) The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

Phoenix, Arizona

State Climate. Both desert and alpine climates are found in Arizona. There are great diurnal and annual variations in temperature, and great geographical and seasonal variations in precipitation. The air is generally dry and clear, with relatively low humidity and a high percentage of sunshine. (A-1, pp 503-504)

Local Climate: Phoenix is located in the south-central region of Arizona, in the broad, flat valley of the Salt River, at latitude 33°N and longitude 112°W. Owing to impounding dams upstream, the Salt River is usually dry. The valley has a desert climate with a consistently high percentage of sunshine all year, low rainfall, low relative humidity, and mild winters. The valley floor is sheltered from the wind by five mountains that lie in different directions from Phoenix. The weather station is at Sky Harbor Airport, which is in the southeastern part of Phoenix at an elevation of 335 m (1100 ft) above sea level.(A-3)

Temperature. There are large diurnal, daily, monthly, and annual variations in temperature at Phoenix. On a typical January day during the years 1941-1970, the temperature ranged from 3 C (38 F) to 18 C (65 F); on a typical July day, the temperature ranged 27 C (80 F) to 41 C (105 F). For the years 1965-1974, Part 2 of this appendix shows a range of 5.1 C (41 F) at 8 a.m. to 17.8 C (64 F) at 5 p.m. for a typical January day and a range of 27.9 C (82 F) at 5 a.m. to 40.1 C (104 F) at 5 p.m. for a typical July day. During 14 years of record keeping at the airport, the highest temperature was 47 C (116 F) in 1974.(A-3) Part 2 of this appendix shows the highest temperature to be 46.7 C (116 F) for a June day at 5 p.m. For the 14 years of record, the temperature was 32 C (90 F) or above on an average of 165 days per year; freezing temperatures were recorded on an average of 14 days per year, and temperatures of -18 C (0 F) or lower did not occur.(A-3)

Precipitation. Phoenix is situated in one of the driest regions of the North American continent. (A-4, p 11) On the basis of records for the period 1931-1960 at Sky Harbor Airport, the normal yearly rainfall is only 18 cm (7 in.) (A-1, p 512) Maximum precipitation in 24 hours was 13 cm (5 in.) in 1911. Snowfall occurs very rarely in the Salt River Valley, while light snows occasionally fall in the higher mountains surrounding the valley.(A-3) During the period 1900-1956, only 5 days are recorded with measurable snowfall in Phoenix. (A-4, p 10)

Winds, Storms, and Floods. The average wind speed is 10 km/h (6 mph). During 35 years of record keeping, the peak gust was 121 km/h (75 mph) in 1950, and thunderstorms occurred 23 days per year, on the average, mostly during July, August, and September. The area is sheltered from heavy winter storms by the high coastal mountains of California. From March through June Phoenix is virtually free of stormy weather. Earthquakes, tornadoes, and hurricanes are practically unknown. (A-4, pp 8 and 11)

Sunshine. More sunshine is recorded in the area than in any other section of the nation. (A-4, p 10) On the basis of daily observations at the airport at noon for the period 1951-1960, clouds cover 3 tenths or less of the sky 64 percent of the time, from 4 to 7 tenths of the sky 11 percent of the time, and 8 tenths or more of the sky 25 percent of the time. (A-2, p 15) During 16 years of record keeping, the average daily solar radiation ranged from 3180 Wh/m^2 (274 ly) in December to 8380 Wh/m^2 (721 ly) in June. (A-1, p 512)

Air Pollution. Occasionally, cold fronts and summer thunderstorms bring periods of dusty windy weather. This dust normally lasts about 5 or 10 minutes before it is settled by showers brought by the wind. Prior to World War II, farming and tourism were the main occupations in Phoenix. Since then, industry has moved in, but it has been largely of a smokeless variety. (A-4, p 37) However, rapid growth in population (doubling every 20 years) has meant a corresponding increase in air pollution from cars. The suspended-particulate and SO_2 air quality in neighboring areas is indicated by maps at the end of this appendix.

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A-2 U.S. Weather Bureau, *Summary of Hourly Observations*, Decennial Census of United States Climate (1951-1960), U.S. Government Printing Office, Washington, D.C. (1974).

A-3 National Oceanic and Atmospheric Administration, U.S. Department of Commerce. *Local Climatological Data*, National Climatic Center, Asheville, North Carolina (1974).

A-4 *Arizona Highways*, April, 1957.

A-5 Office of Air and Waste Management, U.S. Environment Protection Agency, *Monitoring and Air Quality Trends Report*, 1973, EPA-450/1-74-007, U.S. Government Printing Office, Washington, D.C. (1974).

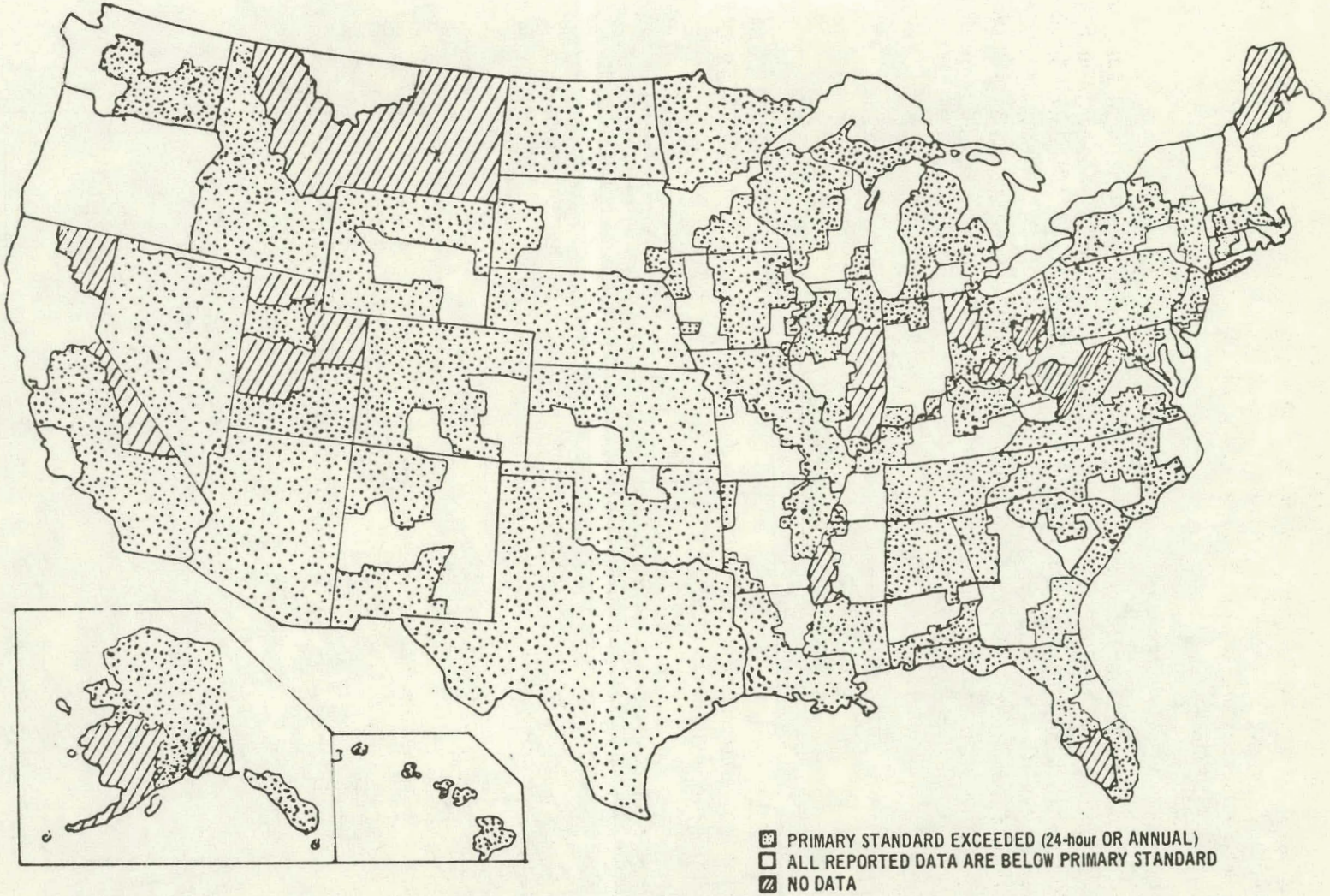

FIGURE A-1. STATUS OF SUSPENDED PARTICULATE LEVELS, 1973

(Reference A-5)

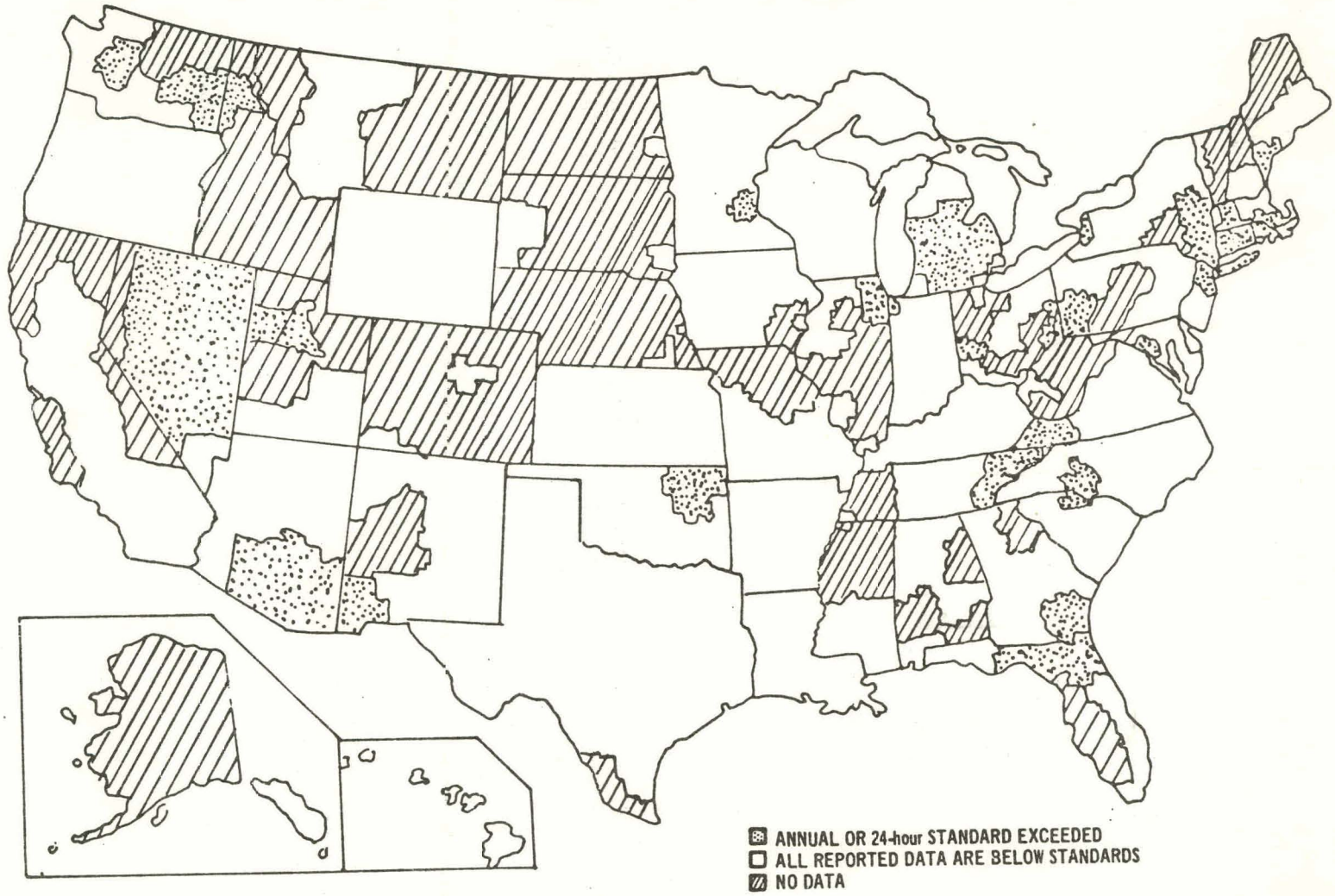

FIGURE A-2. STATUS OF SULFUR DIOXIDE LEVELS, 1973

(Reference A-5)

APPENDIX A

Part 2. Diurnal Climatic Statistics for Each of the Nine Selected Locations* at 3-Hour Intervals by Month for the Years 1965-1974

Albuquerque, New Mexico
Bismarck, North Dakota
Boston, Massachusetts
Brownsville, Texas
Cleveland, Ohio
Fairbanks, Alaska
Los Angeles, California
Miami, Florida
Phoenix, Arizona

* The following notations pertain to all tables for the nine geographic locations:

(a) Maximum and minimum values for "Sky Cover" are 100 and 0 percent, respectively, for all months and hours.

(b) Approximate number of observations for each entry equals 282 for February; 300 for April, June, September, and November, and 310 for all other months. For Phoenix, only, for solar radiation the time period covered consists of 30 months beginning in January, 1965, for a total of approximately 93 days for January, March, and May; 90 days for April and June; 62 days for July, August, October, and December; 60 days for September and November; and 84 days for February.

(c) In the tables (Tables A-2, A-4, etc.) of observations of selected climatic events (fog, drizzle, rain, etc.), a blank indicates a "0"; that is, the event never occurred during the period from 1965-74 (at that location for the given month and time). In several of the tables (Tables A-9, A-11, A-13, and A-17) of descriptive climatic statistics (air temperature, dew point, etc.), there are several instances in which data on the dew point were lost in the computerized data processing; these instances are marked with an asterisk (*) and footnoted.

TABLE A-1. DESCRIPTIVE CLIMATIC STATISTICS FOR ALBUQUERQUE, NEW MEXICO AT 3-HOURLY INTERVALS BY MONTH FOR YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 2	-1.9	4.8	10.0	-20.6	-8.5	5.3	5.6	-26.7	63.6	16.2	100.0	17.0	3.2	1.9	12.3	0.0
1 5	-3.3	4.8	9.4	-23.9	-8.8	5.3	5.6	-27.8	68.1	15.3	100.0	23.0	3.1	2.0	13.4	0.0
1 8	-3.5	5.0	8.3	-26.1	-8.7	5.2	5.6	-28.9	69.0	15.2	100.0	30.0	2.9	1.9	15.4	0.0
1 11	3.0	5.5	15.6	-20.0	-7.6	5.3	8.3	-26.1	48.5	16.4	100.0	18.0	3.4	2.2	15.9	0.0
1 14	7.1	5.8	19.4	-15.0	-8.2	5.3	4.4	-25.0	36.0	15.7	100.0	5.0	4.0	2.9	15.4	0.0
1 17	6.4	5.9	19.4	-15.6	-8.5	5.5	5.6	-26.1	37.0	17.1	100.0	5.0	4.0	2.8	14.4	0.0
1 20	1.7	5.1	13.3	-18.3	-8.2	5.4	5.0	-25.0	50.2	17.2	100.0	15.0	3.5	2.1	12.9	0.0
1 23	-.4	4.9	11.7	-20.6	-8.3	5.4	6.1	-25.6	57.6	16.7	100.0	16.0	3.2	1.9	12.9	0.0
2 2	.3	4.2	10.0	-10.0	-8.5	4.6	3.3	-21.7	54.7	17.4	96.0	15.0	3.7	2.3	14.4	0.0
2 5	-1.1	4.1	10.6	-10.6	-8.7	4.6	2.2	-23.9	59.1	16.9	100.0	16.0	3.6	2.0	13.4	0.0
2 8	-.6	3.9	9.4	-10.6	-8.2	4.5	2.8	-22.2	59.2	17.0	100.0	16.0	3.3	2.3	15.4	0.0
2 11	5.7	4.7	18.9	-5.0	-7.9	4.8	3.3	-21.1	40.4	17.5	100.0	10.0	4.0	2.6	15.4	0.0
2 14	9.7	5.5	21.7	-2.8	-8.7	4.9	3.3	-22.2	30.6	17.2	85.0	5.0	4.5	2.6	14.9	0.0
2 17	9.7	5.7	22.2	-4.4	-9.5	5.3	4.4	-29.4	29.2	17.7	89.0	4.0	5.0	2.9	12.9	0.0
2 20	4.6	4.7	15.0	-6.1	-9.0	5.1	4.4	-23.3	40.9	18.9	92.0	7.0	4.2	2.3	14.4	0.0
2 23	2.3	4.3	12.2	-7.8	-8.7	4.9	3.3	-22.2	47.8	18.2	96.0	11.0	3.9	2.4	14.4	0.0
3 2	4.1	4.9	17.8	-10.0	-7.5	5.1	3.9	-22.2	47.0	19.8	96.0	11.0	3.8	2.2	13.4	0.0
3 5	2.2	4.6	15.0	-11.7	-7.4	5.0	7.2	-20.6	52.9	19.2	100.0	12.0	3.6	2.2	12.9	0.0
3 8	4.5	5.0	16.7	-9.4	-6.7	4.8	6.7	-20.6	47.7	18.4	96.0	12.0	3.6	2.4	14.4	0.0
3 11	11.0	5.9	22.8	-6.7	-7.0	5.1	6.7	-23.3	31.4	16.1	93.0	7.0	4.4	2.8	14.4	0.0
3 14	14.8	6.5	27.8	-3.3	-8.6	5.5	3.3	-27.8	23.0	15.6	92.0	2.0	5.5	3.1	15.4	0.0
3 17	14.8	6.6	28.3	-3.3	-9.5	5.8	5.0	-27.8	22.3	16.3	100.0	4.0	6.1	3.0	15.4	0.0
3 20	9.3	5.6	22.8	-6.1	-8.4	5.5	4.4	-22.2	32.6	19.3	100.0	6.0	4.6	2.4	14.4	1.0
3 23	6.5	5.3	19.4	-8.3	-7.8	5.3	3.3	-21.7	39.9	19.9	100.0	7.0	4.0	2.3	12.9	0.0
4 2	7.6	3.9	17.8	-5.0	-7.3	5.8	6.1	-21.7	38.1	19.2	96.0	10.0	3.9	2.2	12.3	0.0
4 5	5.6	3.7	14.4	-5.0	-7.0	5.6	5.6	-20.6	44.0	19.3	96.0	13.0	3.8	2.0	11.8	0.0
4 8	9.6	4.0	17.2	-3.9	-5.6	5.3	7.2	-18.9	37.3	17.6	100.0	8.0	4.0	2.6	12.9	0.0
4 11	15.8	4.7	24.4	-.6	-6.6	5.7	6.1	-23.9	24.0	15.2	100.0	4.0	5.0	2.8	16.5	0.0
4 14	19.4	5.1	30.6	0.0	-9.1	6.4	6.7	-32.8	17.1	13.5	96.0	2.0	6.4	3.2	17.5	1.5
4 17	19.3	5.3	28.9	1.1	-10.1	6.8	6.1	-26.1	16.8	15.3	89.0	2.0	6.8	3.4	16.5	0.0
4 20	14.1	4.5	23.3	-.6	-8.7	6.7	7.8	-25.0	24.5	17.7	96.0	4.0	5.2	2.3	13.4	0.0
4 23	10.5	4.1	20.0	-1.1	-7.6	6.1	7.2	-23.3	31.9	19.2	96.0	6.0	4.4	2.4	14.4	0.0
5 2	12.6	3.9	23.3	0.0	-2.9	6.6	9.4	-21.1	37.9	18.8	96.0	11.0	4.0	2.5	14.4	0.0
5 5	10.5	3.7	20.0	-1.1	-2.4	6.4	9.4	-21.1	44.3	18.7	100.0	10.0	3.9	2.5	14.4	0.0
5 8	15.7	4.1	24.4	3.9	-.8	5.9	10.0	-17.8	35.8	16.4	86.0	10.0	4.0	2.4	12.3	0.0
5 11	21.5	4.5	30.6	7.2	-2.5	6.4	9.4	-21.1	22.9	13.0	86.0	4.0	4.7	2.5	14.4	0.0
5 14	24.8	5.0	33.9	5.6	-5.0	6.7	11.1	-25.6	16.5	13.4	87.0	2.0	5.9	2.8	16.5	0.0
5 17	24.7	4.7	33.3	6.7	-6.1	7.1	11.7	-25.0	15.7	12.9	77.0	3.0	6.5	2.9	16.5	1.5
5 20	19.4	4.3	28.3	5.6	-4.5	6.8	11.7	-26.1	23.6	17.2	90.0	3.0	5.1	2.4	15.4	0.0
5 23	15.7	4.0	24.4	4.4	-3.4	6.7	12.8	-21.1	31.0	18.5	100.0	5.0	4.5	2.6	16.5	0.0
6 2	17.5	3.7	28.3	7.8	2.2	6.7	15.6	-15.6	40.1	20.2	100.0	10.0	4.3	2.5	14.9	0.0
6 5	15.4	3.5	26.7	5.6	2.4	6.5	15.0	-15.0	45.8	20.1	100.0	15.0	3.7	2.1	15.4	0.0
6 8	20.7	3.5	30.0	11.1	3.8	5.9	16.1	-13.3	36.2	16.6	97.0	9.0	3.9	2.2	16.5	0.0
6 11	26.4	3.9	36.7	13.9	2.6	5.8	16.1	-13.9	23.8	12.3	73.0	6.0	4.1	1.9	11.3	1.5
6 14	29.8	4.4	38.9	14.4	.0	6.4	16.1	-18.3	17.0	11.2	66.0	4.0	5.3	2.8	21.6	1.5
6 17	29.4	5.0	40.6	13.9	-.8	7.0	15.6	-19.4	17.9	14.9	84.0	2.0	6.1	2.8	14.4	0.0
6 20	24.5	4.2	32.8	11.7	.7	6.8	15.6	-20.0	25.4	17.8	90.0	5.0	5.4	2.6	15.9	0.0
6 23	20.8	3.8	29.4	11.0	1.7	6.8	17.2	-19.4	32.8	19.6	100.0	6.0	5.0	2.8	15.4	0.0

ALBUQUERQUE

TABLE A-1. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 2	20.7	2.4	26.1	15.0	10.6	3.9	17.2	-8.9	55.0	17.0	93.0	14.0	3.9	2.4	16.5	0.0
7 5	19.1	2.2	24.4	13.3	10.8	3.9	17.2	-10.6	61.2	17.2	97.0	16.0	3.3	2.3	13.9	0.0
7 8	22.8	2.4	28.3	15.6	11.3	3.5	17.2	-5.6	50.4	14.8	93.0	14.0	3.4	2.1	13.9	0.0
7 11	28.0	2.8	33.9	16.7	10.4	3.5	17.8	-7.8	35.3	11.7	83.0	8.0	3.5	1.5	9.8	0.0
7 14	31.5	3.2	38.3	18.3	8.4	4.0	17.2	-7.8	25.7	11.0	78.0	7.0	4.1	1.9	12.9	0.0
7 17	30.3	4.5	38.3	16.7	7.9	4.7	18.3	-8.9	28.3	15.8	93.0	5.0	5.6	2.8	15.4	0.0
7 20	25.7	3.6	34.4	16.1	9.2	4.5	17.2	-8.3	39.2	17.8	97.0	7.0	4.8	2.4	14.4	0.0
7 23	22.8	2.9	41.1	16.7	10.3	4.1	17.8	-9.4	48.7	17.9	90.0	8.0	4.4	2.4	14.4	0.0
8 2	19.3	2.4	26.7	13.3	10.9	3.4	18.3	-5.6	60.5	16.1	97.0	22.0	3.6	2.1	11.3	0.0
8 5	17.7	2.2	24.4	12.2	11.1	3.3	17.8	-5.6	67.0	15.1	100.0	27.0	2.9	1.8	11.3	0.0
8 8	20.9	2.4	26.7	14.4	11.5	3.1	18.3	-3.9	56.6	13.5	97.0	17.0	3.0	1.6	9.8	0.0
8 11	26.2	2.8	32.2	15.6	10.7	3.3	18.9	-10.0	39.5	11.8	87.0	3.0	3.3	1.5	9.8	0.0
8 14	29.5	3.3	36.1	15.6	8.9	3.7	16.1	-7.2	29.6	11.4	87.0	9.0	4.0	2.0	13.4	0.0
8 17	28.6	3.8	35.6	16.1	8.3	4.1	18.9	-9.4	30.6	14.1	87.0	7.0	5.2	2.5	18.0	0.0
8 20	23.6	3.0	29.4	16.1	9.7	4.0	17.8	-6.7	44.2	16.6	90.0	11.0	4.6	2.3	13.4	0.0
8 23	21.2	2.6	28.3	15.6	10.4	3.7	17.8	-6.7	52.8	16.9	100.0	18.0	4.1	2.2	12.3	0.0
9 2	15.1	3.3	22.8	4.4	6.2	5.4	15.6	-10.0	58.3	18.5	100.0	16.0	3.8	2.4	12.3	0.0
9 5	13.6	3.2	20.6	3.3	6.3	5.2	15.0	-9.4	64.1	17.5	100.0	21.0	3.4	2.1	13.9	0.0
9 8	16.6	3.2	23.3	2.8	6.9	5.2	17.8	-11.7	55.5	17.1	100.0	17.0	3.5	2.2	12.9	0.0
9 11	22.3	3.7	31.1	3.3	6.2	5.3	15.6	-16.1	38.0	15.0	93.0	9.0	3.9	2.3	12.3	0.0
9 14	25.7	4.3	33.3	4.4	4.6	5.5	15.6	-15.6	38.7	14.5	93.0	6.0	4.4	2.2	12.9	0.0
9 17	25.1	4.6	35.0	4.4	3.7	6.0	16.1	-17.8	29.0	17.2	93.0	4.0	5.2	2.5	12.9	0.0
9 20	19.6	3.8	30.0	3.9	4.8	6.0	15.6	-16.7	42.0	19.7	96.0	8.0	4.3	2.3	14.9	0.0
9 23	17.0	3.4	25.6	3.9	5.5	5.7	16.1	-9.4	50.2	19.5	100.0	15.0	4.0	2.4	14.4	0.0
10 2	9.2	4.0	19.4	-2.2	-.4	6.1	12.8	-16.1	55.0	20.9	100.0	19.0	3.7	2.2	14.9	0.0
10 5	7.7	4.0	17.8	-2.8	-.4	6.0	12.8	-15.0	59.9	19.9	100.0	15.0	3.5	2.1	14.4	0.0
10 8	10.0	4.2	19.4	-1.1	.3	5.8	13.3	-12.8	54.4	19.5	100.0	19.0	3.5	2.3	15.4	0.0
10 11	16.2	4.7	25.0	1.7	.4	5.7	13.9	-12.2	37.9	17.3	93.0	11.0	4.1	2.6	18.0	0.0
10 14	19.7	5.3	28.9	3.3	-.6	5.9	12.8	-19.4	29.9	18.1	100.0	5.0	4.6	2.8	17.5	0.0
10 17	18.9	5.3	28.9	1.1	-1.3	6.2	12.8	-20.6	30.3	19.0	92.0	6.0	4.8	2.8	17.5	0.0
10 20	13.3	4.2	22.2	-.6	-.6	6.5	13.3	-23.3	43.2	21.3	100.0	6.0	4.2	2.4	15.4	0.0
10 23	11.0	4.1	20.6	-1.1	-.3	6.1	13.9	-17.8	50.0	21.6	100.0	14.0	4.0	2.6	14.4	0.0
11 2	3.2	3.7	12.8	-6.7	-5.1	4.4	8.9	-17.8	57.6	17.6	96.0	16.0	3.2	1.9	14.9	0.0
11 5	1.7	3.7	11.1	-10.0	-5.4	4.3	6.7	-18.3	62.2	17.5	100.0	17.0	3.2	1.8	12.9	0.0
11 8	3.0	3.7	12.8	-7.8	-4.6	4.3	6.7	-17.8	59.8	17.2	100.0	23.0	3.0	1.9	12.3	0.0
11 11	9.3	4.1	18.3	-1.7	-4.3	4.3	7.2	-17.8	40.7	14.6	89.0	11.0	3.5	2.2	11.3	0.0
11 14	13.0	4.8	22.2	1.1	-5.2	4.5	9.4	-21.1	30.8	14.0	89.0	7.0	4.2	2.6	12.9	0.0
11 17	11.5	4.7	21.1	0.0	-5.4	4.7	7.8	-18.9	33.6	16.0	92.0	9.0	4.0	2.5	13.4	0.0
11 20	6.7	3.8	15.6	-3.3	-5.1	4.7	8.9	-16.7	46.0	17.2	100.0	15.0	3.7	2.0	14.4	0.0
11 23	4.7	3.7	12.2	-4.4	-5.0	4.6	9.4	-15.6	52.4	17.5	100.0	15.0	3.5	2.1	14.4	0.0
12 2	-1.9	4.1	11.1	-12.2	-7.9	4.3	7.2	-18.3	65.7	15.6	100.0	29.0	3.7	2.3	12.9	0.0
12 5	-3.0	4.2	10.6	-15.0	-8.1	4.4	6.7	-19.4	69.6	14.9	100.0	22.0	3.5	2.2	15.4	0.0
12 8	-3.0	4.1	10.6	-14.4	-8.0	4.4	6.1	-20.6	70.3	14.7	100.0	33.0	3.4	2.2	15.4	0.0
12 11	3.0	4.5	14.4	-9.4	-7.0	4.4	7.2	-17.8	51.0	16.9	100.0	17.0	4.0	2.8	15.9	0.0
12 14	6.5	5.0	18.9	-5.0	-7.3	4.4	4.4	-17.8	39.8	16.9	96.0	13.0	4.4	3.1	18.5	0.0
12 17	4.9	4.7	15.6	-7.8	-7.7	4.6	5.6	-19.4	43.1	18.1	100.0	16.0	4.0	2.7	16.5	0.0
12 20	1.1	4.2	13.9	-10.6	-7.7	4.5	6.1	-19.4	54.8	17.7	100.0	19.0	3.7	2.2	17.5	0.0
12 23	-.6	4.2	10.0	-12.8	-7.7	4.4	6.7	-20.0	61.0	16.5	100.0	25.0	3.6	2.3	16.5	0.0

ALBUQUERQUE

TABLE A-1. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 2	83.9	.5	85.2	81.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.4	42.9	25.6	38.7
1 5	83.9	.5	85.1	81.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.9	42.9	26.1	38.1
1 8	83.9	.5	85.2	82.2	54.6	28.1	140.6	0.0	162.5	11.7	174.3	151.1	46.2	43.1	29.1	36.0
1 11	84.0	.5	85.3	82.4	481.5	130.4	662.3	41.8	727.6	33.3	778.5	674.0	45.9	42.5	26.9	34.2
1 14	83.7	.5	85.2	81.9	468.7	138.1	663.5	73.2	727.8	33.4	778.5	674.0	49.6	43.3	30.6	35.9
1 17	83.7	.5	85.1	82.0	55.6	28.1	163.8	0.0	162.6	11.7	174.3	151.1	49.5	42.7	30.5	35.8
1 20	83.8	.5	85.1	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.2	42.6	26.2	37.3
1 23	83.9	.5	85.2	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0	41.6	25.3	36.9
2 2	83.8	.5	85.0	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.4	43.3	30.3	41.0
2 5	83.8	.5	84.9	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.3	42.5	32.1	40.9
2 8	83.9	.5	85.1	82.3	120.1	55.5	237.0	7.0	262.7	39.5	325.4	209 2	45.2	43.2	32.4	38.9
2 11	83.9	.5	85.1	82.3	589.4	164.6	898.2	44.2	871.6	43.4	941.2	801.8	47.2	43.6	30.7	36.8
2 14	83.7	.5	84.9	82.4	581.2	165.9	879.6	26.7	871.6	43.4	941.2	801.8	51.2	42.5	34.2	36.4
2 17	83.6	.5	84.9	82.2	118.6	52.3	233.6	0.0	262.7	39.5	325.4	209.2	51.5	44.0	34.3	36.8
2 20	83.7	.5	84.9	82.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.7	43.7	31.5	38.7
2 23	83.8	.5	85.0	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.2	43.0	31.7	39.7
3 2	83.6	.5	84.8	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.2	43.4	31.0	39.5
3 5	83.6	.5	84.8	82.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.2	43.0	30.4	39.3
3 8	83.7	.5	84.9	82.2	229.9	80.8	391.6	11.6	413.4	46.3	499.7	348.6	41.2	42.8	28.4	36.3
3 11	83.7	.5	84.8	82.2	733.5	184.0	1088.8	11.6	1040.6	46.4	1115.5	941.2	48.3	41.4	31.0	34.8
3 14	83.5	.5	84.6	82.2	707.9	195.0	995.8	83.7	1040.6	46.4	1115.5	941.2	54.5	40.5	36.3	34.7
3 17	83.4	.5	84.5	82.2	216.8	81.2	366.0	4.6	413.4	46.3	499.7	348.6	55.9	40.6	39.7	34.9
3 20	83.5	.5	84.6	82.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6	41.6	33.7	38.0
3 23	83.6	.5	84.8	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.1	42.8	31.2	39.2
4 2	83.6	.5	84.9	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.3	39.2	21.3	35.3
4 5	83.6	.5	84.9	82.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.9	40.9	22.6	35.3
4 8	83.7	.5	85.1	82.4	344.1	97.1	483.4	5.8	564.3	37.3	627.5	499.7	35.4	41.3	23.6	34.3
4 11	83.7	.5	85.0	82.3	864.6	183.4	1109.7	116.2	1167.8	28.8	1208.5	1115.5	38.7	40.9	26.4	33.6
4 14	83.5	.5	84.7	82.2	823.6	203.5	1086.5	8.1	1167.8	28.8	1208.5	1115.5	45.9	40.0	33.9	34.4
4 17	83.4	.5	84.5	82.1	315.1	114.5	542.7	11.6	564.3	37.3	627.5	499.7	48.5	41.1	36.7	36.4
4 20	83.5	.5	84.6	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.1	40.4	27.7	35.8
4 23	83.6	.4	84.7	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.9	39.3	21.0	33.3
5 2	83.7	.4	84.9	82.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5	35.9	18.7	31.1
5 5	83.7	.4	84.9	82.7	.1	.5	2.3	0.0	0.0	0.0	0.0	0.0	27.5	36.1	16.9	27.8
5 8	83.9	.4	84.9	82.7	437.8	87.3	579.8	8.1	658.6	16.8	685.6	627.5	28.8	37.8	16.3	27.7
5 11	83.8	.4	84.9	82.8	947.3	175.3	1208.5	122.0	1226.1	8.8	1231.7	1208.5	34.3	40.0	20.2	28.2
5 14	83.6	.4	84.7	82.6	883.4	226.8	1151.5	44.2	1226.1	8.8	1231.7	1208.5	45.0	39.7	31.4	31.0
5 17	83.4	.4	84.7	82.5	379.7	132.2	604.2	16.3	658.6	16.8	685.6	627.5	49.5	39.2	36.6	33.3
5 20	83.5	.4	84.8	82.6	.2	.6	2.3	0.0	0.0	0.0	0.0	0.0	40.6	38.4	29.9	33.1
5 23	83.7	.4	84.9	82.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.9	38.5	24.0	33.0
6 2	83.8	.3	84.6	82.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7	35.0	20.3	31.3
6 5	83.8	.3	84.7	82.8	.6	.9	5.8	0.0	0.0	0.0	0.0	0.0	24.0	33.3	16.6	26.9
6 8	83.9	.3	84.8	82.8	464.0	82.3	633.3	12.8	695.7	5.8	697.2	674.0	22.6	33.5	14.6	25.8
6 11	83.9	.3	84.9	82.7	973.1	144.0	1243.3	210.3	1242.6	2.9	1243.2	1231.7	23.1	34.7	15.6	26.6
6 14	83.7	.3	84.6	82.4	891.5	217.5	1198.0	55.8	1242.6	2.9	1243.2	1231.7	40.8	37.0	31.6	30.7
6 17	83.5	.3	84.5	82.2	386.8	144.6	591.5	8.1	695.7	5.7	697.2	674.0	52.7	37.0	41.4	33.1
6 20	83.6	.3	84.5	82.2	1.0	1.3	7.0	0.0	0.0	0.0	0.0	0.0	47.5	39.3	37.1	34.9
6 23	83.7	.3	84.6	82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.7	38.6	27.6	35.1

ALBUQUERQUE

Table A-1. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 2	84.1	.2	84.7	83.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.4	40.5	41.5	38.5
7 5	84.1	.2	84.7	83.5	.3	.6	4.6	0.0	0.0	0.0	0.0	0.0	47.1	38.1	33.4	33.7
7 8	84.2	.2	84.8	83.7	417.4	91.6	576.4	61.6	678.1	14.0	697.2	662.3	39.5	37.2	25.2	30.6
7 11	84.2	.2	84.7	83.6	916.2	166.4	1199.2	86.0	1229.1	12.4	1243.3	1208.5	33.9	35.2	21.6	27.2
7 14	84.0	.2	84.5	83.3	864.3	217.0	1166.6	72.0	1229.1	12.5	1243.3	1208.5	44.4	31.1	32.6	25.2
7 17	83.8	.2	84.6	83.2	328.6	151.0	585.6	0.0	678.1	14.0	697.2	662.3	68.5	31.3	55.1	30.3
7 20	83.9	.2	84.6	83.2	.5	1.0	5.8	0.0	0.0	0.0	0.0	0.0	69.7	34.2	57.8	33.5
7 23	84.1	.2	84.6	83.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	38.8	51.7	38.8
8 2	84.1	.2	84.7	83.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.2	40.6	35.5	38.2
8 5	84.1	.2	84.7	83.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.1	39.8	30.5	36.4
8 8	84.2	.2	84.8	83.4	351.0	88.5	521.7	29.1	596.4	34.4	639.1	534.5	32.3	37.3	23.9	32.1
8 11	84.2	.2	84.8	83.4	854.0	166.2	1109.7	53.5	1184.7	19.9	1208.5	1138.8	30.2	36.1	20.9	28.6
8 14	84.0	.2	84.7	83.3	811.2	208.6	1052.8	12.8	1185.1	19.8	1208.5	1138.8	41.7	33.1	33.3	27.5
8 17	83.8	.2	84.6	83.1	276.8	128.2	576.4	0.0	596.4	34.4	639.1	534.5	63.3	34.4	50.7	31.0
8 20	84.0	.2	84.7	83.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.1	38.6	50.3	36.1
8 23	84.1	.2	84.7	83.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.6	38.5	48.0	37.8
9 2	84.0	.3	84.7	83.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.1	38.6	24.4	36.2
9 5	84.0	.3	84.8	83.1	1.2	0.0	1.2	1.2	0.0	0.0	0.0	0.0	29.2	38.3	23.3	34.0
9 8	84.1	.3	85.0	83.1	305.6	108.2	1078.3	13.9	512.8	76.3	674.0	429.9	28.9	39.1	22.1	33.6
9 11	84.1	.3	84.9	83.1	783.4	167.3	1029.5	65.1	1094.6	28.9	1138.8	1034.2	29.0	38.2	21.3	31.9
9 14	83.9	.3	84.6	82.8	704.4	199.8	956.3	3.5	1056.3	86.5	1138.8	859.9	36.2	37.5	27.9	31.1
9 17	83.8	.3	84.5	82.7	202.7	114.1	426.5	3.5	468.4	73.4	534.5	139.4	44.4	40.2	35.5	35.4
9 20	83.9	.3	84.6	82.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	41.2	31.0	37.3
9 23	84.0	.3	84.7	83.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.2	39.2	27.4	35.9
10 2	84.0	.5	85.0	82.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.7	40.3	23.6	37.0
10 5	84.0	.5	85.1	82.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.4	40.0	24.0	37.2
10 8	84.1	.5	85.1	82.8	343.5	105.1	500.8	0.0	568.6	53.9	662.3	488.0	35.5	41.5	23.8	35.0
10 11	84.1	.5	85.1	82.7	692.3	176.8	998.2	0.0	998.8	54.5	1080.7	906.4	34.9	40.1	24.0	33.9
10 14	83.9	.5	84.8	82.3	488.5	150.4	720.4	18.6	777.8	47.7	859.9	708.8	40.3	41.0	28.2	34.5
10 17	83.8	.5	84.7	82.3	16.7	13.1	82.5	0.0	0.0	0.0	0.0	0.0	43.0	42.6	31.0	36.3
10 20	83.9	.5	84.8	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.7	42.4	29.0	38.9
10 23	84.0	.5	85.0	82.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.9	39.8	24.1	36.1
11 2	84.0	.5	85.3	82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.1	41.7	26.2	38.1
11 5	84.0	.5	85.3	82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.9	41.0	24.2	37.0
11 8	84.1	.5	85.5	82.5	232.4	83.8	366.0	0.0	418.3	37.1	488.0	371.8	42.8	42.5	28.2	36.5
11 11	84.1	.5	85.5	82.5	551.3	160.6	820.4	37.2	841.3	39.0	906.4	778.5	46.7	42.5	29.1	34.8
11 14	83.8	.5	85.2	82.3	367.9	118.7	590.3	1.2	625.6	40.7	697.2	557.8	49.2	42.2	30.8	34.6
11 17	83.8	.5	85.1	82.5	1.5	2.4	16.3	0.0	0.0	0.0	0.0	0.0	48.0	42.9	32.3	37.5
11 20	83.9	.5	85.1	82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.4	41.5	26.0	37.8
11 23	84.0	.5	85.3	82.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.2	41.6	25.8	38.0
12 2	83.8	.6	85.6	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	43.5	29.4	40.7
12 5	83.8	.6	85.5	81.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.2	42.1	27.7	40.4
12 8	83.9	.6	85.5	81.8	71.8	74.8	306.8	0.0	348.6	0.0	348.6	348.6	46.9	42.6	31.9	37.6
12 11	83.9	.6	85.5	81.9	447.8	136.7	701.8	0.0	697.2	41.6	778.5	674.0	45.9	42.9	31.6	38.2
12 14	83.7	.6	85.4	81.9	397.1	135.0	650.7	0.0	646.2	53.7	697.2	534.5	50.2	42.6	34.4	38.2
12 17	83.7	.6	85.3	82.2	36.8	15.8	82.5	1.2	0.0	0.0	0.0	0.0	51.4	43.5	35.3	38.1
12 20	83.8	.6	85.6	82.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.6	43.7	32.3	40.6
12 23	83.8	.6	85.6	82.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.2	42.6	30.5	39.9

ALBUQUERQUE

TABLE A-2. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR ALBUQUERQUE, NEW MEXICO

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 2	4		3	1			6	2							
1 5	4		1				9	1						1	
1 8	5		2		1		5	1							
1 11	6		1				7	1							
1 14	3		3	1			7	1						1	
1 17	3		3	1			7								
1 20	3		3				4								
1 23	2		2				5								
2 2	3		2				9	2							
2 5	4		4				7	1							
2 8	12	1	2	1			10								
2 11	6		1	1			7								
2 14	2		2				5	2							
2 17			2	1			3	3						1	
2 20			1	1			3	2						1	
2 23			5	1			5	1						1	
3 2	3		5	3			8	1							
3 5	5		3	2			6	2			1				
3 8	6		2				6	3							
3 11			1	3	1		4	2			1				
3 14				4	1		1	2			1			1	
3 17	2			2			2	1						2	
3 20	2		4	2			5	1						2	
3 23	2		2	1			6	1							
4 2	1		1	2							1				
4 5	1		2	4			2								
4 8	4		1	3			2	1							
4 11	2			2	1		2	1						1	
4 14	1			6			3							8	1
4 17	1			7	2									5	2
4 20			1	3											
4 23	1		1												
5 2			1	3											
5 5			1	3											
5 8			1	2										1	
5 11			2	2	1									1	
5 14				7	1									5	
5 17				11	5										
5 20				7	1										
5 23				7	1									1	
6 2				7											
6 5			2	3											
6 8			2	1											
6 11			2	1											
6 14			1	9	6									2	
6 17				18	12										
6 20			2	9	7									1	
6 23			1	9	3										

ALBUQUERQUE

TABLE A-2. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 2			2	12	2									1	
7 5	1		1	5	3										
7 8	1			5	1										
7 11				4	1										
7 14			1	6	6										
7 17		1	1	23	17										
7 20				27	18										
7 23				22	11										
8 2			2	15	4										
8 5				8											
8 8				5											
8 11			1	2											
8 14	1			11	10										
8 17			1	15	19										
8 20				26	14										
8 23			1	22	11										
9 2			2	9	4										
9 5	2		1	7	3										
9 8	1		3	3	1										
9 11			2	6											
9 14	1		3	5	3										
9 17			3	15	6										
9 20			3	13	5										
9 23	1		2	11	3										
10 2	1		3	7											
10 5	1		4	6	1										
10 8	6		5	5		1									
10 11	3		5	4	1	1									
10 14	2		1	9	1		1								
10 17	1		2	11	5	1	1							1	
10 20			6	13											
10 23	2		8	6	1										
11 2	2		1			1	2								
11 5	3		2	1		2	2								
11 7	4		2	2		3	1								
11 11				3			1								
11 14			2	6			1								
11 17			3	3			2				1				
11 20	1		3	5		1	2								
11 23	2	1	5	1		1	2				1				
12 2	10		5	1		12	1								
12 5	10		4	1		10	1			1					
12 8	13	1	5	1		8	2								
12 11	6		5			8							1		
12 14	7		3	1		5	2								
12 17	5		2	1		5	2								
12 20	5		2	2		9	1								
12 23	7		3	3		8	1								

ALBUQUERQUE

TABLE A-3. DESCRIPTIVE CLIMATIC STATISTICS FOR BISMARCK, NORTH DAKOTA AT 3-HOURLY INTERVALS BY MONTH FOR YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 0	-15.2	9.6	4.4	-38.3	-18.7	10.2	.6	-40.0	73.2	10.9	96.0	52.0	4.0	2.8	12.9	0.0
1 3	-15.7	9.3	4.4	-37.2	-19.3	10.1	.6	-40.6	73.3	10.7	100.0	48.0	3.8	2.8	11.3	0.0
1 6	-16.1	9.4	5.0	-37.8	-19.8	10.0	1.1	-40.6	73.1	11.0	100.0	47.0	4.2	3.0	16.5	0.0
1 9	-16.2	9.4	3.9	-38.3	-20.0	10.1	.6	-41.1	72.0	11.1	100.0	48.0	4.2	2.8	12.3	0.0
1 12	-12.9	8.8	5.6	-30.0	-17.4	9.6	1.7	-36.7	67.5	10.7	100.0	47.0	5.0	2.9	12.9	0.0
1 15	-10.9	8.9	7.2	-29.4	-16.0	9.4	2.8	-35.0	65.8	10.0	96.0	40.0	5.3	2.8	12.9	0.0
1 18	-12.4	9.0	5.6	-30.0	-16.7	9.8	1.7	-37.2	69.6	10.6	96.0	45.0	4.5	2.6	12.3	0.0
1 21	-14.3	9.4	4.4	-36.1	-18.0	10.1	1.1	-38.3	72.6	11.3	100.0	47.0	4.1	2.8	13.4	0.0
2 0	-10.9	8.3	5.6	-32.2	-14.3	8.9	1.1	-36.1	75.2	11.7	100.0	9.0	4.1	3.0	15.4	0.0
2 3	-11.9	8.5	6.7	-34.4	-15.3	9.0	.6	-37.8	75.3	11.0	100.0	51.0	3.8	3.1	20.6	0.0
2 6	-12.9	8.8	3.9	-38.3	-16.3	9.5	1.1	-41.1	74.6	11.2	100.0	45.0	3.9	2.9	19.5	0.0
2 9	-12.1	8.3	3.9	-31.7	-15.7	9.0	0.0	-37.8	73.6	11.5	100.0	49.0	3.9	2.9	15.4	0.0
2 12	-8.1	8.0	7.8	-27.2	-13.1	8.6	1.7	-34.4	67.4	11.1	96.0	41.0	5.1	3.0	14.4	0.0
2 15	-5.9	7.8	13.3	-24.4	-11.4	8.0	1.7	-31.1	64.8	10.8	92.0	36.0	5.7	2.7	14.4	0.0
2 18	-7.0	7.7	10.0	-24.4	-11.9	8.2	2.8	-31.1	68.8	10.5	100.0	35.0	4.9	2.6	14.4	0.0
2 21	-9.9	8.0	5.0	-28.9	-13.4	8.5	1.1	-32.8	75.0	10.8	96.0	37.0	4.1	2.9	15.4	0.0
3 0	-4.5	7.1	10.6	-27.8	-8.2	7.0	3.9	-32.2	75.7	10.6	100.0	40.0	3.9	2.9	14.4	0.0
3 3	-5.5	7.2	10.6	-30.0	-8.9	7.4	3.9	-34.4	76.7	10.2	96.0	44.0	3.8	2.8	17.5	0.0
3 6	-6.2	7.4	11.7	-28.9	-9.1	7.3	3.9	-29.4	77.5	10.0	96.0	40.0	4.0	2.9	15.4	0.0
3 9	-4.4	7.3	11.7	-25.0	-8.6	7.5	3.9	-30.0	72.7	10.9	96.0	37.0	4.6	3.0	15.9	0.0
3 12	-.4	7.6	21.1	-18.3	-7.3	6.7	3.9	-26.7	61.3	14.0	96.0	26.0	5.9	3.0	17.0	0.0
3 15	1.7	7.9	26.1	-16.7	-6.6	6.2	5.0	-25.0	57.0	16.4	96.0	15.0	6.4	3.0	17.0	0.0
3 18	.9	7.7	23.9	-18.3	-6.6	6.4	5.6	-25.6	59.6	16.2	96.0	16.0	5.8	2.7	17.0	0.0
3 21	-2.9	7.0	15.0	-25.6	-7.2	6.5	5.0	-30.0	72.3	11.3	96.0	38.0	4.2	2.9	14.4	0.0
4 0	3.0	4.6	16.7	-10.6	-1.8	4.7	10.6	-18.9	72.9	14.8	100.0	30.0	4.4	2.8	12.9	0.0
4 3	1.7	4.6	14.4	-11.1	-2.2	4.7	11.1	-17.2	76.8	13.0	100.0	40.0	4.1	2.9	11.8	0.0
4 6	.8	4.4	13.3	-12.2	-2.7	4.7	11.7	-17.2	78.9	11.9	100.0	36.0	4.1	2.9	14.9	0.0
4 9	4.4	4.7	19.4	-10.0	-1.6	4.7	11.7	-16.1	67.2	16.4	100.0	25.0	5.6	2.9	15.4	0.0
4 12	8.3	6.2	27.2	-5.0	-1.7	5.0	13.3	-18.9	54.1	20.6	100.0	17.0	6.6	2.7	14.4	0.0
4 15	10.1	6.7	29.4	-3.3	-1.6	5.3	15.6	-15.0	49.5	22.1	100.0	9.0	6.7	2.7	15.4	0.0
4 18	9.5	6.5	28.9	-2.8	-1.8	5.4	16.7	-16.7	50.9	22.8	100.0	12.0	6.2	2.6	14.4	0.0
4 21	5.1	4.9	18.3	-5.6	-1.3	4.8	15.6	-13.9	66.2	17.3	100.0	24.0	4.6	2.8	17.0	0.0
5 0	8.6	4.9	25.6	-6.1	3.5	4.9	17.8	-9.4	72.2	14.9	100.0	38.0	3.8	2.8	12.9	0.0
5 3	7.0	4.9	21.7	-8.3	2.9	4.9	16.7	-11.1	76.8	14.3	100.0	38.0	3.6	2.7	12.3	0.0
5 6	6.3	4.7	20.6	-8.9	2.7	4.9	16.1	-11.7	79.0	12.5	100.0	41.0	3.9	2.8	11.8	0.0
5 9	11.6	5.3	25.6	-5.6	4.2	5.0	19.4	-12.2	62.9	17.0	100.0	26.0	5.6	2.9	14.4	0.0
5 12	15.6	6.5	30.6	-4.4	3.9	5.4	18.9	-8.9	49.9	20.5	100.0	17.0	6.5	2.8	12.9	0.0
5 15	17.4	6.8	33.3	-2.2	3.6	5.7	20.0	-13.3	44.5	21.1	100.0	10.0	6.7	2.9	14.4	0.0
5 18	16.9	6.4	34.4	-1.1	3.6	5.7	18.3	-12.2	45.9	21.2	100.0	9.0	6.5	2.8	14.4	0.0
5 21	11.7	5.1	25.0	-4.4	3.9	5.1	16.1	-8.9	61.9	17.6	100.0	22.0	4.2	2.5	12.3	0.0
6 0	14.2	3.9	27.2	3.3	10.5	4.0	19.4	-4.4	79.3	12.7	100.0	36.0	3.2	2.4	11.3	0.0
6 3	12.5	4.0	23.9	1.1	9.7	4.1	19.4	-7.2	84.2	11.1	100.0	34.0	3.1	2.4	10.3	0.0
6 6	12.3	3.8	23.9	1.1	9.7	3.9	19.4	-5.6	85.2	10.9	100.0	44.0	3.3	2.5	10.3	0.0
6 9	17.7	4.0	28.3	5.0	11.2	3.9	20.6	-5.6	67.3	14.5	100.0	31.0	4.7	2.5	11.3	0.0
6 12	21.4	4.8	32.8	8.3	11.0	4.5	22.8	-3.3	54.3	17.4	97.0	19.0	5.8	2.5	12.3	0.0
6 15	23.0	5.1	35.0	10.6	10.5	4.7	21.1	-3.3	48.5	18.1	97.0	16.0	6.1	2.4	14.4	0.0
6 18	22.3	4.8	33.3	10.6	10.5	4.8	21.1	-3.3	50.2	18.0	97.0	18.0	5.6	2.4	13.9	0.0
6 21	17.5	3.8	28.3	8.9	11.1	4.2	20.6	-4.4	67.7	14.8	100.0	28.0	3.7	2.1	12.9	0.0

BISMARCK

TABLE A-3. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 0	17.1	4.0	27.8	5.5	12.6	3.9	21.1	2.2	76.0	13.6	100.0	38.0	2.9	2.4	14.4	0.0
7 3	15.1	4.1	25.6	3.3	11.9	3.8	20.0	1.1	82.3	11.9	100.0	45.0	2.7	2.3	10.3	0.0
7 6	14.4	3.9	23.9	2.2	11.7	3.8	20.0	.6	85.0	9.8	100.0	46.0	2.7	2.1	10.3	0.0
7 9	21.1	3.2	30.0	11.1	13.3	3.8	22.8	1.7	62.4	12.9	97.0	28.0	4.3	2.3	11.8	0.0
7 12	25.7	4.2	37.2	12.2	12.7	4.5	23.9	1.1	46.5	14.5	97.0	17.0	5.5	2.3	11.3	0.0
7 15	27.7	4.6	42.2	12.8	12.1	4.8	24.4	.6	40.8	15.5	100.0	11.0	5.7	2.5	12.9	0.0
7 18	26.8	4.5	38.3	12.2	12.0	4.8	25.0	-1.1	42.5	16.2	100.0	12.0	5.5	2.3	15.4	0.0
7 21	20.7	3.5	29.4	10.0	13.0	4.2	21.1	-.6	63.2	15.0	100.0	21.0	3.5	1.9	11.3	0.0
8 0	16.7	4.7	28.3	6.1	11.2	3.9	20.6	1.7	72.1	15.2	100.0	30.0	3.2	2.4	11.3	0.0
8 3	14.5	4.7	29.4	4.4	10.7	4.0	20.6	2.2	79.3	13.4	100.0	29.0	2.9	2.3	12.3	0.0
8 6	13.2	4.5	26.1	2.8	10.4	4.1	20.0	.6	84.5	11.4	100.0	38.0	3.0	2.1	11.3	0.0
8 9	19.7	4.0	28.3	10.0	12.2	3.9	21.1	1.7	63.4	12.7	100.0	33.0	4.3	2.5	13.9	0.0
8 12	25.2	5.1	35.6	12.2	11.5	4.3	20.6	.6	44.4	13.9	100.0	15.0	5.5	2.4	13.4	0.0
8 15	27.4	5.8	40.0	11.7	10.4	4.3	20.6	-.6	37.5	16.2	100.0	9.0	5.7	2.4	12.9	0.0
8 18	26.6	5.4	38.3	11.7	10.1	4.4	20.6	-1.1	38.3	15.4	97.0	11.0	5.3	2.3	13.9	0.0
8 21	19.7	4.6	30.6	8.9	11.2	4.0	21.1	.6	60.4	15.9	100.0	23.0	3.5	2.1	15.4	0.0
9 0	10.5	5.4	25.0	-4.4	5.5	4.9	17.8	-7.8	73.6	16.1	100.0	34.0	3.4	2.6	11.3	0.0
9 3	8.8	5.1	22.8	-7.8	5.2	4.9	17.8	-9.4	79.6	13.3	100.0	41.0	3.1	2.5	11.8	0.0
9 6	7.8	5.2	21.7	-8.9	4.8	5.0	18.3	-10.0	82.6	12.0	100.0	39.0	3.2	2.4	11.8	0.0
9 9	12.2	5.2	27.8	-3.9	6.5	4.7	18.3	-6.7	70.0	14.9	100.0	30.0	4.4	2.7	17.5	0.0
9 12	17.8	6.4	32.8	1.1	6.1	5.3	19.4	-9.4	49.4	17.9	100.0	14.0	5.7	2.7	14.4	0.0
9 15	20.1	7.2	36.7	1.1	5.3	5.4	18.3	-9.4	41.9	19.3	100.0	8.0	6.1	2.7	13.9	0.0
9 18	18.6	6.8	36.1	1.7	5.4	5.2	18.9	-7.8	45.8	19.5	100.0	16.0	5.3	2.6	17.5	0.0
9 21	12.7	5.5	26.7	-1.7	5.9	4.8	17.2	-7.8	65.8	16.8	100.0	31.0	3.6	2.5	12.9	0.0
10 0	4.5	4.7	16.7	-7.8	-.2	4.8	12.2	-17.8	73.3	14.9	100.0	25.0	3.6	2.8	12.9	0.0
10 3	3.2	4.6	13.3	-9.4	-.7	4.6	12.2	-13.3	77.6	13.7	100.0	32.0	3.5	2.7	11.3	0.0
10 6	2.5	4.5	12.8	-11.7	-1.0	4.6	11.1	-15.6	79.0	13.1	100.0	36.0	3.7	2.8	12.9	0.0
10 9	5.3	4.4	17.8	-6.7	.4	4.4	15.6	-13.3	72.0	14.5	100.0	30.0	4.3	2.8	13.9	0.0
10 12	11.1	5.9	26.1	-4.4	.5	4.8	15.6	-15.6	51.4	18.3	100.0	22.0	6.1	2.9	14.4	0.0
10 15	13.4	6.9	30.0	-2.8	-.2	4.9	13.9	-16.1	43.8	19.9	100.0	11.0	6.5	2.9	16.5	0.0
10 18	10.4	6.0	25.6	-5.0	-.0	4.8	12.8	-14.4	52.1	19.4	100.0	16.0	4.7	2.4	13.9	0.0
10 21	6.2	4.9	20.6	-7.2	-.1	4.7	12.2	-17.2	66.5	16.4	100.0	22.0	3.7	2.6	12.3	0.0
11 0	-3.5	5.0	9.4	-19.4	-6.6	4.9	3.9	-22.2	79.8	11.9	100.0	40.0	3.5	2.5	11.3	0.0
11 3	-4.2	5.1	12.8	-19.4	-7.2	5.2	3.3	-22.2	81.1	11.2	100.0	35.0	3.5	2.6	15.4	0.0
11 6	-4.8	5.2	7.2	-21.1	-7.4	5.2	4.4	-24.4	82.4	10.0	100.0	52.0	3.5	2.7	13.4	0.0
11 9	-3.8	5.0	8.3	-20.0	-6.7	5.2	2.2	-27.2	80.9	10.7	100.0	47.0	3.9	2.9	13.9	0.0
11 12	.5	5.5	16.1	-16.1	-5.4	4.9	4.4	-23.3	66.8	14.7	100.0	28.0	5.3	2.9	16.5	0.0
11 15	2.4	6.4	22.8	-15.6	-5.4	4.8	5.6	-21.7	59.6	17.2	100.0	19.0	5.5	2.8	14.4	0.0
11 18	-.6	5.3	12.2	-15.6	-5.7	4.8	4.4	-21.1	70.4	15.0	100.0	28.0	4.0	2.5	13.9	0.0
11 21	-2.7	5.1	12.2	-16.9	-6.3	4.9	3.9	-21.7	77.2	12.7	100.0	37.0	3.7	2.6	12.9	0.0
12 0	-10.6	7.5	6.1	-32.2	-13.4	7.7	.6	-36.7	78.3	11.1	100.0	45.0	3.4	2.7	15.4	0.0
12 3	-11.1	7.4	5.0	-35.0	-14.1	7.8	0.0	-36.1	78.2	10.7	100.0	48.0	3.6	2.7	13.4	0.0
12 6	-11.6	7.5	5.6	-40.6	-14.3	7.8	1.7	-35.6	78.4	10.4	100.0	48.0	3.5	2.6	11.3	0.0
12 9	-10.9	7.3	3.9	-32.8	-14.0	8.0	0.0	-44.4	77.8	10.4	100.0	44.0	3.9	2.8	12.9	0.0
12 12	-7.5	7.7	14.4	-29.4	-12.0	7.3	0.0	-34.4	70.6	12.7	100.0	28.0	4.9	2.8	15.4	0.0
12 15	-5.6	7.9	16.7	-27.2	-11.0	7.1	1.7	-33.3	66.4	13.9	96.0	17.0	5.3	2.8	14.4	0.0
12 18	-8.0	7.3	8.9	-28.9	-12.0	7.3	1.1	-34.4	73.8	11.4	96.0	29.0	4.0	2.7	12.9	0.0
12 21	-9.9	7.5	6.1	-30.0	-13.1	7.7	-.6	-36.1	77.7	10.8	100.0	36.0	3.6	2.7	14.4	0.0

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TABLE A-3. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 0	95.7	1.0	97.9	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.5	42.0	47.2	41.9
1 3	95.7	1.0	98.0	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.7	41.5	41.9	42.5
1 6	95.7	.9	98.1	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.2	42.0	57.6	43.1
1 9	95.7	1.0	98.2	93.4	86.4	43.7	227.8	5.8	190.8	38.1	255.6	151.1	72.3	36.5	59.2	39.2
1 12	95.8	1.0	98.3	93.1	331.8	116.3	588.0	81.3	539.0	44.8	615.9	488.0	71.8	37.9	55.8	40.1
1 15	95.6	.9	98.0	92.2	197.0	71.9	380.0	26.7	357.6	35.8	418.3	302.1	71.2	36.0	55.3	39.0
1 18	95.7	.9	97.9	92.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.2	39.5	55.2	40.7
1 21	95.7	.9	97.9	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.5	40.8	52.5	42.4
2 0	95.7	.8	97.9	93.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.4	42.9	54.0	44.1
2 3	95.7	.9	97.9	93.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.0	43.2	55.2	44.6
2 6	95.7	.9	97.9	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.0	42.1	56.8	44.1
2 9	95.8	.9	97.9	93.4	184.9	75.4	374.2	24.4	354.0	66.8	1022.6	278.9	70.4	37.6	58.9	39.4
2 12	95.8	.9	97.9	93.4	483.0	148.4	1045.8	66.2	712.1	68.6	813.4	23.2	69.3	37.9	54.3	40.1
2 15	95.7	.8	97.8	93.4	323.5	106.7	545.0	56.9	521.2	54.4	627.5	441.6	68.2	38.7	53.2	39.7
2 18	95.7	.8	97.8	93.2	3.9	3.8	26.7	0.0	0.0	0.0	0.0	0.0	64.0	41.4	49.4	41.3
2 21	95.7	.8	97.9	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.2	42.2	49.1	43.4
3 0	95.6	.8	98.1	92.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.7	43.2	48.5	43.9
3 3	95.6	.8	98.0	92.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.7	42.7	50.9	43.8
3 6	95.6	.9	98.0	92.6	2.6	2.8	13.9	0.0	0.0	0.0	0.0	0.0	63.9	40.6	55.5	43.5
3 9	95.7	.9	100.5	92.7	305.0	139.1	550.8	19.8	554.0	66.1	662.3	441.6	69.9	37.9	56.3	40.4
3 12	95.6	.9	98.0	92.9	588.4	234.8	1004.0	39.5	921.0	63.3	1022.6	813.4	71.6	35.5	54.8	39.7
3 15	95.5	.8	98.1	93.0	421.4	176.8	785.5	43.0	729.1	56.5	813.4	627.5	71.6	35.3	57.3	38.7
3 18	95.5	.8	98.0	93.0	38.4	29.7	148.7	0.0	160.4	22.0	185.9	116.2	67.1	38.3	54.5	40.4
3 21	95.6	.8	98.1	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.3	42.0	50.3	43.1
4 0	95.4	.7	97.4	93.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.1	42.5	52.8	44.2
4 3	95.4	.8	97.4	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.7	43.2	53.5	44.6
4 6	95.4	.8	97.4	93.0	21.9	18.8	91.8	0.0	0.0	139.4	0.0	0.0	65.7	41.3	56.9	42.7
4 9	95.5	.8	97.4	93.2	374.3	201.8	671.6	5.8	737.4	44.1	813.4	662.3	65.4	41.2	56.8	42.9
4 12	95.4	.8	97.3	93.1	598.9	309.3	1035.3	33.7	1093.1	39.9	1162.0	1022.6	70.6	38.0	59.7	41.5
4 15	95.3	.7	97.2	93.0	454.8	251.5	836.6	27.9	907.9	44.8	976.1	836.6	73.4	36.2	62.5	40.0
4 18	95.3	.7	97.2	93.0	108.8	67.6	269.6	0.0	295.1	53.8	383.5	185.9	74.2	35.3	60.2	39.0
4 21	95.4	.7	97.4	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.9	38.5	56.9	41.1
5 0	95.4	.7	97.2	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.2	41.9	44.9	43.0
5 3	95.4	.7	97.2	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.5	41.9	48.1	43.9
5 6	95.4	.7	97.3	93.1	76.9	43.1	176.6	0.0	210.3	42.5	267.3	139.4	66.6	38.1	50.5	40.5
5 9	95.5	.7	97.3	93.5	471.8	222.0	765.8	10.5	855.8	23.6	883.1	801.8	65.8	38.3	50.5	40.0
5 12	95.4	.7	97.3	93.4	720.8	298.6	1153.9	50.0	1193.6	19.4	1220.1	1150.4	69.4	34.4	53.3	38.3
5 15	95.3	.7	97.0	93.1	581.6	256.4	937.7	20.9	1021.6	21.9	1057.4	976.1	71.7	33.1	56.4	36.4
5 18	95.3	.7	97.0	92.9	196.5	95.5	356.7	2.3	432.4	33.4	476.4	371.8	68.6	35.0	53.3	36.8
5 21	95.4	.7	97.1	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.3	38.2	47.3	39.2
6 0	95.3	.7	100.9	92.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.0	40.1	43.7	40.3
6 3	95.3	.6	96.8	92.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.8	40.8	43.0	41.8
6 6	95.3	.6	96.9	92.4	105.1	53.4	213.8	0.0	276.6	4.7	278.9	267.3	63.9	39.5	50.5	40.0
6 9	95.3	.6	96.9	92.6	528.7	212.7	836.6	34.9	904.8	5.8	906.4	883.1	58.5	39.0	46.3	38.6
6 12	95.3	.6	96.8	92.6	754.0	271.8	1098.1	70.9	1225.1	7.2	1231.7	1298.5	62.9	37.3	51.1	37.8
6 15	95.2	.6	96.7	92.3	628.7	243.6	1036.5	12.8	1066.7	4.7	1069.0	1057.4	67.3	33.9	55.4	35.0
6 18	95.2	.6	96.5	92.2	230.3	104.6	405.5	10.5	495.0	9.3	499.7	476.4	61.9	36.6	50.6	36.9
6 21	95.2	.6	96.5	92.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.8	36.2	48.1	36.3

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TABLE A-3. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 0	95.5	.5	97.0	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.1	36.4	25.5	33.8
7 3	95.5	.5	97.1	93.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.5	38.4	27.5	36.9
7 6	95.6	.5	97.1	94.1	102.4	43.1	180.1	0.0	250.4	25.6	278.9	185.9	50.6	39.3	36.5	37.2
7 9	95.6	.5	97.2	94.1	561.2	127.0	768.1	3.5	880.9	21.6	906.4	848.3	46.1	38.2	35.6	35.5
7 12	95.6	.5	97.1	93.9	807.3	234.3	1117.8	15.1	1207.0	12.1	1220.1	1185.2	47.9	36.6	36.8	34.1
7 15	95.5	.5	96.9	93.8	672.8	203.0	907.5	4.6	1041.7	18.6	1069.0	1010.9	49.5	33.9	40.5	32.2
7 18	95.4	.5	96.8	93.8	237.2	85.1	418.3	1.2	466.3	22.5	499.7	418.3	46.1	35.4	34.6	32.6
7 21	95.5	.5	96.9	93.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.8	36.6	34.8	32.7
8 0	95.5	.5	97.1	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.4	38.3	25.0	36.0
8 3	95.5	.5	97.1	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.2	40.2	26.6	37.3
8 6	95.5	.5	97.2	94.0	46.9	27.6	119.7	0.0	161.0	18.6	185.9	139.4	46.1	38.6	33.3	35.5
8 9	95.6	.5	97.3	93.9	487.6	159.3	685.6	37.2	781.1	39.0	836.6	708.8	46.1	39.2	34.0	35.4
8 12	95.5	.5	97.3	93.7	757.4	223.1	1101.6	25.6	1126.8	33.3	1173.6	1069.0	47.4	38.5	34.6	35.1
8 15	95.4	.5	97.1	93.7	594.9	194.0	878.5	19.8	949.1	41.3	1010.9	871.5	49.6	37.9	38.7	34.5
8 18	95.4	.5	97.0	93.9	185.4	69.6	299.8	1.2	355.0	43.2	418.3	267.3	46.8	38.2	34.1	33.8
8 21	95.5	.5	97.1	94.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.2	37.1	29.6	33.1
9 0	95.6	.7	97.3	93.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.2	41.9	36.6	41.4
9 3	95.6	.7	97.3	94.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.6	43.0	38.2	42.9
9 6	95.6	.7	97.2	93.2	5.8	6.8	31.4	0.0	0.0	0.0	0.0	0.0	53.2	42.7	44.2	42.2
9 9	95.6	.7	97.2	93.6	344.7	149.8	596.1	20.9	624.1	54.1	708.0	522.9	55.2	40.8	45.5	40.7
9 12	95.6	.7	97.2	93.6	601.7	227.2	954.0	50.0	981.6	52.3	1069.0	984.7	56.8	40.9	46.2	40.2
9 15	95.4	.7	97.2	93.5	457.8	179.2	726.3	39.5	791.7	50.8	871.5	697.2	57.6	39.2	46.6	38.9
9 18	95.4	.7	97.2	93.7	65.0	39.2	182.4	2.3	196.5	47.1	267.3	116.2	56.1	40.1	42.8	39.0
9 21	95.5	.7	97.3	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.4	40.0	38.4	39.8
10 0	95.5	.8	97.6	93.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.8	43.2	38.5	43.1
10 3	95.5	.8	97.6	93.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.1	43.4	40.7	43.5
10 6	95.5	.8	97.5	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.9	42.8	42.5	43.4
10 9	95.6	.8	97.5	93.2	208.3	105.9	426.5	2.3	415.3	63.3	522.9	313.7	61.6	40.4	49.1	41.2
10 12	95.6	.8	97.5	92.9	449.2	200.9	800.6	24.4	784.2	60.9	894.7	685.6	61.7	41.3	47.6	42.2
10 15	95.4	.8	97.4	92.9	313.4	149.1	563.6	19.8	592.2	66.2	697.2	476.4	62.7	39.4	48.1	40.7
10 18	95.5	.8	97.2	93.3	8.2	9.5	46.5	0.0	0.0	0.0	0.0	0.0	63.1	40.7	48.6	40.8
10 21	95.5	.8	97.4	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.6	40.6	43.0	42.0
11 0	95.6	.8	97.6	93.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.3	42.5	51.7	43.9
11 3	95.6	.8	97.6	92.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.3	42.6	53.5	44.0
11 6	95.6	.8	97.6	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.6	41.8	56.1	44.1
11 9	95.7	.8	97.6	93.3	89.8	60.1	280.0	0.0	239.8	47.4	325.4	174.3	73.9	36.4	63.2	39.6
11 12	95.7	.8	97.5	93.1	298.0	137.3	604.2	29.1	586.4	51.7	674.0	511.3	73.6	36.6	61.9	39.5
11 15	95.5	.8	97.4	93.0	185.5	89.8	420.6	17.4	406.7	44.1	488.0	348.6	69.8	38.5	57.3	39.7
11 18	95.6	.8	97.5	93.1	.5	1.0	2.3	0.0	0.0	0.0	0.0	0.0	68.0	39.2	56.8	41.9
11 21	95.6	.8	97.5	92.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.6	40.6	55.7	43.7
12 0	95.6	.8	97.6	92.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.5	43.1	54.5	44.1
12 3	95.6	.8	97.6	92.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.1	42.8	53.5	45.0
12 6	95.5	.8	97.7	92.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.2	42.7	55.3	44.4
12 9	95.6	.8	97.8	91.9	55.3	31.3	147.6	2.3	151.1	0.0	151.1	151.1	70.9	38.6	60.0	41.6
12 12	95.6	.8	97.8	91.7	264.1	102.8	450.9	26.7	480.5	16.1	511.3	464.8	71.5	38.6	58.6	41.8
12 15	95.5	.8	97.7	91.6	150.8	63.4	271.9	16.3	308.1	10.2	325.4	302.1	68.1	39.8	54.7	41.6
12 18	95.5	.8	97.7	91.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.3	40.2	53.1	42.3
12 21	95.6	.8	97.7	92.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.4	41.6	56.5	43.5

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TABLE A-4. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR BISMARCK, NORTH DAKOTA

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 0	10						67		1		9				
1 3	10		1				76		1		10				
1 6	6						81	2	3	1	15				
1 9	12		1				75	1	2		11				1
1 12	14						76	3	4	3	9				
1 15	10						71		1	1	1				
1 18	8						56	1	1	1	3		1		1
1 21	3						80		1	1	7		2		1
2 0	15			1			71	4		1	6				
2 3	16	1					78		1	1	11				
2 6	18	1	1				83				8				
2 9	33	1					72	1	1	1	2				
2 12	16		1	1			69	2			2			1	
2 15	12		1				43		1						
2 18	14		1				45	3	2						
2 21	11		1	1			64	4	1	1	3				
3 0	21	3	1				50	3			1				
3 3	28	5	2				50		1	1	2		1		
3 6	30	5	2	1			60		3	1	2		1		
3 9	34	4	3	2			55	2	3				1		3
3 12	16	2	5	1			40	5	1		1				4
3 15	7		7	1			33	14	1						2
3 18	12		5	1			32	7	2		1			1	1
3 21	16	2	3	1			38	10	1						2
4 0	20	4	14	8			23	6			1				3
4 3	25	5	18	7	1		23	3							2
4 6	36	8	17	2	1		26	2	1	1					1
4 9	30	8	13	7	1		31	4	1				1		1
4 12	21	9	10	9			17	4		1			1		1
4 15	19	8	18	10	2		16	5					1	1	
4 18	19	4	22	9	2		18	2		1			1		
4 21	18	4	18	8	2		24	3						2	
5 0	8	3	12	11	2		4	1							
5 3	12	6	14	9	1		5	1						1	
5 6	20	3	16	17			4						1		
5 9	13	6	15	14	1		6								
5 12	8	1	23	14	2		4	1					1	1	
5 15	7	2	19	20	4		2	1					1	1	
5 18	8	3	14	18	3		2	2					1	2	
5 21	6	2	14	13	4		3	2							
6 0	3	2	7	11	11										
6 3	8	1	13	14	10										
6 6	22	4	10	16	6										1
6 9	6	4	11	14	2										1
6 12	1		9	13	3										
6 15	1		6	15	8										
6 18	1		5	18	8										
6 21	1	1	7	22	11									1	

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TABLE A-4. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 0				11	7										
7 3	5	1	1	15	9										
7 6	14	1	5	9	6										
7 9	4		1	8	1										1
7 12	1		1	5	3										
7 15			2	12	2										
7 18		2	1	14	6										
7 21				10	11										
8 0	2	2	3	10	8										
8 3	5		6	9	7										
8 6	15	2	6	10	3										1
8 9	8	2	4	5											3
8 12	1	2	5	2	2										1
8 15	1	1	4	9	2							1			2
8 18	1	1	4	13	6										1
8 21	2	1	2	12	6										
9 0	6	3	4	9	3		1								1
9 3	8	5	9	8	2		1								
9 6	12	4	12	15	3		2								
9 9	12	6	9	12	4		1	1						1	
9 12	6	3	8	7	1		3								
9 15	3	1	12	10			1	1							
9 18	4	1	7	7	1		1								
9 21	2	1	7	9	2		2								
10 0	8	3	11	7	1		8	1							
10 3	9	3	9	4	1		7	2	1						
10 6	18		11	5			7	3							
10 9	23	5	9	1			7	1							
10 12	10	2	7	4			4	2							1
10 15	8	3	10	7			3	3							
10 18	10	2	15	4			4	4							
10 21	7	3	12	2			9	5							
11 0	17	3	3	1			35	8	3		1				
11 3	18	2	4	2			44	3	2						
11 6	24	2	1	2			37	3	1		1				
11 9	31		2	2			40	2	2		2		1		
11 12	18	1	3	1			32	9	1	2	3		1		
11 15	9	1	4				29	3	1						1
11 18	8			1			29	6							1
11 21	13	2		1			40	2	1						
12 0	23			1			73		1	1	7				
12 3	23						78		1	2	8				
12 6	29						81		1		12				
12 9	35			1			73		2	1	3		1		
12 12	26						76	2	1	1	3				1
12 15	18		1				68	1					1		
12 18	12						67	1		2					
12 21	11		1				76	2	1	2	1				

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TABLE A-5. DESCRIPTIVE ENVIRONMENTAL STATISTICS FOR BOSTON, MASSACHUSETTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 1	-2.8	6.0	14.4	-20.0	-8.7	8.1	12.8	-31.7	65.4	17.3	100.0	29.0	6.0	2.6	17.5	1.0
1 4	-3.3	6.2	11.1	-20.0	-8.8	8.1	11.1	-30.6	66.2	16.8	100.0	30.0	6.0	2.5	14.4	1.0
1 7	-3.6	6.4	14.4	-20.0	-9.1	8.3	13.3	-30.6	66.6	16.3	100.0	35.0	6.0	2.5	13.4	.5
1 10	-1.9	6.3	15.0	-17.2	-8.5	8.0	12.8	-27.8	61.7	16.8	100.0	26.0	6.5	2.9	17.0	0.0
1 13	.1	6.1	16.7	-16.1	-7.9	7.8	10.0	-27.2	57.0	18.4	100.0	24.0	6.8	3.0	17.0	1.0
1 16	.2	5.8	16.1	-16.7	-8.0	7.7	12.8	-28.9	56.3	19.1	100.0	21.0	6.5	2.9	16.5	0.0
1 19	-1.1	5.6	14.4	-18.3	-8.2	7.9	12.2	-31.1	60.6	18.9	100.0	23.0	6.1	2.7	17.5	1.0
1 22	-2.1	5.7	14.4	-18.9	-8.5	7.8	12.8	-30.6	63.1	18.0	100.0	25.0	6.2	2.8	16.5	0.0
2 1	-2.6	5.1	11.7	-17.2	-8.5	7.6	10.0	-35.0	64.9	18.7	100.0	20.0	6.1	2.6	15.4	1.0
2 4	-3.2	5.3	10.6	-18.9	-8.7	7.7	8.3	-32.2	67.1	17.5	100.0	29.0	6.0	2.6	14.9	1.0
2 7	-3.6	5.3	9.4	-18.9	-8.9	7.5	7.8	-30.0	67.8	17.5	100.0	29.0	6.0	2.7	14.4	0.0
2 10	-1.7	4.9	11.1	-16.1	-8.6	7.5	8.3	-30.0	62.0	19.0	100.0	19.0	6.5	3.0	18.0	1.0
2 13	.3	4.8	12.8	-12.8	-7.7	7.0	7.8	-26.1	57.8	20.4	100.0	14.0	6.8	3.1	19.0	0.0
2 16	.7	4.7	13.9	-12.2	-7.5	7.2	11.7	-30.6	57.2	21.0	100.0	18.0	6.9	3.0	20.1	1.0
2 19	-.6	4.6	13.3	-12.8	-7.7	7.3	10.6	-30.0	61.0	19.8	100.0	22.0	6.2	2.8	15.4	.5
2 22	-1.6	4.9	13.9	-15.6	-8.0	7.3	10.0	-26.7	63.2	18.9	100.0	24.0	6.1	2.8	12.9	0.0
3 1	1.6	4.2	16.7	-13.3	-4.3	6.2	11.1	-23.3	67.0	18.1	100.0	25.0	5.8	2.5	14.4	0.0
3 4	.8	4.1	15.0	-13.9	-4.7	6.2	9.4	-23.3	68.8	17.5	100.0	23.0	5.6	2.7	17.5	0.0
3 7	.8	4.2	13.3	-14.4	-4.7	6.3	11.1	-21.7	68.2	16.9	100.0	26.0	5.9	2.6	18.5	1.0
3 10	3.2	4.4	16.7	-10.6	-4.2	6.3	12.8	-21.7	61.6	19.8	100.0	23.0	6.3	2.9	18.0	.5
3 13	5.0	4.7	20.6	-8.9	-3.6	6.3	13.9	-21.1	58.0	21.3	100.0	16.0	6.9	2.7	19.5	.5
3 16	5.2	4.6	19.4	-7.2	-3.6	6.4	14.4	-20.6	57.5	22.1	100.0	16.0	6.8	2.8	17.0	1.0
3 19	3.6	4.1	17.2	-10.6	-3.8	6.4	14.4	-22.2	61.8	20.8	100.0	19.0	6.0	2.7	19.0	.5
3 22	2.5	4.0	14.4	-11.7	-4.0	6.3	11.1	-22.2	65.2	19.2	100.0	25.0	5.8	2.7	18.0	0.0
4 1	6.4	4.1	23.9	-3.9	.4	5.6	13.3	-14.4	67.7	17.4	100.0	26.0	5.5	2.4	13.9	0.0
4 4	5.6	4.0	21.1	-4.4	.1	5.6	13.3	-15.6	70.0	16.8	100.0	29.0	5.3	2.4	14.4	0.0
4 7	6.3	4.1	20.6	-4.4	.2	5.7	13.3	-16.7	67.5	17.8	100.0	27.0	5.6	2.5	14.9	0.0
4 10	9.5	4.9	23.9	-2.2	.5	5.8	14.4	-16.1	57.0	20.0	100.0	23.0	6.2	2.6	16.5	.5
4 13	10.9	5.4	28.9	-2.2	.9	5.7	15.0	-13.9	54.4	21.1	100.0	16.0	6.9	2.5	16.5	.5
4 16	10.9	5.3	28.9	.6	.9	5.4	15.0	-14.4	55.0	21.5	100.0	15.0	7.0	2.5	16.5	1.0
4 19	9.0	4.6	23.9	-1.1	.9	5.5	13.3	-15.0	60.8	20.6	100.0	16.0	6.0	2.4	12.9	0.0
4 22	7.6	4.0	22.2	-1.7	.8	5.3	13.3	-14.4	65.4	19.0	100.0	24.0	5.5	2.3	12.3	1.0
5 1	11.2	3.3	21.7	4.4	6.1	5.0	17.2	-12.8	73.2	17.7	100.0	28.0	4.6	2.0	10.8	0.0
5 4	10.5	3.3	20.6	2.8	6.1	4.8	17.8	-12.2	76.4	15.7	100.0	33.0	4.5	2.0	12.9	0.0
5 7	11.9	3.4	22.8	3.9	6.3	5.0	19.4	-12.8	70.7	17.3	100.0	29.0	4.9	2.0	13.4	0.0
5 10	14.7	4.6	28.9	5.6	6.5	5.3	18.3	-11.7	61.6	20.5	100.0	19.0	5.6	2.3	15.4	.5
5 13	16.0	5.3	31.7	5.6	6.6	5.4	17.8	-11.7	58.3	21.7	100.0	13.0	6.5	2.3	15.4	1.5
5 16	15.9	5.5	32.8	4.4	6.4	5.4	17.2	-11.7	58.4	23.0	100.0	13.0	6.7	2.5	20.1	1.5
5 19	14.1	4.7	30.0	3.9	6.5	5.2	17.2	-11.7	64.6	21.8	100.0	15.0	5.6	2.5	21.6	0.0
5 22	12.5	3.8	23.9	4.4	6.3	5.2	17.8	-12.8	69.2	19.7	100.0	22.0	5.1	2.3	14.9	0.0
6 1	17.1	3.5	28.3	8.9	12.8	3.8	20.6	-1.7	77.4	13.7	100.0	32.0	4.3	1.8	10.3	0.0
6 4	16.1	3.4	23.9	8.3	12.6	3.7	20.6	2.2	80.8	12.0	100.0	44.0	4.1	1.7	12.3	0.0
6 7	17.8	3.5	27.8	9.4	12.8	3.8	20.6	1.1	74.0	14.1	100.0	39.0	4.5	1.8	10.3	0.0
6 10	21.1	4.8	32.8	10.6	13.2	4.4	21.1	-.6	63.3	17.9	100.0	26.0	5.1	1.8	12.3	0.0
6 13	22.3	5.5	35.0	10.6	13.3	4.3	21.7	-.6	60.1	19.7	100.0	23.0	5.9	2.0	11.3	1.0
6 16	22.2	5.6	35.6	10.6	13.3	4.3	22.2	-2.2	60.6	19.2	100.0	18.0	5.9	2.0	12.3	.5
6 19	20.1	4.6	33.3	9.4	13.3	4.2	22.2	-2.8	67.9	17.9	100.0	20.0	5.1	2.1	11.3	.5
6 22	18.2	3.9	30.0	9.4	13.2	3.9	21.7	-2.8	74.6	15.4	100.0	25.0	4.6	2.0	10.3	0.0

BOSTON

TABLE A-5. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 1	20.4	2.7	29.4	13.9	15.8	3.4	22.8	5.0	76.3	12.9	100.0	42.0	4.2	1.7	9.3	0.0
7 4	19.4	2.7	27.2	12.8	15.6	3.3	22.2	6.1	79.4	11.5	100.0	44.0	4.0	1.5	7.2	0.0
7 7	21.1	2.6	28.9	15.0	15.7	3.4	22.2	5.6	72.8	13.2	100.0	42.0	4.3	1.7	9.3	.5
7 10	24.3	3.4	32.8	17.2	15.8	3.9	22.2	1.7	61.0	14.9	93.0	24.0	5.0	1.7	11.8	.5
7 13	25.8	4.0	35.6	17.8	15.7	4.0	22.8	2.2	55.9	16.3	93.0	25.0	5.7	1.9	11.8	.5
7 16	25.6	4.1	36.1	16.7	15.7	3.9	22.8	3.3	57.0	17.0	97.0	18.0	6.0	1.9	12.3	.5
7 19	23.3	3.4	34.4	16.1	16.0	3.7	22.8	2.8	65.7	15.9	100.0	27.0	4.9	1.8	10.3	.5
7 22	21.4	2.8	31.7	15.6	16.0	3.5	23.3	3.9	72.8	14.4	100.0	37.0	4.4	1.8	9.3	0.0
8 1	20.0	2.8	26.7	10.0	15.7	3.8	22.8	1.7	77.1	13.0	100.0	33.0	4.3	1.8	9.3	0.0
8 4	19.1	2.9	26.1	8.9	15.4	3.9	22.2	2.2	79.9	11.7	100.0	44.0	4.0	1.6	9.3	0.0
8 7	20.2	2.9	26.7	10.0	15.3	4.0	22.2	2.2	74.5	12.3	100.0	49.0	4.3	1.8	9.3	.5
8 10	23.7	3.6	32.2	13.3	15.5	4.1	22.8	1.7	61.7	15.0	100.0	36.0	4.9	1.9	14.4	.5
8 13	25.4	4.2	36.1	14.4	15.3	4.1	22.8	1.1	56.0	15.9	100.0	28.0	5.9	1.9	12.9	.5
8 16	24.9	4.2	34.4	13.9	15.4	4.1	23.3	0.0	58.2	16.9	100.0	26.0	6.0	1.9	11.3	.5
8 19	22.5	3.6	31.1	11.7	15.7	3.9	22.2	-.6	67.4	16.1	100.0	29.0	4.9	1.9	12.9	1.0
8 22	21.0	3.0	27.8	11.1	15.8	3.8	22.2	2.8	73.4	14.1	100.0	40.0	4.5	1.8	8.7	.5
9 1	16.1	3.6	25.6	5.6	12.3	4.7	21.7	0.0	79.4	12.0	100.0	47.0	4.6	1.8	10.8	0.0
9 4	15.2	3.7	25.6	4.4	12.0	4.7	21.1	.6	81.8	11.0	100.0	54.0	4.4	1.7	9.8	0.0
9 7	15.8	3.7	26.7	5.6	11.9	4.8	20.6	.6	78.7	11.5	100.0	51.0	4.7	1.9	12.9	0.0
9 10	19.2	4.1	31.7	8.3	12.3	5.0	22.2	-.6	66.1	15.5	100.0	33.0	5.4	2.0	12.3	1.0
9 13	20.8	4.6	34.4	10.6	12.4	5.1	22.2	-1.1	60.7	16.6	100.0	26.0	6.1	2.0	11.3	1.5
9 16	20.3	4.5	33.9	10.6	12.4	5.0	22.8	0.0	63.1	17.8	100.0	24.0	6.0	1.8	13.4	2.1
9 19	18.1	3.8	30.0	8.9	12.5	4.9	21.7	-2.8	71.7	16.3	100.0	28.0	4.8	1.9	13.4	0.0
9 22	16.8	3.5	27.8	7.8	12.3	4.8	21.7	-2.2	75.8	14.0	100.0	39.0	4.6	2.0	12.3	0.0
10 1	10.6	4.2	22.2	-1.1	6.0	6.5	17.8	-11.1	74.6	16.5	100.0	28.0	4.9	2.1	13.9	1.0
10 4	9.9	4.3	18.9	-1.1	5.7	6.2	16.7	-10.6	76.4	15.2	100.0	35.0	4.8	2.0	13.4	.5
10 7	9.9	4.3	18.9	-.6	5.5	6.2	18.3	-10.0	75.5	14.6	100.0	39.0	4.9	2.0	11.3	0.0
10 10	13.5	4.4	25.6	1.7	5.9	6.7	18.3	-10.6	62.5	17.5	100.0	25.0	5.7	2.4	13.9	1.0
10 13	15.4	4.9	29.4	3.3	6.0	6.8	18.9	-11.7	56.5	18.6	100.0	15.0	6.3	2.3	13.9	1.0
10 16	14.8	4.6	28.9	2.8	5.8	6.9	18.3	-13.3	57.9	19.8	100.0	17.0	6.0	2.1	13.9	2.1
10 19	12.5	4.1	24.4	0.0	5.9	6.7	19.4	-12.8	66.5	18.6	100.0	24.0	5.1	2.2	12.9	0.0
10 22	11.4	4.1	23.9	-.6	6.0	6.6	19.4	-11.7	71.3	17.3	100.0	33.0	5.1	2.2	12.3	1.0
11 1	5.6	4.5	20.0	-6.1	.8	6.5	16.7	-13.9	72.9	16.0	100.0	37.0	5.4	2.3	14.4	1.0
11 4	5.2	4.7	18.3	-7.2	.6	6.6	15.0	-12.8	73.9	15.7	100.0	35.0	5.4	2.2	13.4	.5
11 7	4.9	4.7	17.2	-8.3	.5	6.6	15.6	-13.9	75.0	15.3	100.0	40.0	5.6	2.2	11.3	1.0
11 10	7.0	4.5	22.2	-3.9	.9	6.7	16.7	-13.9	67.2	17.9	100.0	30.0	6.1	2.8	17.5	.5
11 13	8.6	4.3	24.4	-1.1	1.0	6.6	18.9	-15.6	61.8	19.6	100.0	21.0	6.5	2.8	17.0	0.0
11 16	8.0	4.3	23.3	-3.3	.8	6.8	18.3	-16.7	63.4	19.9	100.0	22.0	6.1	2.5	14.9	1.5
11 19	6.7	4.2	21.7	-5.0	.8	6.5	18.3	-15.0	68.4	17.8	100.0	26.0	5.7	2.4	14.9	1.0
11 22	6.0	4.4	21.7	-5.0	.8	6.5	17.8	-13.3	71.0	16.5	100.0	31.0	5.5	2.4	18.5	0.0
12 1	.6	5.1	17.2	-18.3	-4.7	6.9	15.0	-30.6	69.5	15.6	100.0	32.0	5.9	2.5	13.9	0.0
12 4	.2	5.4	16.1	-18.9	-4.7	7.1	14.4	-28.9	71.4	15.2	100.0	32.0	5.8	2.5	15.4	.5
12 7	-.0	5.6	15.0	-19.4	-4.7	7.3	13.9	-30.0	72.3	15.1	100.0	32.0	6.0	2.6	18.0	.5
12 10	1.5	5.5	15.6	-18.3	-4.4	7.3	13.9	-29.4	66.3	17.0	100.0	26.0	6.4	2.8	17.5	1.0
12 13	3.2	5.3	20.0	-13.3	-3.9	6.9	13.3	-26.7	62.1	19.2	100.0	22.0	6.4	2.9	18.5	1.0
12 16	2.9	4.9	17.2	-13.3	-4.1	7.1	14.4	-28.9	63.1	19.6	100.0	22.0	6.2	2.8	17.0	0.0
12 19	1.8	4.9	15.0	-14.4	-4.3	7.1	14.4	-28.9	66.4	18.4	100.0	27.0	6.2	2.7	15.9	1.0
12 22	1.0	5.0	16.1	-16.1	-4.5	7.0	13.9	-29.4	68.2	16.7	100.0	31.0	6.0	2.6	17.5	0.0

BOSTON

TABLE A-5. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 1	101.5	1.0	104.0	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.7	45.7	49.1	45.9
1 4	101.5	1.0	104.1	98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.5	46.1	50.2	46.1
1 7	101.6	1.0	104.0	98.4	12.1	11.4	48.8	0.0	0.0	0.0	0.0	0.0	54.8	44.7	48.1	45.3
1 10	101.7	1.0	104.0	97.8	255.7	135.9	495.0	0.0	548.4	62.2	650.7	302.1	59.0	43.8	47.9	43.4
1 13	101.5	1.0	103.9	97.6	282.2	142.4	525.2	0.0	601.3	63.6	720.4	534.5	61.9	42.7	48.6	42.3
1 16	101.5	1.0	103.8	97.7	32.4	47.5	206.8	0.0	341.3	63.5	511.3	302.1	58.2	43.8	47.9	43.2
1 19	101.6	1.0	103.9	97.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.8	45.4	46.4	45.2
1 22	101.6	1.0	104.1	97.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.0	45.5	46.5	44.8
2 1	101.4	1.1	104.1	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.8	45.4	48.7	45.2
2 4	101.4	1.1	104.2	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.5	45.5	52.9	45.9
2 7	101.5	1.1	104.2	98.2	3.2	5.3	30.2	0.0	0.0	0.0	0.0	0.0	62.6	43.7	55.4	44.3
2 10	101.5	1.1	104.3	98.6	270.0	154.0	567.1	0.0	617.3	54.7	697.2	534.5	65.2	43.4	54.4	44.0
2 13	101.3	1.1	104.1	98.6	400.1	216.3	770.4	0.0	816.9	53.3	906.4	650.7	64.6	41.7	53.5	41.8
2 16	101.3	1.1	104.0	97.8	163.2	98.8	371.8	0.0	421.2	47.4	499.7	348.6	61.8	42.7	49.1	42.6
2 19	101.4	1.1	104.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.2	45.6	48.6	44.4
2 22	101.4	1.1	104.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.6	45.6	49.5	45.8
3 1	101.4	1.1	103.7	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.8	44.9	52.6	45.4
3 4	101.3	1.1	103.9	97.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.8	44.8	51.2	45.8
3 7	101.4	1.1	104.0	97.2	121.3	98.7	363.7	0.0	383.9	47.7	453.2	313.7	56.1	41.9	55.8	43.5
3 10	101.4	1.2	104.0	97.0	426.6	249.5	855.2	19.8	913.8	96.3	1022.6	708.8	67.5	41.5	55.4	42.6
3 13	101.3	1.2	103.9	96.3	429.8	258.6	883.1	4.6	946.8	46.1	1022.6	859.9	70.8	39.0	58.0	40.7
3 16	101.2	1.1	103.7	97.1	143.0	114.6	1119.0	0.0	406.9	68.9	534.5	313.7	71.5	39.4	59.0	41.3
3 19	101.3	1.1	103.7	97.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	42.9	52.4	44.4
3 22	101.4	1.1	103.7	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.2	45.5	50.7	46.0
4 1	101.4	.9	103.5	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.3	45.0	47.8	45.5
4 4	101.4	.9	103.5	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.6	45.0	47.4	45.4
4 7	101.5	.9	103.7	98.8	233.5	135.5	467.1	0.0	545.4	45.9	627.5	476.4	57.8	44.6	48.3	44.2
4 10	101.4	.9	103.7	98.8	538.3	285.9	908.7	18.6	1094.2	36.5	1150.4	1022.6	61.3	42.5	50.6	43.3
4 13	101.3	.9	103.8	98.8	521.2	286.9	906.4	20.9	1094.2	36.5	1150.4	1022.6	64.5	40.3	52.9	41.7
4 16	101.2	.9	103.6	98.5	217.8	124.2	435.8	0.0	544.7	45.9	627.5	453.2	62.3	40.8	51.1	41.6
4 19	101.3	.9	103.5	97.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.3	43.3	51.5	43.3
4 22	101.4	.9	103.4	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.3	44.5	48.7	44.1
5 1	101.4	.7	103.5	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.6	43.6	51.3	44.8
5 4	101.4	.7	103.5	98.4	1.4	2.6	15.1	0.0	0.0	0.0	0.0	0.0	61.2	42.9	52.6	45.0
5 7	101.5	.7	103.5	98.9	280.2	163.5	680.9	0.0	665.3	22.5	697.2	627.5	65.7	42.7	55.4	44.7
5 10	101.5	.7	103.6	99.1	584.2	292.9	991.2	12.8	1182.9	17.6	1208.5	1150.4	67.6	39.7	54.1	42.5
5 13	101.4	.7	103.6	99.2	572.2	283.0	970.3	23.2	1183.1	17.6	1208.5	1150.4	67.0	38.4	54.0	40.3
5 16	101.3	.7	103.6	99.3	269.8	152.7	497.3	0.0	665.3	22.5	697.2	627.5	66.5	38.6	51.9	40.3
5 19	101.4	.7	103.5	99.5	1.2	2.1	12.8	0.0	0.0	0.0	0.0	0.0	69.5	38.7	56.6	41.6
5 22	101.4	.7	103.5	98.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.6	41.9	56.1	43.3
6 1	101.4	.5	103.1	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.0	42.8	49.4	44.0
6 4	101.4	.5	103.1	99.8	5.7	6.5	63.9	0.0	0.0	0.0	0.0	0.0	60.5	40.4	49.5	43.0
6 7	101.5	.6	103.2	99.8	328.1	166.7	606.6	17.4	715.8	9.3	720.4	697.2	59.8	42.5	47.1	43.7
6 10	101.5	.6	103.2	99.5	635.9	285.6	1008.6	48.8	1208.5	0.0	1208.5	1208.5	59.6	52.1	46.8	42.3
6 13	101.4	.6	103.0	99.2	625.4	271.4	1006.3	38.3	1208.5	0.0	1208.5	1208.5	66.1	36.3	53.0	38.6
6 16	101.3	.6	102.8	98.8	317.8	151.2	584.5	12.8	715.8	9.3	720.4	697.2	65.3	35.7	51.7	37.5
6 19	101.3	.6	102.8	99.1	7.3	11.6	125.5	0.0	0.0	0.0	0.0	0.0	67.5	38.0	50.2	41.0
6 22	101.4	.5	103.0	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.8	41.1	50.3	43.5

BOSTON

TABLE A-5. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 1	101.4	.5	102.6	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.9	41.2	46.4	41.9
7 4	101.4	.5	102.6	100.2	3.1	4.0	23.2	0.0	0.0	0.0	0.0	0.0	61.1	40.4	48.8	41.7
7 7	101.5	.5	102.8	100.2	312.1	145.2	555.4	12.8	687.1	20.0	720.4	662.3	63.0	40.6	48.6	42.2
7 10	101.5	.5	102.7	100.0	641.1	248.4	978.4	22.1	1195.4	13.1	1208.5	1173.6	61.1	39.8	46.6	39.7
7 13	101.4	.5	102.6	100.0	643.7	232.8	971.4	20.9	1195.4	13.1	1208.5	1173.6	62.4	35.6	48.6	35.2
7 16	101.3	.5	102.6	100.0	311.7	137.4	564.7	0.0	687.1	20.0	720.4	662.3	61.5	36.3	48.5	36.6
7 19	101.4	.5	102.5	100.1	3.7	4.8	36.0	0.0	0.0	0.0	0.0	0.0	62.8	38.5	46.2	38.0
7 22	101.4	.5	102.6	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.7	40.8	45.5	41.7
8 1	101.5	.5	103.0	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.0	43.3	42.8	42.9
8 4	101.5	.5	103.0	99.9	.3	.9	7.0	0.0	0.0	0.0	0.0	0.0	49.1	42.8	39.9	43.4
8 7	101.6	.5	103.1	100.1	269.3	120.2	488.0	12.8	589.6	42.1	662.3	511.3	55.2	42.1	42.5	42.1
8 10	101.6	.5	103.2	100.0	634.2	207.1	911.0	19.8	1122.3	28.6	1162.0	1069.0	51.7	40.9	36.3	37.9
8 13	101.5	.5	103.1	100.1	617.9	214.5	913.3	34.9	1122.1	28.6	1162.0	1069.0	58.6	37.1	44.6	34.9
8 16	101.4	.5	103.0	100.0	262.7	110.5	450.9	0.0	589.6	42.1	662.3	511.3	53.9	37.6	42.0	35.3
8 19	101.4	.5	102.9	100.1	.1	.4	2.3	0.0	0.0	0.0	0.0	0.0	54.0	39.6	41.0	38.4
8 22	101.5	.5	102.9	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.4	42.6	43.2	42.6
9 1	101.7	.7	103.3	99.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.2	44.3	47.7	44.1
9 4	101.7	.7	103.3	99.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.3	43.9	45.7	44.2
9 7	101.8	.7	103.4	99.5	172.7	99.9	374.2	0.0	435.8	48.8	511.3	337.0	57.9	43.6	48.4	43.7
9 10	101.8	.7	103.4	99.6	504.9	228.3	819.2	7.0	990.4	49.8	1069.0	906.4	53.8	42.5	43.6	41.5
9 13	101.7	.7	103.3	99.6	497.2	225.3	839.0	0.0	990.3	49.9	1069.0	906.4	56.4	39.3	47.0	39.9
9 16	101.6	.7	103.1	99.6	165.8	88.6	357.9	0.0	435.8	48.8	511.3	337.0	56.0	39.6	46.9	39.4
9 19	101.7	.7	103.2	99.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.2	41.7	45.1	42.6
9 22	101.7	.7	103.2	99.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.7	43.3	47.8	43.7
10 1	101.8	.9	104.0	98.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.1	45.3	41.5	45.2
10 4	101.8	.9	104.0	98.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.9	44.2	40.8	44.6
10 7	101.8	.9	104.1	98.9	85.1	55.4	246.3	0.0	247.4	58.2	337.0	162.7	55.2	44.1	45.7	44.1
10 10	101.9	.9	104.1	99.0	416.9	179.3	715.8	4.6	808.2	56.5	906.4	708.8	52.1	43.1	42.0	42.1
10 13	101.7	.9	103.8	98.9	400.5	184.5	707.7	13.9	808.2	56.5	906.4	708.8	55.4	41.0	44.4	40.5
10 16	101.7	.9	103.6	98.5	81.9	52.5	216.1	0.0	247.2	58.1	337.0	162.7	53.5	42.9	43.4	41.4
10 19	101.8	.9	103.8	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.5	42.2	37.5	41.9
10 22	101.8	.9	103.9	98.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.5	44.5	38.8	44.0
11 1	101.5	1.0	103.5	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.2	44.3	58.5	45.2
11 4	101.5	1.0	103.6	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.1	44.3	56.3	45.6
11 7	101.6	1.0	103.7	98.0	17.6	18.0	87.1	0.0	130.1	11.5	139.4	116.2	67.4	41.4	59.9	43.0
11 10	101.6	1.0	103.9	98.1	250.2	149.0	539.2	0.0	632.5	43.9	708.8	557.8	65.4	40.6	56.3	42.6
11 13	101.4	1.0	103.7	98.0	244.0	146.2	539.2	0.0	632.5	44.0	708.8	557.8	67.9	39.9	57.3	41.4
11 16	101.4	1.0	103.6	97.6	18.9	17.9	81.3	0.0	130.1	11.5	139.4	116.2	68.5	39.2	58.0	41.3
11 19	101.5	1.0	103.6	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.6	42.9	55.9	44.6
11 22	101.5	1.0	103.6	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	43.9	56.2	45.2
12 1	101.5	1.0	104.2	97.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.0	44.6	54.9	45.6
12 4	101.5	1.1	104.3	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.6	45.4	54.6	46.1
12 7	101.6	1.1	104.4	97.6	6.6	7.1	27.9	0.0	0.0	0.0	0.0	0.0	63.7	42.6	56.6	44.2
12 10	101.6	1.1	104.5	98.0	213.4	128.5	403.2	0.0	527.5	16.3	557.8	511.3	65.9	42.3	55.1	44.5
12 13	101.4	1.1	104.2	97.9	209.9	129.1	395.1	0.0	527.5	16.3	557.9	511.3	68.1	40.5	56.8	42.4
12 16	101.5	1.1	104.0	98.1	6.9	6.5	23.2	0.0	0.0	0.0	0.0	0.0	68.9	40.9	58.3	42.2
12 19	101.5	1.1	103.9	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.5	43.5	57.6	44.9
12 22	101.5	1.0	104.1	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.6	43.7	56.4	44.9

BOSTON

TABLE A-6. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR BOSTON, MASSACHUSETTS

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 1	38	5	18				32	2	1	2	1				15
1 4	34	3	12	2			31	5	1	3			2		17
1 7	23	3	8	3			26	5	1	1			1		33
1 10	28	3	12				26	5		1					39
1 13	24	3	12	3			25	6					1		24
1 16	26	3	19	1			21	3	1				2		22
1 19	28	4	21	1			24	5	2						19
1 22	26	2	23				29	6	1						17
2 1	24	5	11				31	5	1				2		9
2 4	25	3	11	1			38	6	1				2		16
2 7	33	3	8	1			37	6	1	1			1		33
2 10	31	3	12	1			44	9		2			3		39
2 13	27	4	12				27	6		2			6		23
2 16	25	6	14	1			17	9					2		10
2 19	25	5	15	1			29	5		2			3		8
2 22	22	3	14	2			29	7	2	1					11
3 1	38	11	24	4			20	4			1		1		9
3 4	45	15	17	1			17	3	2	1					9
3 7	53	20	18	4			15						1		28
3 10	44	14	18	6	1		16	5			1		2		20
3 13	41	13	19	4			17	1					1		10
3 16	42	13	12	10			15	3		1	1		3		16
3 19	39	9	14	6			18	1	1	2			2		19
3 22	41	11	16	5			17	2	1	2			2		14
4 1	26	3	25	8	2		5			1			1		3
4 4	33	6	27	6	1		6								5
4 7	40	4	23	7			5	1					2		38
4 10	28	6	25	15			3						1		18
4 13	23	5	24	14			3	1							7
4 16	23	4	28	12			2	1			1		2		5
4 19	32	4	29	10	3		4	1							6
4 22	29	5	23	10			2	2							7
5 1	51	7	29	18	1								1		17
5 4	54	8	21	18	1										21
5 7	56	10	25	20	1										36
5 10	46	8	27	13											26
5 13	34	6	25	12											20
5 16	41	6	22	12											20
5 19	51	10	24	19	3										15
5 22	51	10	25	12											11
6 1	46	5	15	14	1										41
6 4	62	9	13	19	2										51
6 7	52	14	15	10											89
6 10	33	6	12	11											62
6 13	30	4	14	13	1										49
6 16	24	4	8	15	2										47
6 19	29	4	10	20	5										44
6 22	34	3	14	16	3										42

BOSTON

TABLE A-6. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 1	35	2		7	2										61
7 4	53	4	4	19											73
7 7	46	2	5	12											97
7 10	25		3	13											89
7 13	11		4	21	2										76
7 16	16	1	6	19	4										64
7 19	16		3	13	5										68
7 22	21	2	3	15	2										66
8 1	39	5	6	16	2										50
8 4	48	2	3	14											62
8 7	47	2	8	10	1										102
8 10	25		6	6											84
8 13	15	3	6	6	2										68
8 16	19	1	8	8	1										57
8 19	25	4	6	14	5										63
8 22	28	1	4	10	2										55
9 1	42	3	11	13											47
9 4	50	2	16	13											47
9 7	62	4	15	7											72
9 10	26	1	12	7											52
9 13	21	5	10	8	2										40
9 16	26	6	16	11	1										39
9 19	28	5	17	6											36
9 22	38	4	15	7	1										40
10 1	46	8	10	11			1								26
10 4	49	3	17	6											30
10 7	56	7	19	5			1								76
10 10	31	6	14	6											45
10 13	23	6	14	8				1							19
10 16	23	4	16	9	1										13
10 19	24	5	15	6											19
10 22	29	8	11	5				1							24
11 1	57	9	42	7			5	1							13
11 4	50	9	40	6			5	2							10
11 7	55	11	30	12			6	1							28
11 10	53	6	36	9	1		4								24
11 13	38	9	33	15			3								14
11 16	38	8	33	9			1	1							7
11 19	41	8	35	4			2								8
11 22	48	12	33	5			6								9
12 1	35	7	24	1			22	5	2	4			3		9
12 4	39	11	26	2			22	4	1	1			3		9
12 7	45	7	30	4			23	2	2	2			2		24
12 10	52	9	23	4			27	1	2		2		2		36
12 13	39	9	28	3	1		24	3		2			1		22
12 16	49	9	25	3			27		2	1			3		18
12 19	48	5	25	2			21	1	1	2			3		12
12 22	34	8	25	2			27	8	2	3	1		3		11

BOSTON

TABLE A-7. DESCRIPTIVE ENVIRONMENTAL STATISTICS FOR BROWNSVILLE, TEXAS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974.

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 0	13.8	5.8	23.9	-.6	11.4	6.8	21.1	-9.4	86.4	11.8	100.0	31.0	4.1	2.0	10.8	0.0
1 3	13.2	6.1	23.3	-1.7	10.9	7.0	20.6	-10.0	87.1	12.4	100.0	31.0	4.1	2.4	10.3	0.0
1 6	12.7	6.2	23.3	-2.2	10.5	7.1	20.6	-7.2	87.5	11.8	100.0	35.0	4.2	2.4	12.3	0.0
1 9	14.3	6.1	25.0	0.0	11.5	7.2	21.1	-7.2	84.1	13.2	100.0	33.0	4.9	2.6	11.8	0.0
1 12	18.3	6.9	28.9	1.1	11.8	6.9	21.7	-12.2	68.4	16.7	100.0	20.0	6.7	2.6	16.5	0.0
1 15	19.1	6.9	33.3	.6	11.6	6.8	22.2	-11.7	64.5	17.8	100.0	9.0	6.9	2.5	13.4	1.5
1 18	16.8	5.9	25.0	.6	11.9	6.7	21.1	-7.8	74.6	14.0	97.0	16.0	5.7	2.1	11.3	0.0
1 21	14.5	5.7	23.9	.6	11.8	6.6	21.1	-8.9	84.5	11.3	100.0	31.0	4.3	2.1	12.3	0.0
2 0	14.6	4.8	22.8	-.6	11.8	5.8	21.1	-4.4	84.4	11.9	100.0	24.0	4.0	2.2	12.3	0.0
2 3	13.9	5.1	23.9	-1.7	11.5	6.0	21.1	-5.0	86.3	12.0	100.0	32.0	4.1	2.5	20.6	0.0
2 6	13.5	5.2	23.3	-2.2	11.2	6.1	21.1	-6.1	86.8	11.6	100.0	39.0	4.1	2.4	14.9	0.0
2 9	16.0	4.8	25.6	0.0	12.2	6.2	21.1	-7.8	79.8	14.7	100.0	18.0	5.4	2.4	14.4	0.0
2 12	19.9	5.2	29.4	2.8	11.6	6.4	22.2	-7.8	61.9	18.6	97.0	14.0	7.1	2.7	15.4	1.5
2 15	20.6	5.3	31.7	2.2	14.4	6.5	22.8	-8.3	59.1	19.3	100.0	11.0	7.2	2.4	15.4	1.5
2 18	18.2	4.6	27.2	2.8	11.7	6.2	21.7	-11.7	68.4	17.2	100.0	10.0	6.3	2.0	13.9	2.1
2 21	15.4	4.5	23.9	1.1	12.1	5.7	21.1	-3.9	81.4	12.4	100.0	21.0	4.4	2.2	12.3	0.0
3 0	17.6	4.7	25.0	5.0	14.9	5.7	23.3	-6.7	84.9	11.1	100.0	28.0	4.7	2.5	11.8	0.0
3 3	17.1	4.9	25.0	3.3	14.7	5.8	22.2	-5.0	86.6	10.0	100.0	35.0	4.5	2.4	11.8	0.0
3 6	16.8	5.0	24.4	2.2	14.5	6.0	22.2	-5.6	87.2	11.2	100.0	40.0	4.5	2.3	11.3	0.0
3 9	19.7	4.4	26.7	6.7	15.3	6.0	22.2	-5.6	76.9	14.5	100.0	28.0	6.4	2.5	13.4	0.0
3 12	23.1	4.8	31.7	8.3	14.4	6.6	22.2	-12.8	60.6	16.9	97.0	14.0	7.6	2.6	15.4	1.5
3 15	23.8	4.9	33.9	7.8	14.1	6.6	22.8	-11.7	57.5	17.0	97.0	12.0	7.8	2.5	16.5	1.5
3 18	21.3	4.2	31.1	6.7	14.6	6.4	23.3	-10.0	67.7	16.1	97.0	10.0	7.2	2.1	13.4	1.5
3 21	18.5	4.2	24.4	6.7	15.1	5.8	22.2	-6.1	81.3	12.5	100.0	26.0	5.0	2.2	11.8	0.0
4 0	21.6	3.3	26.7	10.0	18.8	4.0	23.3	5.0	84.7	8.3	100.0	38.0	4.9	2.4	14.4	0.0
4 3	21.1	3.5	26.1	9.4	18.6	4.1	23.3	3.3	86.1	8.2	100.0	38.0	4.8	2.5	12.3	0.0
4 6	20.7	3.7	26.1	7.8	18.4	4.2	23.3	.6	87.1	8.2	100.0	43.0	4.7	2.4	12.9	0.0
4 9	24.4	2.7	28.9	12.8	19.0	4.0	23.3	-1.7	72.6	11.2	97.0	31.0	7.3	2.5	14.4	1.5
4 12	27.2	3.1	36.7	16.1	18.4	4.4	23.3	-.6	59.8	12.6	100.0	20.0	8.0	2.5	16.5	1.5
4 15	27.6	3.1	35.6	18.3	18.2	4.5	23.9	-1.7	58.2	12.6	90.0	16.0	8.2	2.2	14.9	2.1
4 18	24.7	2.6	29.4	15.6	18.5	4.4	23.3	1.7	69.3	11.6	93.0	28.0	7.5	1.9	13.4	2.6
4 21	22.3	2.8	26.7	10.6	19.0	4.0	23.9	4.4	82.0	8.8	97.0	40.0	5.6	2.3	13.9	0.0
5 0	23.5	2.6	32.8	13.9	21.1	2.8	25.0	9.4	86.8	6.4	100.0	52.0	4.5	2.4	15.4	0.0
5 3	22.8	2.8	27.2	12.2	20.8	2.9	25.6	9.4	88.7	5.4	100.0	63.0	4.1	2.5	14.4	0.0
5 6	22.4	2.8	26.7	11.1	20.6	3.0	25.0	8.9	89.6	5.6	100.0	65.0	3.9	2.2	9.8	0.0
5 9	26.5	2.4	31.1	15.6	21.0	2.7	25.6	10.0	72.5	9.4	100.0	43.0	6.5	2.5	13.4	1.5
5 12	29.0	2.9	37.2	16.7	20.5	2.8	25.0	9.4	61.3	11.1	100.0	32.0	7.3	2.4	15.4	1.5
5 15	29.1	2.8	36.7	16.1	20.5	3.0	28.3	8.3	60.4	11.1	97.0	30.0	7.5	2.0	12.9	1.5
5 18	26.7	2.3	31.1	15.6	20.6	3.0	25.6	6.7	70.1	10.4	100.0	30.0	7.0	1.8	12.3	2.1
5 21	24.2	2.3	27.8	15.6	21.2	2.8	25.6	9.4	83.5	7.0	100.0	54.0	5.0	2.1	11.3	0.0
6 0	25.2	1.8	28.3	19.4	22.7	1.8	25.6	15.0	86.2	4.7	100.0	72.0	3.9	2.1	10.3	0.0
6 3	24.5	2.0	28.3	16.7	22.4	1.9	25.6	14.4	88.3	4.4	100.0	74.0	3.4	3.0	8.2	0.0
6 6	24.0	2.0	27.8	16.1	22.1	1.9	25.6	14.4	89.5	4.6	100.0	77.0	3.2	1.8	9.3	0.0
6 9	28.6	1.8	32.2	22.2	22.4	1.7	26.1	14.4	69.8	8.6	97.0	49.0	6.2	2.3	12.9	0.0
6 12	30.6	2.4	35.0	21.1	21.9	1.9	25.6	13.3	60.7	11.2	97.0	38.0	6.9	2.2	13.4	1.5
6 15	30.8	2.3	35.0	22.2	21.9	2.0	26.1	12.8	59.5	11.0	97.0	34.0	7.4	1.9	14.4	2.1
6 18	28.8	1.7	32.2	22.2	22.0	2.0	25.6	12.8	67.2	8.8	93.0	40.0	6.9	1.7	11.8	1.5
6 21	26.0	1.6	28.9	20.6	22.7	1.8	25.6	15.0	82.4	5.7	100.0	64.0	4.7	1.8	9.8	1.0

BROWNSVILLE

TABLE A-7. (Continued)

Month /Hour (1)	Air Temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 0	25.8	1.2	28.3	22.2	23.2	1.1	25.6	18.3	85.9	4.4	97.0	67.0	3.5	1.5	8.2	0.0
7 3	25.0	1.3	28.3	21.1	23.0	1.1	25.6	20.0	88.7	3.8	97.0	79.0	2.9	1.6	7.2	0.0
7 6	24.3	1.3	27.2	19.4	22.6	1.1	25.0	19.4	90.4	3.6	100.0	77.0	2.6	1.3	7.2	0.0
7 9	29.4	1.6	32.8	22.2	23.0	.9	25.0	20.6	68.7	7.5	97.0	54.0	5.7	2.0	10.3	1.0
7 12	32.1	2.0	35.6	25.0	22.0	1.6	26.1	15.0	56.1	10.2	91.0	32.0	6.7	2.0	12.3	0.0
7 15	32.4	1.9	36.1	23.9	21.9	1.4	25.6	15.0	54.6	9.0	91.0	32.0	7.4	1.7	11.3	0.0
7 18	30.1	1.4	32.8	23.9	22.2	1.2	24.4	17.8	63.0	7.2	91.0	45.0	7.2	1.6	11.3	1.5
7 21	26.7	1.2	28.9	22.8	23.1	1.1	25.0	17.2	80.8	5.2	97.0	58.0	4.3	1.6	8.2	0.0
8 0	25.6	1.4	28.9	20.6	23.1	1.1	25.6	15.6	86.3	4.7	97.0	73.0	3.0	1.6	8.2	0.0
8 3	24.8	1.4	28.3	18.3	22.8	1.2	25.0	15.6	89.0	4.1	97.0	74.0	2.4	1.5	7.7	0.0
8 6	24.1	1.4	27.2	17.8	22.5	1.2	25.0	15.6	90.6	4.0	100.0	77.9	2.2	1.3	7.2	0.0
8 9	29.1	1.9	32.2	22.2	23.2	1.0	25.6	17.2	71.1	8.6	97.0	55.0	4.9	2.2	11.3	0.0
8 12	31.7	2.7	35.6	23.3	22.0	1.5	25.6	15.0	57.6	12.2	97.0	38.0	6.0	2.2	12.3	0.0
8 15	31.9	2.5	36.1	24.4	21.9	1.4	25.6	16.1	56.4	11.2	94.0	35.0	6.8	1.8	11.3	1.5
8 18	29.8	1.7	32.8	24.4	22.3	1.3	25.0	15.0	64.6	8.7	94.0	43.0	6.6	1.9	11.3	1.5
8 21	26.6	1.2	29.4	23.3	23.1	1.0	25.6	16.1	81.5	5.4	97.0	64.0	3.8	1.6	8.7	0.0
9 0	24.8	2.2	28.9	13.3	22.3	2.3	26.1	11.7	86.2	5.6	100.0	56.0	3.0	1.9	20.6	0.0
9 3	24.0	2.3	28.3	13.9	21.9	2.3	26.1	11.7	88.2	5.3	100.0	63.0	2.7	2.4	29.8	0.0
9 6	23.4	2.3	27.8	13.9	21.5	2.5	25.6	10.6	89.3	5.2	100.0	66.0	2.7	1.9	17.5	0.0
9 9	27.6	2.6	32.2	16.1	22.5	2.5	25.6	10.0	74.1	9.5	100.0	42.0	4.8	2.4	24.7	0.0
9 12	30.5	3.0	35.6	17.8	21.8	2.6	25.6	10.0	61.0	12.7	94.0	26.0	5.9	2.4	24.7	1.5
9 15	30.5	3.0	35.6	17.8	21.6	2.7	26.7	10.0	60.3	12.9	97.0	23.0	6.4	1.9	19.0	2.1
9 18	28.2	2.2	32.2	17.2	21.8	2.4	25.6	8.9	69.1	9.8	94.0	33.0	5.8	1.8	15.4	1.5
9 21	25.6	2.0	28.9	16.1	22.3	2.4	26.1	12.2	82.4	6.5	94.0	59.0	3.5	1.6	13.4	0.0
10 0	21.5	3.7	28.3	10.6	19.0	4.0	25.0	2.8	86.0	6.7	100.0	43.0	2.9	1.7	9.3	0.0
10 3	20.7	3.9	28.3	9.4	18.5	4.1	25.0	6.1	87.7	6.6	100.0	44.0	2.9	1.8	8.2	0.0
10 6	20.1	4.0	28.3	8.9	18.1	4.3	25.0	3.9	88.5	7.2	100.0	39.0	3.0	1.8	9.8	0.0
10 9	24.4	3.6	30.6	13.9	19.8	4.2	25.6	3.9	75.8	9.7	100.0	40.0	4.8	2.3	12.9	0.0
10 12	27.5	3.3	32.8	13.3	18.9	4.5	25.6	-1.1	60.9	12.6	94.0	20.0	6.0	2.2	12.3	1.0
10 15	27.6	3.0	32.8	15.6	18.7	4.6	25.0	-1.1	59.4	12.8	100.0	17.0	6.2	1.9	12.3	2.1
10 18	24.8	2.9	29.4	15.0	19.0	4.2	25.0	2.2	70.5	10.4	97.0	31.0	4.8	1.6	9.3	0.0
10 21	22.4	3.4	28.9	11.7	19.2	4.0	25.0	4.4	82.9	6.9	97.0	53.0	3.2	1.5	8.2	0.0
11 0	18.0	4.9	26.7	3.3	15.1	5.9	24.4	-10.0	83.7	11.0	100.0	29.0	3.4	2.1	10.3	0.0
11 3	17.4	5.0	26.1	2.2	14.8	6.0	23.9	-9.4	85.3	10.9	100.0	33.0	3.3	2.1	12.3	0.0
11 6	17.0	5.3	25.6	2.2	14.6	6.1	23.9	-8.3	86.5	10.1	100.0	38.0	3.3	2.0	9.8	0.0
11 9	20.4	4.8	27.2	5.6	16.1	6.3	24.4	-5.6	77.7	13.6	100.0	29.0	5.1	2.4	12.9	0.0
11 12	24.1	4.9	32.2	6.7	15.6	5.9	23.9	-6.7	60.8	14.1	93.0	22.0	6.6	2.5	15.4	0.0
11 15	24.3	4.7	32.8	7.8	15.3	5.9	23.9	-6.1	59.1	14.5	93.0	20.0	6.6	2.2	15.4	0.0
11 18	21.1	4.4	27.2	7.2	15.6	5.8	23.9	-6.1	71.9	12.1	96.0	25.0	4.9	1.8	12.3	2.1
11 21	18.7	4.7	26.1	3.9	15.3	5.9	24.4	-8.9	81.5	10.3	97.0	25.0	3.5	1.9	11.3	0.0
12 0	15.7	5.4	24.0	0.0	12.9	6.4	22.2	-8.9	84.4	11.3	100.0	33.0	3.7	2.1	9.3	0.0
12 3	15.2	5.5	23.9	-.6	12.6	6.5	22.8	-8.3	85.1	11.7	100.0	36.0	3.7	2.3	10.8	0.0
12 6	14.7	5.7	24.4	-1.7	12.1	6.6	22.2	-8.3	85.5	11.3	100.0	32.0	3.8	2.2	10.8	0.0
12 9	17.0	5.2	25.6	2.8	13.4	6.6	22.8	-8.3	80.2	13.2	100.0	33.0	5.0	2.3	12.9	0.0
12 12	21.1	5.4	28.9	3.9	13.4	6.4	22.2	-7.8	63.8	16.2	97.0	25.0	6.5	2.6	15.4	0.0
12 15	21.7	5.2	30.0	4.4	13.0	6.5	22.2	-11.1	60.1	16.7	100.0	19.0	6.7	2.5	14.9	0.0
12 18	18.6	4.7	26.1	4.4	13.4	6.2	22.2	-12.2	73.1	13.3	100.0	23.0	4.8	2.0	10.8	0.0
12 21	16.3	5.0	25.0	1.1	13.1	6.2	22.2	-10.0	82.1	11.4	100.0	36.0	3.9	2.1	10.3	0.0

BROWNSVILLE

TABLE A-7. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 0	101.8	.6	103.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.4	44.0	58.6	44.1
1 3	101.8	.6	103.6	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.8	42.5	62.6	42.9
1 6	101.8	.6	103.5	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.6	41.9	65.2	43.0
1 9	101.9	.6	103.6	100.2	207.5	124.2	439.2	8.1	509.1	28.0	557.8	464.8	70.7	39.7	66.1	41.1
1 12	101.9	.6	103.7	100.1	460.7	245.9	866.9	55.8	970.5	35.0	1022.6	918.0	73.0	36.3	69.4	37.3
1 15	101.7	.6	103.5	99.8	332.5	184.7	618.2	26.7	736.2	29.5	778.5	697.2	70.4	36.7	65.2	37.5
1 18	101.7	.6	103.5	99.7	4.7	3.8	22.1	0.0	0.0	0.0	0.0	0.0	65.9	40.8	58.9	41.2
1 21	101.8	.6	103.6	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.8	44.0	55.8	44.5
2 0	101.8	.7	103.5	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.2	44.7	52.5	44.8
2 3	101.7	.7	103.4	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.2	44.1	56.0	44.5
2 6	101.7	.7	103.4	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.7	43.5	60.9	44.4
2 9	101.9	.7	103.6	99.8	275.9	156.8	546.1	5.8	630.0	36.5	697.2	557.8	65.6	41.5	61.1	42.1
2 12	101.9	.7	103.7	100.2	552.1	295.5	1015.6	36.0	1104.7	38.1	1162.0	1034.2	71.2	37.9	67.3	38.6
2 15	101.6	.7	103.4	99.8	410.1	213.0	761.1	5.8	852.4	35.1	906.4	801.8	67.1	39.8	62.2	40.4
2 18	101.6	.7	103.3	99.8	15.2	10.1	46.5	0.0	0.0	0.0	0.0	0.0	62.6	41.7	57.8	42.1
2 21	101.8	.7	103.4	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.3	43.8	52.3	44.6
3 0	101.5	.6	103.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.8	43.0	57.4	43.7
3 3	101.4	.6	102.9	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.9	42.4	61.8	43.2
3 6	101.4	.6	102.9	99.8	.8	1.4	9.3	0.0	0.0	0.0	0.0	0.0	67.3	40.5	64.5	41.7
3 9	101.6	.6	103.1	100.0	352.9	173.8	703.0	29.1	749.7	34.2	801.8	697.2	71.4	36.8	66.5	37.8
3 12	101.6	.6	103.1	100.0	701.1	313.1	1153.9	19.8	1231.7	31.3	1278.2	1173.6	65.8	37.9	60.5	38.6
3 15	101.3	.6	102.9	99.9	536.6	232.0	897.1	16.3	984.0	37.0	1034.2	929.6	61.9	39.5	55.2	39.1
3 18	101.3	.6	102.9	99.8	43.7	24.4	112.7	0.0	209.6	595.1	8145.6	139.4	59.4	41.4	51.7	41.2
3 21	101.5	.6	103.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.6	44.2	50.0	44.6
4 0	101.3	.5	102.9	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.4	40.6	64.4	41.3
4 3	101.2	.5	102.9	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.5	40.1	61.3	40.5
4 6	101.2	.5	102.9	99.8	4.8	3.8	19.8	0.0	0.0	0.0	0.0	0.0	68.5	37.0	63.0	38.4
4 9	101.3	.6	103.0	100.1	412.9	172.0	699.5	4.6	845.2	21.9	883.1	801.8	72.2	33.4	67.8	33.7
4 12	101.3	.6	103.1	100.0	761.6	287.0	1156.2	53.5	1313.1	15.0	1336.3	1278.2	68.1	35.3	62.3	35.4
4 15	101.1	.6	103.0	99.9	609.1	216.3	913.3	9.3	1079.1	19.9	1103.9	1034.2	61.5	37.5	53.9	36.5
4 18	101.1	.6	102.6	99.8	84.2	37.1	194.1	0.0	277.1	200.3	3695.2	220.8	61.7	40.0	53.8	39.1
4 21	101.2	.5	102.9	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.2	40.7	56.2	41.9
5 0	101.2	.4	102.5	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.5	39.4	57.3	40.1
5 3	101.1	.4	102.4	99.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.8	40.2	57.0	40.8
5 6	101.2	.4	102.5	99.6	17.3	10.6	59.3	0.0	150.5	11.6	162.7	139.4	62.7	35.9	54.1	36.7
5 9	101.3	.4	102.6	99.7	475.5	181.4	726.3	7.0	895.1	12.7	906.4	871.5	64.7	31.8	59.6	32.2
5 12	101.2	.4	102.6	99.9	822.4	289.0	1208.5	19.8	1337.8	6.4	1347.9	1324.7	65.4	30.9	61.4	31.0
5 15	101.1	.4	102.5	99.8	656.0	221.3	1005.1	10.5	1109.1	7.7	1127.1	1092.3	56.7	33.4	52.5	32.9
5 18	101.0	.4	102.4	99.6	123.2	55.9	298.6	0.0	352.0	18.3	371.8	313.7	55.6	37.6	48.4	36.9
5 21	101.2	.4	102.5	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.8	40.3	52.6	40.0
6 0	101.2	.3	101.9	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.1	37.9	34.4	36.2
6 3	101.2	.3	101.8	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.0	38.0	33.3	37.1
6 6	101.2	.3	101.8	100.0	30.6	11.5	63.9	0.0	184.4	5.8	185.9	162.7	42.0	36.0	32.9	33.6
6 9	101.3	.3	102.0	100.1	537.1	163.7	761.1	0.0	912.2	5.8	918.0	906.4	59.1	28.7	55.8	27.8
6 12	101.3	.3	101.9	100.1	872.4	291.4	1259.6	13.9	1336.3	0.0	1336.3	1336.3	63.9	27.3	60.7	26.4
6 15	101.1	.3	101.8	100.0	706.1	209.8	985.4	7.0	1127.1	0.0	1127.1	1127.1	54.2	31.3	50.6	30.0
6 18	101.1	.3	101.8	99.9	168.3	52.2	299.8	5.8	371.8	0.0	371.8	371.8	46.1	35.2	41.7	33.4
6 21	101.2	.3	101.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.7	38.9	36.7	36.9

BROWNSVILLE

TABLE A-7. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 0	101.5	.2	102.1	101.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4	29.8	13.9	24.0
7 3	101.4	.2	102.0	100.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.3	30.8	16.9	26.3
7 6	101.4	.2	102.0	100.9	26.6	11.4	81.3	0.0	163.4	18.2	185.9	139.4	33.8	32.2	21.9	26.0
7 9	101.5	.2	102.2	101.0	553.9	143.3	800.6	30.2	901.1	9.7	906.4	883.1	52.6	25.6	45.7	24.2
7 12	101.5	.2	102.1	101.0	924.8	230.5	1220.1	25.6	1334.4	4.3	1336.3	1324.7	57.9	25.9	51.8	24.7
7 15	101.4	.2	102.0	100.9	749.6	161.7	958.6	36.0	1113.6	11.5	1127.1	1103.9	51.0	28.4	43.2	26.7
7 18	101.3	.2	101.9	100.8	170.3	43.9	371.8	24.4	362.8	11.3	371.8	348.6	40.8	32.8	30.6	28.6
7 21	101.4	.2	102.0	100.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.1	31.7	18.4	26.2
8 0	101.4	.2	101.9	100.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	35.3	19.3	29.7
8 3	101.3	.2	101.9	100.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.6	34.6	21.3	31.0
8 6	101.3	.2	101.9	100.4	10.3	6.9	38.3	0.0	139.4	0.0	139.4	139.4	39.8	33.9	29.1	30.8
8 9	101.5	.2	102.1	100.5	500.0	151.5	787.8	29.1	861.3	17.2	883.1	825.0	57.8	26.9	48.5	25.2
8 12	101.4	.2	102.1	100.5	841.3	282.4	1216.6	3.5	1312.7	9.1	1324.7	1289.8	64.3	26.1	57.9	25.3
8 15	101.3	.2	101.9	100.3	646.5	224.3	950.5	17.4	1083.7	11.0	1092.3	1045.8	57.5	29.8	49.3	28.3
8 18	101.2	.2	101.8	100.3	119.1	41.9	213.8	0.0	297.2	23.6	325.4	244.0	50.0	35.4	37.2	31.7
8 21	101.3	.2	101.9	100.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.8	36.1	24.9	31.5
9 0	101.3	.3	102.1	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.2	39.4	30.6	37.0
9 3	101.2	.4	102.1	97.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.1	38.5	28.3	36.3
9 6	101.2	.4	102.1	96.5	1.9	1.8	8.1	0.0	0.0	0.0	0.0	0.0	40.8	37.8	32.3	34.8
9 9	101.3	.4	102.3	97.0	437.4	142.3	683.3	0.0	782.4	29.0	825.0	743.7	52.9	33.5	46.5	32.1
9 12	101.3	.4	102.2	98.2	764.5	262.3	1149.2	15.1	1253.4	24.2	1289.8	1208.5	62.7	28.8	58.2	28.0
9 15	101.1	.3	102.0	99.1	575.7	217.6	904.0	29.1	1014.7	26.8	1045.8	976.1	58.4	32.1	52.7	30.5
9 18	101.1	.3	102.1	99.7	65.2	30.3	211.5	2.3	191.1	37.0	344.0	139.4	48.8	37.8	39.9	35.5
9 21	101.3	.3	102.1	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.3	40.0	29.2	37.5
10 0	101.5	.4	102.5	100.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.5	38.7	30.6	37.5
10 3	101.4	.4	102.4	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.0	39.7	34.2	38.9
10 6	101.5	.4	102.4	100.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.3	39.8	35.4	38.6
10 9	101.6	.4	102.5	100.4	360.6	124.6	654.2	17.4	666.4	38.1	743.7	604.2	45.9	37.8	41.1	36.1
10 12	101.6	.4	102.6	100.3	685.5	230.6	1016.8	23.2	1141.0	41.4	1208.5	1069.0	58.7	31.6	54.7	31.4
10 15	101.4	.4	102.4	100.3	486.8	176.5	811.1	48.8	892.5	38.5	976.1	825.0	54.8	32.2	50.9	31.6
10 18	101.4	.4	102.4	100.2	25.6	15.0	116.2	0.0	0.0	0.0	0.0	0.0	41.1	38.1	34.8	35.2
10 21	101.5	.4	102.5	100.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.5	39.2	29.9	36.6
11 0	101.7	.6	103.5	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.9	42.1	36.7	41.6
11 3	101.6	.6	103.4	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.3	41.6	38.8	41.1
11 6	101.7	.6	103.4	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.5	42.0	42.9	41.8
11 9	101.8	.6	103.6	100.2	268.7	122.0	447.4	7.0	539.6	32.2	604.2	488.0	49.9	40.8	45.2	40.4
11 12	101.8	.6	103.6	100.3	551.8	220.1	944.7	39.5	1008.6	37.5	1080.7	952.8	61.0	35.8	57.8	36.1
11 15	101.6	.6	103.4	100.1	395.2	167.0	669.3	25.6	767.8	29.0	813.4	720.4	54.9	36.2	50.8	36.1
11 18	101.6	.6	103.4	100.2	7.5	6.1	45.3	0.0	0.0	0.0	0.0	0.0	47.3	40.1	41.0	39.8
11 21	101.7	.6	103.6	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.8	42.4	35.5	41.8
12 0	101.7	.6	104.0	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.1	43.7	54.2	43.8
12 3	101.7	.6	104.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.3	43.9	56.3	44.2
12 6	101.7	.6	104.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.1	43.3	36.9	43.5
12 9	101.8	.6	104.2	100.3	198.9	101.6	413.7	3.5	470.8	10.2	488.0	464.8	62.0	42.2	57.1	41.9
12 12	101.8	.6	104.0	100.2	472.6	218.0	841.3	39.5	924.0	10.2	941.2	918.0	66.1	37.4	62.0	38.0
12 15	101.5	.6	103.7	100.1	325.4	156.2	592.6	15.1	700.2	7.8	720.4	697.2	65.7	36.2	59.7	36.5
12 18	101.6	.7	103.8	100.1	3.0	3.0	30.2	0.0	0.0	0.0	0.0	0.0	58.7	40.6	52.7	41.0
12 21	101.7	.6	103.9	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.9	44.5	51.5	44.8

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TABLE A-8. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR BROWNSVILLE, TEXAS

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 0	43	23	16	1	1										2
1 3	62	23	15	3	1										
1 6	74	21	18	2	1				1						
1 9	90	17	19	1											11
1 12	27	19	18	1											16
1 15	19	18	11										1		21
1 18	21	13	11	1									1		23
1 21	22	19	19	3											5
2 0	23	12	15	1											2
2 3	42	7	15		1										1
2 6	48	13	12	1											4
2 9	51	11	16	3	1										19
2 12	12	8	11	3	1									2	25
2 15	8	11	6	2	1									1	21
2 18	8	14	7	1	1										17
2 21	10	12	15												5
3 0	28	6	7	1											3
3 3	34	10	9	2											1
3 6	50	12	7	3											3
3 9	39	10	11	2											26
3 12	6	10	10	2										1	27
3 15	6	7	3	1											21
3 18	4	7	4		1									1	10
3 21	16	3	9	1	1										5
4 0	12	4	4	2	3										16
4 3	31	3	5	4	3										7
4 6	63	5	5		1										23
4 9	20	2	2	2	3										42
4 12		1	4	7											37
4 15	2		5	2											36
4 18	2	1	3		1										38
4 21	4	3	6	1	2										26
			4												
5 0	14		4	2	3										15
5 3	27	2	9	2	1										11
5 6	83	2	7	3	2										26
5 9	4	1	6	7	1										49
5 12	2	2	4	2	8										37
5 15		1	6	3	5									1	32
5 18	1	1	2	3	1										30
5 21	1		8	1	4										26
6 0			2		1										2
6 3	2		6	3	1										1
6 6	33		6	3	1										13
6 9			5	13	2										12
6 12			5	15	4										11
6 15			5	12	1										14
6 18			5	3	1										17
6 21			2	5											9

BROWNSVILLE

TABLE A-8. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 0				2	2										1
7 3	5			3	1										
7 6	32		1	7	1										10
7 9	2			5	2										6
7 12			1	9	1										4
7 15			2	6	1										4
7 18			2	2	1										4
7 21					1										2
8 0	2		3		1										4
8 3	4		1	2	2										6
8 6	21		5	5											3
8 9	1		6	10	1										15
8 12			4	13	10										13
8 15			4	11	7										13
8 18			4	1											11
8 21			2	2											10
9 0	1		2	8	1										3
9 3	6		5	12	3										3
9 6	25		9	10	1										5
9 9	10		5	15	1										12
9 12	1		8	14	5										9
9 15			6	10	8										7
9 18	1	1	4	3	6										6
9 21	1		6	5											3
10 0	3		4	4	2										1
10 3	16		7	7	2										1
10 6	32	2	7	8	2										2
10 9	18		4	8											15
10 12	2		8	7	1										11
10 15	2		4	8	1										8
10 18	1		6	3											11
10 21	2		5	2											6
11 0	22	2	8	2											
11 3	42	5	13	1											1
11 6	56	4	13	5	1										
11 9	34	5	9	4	1										14
11 12	8	3	9	1											10
11 15	4	5	6	3											10
11 18	3	8	5	2											5
11 21	10	6	7	2	1										1
12 0	33	12	8	1	1										
12 3	49	13	8	2											
12 6	55	13	8	3	1										
12 9	47	12	12	3											6
12 12	11	16	12												12
12 15	6	10	11	3											10
12 18	8	8	12		1										4
12 21	10	14	7	1											4

BROWNSVILLE

TABLE A-9. DESCRIPTIVE CLIMATIC STATISTICS FOR CLEVELAND, OHIO
AT 3-HOURLY INTERVALS BY MONTH FOR YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 1	-3.9	7.2	16.1	-20.6	-8.3	7.7	11.7	-27.2	72.4	11.7	100.0	28.0	5.2	2.2	14.9	0.0
1 4	-4.4	7.5	15.6	-23.3	-10.3	8.3	11.7	*	73.6	11.3	96.0	43.0	5.1	2.3	15.4	1.5
1 7	-4.7	7.5	16.7	-25.0	-8.7	7.9	12.2	*	74.4	11.5	100.0	41.0	5.1	2.2	12.3	0.0
1 10	-3.7	7.4	16.7	-22.2	-9.7	8.6	12.8	*	73.1	11.2	100.0	44.0	5.7	2.2	12.3	0.0
1 13	-1.8	7.2	18.3	-21.1	-7.1	7.5	12.2	*	68.2	13.1	96.0	32.0	6.2	2.4	13.4	0.0
1 16	-1.6	7.0	18.9	-20.0	-7.3	7.5	12.8	-26.1	66.6	13.6	100.0	31.0	6.0	2.3	13.9	0.0
1 19	-2.8	6.8	16.1	-20.0	-7.7	7.5	12.2	-26.7	69.8	12.1	100.0	35.0	5.1	2.4	13.9	0.0
1 22	-3.4	7.2	15.6	-20.0	-8.0	7.8	12.8	*	71.5	12.2	100.0	31.0	5.3	2.3	12.9	0.0
2 1	-3.5	6.2	14.4	-20.0	-8.2	12.2	10.6	*	72.2	12.1	96.0	38.0	5.1	2.3	12.9	0.0
2 4	-4.2	6.3	14.4	-20.6	-8.5	6.5	10.6	-26.1	73.2	11.5	100.0	42.0	5.0	2.4	15.4	0.0
2 7	-4.8	6.6	15.0	-21.1	-8.8	6.8	11.7	-26.1	74.6	10.8	100.0	46.0	4.9	2.4	15.4	0.0
2 10	-3.2	6.2	15.0	-18.9	-7.8	6.5	11.7	-25.0	71.8	12.4	96.0	36.0	5.4	2.3	12.9	0.0
2 13	-1.2	6.1	17.2	-16.1	-7.1	6.2	9.4	-23.3	66.1	13.6	100.0	26.0	5.8	2.4	16.5	1.0
2 16	-.8	6.1	16.1	-15.6	-6.9	6.1	9.4	-21.1	65.1	13.8	100.0	26.0	5.9	2.4	16.5	0.0
2 19	-2.0	6.0	15.0	-16.1	-7.3	6.3	8.9	-22.2	68.5	12.9	100.0	30.0	4.9	2.4	12.3	0.0
2 22	-2.8	6.1	15.0	-17.2	-7.6	6.4	9.4	-24.4	71.0	12.5	96.0	35.0	5.1	2.3	12.3	0.0
3 1	1.1	5.9	20.0	-11.7	-3.5	6.1	12.2	-16.7	73.0	14.2	100.0	22.0	4.7	2.3	13.4	0.0
3 4	.4	5.9	17.2	-12.8	-3.8	6.2	12.8	-18.3	74.7	13.4	100.0	27.0	4.6	2.1	12.3	0.0
3 7	.1	6.0	16.1	-15.0	-3.9	6.5	12.2	-18.9	75.6	12.9	100.0	36.0	4.6	2.0	11.8	0.0
3 10	2.6	6.4	21.7	-11.1	-2.7	6.6	13.9	-16.7	69.8	16.0	100.0	23.0	5.4	2.2	13.4	0.0
3 13	4.7	7.3	25.6	-9.4	-2.3	6.6	13.3	-16.1	63.5	17.5	100.0	21.0	6.1	2.5	13.9	0.0
3 16	4.7	7.1	24.4	-7.8	-2.3	6.5	13.3	-15.0	63.4	17.4	100.0	22.0	6.0	2.5	15.4	1.5
3 19	3.0	6.4	21.1	-9.4	-2.8	6.5	12.8	-16.1	68.1	16.6	100.0	26.0	4.6	2.2	14.4	0.0
3 22	2.0	6.1	19.4	-10.6	-2.9	6.2	12.8	-16.7	71.6	14.4	100.0	25.0	4.7	2.4	15.4	0.0
4 1	6.8	5.9	21.7	-5.0	1.4	5.9	16.7	-11.7	70.1	13.9	100.0	27.0	4.1	2.1	10.3	0.0
4 4	5.9	5.9	21.1	-7.2	1.1	5.9	15.6	-12.2	72.7	13.5	100.0	30.0	4.1	2.1	11.3	0.0
4 7	6.1	6.0	20.6	-7.8	1.4	6.0	17.8	-11.7	73.0	13.3	100.0	32.0	4.4	2.2	11.3	0.0
4 10	10.2	6.3	25.0	-4.4	2.5	6.0	17.8	-10.6	61.6	16.6	100.0	23.0	5.8	2.4	11.3	0.0
4 13	12.1	6.9	28.3	-4.4	2.9	6.2	20.0	-10.6	56.2	17.2	96.0	18.0	6.3	2.3	15.4	1.5
4 16	12.0	6.7	28.9	-5.0	2.6	6.3	19.4	-10.6	55.7	17.6	96.0	18.0	6.1	2.3	14.4	1.5
4 19	10.2	6.3	27.2	-5.6	1.9	6.4	18.9	-10.0	59.2	16.8	93.0	22.0	4.6	2.2	13.9	0.0
4 22	8.2	5.9	25.0	-5.6	1.9	6.0	17.2	-10.6	66.2	15.3	96.0	31.0	4.2	2.2	11.8	0.0
5 1	11.4	4.8	24.4	-2.2	6.7	5.4	19.4	-8.9	74.5	14.1	100.0	37.0	3.4	1.7	8.7	0.0
5 4	10.5	4.9	23.9	-2.2	6.5	5.3	18.9	-7.2	77.4	13.0	100.0	38.0	3.4	1.8	9.8	0.0
5 7	11.8	4.7	23.3	-.6	7.4	5.1	19.4	-4.4	75.8	13.2	100.0	38.0	3.9	1.8	9.3	0.0
5 10	15.8	5.5	27.2	3.9	8.3	5.5	20.0	-7.8	63.7	16.4	100.0	26.0	5.1	2.1	12.3	0.0
5 13	17.7	6.1	30.6	4.4	8.7	5.5	20.6	-5.6	58.4	16.6	100.0	26.0	5.7	2.1	14.4	1.5
5 16	17.8	6.0	31.1	3.3	8.0	5.8	20.0	-5.6	55.5	17.0	100.0	25.0	5.7	2.0	14.9	0.0
5 19	15.8	5.4	28.3	3.3	7.3	5.9	18.9	-11.7	59.9	17.2	100.0	23.0	4.2	1.8	10.3	0.0
5 22	13.0	4.8	23.9	1.1	7.2	5.6	19.4	-8.9	69.5	15.6	100.0	36.0	3.5	1.7	9.3	0.0
6 1	17.0	4.3	26.7	2.8	13.0	4.2	21.1	0.0	78.1	10.7	100.0	45.0	3.3	1.7	11.3	0.0
6 4	16.0	4.3	25.0	.6	12.7	4.2	20.6	-.6	81.6	9.9	100.0	45.0	3.2	1.7	10.3	0.0
6 7	17.7	3.8	26.1	5.0	13.6	3.9	21.1	-2.2	77.9	10.2	100.0	52.0	3.8	1.6	9.3	0.0
6 10	21.9	4.7	31.1	8.3	14.6	4.2	22.2	.6	64.5	12.9	97.0	36.0	4.6	1.8	11.8	0.0
6 13	23.7	5.1	33.9	8.9	14.7	4.2	23.3	1.1	58.5	13.5	93.0	27.0	5.3	1.9	10.3	0.0
6 16	23.6	5.0	34.4	9.4	14.3	4.3	22.8	2.2	57.6	14.4	97.0	25.0	5.1	1.8	10.3	0.0
6 19	22.0	4.6	33.3	7.8	13.8	4.4	22.2	1.1	61.6	15.0	100.0	29.0	3.9	1.7	10.3	0.0
6 22	18.7	4.1	27.8	7.8	13.5	4.2	21.7	-2.8	73.1	12.0	100.0	43.0	3.4	1.8	10.3	0.0

CLEVELAND

*Data are not available.

TABLE A-9. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 1	18.7	3.4	27.2	8.3	15.1	3.6	22.8	5.0	80.3	9.0	100.0	46.0	2.9	1.4	8.7	0.0
7 4	17.6	3.7	25.6	6.7	14.7	3.6	22.2	5.0	83.7	8.3	100.0	57.0	2.9	1.5	10.3	0.0
7 7	19.2	3.2	25.6	10.6	15.7	3.2	22.8	7.2	80.7	8.4	100.0	54.0	3.3	1.6	9.3	0.0
7 10	24.0	3.3	31.7	12.8	16.5	3.7	23.9	6.7	64.3	11.6	93.0	35.0	4.3	1.7	10.3	0.0
7 13	25.6	3.7	33.9	12.8	16.3	3.9	23.9	5.6	57.9	12.8	97.0	26.0	4.8	1.7	10.8	0.0
7 16	25.5	3.8	34.4	13.9	15.9	3.9	23.9	5.6	56.9	13.2	97.0	30.0	4.8	1.6	8.7	0.0
7 19	23.8	3.3	31.7	14.4	15.6	3.9	23.3	3.3	61.6	12.9	100.0	33.0	3.6	1.6	9.3	0.0
7 22	20.5	3.1	31.1	11.1	15.5	3.5	23.9	5.6	73.7	9.9	97.0	44.0	2.9	1.5	6.7	0.0
8 1	18.2	3.4	26.1	9.4	15.1	3.5	22.8	5.6	82.5	8.6	100.0	60.0	2.8	1.6	9.3	0.0
8 4	17.1	3.6	25.6	7.2	14.5	3.7	22.2	5.0	85.4	8.2	100.0	50.0	2.7	1.4	8.7	0.0
8 7	17.8	3.3	26.7	7.2	15.1	3.5	22.8	6.1	84.6	8.0	100.0	58.0	3.0	1.5	8.2	0.0
8 10	23.3	3.2	30.0	13.9	16.5	3.6	24.4	7.2	66.7	11.1	93.0	42.0	4.2	1.9	9.3	0.0
8 13	25.2	3.6	33.3	15.6	16.4	3.6	24.4	7.2	59.2	11.6	93.0	33.0	4.7	1.7	10.3	0.0
8 16	25.2	3.7	33.9	15.0	16.1	3.6	23.9	6.7	58.0	11.7	93.0	29.0	4.7	1.5	8.7	0.0
8 19	22.9	3.3	31.7	13.3	15.8	3.7	24.4	6.1	65.0	10.7	93.0	43.0	3.3	1.5	8.7	0.0
8 22	19.9	3.3	27.8	11.1	15.6	3.5	23.3	3.9	76.8	8.9	97.0	54.0	2.9	1.5	8.2	0.0
9 1	15.4	4.5	25.0	2.8	12.1	4.8	21.1	-2.2	81.3	10.3	100.0	49.0	3.2	1.6	8.7	0.0
9 4	14.4	4.7	23.9	2.2	11.7	4.8	20.6	-2.2	84.0	9.8	100.0	51.0	3.1	1.8	8.2	0.0
9 7	14.5	4.7	23.3	2.8	11.7	4.9	21.1	-.6	84.2	9.3	100.0	49.0	3.3	1.7	9.8	0.0
9 10	19.5	4.5	30.6	5.6	13.7	4.6	22.8	1.1	70.0	12.3	100.0	37.0	4.4	2.0	9.8	0.0
9 13	21.7	5.0	32.8	7.2	13.4	4.9	22.2	0.0	61.2	14.3	97.0	28.0	4.8	1.9	10.3	0.0
9 16	21.4	4.9	32.2	7.2	13.1	4.9	22.2	.6	60.9	13.9	96.0	30.0	4.8	1.7	9.3	0.0
9 19	18.7	4.4	28.3	7.2	12.7	4.9	22.2	-.6	69.2	12.2	97.0	33.0	3.2	1.5	8.2	0.0
9 22	16.4	4.4	26.1	3.9	12.4	4.6	21.7	0.0	77.9	10.2	100.0	49.0	3.3	1.7	9.3	0.0
10 1	9.7	5.1	21.1	-3.9	5.8	5.7	18.3	-7.2	77.6	13.1	100.0	38.0	3.9	1.8	11.3	0.0
10 4	8.9	5.2	21.1	-3.9	5.5	5.8	18.3	-7.2	80.1	12.7	100.0	42.0	3.8	1.8	10.3	0.0
10 7	8.5	5.2	20.0	-5.6	5.3	5.8	17.8	-7.8	81.2	11.9	100.0	45.0	3.9	1.9	9.3	0.0
10 10	12.8	5.0	25.0	.6	7.3	5.5	18.9	-5.0	70.5	13.5	100.0	36.0	5.0	2.1	11.3	0.0
10 13	15.3	5.8	28.3	2.2	7.4	5.8	18.3	-5.6	61.0	15.5	100.0	27.0	5.4	2.2	15.9	0.0
10 16	15.3	5.8	28.3	1.7	7.1	6.0	18.9	-5.6	60.6	16.4	100.0	25.0	5.0	1.9	12.3	0.0
10 19	12.4	5.1	24.4	1.1	6.6	5.8	18.3	-6.1	69.2	14.8	100.0	35.0	3.6	1.9	11.3	0.0
10 22	10.6	5.1	21.7	-2.8	6.1	5.7	17.8	-6.7	75.0	14.1	100.0	33.0	3.9	2.0	10.8	0.0
11 1	4.6	5.3	18.3	-9.4	.6	5.9	15.0	-12.8	76.4	12.7	100.0	36.0	4.6	2.2	10.8	0.0
11 4	4.2	5.4	20.0	-8.9	.4	6.0	16.1	-13.3	77.6	12.0	100.0	41.0	4.7	2.2	15.4	0.0
11 7	3.9	5.3	21.1	-8.9	.3	6.0	15.6	-15.0	78.5	11.7	100.0	42.0	4.8	2.2	11.3	0.0
11 10	5.5	5.3	20.0	-8.9	1.4	5.9	16.7	-16.1	75.8	12.4	100.0	46.0	5.4	2.2	14.4	0.0
11 13	7.3	5.6	23.3	-7.2	1.7	6.0	17.2	-15.0	69.1	14.5	100.0	36.0	5.8	2.3	13.4	1.0
11 16	7.3	5.6	23.9	-7.2	1.4	6.1	16.1	-14.4	68.0	14.7	100.0	32.0	5.4	2.3	13.9	0.0
11 19	5.8	5.2	20.6	-7.8	1.0	5.9	15.6	-14.4	72.7	13.3	100.0	37.0	4.8	2.4	12.9	0.0
11 22	4.9	5.2	18.9	-10.6	.7	5.8	16.1	-12.2	75.2	12.8	100.0	35.0	4.7	2.2	11.8	0.0
12 1	.2	5.4	15.6	-12.8	-4.0	5.9	13.3	-18.3	74.5	11.7	100.0	38.0	5.1	2.3	11.8	0.0
12 4	-.2	5.4	16.1	-13.9	-4.2	5.9	14.4	-19.4	75.3	11.6	100.0	37.0	5.1	2.3	12.9	0.0
12 7	-.5	5.4	16.1	-15.0	-4.4	6.0	13.3	-18.3	75.9	11.5	100.0	42.0	5.1	2.3	12.9	0.0
12 10	.3	5.3	17.8	-13.3	-3.8	5.9	14.4	-17.2	75.2	12.0	100.0	32.0	5.5	2.3	12.9	0.0
12 13	1.7	5.3	17.8	-10.6	-3.2	5.8	14.4	-17.8	71.4	13.5	100.0	36.0	5.9	2.4	14.4	0.0
12 16	1.8	5.4	20.0	-10.0	-3.2	6.0	13.9	-17.2	70.8	13.9	100.0	32.0	5.6	2.3	14.4	0.0
12 19	1.0	5.4	18.3	-12.8	-3.5	6.1	13.3	-17.8	73.4	12.6	100.0	28.0	5.1	2.5	14.4	0.0
12 22	.5	5.6	16.7	-14.4	-3.7	6.3	13.3	-19.4	74.9	12.2	100.0	34.0	5.2	2.5	13.9	0.0

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TABLE A-9. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 1	98.9	.8	101.0	96.0									77.9	37.4	74.2	39.6
1 4	98.9	.8	101.2	96.3									76.1	38.4	71.9	39.7
1 7	98.9	.8	101.2	96.1									80.5	35.1	76.8	37.2
1 10	99.0	.8	101.4	96.2									83.7	29.9	74.3	35.4
1 13	98.9	.8	101.3	96.1									85.0	27.7	75.5	33.1
1 16	98.9	.8	101.0	96.4									80.5	33.0	73.9	35.4
1 19	98.9	.8	101.0	96.1									78.1	34.4	71.0	38.0
1 22	98.9	.8	100.9	95.4									75.5	37.3	70.9	39.4
2 1	98.8	.8	100.7	96.2									72.5	41.3	69.1	42.3
2 4	98.8	.8	100.7	95.5									74.3	38.8	70.5	40.4
2 7	98.8	.8	100.8	95.1									76.2	36.9	71.1	38.8
2 10	98.9	.9	100.8	94.9									78.0	35.5	70.3	38.0
2 13	98.8	.9	100.7	95.2									75.1	35.8	69.0	38.2
2 16	98.7	.9	100.7	95.8									76.4	35.7	70.0	38.1
2 19	98.8	.8	100.8	96.4									72.3	39.5	66.6	41.5
2 22	98.8	.8	100.8	96.3									69.9	41.0	65.5	42.6
3 1	98.6	.8	100.7	96.2									72.0	39.5	66.6	41.6
3 4	98.6	.8	100.6	95.5									74.5	38.7	70.9	40.3
3 7	98.7	.8	100.7	95.3									78.2	35.0	73.1	37.3
3 10	98.7	.9	100.8	95.1									78.9	34.7	72.4	37.7
3 13	98.7	.9	100.8	95.0									77.9	34.4	70.0	37.1
3 16	98.6	.8	100.7	95.5									77.1	35.4	68.0	39.0
3 19	98.6	.8	100.7	96.1									75.5	37.2	67.4	40.2
3 22	98.7	.8	100.7	96.3									71.8	40.5	66.6	41.8
4 1	98.7	.8	100.2	96.3									66.8	42.5	61.1	43.6
4 4	98.6	.8	100.2	95.8									66.0	42.4	60.2	44.1
4 7	98.7	.8	100.4	95.2									71.4	38.5	61.6	40.8
4 10	98.7	.8	100.4	95.3									70.2	39.0	59.6	40.9
4 13	98.7	.8	100.3	95.6									69.5	38.8	59.2	40.8
4 16	98.6	.7	100.3	96.1									68.0	40.3	58.0	42.0
4 19	98.6	.7	100.2	96.3									68.6	40.3	59.7	41.1
4 22	98.7	.7	100.3	96.5									65.5	42.6	59.3	44.0
5 1	98.7	.6	100.1	96.9									59.8	42.9	53.4	43.8
5 4	98.6	.6	100.2	96.7									62.4	43.4	56.4	43.8
5 7	98.7	.6	100.4	96.5									65.5	40.1	56.0	42.0
5 10	98.7	.7	100.6	96.4									64.7	39.5	54.1	41.9
5 13	98.7	.6	100.6	96.4									63.8	39.1	53.2	40.1
5 16	98.6	.6	100.4	96.5									66.0	37.7	53.8	39.4
5 19	98.6	.6	100.2	96.7									69.4	37.2	56.5	39.8
5 22	98.7	.6	100.0	96.8									63.3	41.0	56.3	42.6
6 1	98.6	.5	99.6	97.1									56.8	43.2	48.0	42.8
6 4	98.6	.5	99.7	96.9									58.5	42.1	50.9	43.0
6 7	98.7	.5	99.9	97.0									62.7	40.5	51.5	40.5
6 10	98.7	.5	99.8	97.0									62.4	39.9	49.2	39.8
6 13	98.7	.5	99.7	97.3									65.9	35.7	54.2	35.9
6 16	98.6	.5	99.6	97.4									61.9	37.5	48.8	37.3
6 19	98.6	.5	99.6	97.0									61.9	39.2	48.3	40.0
6 22	98.6	.4	99.7	96.9									58.1	41.2	49.0	41.2

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TABLE A-9. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 1	98.8	.4	99.6	97.5									45.3	41.7	38.7	40.5
7 4	98.7	.4	99.6	97.5									48.0	42.0	41.5	41.7
7 7	98.8	.4	99.7	97.7									60.1	40.0	47.7	39.8
7 10	98.9	.4	99.8	97.7									59.5	38.5	46.3	37.2
7 13	98.8	.4	99.7	97.6									62.2	35.9	50.8	35.5
7 16	98.8	.4	99.6	97.5									59.0	38.9	47.6	37.5
7 19	98.7	.4	99.6	97.5									56.4	41.2	44.3	39.8
7 22	98.8	.4	99.6	97.5									51.4	41.7	42.7	40.8
8 1	98.8	.4	99.8	97.4									42.9	42.6	38.3	41.8
8 4	98.8	.4	99.8	97.4									42.6	42.9	37.9	41.3
8 7	98.9	.4	99.9	97.4									56.5	40.8	47.3	40.1
8 10	98.9	.4	100.0	97.5									54.7	39.9	45.6	38.9
8 13	98.9	.4	99.9	97.5									60.0	35.4	50.6	34.7
8 16	98.8	.4	99.8	97.5									54.1	37.2	45.8	36.6
8 19	98.8	.4	99.8	97.4									50.1	39.7	40.1	38.3
8 22	98.8	.4	99.9	97.5									45.8	40.7	39.4	40.2
9 1	98.9	.5	100.0	97.2									53.3	42.5	47.7	42.9
9 4	98.9	.5	100.0	97.3									51.4	44.0	47.6	43.8
9 7	99.0	.5	100.2	97.1									61.4	41.4	53.8	41.3
9 10	99.0	.6	100.3	97.0									62.2	40.2	53.4	41.0
9 13	99.0	.5	100.1	96.6									66.9	34.3	57.8	36.1
9 16	98.9	.5	100.0	96.4									63.7	38.4	54.6	39.7
9 19	98.9	.5	100.0	96.8									59.9	40.3	50.3	40.8
9 22	98.9	.5	100.0	97.1									56.6	42.3	50.0	42.9
10 1	98.9	.6	100.6	96.3									56.8	43.7	53.2	44.5
10 4	98.9	.7	100.6	96.3									56.1	44.1	53.4	44.5
10 7	99.0	.7	100.8	96.2									64.7	41.0	59.3	42.5
10 10	99.0	.7	100.9	96.3									63.2	41.3	46.0	42.0
10 13	99.0	.7	100.8	96.3									67.0	38.8	57.9	40.9
10 16	98.9	.7	100.6	96.4									67.6	39.3	58.3	40.3
10 19	98.9	.7	100.6	96.5									62.4	41.1	55.8	42.1
10 22	99.0	.7	100.7	93.6									58.4	43.1	53.2	43.5
11 1	98.7	.8	100.4	96.2									77.0	37.4	74.2	38.9
11 4	98.7	.8	100.4	96.1									80.3	35.0	77.7	37.1
11 7	98.8	.8	100.3	96.1									83.8	30.2	79.9	33.3
11 10	98.8	.8	100.5	96.1									84.9	29.3	79.9	33.4
11 13	98.7	.8	100.3	96.0									84.5	29.6	79.7	32.3
11 16	98.7	.8	100.4	96.0									84.9	29.7	78.3	33.6
11 19	98.8	.8	100.4	96.2									82.0	33.4	77.8	35.6
11 22	98.8	.8	100.5	96.5									81.9	34.0	77.8	36.3
12 1	98.8	.8	101.0	96.6									86.5	30.4	84.1	32.5
12 4	98.8	.8	101.0	96.2									86.0	31.1	83.3	33.2
12 7	98.8	.8	101.2	95.8									87.3	27.8	84.2	30.6
12 10	98.9	.8	101.4	95.5									88.0	28.1	83.9	31.5
12 13	98.8	.8	101.4	95.3									89.4	25.2	85.3	28.5
12 16	98.7	.8	101.3	95.5									88.7	26.5	84.3	30.2
12 19	98.8	.8	101.3	95.9									87.2	27.6	84.0	31.1
12 22	98.8	.8	101.2	96.4									85.1	30.9	81.9	33.8

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TABLE A-10. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR CLEVELAND, OHIO

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 1	29	6	13	7			33	57	1	1	1				54
1 4	35	9	15	7			34	47	1	1					41
1 7	32	2	13	3			38	48	4	1	1		2		40
1 10	38	4	13	3			48	50	2	2	4		2		95
1 13	33	5	14	2			36	45	2						83
1 16	30	5	10	2			37	45	1		1				75
1 19	24	4	18	2			31	49	1		1				73
1 22	29	8	15	3			28	44	2	2			1		50
2 1	28	2	9	5			39	36	1				1		28
2 4	27	1	9	5			36	46			1				34
2 7	29	3	12	5	1		40	46	3						45
2 10	42	3	10	4			38	37		1	1				82
2 13	27	3	12	3			37	38							65
2 16	23	5	8	1			36	44	1	1					67
2 19	24	1	9	2			31	33							56
2 22	26	3	10	5	1		33	37							41
3 1	46	5	16	12	1		23	37	2						26
3 4	53	6	10	10			32	29	2	1					27
3 7	68	6	8	15			24	33	3	1					54
3 10	63	12	16	6			22	26	1	2					69
3 13	40	2	10	7	1		18	32		2					53
3 16	36	6	15	13			19	32			1				48
3 19	48	5	12	18	1		23	26					1		54
3 22	47	8	14	12			19	27	1	1			1		39
4 1	29	4	17	11	1		7	6		1			1		11
4 4	29	5	19	14	1		4	6							13
4 7	43	6	19	16	1		4	7							68
4 10	21	5	17	20			5	7							49
4 13	19	5	16	19			1	9							35
4 16	17	3	13	17	1		2	9							33
4 19	23	2	16	16	1		2	5							48
4 22	21	7	18	23	4		3	6							31
5 1	37	3	15	26	1										23
5 4	41	2	13	22			1								24
5 7	60	5	14	29			1				2				60
5 10	34	6	13	20											41
5 13	23	7	9	15	2										34
5 16	19	3	11	15	4										42
5 19	24	5	10	35	8										43
5 22	31	3	14	22	4		1								30
6 1	33	2	3	14	2										45
6 4	36	3	4	21	4										44
6 7	57	3	10	15											89
6 10	22	5	8	10	1										79
6 13	11	1	7	21	4										79
6 16	7		6	17	4										73
6 19	12	1	4	18	8										67
6 22	16	2	5	15	3										54

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TABLE A-10. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 1	22		7	13	2										60
7 4	44	1	3	9	2										64
7 7	65	1	3	14	2										113
7 10	12	1	5	8	1										106
7 13	11	2	3	20	6							1			78
7 16	4	1		22	4										89
7 19	4		4	21	3										83
7 22	8		3	12	4										71
8 1	30		3	12	2										71
8 4	45	1	1	14	2										72
8 7	90	2	1	14	1										128
8 10	18		2	11											130
8 13	9			16	3										96
8 16	7	3	2	15	3										105
8 19	10		3	16	4										107
8 22	15		2	11	4										80
9 1	29	1	11	14	4										55
9 4	49	1	14	13											59
9 7	89	1	13	10											101
9 10	29	5	11	19	1										99
9 13	17	3	9	11	2										72
9 16	11	2	10	20	5										81
9 19	15		6	13	4										95
9 22	15	4	4	18	2										71
10 1	44	4	22	13	2		1								28
10 4	45	1	17	12	1		1	1							29
10 7	79	9	17	15			1	1			1				55
10 10	42	5	17	12			1	3			1				70
10 13	18	6	15	17			1	1			1				47
10 16	24	4	13	14	1		1	3							45
10 19	32	4	14	15			1	1							52
10 22	41	3	19	12			1	1			1				45
11 1	50	6	28	10	1		6	15							34
11 4	45	7	24	8			12	11							23
11 7	62	10	24	13			13	16							23
11 10	60	9	18	13			14	24							69
11 13	37	9	28	13	1		13	21							59
11 16	35	4	28	7			11	19			1				49
11 19	43	6	29	9			16	15							39
11 22	39	4	26	9			7	14							29
12 1	42	15	15	9			24	37	1	1					35
12 4	43	11	24	6			23	40		2			1		33
12 7	43	12	27	3			29	44		1			1		36
12 10	57	10	21	2			25	44					2		76
12 13	42	10	24	3			17	43	1	1					82
12 16	48	6	22	3			18	35	1						75
12 19	43	14	28	7			24	28							58
12 22	46	17	12	1			25	37					1		45

CLEVELAND

TABLE A-11. DESCRIPTIVE CLIMATIC STATISTICS FOR FAIRBANKS, ALASKA AT 3-HOURLY INTERVALS BY MONTH FOR YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 2	-29.0	12.2	-.6	-50.0		*			67.1	11.9	100.0	35.0	1.1	1.3	6.7	0.0
1 5	-29.0	12.2	0.0	-49.4					67.4	11.9	100.0	34.0	1.1	1.3	6.2	0.0
1 8	-29.2	12.1	0.0	-50.0					67.6	12.1	96.0	34.0	1.1	1.3	6.2	0.0
1 11	-28.1	11.7	-.5	-49.4					67.9	12.1	96.0	33.0	1.1	1.3	6.2	0.0
1 14	-26.6	11.1	.5	-50.0					67.9	13.6	100.0	35.0	1.0	1.4	11.3	0.0
1 17	-27.7	11.4	-2.8	-48.9					67.5	13.1	100.0	33.0	1.1	1.3	8.7	0.0
1 20	-28.6	11.5	-2.2	-48.9					67.3	12.7	100.0	35.0	1.1	1.3	6.7	0.0
1 23	-28.5	11.7	-1.1	-50.0					67.2	12.4	100.0	35.0	1.2	1.3	8.7	0.0
2 2	-23.4	10.0	2.2	-47.2					63.3	14.9	100.0	26.0	1.8	1.5	10.3	0.0
2 5	-23.7	10.0	3.3	-48.3					62.9	14.8	100.0	23.0	1.8	1.5	10.3	0.0
2 8	-23.7	9.9	4.4	-48.3					63.1	14.4	100.0	28.0	1.7	1.6	7.2	0.0
2 11	-20.4	9.5	5.0	-42.8					62.6	15.7	100.0	27.0	1.6	1.7	8.7	0.0
2 14	-17.3	9.1	6.1	-40.6					61.0	16.3	100.0	27.0	1.7	1.7	10.8	0.0
2 17	-18.8	9.3	5.0	-42.8					62.0	16.3	100.0	30.0	2.0	1.8	11.3	0.0
2 20	-21.2	9.5	5.6	-44.4					63.1	15.1	100.0	34.0	2.1	1.5	10.3	0.0
2 23	-22.3	9.9	3.9	-44.4					62.6	14.9	100.0	29.0	2.0	1.5	8.2	0.0
3 2	-15.5	10.0	5.6	-38.3					62.3	16.1	100.0	30.0	2.4	1.8	9.3	0.0
3 5	-16.4	10.2	5.0	-37.8					62.7	15.6	100.0	35.0	2.1	1.7	9.3	0.0
3 8	-15.3	10.2	6.7	-37.8					61.7	15.2	96.0	33.0	2.1	2.0	15.9	0.0
3 11	-9.7	9.4	9.4	-33.3					55.6	14.8	100.0	26.0	2.1	2.1	13.4	0.0
3 14	-6.9	9.1	8.9	-30.0					51.8	13.9	100.0	30.0	2.6	2.0	11.3	0.0
3 17	-7.3	8.9	9.4	-27.8					52.4	15.0	100.0	29.0	2.9	2.0	11.8	0.0
3 20	-11.3	9.3	5.0	-33.3					59.1	14.9	96.0	34.0	2.7	1.9	10.3	0.0
3 23	-13.7	9.6	4.4	-35.6					61.6	16.0	100.0	34.0	2.6	1.8	10.3	0.0
4 2	-4.1	5.5	5.6	-20.0					62.5	14.6	100.0	36.0	3.0	1.7	7.7	0.0
4 5	-5.2	5.8	5.6	-24.4					64.7	15.0	100.0	37.0	2.6	1.8	7.7	0.0
4 8	-2.1	5.8	11.1	-18.3					57.1	15.7	96.0	25.0	2.6	1.9	7.7	0.0
4 11	1.5	5.8	13.9	-12.2					48.9	15.5	100.0	18.0	3.3	2.1	11.8	0.0
4 14	3.5	5.6	17.2	-11.1					44.3	14.9	100.0	14.0	3.6	2.2	10.3	0.0
4 17	3.5	5.6	17.8	-12.2					44.4	15.4	100.0	18.0	3.8	2.2	12.3	0.0
4 20	.7	5.4	12.8	-17.8					51.4	15.2	100.0	27.0	3.3	1.8	11.8	0.0
4 23	-2.0	5.5	11.7	-19.4					58.8	14.9	100.0	34.0	3.2	1.7	9.3	0.0
5 2	4.4	3.8	15.6	-10.6	-2.3	4.3	8.9	-15.0	63.8	15.8	96.0	29.0	3.0	1.8	11.3	0.0
5 5	4.5	3.8	15.6	-8.9	-2.2	4.4	8.3	-15.6	64.0	15.6	100.0	29.0	2.5	1.8	9.3	0.0
5 8	8.6	4.3	20.[illegible]	-9.4	-1.8	4.5	8.9	-17.8	50.8	16.4	100.0	19.0	3.3	2.1	11.3	0.0
5 11	11.9	4.9	23.[illegible]	-8.3	-2.1	4.2	7.8	-15.6	40.3	15.2	93.0	15.0	4.1	2.1	12.3	0.0
5 14	13.3	5.0	25.0	-7.2	-2.7	4.2	7.8	-15.6	35.5	14.6	93.0	15.0	4.6	2.2	12.3	0.0
5 17	13.3	4.8	25.6	-7.2	-2.5	4.3	8.3	-15.0	36.1	14.7	86.0	14.0	4.8	2.3	12.3	0.0
5 20	11.2	4.6	23.9	-7.8	-1.9	4.4	8.9	-15.0	42.6	15.2	93.0	16.0	4.0	1.9	9.8	0.0
5 23	7.1	4.0	17.2	-8.9	-1.8	4.5	8.3	-15.0	55.7	16.0	93.0	23.0	3.3	1.7	10.3	0.0
6 2	11.1	3.6	22.2	3.3		*			69.0	15.6	96.0	29.0	2.8	1.4	7.2	0.0
6 5	11.4	3.4	20.6	3.9					69.9	14.7	100.0	35.0	2.5	1.5	7.2	0.0
6 8	15.0	4.0	26.1	4.4					58.3	16.1	96.0	26.0	2.9	1.8	10.3	0.0
6 11	18.5	4.6	31.1	6.7					45.3	16.7	100.0	14.0	3.7	1.9	11.3	0.0
6 14	19.9	4.9	33.3	7.8					39.8	16.1	90.0	15.0	4.2	1.9	11.8	1.5
6 17	19.9	5.0	34.4	7.8					40.0	17.1	93.0	14.0	4.1	2.0	10.8	0.0
6 20	18.2	4.6	29.4	7.2					46.4	17.8	93.0	19.0	3.6	1.6	11.3	0.0
6 23	14.0	3.7	22.8	5.0					61.1	16.8	96.0	24.0	3.0	1.4	9.3	0.0

FAIRBANKS

*Data for January—April and June are not available.

TABLE A-11. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 2	12.4	2.7	20.0	3.9	8.4	2.6	15.6	0.0	77.3	12.0	100.0	35.0	2.5	1.4	8.7	0.0
7 5	12.3	2.5	18.9	5.0	8.4	2.5	15.0	.6	78.0	11.1	100.0	42.0	2.4	1.3	7.7	0.0
7 8	15.5	3.2	26.1	7.2	9.1	2.5	15.6	1.7	67.6	14.1	96.0	29.0	2.6	1.6	9.3	0.0
7 11	19.0	3.9	28.9	10.0	8.7	2.8	16.7	0.0	53.8	15.5	93.0	23.0	3.4	1.7	9.3	0.0
7 14	20.6	4.3	30.6	11.2	8.3	3.1	17.2	0.0	48.0	16.8	87.0	18.0	4.0	1.8	9.3	0.0
7 17	20.7	4.4	30.0	10.6	8.0	3.2	16.1	-.6	47.0	17.0	93.0	19.0	3.7	1.7	10.8	0.0
7 20	18.8	4.0	27.8	9.4	8.9	3.0	16.1	1.7	55.4	16.6	97.0	21.1	3.3	1.5	9.3	0.0
7 23	14.9	2.9	22.2	6.1	9.1	2.6	16.1	.6	69.6	13.5	100.0	31.0	2.8	1.4	8.7	0.0
8 2	9.9	3.6	16.7	0.0	6.6	4.0	15.0	-5.0	80.7	11.4	100.0	41.0	2.5	1.5	8.7	0.0
8 5	9.0	3.7	16.7	-1.1	6.2	3.9	13.3	-5.0	83.1	10.1	100.0	46.0	2.4	1.5	10.3	0.0
8 8	11.7	3.5	20.6	2.8	7.2	3.8	15.0	-7.2	75.7	13.9	100.0	35.0	2.5	1.8	14.9	0.0
8 11	15.5	3.9	27.2	4.4	7.5	4.0	16.1	-7.8	61.7	16.6	93.0	27.0	3.3	1.9	9.8	0.0
8 14	17.5	4.2	28.3	6.1	7.0	4.4	15.0	-7.8	52.8	17.2	96.0	20.0	3.7	1.8	10.3	0.0
8 17	17.5	4.3	27.8	5.6	6.9	4.4	16.1	-6.1	52.7	17.6	100.0	19.0	3.6	1.6	9.3	0.0
8 20	14.7	3.8	24.4	5.0	7.9	4.0	16.1	-5.0	65.5	14.1	96.0	30.0	3.0	1.6	9.3	0.0
8 23	11.4	3.6	19.4	1.7	7.2	3.9	14.4	-5.6	76.3	12.0	100.0	34.0	2.8	1.5	10.3	0.0
9 2	4.5	4.2	14.4	-6.7	.1	4.3	12.2	-12.2	74.4	12.5	96.0	35.0	2.6	1.4	7.7	0.0
9 5	3.4	4.1	13.9	-8.9	-.4	4.3	10.6	-12.2	77.4	11.3	100.0	37.0	2.3	1.5	7.2	0.0
9 8	5.4	4.4	15.6	-6.7	.6	4.4	12.8	-12.2	72.6	14.1	96.0	27.0	2.4	1.5	8.7	0.0
9 11	10.0	5.3	22.2	-3.9	1.1	4.5	13.3	-12.2	57.1	17.3	96.0	21.0	3.2	2.1	15.9	0.0
9 14	12.3	5.7	23.3	-2.8	.9	4.5	14.4	-12.2	48.7	17.0	96.0	17.0	3.5	2.0	11.3	0.0
9 17	12.0	5.7	23.9	-2.2	.8	4.6	14.4	-11.7	49.5	16.9	93.0	17.0	3.2	1.6	8.7	0.0
9 20	7.9	4.7	17.2	-6.1	1.0	4.6	13.9	-11.7	63.6	14.7	96.0	27.0	2.9	1.5	8.2	0.0
9 23	5.8	4.4	15.6	-11.1	.3	4.4	12.2	-13.3	69.7	13.5	96.0	31.0	2.9	1.6	9.3	0.0
10 2	-5.7	6.7	11.7	-25.0	*				74.8	11.6	100.0	33.0	2.4	1.6	10.3	0.0
10 5	-6.1	6.9	12.8	-25.6					75.4	11.1	100.0	33.0	2.3	1.5	7.2	0.0
10 8	-6.0	7.0	15.0	-26.1					74.6	11.1	100.0	29.0	2.3	1.4	7.2	0.0
10 11	-3.2	6.8	16.7	-20.0					68.9	13.7	100.0	24.0	2.4	1.7	9.3	0.0
10 14	-1.4	6.9	18.3	-17.2					64.4	15.0	96.0	21.0	2.6	1.9	12.3	0.0
10 17	-2.8	6.8	14.4	-18.9					69.0	14.4	96.0	24.0	2.6	1.6	8.2	0.0
10 20	-4.4	6.7	12.8	-22.2					72.3	12.8	100.0	25.0	2.5	1.6	10.3	0.0
10 23	-5.3	6.7	11.7	-23.9					73.5	12.0	96.0	30.0	2.6	1.5	7.7	0.0
11 2	-15.8	8.5	6.7	-38.3					70.7	13.5	100.0	27.0	1.8	1.8	11.3	0.0
11 5	-16.2	8.7	7.2	-37.2					70.9	13.4	100.0	42.0	1.7	1.7	9.3	0.0
11 8	-16.3	8.5	4.4	-38.3					70.7	13.0	100.0	41.0	1.7	1.6	9.3	0.0
11 11	-14.8	8.1	5.6	-36.1					70.5	13.4	100.0	42.0	1.8	1.7	11.3	0.0
11 14	-13.2	7.5	5.6	-33.3					69.7	13.3	100.0	42.0	1.8	1.7	14.4	0.0
11 17	-14.5	7.8	2.2	-35.0					70.5	13.9	100.0	33.0	1.9	1.5	9.3	0.0
11 20	-15.5	8.4	3.3	-36.7					70.4	13.5	100.0	40.0	1.9	1.6	9.3	0.0
11 23	-15.9	8.5	2.2	-37.8					70.3	13.6	100.0	41.0	1.9	1.6	9.3	0.0
12 2	-21.9	10.7	2.2	-45.6					66.2	13.0	100.0	32.0	1.7	1.8	11.3	0.0
12 5	-21.6	10.7	2.2	-45.6					65.9	13.2	100.0	35.0	1.7	1.9	15.4	0.0
12 8	-22.1	10.7	4.4	-45.6					65.9	13.2	100.0	33.0	1.7	1.9	12.9	0.0
12 11	-21.6	10.9	4.4	-45.6					66.0	13.2	100.0	33.0	1.5	1.7	11.8	0.0
12 14	-21.2	10.6	5.6	-46.1					65.5	13.3	100.0	22.0	1.5	1.7	10.3	0.0
12 17	-21.7	10.9	5.0	-45.6					65.9	13.1	100.0	34.0	1.5	1.6	10.3	0.0
12 20	-21.7	10.9	4.4	-45.6					66.0	13.3	100.0	33.0	1.5	1.7	12.3	0.0
12 23	-22.0	10.8	2.2	-47.2					66.3	13.1	100.0	37.0	1.6	1.7	14.4	0.0

FAIRBANKS

*Data for October—December are not available.

TABLE A-11. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 2	100.2	1.3	103.5	96.7									52.2	39.3	45.6	37.9
1 5	100.1	1.3	103.4	96.6									53.4	39.6	47.9	39.1
1 8	100.1	1.3	103.5	96.7									56.4	38.9	50.5	38.5
1 11	100.2	1.3	103.6	96.8									57.6	39.3	47.1	37.3
1 14	100.1	1.3	103.6	96.9									56.4	40.2	47.0	37.5
1 17	100.1	1.3	103.5	96.7									56.7	38.9	48.6	37.4
1 20	100.1	1.3	103.4	96.7									55.8	39.2	47.8	38.1
1 23	100.1	1.3	103.3	96.7									54.9	40.7	48.6	39.6
2 2	99.5	1.2	102.9	96.6									56.1	42.1	47.7	41.0
2 5	99.5	1.2	102.7	96.9									59.3	40.9	51.7	40.7
2 8	99.5	1.2	102.5	96.7									63.4	39.5	53.0	37.8
2 11	99.5	1.2	102.6	96.6									65.3	38.4	50.2	36.5
2 14	99.5	1.1	102.7	96.4									62.6	40.6	48.6	38.7
2 17	99.4	1.1	102.8	96.4									59.1	41.1	47.1	39.4
2 20	99.4	1.1	102.9	96.4									56.9	41.1	47.9	40.6
2 23	99.5	1.2	102.9	96.4									53.9	42.2	46.3	41.5
3 2	99.6	1.2	102.9	96.3									52.9	42.2	43.4	42.2
3 5	99.6	1.2	102.8	96.4									59.7	41.9	49.5	42.6
3 8	99.6	1.2	102.7	96.5									62.6	41.5	49.8	40.9
3 11	99.6	1.2	102.6	96.6									61.1	41.8	45.3	38.8
3 14	99.5	1.2	102.5	96.7									63.2	41.5	46.9	39.1
3 17	99.5	1.2	102.5	96.6									61.9	40.8	47.1	38.2
3 20	99.5	1.1	102.8	96.5									57.9	42.1	45.5	40.3
3 23	99.6	1.1	102.9	96.5									54.4	42.9	44.1	42.0
4 2	99.4	1.0	102.0	95.6									61.1	39.7	47.0	39.3
4 5	99.4	1.1	101.9	95.8									68.8	37.0	53.4	37.2
4 8	99.4	1.1	101.9	95.9									69.4	38.2	50.3	37.7
4 11	99.4	1.0	101.9	96.2									67.3	38.4	48.9	36.8
4 14	99.3	1.0	101.8	96.4									70.4	35.5	52.1	35.5
4 17	99.3	1.0	101.8	96.1									69.6	36.1	53.1	36.6
4 20	99.3	1.0	101.9	95.8									66.9	38.4	49.8	37.6
4 23	99.3	1.0	102.0	95.6									63.6	39.7	48.1	39.3
5 2	99.4	.8	101.3	96.1									68.4	35.9	51.8	35.7
5 5	99.5	.8	101.5	95.9									70.2	34.4	53.5	35.0
5 8	99.5	.8	101.5	96.0									68.3	35.0	50.3	35.0
5 11	99.4	.8	101.4	96.1									71.3	32.3	52.7	32.3
5 14	99.3	.8	101.4	96.2									76.8	28.7	61.4	30.5
5 17	99.3	.8	101.3	96.2									76.7	28.7	61.0	30.1
5 20	99.3	.8	101.3	96.5									73.4	30.8	56.1	31.9
5 23	99.4	.8	101.3	96.4									68.9	35.7	52.5	35.3
6 2	99.3	.6	100.8	97.3									70.4	33.9	56.0	34.9
6 5	99.4	.6	100.8	97.4									71.3	33.4	56.2	35.5
6 8	99.4	.6	100.8	97.4									71.1	34.0	54.5	34.9
6 11	99.3	.6	100.8	97.5									73.5	29.7	57.7	30.1
6 14	99.3	.6	100.8	97.7									76.9	26.7	62.5	28.3
6 17	99.2	.6	100.7	97.7									76.5	28.5	60.8	30.0
6 20	99.2	.6	100.8	97.7									72.2	32.8	56.2	32.5
6 23	99.3	.6	100.8	97.7									70.6	33.8	56.1	34.2

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TABLE A-11. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 2	99.7	.6	101.3	97.8									76.1	31.9	60.9	35.8
7 5	99.7	.6	101.4	97.8									78.0	31.4	63.5	35.4
7 8	99.7	.6	101.3	97.8									75.2	32.7	62.1	35.9
7 11	99.7	.6	101.3	97.7									74.8	31.6	61.2	32.7
7 14	99.6	.6	101.2	97.6									80.1	26.6	65.0	29.5
7 17	99.6	.6	101.1	97.6									78.0	26.9	61.8	29.5
7 20	99.6	.6	101.2	97.6									76.8	29.2	60.0	31.8
7 23	99.6	.6	101.3	97.7									76.0	31.3	60.9	34.5
8 2	99.4	.7	101.1	96.9									73.2	35.5	63.5	37.4
8 5	99.5	.7	101.1	97.4									78.7	32.6	68.0	36.0
8 8	99.5	.7	101.1	97.3									77.8	34.1	67.7	36.9
8 11	99.4	.7	101.1	97.1									75.8	32.3	63.5	34.8
8 14	99.4	.7	101.0	97.0									77.1	29.1	66.2	31.2
8 17	99.3	.7	101.0	96.9									75.4	30.7	63.3	32.0
8 20	99.3	.7	101.0	96.9									71.4	34.3	58.6	35.4
8 23	99.4	.7	101.1	96.9									72.1	35.7	63.0	37.9
9 2	99.3	1.0	101.6	95.7									62.3	41.3	54.8	42.0
9 5	99.3	1.0	101.6	95.9									68.2	38.9	58.5	39.6
9 8	99.3	1.0	101.7	96.2									70.6	37.6	59.3	38.4
9 11	99.3	1.0	101.6	96.3									68.8	37.8	56.2	37.9
9 14	99.3	1.0	101.5	96.4									71.3	35.4	58.2	36.5
9 17	99.2	1.0	101.5	96.2									68.7	37.1	56.0	37.0
9 20	99.2	1.0	101.5	95.9									64.2	39.8	53.7	39.9
9 23	99.3	1.0	101.5	95.7									62.5	41.9	53.7	42.0
10 2	99.0	1.0	101.7	96.1									72.0	38.5	65.1	41.4
10 5	99.0	1.0	101.7	96.0									74.1	36.2	66.2	39.3
10 8	99.0	1.0	101.8	96.1									79.8	32.4	68.2	37.1
10 11	99.0	1.0	101.8	96.3									79.1	33.1	65.9	36.6
10 14	98.9	1.0	101.8	96.5									79.6	33.3	66.6	37.0
10 17	98.9	1.0	102.0	96.5									78.0	34.4	66.6	37.7
10 20	99.0	1.0	102.2	96.4									76.4	36.4	69.1	39.1
10 23	99.0	1.0	102.3	96.2									75.2	36.2	67.4	39.4
11 2	99.3	1.3	102.6	96.2									64.1	41.6	56.6	42.3
11 5	99.3	1.3	102.7	96.1									65.6	40.3	57.2	41.5
11 8	99.4	1.3	102.8	96.0									70.6	36.4	59.2	39.5
11 11	99.4	1.3	102.8	95.7									72.3	35.7	57.5	37.7
11 14	99.4	1.3	102.7	95.5									70.3	37.7	56.6	38.7
11 17	99.4	1.3	102.8	95.5									68.7	39.1	60.0	40.6
11 20	99.4	1.3	102.8	95.7									65.1	40.6	56.8	41.8
11 23	99.4	1.3	102.8	96.0									64.2	40.8	57.5	42.3
12 2	99.3	1.4	103.0	95.9									65.3	38.0	56.4	39.1
12 5	99.3	1.4	103.0	95.9									65.8	38.7	58.5	40.3
12 8	99.3	1.4	102.9	96.0									65.5	36.1	56.4	38.1
12 11	99.3	1.4	102.9	96.2									70.1	35.3	57.4	36.6
12 14	99.3	1.4	102.9	96.2									69.7	36.5	56.4	37.1
12 17	99.3	1.4	103.0	96.3									68.1	36.3	57.5	37.9
12 20	99.3	1.4	103.3	96.2									66.6	37.4	57.2	38.7
12 23	99.3	1.4	103.6	95.9									65.1	38.2	56.2	39.6

FAIRBANKS

TABLE A-12. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR FAIRBANKS, ALASKA

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 2	117						54		2		16				
1 5	115						54		2		17				
1 8	111						60				17				
1 11	121						53		1		12				
1 14	108						56		4		9				
1 17	129						61		3		10				1
1 20	126						55				14				
1 23	125						58		2		13				
2 2	47						55				4				
2 5	42						58				6				
2 8	48						55				6				
2 11	49						54								1
2 14	18						39				2				1
2 17	20						37								
2 20	35						53	1			3				
2 23	39						52				3				
3 2	14		2				49	2			4				
3 5	17		1				61	1			2				1
3 8	25		2				58	3			4				
3 11	12						47	4							
3 14	5		2				36	2							
3 17	4		3				34	3							
3 20	5		3				51	2							
3 23	9	1	2				47								
4 2	3		5				27	2							
4 5	4		5				28	4							
4 8	3		4				34	7							
4 11	6	1	3				25	7			1				
4 14	4	1	3				20	7			1				
4 17	3	1	3				19	5			1				
4 20	4		5	1			17	3							
4 23	3		5				21	1							
5 2	2		9	11			5	1							
5 5	7		14	5			4	1							
5 8	1		13	7				2							
5 11	1	1	11	5			2	1			1				
5 14	1		7	16	1		3								
5 17	1		3	16	2		3								
5 20	2	2	5	11			3								
5 23	1		8	9			4								1
6 2	1		13	11											7
6 5	8		25	9											8
6 8	4		19	8											9
6 11	1	2	14	13	1										9
6 14		1	13	17	5										9
6 17			7	27	2										8
6 20	1		7	17	1										6
6 23	1		11	15											8

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(TABLE A-12. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 2	5		31	11											5
7 5	10		36	7											5
7 8	6		33	11											6
7 11	4		21	8											7
7 14	2		23	17	3										5
7 17	1		19	12											4
7 20	3		28	18	1										4
7 23	6		28	16	1										3
8 2	10	1	37	9											7
8 5	35	7	51	5											4
8 8	34	8	43	10											4
8 11	7	1	40	5											7
8 14	3	3	26	13											9
8 17	7		22	16	1										9
8 20	8		22	17											9
8 23	9	1	31	17											8
9 2	9	1	24	4			11	3							
9 5	18	2	26	3			16	1							
9 8	29	2	26	5			15	5							
9 11	8	2	15	3			7	3							1
9 14	8	2	15	5			5	2							
9 17	7	1	15	3	1		6	3							
9 20	7	2	18	7			9	3							
9 23	6	1	27	1			8	3							
10 2	22	1	8				82	1	1						
10 5	19	2	8				90	2			1				
10 8	27	2	7	1			77	3	1						
10 11	30	1	5	1			62	3	1		3				
10 14	16		8				64	3							1
10 17	16	1	6				61	2	1						
10 20	13		7				80	1							
10 23	12		6				86	1			2				
11 2	28						85	2			9				
11 5	29		1				97	2			8				
11 8	28						95	3			13				
11 11	41						78	2	1	1	3				
11 14	31						72	1	1		2				1
11 17	28						85				7				
11 20	27				1		81				7				
11 23	29						89	1			10				
12 2	62		2				83		5		18		1		
12 5	63						90		1		15				1
12 8	57						95		1	2	17				
12 11	66		1				73		1	2	9		1		
12 14	66						62		2	2	12				
12 17	70						67				18				
12 20	67						70	1		1	19				
12 23	63		1				73	1	2		17				

FAIRBANKS

TABLE A-13. DESCRIPTIVE CLIMATIC STATISTICS FOR LOS ANGELES, CALIFORNIA AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 1	11.1	2.7	19.4	4.4	5.1	6.4	15.0	-25.0	70.9	22.6	100.0	7.0	2.8	1.4	8.7	0.0
1 4	10.0	2.8	17.8	2.2	4.2	6.4	14.4	-22.2	71.1	22.2	100.0	10.0	2.8	1.5	10.8	0.0
1 7	9.6	2.9	16.7	2.2	3.5	6.3	15.0	-13.9	69.3	21.9	100.0	17.0	2.9	1.3	12.3	0.0
1 10	14.1	3.2	23.9	8.3	4.3	6.4	15.0	-18.3	57.5	24.6	100.0	8.0	3.2	1.4	9.8	0.0
1 13	16.6	3.6	27.8	8.9	5.6	6.3	15.6	-17.8	54.0	23.1	100.0	6.0	4.1	1.6	10.3	1.0
1 16	15.3	2.7	25.0	10.0	6.8	5.4	15.0	-20.0	61.6	20.7	100.0	5.0	4.5	1.4	10.8	1.0
1 19	13.0	2.2	21.7	7.8	6.7	5.8	14.4	-17.8	70.2	21.1	100.0	9.0	3.2	1.5	9.8	0.0
1 22	12.3	2.4	21.1	6.7	6.1	6.1	14.4	-17.2	70.4	21.7	100.0	10.0	2.7	1.5	10.8	0.0
2 1	12.0	2.1	18.3	6.1	6.5	5.3	14.4	-11.7	72.7	20.1	100.0	15.0	2.7	1.3	8.7	0.0
2 4	10.8	2.4	16.7	3.9	5.5	5.6	14.4	-17.2	73.7	20.7	100.0	9.0	2.8	1.4	12.3	0.0
2 7	10.4	2.5	17.2	2.8	4.6	5.7	13.3	-12.2	71.0	20.9	100.0	18.0	2.9	1.3	9.3	0.0
2 10	15.5	2.9	25.6	9.4	5.7	5.8	13.9	-11.7	57.5	22.5	96.0	13.0	3.1	1.3	9.3	1.0
2 13	17.4	3.4	29.4	10.6	7.2	5.6	14.4	-19.4	56.2	21.0	97.0	6.0	4.7	1.5	9.3	1.0
2 16	16.2	2.7	26.7	10.6	7.8	5.0	14.4	-19.4	61.5	19.0	96.0	6.0	5.1	1.7	12.9	0.0
2 19	13.8	2.1	21.1	8.3	7.9	4.7	14.4	-20.6	71.0	18.3	100.0	6.0	3.6	1.6	11.3	0.0
2 22	13.1	2.0	20.0	8.9	7.4	5.1	14.4	-19.4	71.7	19.2	100.0	7.0	2.8	1.5	10.3	0.0
3 1	12.6	1.8	20.6	5.6	8.0	4.4	14.4	-15.0	76.1	17.0	100.0	18.0	2.7	1.4	10.3	0.0
3 4	11.6	2.0	16.1	5.0	7.5	4.6	13.9	-15.0	78.3	17.3	100.0	21.0	2.6	1.4	10.8	0.0
3 7	11.7	2.0	16.1	3.9	7.2	4.9	13.9	-12.2	76.4	18.1	100.0	21.0	2.9	1.2	8.7	1.0
3 10	16.1	2.7	26.1	10.6	7.7	5.0	15.6	-13.9	61.5	19.4	100.0	10.0	3.4	1.6	9.3	0.0
3 13	17.2	2.6	28.3	11.1	9.0	4.7	15.6	-16.1	61.7	16.6	96.0	6.0	5.6	1.6	13.4	1.5
3 16	16.1	2.2	22.2	8.9	9.1	3.5	13.9	-10.0	65.3	15.1	96.0	16.0	5.8	1.7	13.4	1.5
3 19	13.9	1.9	24.4	8.9	8.8	3.6	13.9	-13.9	73.4	15.5	100.0	15.0	4.1	1.6	11.8	1.0
3 22	13.4	1.9	23.3	7.2	8.2	4.6	13.9	-13.9	73.9	18.0	100.0	16.0	3.1	1.5	10.3	0.0
4 1	13.2	1.9	23.3	7.8	9.0	3.3	14.4	-6.1	77.4	13.5	96.0	20.0	2.8	1.5	10.3	0.0
4 4	12.3	2.0	22.8	7.2	8.3	3.6	13.9	-7.8	78.7	14.2	96.0	19.0	2.7	1.4	9.3	0.0
4 7	13.3	2.0	21.7	8.3	8.6	3.6	15.0	-5.6	74.9	15.2	97.0	20.0	3.1	1.4	11.8	0.0
4 10	17.8	3.3	32.8	10.0	8.8	4.1	15.6	-6.1	58.3	15.6	89.0	14.0	4.0	1.7	12.9	1.0
4 13	18.4	3.1	33.3	8.9	9.7	3.4	15.6	-9.4	59.0	13.4	86.0	9.0	6.2	1.7	14.4	2.1
4 16	17.5	2.5	28.3	11.1	9.8	3.1	15.6	-12.2	62.5	12.4	90.0	7.0	6.4	2.1	14.4	1.5
4 19	14.6	2.1	24.4	8.9	9.4	3.3	15.0	-13.3	72.9	14.5	93.0	8.0	4.7	1.9	12.3	1.0
4 22	13.9	1.9	22.8	7.8	9.2	3.6	14.4	-6.1	75.2	15.2	100.0	24.0	3.3	1.6	8.7	0.0
5 1	14.8	1.7	21.7	10.6	11.3	3.0	16.7	*	80.8	10.3	100.0	9.0	2.5	1.1	7.2	0.0
5 4	14.3	1.7	21.1	9.4	11.1	2.6	16.1	-7.2	82.0	10.0	100.0	15.0	2.6	1.1	10.3	0.0
5 7	15.6	1.9	25.6	10.6	11.4	2.7	16.7	-2.2	77.5	12.2	100.0	20.0	2.8	1.0	7.7	1.0
5 10	18.7	3.0	35.0	11.7	11.5	3.1	17.2	-6.7	65.5	13.2	93.0	9.0	4.1	1.2	9.3	1.5
5 13	19.6	2.5	33.3	13.9	11.7	2.9	17.2	-8.9	61.8	11.0	84.0	8.0	5.8	1.3	11.3	1.0
5 16	18.5	2.1	30.6	12.8	11.7	2.4	16.7	0.0	65.5	10.3	87.0	16.0	5.9	1.3	11.3	2.1
5 19	15.8	1.9	26.7	12.8	11.3	2.6	16.7	-8.9	75.9	11.4	93.0	10.0	4.5	1.4	10.8	2.1
5 22	15.2	1.9	28.9	11.7	11.4	2.4	16.1	-3.9	79.0	11.0	100.0	18.0	3.0	1.3	8.2	0.0
6 1	16.3	1.4	21.1	11.7	13.4	1.7	16.7	5.1	83.4	7.0	97.0	55.0	2.6	1.0	5.7	0.0
6 4	16.0	1.5	22.2	11.1	13.2	1.8	16.7	5.6	84.4	7.4	100.0	40.0	2.4	1.0	5.7	0.0
6 7	17.1	1.6	27.8	13.3	13.6	1.8	16.7	6.1	80.5	8.6	100.0	25.0	2.8	1.0	6.2	0.0
6 10	19.9	2.3	31.1	14.4	13.8	2.0	17.8	4.7	68.7	8.7	97.0	43.0	4.1	1.1	7.2	1.0
6 13	20.9	1.9	31.1	15.6	13.9	1.8	17.2	8.3	64.8	7.3	87.0	31.0	5.7	1.1	8.2	1.5
6 16	20.2	1.8	28.9	16.1	13.9	1.7	17.2	7.8	67.5	7.3	87.0	38.0	6.0	1.2	9.3	3.1
6 19	17.6	1.6	25.6	14.4	13.5	1.7	16.7	3.9	77.2	7.8	100.0	40.0	4.5	1.2	8.2	1.0
6 22	16.7	1.4	24.4	13.3	13.5	1.6	16.7	8.3	81.6	7.2	100.0	45.0	3.1	1.1	8.2	0.0

LOS ANGELES

*Data point is not available.

TABLE A-13. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 0	17.9	1.7	27.8	13.9	15.2	1.4	19.4	11.7	84.4	5.6	97.0	44.0	2.4	.9	6.2	0.0
7 4	17.6	1.5	21.7	13.9	15.2	1.5	19.4	11.1	86.1	5.4	100.0	72.0	2.3	.8	5.1	0.0
7 7	18.7	1.7	24.4	14.4	15.6	1.5	19.4	11.1	82.3	6.5	100.0	62.0	2.5	.8	5.7	0.0
7 10	22.1	2.3	30.0	17.2	15.9	1.6	19.4	11.7	68.4	7.4	87.0	40.0	4.0	1.0	6.7	1.0
7 13	22.7	1.8	30.0	18.3	15.8	1.6	19.4	11.7	65.5	5.9	84.0	40.0	5.7	1.0	9.3	2.1
7 16	22.0	1.6	26.7	17.2	15.7	1.6	19.4	10.0	67.9	6.1	82.0	41.0	6.0	1.0	8.7	2.6
7 19	19.3	1.7	23.3	14.4	15.3	1.5	18.9	11.7	78.1	6.7	90.0	55.0	4.7	1.0	7.2	1.5
7 22	18.4	1.7	28.9	13.9	15.2	1.5	18.9	11.7	81.9	6.6	97.0	36.0	3.0	1.0	6.2	0.0
8 1	19.2	1.6	25.6	16.1	16.3	1.4	20.0	12.2	83.6	6.5	100.0	58.0	2.4	.8	5.1	0.0
8 4	18.9	1.6	23.3	15.0	16.3	1.5	20.6	10.6	84.9	6.1	100.0	61.0	2.3	.8	4.6	0.0
8 7	19.8	1.8	25.0	15.0	16.6	1.7	21.1	8.9	82.0	7.1	97.0	47.0	2.5	.8	5.1	0.0
8 10	23.4	2.4	32.2	18.3	16.9	1.9	21.7	1.7	67.6	8.1	87.0	14.0	3.9	1.0	6.7	1.5
8 13	24.0	2.0	31.1	20.0	16.9	1.6	21.1	11.1	65.1	6.8	84.0	33.0	5.8	.9	8.2	2.6
8 16	22.9	1.8	29.4	18.3	16.8	1.6	21.1	10.0	69.0	7.1	84.0	31.0	6.0	1.0	8.7	2.1
8 19	20.2	1.6	26.1	16.1	16.4	1.6	20.0	7.8	78.9	7.9	93.0	40.0	4.4	1.0	7.7	1.5
8 22	19.5	1.7	26.7	15.0	16.3	1.5	20.0	10.0	82.3	6.9	97.0	49.0	2.8	.9	5.7	0.0
9 1	18.2	1.8	24.4	14.4	14.8	2.5	19.4	0.0	81.5	11.3	100.0	24.0	2.4	1.0	6.2	0.0
9 4	17.8	1.8	24.4	13.3	14.5	2.9	20.0	-2.8	82.3	11.7	100.0	20.0	2.3	.9	5.7	0.0
9 7	18.4	2.0	27.2	14.4	14.6	3.2	20.0	-3.3	80.1	13.5	100.0	16.0	2.6	.9	5.7	0.0
9 10	22.3	3.2	34.4	16.7	14.7	3.8	20.0	-6.1	65.2	15.1	93.0	7.0	3.6	1.1	7.2	1.0
9 13	23.1	2.7	37.8	18.9	15.0	3.2	20.6	-11.7	62.5	12.3	87.0	5.0	5.6	1.0	8.7	2.1
9 16	21.9	2.3	33.3	17.2	15.1	2.7	20.6	-4.4	67.1	11.8	90.0	8.0	5.8	1.1	9.8	1.5
9 19	19.4	1.9	28.9	15.6	15.0	2.4	19.4	-10.6	77.1	11.1	97.0	7.0	4.0	1.1	7.2	1.0
9 22	18.8	1.8	25.5	15.0	15.0	2.4	19.4	-8.9	79.8	11.0	100.0	9.0	2.7	1.0	6.7	0.0
10 1	16.6	2.3	25.6	7.2	11.5	5.0	18.3	-10.0	75.3	19.4	100.0	13.0	2.3	1.1	8.2	0.0
10 4	15.8	2.3	23.3	6.7	10.8	5.5	17.8	-11.7	76.1	20.2	100.0	17.0	2.2	1.0	8.2	0.0
10 7	16.2	2.7	32.2	7.2	10.4	5.9	17.2	-16.7	73.3	21.9	100.0	8.0	2.6	1.0	8.2	0.0
10 10	21.4	4.1	36.1	13.9	10.3	6.5	17.8	-14.4	56.1	22.7	97.0	6.0	3.1	1.2	8.2	1.0
10 13	22.4	3.9	37.2	15.0	11.5	5.9	18.3	-17.8	55.4	19.1	90.0	3.0	5.2	1.2	11.3	1.0
10 16	20.9	3.2	35.6	13.9	12.2	4.6	18.3	-12.2	61.7	17.9	90.0	4.0	5.5	1.4	15.4	2.1
10 19	18.3	2.4	29.4	11.7	12.6	4.2	17.2	-16.7	72.7	17.1	97.0	7.0	3.6	1.4	10.8	0.0
10 22	17.4	2.3	27.8	6.1	12.3	4.5	17.2	-18.3	74.8	17.5	100.0	8.0	2.7	1.2	9.8	0.0
11 1	14.2	2.1	21.7	8.9	9.1	5.4	16.1	-8.3	74.8	20.2	100.0	17.0	2.5	1.3	8.7	0.0
11 4	13.2	2.5	21.7	7.8	8.3	5.6	16.1	-7.2	75.7	20.0	100.0	22.0	2.5	1.3	8.7	0.0
11 7	12.9	2.6	20.6	6.7	7.9	5.6	16.1	-7.2	74.6	20.0	100.0	23.0	2.8	1.4	7.7	0.0
11 10	18.0	3.1	34.4	10.6	8.3	5.8	16.1	-11.7	58.4	22.5	100.0	9.0	3.2	1.7	10.3	1.0
11 13	19.9	3.4	37.8	12.8	9.3	5.5	16.7	-12.2	55.4	19.8	97.0	7.0	4.7	1.5	14.4	1.0
11 16	18.1	2.7	36.7	12.2	10.2	4.8	17.8	-20.0	63.8	18.7	97.0	4.0	4.8	1.6	13.4	0.0
11 19	15.9	2.1	26.7	11.1	10.1	5.2	17.2	-19.4	72.5	19.6	100.0	5.0	3.3	1.5	10.3	0.0
11 22	15.2	2.0	26.7	8.9	9.7	5.4	17.2	-9.4	73.5	20.5	100.0	16.0	2.6	1.5	11.8	0.0
12 1	11.3	2.7	20.6	3.9	4.5	6.2	16.7	-16.7	66.8	22.4	100.0	15.0	2.8	1.6	8.7	0.0
12 4	10.0	2.8	20.0	2.2	3.6	6.1	16.1	-19.4	67.9	21.3	100.0	10.0	2.7	1.4	8.2	0.0
12 7	9.6	2.9	17.8	1.1	2.9	6.0	16.1	-16.7	66.5	21.0	100.0	17.0	3.0	1.6	10.3	0.0
12 10	14.5	3.2	23.3	7.2	3.8	6.1	16.7	-21.7	53.4	22.4	100.0	10.0	3.5	1.7	11.8	1.0
12 13	17.1	3.6	27.8	8.9	4.7	6.3	16.7	-19.4	48.8	21.4	100.0	10.0	4.1	1.8	12.9	1.0
12 16	15.6	2.8	26.1	8.3	6.2	6.0	16.7	-23.3	57.9	20.3	100.0	8.0	4.7	1.9	13.4	1.0
12 19	13.3	2.5	22.2	5.6	6.2	6.4	16.7	-20.6	66.4	22.0	100.0	10.0	3.3	1.9	11.3	0.0
12 22	12.4	2.5	21.1	4.4	5.4	6.5	16.7	-18.9	66.5	22.5	100.0	10.0	2.9	1.7	12.3	0.0

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TABLE A-13. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 1	101.5	.4	102.7	100.2									46.9	45.1	40.7	43.8
1 4	101.5	.4	102.6	100.1									50.5	46.2	44.7	45.0
1 7	101.5	.4	102.6	100.0									55.9	41.9	45.9	42.0
1 10	101.6	.4	102.6	100.2									54.5	42.3	41.7	39.8
1 13	101.4	.4	102.4	100.1									51.6	42.3	38.8	38.2
1 16	101.4	.4	102.4	99.9									54.1	41.9	39.9	38.5
1 19	101.4	.4	102.5	99.9									48.8	43.3	38.7	41.0
1 22	101.5	.4	102.6	100.2									44.2	45.2	37.1	42.9
2 1	101.4	.4	102.2	100.2									46.3	44.9	39.2	42.7
2 4	101.4	.4	102.3	99.9									47.6	44.8	41.5	43.3
2 7	101.4	.4	102.4	99.8									56.1	42.1	45.5	41.3
2 10	101.5	.4	102.5	99.9									52.4	42.3	40.3	39.6
2 13	101.4	.4	102.3	100.0									52.1	42.2	40.2	39.0
2 16	101.3	.4	102.1	100.1									50.3	42.3	38.5	38.3
2 19	101.3	.4	102.2	100.2									47.8	42.4	37.0	39.6
2 22	101.4	.4	102.2	100.2									43.5	44.3	36.2	41.8
3 1	101.3	.4	102.5	99.6									51.2	45.3	46.0	44.4
3 4	101.2	.4	102.5	99.6									55.3	45.2	51.1	45.2
3 7	101.3	.4	102.7	99.8									62.2	43.5	55.0	43.0
3 10	101.4	.4	102.8	100.2									57.8	41.3	48.5	40.1
3 13	101.3	.4	102.6	100.2									47.9	40.4	37.0	37.7
3 16	101.2	.4	102.5	100.0									49.2	42.2	39.0	39.3
3 19	101.2	.4	102.4	99.9									51.0	43.7	41.9	41.0
3 22	101.3	.4	102.5	99.8									49.4	43.7	42.8	42.2
4 1	101.2	.3	101.9	100.3									37.8	44.4	33.9	43.2
4 4	101.2	.3	101.9	100.2									43.6	45.1	40.3	44.2
4 7	101.3	.3	102.1	100.2									50.5	43.7	44.7	43.1
4 10	101.3	.3	102.1	100.3									41.0	41.1	34.3	38.8
4 13	101.2	.3	102.0	100.2									36.2	41.9	27.6	35.9
4 16	101.1	.3	101.8	100.2									34.4	40.0	26.2	35.0
4 19	101.1	.3	101.8	100.2									36.3	41.7	28.7	38.1
4 22	101.2	.3	101.9	100.3									35.7	42.6	31.0	40.7
5 1	101.1	.3	101.8	100.0									61.0	45.5	58.6	45.8
5 4	101.0	.3	101.8	99.9									67.6	43.7	65.6	44.2
5 7	101.1	.3	101.9	100.1									74.0	38.7	70.0	40.1
5 10	101.2	.3	102.0	100.2									61.6	40.9	57.2	41.3
5 13	101.1	.3	101.9	100.2									42.2	40.6	35.0	38.6
5 16	101.0	.3	101.7	100.2									42.1	41.7	35.2	38.9
5 19	101.0	.3	101.8	100.3									48.7	43.5	41.8	42.0
5 22	101.1	.3	101.9	100.2									52.6	45.8	49.4	45.6
6 1	100.9	.2	101.5	100.3									66.3	43.8	64.0	44.1
6 4	100.9	.2	101.5	100.3									74.7	40.5	72.7	41.0
6 7	101.0	.2	101.6	100.4									78.0	36.9	75.1	37.8
6 10	101.0	.2	101.6	100.4									62.6	41.7	57.9	41.8
6 13	101.0	.2	101.5	100.3									42.1	41.7	36.6	39.1
6 16	100.9	.2	101.5	100.2									42.0	41.9	36.6	39.7
6 19	100.9	.2	101.5	100.2									49.9	44.3	44.7	42.9
6 22	100.9	.2	101.6	100.3									54.6	46.0	52.0	45.6

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TABLE A-13. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 1	101.0	.2	101.6	100.3									51.6	45.4	49.3	45.0
7 4	100.9	.2	101.6	100.3									60.9	45.5	58.3	45.6
7 7	101.0	.2	101.7	100.5									68.7	40.1	64.2	40.7
7 10	101.1	.2	101.7	100.5									42.2	40.9	36.9	38.8
7 13	101.0	.2	101.6	100.5									25.8	33.9	19.5	28.7
7 16	100.9	.2	101.5	100.3									28.8	35.1	21.4	29.3
7 19	100.9	.2	101.4	100.4									43.4	4.16	36.2	38.8
7 22	101.0	.2	101.6	100.4									43.8	43.6	40.5	42.4
8 1	100.9	.2	101.4	100.3									53.6	45.2	50.5	45.3
8 4	100.8	.2	101.3	100.2									61.2	44.5	58.8	44.9
8 7	100.9	.2	101.5	100.3									65.7	43.0	62.1	43.2
8 10	101.0	.2	101.5	100.3									38.7	40.3	33.4	38.6
8 13	100.9	.2	101.4	100.2									22.7	32.6	17.7	28.3
8 16	100.8	.2	101.3	100.1									28.3	36.4	24.0	33.2
8 19	100.8	.2	101.3	100.1									42.1	42.2	37.7	40.7
8 22	100.9	.2	101.4	100.3									43.8	43.4	41.0	42.5
9 1	100.9	.3	101.5	100.1									52.8	45.6	50.8	45.5
9 4	100.8	.3	101.6	100.1									59.9	45.4	57.6	45.5
9 7	100.9	.3	101.7	100.2									68.9	41.7	65.8	42.0
9 10	101.0	.3	101.8	100.2									54.1	43.8	50.4	43.0
9 13	100.9	.3	101.6	100.1									31.8	39.6	27.8	37.4
9 16	100.8	.3	101.5	99.9									34.9	41.0	30.3	38.3
9 19	100.8	.3	101.4	99.9									44.2	45.4	41.1	44.7
9 22	100.9	.3	101.5	100.0									49.3	45.4	46.7	44.6
10 1	101.1	.3	101.9	100.0									47.5	46.5	44.0	45.8
10 4	101.0	.3	101.9	99.9									52.3	45.5	49.2	45.0
10 7	101.1	.3	102.0	100.0									56.9	44.7	52.8	44.3
10 10	101.2	.3	101.9	100.2									48.9	41.7	42.4	40.5
10 13	101.1	.3	101.7	100.1									38.0	39.4	29.2	34.6
10 16	101.0	.3	101.7	100.0									37.2	39.9	29.7	36.3
10 19	101.0	.3	101.8	99.9									39.0	42.8	34.0	40.8
10 22	101.1	.3	101.9	100.0									38.7	44.2	35.0	42.5
11 1	101.3	.3	102.3	100.3									48.2	44.9	43.1	44.1
11 4	101.3	.3	102.3	100.2									50.8	45.0	46.0	44.3
11 7	101.4	.3	102.5	100.2									57.3	42.8	48.7	42.1
11 10	101.5	.3	102.6	100.3									52.0	42.4	42.4	39.6
11 13	101.3	.3	102.4	100.1									45.6	41.8	34.8	37.6
11 16	101.2	.3	102.3	100.1									49.5	41.7	37.1	38.0
11 19	101.3	.3	102.4	100.3									48.0	43.0	39.8	40.7
11 22	101.3	.3	102.4	100.4									45.5	43.3	38.5	41.7
12 1	101.4	.4	102.6	100.1									40.3	44.1	34.8	42.6
12 4	101.4	.4	102.6	100.2									41.0	43.8	36.2	42.7
12 7	101.4	.4	102.6	100.2									48.9	41.3	37.7	39.1
12 10	101.6	.4	102.7	100.1									49.5	42.3	36.6	37.6
12 13	101.3	.4	102.4	100.0									48.4	41.9	36.2	38.0
12 16	101.3	.4	102.5	100.0									45.5	42.0	33.5	37.7
12 19	101.4	.4	102.6	100.1									43.7	43.1	34.8	40.0
12 22	101.4	.4	102.7	100.2									40.7	43.8	34.0	41.1

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TABLE A-14. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR LOS ANGELES, CALIFORNIA

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 1	50	2	20	4											103
1 4	56	1	20	4											90
1 7	52		16	8											88
1 10	39	3	16	2											136
1 13	18	3	16	6											127
1 16	27		19	2											86
1 19	31		17	2											65
1 22	35	2	15	2											73
2 1	23		10	4											72
2 4	44		12	3											77
2 7	42		10	5											105
2 10	12		9	2											140
2 13	8		12	4											98
2 16	10		8	3											63
2 19	14		5	3										1	35
2 22	15		8	5										1	45
3 1	20		5	3											64
3 4	32	1	9	7											91
3 7	42	3	9	6											129
3 10	11	1	4	4											144
3 13	7	1	3	4											98
3 16	9	2	7	5											62
3 19	13		5	5											48
3 22	15		2	4											45
4 1	10		5	1	1										39
4 4	14		5	5											60
4 7	21	1	7	3											119
4 10			4	6										1	110
4 13	1		2	6										1	58
4 16	1		3	4											34
4 19	5		3	3											31
4 22	9		3	4											33
5 1	15	8	1												72
5 4	22	11	3	2											95
5 7	27	9		2											183
5 10	4	1	1	2											163
5 13		2		3											106
5 16				2											74
5 19	10			1											81
5 22	15	3													68
6 1	11	8													94
6 4	22	8	1	1											108
6 7	27	6													182
6 10	2	1													173
6 13															129
6 16				1											103
6 19	5														98
6 22	10	3													84

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TABLE A-1. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 1	10	1													103
7 4	24	2		1											126
7 7	33	1	1												234
7 10		1	1												232
7 13				2	1										166
7 16															123
7 19	5			1											110
7 22	9	1			1										103
8 1	21														104
8 4	32	1			1										123
8 7	32	3													222
8 10	1	1		1											231
8 13	1			1											150
8 16	1														118
8 19	10														112
8 22	16	1													97
9 1	16		1	1	1										90
9 4	22	1													116
9 7	35	5	1	1											197
9 10	2	2		1											205
9 13					1										142
9 16	2		1	2											91
9 19	8			1	1										82
9 22	13		1												75
10 1	27	1		1	1										112
10 4	39	2		2											129
10 7	53	6	3	3											159
10 10	6	2	2	5											171
10 13	3			1											133
10 16	3			1											100
10 19	16			2											88
10 22	19	1	1	1	1										92
11 1	30	2	7	8											96
11 4	49	2	15	3											93
11 7	47	1	11	6											116
11 10	21		13	3											148
11 13	7		9	6											109
11 16	13	1	8	8											78
11 19	18		13	6	1										56
11 22	25		12	2	1										68
12 1	31	2	19	3											74
12 4	34	1	15												74
12 7	40	1	17	6											80
12 10	19	1	10	5											106
12 13	11		12	8	1										88
12 16	15	2	13	2											66
12 19	20	2	11	3											42
12 22	29	2	13	7											54

LOS ANGELES

TABLE A-15. DESCRIPTIVE ENVIRONMENTAL STATISTICS FOR MIAMI, FLORIDA AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 1	18.9	4.5	25.0	2.8	15.3	5.1	23.9	-5.0	80.4	10.0	100.0	47.0	3.5	1.8	10.3	0.0
1 4	18.0	4.7	25.0	1.7	15.0	5.2	23.3	-5.6	83.0	10.4	100.0	47.0	3.4	1.8	9.3	0.0
1 7	17.5	4.9	24.4	1.7	14.6	5.4	23.3	-5.6	83.9	10.5	100.0	49.0	3.3	1.7	9.8	0.0
1 10	21.0	4.4	26.7	5.6	15.5	5.6	23.3	-6.7	71.5	11.7	100.0	38.0	4.9	2.2	10.3	1.0
1 13	23.5	3.6	28.9	9.4	15.2	5.3	22.2	-6.7	60.5	12.1	97.0	26.0	5.6	2.2	11.3	.5
1 16	23.5	3.3	29.4	10.0	15.1	5.5	23.3	-7.8	60.8	13.3	97.0	21.0	5.3	1.9	10.8	1.0
1 19	21.3	3.7	26.1	6.1	15.5	5.3	23.3	-5.6	70.0	11.4	97.0	36.0	3.8	1.7	15.4	0.0
1 22	19.8	4.2	25.0	4.4	15.5	5.2	23.9	-3.3	76.7	10.2	100.0	41.0	3.5	1.8	9.8	0.0
2 1	17.9	4.5	25.6	5.6	13.8	5.5	22.8	-3.9	77.4	11.1	97.0	39.0	3.9	2.1	10.8	0.0
2 4	16.9	4.9	25.0	3.3	13.4	5.6	22.2	-5.6	80.6	10.5	100.0	42.0	3.9	2.1	10.3	0.0
2 7	16.4	5.1	25.0	2.8	13.1	5.7	22.2	-3.3	81.5	10.3	100.0	50.0	3.7	2.0	9.3	0.0
2 10	20.3	4.4	26.7	7.2	13.6	6.1	23.9	-10.6	66.6	13.3	100.0	19.0	5.5	2.2	11.3	1.0
2 13	23.0	3.5	29.4	10.6	13.4	5.9	22.2	-6.7	56.0	13.1	97.0	22.0	6.1	2.3	13.4	1.5
2 16	23.2	3.3	30.0	12.2	13.3	6.1	22.2	-7.2	55.4	14.1	97.0	21.0	6.0	2.0	12.3	1.5
2 19	20.9	3.4	27.8	10.6	13.8	5.6	22.2	-5.6	65.1	13.0	97.0	28.0	4.3	1.7	10.8	1.0
2 22	19.2	4.0	25.6	7.8	14.1	5.4	22.2	-4.4	73.1	11.8	97.0	31.0	4.0	1.8	10.3	0.0
3 1	20.1	3.7	26.1	5.6	15.9	4.7	22.8	0.0	77.2	10.2	100.0	47.0	3.9	1.8	10.3	0.0
3 4	19.2	4.1	26.1	4.4	15.7	4.7	23.3	1.1	80.6	10.0	100.0	49.0	3.7	1.7	9.3	0.0
3 7	18.8	4.4	25.6	4.4	15.5	4.9	23.3	-.6	82.1	10.1	100.0	49.0	3.6	1.9	12.9	0.0
3 10	22.9	3.5	28.3	9.4	15.8	5.0	23.3	-1.1	65.1	11.0	93.0	30.0	5.9	1.9	12.3	1.5
3 13	25.0	3.2	31.1	12.2	15.3	5.2	22.8	-1.7	56.1	12.3	94.0	21.0	6.3	1.9	12.3	.5
3 16	25.0	2.8	31.7	13.9	15.3	5.1	22.2	-2.2	56.5	13.3	93.0	20.0	6.2	1.7	12.3	1.5
3 19	22.9	2.7	28.3	11.1	15.7	5.0	22.2	-1.1	64.9	12.2	93.0	26.0	4.9	1.5	10.8	1.5
3 22	21.3	3.2	26.7	7.8	16.0	4.8	23.3	-2.2	72.6	11.0	97.0	36.0	4.1	1.7	9.8	0.0
4 1	22.4	2.5	26.7	12.2	17.6	3.4	23.9	3.3	75.3	10.4	100.0	41.0	3.9	1.9	10.3	1.0
4 4	21.4	2.8	26.1	9.4	17.3	3.4	23.3	2.8	78.3	11.4	100.0	43.0	3.6	1.8	8.7	0.0
4 7	21.3	2.9	26.1	7.8	17.4	3.4	23.9	6.1	79.4	11.6	100.0	49.0	3.7	2.0	9.8	0.0
4 10	25.5	2.1	30.6	17.8	17.3	3.6	23.9	2.8	61.3	10.1	94.0	36.0	5.6	2.2	11.3	1.0
4 13	27.3	2.2	32.8	21.1	17.0	3.6	23.9	3.3	54.4	10.0	91.0	26.0	6.1	1.9	12.3	1.5
4 16	26.9	2.3	33.9	20.6	17.0	3.5	23.9	1.7	55.7	10.8	93.0	22.0	6.2	1.7	11.3	1.5
4 19	24.9	2.0	30.0	18.9	17.3	3.5	23.3	0.0	63.5	10.5	90.0	26.0	5.0	1.6	9.8	1.0
4 22	23.5	2.0	26.7	14.4	17.7	3.3	24.4	5.6	70.7	9.9	100.0	46.0	4.2	1.8	10.3	0.0
5 1	24.0	1.6	28.9	18.9	20.1	2.6	26.7	12.2	79.4	10.7	100.0	52.0	3.5	1.7	8.2	0.0
5 4	23.3	1.8	28.9	17.2	19.9	2.7	27.2	9.4	82.2	10.8	100.0	47.0	3.3	1.6	9.8	0.0
5 7	23.5	1.9	28.3	17.8	20.1	2.6	26.7	10.0	82.1	10.8	100.0	52.0	3.6	1.9	9.3	0.0
5 10	27.0	1.6	31.1	21.1	19.9	2.7	26.1	6.1	65.7	10.7	100.0	33.0	5.1	2.0	11.3	1.0
5 13	28.5	1.8	33.3	21.7	19.7	2.7	26.1	9.4	59.8	11.6	94.0	31.0	5.9	1.8	12.3	1.0
5 16	28.0	2.0	32.8	20.6	19.6	2.6	26.1	8.3	61.8	12.5	100.0	31.0	6.0	1.8	11.3	1.0
5 19	26.1	1.7	30.6	20.6	20.0	2.5	26.7	11.1	69.7	11.5	100.0	42.0	4.9	1.7	10.8	0.0
5 22	24.9	1.5	31.1	21.1	20.1	2.5	26.7	11.7	75.3	11.0	100.0	52.0	4.1	1.8	12.3	0.0
6 1	25.1	1.6	28.9	21.1	22.1	1.3	26.1	17.8	84.2	8.1	100.0	64.0	2.9	1.7	10.3	0.0
6 4	24.5	1.5	27.8	20.6	22.1	1.3	25.0	16.7	86.8	7.4	100.0	64.0	2.6	1.6	10.3	0.0
6 7	24.9	1.5	29.4	21.1	22.4	1.3	25.0	17.2	86.5	7.9	100.0	62.0	2.9	1.6	10.3	0.0
6 10	28.2	1.8	31.1	22.8	22.3	1.4	25.6	16.7	71.0	9.9	100.0	48.0	4.3	2.0	11.8	0.0
6 13	28.9	2.5	32.8	21.1	22.0	1.6	25.6	12.8	67.2	12.5	100.0	35.0	5.1	2.0	12.9	0.0
6 16	28.2	2.5	32.8	22.2	21.9	1.6	25.6	15.0	69.7	12.2	100.0	35.0	5.1	2.1	16.5	0.0
6 19	26.8	2.1	31.1	21.1	21.9	1.5	25.0	16.1	75.5	10.8	100.0	49.0	4.0	1.8	12.3	0.0
6 22	25.8	1.8	29.4	20.6	22.0	1.4	25.6	17.2	80.5	9.2	100.0	54.0	3.5	1.8	13.4	0.0

MIAMI

TABLE A-15. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 1	26.1	1.5	29.4	22.2	22.9	1.1	25.6	20.0	82.8	7.9	100.0	65.0	2.4	1.2	6.2	0.0
7 4	25.4	1.4	28.9	21.7	22.9	1.1	25.6	18.3	86.5	7.2	100.0	67.0	2.2	1.1	6.2	0.0
7 7	25.7	1.4	29.4	22.2	23.1	1.1	25.6	13.9	86.0	8.0	100.0	43.0	2.5	1.2	6.2	0.0
7 10	29.1	1.5	31.7	23.3	22.9	1.2	29.4	18.3	69.5	7.9	100.0	51.0	4.1	1.6	8.7	0.0
7 13	30.1	2.0	33.9	21.7	22.6	1.3	26.7	17.8	64.7	9.3	97.0	38.0	5.0	1.4	11.8	1.5
7 16	29.3	2.3	34.4	22.2	22.5	1.3	26.1	17.2	67.6	10.8	100.0	37.0	4.7	1.5	8.7	0.0
7 19	28.0	1.9	32.2	22.2	22.5	1.2	25.6	18.3	72.7	9.4	97.0	52.0	3.6	1.4	8.7	0.0
7 22	26.8	1.7	30.0	22.8	22.7	1.1	25.6	18.3	78.7	8.5	100.0	60.0	2.8	1.2	7.2	0.0
8 1	26.3	1.6	29.4	21.7	23.0	1.1	26.1	20.0	82.3	7.8	100.0	63.0	2.7	1.3	8.7	0.0
8 4	25.6	1.5	28.9	21.1	23.0	1.1	25.6	19.4	85.7	7.3	100.0	67.0	2.4	1.2	7.2	0.0
8 7	25.8	1.5	28.9	22.2	23.2	1.1	25.6	20.6	86.2	7.6	100.0	67.0	2.6	1.3	8.2	0.0
8 10	29.1	1.5	31.1	23.9	23.2	1.2	26.1	20.0	70.7	8.0	97.0	55.0	4.3	1.7	9.3	1.0
8 13	30.2	1.9	34.4	22.8	22.9	1.3	25.6	18.3	65.5	9.5	97.0	47.0	5.1	1.6	10.3	0.0
8 16	29.6	2.1	34.4	23.3	22.7	1.2	26.7	18.9	66.9	9.9	100.0	46.0	4.8	1.5	10.8	1.0
8 19	28.1	1.8	31.1	22.8	22.8	1.2	25.6	16.7	73.3	9.0	100.0	46.0	3.7	1.4	7.7	0.0
8 22	27.1	1.7	30.0	22.8	23.0	1.1	25.6	20.0	78.6	8.4	100.0	61.0	3.1	1.5	8.7	0.0
9 1	25.8	1.5	28.9	22.8	23.0	1.3	26.7	18.9	85.1	7.7	100.0	67.0	2.9	1.6	16.5	0.0
9 4	25.1	1.4	28.3	21.1	22.9	1.3	25.6	18.3	88.0	7.0	100.0	64.0	2.5	2.0	25.7	0.0
9 7	25.1	1.3	28.3	22.2	23.1	1.2	25.6	17.8	89.0	6.7	100.0	65.0	2.8	1.8	22.6	0.0
9 10	28.5	1.7	31.1	23.3	23.2	1.3	26.7	17.2	73.2	9.0	97.0	53.0	4.3	2.1	21.6	0.0
9 13	29.7	1.9	33.3	22.8	22.8	1.4	25.6	18.9	67.1	10.0	97.0	45.0	5.2	1.8	15.4	1.0
9 16	28.9	2.2	32.8	22.8	22.7	1.4	25.6	18.9	70.2	11.0	100.0	45.0	5.0	1.8	12.9	1.5
9 19	27.4	1.7	30.6	22.8	22.9	1.2	26.1	19.4	77.0	8.7	97.0	59.0	3.9	1.6	12.9	1.0
9 22	26.5	1.6	29.4	22.8	23.0	1.3	26.1	19.4	81.5	8.0	100.0	60.0	3.3	1.6	15.4	0.0
10 1	24.1	2.2	28.3	16.1	20.9	2.6	25.6	11.7	82.8	9.5	100.0	52.0	3.5	1.8	10.3	0.0
10 4	23.3	2.3	27.8	13.9	20.7	2.5	25.0	11.7	85.6	9.1	100.0	52.0	3.3	1.9	12.3	0.0
10 7	23.1	2.3	27.2	13.3	20.7	2.6	25.0	11.1	86.7	8.7	100.0	50.0	3.3	1.7	12.3	0.0
10 10	26.7	2.0	30.6	20.0	21.1	2.6	25.6	9.4	72.0	10.6	97.0	44.0	5.1	2.3	16.5	1.0
10 13	28.1	1.9	31.7	21.1	20.6	2.8	25.0	5.6	64.6	11.2	100.0	31.0	5.7	2.1	17.0	1.5
10 16	27.7	1.8	31.7	22.2	20.5	2.8	25.0	7.2	65.9	11.6	100.0	34.0	5.6	2.0	14.9	1.0
10 19	25.9	1.6	28.9	20.0	20.7	2.7	25.0	10.0	73.8	10.3	100.0	48.0	4.3	1.9	12.9	0.0
10 22	24.9	1.8	28.3	17.8	20.8	2.7	25.0	11.1	78.5	9.4	100.0	47.0	3.8	2.1	13.9	0.0
11 1	20.8	3.6	26.7	5.6	17.0	3.9	23.3	.6	79.9	10.3	97.0	51.0	3.6	1.8	8.7	0.0
11 4	19.9	3.8	26.1	5.6	16.8	4.0	23.3	.6	82.9	10.0	100.0	50.0	3.3	1.8	9.3	0.0
11 7	19.4	4.0	25.6	4.4	16.5	4.2	23.3	0.0	84.0	10.5	100.0	47.0	3.4	1.7	10.3	0.0
11 10	23.5	3.4	28.9	10.0	17.1	4.4	23.9	.6	68.2	10.4	94.0	36.0	5.3	2.0	11.3	1.0
11 13	25.4	2.7	30.0	13.9	16.7	4.2	23.9	1.1	59.5	11.0	94.0	26.0	5.7	2.0	13.4	1.0
11 16	25.2	2.5	29.4	12.8	16.6	4.3	23.3	0.0	59.8	11.3	94.0	26.0	5.6	1.8	12.3	1.5
11 19	23.0	2.9	28.3	8.9	16.9	4.1	23.9	-.6	69.5	9.8	97.0	43.0	4.1	1.7	10.3	0.0
11 22	21.6	3.4	27.2	6.1	16.9	4.0	23.3	-.6	75.3	10.0	94.0	47.0	3.9	1.9	10.3	0.0
12 1	18.9	4.5	25.0	5.0	14.9	5.1	23.3	0.0	78.4	10.4	97.0	47.0	3.5	1.9	14.9	0.0
12 4	18.1	4.8	24.4	2.8	14.7	5.2	22.2	-.6	81.3	10.5	100.0	44.0	3.3	1.8	12.9	0.0
12 7	17.6	5.0	24.4	1.7	14.5	5.2	22.2	-3.3	82.9	10.9	100.0	46.0	3.2	1.7	12.3	0.0
12 10	21.5	3.9	26.1	7.2	15.3	5.2	23.3	-2.2	68.2	11.0	100.0	36.0	5.2	1.9	10.3	1.0
12 13	24.0	3.0	28.9	13.9	15.1	5.1	22.8	-6.1	58.5	11.1	93.0	24.0	5.8	2.0	11.8	.5
12 16	23.8	2.6	28.9	15.6	14.9	5.2	22.2	-7.2	58.4	12.3	97.0	19.0	5.5	1.6	10.3	1.5
12 19	21.4	3.3	25.6	10.0	15.2	5.0	23.3	-2.8	68.8	11.0	97.0	38.0	3.9	1.6	12.9	0.0
12 22	19.9	4.1	25.0	7.8	15.2	5.0	23.3	-1.1	75.0	10.3	97.0	44.0	3.6	1.8	10.3	0.0

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TABLE A-15. (Continued)

Month /Hour (1)	Station pressure (Kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 1	101.9	.4	103.0	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6	39.5	38.5	38.6
1 4	101.8	.4	103.0	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.5	39.0	41.6	38.3
1 7	101.9	.4	103.0	100.8	4.4	3.2	16.3	0.0	0.0	0.0	0.0	0.0	49.5	36.9	44.3	36.4
1 10	102.1	.4	103.1	100.9	404.3	133.2	633.3	46.5	736.2	29.5	778.5	697.2	52.7	35.9	46.6	34.6
1 13	101.9	.4	102.9	100.7	560.3	182.1	888.9	50.0	970.6	34.9	1022.6	918.0	64.6	30.2	58.5	29.8
1 16	101.8	.4	102.9	100.5	245.8	94.0	441.6	18.6	509.0	28.0	557.8	464.8	60.4	33.1	54.8	32.6
1 19	101.9	.4	102.9	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.4	37.6	45.5	37.4
1 22	102.0	.4	102.9	100.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.9	39.3	37.7	38.1
2 1	101.8	.4	102.8	100.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	40.6	40.2	39.7
2 4	101.7	.4	102.7	100.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.3	40.6	42.1	40.6
2 7	101.8	.4	102.8	100.6	15.7	10.4	51.1	0.0	0.0	0.0	0.0	0.0	50.6	38.7	45.2	37.5
2 10	102.0	.4	102.9	100.6	481.2	160.3	769.2	93.0	852.4	35.1	906.4	801.8	52.2	38.8	47.2	36.8
2 13	101.8	.4	102.8	100.4	623.9	224.6	1069.0	16.3	1104.7	38.1	1162.0	1034.2	60.7	33.8	55.4	32.6
2 16	101.7	.4	102.7	100.6	309.8	122.5	568.2	9.3	630.0	36.5	697.2	557.8	58.0	34.4	51.4	32.7
2 19	101.8	.4	102.8	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.4	37.6	42.8	37.0
2 22	101.9	.4	102.8	100.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.1	39.5	38.8	39.1
3 1	101.8	.4	102.6	100.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.8	37.1	34.7	35.8
3 4	101.7	.4	102.5	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.2	36.4	34.9	35.2
3 7	101.8	.4	102.6	100.5	45.3	20.1	108.1	0.0	165.4	18.9	185.9	139.4	48.7	35.9	40.7	32.8
3 10	101.9	.4	102.7	100.6	568.2	175.1	933.1	33.7	984.0	37.0	1034.2	929.6	56.7	33.9	40.9	32.2
3 13	101.8	.4	102.6	100.5	719.1	230.7	1173.6	45.3	1231.7	31.3	1278.2	1173.6	61.5	31.6	55.5	30.6
3 16	101.6	.4	102.5	100.3	383.0	140.9	668.2	23.2	749.7	34.3	801.8	697.2	57.2	32.5	51.1	32.2
3 19	101.7	.4	102.5	100.4	.9	1.1	7.0	0.0	0.0	0.0	0.0	0.0	48.5	36.0	41.4	34.2
3 22	101.8	.4	102.7	100.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.7	36.8	33.1	35.4
4 1	101.7	.3	102.6	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.9	35.1	32.1	33.7
4 4	101.6	.3	102.6	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.6	32.7	31.0	31.2
4 7	101.8	.3	102.6	100.8	99.4	30.9	192.9	8.1	265.7	30.1	313.7	220.8	45.2	34.7	36.6	31.0
4 10	101.9	.4	102.8	100.8	643.3	153.3	954.0	23.2	1079.0	19.9	1103.9	1034.2	55.1	32.0	49.9	30.5
4 13	101.8	.4	102.7	100.8	810.5	205.2	1218.9	41.8	1313.1	15.0	1336.3	1278.2	56.2	31.0	51.6	29.6
4 16	101.6	.4	102.6	100.7	468.4	138.1	811.1	17.4	845.2	21.8	883.1	801.8	50.5	33.8	44.5	31.8
4 19	101.7	.4	102.6	100.7	5.6	4.3	26.7	0.0	0.0	0.0	0.0	0.0	44.4	35.5	37.9	34.5
4 22	101.8	.3	102.7	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.1	34.2	28.8	32.8
5 1	101.6	.3	102.1	100.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.5	33.5	35.8	32.8
5 4	101.5	.3	102.1	100.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.5	33.9	33.9	32.7
5 7	101.6	.3	102.2	100.8	135.9	47.6	277.7	4.6	342.0	18.3	371.8	313.7	51.2	35.4	42.5	32.2
5 10	101.7	.3	102.3	100.9	616.9	171.2	981.9	115.0	1109.1	7.7	1127.1	1092.3	65.2	28.5	59.8	27.9
5 13	101.6	.3	102.2	100.7	751.0	250.2	1227.1	17.4	1337.8	6.4	1347.9	1324.7	67.8	27.9	61.6	27.7
5 16	101.5	.3	102.1	100.6	418.2	176.9	775.1	5.8	895.1	12.7	906.4	871.5	65.3	30.0	58.9	29.9
5 19	101.5	.3	102.1	100.7	16.5	10.5	77.9	0.0	150.5	11.6	162.7	139.4	62.9	33.3	53.5	33.1
5 22	101.6	.3	102.2	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.7	35.8	42.2	35.6
6 1	101.5	.3	102.3	100.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.6	34.7	42.2	34.5
6 4	101.4	.3	102.2	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.1	35.9	39.5	35.3
6 7	101.5	.3	102.2	100.2	144.5	59.8	268.4	1.2	371.8	0.0	371.8	371.8	61.2	32.8	50.4	32.7
6 10	101.6	.3	102.4	100.2	584.7	217.4	979.6	39.5	1127.1	0.0	1127.1	1127.1	72.8	24.8	65.3	25.0
6 13	101.6	.3	102.3	100.3	630.1	324.7	1155.0	10.5	1336.3	0.0	1336.3	1336.3	76.1	24.2	69.9	24.7
6 16	101.5	.3	102.2	100.2	332.8	211.9	735.5	3.5	912.1	5.9	918.0	894.7	77.9	26.9	72.1	28.5
6 19	101.5	.3	102.3	100.3	17.5	13.1	65.1	0.0	184.4	5.8	185.9	162.7	79.1	26.5	71.2	28.5
6 22	101.6	.3	102.3	100.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.3	31.8	55.6	33.1

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TABLE A-15. (Continued)

Month /Hour (1)	Station pressure (Kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 1	101.7	.2	102.2	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.7	31.2	41.4	31.1
7 4	101.7	.2	102.1	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.5	30.4	37.3	29.2
7 7	101.7	.2	102.2	100.9	152.3	53.7	292.8	0.0	362.8	11.3	371.8	348.6	59.1	29.0	45.7	27.1
7 10	101.8	.2	102.3	101.1	659.5	189.3	1013.3	13.9	1113.6	11.5	1127.1	1103.9	69.2	22.3	60.3	22.0
7 13	101.8	.2	102.3	101.1	751.1	311.2	1340.9	13.9	1334.4	4.3	1336.3	1324.7	71.6	23.9	63.4	23.7
7 16	101.7	.2	102.3	101.0	400.9	212.4	832.0	2.3	901.1	9.7	906.4	883.1	72.0	26.8	63.7	26.6
7 19	101.7	.2	102.2	101.1	14.7	9.8	54.6	0.0	163.4	18.2	185.9	139.4	70.9	29.2	60.8	29.8
7 22	101.8	.2	102.2	101.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.6	31.4	44.1	30.7
8 1	101.6	.2	102.2	101.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.7	29.4	36.0	26.7
8 4	101.5	.2	102.0	100.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.6	27.5	32.1	25.0
8 7	101.6	.2	102.1	100.9	118.6	46.5	235.9	9.3	298.3	29.3	604.2	244.0	55.5	30.1	41.1	26.6
8 10	101.7	.2	102.2	101.0	621.1	187.5	987.7	61.6	1083.6	11.1	1092.3	1045.8	69.0	22.5	61.0	22.1
8 13	101.7	.2	102.2	101.0	760.4	285.9	1208.5	29.1	1312.7	9.1	1324.7	1289.8	71.9	22.4	64.2	22.1
8 16	101.5	.2	102.0	100.9	414.2	196.7	690.2	9.3	861.4	17.2	883.1	825.0	69.7	24.7	61.8	25.4
8 19	101.6	.2	102.0	100.9	6.0	5.8	37.2	0.0	139.4	0.0	139.4	139.4	69.6	26.7	57.5	27.4
8 22	101.7	.2	102.1	101.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.9	29.6	40.9	27.8
9 1	101.4	.3	102.1	98.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.4	32.3	44.9	31.4
9 4	101.4	.3	102.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.8	32.3	37.3	30.8
9 7	101.5	.3	102.1	98.7	59.6	33.1	195.2	0.0	191.1	37.0	244.0	139.4	62.2	31.8	49.6	30.3
9 10	101.6	.3	102.2	99.5	563.4	193.7	897.1	4.6	1014.8	26.8	1045.8	976.1	70.3	24.6	62.0	24.1
9 13	101.5	.3	102.1	99.9	655.4	264.5	1135.3	15.1	1253.3	24.1	1289.8	1208.5	74.4	23.2	67.7	23.4
9 16	101.3	.3	102.0	100.0	348.6	173.6	674.0	2.3	782.4	29.0	825.0	743.7	73.5	24.9	67.0	25.6
9 19	101.4	.3	102.0	99.8	1.0	1.7	11.6	0.0	0.0	0.0	0.0	0.0	70.8	29.0	62.1	30.4
9 22	101.5	.3	102.1	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.2	31.9	52.3	32.5
10 1	101.4	.3	102.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.4	37.0	41.5	36.0
10 4	101.4	.3	102.6	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.6	35.9	37.2	34.3
10 7	101.5	.3	102.8	99.6	23.3	14.3	63.9	0.0	0.0	0.0	0.0	0.0	53.3	35.6	45.8	33.7
10 10	101.6	.3	102.9	99.8	500.9	164.5	813.4	32.5	892.5	38.5	976.1	825.0	60.2	32.4	54.5	31.5
10 13	101.4	.3	102.7	99.8	637.2	222.1	1030.7	32.5	1140.7	41.5	1208.5	1069.0	66.9	29.1	60.5	28.2
10 16	101.3	.3	102.7	100.1	304.9	128.5	556.6	11.6	666.5	38.0	743.7	604.2	64.6	30.4	58.9	30.0
10 19	101.4	.3	102.7	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.5	35.3	51.8	35.6
10 22	101.5	.3	102.7	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.2	36.5	45.3	36.3
11 1	101.7	.3	102.4	100.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	35.7	33.1	34.1
11 4	101.6	.3	102.4	100.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.5	35.8	31.6	34.4
11 7	101.7	.3	102.5	100.5	6.6	5.1	23.2	0.0	0.0	0.0	0.0	0.0	48.9	34.2	40.8	32.7
11 10	101.9	.3	102.6	100.6	445.5	133.7	643.7	32.5	767.6	29.0	813.4	720.4	49.5	34.1	44.4	32.3
11 13	101.7	.3	102.5	100.5	590.4	184.5	884.3	16.3	1008.6	37.5	1080.7	952.8	59.7	30.2	53.9	29.3
11 16	101.6	.3	102.4	100.4	271.3	94.3	459.0	18.6	539.6	32.2	604.2	488.0	53.7	32.7	48.2	30.7
11 19	101.7	.3	102.5	100.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.8	35.0	36.8	33.4
11 22	101.8	.3	102.6	100.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	35.3	33.7	33.8
12 1	101.9	.3	102.8	100.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.5	35.5	32.8	34.8
12 4	101.8	.4	102.7	100.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.9	35.1	31.5	34.4
12 7	101.9	.4	102.9	100.5	2.5	2.3	18.6	0.0	0.0	0.0	0.0	0.0	45.2	36.2	39.4	34.6
12 10	102.0	.4	103.0	100.8	411.2	109.0	594.9	54.6	700.2	7.8	720.4	697.2	45.5	36.0	39.5	34.2
12 13	101.9	.4	102.8	100.7	583.3	158.8	832.0	18.6	924.0	10.2	941.2	918.0	55.3	33.6	49.3	31.4
12 16	101.8	.4	102.7	100.5	244.6	86.5	456.7	0.0	470.8	10.2	488.0	464.8	51.8	34.0	46.1	32.7
12 19	101.9	.3	102.8	100.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.3	38.1	37.6	37.2
12 22	101.9	.3	102.9	100.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.7	36.0	33.0	35.3

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TABLE A-16. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR MIAMI, FLORIDA

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 1	7		10	4											7
1 4	15	1	6	3											13
1 7	30		8		1										32
1 10	9	1	9	4											44
1 13	2		9	2	1										11
1 16			10	7											12
1 19			12	2											9
1 22	1		6	4											3
2 1	2		13	3	1										3
2 4	7		12	5											5
2 7	10	2	9	3	2										31
2 10	3		6	1											32
2 13	1		4		1										13
2 16			10	7	1										5
2 19			9	5	2										2
2 22			12	5											2
3 1	1		8	2											9
3 4	7		9	5											13
3 7	9		3	4											33
3 10			6	5	1										11
3 13			6	6	3										4
3 16			3	5											6
3 19			4	3	2										7
3 22			6	4											3
4 1			2	3	2										16
4 4	1		1	2	1										30
4 7	6		1	4											71
4 10			2	6											37
4 13			3	5											17
4 16	1		3	2	1										12
4 19			6	5	2										9
4 22			1	1	2										10
5 1			5	6	2										15
5 4	1		3	4	4										19
5 7	1		3	4	5										48
5 10			2	5											26
5 13			1	9	10										19
5 16			4	11	12										20
5 19			6	12	10										19
5 22			4	3	4										12
6 1			8	4	2										2
6 4			11	7	3										2
6 7			8	12	5										21
6 10			12	11	7										9
6 13			10	13	37	1									8
6 16			17	10	34										8
6 19			23	17	19										5
6 22			14	10	4										1

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TABLE A-16. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 1			4	5	10										2
7 4	1		4	7	10										
7 7	3		1	5	5										8
7 10			4	6	3										1
7 13			6	4	29										3
7 16			11	8	22										5
7 19			3	8	9										2
7 22			8	6	6										1
8 1			1	3	7										
8 4	1			4	4										
8 7			2	5	8										5
8 10			2	13	7										4
8 13			4	4	31										3
8 16			7	7	16										1
8 19			8	5	14										1
8 22			2	8	5										
9 1			6	8	6										2
9 4			9	4	3										2
9 7	5		7	10	2										13
9 10			7	8	4										8
9 13			10	11	19	1									7
9 16			13	12	15										6
9 19			16	8	15										7
9 22			12	7	6										3
10 1			13	13	5										1
10 4	4	1	12	12	1										4
10 7	15		18	9	1										20
10 10	2		11	10											19
10 13	1		11	11	2										5
10 16			9	8	2										5
10 19			14	16	4										3
10 22			18	7											
11 1	2		4	4											3
11 4	8	1	3	6											11
11 7	17		6	3											30
11 10	2		2	7											17
11 13			5	7	2										10
11 16			2	4											7
11 19			2	7											7
11 22			2	6	1										3
12 1	2		4	3											5
12 4	4		3	3											11
12 7	20	1	3	4											27
12 10	1		5	3											23
12 13			3	3	1										2
12 16			1	4											5
12 19			6	2											5
12 22			3	7											5

MIAMI

TABLE A-17. DESCRIPTIVE ENVIRONMENTAL STATISTICS FOR PHOENIX, ARIZONA AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
1 2	6.8	3.5	16.1	-2.8	.3	5.5	12.2	-19.4	66.2	17.9	96.0	22.0	2.6	1.3	7.7	0.0
1 5	5.4	3.8	16.7	-3.9	-.1	5.2	12.8	-16.1	69.8	17.0	100.0	21.0	2.6	1.3	6.7	0.0
1 8	5.1	3.9	14.4	-5.0	-.5	5.2	12.2	-17.8	69.8	17.4	96.0	19.0	2.6	1.3	7.7	0.0
1 11	12.9	3.3	23.3	3.3	.4	6.0	12.8	-24.4	45.8	17.7	96.0	5.0	3.1	1.8	9.3	0.0
1 14	17.4	3.8	30.0	6.1	-.6	6.6	12.8	-24.4	32.9	16.4	96.0	4.0	2.9	1.5	8.2	0.0
1 17	17.8	3.9	30.0	6.7	-1.0	6.6	13.3	-25.6	31.7	17.0	97.0	4.0	2.8	1.5	8.7	0.0
1 20	12.6	3.3	21.1	1.7	.6	6.0	13.9	-18.9	47.1	18.0	96.0	9.0	2.0	1.5	9.8	0.0
1 23	9.0	3.4	17.8	-1.1	.6	5.6	12.8	-20.6	59.1	18.6	96.0	16.0	2.4	1.4	8.7	0.0
2 2	9.1	3.7	17.8	.6	-.5	6.2	13.3	-18.3	55.7	22.1	96.0	8.0	2.7	1.4	7.2	0.0
2 5	7.5	3.7	20.0	-.6	-.9	6.0	12.2	-18.9	59.8	21.8	100.0	9.0	2.7	1.5	8.2	0.0
2 8	7.4	3.6	17.8	-.6	-.9	5.8	11.7	-17.8	59.5	21.2	100.0	9.0	2.7	1.5	8.2	0.0
2 11	15.7	3.7	25.6	4.4	-.5	6.5	13.3	*	37.5	19.0	90.0	5.0	3.4	1.8	11.3	0.0
2 14	19.9	4.3	29.4	6.1	-1.8	7.4	12.8	*	27.6	17.7	93.0	4.0	3.4	2.0	13.4	0.0
2 17	20.4	4.5	30.0	5.0	-2.5	7.1	12.2	-25.6	25.8	17.6	93.0	3.0	3.4	1.9	13.9	0.0
2 20	15.6	3.8	25.0	3.9	-.9	6.7	12.8	-20.0	37.0	19.5	100.0	6.0	2.4	1.6	9.3	0.0
2 23	11.9	3.8	23.9	2.8	-.3	6.4	13.3	-21.7	47.7	21.2	100.0	8.0	2.8	1.6	10.3	0.0
3 2	11.8	4.3	25.0	-.6	1.5	5.3	12.2	-13.9	54.0	21.2	96.0	13.0	2.8	1.2	9.3	0.0
3 5	9.9	3.9	19.4	-1.7	1.2	5.2	12.2	-13.9	59.2	20.9	100.0	14.0	2.9	1.2	7.7	0.0
3 8	11.4	3.9	20.0	0.0	1.5	5.0	11.1	-12.8	54.9	20.2	100.0	16.0	3.0	1.3	7.2	0.0
3 11	19.1	4.6	30.6	7.8	1.0	5.8	10.6	*	33.6	17.3	86.0	4.0	3.3	1.5	9.3	0.0
3 14	22.8	5.4	34.4	9.4	-.7	6.3	13.3	*	25.0	16.1	100.0	3.0	3.5	2.0	12.9	0.0
3 17	23.3	5.7	34.4	7.8	-1.3	6.1	13.9	-21.7	23.6	16.5	100.0	3.0	4.0	1.9	10.8	0.0
3 20	19.1	5.1	29.4	6.1	.0	5.7	11.7	-17.8	32.5	19.2	93.0	5.0	2.7	1.6	8.7	0.0
3 23	14.9	4.5	27.8	2.2	1.3	5.6	11.7	-21.1	44.9	20.7	93.0	4.0	2.8	1.6	10.3	0.0
4 2	15.1	3.5	27.2	5.6	-.2	4.8	12.2	-16.7	38.3	16.0	96.0	8.0	3.0	1.3	10.3	0.0
4 5	12.5	3.5	23.3	4.4	-.2	4.7	11.7	-16.1	45.0	17.4	96.0	8.0	3.1	1.4	7.7	0.0
4 8	16.3	3.5	25.6	6.1	.3	4.8	11.1	-16.7	37.0	16.4	93.0	6.0	3.6	1.6	10.8	0.0
4 11	23.0	4.2	31.1	7.8	-.9	5.3	11.7	-20.6	23.1	13.3	89.0	4.0	3.5	1.8	10.3	0.0
4 14	26.7	4.8	35.0	8.3	-2.6	5.5	12.8	-20.0	16.8	11.9	89.0	3.0	4.1	2.0	12.3	0.0
4 17	27.2	4.8	35.0	8.9	-3.5	5.2	11.1	-18.9	15.0	10.4	79.0	3.0	4.6	2.1	12.9	0.0
4 20	23.2	4.2	32.2	8.3	-2.5	4.9	13.3	-13.9	20.4	12.9	86.0	6.0	3.4	1.9	13.4	0.0
4 23	18.7	3.8	28.3	6.1	-1.0	5.0	12.2	-18.9	29.7	15.8	96.0	7.0	2.9	1.8	12.3	0.0
5 2	20.5	3.9	29.4	7.2	1.8	4.2	15.0	-12.2	30.5	11.1	96.0	10.0	2.8	1.3	8.7	0.0
5 5	17.5	3.7	25.6	4.4	1.9	4.4	15.6	-8.9	36.7	12.0	96.0	14.0	2.9	1.1	8.2	0.0
5 8	22.9	3.8	31.1	11.1	2.2	4.3	15.6	-8.9	27.1	10.4	90.0	12.0	3.7	1.3	8.7	0.0
5 11	29.3	4.1	38.3	15.0	1.1	4.7	12.8	-14.4	17.5	7.7	60.0	5.0	3.4	1.6	12.9	0.0
5 14	32.8	4.5	42.2	17.2	-.1	5.1	17.2	-19.4	13.4	7.4	69.0	4.0	4.2	1.5	9.3	1.0
5 17	33.2	4.6	42.2	12.8	-1.0	5.1	13.9	-15.0	12.4	8.2	86.0	4.0	4.8	1.9	12.9	1.0
5 20	29.4	4.1	38.9	11.1	-.2	4.7	14.4	-17.8	16.1	9.2	83.0	5.0	3.7	1.6	10.8	0.0
5 23	24.8	4.0	33.3	11.1	1.0	4.6	14.4	-16.7	22.7	10.9	93.0	6.0	2.9	1.5	10.3	0.0
6 2	25.2	4.2	35.0	16.7	5.5	4.8	19.4	-10.6	30.0	11.3	84.0	8.0	2.7	1.2	7.2	0.0
6 5	22.2	4.0	33.3	11.1	5.7	4.7	18.3	-8.9	36.0	11.4	84.0	8.0	2.8	1.0	6.7	0.0
6 8	27.5	3.5	35.6	18.3	5.7	4.9	19.4	-8.3	26.5	10.1	84.0	7.0	3.4	1.2	7.2	0.0
6 11	33.5	3.9	43.9	20.0	5.0	5.0	20.0	-10.6	18.1	8.5	76.0	5.0	3.3	1.5	12.9	0.0
6 14	37.1	4.4	46.1	21.1	4.0	5.0	20.0	-10.6	14.1	8.4	84.0	4.0	4.2	1.4	10.3	0.0
6 17	37.9	4.4	46.7	23.3	3.2	5.1	18.3	-12.2	12.7	7.7	73.0	3.0	5.0	1.8	12.3	1.0
6 20	34.2	4.2	42.8	22.2	3.8	4.8	19.4	-9.4	16.0	8.7	79.0	7.0	4.0	1.7	13.9	0.0
6 23	29.5	4.0	38.3	18.9	5.0	4.9	19.4	-6.1	22.6	10.6	81.0	8.0	2.9	1.4	8.7	0.0

*Data are not available.

TABLE A-17. (Continued)

Month /Hour (1)	Air temperature (Celsius) Mean (2)	Standard Deviation (3)	Maximum (4)	Minimum (5)	Dew point (Celsius) Mean (6)	Standard Deviation (7)	Maximum (8)	Minimum (9)	Relative humidity (percent) Mean (10)	Standard Deviation (11)	Maximum (12)	Minimum (13)	Wind speed (meters/second) Mean (14)	Standard Deviation (15)	Maximum (16)	Minimum (17)
7 2	30.1	2.7	37.2	21.7	14.1	4.8	24.4	-1.1	40.1	15.2	91.0	15.0	3.3	1.6	12.9	0.0
7 5	27.9	2.8	35.6	19.4	14.6	4.7	23.3	-1.1	46.2	14.8	97.0	18.0	2.9	1.2	8.2	0.0
7 8	30.9	2.1	35.6	23.3	14.7	4.6	23.3	-.6	39.4	13.7	84.0	15.0	3.2	1.2	7.7	0.0
7 11	35.7	2.4	41.1	28.9	13.7	4.5	22.8	0.0	28.3	10.4	61.0	9.0	3.2	1.2	9.3	0.0
7 14	39.1	2.8	45.0	26.1	12.6	4.5	22.2	-2.8	22.0	9.1	71.0	5.0	4.1	1.3	9.3	1.0
7 17	40.1	2.9	46.1	26.7	11.7	4.4	22.8	-5.6	19.8	8.7	67.0	5.0	4.8	1.7	18.0	1.0
7 20	36.8	3.1	42.2	24.4	12.1	4.5	21.7	-1.7	24.6	11.3	79.0	8.0	4.2	2.0	12.3	0.0
7 23	33.0	2.8	38.9	23.9	13.4	4.6	23.9	-3.9	32.9	14.0	94.0	11.0	3.6	1.7	10.3	0.0
8 2	28.9	2.7	34.4	21.1	15.3	4.5	23.9	-1.7	45.9	14.9	91.0	15.0	3.1	1.5	8.7	0.0
8 5	26.9	2.7	33.9	17.2	15.8	4.3	23.9	2.8	52.6	14.6	97.0	22.0	2.8	1.3	10.3	0.0
8 8	29.5	2.3	35.6	22.2	16.0	4.2	23.9	-2.8	45.7	13.0	91.0	19.0	3.1	1.3	7.2	0.0
8 11	34.5	2.4	41.1	27.2	15.2	4.3	23.3	-1.1	32.9	10.8	79.0	11.0	3.0	1.3	7.7	0.0
8 14	38.0	2.5	44.4	27.8	13.7	4.7	23.3	-2.2	25.0	9.1	65.0	7.0	3.8	1.2	9.3	1.0
8 17	38.7	2.8	45.6	27.8	12.9	4.6	22.8	.6	22.8	9.2	65.0	8.0	4.3	1.8	14.4	1.0
8 20	35.1	2.9	42.2	25.0	13.3	4.5	23.9	0.0	28.8	12.0	84.0	10.0	3.9	2.2	18.0	0.0
8 23	31.5	2.9	37.8	21.7	14.5	4.6	23.9	2.2	37.8	14.7	97.0	14.0	3.4	1.8	10.3	0.0
9 2	24.6	3.6	32.2	11.1	11.4	5.7	22.8	-6.1	46.0	16.1	97.0	15.0	2.7	1.3	8.2	0.0
9 5	22.6	3.6	30.6	9.4	11.5	5.6	22.2	-6.7	51.6	16.1	97.0	16.0	2.9	1.3	7.7	0.0
9 8	25.3	3.4	33.3	12.2	11.5	5.7	22.8	-7.2	44.3	15.7	100.0	12.0	3.4	1.3	8.7	0.0
9 11	31.9	3.4	40.0	17.8	11.0	6.0	22.2	-11.1	30.2	14.6	97.0	6.0	3.6	1.5	9.3	0.0
9 14	35.3	3.8	42.2	18.3	9.7	5.9	21.7	-10.0	23.2	12.8	84.0	6.0	3.7	1.6	9.3	0.0
9 17	35.4	4.1	42.8	16.1	8.7	6.2	22.2	-8.9	22.1	14.1	97.0	6.0	4.2	1.8	13.4	0.0
9 20	30.9	4.0	38.9	12.8	10.3	5.6	22.2	-10.0	30.8	16.3	97.0	8.0	2.8	1.8	11.3	0.0
9 23	27.2	3.8	35.0	12.2	11.0	5.8	22.8	-12.2	39.4	16.9	97.0	8.0	2.8	1.6	8.2	0.0
10 2	17.4	4.0	27.2	3.9	6.4	6.2	20.0	-13.3	51.1	17.4	100.0	10.0	2.7	1.5	11.3	0.0
10 5	15.8	4.3	26.1	1.1	6.1	6.2	20.0	-11.1	55.4	17.9	100.0	15.0	2.8	1.3	9.3	0.0
10 8	17.9	4.1	27.8	4.4	6.2	6.0	20.0	-10.6	49.2	17.5	97.0	17.0	3.0	1.5	8.7	0.0
10 11	25.7	4.4	34.4	11.1	5.4	6.7	20.0	-13.3	30.6	16.3	87.0	8.0	3.5	1.7	8.7	0.0
10 14	29.2	4.8	38.9	13.9	4.1	6.8	20.0	-15.0	23.4	14.6	82.0	6.0	3.5	1.8	15.4	1.0
10 17	29.0	4.9	38.3	12.2	3.6	6.6	20.0	-13.3	23.1	15.6	93.0	4.0	3.7	1.8	10.8	0.0
10 20	23.6	4.2	32.8	10.0	5.9	6.2	21.1	-13.9	34.8	16.4	97.0	9.0	2.3	1.7	10.3	0.0
10 23	19.8	4.1	31.7	6.7	6.2	6.3	21.1	-16.7	44.1	16.6	93.0	6.0	2.5	1.5	8.7	0.0
11 2	11.5	3.1	19.4	3.3	3.2	4.9	15.0	-8.9	59.7	19.5	100.0	23.0	2.7	1.4	8.2	0.0
11 5	10.2	3.3	17.8	1.1	2.8	4.8	15.6	-9.4	63.1	19.0	100.0	21.0	2.7	1.3	6.7	0.0
11 8	10.7	3.5	20.0	1.7	2.9	4.8	15.6	-9.4	61.7	19.6	100.0	23.0	2.8	1.5	12.3	0.0
11 11	19.0	3.9	29.0	8.3	2.8	5.3	15.6	-12.8	38.2	18.4	97.0	8.0	3.2	1.8	11.3	0.0
11 14	22.7	4.2	32.8	11.1	1.9	5.6	15.0	-15.6	28.9	16.3	96.0	5.0	2.9	1.6	8.7	0.0
11 17	22.4	4.1	31.7	10.6	1.7	5.3	15.6	-12.2	29.0	16.2	93.0	8.0	2.8	1.3	8.2	0.0
11 20	17.1	3.1	24.4	8.9	3.6	4.9	15.6	-17.8	43.8	17.4	93.0	9.0	1.9	1.4	7.7	0.0
11 23	13.6	3.2	21.1	5.6	3.6	4.9	15.0	-14.4	54.0	19.2	97.0	14.0	2.5	1.4	8.2	0.0
12 2	7.1	3.5	17.2	-2.2	.9	4.6	13.3	-13.3	67.3	18.2	100.0	19.0	2.7	1.5	12.3	0.0
12 5	5.9	3.6	16.1	-2.8	.5	4.6	13.3	-13.9	71.0	17.8	100.0	21.0	2.7	1.4	8.2	0.0
12 8	5.4	3.7	16.1	-3.3	.4	4.4	13.9	-11.7	72.3	17.1	100.0	20.0	2.6	1.3	7.2	0.0
12 11	13.0	4.0	23.3	3.3	1.1	4.8	14.4	-12.2	48.3	19.0	100.0	15.0	3.1	1.9	11.8	0.0
12 14	17.0	4.6	27.2	3.9	.1	5.3	14.4	-16.7	35.8	18.6	96.0	9.0	3.1	1.8	14.4	0.0
12 17	16.8	4.4	25.6	4.4	-.1	5.2	13.3	-12.8	35.7	18.6	97.0	11.0	2.9	1.7	8.7	0.0
12 20	11.9	3.4	21.7	.6	1.4	4.6	13.3	-12.2	51.8	18.3	100.0	18.0	2.1	1.4	7.7	0.0
12 23	9.0	3.6	20.0	-.6	1.3	4.4	12.8	-11.7	61.5	18.3	100.0	18.0	2.5	1.4	7.2	0.0

PHOENIX

TABLE A-17. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
1 2	97.8	.4	99.2	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.7	40.3	20.8	35.7
1 5	97.8	.4	99.1	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.9	41.7	24.0	37.0
1 8	97.9	.4	99.2	96.3	58.0	25.8	101.1	5.8	167.7	30.3	209.2	116.2	42.8	44.1	26.7	36.4
1 11	98.0	.4	99.1	96.4	463.5	124.0	594.9	124.3	763.9	35.7	825.0	720.4	41.9	44.0	24.7	35.0
1 14	97.7	.4	98.8	96.1	424.8	146.0	581.0	89.5	763.9	35.7	825.0	720.4	46.3	44.3	29.3	35.8
1 17	97.7	.4	98.7	96.2	50.7	19.9	87.1	8.1	167.7	30.3	209.2	116.2	50.1	44.0	32.3	37.7
1 20	97.8	.4	98.9	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.6	42.2	26.2	36.9
1 23	97.8	.4	99.1	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.5	41.2	21.3	35.5
2 2	97.7	.4	98.9	95.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.6	42.4	24.0	37.4
2 5	97.7	.4	99.0	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.5	42.0	24.1	36.3
2 8	97.8	.4	99.1	96.4	114.3	41.8	178.9	47.6	280.5	41.9	348.6	209.2	41.5	43.9	27.6	37.5
2 11	97.9	.4	99.2	96.6	556.7	205.6	741.4	54.6	904.7	43.5	987.7	848.3	42.2	43.8	26.2	35.9
2 14	97.6	.4	98.8	96.3	561.7	129.3	696.0	226.6	904.7	43.5	987.7	848.3	45.9	43.0	28.6	34.7
2 17	97.5	.4	98.6	96.1	121.0	41.1	173.1	15.1	280.5	41.9	348.6	209.2	48.1	43.5	30.6	35.0
2 20	97.6	.4	98.7	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.0	44.4	30.0	38.2
2 23	97.7	.4	98.7	95.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.9	41.9	24.9	36.8
3 2	97.5	.4	98.9	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	41.5	23.4	36.0
3 5	97.5	.4	98.8	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.9	41.4	23.1	35.9
3 8	97.6	.4	98.8	96.5	202.2	82.3	337.0	39.5	426.9	44.0	499.7	348.6	40.7	45.0	28.2	37.9
3 11	97.6	.4	99.0	96.6	753.4	74.8	861.0	550.8	1067.2	41.3	1127.1	987.7	40.8	43.2	26.5	35.2
3 14	97.4	.4	98.8	96.4	612.2	176.6	801.8	153.4	1067.2	41.3	1127.1	987.7	47.3	42.8	31.5	36.7
3 17	97.3	.4	98.7	96.2	186.8	75.9	277.7	27.9	426.9	44.0	499.7	348.6	48.5	43.2	31.5	35.2
3 20	97.4	.4	98.8	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.2	42.5	27.0	35.7
3 23	97.5	.4	98.8	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.7	41.5	23.3	35.1
4 2	97.3	.3	98.2	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.2	37.4	16.8	32.2
4 5	97.3	.3	98.1	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	38.4	17.1	32.5
4 8	97.5	.3	98.3	96.3	311.0	106.2	400.9	55.8	568.2	35.5	627.5	499.7	26.7	39.5	17.6	32.2
4 11	97.5	.3	98.3	96.4	809.7	91.3	900.6	546.1	1186.0	25.4	1220.1	1138.8	26.8	39.2	17.0	30.6
4 14	97.3	.3	98.2	96.1	746.6	141.2	879.6	418.3	1186.0	25.4	1220.1	1138.8	28.5	39.4	19.0	30.3
4 17	97.1	.3	98.0	96.0	264.8	84.6	356.7	89.5	568.2	35.5	627.5	499.7	29.7	39.2	19.2	29.9
4 20	97.2	.3	98.1	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.8	39.1	19.9	31.4
4 23	97.3	.3	98.2	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.6	36.7	16.4	31.3
5 2	97.1	.3	98.3	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.5	33.1	12.4	25.9
5 5	97.1	.3	98.3	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	34.2	12.1	24.2
5 8	97.3	.3	98.4	96.5	400.6	87.7	459.0	96.4	657.1	15.4	674.0	627.5	19.9	34.0	11.2	22.4
5 11	97.3	.3	98.3	96.5	850.4	82.6	904.0	504.3	1235.5	8.6	1243.3	1220.1	21.2	34.7	12.2	24.0
5 14	97.1	.3	98.0	96.3	823.4	116.0	907.5	424.1	1235.5	8.6	1243.3	1220.1	24.5	36.4	15.4	26.6
5 17	96.9	.3	97.8	96.1	365.2	90.3	416.0	52.3	657.1	15.4	674.0	627.5	27.4	37.4	16.5	27.0
5 20	96.9	.3	97.9	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.8	35.9	15.3	25.7
5 23	97.1	.3	98.2	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	30.8	11.1	22.9
6 2	96.9	.2	97.6	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	30.0	9.9	22.9
6 5	97.0	.2	97.7	96.3	.1	.3	1.2	0.0	0.0	0.0	0.0	0.0	19.6	32.2	13.7	25.5
6 8	97.2	.2	97.8	96.5	417.2	60.1	474.1	266.1	692.6	9.3	697.2	674.0	17.7	31.9	11.9	23.3
6 11	97.1	.3	97.8	96.4	856.9	29.2	892.4	801.8	1357.5	980.0	10551.0	1243.3	16.5	31.7	11.0	23.8
6 14	96.9	.3	97.6	96.1	849.0	51.0	901.7	701.8	1254.2	2.9	1225.0	1243.3	16.6	31.3	11.0	23.8
6 17	96.8	.3	97.4	95.9	358.9	109.0	452.0	74.4	692.6	9.3	697.2	674.0	17.3	31.1	11.1	22.6
6 20	96.8	.3	97.4	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.6	35.5	14.2	26.6
6 23	96.9	.3	97.6	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	30.8	10.6	24.7

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TABLE A-17. (Continued)

Month /Hour (1)	Station pressure (kilonewtons/square meter) Mean (18)	Standard Deviation (19)	Maximum (20)	Minimum (21)	Solar radiation (watts/square meter) Mean (22)	Standard Deviation (23)	Maximum (24)	Minimum (25)	Extra terrestrial radiation (watts/square meter) Mean (26)	Standard Deviation (27)	Maximum (28)	Minimum (29)	Sky cover[1] (percent) Mean (30)	Standard Deviation (31)	Opaque sky cover[1] (percent) Mean (32)	Standard Deviation (33)
7 2	97.1	.2	98.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.6	42.1	41.0	39.0
7 5	97.2	.2	97.9	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.4	39.7	41.7	36.2
7 8	97.3	.2	98.1	96.6	339.3	94.0	446.2	101.1	673.2	11.9	697.2	662.3	46.7	40.6	32.8	34.9
7 11	97.3	.2	98.0	96.6	717.0	172.4	880.8	246.3	1240.7	12.5	1255.0	1220.1	33.4	36.9	23.3	31.0
7 14	97.1	.2	97.8	96.3	766.8	125.4	851.7	352.1	1240.7	12.5	1255.0	1220.1	26.7	32.5	16.6	23.4
7 17	96.9	.2	97.7	96.2	303.7	106.9	428.8	44.2	673.2	11.9	697.2	662.3	32.5	36.9	22.9	29.3
7 20	96.9	.2	97.8	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.3	41.8	38.4	35.2
7 23	97.1	.2	98.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.9	41.8	41.8	39.4
8 2	97.1	.2	97.7	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	42.7	35.5	39.1
8 5	97.2	.2	97.8	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.3	39.5	28.3	34.2
8 8	97.3	.2	97.8	96.7	336.4	29.3	388.1	287.0	598.2	33.4	639.1	534.5	33.4	38.3	23.6	31.4
8 11	97.3	.2	97.8	96.7	747.6	68.2	811.1	570.5	1197.6	16.8	1220.1	1162.0	26.8	34.9	19.0	28.2
8 14	97.1	.2	97.7	96.4	767.6	28.1	816.9	700.7	1197.6	16.8	1220.1	1162.0	21.6	30.9	13.9	23.1
8 17	96.9	.2	97.5	96.2	292.2	52.2	350.9	123.2	598.2	33.4	639.1	534.5	30.5	36.5	21.3	28.4
8 20	96.9	.2	97.5	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.4	41.7	36.5	36.6
8 23	97.1	.2	97.8	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.0	41.8	36.8	38.1
9 2	97.1	.3	98.0	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1	35.5	17.6	32.0
9 5	97.1	.3	98.1	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.1	31.7	16.1	29.6
9 8	97.3	.3	98.2	96.3	230.3	83.9	324.2	44.2	476.0	39.9	534.5	406.7	19.8	33.0	15.7	29.0
9 11	97.3	.3	98.2	96.2	679.9	126.9	801.8	255.6	1105.8	36.8	1162.0	1034.2	18.2	32.7	14.3	28.1
9 14	97.1	.3	97.9	95.9	648.6	171.0	764.6	156.9	1105.8	36.8	1162.0	1034.2	18.0	32.4	14.8	27.4
9 17	96.9	.3	97.7	95.7	217.5	47.6	277.7	112.7	476.0	39.9	534.5	406.7	21.9	33.4	17.2	28.8
9 20	97.0	.3	97.9	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.1	38.1	20.0	33.4
9 23	97.1	.3	98.0	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9	35.5	17.1	30.9
10 2	97.4	.4	98.4	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	35.2	14.6	30.5
10 5	97.4	.4	98.3	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.9	35.0	15.7	30.2
10 8	97.5	.4	98.5	96.2	161.0	34.5	225.4	89.5	325.4	47.3	406.7	244.0	27.5	39.1	19.0	31.7
10 11	97.6	.4	98.4	96.2	610.5	83.3	730.9	382.3	955.8	53.4	1034.2	859.9	25.8	38.0	17.4	30.3
10 14	97.3	.4	98.2	96.0	603.3	80.4	701.8	323.0	955.8	53.4	1034.2	859.9	28.5	38.1	19.5	30.7
10 17	97.2	.4	98.1	95.9	136.9	29.6	199.9	76.7	325.4	47.3	406.7	244.0	28.6	37.9	19.3	30.1
10 20	97.3	.4	98.2	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	36.8	17.8	31.4
10 23	97.4	.4	98.4	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.8	35.7	14.9	28.8
11 2	97.7	.4	99.1	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.3	39.9	20.9	35.4
11 5	97.7	.4	99.1	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5	41.6	23.2	36.5
11 8	97.8	.4	99.2	96.8	73.1	33.4	113.9	4.6	187.5	35.6	255.6	151.1	42.2	44.4	28.4	37.9
11 11	97.8	.4	99.3	96.9	440.9	143.0	593.8	52.3	802.2	37.6	871.5	743.7	38.3	43.0	25.9	36.1
11 14	97.6	.4	99.0	96.4	433.5	153.1	571.7	53.5	802.2	37.6	871.5	743.7	41.8	41.8	27.0	34.1
11 17	97.5	.3	99.0	96.4	64.5	25.6	99.9	13.9	187.5	35.6	255.6	151.1	44.8	43.6	30.2	36.5
11 20	97.6	.3	99.1	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.2	41.7	25.2	36.2
11 23	97.7	.4	99.1	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.0	38.1	18.3	32.5
12 2	97.8	.5	99.3	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.1	42.7	25.7	38.4
12 5	97.7	.5	99.3	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	43.1	26.6	39.6
12 8	97.9	.5	99.4	96.4	25.8	18.7	50.0	1.2	116.2	0.0	116.2	116.2	46.0	44.0	31.5	38.6
12 11	97.9	.5	99.3	96.5	396.1	101.9	481.1	188.2	723.4	7.9	743.7	720.4	44.4	43.4	29.3	37.3
12 14	97.7	.5	99.0	96.2	369.3	169.4	511.3	16.3	723.4	7.9	743.7	720.4	47.7	44.2	32.0	37.9
12 17	97.6	.5	98.9	96.3	30.2	13.4	46.5	5.8	116.2	0.0	116.2	116.2	48.1	44.1	34.1	38.7
12 20	97.7	.5	99.1	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.7	42.9	28.2	38.7
12 23	97.8	.5	99.3	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.2	41.9	25.5	38.1

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TABLE A-18. TOTAL NUMBER OF OBSERVATIONS OF SELECTED CLIMATIC EVENTS AT 3-HOURLY INTERVALS BY MONTH FOR THE YEARS 1965-1974 FOR PHOENIX, ARIZONA

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
1 2			7	4											2
1 5	2		8	4											
1 8	2	1	6	3											5
1 11	1		3	4											8
1 14	1		3	5	1										6
1 17			4	6											5
1 20			2	6										1	
1 23	1		2	4											1
2 2			5	4										1	
2 5	1		5	2											
2 8	2		1	1	1										1
2 11			2	5											5
2 14			2	7										1	
2 17			2	7										1	1
2 20			5	4											1
2 23			3	5	1									1	3
3 2			2	6											
3 5	1		2	6											
3 8			2	6	1										2
3 11			4	9											
3 14			1	7											1
3 17			2	5	1										
3 20			1	5											
3 23			4	6											
4 2				6											
4 5				6											
4 8			1	5											
4 11			1	5											
4 14			1	5											
4 17			1	5											
4 20			1	6											
4 23			1	6											
5 2				6											
5 5				6											
5 8				6											
5 11				6											
5 14				6											
5 17				6											
5 20				6											
5 23				6											
6 2				2											
6 5															
6 8				1	2										
6 11				1	1									1	
6 14				1	2							1			
6 17				1	1									2	
6 20				3										5	
6 23				1											

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TABLE A-18. (Continued)

Month /Hour (1)	Fog (2)	Drizzle (3)	Rain (4)	Rain Showers (5)	Thunderstorms (6)	Tornado (7)	Snow, Blowing Snow (8)	Snow Shower (9)	Freezing Drizzle (10)	Freezing Rain (11)	Snow Pellets (12)	Hail (13)	Sleet (14)	Blowing Dust or Sand (15)	Smoke or Haze (16)
7 2				10	5									5	1
7 5				3											
7 8				3											1
7 11				1	1										1
7 14				1	2										1
7 17				1	2									1	
7 20				7	6									8	
7 23				12	10									2	
8 2				9	4									1	
8 5				2	2									2	
8 8				1	2										
8 11				2											
8 14				3											
8 17					3									2	
8 20				3	9									4	
8 23				4	13									1	
9 2			1	4	2										
9 5			2	4	1										
9 8			2	5	1										
9 11				4											
9 14				4											
9 17			1	4	2										
9 20			1	3	6										
9 23				1	2										2
10 2	1		1	8	1									1	
10 5				9											1
10 8				7											
10 11			1	6											
10 14			1	5	1									1	1
10 17			1	9	1										
10 20				6	2										
10 23			1	6											
11 2	2		2	8											
11 5	4		2	6											
11 8	6		3	9											2
11 11	1		1	8											6
11 14			2	5											8
11 17			1	6											4
11 20				5											2
11 23	1		2	4											
12 2			8	8											3
12 5	2		7	10											1
12 8	4		9	6			1								8
12 11	6		5	6											21
12 14			7	11											13
12 17			8	5											8
12 20	1		12	4											3
12 23			10	5											4

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APPENDIX B

COMPUTATIONAL METHODS FOR ESTIMATING SOLAR AND ULTRAVIOLET RADIATION

S. G. Talbert and T. A. Klausing

Terrestrial ultraviolet solar radiation (UV) is generally defined as that portion of the solar-radiation spectrum in the bandwidth between the 290 and 400-nm wavelengths. The UV intensity on a surface near the surface of the earth is a function of (1) geographical location, such as latitude, longitude, and elevation; (2) time of day and time of year; and (3) atmospheric conditions such as particulate matter, water vapor, ozone concentration, pollutant concentration, and cloud cover. These factors also affect the intensity of the solar radiation at other wavelengths, and the magnitude of the effects is generally dependent on wavelength.

The spectral distribution of the extraterrestrial solar radiation is well documented in the literature. (B-1, B-2) However, to obtain the terrestrial spectral distribution of the solar radiation for a given location, corrections for atmospheric transmission losses must be applied, together with the effects of latitude, time of day and year, etc. One basic approach often used to estimate the transmission losses in the atmosphere is to calculate a total spectral transmissivity based on a combination of individual transmissivities for the various factors as shown by the equation(B-1)

$$T = (T_a)^{mp/760} (T_w)^{mw/20} (T_d)^{md/800} (T_o)^{mo/2.5} (T_{wa})^{mw/20} \quad , \qquad \text{(B-1)}$$

where

T = total spectral transmissivity, dimensionless

T_a = dry-air-scattering transmissivity, dimensionless

T_w = water-vapor-scattering transmissivity, dimensionless

T_d = dust-scattering transmissivity, dimensionless

T_o = ozone-absorption transmissivity, dimensionless

T_{wa} = water-vapor-absorption transmissivity, dimensionless

m = air mass (ratio of length of sun's rays through atmosphere to vertical length of path when sun is at zenith position), dimensionless

p = barometric pressure, mm Hg

w = depth of precipitable water in atmosphere, mm

d = number of dust particles per cubic centimeter, cm^{-3}

o = depth of atmospheric ozone (at normal temperature and pressure), mm.

In order to apply the above equation, sufficient empirical data must be available to permit the calculation of the transmission factors of interest. The individual transmissivities are functions of the radiation wavelength, and therefore the total transmissivity is also a function of wavelength.

Figures B-1 through B-3 show spectral transmissivities as a function of wavelength for the atmospheric factors in Equation (B-1). As readily seen in the figures, the transmissivities in the UV portion of the spectrum are strongly affected by atmospheric conditions. The overall effect of these parameters is shown in Figure B-4 where the direct-solar-radiation intensities at both the earth's surface and outside the atmosphere are plotted as a function of wavelength for several representative atmospheric conditions. For reference purposes, the relationship between the air mass m and the solar altitude is shown in Figure B-5.

It should be noted that all curves in Figures B-1 through B-4 are for direct radiation only, and that diffuse radiation components will add to these values, particularly for an air mass equal to 5, since, under these conditions, nearly all of the UV energy is in the form of diffuse radiation. Both the direct and diffuse components are at their maximums when the solar altitude is a maximum. However, the diffuse component decreases less with decreasing solar altitude than does the direct component, so that even on a clear day, the diffuse UV radiation may exceed the direct radiation.[B-2] Figure B-6 shows diffuse versus direct radiation on a horizontal surface as a function of wavelength and solar zenith angle. The diffuse radiation predominates throughout the lower wavelength portion of the UV region below 330 nm at all solar zenith angles. Table B-1 shows the distribution of the diffuse radiation received on a horizontal surface from successive 10-degree zones of the sky for radiation with wavelengths below 320 nm.[B-2, B-3] A method of calculating the amounts of diffuse and direct radiation on tilted surfaces is discussed in a later section.

Many investigators have explored the relationships between atmospheric variables and solar intensity at the earth's surface. The direct flux component can be calculated from the Bouguer-Lambert law if the solar angles, the extraterrestrial solar flux, and the absorption and scattering optical thicknesses of the atmosphere as a function of wavelength are available.[B-2] It is the lack of this information that makes calculations of direct flux impractical or inaccurate in many applications. The calculation of the diffuse radiation component is more complicated than that for direct radiation and requires the numerical solution of radiative-transfer equations. The input parameters required for calculation of diffuse radiation involve the following: the solar zenith angle, the extraterrestrial solar flux, the planetary albedo, the atmospheric optical thickness (scattering and absorption of atmospheric elements), albedo for single scattering, and phase matrix elements for turbid air. Leighton[B-2] and Venkateswaran[B-4], among others, give detailed discussions of the calculation of direct and diffuse radiation components.

Calculation of the Total Daily Solar Radiation From Statistical Data

A method was developed to compute the total daily solar radiation using the 3-hour statistical data that were generated for the nine geographic locations of this study. Using these total daily insolation values, which are based on long-term (10-year) weather data, it is then possible to estimate the long-term ultraviolet exposure for a given site as being between 3 and 5 percent of the total radiation, depending on the local average atmospheric conditions.

The following equation, modified from Reference (B-5), allows the calculation of the total daily solar radiation using only one hourly radiation value from the statistical data for a given day and month of the year:

$$H_{\text{total daily}} = 2H_t T_s / [\pi \sin (180t/T_s)] \quad , \qquad \text{(B-2)}$$

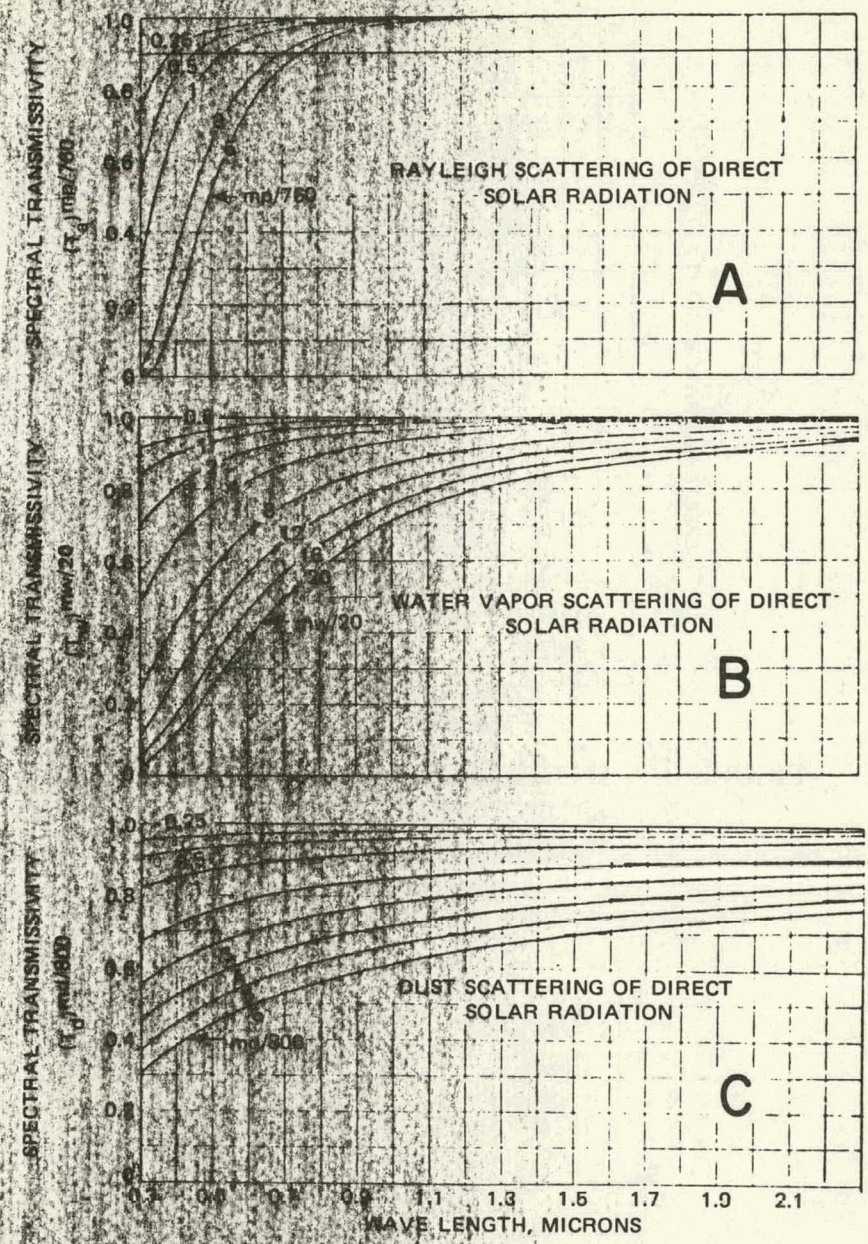

FIGURE B-1. SPECTRAL FRACTION OF DIRECT SOLAR RADIATION TRANSMITTED THROUGH ATMOSPHERE DUE TO SCATTERING.(B-1)

A is Rayleigh scattering at various barometric pressures and air masses, B is scattering at various depths of precipitable water and air masses, and C is dust scattering at various concentrations of dust particles and air masses. (See Equation B-1.)

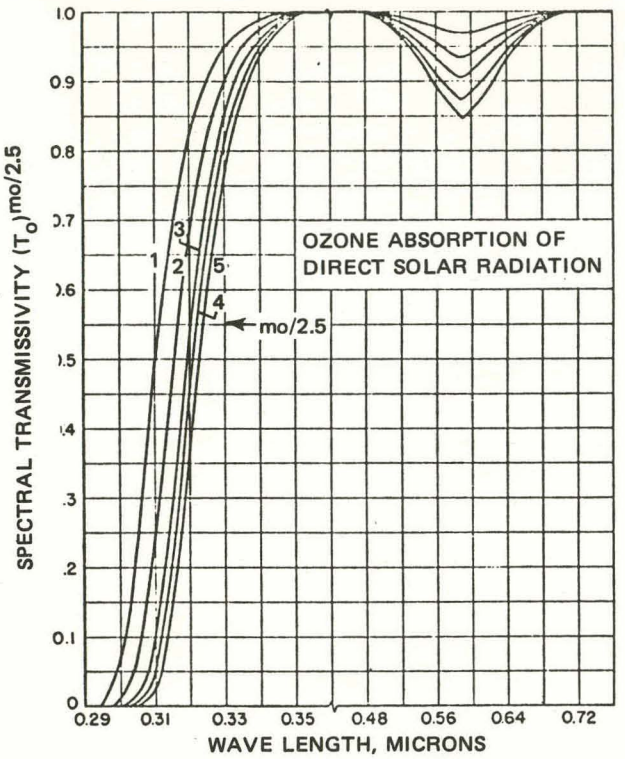

FIGURE B-2. SPECTRAL FRACTION OF DIRECT SOLAR RADIATION TRANSMITTED THROUGH ATMOSPHERIC OZONE DUE TO ABSORPTION FOR VARIOUS AIR MASSES(B-1)

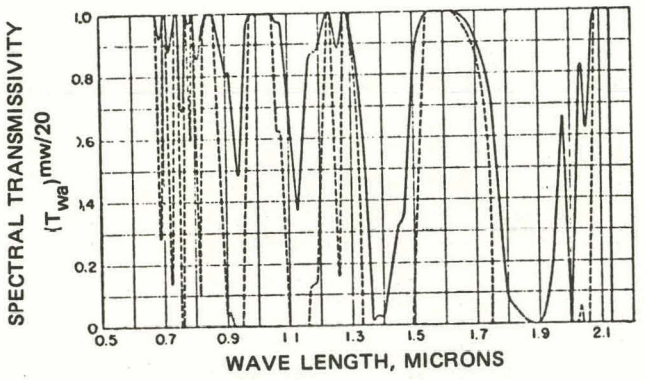

FIGURE B-3. SPECTRAL FRACTION OF SOLAR DIRECT RADIATION TRANSMITTED THROUGH ATMOSPHERIC WATER VAPOR DUE TO ABSORPTION FOR VARIOUS DEPTHS OF PRECIPITABLE WATER AND AIR MASSES(B-1)

Solid lines indicate mw/20 = 1.0 and broken lines mw/20 = 1.50, where mw is air mass times length of precipitable water in atmosphere. (See Equation B-1.)

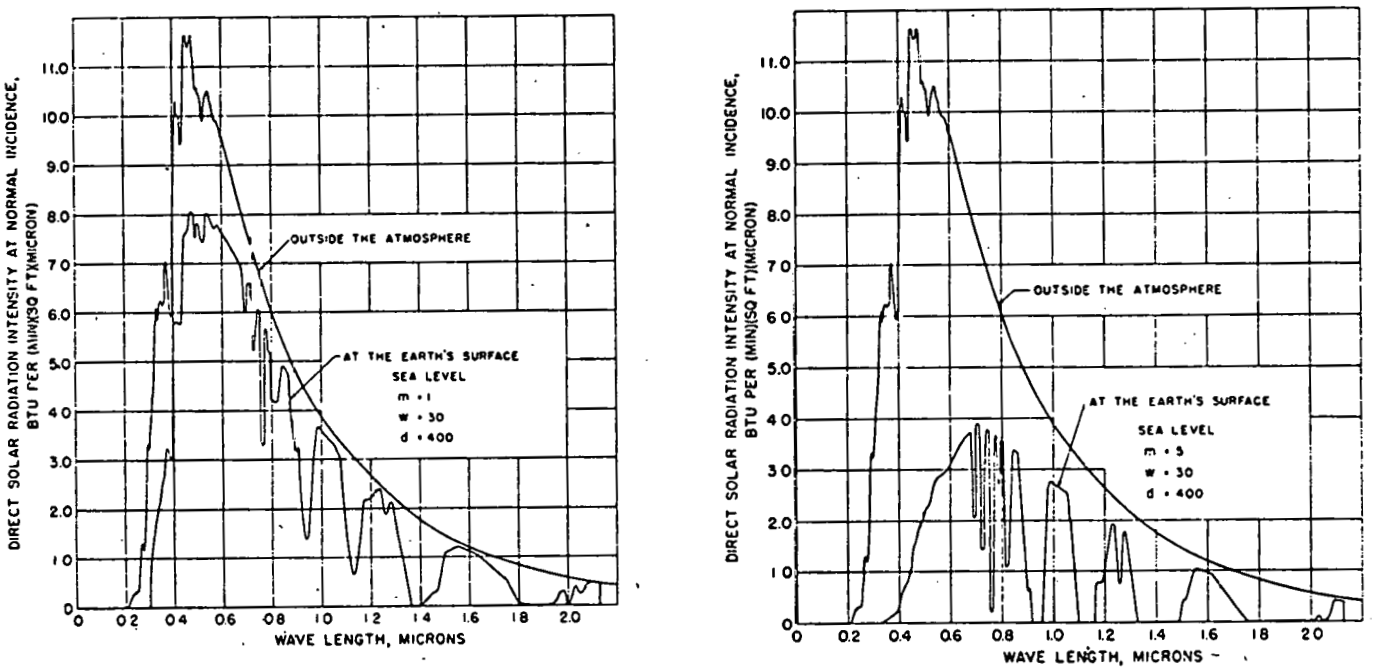

FIGURE B-4. SPECTRAL DISTRIBUTION OF DIRECT SOLAR RADIATION AT NORMAL INCIDENCE FOR THE UPPER LIMIT OF THE ATMOSPHERE AND AT THE EARTH'S SURFACE FOR CONDITIONS AT SEA LEVEL, 30 MM OF PRECIPITABLE WATER, AND 400 DUST PARTICLES PER CC, FOR AIR MASS EQUAL TO 1 AND 5(B-1)

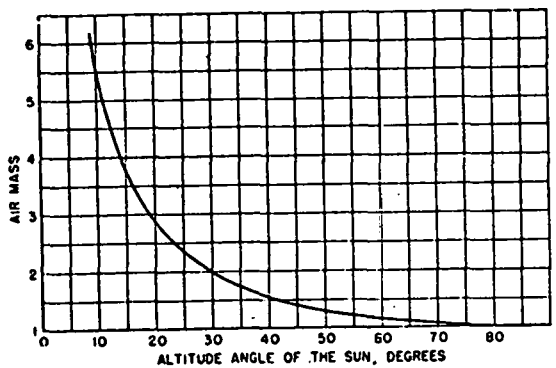

FIGURE B-5. RELATIONSHIP BETWEEN AIR MASS AND ALTITUDE ANGLE OF THE SUN(B-1)

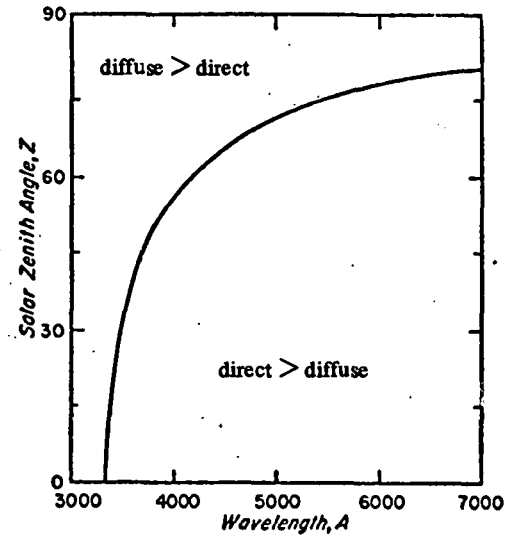

FIGURE B-6. DIFFUSE VERSUS DIRECT RADIATION AS A FUNCTION OF WAVELENGTH AND SOLAR ZENITH ANGLE(B-2)

TABLE B-1. DISTRIBUTION OF DIFFUSE RADIATION RECEIVED ON A HORIZONTAL SURFACE FROM SUCCESSIVE 10-DEGREE ZONES OF THE SKY(B-2)

Zone, degrees	Calculated	Observed, Less Than 320 nm	Ratio, obs/calc
0-10	0.030	0.039	1.30
10-20	0.087	0.101	1.16
20-30	0.133	0.147	1.10
30-40	0.163	0.173	1.06
40-50	0.174	0.180	1.03
50-60	0.163	0.158	0.97
60-70	0.133	0.112	0.84
70-80	0.087	0.060	0.69
80-90	0.030	0.030	1.00

where

$H_{total\ daily}$ = total daily solar radiation incident on a horizontal surface, Wh/m^2

H_t = total instantaneous solar radiation on a horizontal surface, at time t, W/m^2

T_s = time from sunrise to sunset, minus a 1-hour "correction", hr

t = time from "corrected" sunrise to time of radiation measurement, hr.

This equation assumes that the solar intensity varies sinusoidally throughout the day. The calculated sunrise-to-sunset time is "corrected" (shortened) by 1 hour to result in a curve that matches the data more closely. The sunrise-to-sunset time T_s is a function of the day of the year and the latitude of the site, and can be calculated using the following equation:

$$T_s = \frac{2}{15}\cos^{-1}(-\tan\alpha \tan L) - 1.0,\ \text{hr} \quad , \qquad \text{(B-3)}$$

where

α = solar declination, degrees

$= 23.45 \sin\left(\frac{(284+n)}{365}\right) \cdot 360)$

n = day of the year

L = latitude, degrees.

To calculate the time, t, between the "corrected" sunrise time and the local time at which the measurement of H_t is reported, it is first necessary to calculate the time of true solar noon, which depends primarily on the longitude of the site. Then the local "corrected" sunrise time is calculated, from which time t can be determined. The following equations can be used to arrive at the time, t:

$$\text{Solar noon} = 12.00 + \frac{(\text{longitude-std. meridian})}{15} - \frac{E}{60} \quad , \text{hr} \qquad \text{(B-4)}$$

where

longitude = longitude at site, degrees West

Std. meridian = standard meridian of time zone, degrees West

E = equation of time (Figure B-7), to account for variations in the earth's orbit and rate of rotation, minutes.

The sunrise time and local time are then computed as follows:

$$\text{Sunrise time (corrected)} = \text{solar noon} - \frac{T_s}{2} \quad . \qquad \text{(B-5)}$$

$$t = \text{local time of radiation measurement} - \text{sunrise time, hr} \quad . \qquad \text{(B-6)}$$

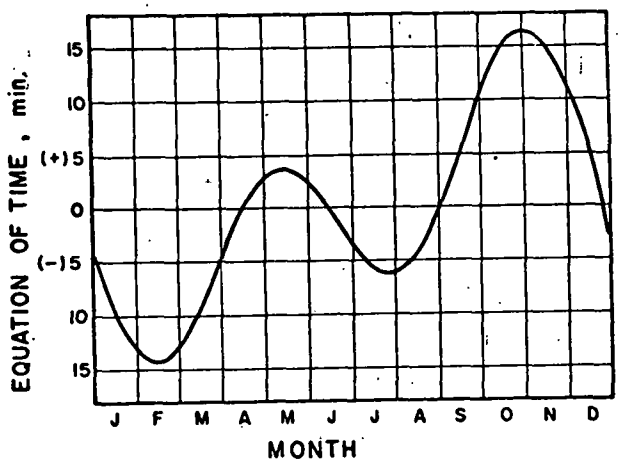

FIGURE B-7. THE EQUATION OF TIME, E, IN MINUTES, AS A FUNCTION OF TIME OF YEAR(B-6)

The standard meridians for the continental U. S. time zones are as follows:

Eastern	75°W
Central	90°W
Mountain	105°W
Pacific	120°W

As an example of the use of these equations, consider a typical solar-radiation day for Phoenix, Arizona. Using May 15 to represent the average day in May, the following values are obtained:

Phoenix, Arizona, Data for May 15th

Latitude	33.05°N
Longitude	112.08°W
Solar noon	12:24 p.m.
Time, sunrise to sunset	13.71 hr
Corrected length of day	12.71 hr
Corrected sunrise time	6:03 a.m.
Time from sunrise to 11 a.m.	4.94 hr
Solar radiation at 11 a.m. (assumed value)	946 W/m^2
Total daily solar radiation[Equation (B-2)]	8148 Wh/m^2
Total daily ultraviolet (5 percent)	407 Wh/m^2

Estimating Ultraviolet Radiation on a Tilted Surface

The total solar-radiation data reported in the statistical tables were measured on a horizontal flat surface. Most of the UV data available in the literature were measured likewise. However, since large solar-cell arrays will generally be mounted in a tilted position, it is desirable to have a method for estimating the amount of UV radiation received by a tilted surface when only horizontal radiation data and correlations are available.

One method that has been used to calculate the total hourly solar radiation incident on a tilted surface, based on hourly horizontal radiation data, is presented by Duffie and Beckman.[B-6] This method takes into account the direct beam radiation, the diffuse sky radiation, and the reflected ground radiation. It is believed that this technique is applicable to the UV component of the total solar flux, and therefore could be used to estimate the hourly UV radiation on a tilted surface, when actual comparison measurements and correlations are not available. However, the hourly percentages, or magnitudes, of UV radiation on the horizontal surface must be known or estimated.

The total solar radiation received by a tilted surface at any time can be calculated using the following equation[B-6]:

$$H_t = H_b R_b + H_d \frac{(1 + \cos S)}{2} + (H_b + H_d) \frac{(1 - \cos S)}{2} \rho \qquad \text{(B-7)}$$

Total flux = direct (beam) component + sky component + ground component,

where

H_t = instantaneous total solar (or UV) radiation per unit area on a tilted surface, W/m^2

H_b = instantaneous direct (beam) radiation per unit area on a horizontal surface, W/m^2

H_d = instantaneous diffuse (sky) radiation per unit area on a horizontal surface, W/m^2

R_b = ratio of direct (beam) radiation incident on a tilted surface to that on a horizontal surface

S = slope of the tilted surface with respect to the horizontal, degrees

ρ = reflectivity of the ground surface, dimensionless.

The term R_b is calculated using the following equation:

$$R_b = \cos(\theta_t)/\cos(\theta_h) \quad , \qquad \text{(B-8)}$$

where

$$\begin{aligned} \cos\theta_t = {} & \cos(S)\sin(\delta)\sin(\phi) \\ & - \sin(\delta)\cos(\phi)\sin(S)\cos(\alpha) \\ & + \cos(\delta)\sin(\phi)\sin(S)\cos(\omega) \\ & + \cos(\omega)\cos(\delta)\sin(S)\sin(\alpha)\sin(\omega) \quad , \end{aligned} \qquad \text{(B-9)}$$

$$\cos\theta_h = \cos(\phi)\cos(\delta)\cos(\omega) + \sin(\phi)\sin(\delta) \quad , \qquad \text{(B-10)}$$

and

$$\delta = 23.45 \sin[(284 + n)\, 360/365] \text{ degrees} \qquad \text{(B-11)}$$

ϕ = latitude, degrees (Northern hemisphere positive)

α = azimuth angle of the horizontal projection of the normal to the tilted surface, measured from the South and positive toward the East, degrees

ω = hour angle, 15 degrees per hour (0°at noon, mornings positive).

For a southward-facing surface ($\alpha = 0°$), the equation for $\cos\theta_t$ can be simplified to

$$\begin{aligned} \cos\theta_t = {} & \cos(\phi - S)\cos(\delta)\cos(\omega) \\ & + \sin(\phi - S)\sin\delta \quad . \end{aligned} \qquad \text{(B-12)}$$

The direct (beam) and diffuse components of the total solar radiation on a horizontal surface, H_b and H_d, are estimated from the following relationship which is derived from the graphical information shown in Figure B-8[B-6 – B-8]:

$$\frac{H_d}{H_h} = 1.0045 + 2.6313\,K_t^3 - 3.5227\,K_t^2 + 0.04349\,K_t \quad , \qquad \text{(B-13)}$$

where

$K_t = H_h/H_o$

H_h = instantaneous radiation per unit area on a horizontal surface, W/m^2

H_o = instantaneous extraterrestrial radiation per unit area on a horizontal surface, W/m^2

$= [1 + 0.033 \cos(360\,n/365)]\,S_c \cos(\theta_h)$ (B-14)

S_c = solar constant, 1393 W/m^2

$H_b = H_h - H_d$.

It is proposed that a similar ralationship be used to calculate the amount of diffuse UV radiation coming from the sky, except that the ratio of diffuse UV to total UV be assumed to vary from 1.0 at $K_t = 0$ to 0.5 at $K_t = 1.0$, as shown by the straight dashed line added to Figure B-8. This assumption is based on reports [B-9] that on clear days ($K_t = 1.0$) approximately 50 percent of the UV comes from the sky as diffuse radiation and 50 percent is direct. Obviously, as the sky becomes hazy or cloudy, and K_t approaches 0.0, a greater percentage of the UV becomes diffuse radiation. Thus, the equations for the UV components of $H_{d,\,UV}$ and $H_{b,\,UV}$ become

$$\frac{H_{d,\,UV}}{H_{h,\,UV}} = 1.0 - 0.5\,K_t \quad , \qquad \text{(B-15)}$$

where

$K_t = H_h/H_o$

and

$$H_{b,\,UV} = H_{h,\,UV} - H_{d,\,UV} \quad . \qquad \text{(B-16)}$$

Finally, Equation (B-7) can be used to calculate (estimate) the amount of UV radiation received by a tilted surface, by substituting $H_{b,\,UV}$ and $H_{d,\,UV}$. Thus, for example, if it is assumed that the instantaneous UV radiation falling on a horizontal surface is 5 percent of the total solar radiation falling on that surface ($H_{h,\,UV} = 0.05\,H_h$), then the above equations can be used to calculate the amount (or percent) of UV incident on a tilted surface. Table B-2 lists the values calculated and the assumptions made to arrive at an estimate of the UV radiation incident on a surface tilted southward at an angle equal to the latitude in Phoenix, Arizona.

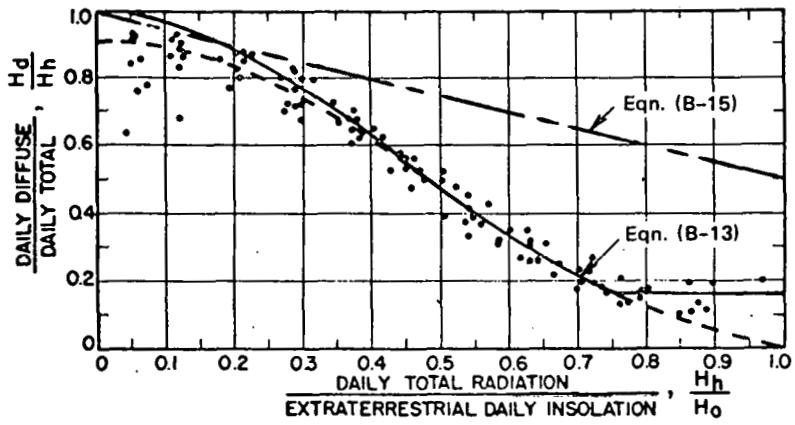

FIGURE B-8. THE RATIO OF THE DAILY DIFFUSE RADIATION TO THE DAILY TOTAL RADIATION AS A FUNCTION OF CLOUDINESS INDEX(B-6)

The above procedure could be carried out for the 15th day of each of the 12 months of an average year for each of the nine sites to arrive at an estimate of the magnitude of UV radiation incident on tilted surfaces for various times of the day for which solar data are available. However, it should be pointed out that more hourly UV data are needed to obtain an accurate correlation for the percent UV on a horizontal surface as a function of the time of day. The available UV data analyzed to date have been only for daily totals and percentages of UV radiation.

TABLE B-2. COMPUTED ULTRAVIOLET RADIATION ON A TILTED SURFACE IN PHOENIX, ARIZONA

Latitude	ϕ = 33°N		
Surface slope	S = 33°		
Azimuth	α = 0°		
Reflectivity	ρ = 0.2		
Hour angle	ω = 21° (at 11 a.m.)		
Day of year	n = 135 (May 15th)		
Solar declination	δ = 18.79°		
Horizontal flux	H_h = 946 W/m^2 (assumed value for 11 a.m.)		
Horizontal UV	$H_{h,UV}$ = 47.3 W/m^2 (5 percent of total)		
	$\cos\theta_t$ = 0.884	(Eq. B-12)	
	$\cos\theta_h$ = 0.917	(Eq. B-10)	
	R_b = 0.964	(Eq. B-8)	
	H_o = 1248 W/m^2	(Eq. B-14)	
	K_t = 0.758		
	$H_{d,UV}/H_{h,UV}$ = 0.621	(Eq. B-15)	
	$H_{d,UV}$ = 29.4 W/m^2		
	$H_{b,UV}$ = 17.9 W/m^2		
	$H_{t,UV}$ = 45.1 W/m^2	(Eq. B-7)	
	H_d/H_h = 0.160	(Eq. B-13)	
	H_d = 151 W/m^2		
	H_b = 795 W/m^2		
	H_t = 920 W/m^2	(Eq. B-7)	
	% UV_t = 4.9 percent (on tilted surface)		

REFERENCES

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B-4 Venkateswaran, S. V., "Solar Ultraviolet Radiation Reaching the Earth's Surface", U. S. Department of Transportation, Third Conference on CIAP (February, 1974).

B-5 Klein, S. A., Cooper, P. I., Beckman, W. A., and Duffie, J. A., "TRNSYS – A Transient Simulation Program," Engineering Experiment Station Report No. 38, Solar Energy Laboratory, University of Wisconsin, (December, 1973, Version), p 74.

B-6 Duffie, John A., and Beckman, William A., *Solar Energy Thermal Processes*, John Wiley & Sons, New York (1974), pp 53-55.

B-7 Liu, B. Y. H., and Jordan, R. C., "The Interrelationship and Characteristic Distribution of Direct, Diffuse, and Total Solar Radiation", Solar Energy, IV, 1-19 (July, 1960).

B-8 Klein, S. A., Beckman, W. A., and Duffie, J. A., "TRNSYS – A Transient Simulation Program", Engineering Experiment Station Report No. 38, Solar Energy Laboratory, University of Wisconsin (November, 1975).

B-9 Oral communication with Dr. William H. Klein of the Smithsonian Radiation Biology Laboratory, Washington D. C. (March 22, 1976).

APPENDIX C

DATA SOURCES

The climatic and insolation data for this effort were obtained from NOAA, Environmental Data Service, National Climatic Center, Asheville, North Carolina. The air-quality data were obtained from the National Aerometric Data Bank, Environmental Protection Agency, Research Triangle Park, North Carolina.

Additional data sources containing potentially useful data are listed in Table C-1.

TABLE C-1. ADDITIONAL DATA SOURCES

Agencies related to the U. S. National Oceanic and Atmospheric Administration (NOAA)
Agencies related to the U. S. Environmental Protection Agency (EPA)
National Weather Service, Silver Spring, Maryland
National Severe Storm Laboratory, Norman, Oklahoma
Smithsonian Institution, Washington, D. C.
National Hurricane Research Laboratory, Coral Gables, Florida
Earthquake Engineering Research Center, Richmond, California
Polar Information Service, Washington, D. C.
National Academy of Sciences, Washington, D. C.
U. S. Air Force Air Weather Service, Washington, D. C.
Bureau of Air Pollution Control, Phoenix, Arizona
Maricopa County Department of Health Services, Phoenix, Arizona
Department of Environmental Conservation, Juneau, Alaska
Fairbanks North Star Borough, Fairbanks, Alaska
Department of Health, Bismarck, North Dakota
Environmental Protection Agency, Columbus, Ohio
Cleveland Division of Air Pollution Control, Cleveland, Ohio
Bureau of Air Quality Control, Boston, Massachusetts
Metropolitan Boston Air Pollution Control, Boston, Massachusetts
Environmental Improvement Agency, Santa Fe, New Mexico
Albuquerque Department of Environmental Health, Albuquerque, New Mexico
Texas Air Control Board, Austin, Texas
San Antonio Metropolitan Health District, San Antonio, Texas
Texas Air Control Board, Brownsville, Texas
Department of Pollution Control, Tallahassee, Florida
Metropolitan Dade County Pollution Control Department, Miami, Florida
Air Resources Board, Sacramento, California
Los Angeles County Air Pollution Control District, Los Angeles, California
Riverside County Air Pollution Control District, Riverside, California

APPENDIX D

POISSON DISTRIBUTION AND FORECASTING

The Poisson distribution may be used to obtain an upper limit for the expected number of exposure hours obtained for each environmental cell. The upper limit depends on both the length of the historical time period and the observed number of occurrences.

Figure D-1 shows the upper 95 percent bounds for the expected number of events in the next 20 years given the observed number and the historical time base. The figure is based on the Poisson distribution and shows, for example, that if no occurrences of an event E have been observed ($X_0 = 0$) in the past 10 years, then the probability is less than 5 percent that more than six occurrences will be observed in the next 20 years. Similarly, if event E was not observed in the past 20 years, then E would not be expected to occur more than three times in the next 20 years. As a final example, if event E occurred three times in the past 20 years, then E would not be expected to occur more than eight times in the next 20 years. Such results are useful to give conservative bounds for design purposes but must, of course, be used with caution. Not all events are physically possible, so that predicted occurrences of impossible events are to be ruled out. In general, it appears desirable to restrict the application of this method to cells where data have actually been observed ($X_0 > 0$) and to empty cells ($X_0 = 0$) which are "adjacent" to occupied cells for which the occurrence of the event E is not judged to be impossible.

The 95 percent upper confidence limits for a 20-year forecast based on a 10-year historical period in which the observed number of occurrences of an event range between 0 and 999 are given in Table D-1.

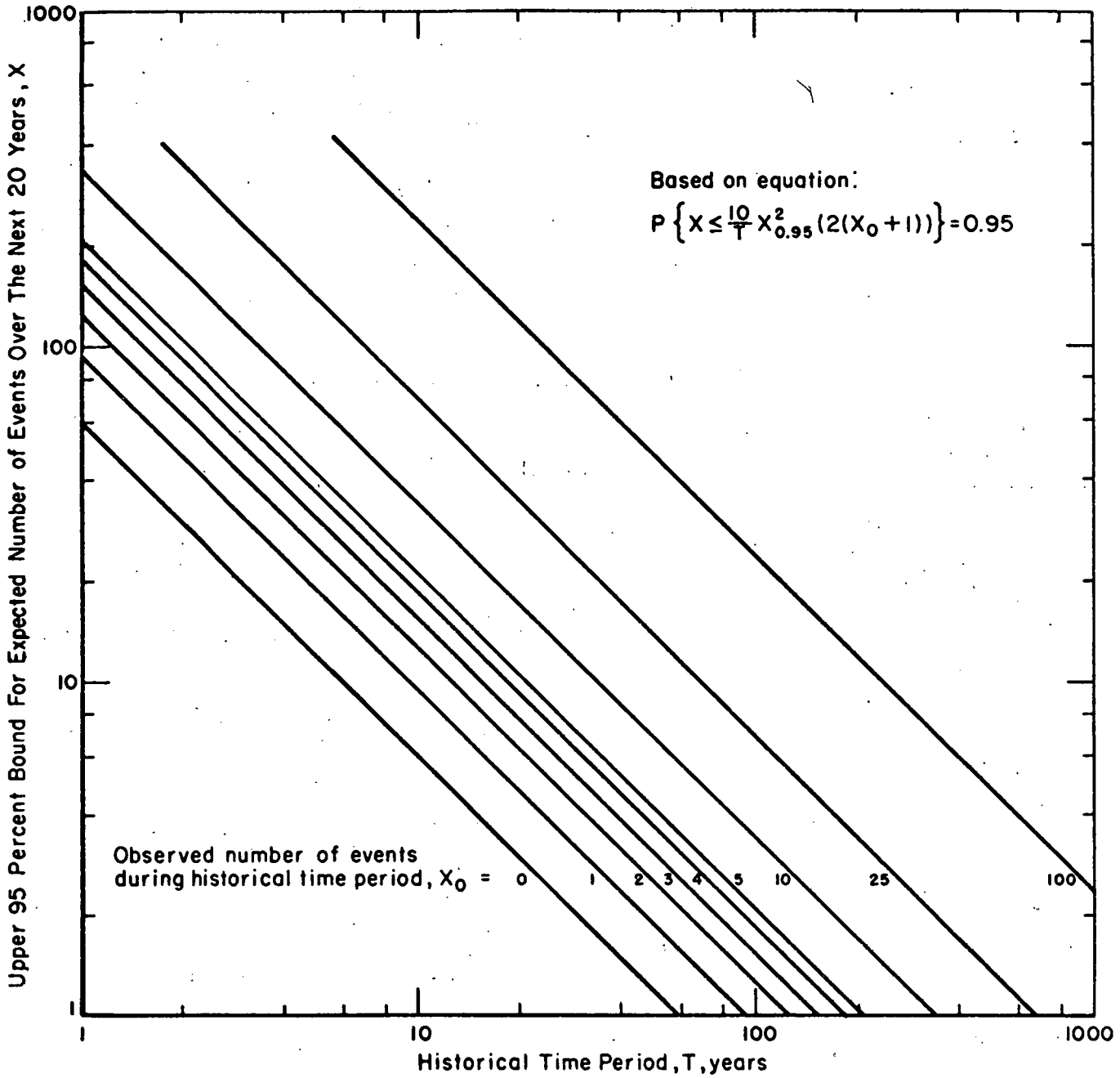

FIGURE D-1. UPPER 95 PERCENT BOUNDS FOR THE EXPECTED NUMBER OF EVENTS IN THE NEXT 20 YEARS GIVEN THE OBSERVED NUMBER AND THE HISTORICAL TIME BASE

TABLE D-1. NINETY FIVE PERCENT CONFIDENCE LIMITS FOR A 20 YEAR FORECAST BASED ON A 10-YEAR HISTORICAL PERIOD WITH 0 to 999 OCCURRENCES OF AN EVENT

OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT
0	0	6	50	100	127	100	200	237	150	300	344
1	2	10	51	102	129	101	202	239	151	302	346
2	4	13	52	104	132	102	204	241	152	304	348
3	6	16	53	106	134	103	206	243	153	306	350
4	8	19	54	108	136	104	208	245	154	308	353
5	10	22	55	110	138	105	210	247	155	310	355
6	12	24	56	112	140	106	212	250	156	312	357
7	14	27	57	114	143	107	214	252	157	314	359
8	16	29	58	116	145	108	216	254	158	316	361
9	18	32	59	118	147	109	218	256	159	318	363
10	20	34	60	120	149	110	220	258	160	320	365
11	22	37	61	122	151	111	222	260	161	322	367
12	24	39	62	124	154	112	224	263	162	324	370
13	26	42	63	126	156	113	226	265	163	326	372
14	28	44	64	128	158	114	228	267	164	328	374
15	30	47	65	130	160	115	230	269	165	330	376
16	32	49	66	132	163	116	232	271	166	332	378
17	34	52	67	134	165	117	234	273	167	334	380
18	36	54	68	136	167	118	236	275	168	336	382
19	38	56	69	138	169	119	238	278	169	338	384
20	40	59	70	140	171	120	240	280	170	340	387
21	42	61	71	142	174	121	242	282	171	342	389
22	44	63	72	144	176	122	244	284	172	344	391
23	46	66	73	146	178	123	246	286	173	346	393
24	48	68	74	148	180	124	248	288	174	348	395
25	50	70	75	150	182	125	250	291	175	350	397
26	52	73	76	152	184	126	252	293	176	352	399
27	54	75	77	154	187	127	254	295	177	354	401
28	56	77	78	156	189	128	256	297	178	356	404
29	58	80	79	158	191	129	258	299	179	358	406
30	60	82	80	160	193	130	260	301	180	360	408
31	62	84	81	162	195	131	262	303	181	362	410
32	64	86	82	164	198	132	264	306	182	364	412
33	66	89	83	166	200	133	266	308	183	366	414
34	68	91	84	168	202	134	268	310	184	368	416
35	70	93	85	170	204	135	270	312	185	370	418
36	72	96	86	172	206	136	272	314	186	372	421
37	74	98	87	174	208	137	274	316	187	374	423
38	76	100	88	176	211	138	276	318	188	376	425
39	78	102	89	178	213	139	278	321	189	378	427
40	80	105	90	180	215	140	280	323	190	380	429
41	82	107	91	182	217	141	282	325	191	382	431
42	84	109	92	184	219	142	284	327	192	384	433
43	86	111	93	186	221	143	286	329	193	386	435
44	88	114	94	188	224	144	288	331	194	388	438
45	90	116	95	190	226	145	290	333	195	390	440
46	92	118	96	192	228	146	292	335	196	392	442
47	94	120	97	194	230	147	294	338	197	394	444
48	96	123	98	196	232	148	296	340	198	396	446
49	98	125	99	198	234	149	298	342	199	398	448

TABLE D-1. (Continued)

OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT
200	400	450	250	500	556	300	600	661	350	700	765
201	402	452	251	502	558	301	602	663	351	702	767
202	404	454	252	504	560	302	604	665	352	704	769
203	406	457	253	506	562	303	606	667	353	706	772
204	408	459	254	508	564	304	608	669	354	708	774
205	410	461	255	510	566	305	610	671	355	710	776
206	412	463	256	512	568	306	612	673	356	712	778
207	414	465	257	514	570	307	614	675	357	714	780
208	416	467	258	516	573	308	616	677	358	716	782
209	418	469	259	518	575	309	618	680	359	718	784
210	420	471	260	520	577	310	620	682	360	720	786
211	422	474	261	522	579	311	622	684	361	722	788
212	424	476	262	524	581	312	624	686	362	724	790
213	426	478	263	526	583	313	626	688	363	726	792
214	428	480	264	528	585	314	628	690	364	728	794
215	430	482	265	530	587	315	630	692	365	730	797
216	432	484	266	532	589	316	632	694	366	732	799
217	434	486	267	534	591	317	634	696	367	734	801
218	436	488	268	536	594	318	636	698	368	736	803
219	438	490	269	538	596	319	638	700	369	738	805
220	440	493	270	540	598	320	640	703	370	740	807
221	442	495	271	542	600	321	642	705	371	742	809
222	444	497	272	544	602	322	644	707	372	744	811
223	446	499	273	546	604	323	646	709	373	746	813
224	448	501	274	548	606	324	648	711	374	748	815
225	450	503	275	550	608	325	650	713	375	750	817
226	452	505	276	552	610	326	652	715	376	752	819
227	454	507	277	554	612	327	654	717	377	754	822
228	456	509	278	556	615	328	656	719	378	756	824
229	458	512	279	558	617	329	658	721	379	758	826
230	460	514	280	560	619	330	660	723	380	760	828
231	462	516	281	562	621	331	662	726	381	762	830
232	464	518	282	564	623	332	664	728	382	764	832
233	466	520	283	566	625	333	666	730	383	766	834
234	468	522	284	568	627	334	668	732	384	768	836
235	470	524	285	570	629	335	670	734	385	770	838
236	472	526	286	572	631	336	672	736	386	772	840
237	474	528	287	574	633	337	674	738	387	774	842
238	476	530	288	576	636	338	676	740	388	776	844
239	478	533	289	578	638	339	678	742	389	778	847
240	480	535	290	580	640	340	680	744	390	780	849
241	482	537	291	582	642	341	682	746	391	782	851
242	484	539	292	584	644	342	684	749	392	784	853
243	486	541	293	586	646	343	686	751	393	786	855
244	488	543	294	588	648	344	688	753	394	788	857
245	490	545	295	590	650	345	690	755	395	790	859
246	492	547	296	592	652	346	692	757	396	792	861
247	494	549	297	594	654	347	694	759	397	794	863
248	496	552	298	596	656	348	696	761	398	796	865
249	498	554	299	598	659	349	698	763	399	798	867

TABLE D-1. (Continued)

OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT
400	800	869	450	900	973	500	1000	1077	550	1100	1181
401	802	872	451	902	976	501	1002	1079	551	1102	1183
402	804	874	452	904	978	502	1004	1081	552	1104	1185
403	806	876	453	906	980	503	1006	1083	553	1106	1187
404	808	878	454	908	982	504	1008	1086	554	1108	1189
405	810	880	455	910	984	505	1010	1088	555	1110	1191
406	812	882	456	912	986	506	1012	1090	556	1112	1193
407	814	884	457	914	988	507	1014	1092	557	1114	1195
408	816	886	458	916	990	508	1016	1094	558	1116	1197
409	818	888	459	918	992	509	1018	1096	559	1118	1199
410	820	890	460	920	994	510	1020	1098	560	1120	1202
411	822	892	461	922	996	511	1022	1100	561	1122	1204
412	824	894	462	924	998	512	1024	1102	562	1124	1206
413	826	897	463	926	1000	513	1026	1104	563	1126	1208
414	828	899	464	928	1003	514	1028	1106	564	1128	1210
415	830	901	465	930	1005	515	1030	1108	565	1130	1212
416	832	903	466	932	1007	516	1032	1110	566	1132	1214
417	834	905	467	934	1009	517	1034	1112	567	1134	1216
418	836	907	468	936	1011	518	1036	1115	568	1136	1218
419	838	909	469	938	1013	519	1038	1117	569	1138	1220
420	840	911	470	940	1015	520	1040	1119	570	1140	1222
421	842	913	471	942	1017	521	1042	1121	571	1142	1224
422	844	915	472	944	1019	522	1044	1123	572	1144	1226
423	846	917	473	946	1021	523	1046	1125	573	1146	1228
424	848	919	474	948	1023	524	1048	1127	574	1148	1231
425	850	922	475	950	1025	525	1050	1129	575	1150	1233
426	852	924	476	952	1027	526	1052	1131	576	1152	1235
427	854	926	477	954	1030	527	1054	1133	577	1154	1237
428	856	928	478	956	1032	528	1056	1135	578	1156	1239
429	858	930	479	958	1034	529	1058	1137	579	1158	1241
430	860	932	480	960	1036	530	1060	1139	580	1160	1243
431	862	934	481	962	1038	531	1062	1141	581	1162	1245
432	864	936	482	964	1040	532	1064	1144	582	1164	1247
433	866	938	483	966	1042	533	1066	1146	583	1166	1249
434	868	940	484	968	1044	534	1068	1148	584	1168	1251
435	870	942	485	970	1046	535	1070	1150	585	1170	1253
436	872	944	486	972	1048	536	1072	1152	586	1172	1255
437	874	946	487	974	1050	537	1074	1154	587	1174	1257
438	876	949	488	976	1052	538	1076	1156	588	1176	1259
439	878	951	489	978	1054	539	1078	1158	589	1178	1262
440	880	953	490	980	1057	540	1080	1160	590	1180	1264
441	882	955	491	982	1059	541	1082	1162	591	1182	1266
442	884	957	492	984	1061	542	1084	1164	592	1184	1268
443	886	959	493	986	1063	543	1086	1166	593	1186	1270
444	888	961	494	988	1065	544	1088	1168	594	1188	1272
445	890	963	495	990	1067	545	1090	1170	595	1190	1274
446	892	965	496	992	1069	546	1092	1173	596	1192	1276
447	894	967	497	994	1071	547	1094	1175	597	1194	1278
448	896	969	498	996	1073	548	1096	1177	598	1196	1280
449	898	971	499	998	1075	549	1098	1179	599	1198	1282

TABLE D-1. (Continued)

OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT
600	1200	1284	650	1300	1388	700	1400	1491	750	1500	1594
601	1202	1286	651	1302	1390	701	1402	1493	751	1502	1596
602	1204	1288	652	1304	1392	702	1404	1495	752	1504	1598
603	1206	1290	653	1306	1394	703	1406	1497	753	1506	1600
604	1208	1293	654	1308	1396	704	1408	1499	754	1508	1602
605	1210	1295	655	1310	1398	705	1410	1501	755	1510	1604
606	1212	1297	656	1312	1400	706	1412	1503	756	1512	1606
607	1214	1299	657	1314	1402	707	1414	1505	757	1514	1608
608	1216	1301	658	1316	1404	708	1416	1507	758	1516	1610
609	1218	1303	659	1318	1406	709	1418	1509	759	1518	1612
610	1220	1305	660	1320	1408	710	1420	1511	760	1520	1614
611	1222	1307	661	1322	1410	711	1422	1513	761	1522	1616
612	1224	1309	662	1324	1412	712	1424	1515	762	1524	1618
613	1226	1311	663	1326	1414	713	1426	1518	763	1526	1621
614	1228	1313	664	1328	1416	714	1428	1520	764	1528	1623
615	1230	1315	665	1330	1419	715	1430	1522	765	1530	1625
616	1232	1317	666	1332	1421	716	1432	1524	766	1532	1627
617	1234	1319	667	1334	1423	717	1434	1526	767	1534	1629
618	1236	1321	668	1336	1425	718	1436	1528	768	1536	1631
619	1238	1324	669	1338	1427	719	1438	1530	769	1538	1633
620	1240	1325	670	1340	1429	720	1440	1532	770	1540	1635
621	1242	1328	671	1342	1431	721	1442	1534	771	1542	1637
622	1244	1330	672	1344	1433	722	1444	1536	772	1544	1639
623	1246	1332	673	1346	1435	723	1446	1538	773	1546	1641
624	1248	1334	674	1348	1437	724	1448	1540	774	1548	1643
625	1250	1336	675	1350	1439	725	1450	1542	775	1550	1645
626	1252	1338	676	1352	1441	726	1452	1544	776	1552	1647
627	1254	1340	677	1354	1443	727	1454	1546	777	1554	1649
628	1256	1342	678	1356	1445	728	1456	1548	778	1556	1651
629	1258	1344	679	1358	1447	729	1458	1551	779	1558	1653
630	1260	1346	680	1360	1449	730	1460	1553	780	1560	1656
631	1262	1348	681	1362	1452	731	1462	1555	781	1562	1658
632	1264	1350	682	1364	1454	732	1464	1557	782	1564	1660
633	1266	1352	683	1366	1456	733	1466	1559	783	1566	1662
634	1268	1355	684	1368	1458	734	1468	1561	784	1568	1664
635	1270	1357	685	1370	1460	735	1470	1563	785	1570	1666
636	1272	1359	686	1372	1462	736	1472	1565	786	1572	1668
637	1274	1361	687	1374	1464	737	1474	1567	787	1574	1670
638	1276	1363	688	1376	1466	738	1476	1569	788	1576	1672
639	1278	1365	689	1378	1468	739	1478	1571	789	1578	1674
640	1280	1367	690	1380	1470	740	1480	1573	790	1580	1676
641	1282	1369	691	1382	1472	741	1482	1575	791	1582	1678
642	1284	1371	692	1384	1474	742	1484	1577	792	1584	1680
643	1286	1373	693	1386	1476	743	1486	1579	793	1586	1682
644	1288	1375	694	1388	1478	744	1488	1581	794	1588	1684
645	1290	1377	695	1390	1480	745	1490	1583	795	1590	1686
646	1292	1379	696	1392	1482	746	1492	1586	796	1592	1688
647	1294	1381	697	1394	1485	747	1494	1588	797	1594	1691
648	1296	1383	698	1396	1487	748	1496	1590	798	1596	1693
649	1298	1385	699	1398	1489	749	1498	1592	799	1598	1695

TABLE D-1. (Continued)

OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT	OBSERVED (10 YRS)	EXPECTED (20 YRS)	.95 CONF LIMIT
800	1600	1697	850	1700	1800	900	1800	1902	950	1900	2005
801	1602	1699	851	1702	1802	901	1802	1904	951	1902	2007
802	1604	1701	852	1704	1804	902	1804	1906	952	1904	2009
803	1606	1703	853	1706	1806	903	1806	1909	953	1906	2011
804	1608	1705	854	1708	1808	904	1808	1911	954	1908	2013
805	1610	1707	855	1710	1810	905	1810	1913	955	1910	2015
806	1612	1709	856	1712	1812	906	1812	1915	956	1912	2017
807	1614	1711	857	1714	1814	907	1814	1917	957	1914	2019
808	1616	1713	858	1716	1816	908	1816	1919	958	1916	2021
809	1618	1715	859	1718	1818	909	1818	1921	959	1918	2024
810	1620	1717	860	1720	1820	910	1820	1923	960	1920	2026
811	1622	1719	861	1722	1822	911	1822	1925	961	1922	2028
812	1624	1721	862	1724	1824	912	1824	1927	962	1924	2030
813	1626	1723	863	1726	1826	913	1826	1929	963	1926	2032
814	1628	1726	864	1728	1828	914	1828	1931	964	1928	2034
815	1630	1728	865	1730	1830	915	1830	1933	965	1930	2036
816	1632	1730	866	1732	1832	916	1832	1935	966	1932	2038
817	1634	1732	867	1734	1835	917	1834	1937	967	1934	2040
818	1636	1734	868	1736	1837	918	1836	1939	968	1936	2042
819	1638	1736	869	1738	1839	919	1838	1941	969	1938	2044
820	1640	1738	870	1740	1841	920	1840	1943	970	1940	2046
821	1642	1740	871	1742	1843	921	1842	1946	971	1942	2048
822	1644	1742	872	1744	1845	922	1844	1948	972	1944	2050
823	1646	1744	873	1746	1847	923	1846	1950	973	1946	2052
824	1648	1746	874	1748	1849	924	1848	1952	974	1948	2054
825	1650	1748	875	1750	1851	925	1850	1954	975	1950	2056
826	1652	1750	876	1752	1853	926	1852	1956	976	1952	2058
827	1654	1752	877	1754	1855	927	1854	1958	977	1954	2061
828	1656	1754	878	1756	1857	928	1856	1960	978	1956	2063
829	1658	1756	879	1758	1859	929	1858	1962	979	1958	2065
830	1660	1758	880	1760	1861	930	1860	1964	980	1960	2067
831	1662	1761	881	1762	1863	931	1862	1966	981	1962	2069
832	1664	1763	882	1764	1865	932	1864	1968	982	1964	2071
833	1666	1765	883	1766	1867	933	1866	1970	983	1966	2073
834	1668	1767	884	1768	1869	934	1868	1972	984	1968	2075
835	1670	1769	885	1770	1872	935	1870	1974	985	1970	2077
836	1672	1771	886	1772	1874	936	1872	1976	986	1972	2079
837	1674	1773	887	1774	1876	937	1874	1978	987	1974	2081
838	1676	1775	888	1776	1878	938	1876	1980	988	1976	2083
839	1678	1777	889	1778	1880	939	1878	1982	989	1978	2085
840	1680	1779	890	1780	1882	940	1880	1985	990	1980	2087
841	1682	1781	891	1782	1884	941	1882	1987	991	1982	2089
842	1684	1783	892	1784	1886	942	1884	1989	992	1984	2091
843	1686	1785	893	1786	1888	943	1886	1991	993	1986	2093
844	1688	1787	894	1788	1890	944	1888	1993	994	1988	2095
845	1690	1789	895	1790	1892	945	1890	1995	995	1990	2097
846	1692	1791	896	1792	1894	946	1892	1997	996	1992	2099
847	1694	1793	897	1794	1896	947	1894	1999	997	1994	2102
848	1696	1795	898	1796	1898	948	1896	2001	998	1996	2104
849	1698	1798	899	1798	1900	949	1898	2003	999	1998	2106

APPENDIX E

DATA MANAGEMENT

Computer Use Requirements

The methodologies developed in this effort make use of large amounts of historical data. In the 10-year period between 1965 and 1974, there were, in general, 29,216 measurements taken at 3-hour intervals for each variable. With approximately 30,000 measurements per variable and 60 variables (50 climatic and 10 air pollution), it follows that approximately 1.8×10^6 measurements were processed for each of the nine geographic locations. This gives a total of 16×10^6 measurements in all.

There are many problems inherent in processing such large quantities of data. Nonnegligible costs are associated with storage of the data, transfer of the data into the central processor, retrieval of selected subsets of the data, and searching for sources of anomalous results. These costs are superimposed on the central processor costs for making the required statistical calculations. Overall, these peripheral costs were found to be approximately 30 percent of the total costs. The percentage would have been higher except that most computer runs were made at reduced costs at low-priority times.

Data Organization

Considerable difficulty was encountered with the air pollution data. In some instances, the data were not received in chronological order on the magnetic tapes, so that expensive sorting and merging procedures were required. The intermittent times at which the air pollution data are taken also pose a special kind of threat when these data are to be merged with the climate data taken at the same time of day. It was necessary to sort out the desired 3-hour-interval data from the large amounts of data taken at other measurement intervals.

In implementing the methodologies developed in this effort, it is recommended that highly skilled computer specialists be used to minimize the problems involved in the technical data processing and thereby minimize the associated computer costs.

APPENDIX F

METEOROLOGICAL DEFINITIONS AND MEASUREMENT METHODS

This appendix consists of brief definitions of the meteorological terms used in this report. Some comments on the methods of measurement are also included. The meteorological terms are grouped into five categories: thermodynamic variables; sky conditions, visibility, wind; weather variables; obstructions to vision; and radiation. This appendix also includes a brief discussion of the weather observations made by the aviation networks and a bibliography.

Thermodynamic Variables

Dry Bulb Temperature. The dry bulb temperature is ideally measured at 4 ft 6 in. above short grass, but the measurement conditions vary with the limitations of the site. The dry bulb temperature is the lowest temperature, to the nearest 0.06 C (0.1 F), obtained in an ambient atmosphere at the place and time of observation. A wide variety of instruments are used, including mercury-in-glass or alcohol-in-glass thermometers, bimetallic thermometers, and electrical (remote indicating) thermometers.

Wet Bulb Temperature. The wet bulb temperature is the lowest temperature, to the nearest 0.06 C (0.1 F), obtained in an ambient atmosphere when water or ice is evaporated from a wick-covered bulb of a thermometer at a specified rate of ventilation. Common measuring instruments include the mercury-in-glass psychrometer, consisting of dry and wet bulb thermometers that are manually or fan ventilated, and the telepsychrograph (recording telepsychrometers), consisting of dry and wick-covered resistance thermometers. The temperatures are remotely recorded at approximately 1-minute intervals.

Dew Point Temperature. The dew point temperature is that temperature to which the ambient atmosphere must be cooled to attain saturation with respect to water. The cooling must be accomplished so that the mixing ratio of the mass of water vapor to that of the containing dry air is constant. The measurements may be obtained by calculation from dry bulb and wet bulb temperatures by means of psychrometric tables, nomographs, or psychrometric calculators. Dew point hygrometers, based on direct observation and thermo-optical principles, are also in use. Hygrothermometers that measure both temperature and humidity are used for remote indications or recordings.

Relative Humidity. The relative humidity is that percentage of the saturation vapor pressure that consists of ambient vapor pressure. The measurement is made with respect to water at ambient pressure and temperature. Relative-humidity values are obtained from wet and dry bulb data by means of psychrometric tables, nomographs, or psychrometric calculators. Also in use are the hair hygrographs, hygrothermographs, and absorption hygrometers.

Station Pressure. The station pressure consists of the ambient atmospheric pressure at the assigned station elevation. The calculated value includes corrections at the time of observation for the measuring instrument, the difference between the actual barometer elevation and the assigned station elevation, gravity (standardized to 980.665 cm/s^2), and temperature (standardized to 0 C). The reported station pressure is the station pressure reduced to a standard elevation, usually sea level. The station pressure is measured in millibars with 1 millibar equal to 0.0295300 inch of mercury. The measuring instruments include the mercury barometer, aneroid barometer, barographs, and microbarographs.

Sky Conditions, Visibility, Wind

Sky Cover. A visual examination is made of the entire sky above the local (apparent) horizon in order to estimate the extent to which the sky or higher clouds are obscured by lower clouds. Synoptic observations of sky cover are made at 3-hour intervals.

Opaque Sky Cover. A sky cover that conceals the sky or higher clouds is called opaque. Such a sky cover includes a translucent sky cover which conceals the sky but through which the sun or moon (but not stars) may be dimly visible.

Ceiling. The ceiling is defined in various ways corresponding to different cloud conditions. If the lowest layer of clouds is classified as broken, or overcast, but not thin, then the ceiling is equal to the height ascribed to the base of the lowest layer of clouds. Broken clouds correspond to sky covers of 0.6 to 0.9, and overcast clouds correspond to sky covers of 1.0. For other obscuring phenomena, such as fog, that conceal more than 0.9 of the sky, the ceiling is measured in terms of the vertical visibility above the point of observation. The instrumentation for measuring ceiling consists of ceilometers and ceiling projector (for night observations), together with radar and aircraft measurement. Ceiling height may also be calculated from the time of balloon disappearance using standard rates of rise.

Visibility. Under specified conditions of observer capability, environment, and background illumination, visibility denotes the greatest distance throughout more than half of the horizon circle at which selected objects can be seen by day or unfocused lights of moderate intensity can be seen by night. If the visibility is variable over time, then average values are reported.

Wind Speed. Wind speed is usually a 1-minute average value of indicator readings. In some instances, 5-minute averages or maximum values are obtained. Various types of anemometers are used to provide indicated or recorded measurements.

Weather Variables

Tornado. A funnel cloud consists of a violently rotating column of air extending downward from a cumulonimbus cloud but not reaching the earth. If the funnel cloud reaches a land surface, the cloud becomes a tornado; if the cloud reaches a water surface, it becomes a waterspout. Tornadoes are reported by direct observation.

Thunderstorms. If, during the 15-minute period that precedes a synoptic measurement time, there occurs thunder, overhead lightning, or hail, then a thunderstorm occurrence is reported. A light thunderstorm is characterized as consisting of lightning within clouds, at intervals of a minute or more, accompanied by thunder that is not loud, and by rainfall, if any, that is light or moderate. The light thunderstorm may have winds gusts of short duration, but the surface wind speed must not exceed 13 m/s (26 knots). A moderate thunderstorm is characterized by frequent cloud-to-ground lightning with loud thunder, moderate to heavy rainfall, surface wind speeds as high as 18 m/s (35 knots), and turbulent sky conditions. Heavy thunderstorms are characterized by nearly continuous cloud-to-ground lightning, heavy rainfall, surface wind speeds in excess of 18 m/s (35 knots), and a rapid decrease in temperature.

Rain. Rain consists of precipitation having water drops with diameters in excess of 0.5 mm (0.02 in.). A very light rain consists of scattered drops that do not completely wet an exposed surface regardless of duration. A measured light rain yields less than 2.5 mm/hr (0.10 in./hr) with a maximum of 0.25 mm/6 min (0.01 in./6 min); a moderate rain yields less than 7.6 mm/hr (0.30 in./hr) and a maximum of 0.76 mm/6 min (0.03 in./6 min); still higher rates are associated with a heavy rainfall. Rainfall is measured by a variety of devices, including stick measurer, tipping buckets, and weighing instruments, and by estimation.

Rain Shower. A rain shower is characterized as a rain from a connective cloud, with rapid onset and cessation, rapid changes in intensity, and rapid changes in sky condition. The measurement and observation methods are the same as those for rain.

Freezing Rain. By direct observation a freezing rain is reported whenever a supercooled rainfall forms an ice glaze on impact with the ground or on exposed objects.

Drizzle. A drizzle consists of slowly falling precipitation leaving droplets that are dense, numerous, and uniformly dispersed, with diameters less than 0.5 mm (0.02 in.). A very light drizzle does not completely wet an exposed surface regardless of duration. A light drizzle yields a trace of rainfall to 0.3 mm/hr (0.01 in./hr) with a visibility in excess of 1 km (5/8 mile). A moderate drizzle yields rainfall between 0.3 mm/hr (0.01 in./hr) and 0.5 mm/hr (0.02 in./hr) with visibility between 1/2 and 1 km (5/16 mile to 5/8 mile). A heavy drizzle yields more than 0.5 mm/hr (0.02 in./hr) with visibility less than 1/2 kilometer (5/16 mile). The intensity of drizzle is determined by the visibility criteria if there are no obstructions to vision. If obstructions occur, then the methods used for measuring rain are used.

Freezing Drizzle. By direct observation, a freezing drizzle is reported whenever a supercooled drizzle forms an ice glaze on impact with the ground or other exposed objects.

Hail. Hail is reported, from direct observation, whenever glaze or glaze-rime particles, having diameters exceeding 5 mm (0.2 in.), precipitate from convective clouds (usually cumulonimbus) when surface temperatures are above freezing. Small hail consists of translucent ice pellets, less then 5 mm in diameter, that rebound on impact.

Sleet. Sleet is reported, from direct observation, when frozen raindrops having diameters less then mm (0.2 in.) precipitate, usually from stratiform clouds, when surface temperatures are below freezing. he intensity of sleet is determined, as for rain, by measurement of the water equivalent or by estimation.

Snow. Snow is reported, from direct observation, whenever a precipitation consists of crystalline water. The intensity of snow is determined by the visibility criteria used for drizzle if there are no obstructions to vision. If obstructions occur, then the intensity of snow is determined, as for rain, by measurement of water equivalent or by estimation. The amount of snowfall is determined by direct measurement at a representative site, or with precipitation gages by determination of the water equivalent (normally 10 cm of snow is equivalent to 1 cm of rain).

Snow Shower. A snow shower is characterized as snow precipitating from a connective cloud, with rapid onset and cessation, rapid changes in intensity, and rapid changes in sky conditions. The observation and measurement methods are the same as those used for snow.

Snow Pellets. Snow pellets are reported, from direct observation, when a showery precipitation consists of white, opaque, usually spherical, snowlike particles, 2 to 5 mm (0.08 to 0.2 in.) in diameter, that rebound on impact. The measurement methods are the same as those used for sleet.

Obstructions to Vision

Blowing Dust (Sand). Blowing dust is reported, from direct observation, whenever windborne local dust (sand) restricts horizontal visibility to 10 km (6 miles) or less.

Blowing Snow. Blowing snow is reported, from direct observation, whenever windborne snow restricts horizontal visibility to 10 km (6 miles) or less at a height of 2 m (6 ft) above the ground.

Blowing Spray. Blowing spray is reported, from direct observation, whenever windborne surface spray restricts horizontal visibility to 10 km (6 miles) or less at a height of 10 m (33 ft) above the ground.

Fog. Fog consists of a suspension of water droplets that reduces visibility to less then 1 km (0.6 mile). The suspension is reported as ground fog if it conceals less then 0.6 of the sky and does not extend to any cloud base.

Haze. Haze is reported, from direct observation, whenever a suspension of microscopic dust or salt particles reduces visibility and makes the atmosphere opalescent.

Smoke. Smoke is reported, from direct observation, whenever a suspension of combustion-produced particles reduces visibility.

Radiation

Solar Radiation. Solar radiation consists of electromagnetic radiation emitted by the sun as a black body at a temperature of approximately 5750 K. The intensity of solar radiation is measured by pyrometers that are sensitive to both direct and diffuse solar radiation and by pyrheliometers that are sensitive to direct radiation only.

Aviation Weather Observations

Aviation weather observations are made at most National Weather Service Stations. In addition, essentially all military stations make weather observations. All of these data are available from the National Climatic Center.

Aviation weather observations are classified in several ways. Hourly data are classified as "record" data. Some data are taken at less then hourly intervals at unscheduled times as mandated by the occurrence of meteorological events. These data are classified as "special" data. In addition, "record special" data consists of special observations made at record observation times.

The "record" and "record special" observations contain nearly all observable data. The criteria for taking "special" observations relate to aircraft operation, and usually pertain to changes in ceilings, sky conditions, visibility, winds, and weather. In general, any event considered to be significant to aircraft operation mandates a "special" observation.

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* This circular has been replaced by Federal Meteorological Handbook No. 1.

APPENDIX G

DERIVATION OF DEGRADATION INEQUALITY USED TO EVALUATE TEST CONDITIONS

Let n denote the number of cells into which the environmental data are classified for a particular geographic location and historical time period. Let $\dot{x}_i$, i = 1, . . ., k denote the time rates of change for cells 1, 2, . . ., k for a material or performance characteristic of interest. It is assumed that each degradation rate $\dot{x}_i$ is constant over time. Let t_i denote the exposure time in cell i over the historical time period T_h. It is assumed that cell i contributes a portion $\dot{x}_i t_i$ of the total degradation due to t_i hours of environmental exposure in cell i. The degradation is obtained by multiplying the hourly degradation rate $\dot{x}_i$ by the exposure time, in hours, spent by the material under the conditions of cell i. The total degradation is then written as follows:

$$\Delta x = \dot{x}_1 t_1 + \dot{x}_2 t_2 + \cdots + \dot{x}_k t_k, \tag{G-1}$$

where

$$t_1 + t_2 + \cdots + t_k = T_h.$$

These equations entail the following implicit assumptions:

(1) The order in which the material is exposed from cell to cell is not important.

(2) The amounts of degradation incurred from cell to cell are cumulative and irreversible.

The exposure times $t_1, \ldots, t_k$ can be estimated from historical data. In contrast, the degradation rates must be based on experimental results where, ideally, a separate experiment would be performed for each environmental cell. The test conditions for each experiment would be identical to the environmental conditions associated with the cell. Clearly, such a procedure is not practical because of the excessive experimentation that would result from a large number of cells.

In order to reduce the required amount of experimentation, the environmental cells are first grouped. Only one experiment is then to be performed for each group, and the test conditions for this experiment are those environmental conditions that correspond to the most stressful cell in each group of cells. In this way, the problem of defining test conditions is seen to be equivalent to grouping the cells into the smallest number of groups possible and then performing one experiment for each group of cells in order to determine the degradation rate for each group of cells. The grouping of the cells is taken to be mutually exclusive and exhaustive so that distinct groups have no cells in common and every environmental cell belongs to some group. In addition, the groups are taken to be nested so that for any pair of groups the degradation rates for one group are not less than those of the other group.

Symbolically, the cells may be renumbered, if necessary, so that $\dot{x}_1$ is the maximum degradation rate for any cell in Group 1; $\dot{x}_2$ is the maximum degradation rate for any cell in Group 2, etc., for all k cells. Then the total amount of degradation for the ith group, say Δx_i, is bounded as follows:

$$\Delta x_i \leqslant \dot{x}_i \Delta t_i, \; i = 1, \cdots, k,$$

where Δt_i denotes the sum of the exposure times over all cells in Group i during the historical time period T_h. The addition of these inequalities then gives an upper bound on the total degradation:

$$\Delta x = \sum_{i=1}^{k} \Delta x_i \leqslant \dot{x}_1 \Delta t_1 + \ldots + \dot{x}_k \Delta t_k, \tag{G-2}$$

where

$$\sum_{k=1}^{n} \Delta t_k = T_h .$$

This is the basic inequality that underlies the proposed approach for the evaluation of test conditions. The exposure times Δt_i are to be obtained directly from historical data at each geographical location of interest and the degradation rates $\dot{x}_i$ are to be obtained from experiments performed using the associated environmental conditions as the test conditions for each group of cells.

APPENDIX H

METRIC TO ENGLISH CONVERSION FACTORS

To Change	Into	Multiply by
cm	in.	0.394
cm^3	$in.^3$	0.0610
kg-m	ft-lb	7.23
kg	lb	2.20
kg	tons	0.00110
kW	hp	1.34
kWh	Btu	3,413
kWh	ft-lb	2.66×10^6
kW	kcal min^{-1}	14.3
m	ft	3.28
m	in.	39.4
m	miles	6.21×10^{-4}
cm^2	ft^2	0.00108
cm^2	$in.^2$	0.155
m^2	ft^2	10.8
m^2	$miles^2$	3.86×10^{-7}
W cm^{-2}	ly min^{-1}	14.3
W m^{-2}	ly hr^{-1}	0.086
km	miles	0.621
m/s	mph	2.24
kN/m^2	in. Hg at 32 F	0.295
C	F	1.8 and add 32

APPENDIX I

GLOSSARY OF SELECTED TERMS USED IN THIS REPORT*

Abbreviated Test. A test is said to be an abbreviated test if the test is performed over a relatively short time period under normal stress levels.

Accelerated Test. A test is said to be an accelerated test whenever the test conditions involve stress levels that exceed those associated with normal or reference operating conditions.

Cell. As used in this report, the range of the measured values of any climatic variable can be divided into class intervals that represent one-dimensional cells. The one-dimensional cells are listed in Table 9 for temperature, relative humidity, wind speed, and insolation. Simultaneous combinations of two of these variables give rise to two-dimensional cells, such as an air temperature between 4 and 20 C and a relative humidity between 70 and 79 percent. The four-dimensional cells involving temperature, relative humidity, wind speed, and insolation are treated in Table 10. In some instances, a cell may also refer to the simultaneous occurrence of a climatic variable, and a weather event, as shown in Table 13 for air temperature combined with fog, rain, snow, etc.

Climatic Condition. In this report, the simultaneous occurrence of the measured values of several climatic variables denotes a climatic condition, such as an air temperature of 25 C, relative humidity of 70 percent, and wind speed of 4 m/s.

Climatic Variable. In this report, the climatic variables are air temperature, solar radiation, extraterrestrial radiation, relative humidity, wind speed, dew point, station pressure, and opaque sky cover.

Diffuse Insolation. Scattered, reflected, or re-emitted insolation received by a collector is called diffuse insolation.

Direct Insolation. That portion of the solar radiation that is transmitted from the sun to the collector without deviation, reflection, or scattering is called direct insolation.

Exposure Hours. As used in this report, exposure hours denote a computed number of hours of exposure to a specified set of environmental conditions. The computation is based on the assumption that a measured condition persists until the next measurement is taken.

Extraterrestrial Insolation. The solar radiation received above the Earth's atmosphere is called the extraterrestrial insolation.

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*Definitions of meteorological terms are given in Appendix F.

Nested Set of Test Conditions. In this report, an ordered set of test conditions is said to be nested provided each climatic variable increases or decreases monotonically as the test condition becomes successively less stressful.

Poisson Distribution. The Poisson distribution is defined by the expression:

$$f(x) = [(\lambda t)^x/x!]e^{-\lambda t}, \; x = 0, 1, 2,...$$

where f(x) denotes the probability of exactly x events occurring in the time interval 0 to t, and λ denotes a constant time rate of occurrence.

Pyranometer. In current usage, a pyranometer is an instrument used to measure total (direct plus diffuse) hemispheric solar radiation.

Pyroheliometer. In current usage, an instrument used to measure direct solar radiation.

SPSS. The Statistical Package for the Social Sciences (SPSS) is a general-purpose set of computer programs used at nearly 600 installations. A users manual is available from the McGraw-Hill Book Company, New York, New York.

Stress. The term stress is used to indicate the general level of severity of environmental conditions. Abrasive or severe conditions are associated with high stress and corresponding high rates of degradation for material or performance characteristics.

Terrestrial Service Environments. Those environmental conditions associated with field operations subject to local weather conditions are said to be terrestrial service environments.

Time Series Analysis. Climatic variables may be considered to be functions of time, and may be analyzed using time series methods to identify periodic structures over time, linear trends over time, etc.

Total Horizontal Insolation. The sum of the direct and diffuse solar radiation received on a horizontal collector is called the total horizontal insolation.

Weather Event. In this report, a weather event denotes any of the following: fog, drizzle, rain, rain shower, thunderstorm, tornado, hail, freezing drizzle, freezing rain, snow, blowing snow, snow shower, snow pellets, sleet, blowing dust, blowing sand, smoke, or haze.

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