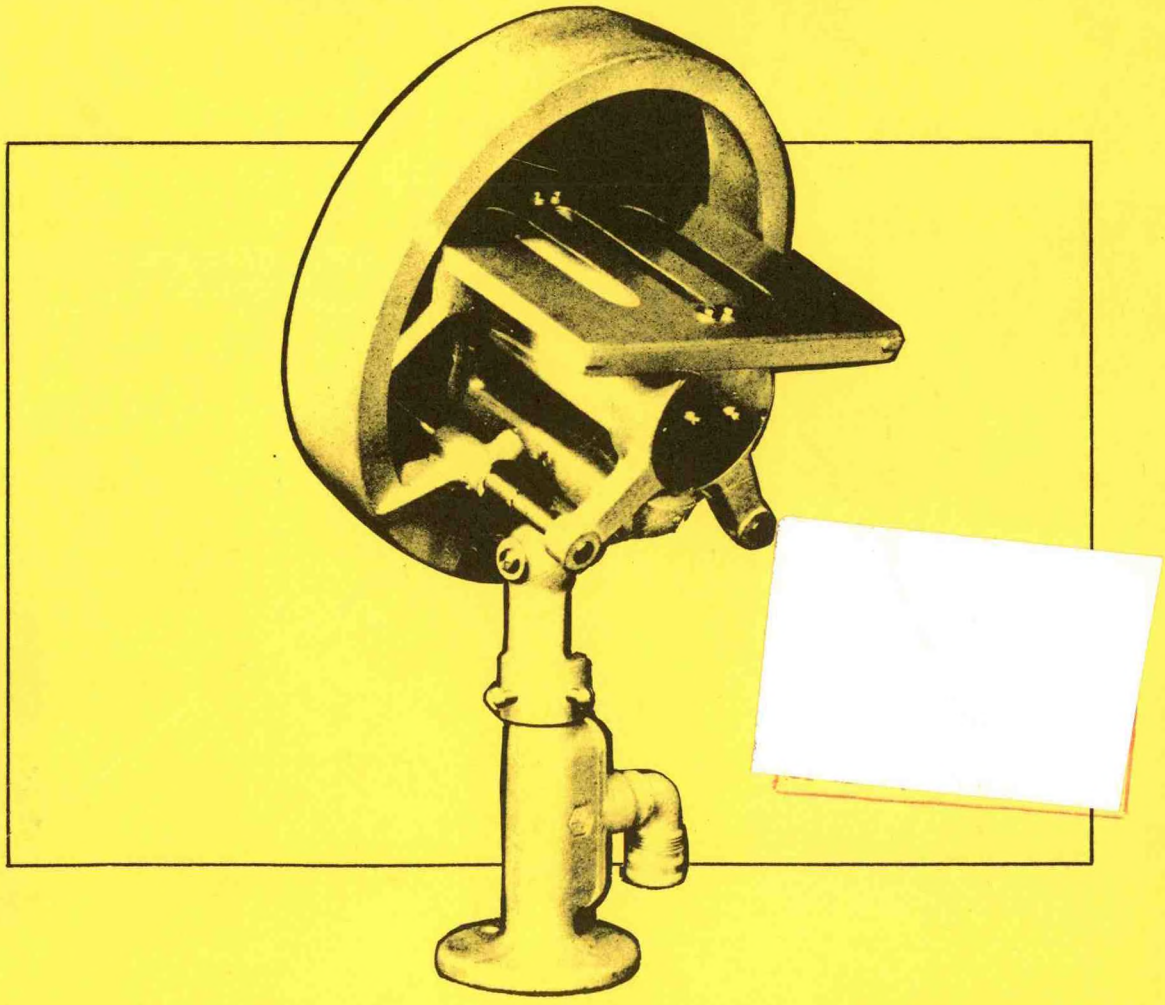
HISTORICAL CLIMATOLOGY SERIES NO. 2-2

A HISTORY OF SUNSHINE DATA IN THE UNITED STATES 1891 — 1980



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   1-3 A Long Record of Weather Observations in Southeastern Iowa 1839-1979 (July 1980).

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A HISTORY OF SUNSHINE DATA IN THE UNITED STATES 1891 - 1980

FRED DOEHRING
THOMAS KARL

NATIONAL CLIMATIC CENTER
ASHEVILLE, NORTH CAROLINA

JULY 1981

Contents

Abstract

This publication inventories "duration of sunshine" records for 239 recording stations. The monthly and annual total hours of sunshine for these sites have been digitized and summarized for each available month and year of record between 1891-1980.

The background and data inventory of sunshine recordings are described in this report. Documentation includes information on the station network, periods of record, types and locations of instruments, and formats for various sources of published data. Data are presented as time series of sunshine values for selected long-term stations, possible sunshine hours, and effective sunshine.

NOTE: Due to the large volume of sunshine data, it was not possible to list monthly and annual values in this report. The complete set will be available in October 1981 on magnetic tape or microfiche. Paper copies of data for individual stations can be provided from computer listings.

Requests for data or more information may be obtained by directing inquiries to:

National Climatic Center
Federal Building
Asheville, NC 28801

or by calling our User Services Branch at (704) 258-2850 extension 683, (FTS 672-0683).

INTRODUCTION and EXECUTIVE SUMMARY

In the United States duration of sunshine measurements have been made at 239 stations during the years 1891-1980. Periods of record of monthly and annual total hours of sunshine vary widely from station to station. Official sunshine records were first published in 1891 for 20 stations in the "Report of the Chief of the U.S. Weather Bureau." By 1920 the number of stations recording sunshine duration had rapidly increased to 165. Since then, the number of stations has remained fairly constant. In 1980 there were 161 stations in operation. Fifteen stations have data covering the entire period since 1891.

Automatic sunshine recording instruments have consisted basically of 3 types: 1) Modified Jordan Photographic Recorder, 2) Maring-Marvin Thermometric Recorder, 3) Foster Electric Sunshine Switch. The Foster Electric Sunshine Switch is the instrument in use today. In most cases sunshine recorders were part of the triple register which has been in use since 1891. The format of original published monthly and annual sunshine totals varied somewhat from 1891 to 1907, but has remained about the same since 1908. Data have been published in the annual issue of the NOAA publication Climatological Data National Summary.

Locations of sunshine recorders have never been specifically documented, but they can be estimated from the station location table in the publication Local Climatological Data, Annual Summary With Comparative Data, for stations in existence since 1949. For sunshine recording stations which closed prior to 1949 (i.e. for which no Local Climatological Data was published) a Station Location table is presented in this paper.

Time series of sunshine values are presented for selected long-term stations. Examination of these graphs suggest many interesting avenues for future research. Some suggested methods of estimating monthly averages of solar radiation based on the sunshine values are presented.

A. Station Network

Official Sunshine Recordings from a newly established sunshine network (see Fig.1) were first published in the year 1891 for 20 stations in the "Report of the Chief of the US Weather Bureau." A list of the number of sunshine recording stations at the beginning of each decade is shown below:

1891 - 20	1941 - 173
1901 - 84	1951 - 180
1911 - 138	1961 - 173
1921 - 165	1971 - 160
1931 - 165	1981 - 161

The number of stations with sunshine recordings increased rapidly from 20 stations in 1891 to 165 stations by the year 1920. Since then, the number of stations remained fairly constant, with the maximum number of stations operating between 1940 and 1960. The greatest number of stations in operation in any one year during this period was 183 stations in the year 1945, with a small decrease taking place thereafter due to station closings and movement of city offices to airports. Figs.1-6 show the stations in operation during selected years. A good distribution of stations in the network was not achieved until after 1920. The letters P and T in Fig.2 indicate the type of sunshine recorder used at different stations (P = Photographic, T = Thermometric).

B. Period of Record and Summarized Sunshine Data

Of the 20 sunshine recording stations in existence in the year 1891, 15 stations have a continuous period of record through 1980. Of the 84 stations in existence in the year 1900, 57 stations have a continuous period of record through 1980. Seven more have records covering a total of about 80 years, although there are some gaps in such long-term stations as Central Park, NY and Los Angeles Civic Center, CA.

The 15 continuous Long-Term Stations (1891-1980) are:

Buffalo, NY	Dodge City, KS	Salt Lake City, UT
Cincinnati, OH	Galveston, TX	San Diego, CA
Cleveland, OH	Kansas City, MO	Savannah, GA
Denver, CO	Philadelphia, PA	St. Louis, MO
Detroit, MI	Portland, OR	Washington, DC

A list of the number of stations versus total years of record (including stations which had a break in their period of record or stations which closed prior to 1980) follows:

Equal to or greater than	90 years:	15 stations
	80 years:	64 stations
	70 years:	97 stations
	60 years:	115 stations
	50 years:	135 stations
	40 years:	160 stations
	30 years:	185 stations

A graphical depiction of periods of record for all sunshine recording stations in existence between 1891 and 1980 is shown in Fig.7.

The most recently published averages of monthly/annual mean total hours of sunshine, are those in the Climatic Atlas of the United States. These averages were computed for the period 1931-1960 or shorter periods when the 30-year period was not available. Averages were also published in the Climatic Summary of the U.S. (Bulletin W) for the period of record ending in 1930, in Technical Paper No.12 for the period of record ending in 1948, and in the 1971 WMO Climatological Normals (CLINO) Publication (WMO/OMM No. 117.T.P.52) for 48 U.S. Sunshine Stations. However, these were mostly for non-standard periods. From the data available now, long-term averages can be computed for periods of record up to 70 years for a reasonable network of stations (see Fig.8.).

Long-term averages of "Percent of Possible Sunshine" have been published since 1949 in Local Climatological Data Annual Summary With Comparative Data (LCDA) and since 1953 in the Annual Climatological Data National Summary (January and July data only).

The relatively short periods of record noted in the Normals, Means, and Extreme tables of the LCDA result from using only data from current station locations, mostly at airports. Since station moves have rarely exceeded 10 miles and site-specific corrections are included in the measurements (such as premature sunset due to mountains), it may be assumed that station relocation effects on "duration of sunshine" have been negligible. Therefore for the purposes of this publication they are not taken into consideration.

C. Instruments

The automatic sunshine recorders consisted basically of three types:

1. Modified design of the Jordan Photographic Sunshine Recorder, designed by C.F. Marvin in 1888.

2. Maring-Marvin Thermometric Sunshine Recorder, sometimes referred to as the Black-Bulb Type Sunshine Recorder.

3. Foster Photoelectric Sunshine Switch, in technical terms referred to as the A-081 Sunshine Switch.

An illustration of the above instruments is given in Fig.9.

The photographic sunshine recorder was in use from 1891-1907 at various sunshine recording stations, with all stations using this instrument in 1891 and 1892. Beginning in 1893, the photographic sunshine recorders were gradually replaced by thermometric sunshine recorders as they became available to the U.S. Weather Bureau, which was a very slow process at that time.

By 1908 all stations were using the thermometric sunshine recorder. This instrument remained in use until 1952. In 1953, it was finally replaced by the photoelectric sunshine switch designed by N.B. Foster. This instrument is still in use today, with no plans for its replacement.

Prior to 1953, the sunshine recorder was always part of the triple register, an instrument used since 1891 for the autographic recording of wind (direction and speed), precipitation and sunshine. Since 1953, with the installation of the A-081 sunshine switch, all stations used a sunshine totalizer to record daily minutes of sunshine, with the triple register serving as a back-up and also to provide a more detailed record if needed (See Fig.10.).

D. Format of Published Data and Data Sources

The format of published sunshine data varied somewhat for the years 1891-1907, but remained basically the same from 1908-1980. For the years 1891-1893, published sunshine totals had no corrections for low sun angle applied to their readings. These corrections include the observed (unrecorded) sunshine associated with a clear sunrise or sunset when the sunshine switch was not recording the events. Thus, the annual totals were about 200 hours lower than those published since 1893. Totals for 1891-1893 are omitted for the purpose of time series graphs and long-term averages in this publication.

A data inventory was compiled from annual publications which contain monthly/annual sunshine totals. These publications include:

1891-1934: Report of the Chief of the U.S. Weather Bureau

1935-1949: United States Meteorological Yearbook

1950-1980: Climatological Data National Summary (Annual)

Other publications which contain data related to sunshine are as follows:

1. Local Climatological Data (Monthly)

   Daily and monthly duration of sunshine, 1949 to present

Daily and monthly percent of possible sunshine, 1949 to present

Monthly duration of possible sunshine, 1949 to present

2. Local Climatological Data (Annual)

Monthly and annual percent of possible sunshine for each month and year since 1949

Monthly and annual mean percent of possible sunshine for the period of record.

3. Climatological Data (Monthly):

Monthly percent of possible sunshine (under Supplemental Data or Separate Tables), January 1914 to present.

4. Climatological Data National Summary (Monthly):

Monthly percent of possible sunshine, January 1950 to December 1980

Monthly percent of possible sunshine maps, January 1951 to June 1972

5. Monthly Climatic Data for the World:

Monthly percentage of long-term average sunshine to nearest 5%, 1969 to present

6. Weekly Weather and Crop Bulletin:

Monthly percent of possible sunshine maps, March 1973 to present

E. LOCATION OF SUNSHINE RECORDERS

A comprehensive summary of the location of sunshine recorders has never been published. Since all sunshine recorders were located at First-Order Stations, operated by the National Weather Service (Weather Bureau in earlier years), Station Location tables have been published for these Stations since 1949 each year in the publication LCDA. These Station Location tables reflect the station location of each station since its origination (see Fig.11). The locations of Sunshine Recorders can be estimated using these tables and the period of record of each Sunshine Recording Station (Fig.7), More detailed information on station location can be furnished from the Station History files which are archived at the National Climatic Center, Asheville, NC.

For stations which were closed prior to 1949 (i.e., for which no LCDA was published) a summary of the locations of sunshine stations is presented in Table 1, which was extracted from the Station History Files at the National Climatic Center. The "Lists of Observing Stations" in the Report of the Chief of the Weather Bureau was used for the years 1891-1930 if the Station History File was either missing or incomplete during this period (Fig. 12).

F. Time Series of Annual Sunshine Data

Time series graphs of annual sunshine hours illustrating the long-term variability are presented for 6 selected stations for the period 1894-1978. (Fig.13). The large annual amount of sunshine received at Dodge City, KS between 1920 and 1935 is indicative of the conditions leading up the Dust Bowl years during the 1930's. Also, the unusually large sunshine amount from 1952 to 1955 at both Dodge City, KS and El Paso, TX reflects the drought of early 1950's in the mid-west and southwest. On the other hand, San Diego's relatively small year-to-year fluctuations are indicative of the relatively invariant climate in that area.

G. Data Interpretation

Possible sunshine duration is the time between sunrise and sunset assuming a smooth spherical earth. Sunrise and sunset are considered to be when the sun's upper disc appears just above the horizon in the morning and disappears below the horizon in the evening. The horizon constitutes a smooth surface which is not obscured by mountains, tall buildings, trees, etc. The best example of a smooth surface is a calm ocean. On a smooth spherical earth, possible sunshine duration varies only with latitude and time of year, but complex terrain features such as mountains make the actual duration of sunshine somewhat shorter than on a smooth earth. In order to standardize measurements, all stations correct the recorded sunshine duration by adding the minutes of sunshine lost due to the permanent obstructions.

Another complexity arises because the sunshine instrument does not record satisfactorily when the sun is close to the horizon. Therefore, observers have been instructed to include the observed, but unrecorded, sunshine associated with a clear sunrise or sunset (or other estimated periods of sunshine) in the daily totals for sunshine durations (Federal Meteorological Handbook No.1, Surface Observations). Some of this lost sunshine time results from the failure of the sunshine switch to activate during certain hazy or polluted conditions. It is not known how much sunshine time is lost through these effects.

Where the terrain is flat, skies are clear, and the air is clean, unrecorded sunshine should be minimal, usually no more than 10 to 20 minutes. Yet, upon checking the triple register charts for some of the sunshine recording stations located on relatively flat terrain, it was found that on some days more than 60 minutes elapsed between switch activation and sunrise or sunset. Sunrise and sunset were noted as clear; no clouds or fog were present during these days. The percent of possible sunshine was noted as 100%, while the recorded sunshine was only 80% because

of haze, distant fog or smog. To investigate this problem on a station-by-station basis one must consult the original records on file at the NCC. Depending upon the particular applications, this may be necessary for areas where distant fog or air pollution are common occurrences.

In Table 2 the monthly possible sunshine duration is given in hours and tenths for all U.S. Sunshine Recording Stations which were in operation during 1979. Using this Table and the percent of possible sunshine listed in the LCDA, one can easily compute the average or actual monthly sunshine hours. Possible sunshine values for the contiguous 48 states range from a minimum of 4437 hours at the most southern station (Key West, FL) to a maximum of 4471 hours at the most northern station (Havre, MT) except for Mt. Washington, NH, which is a special case because of its elevate vantage point. The highest annual sunshine value ever recorded in the U.S. was at Yuma, AZ with 4272 hours in 1958 (96 percent) and the lowest annual sunshine value recorded was at Mt. Washington, NH with 1181 hours in 1943 (26 percent).

In Fig.14 a graph is presented from which the daily possible sunshine (sunrise to sunset) can be approximated for any location in the Northern Hemisphere. Given the latitude of a particular location, the daily possible sunshine can be interpolated for any given date; (i.e., for latitude 30 degrees north on the 20th of January the possible duration of sunshine is 10 hours and 30 minutes.

Sunshine duration measurements cannot be directly converted to units of solar radiation because the duration of sunshine measurements are insensitive to invisible portions of the solar spectrum. However, by using monthly values of the percentage of possible sunshine, an estimate can be calculated for the monthly average solar radiation on a horizontal surface. One approach, provided by the Smithsonian Meteorological Tables, is to use a regression equation of the form:

$$\frac{Q}{Q_o} = 0.61\ S + 0.35 \qquad (1)$$

where Q is the monthly average radiation on a horizontal surface, Q_o is the average radiation during cloudless days within a specific month, and S is the fraction of possible sunshine (see Fig.15).

The main difficulty with equation (1) is that the value Q_o is difficult to determine, since the number of clear days in a month is small and moisture and dust in the atmosphere significantly affect Q_o. Prescott (1940)[1] modified equation (1) to

$$Q = Q_T (a + b S) \qquad (2)$$

where Q_T is the shortwave radiation at the top of the atmosphere and a and b are constants. Values of Q_T can be found in the Smithsonian Tables. Table 3 contains the a's and b's for various locations in the United States as calculated by Baker and Haines (1969)[2]. Rietveld (1978)[3] has examined numerous published reports of the values of a and b at various locations and shows that a is related linearly and b is related hyperbolically to the mean value of S (Fig.16).

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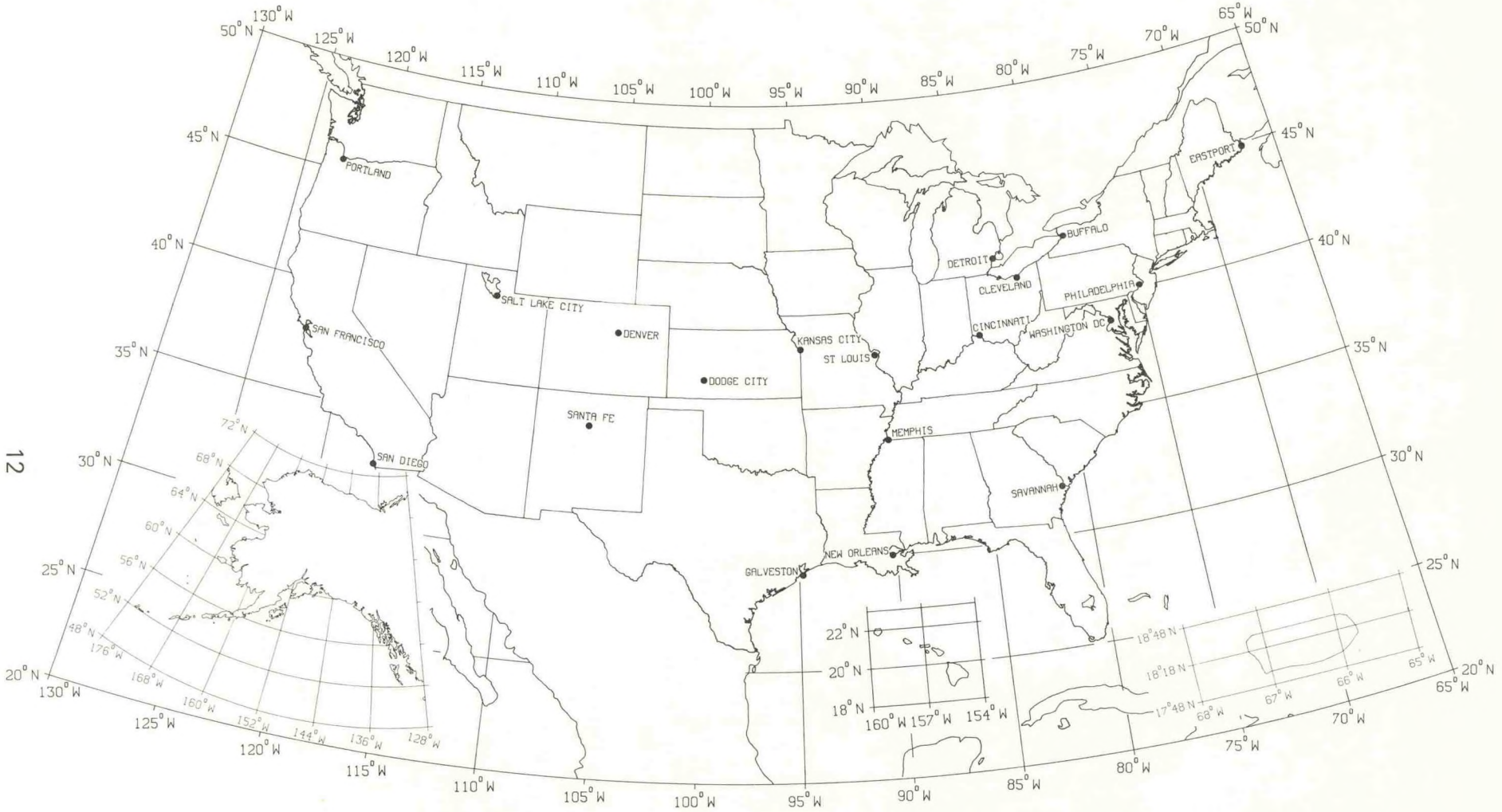
[1] Prescott, J.A., 1940. Evaporation from a water surface in relation to solar radiation. Trans. R. Soc. S. Austr., 64: 114-118.

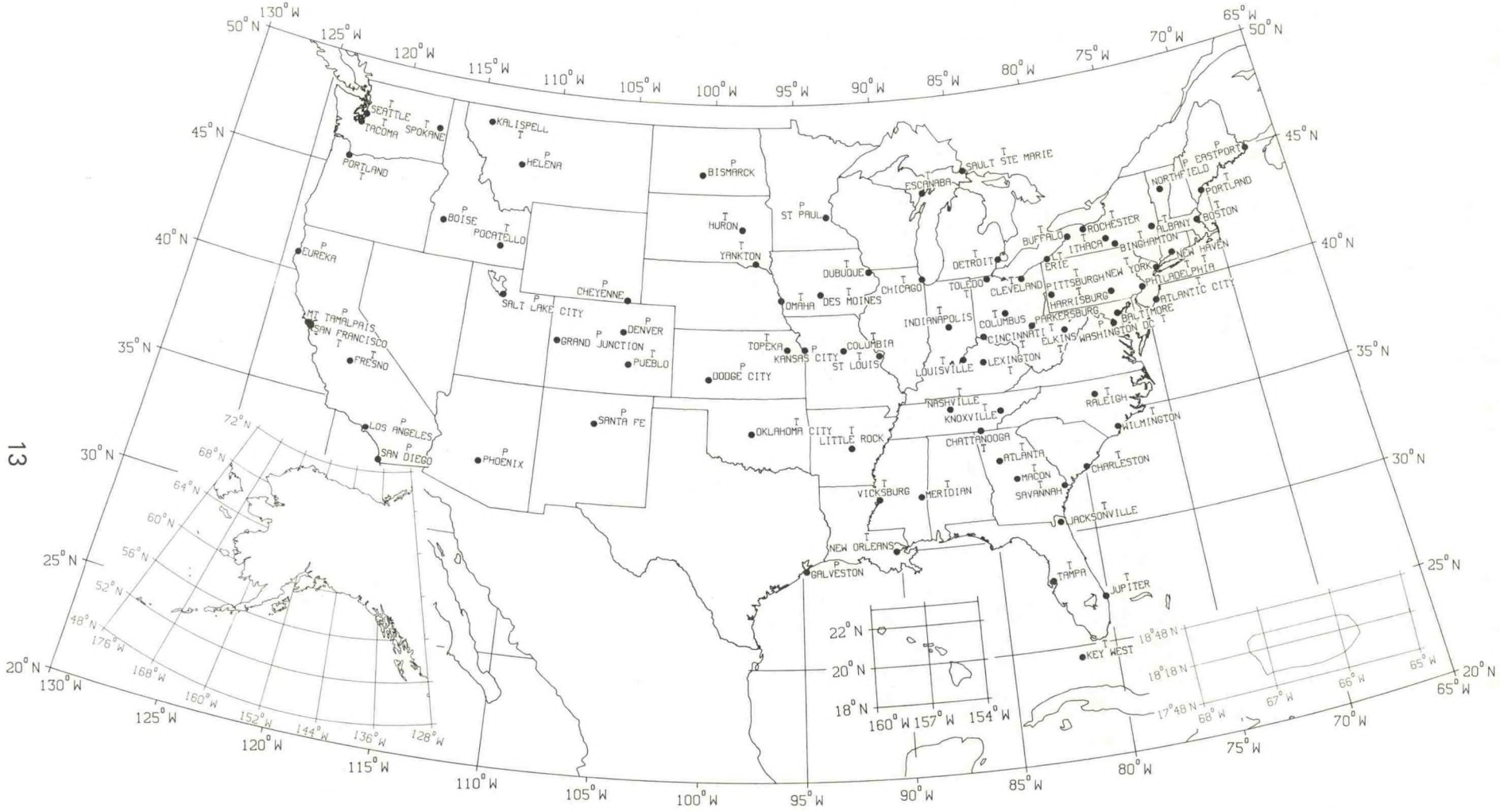
[2] Baker, D. and Haines, D., 1969. Solar Radiation and Sunshine Duration Relationships in the U.S.A. Agric. Exp. Stn., Univ. Minnesota.

[3] Rietveld, M.R., 1978. A new method for estimating the regression coefficients in the formula relating solar radiation to sunshine. Agric. Meteor. 19: 243-252.



Sunshine Station Network 1891

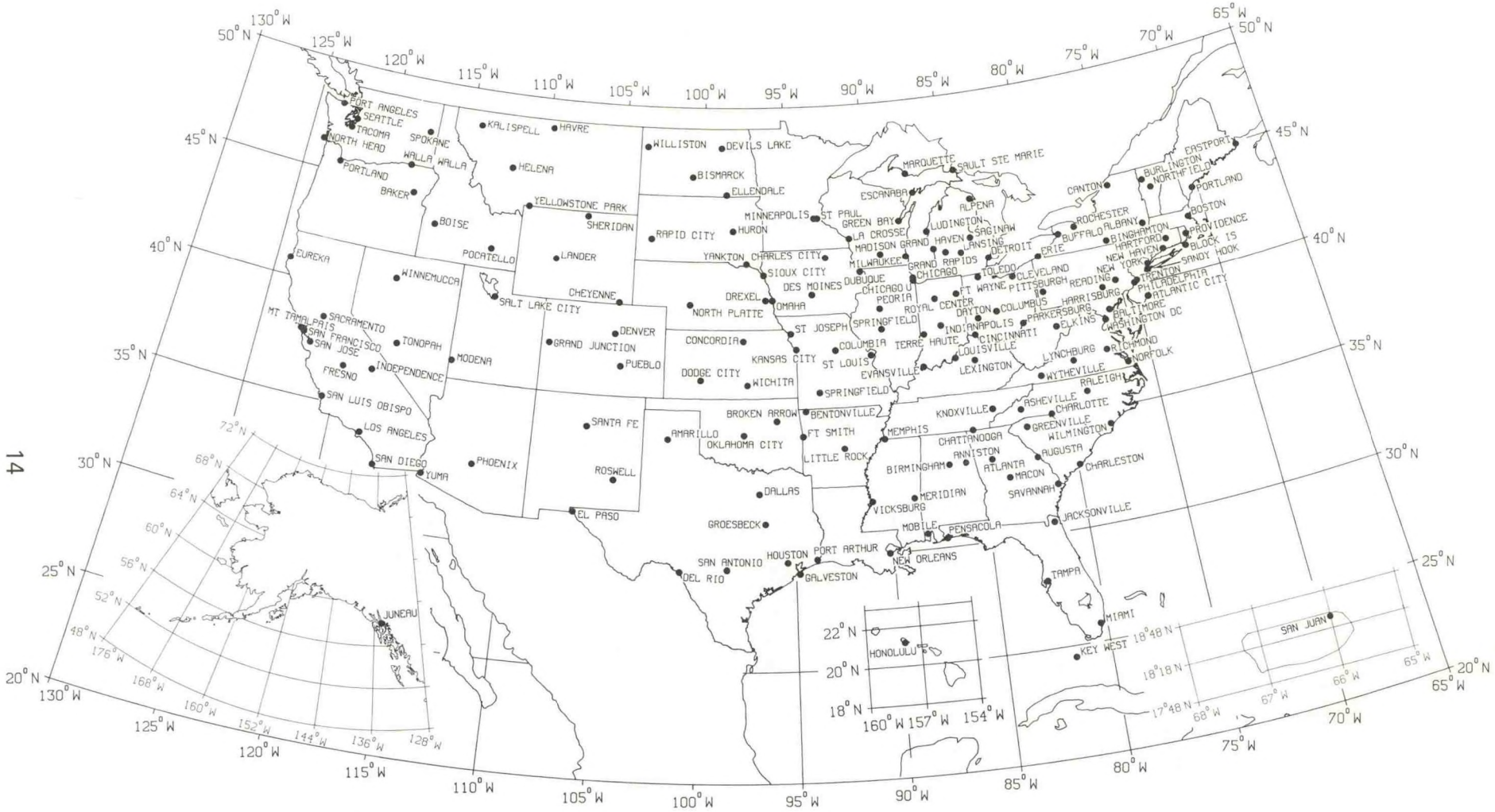
FIG. 1



P = Photographic T = Thermometric

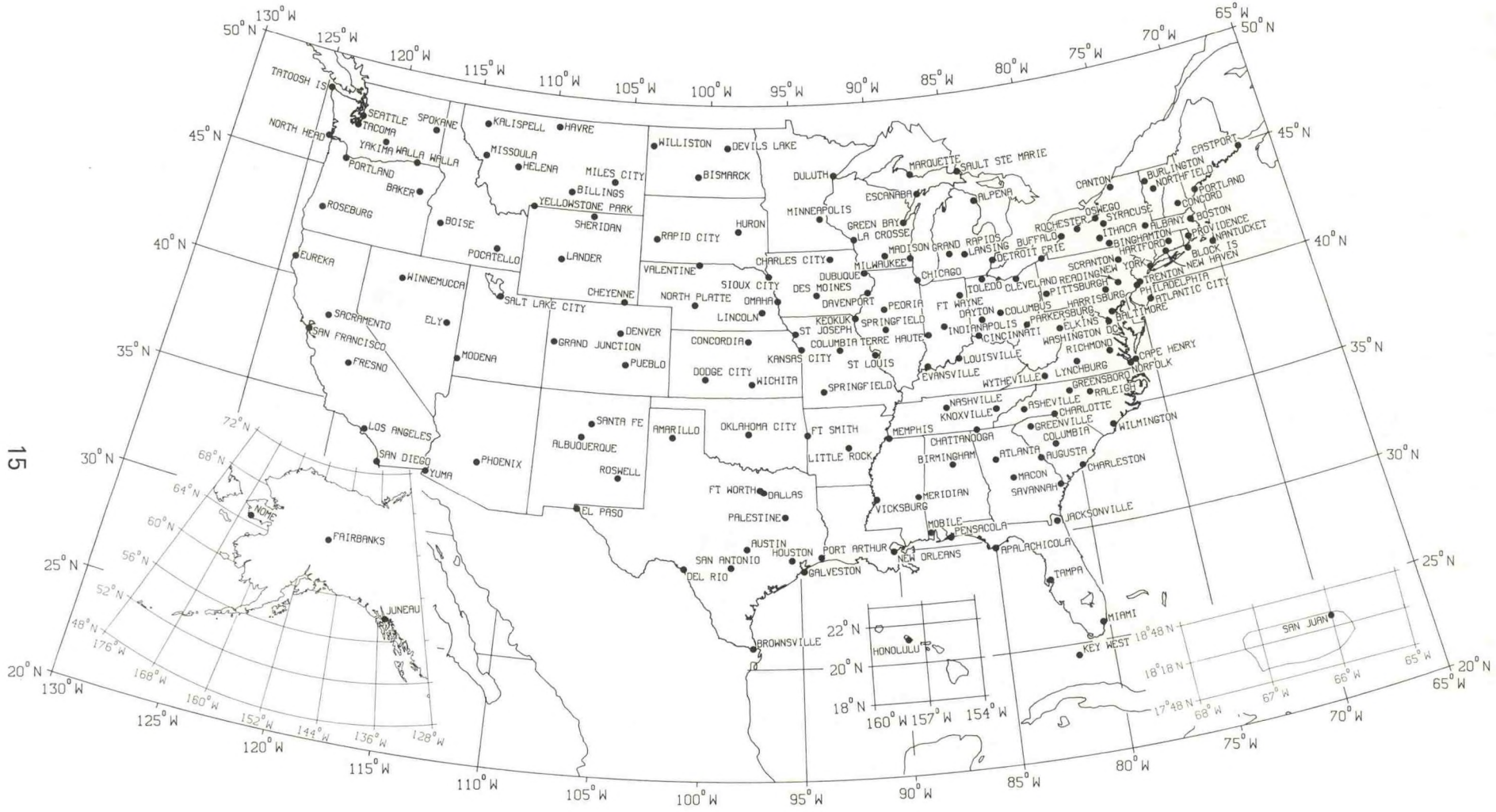
Sunshine Station Network 1900

FIG. 2



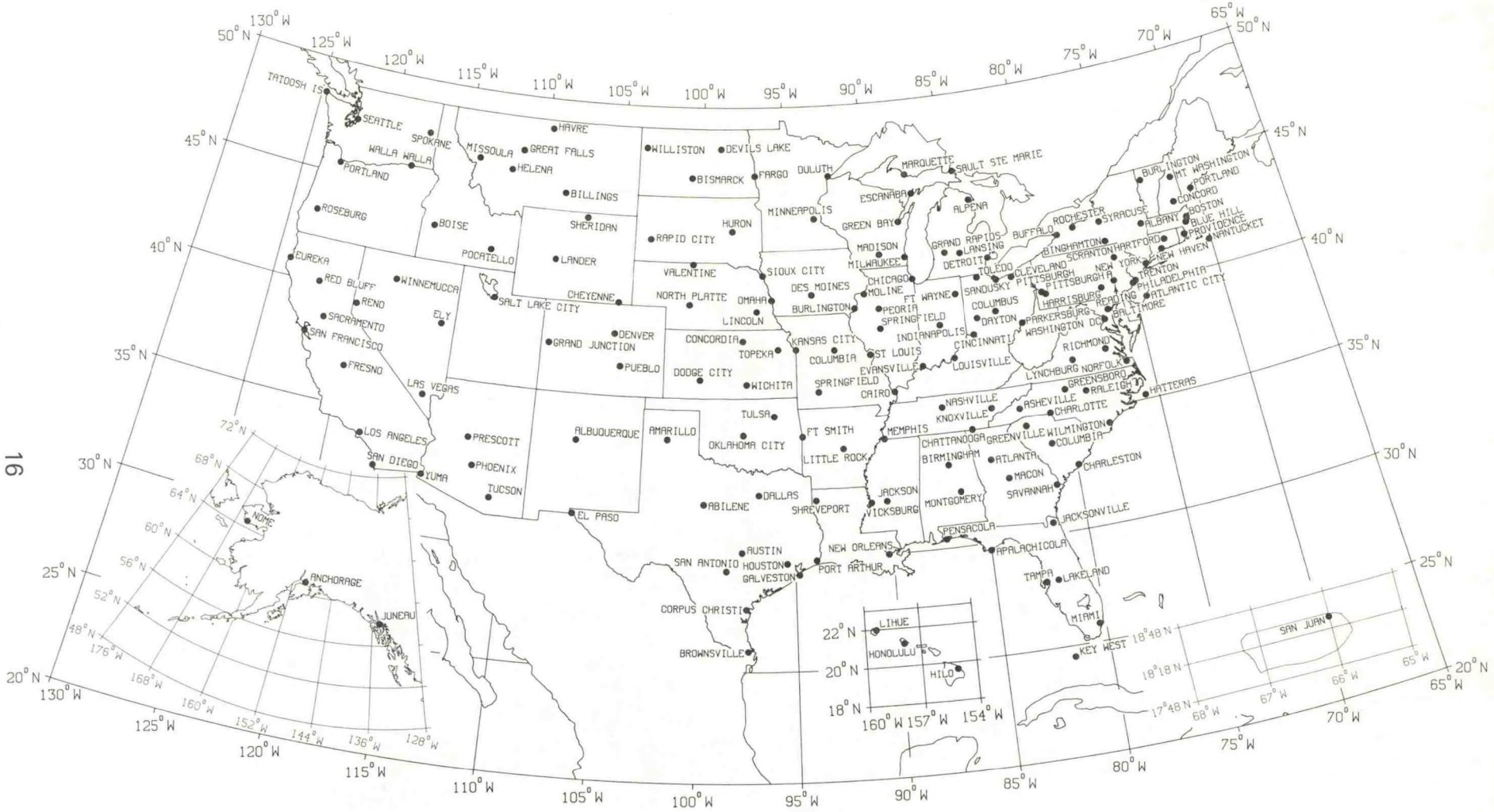
Sunshine Station Network 1920

FIG. 3



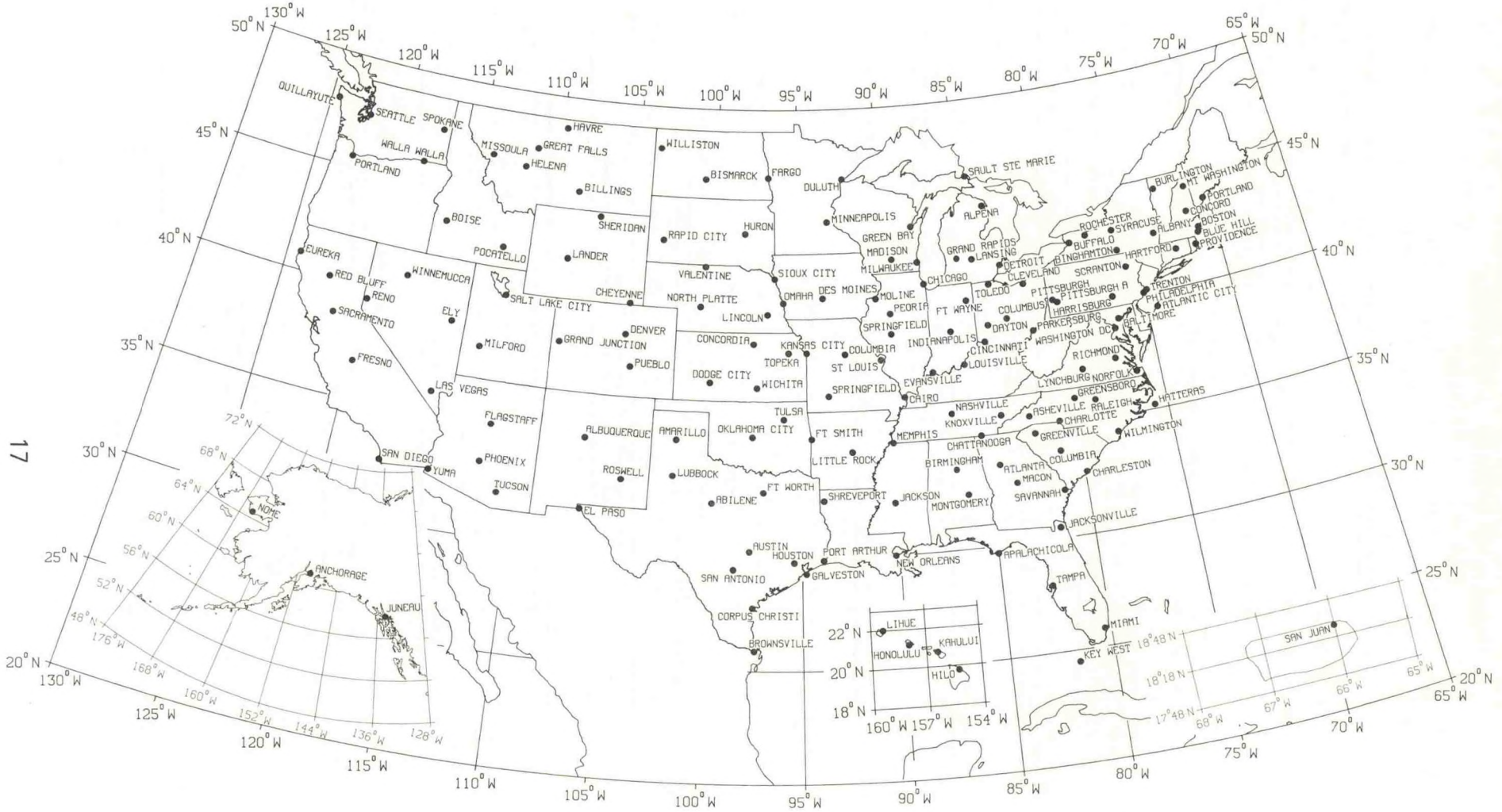
Sunshine Station Network 1940

FIG. 4



Sunshine Station Network 1960

FIG. 5



Sunshine Station Network 1980

FIG. 6

FIG. 7

SUNSHINE STATION NETWORK
PERIOD OF RECORD

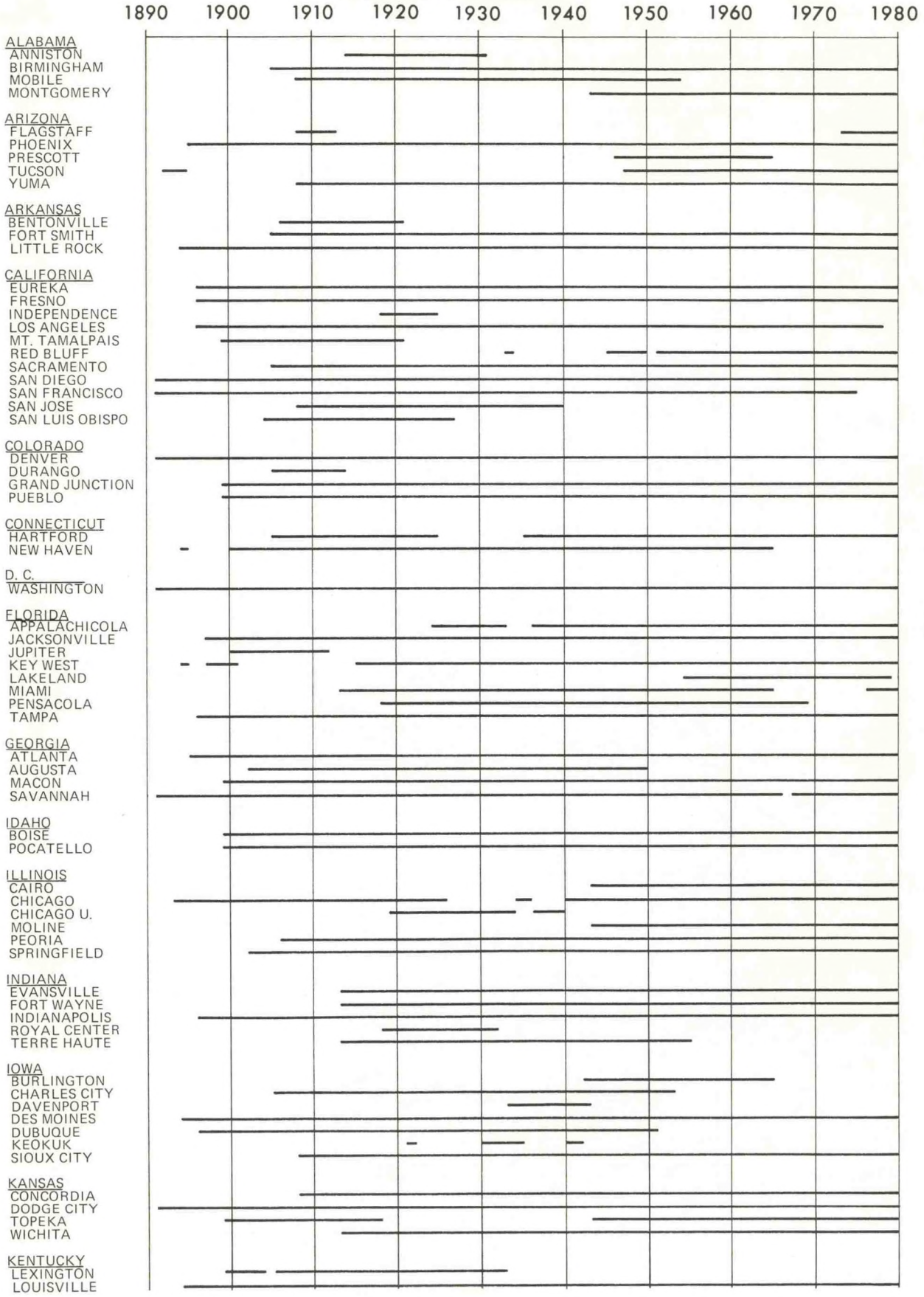


FIG. 7 (CONT'D.)

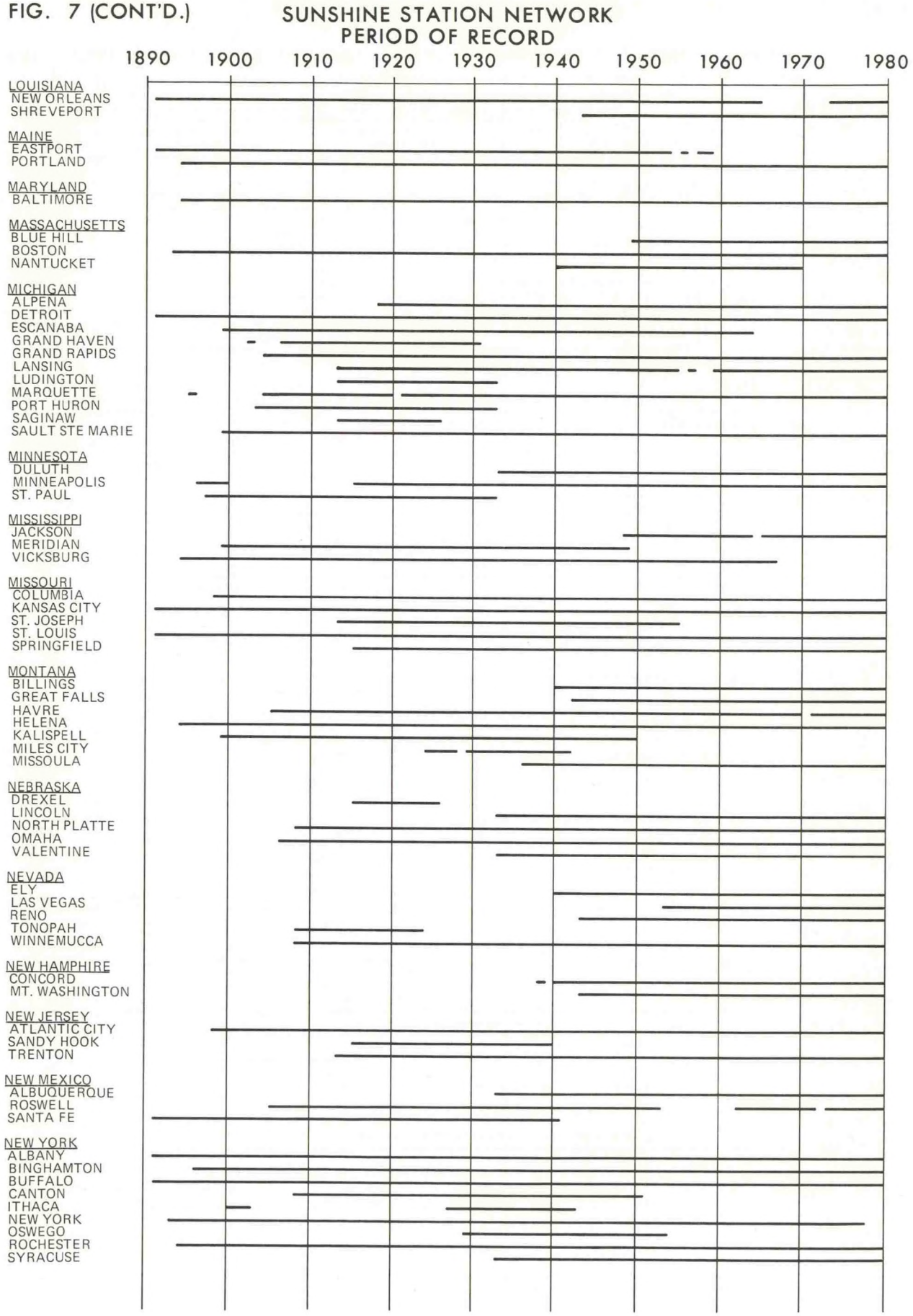

SUNSHINE STATION NETWORK
PERIOD OF RECORD
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
LOUISIANA
NEW ORLEANS
SHREVEPORT
MAINE
EASTPORT
PORTLAND
MARYLAND
BALTIMORE
MASSACHUSETTS
BLUE HILL
BOSTON
NANTUCKET
MICHIGAN
ALPENA
DETROIT
ESCANABA
GRAND HAVEN
GRAND RAPIDS
LANSING
LUDINGTON
MARQUETTE
PORT HURON
SAGINAW
SAULT STE MARIE
MINNESOTA
DULUTH
MINNEAPOLIS
ST. PAUL
MISSISSIPPI
JACKSON
MERIDIAN
VICKSBURG
MISSOURI
COLUMBIA
KANSAS CITY
ST. JOSEPH
ST. LOUIS
SPRINGFIELD
MONTANA
BILLINGS
GREAT FALLS
HAVRE
HELENA
KALISPELL
MILES CITY
MISSOULA
NEBRASKA
DREXEL
LINCOLN
NORTH PLATTE
OMAHA
VALENTINE
NEVADA
ELY
LAS VEGAS
RENO
TONOPAH
WINNEMUCCA
NEW HAMPHIRE
CONCORD
MT. WASHINGTON
NEW JERSEY
ATLANTIC CITY
SANDY HOOK
TRENTON
NEW MEXICO
ALBUQUERQUE
ROSWELL
SANTA FE
NEW YORK
ALBANY
BINGHAMTON
BUFFALO
CANTON
ITHACA
NEW YORK
OSWEGO
ROCHESTER
SYRACUSE

FIG. 7 (CONT'D.) SUNSHINE STATION NETWORK
PERIOD OF RECORD

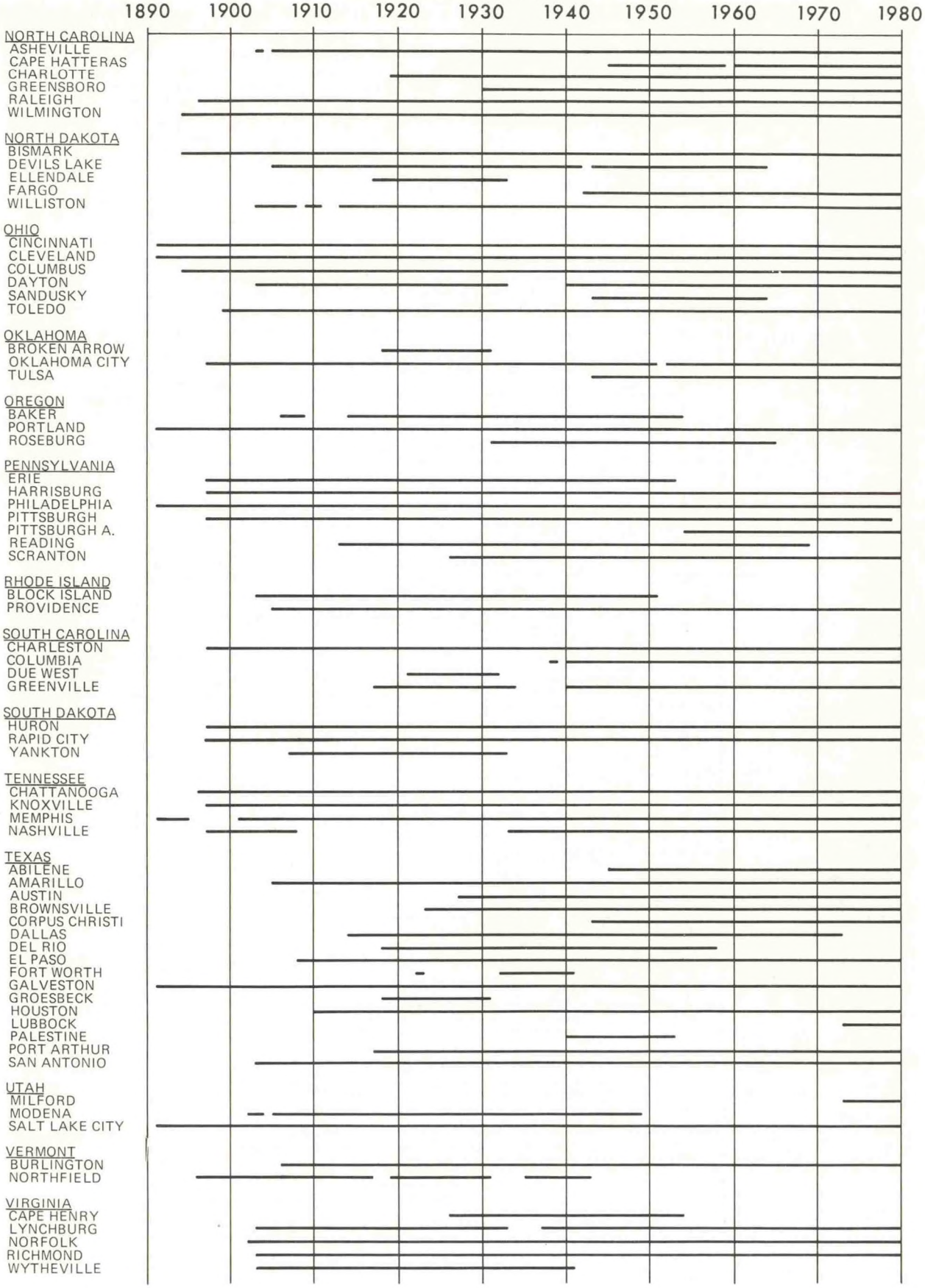
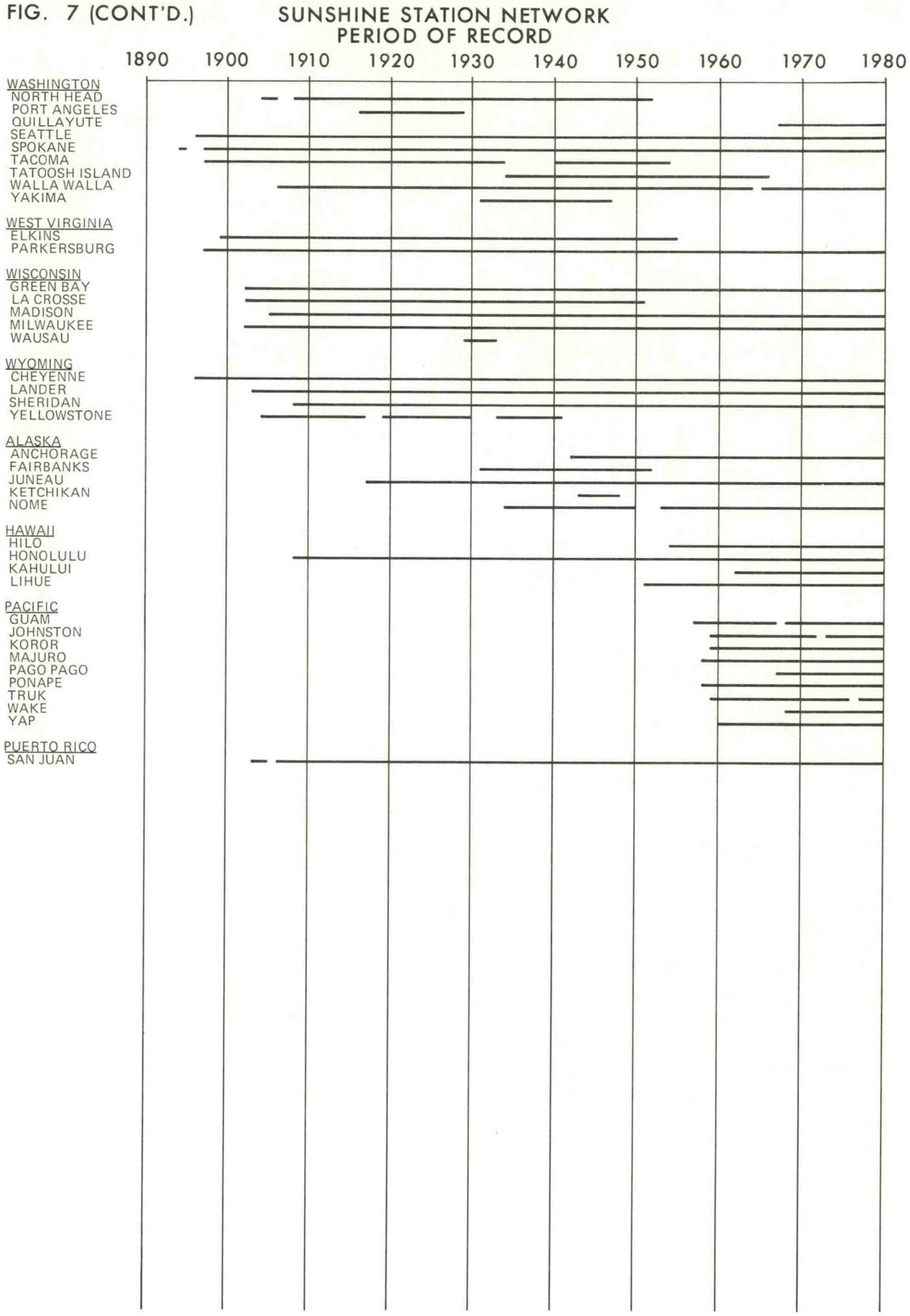
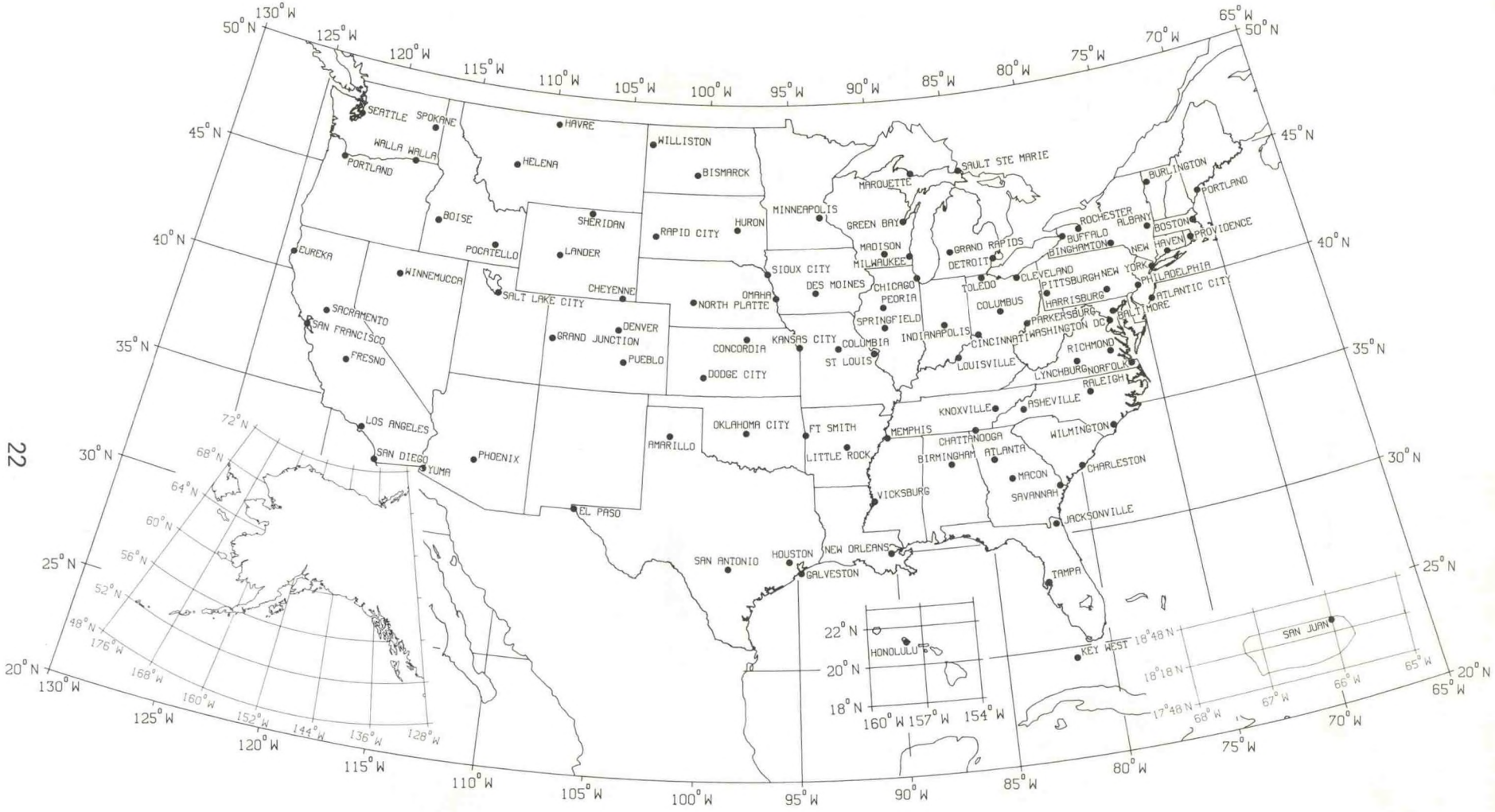


FIG. 7 (CONT'D.)

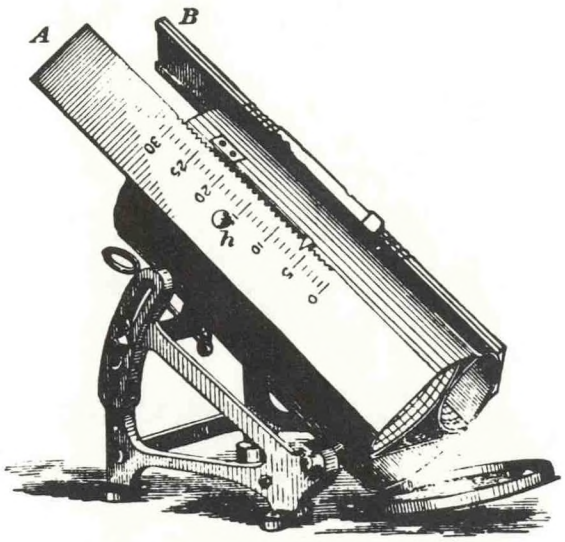

SUNSHINE STATION NETWORK
PERIOD OF RECORD
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
WASHINGTON
NORTH HEAD
PORT ANGELES
QUILLAYUTE
SEATTLE
SPOKANE
TACOMA
TATOOSH ISLAND
WALLA WALLA
YAKIMA
WEST VIRGINIA
ELKINS
PARKERSBURG
WISCONSIN
GREEN BAY
LA CROSSE
MADISON
MILWAUKEE
WAUSAU
WYOMING
CHEYENNE
LANDER
SHERIDAN
YELLOWSTONE
ALASKA
ANCHORAGE
FAIRBANKS
JUNEAU
KETCHIKAN
NOME
HAWAII
HILO
HONOLULU
KAHULUI
LIHUE
PACIFIC
GUAM
JOHNSTON
KOROR
MAJURO
PAGO PAGO
PONAPE
TRUK
WAKE
YAP
PUERTO RICO
SAN JUAN



Sunshine Station Network Period of Record ≥ 70 Years

FIG. 8

FIG. 9



Photographic Sunshine Recorder 1891 – 1907.

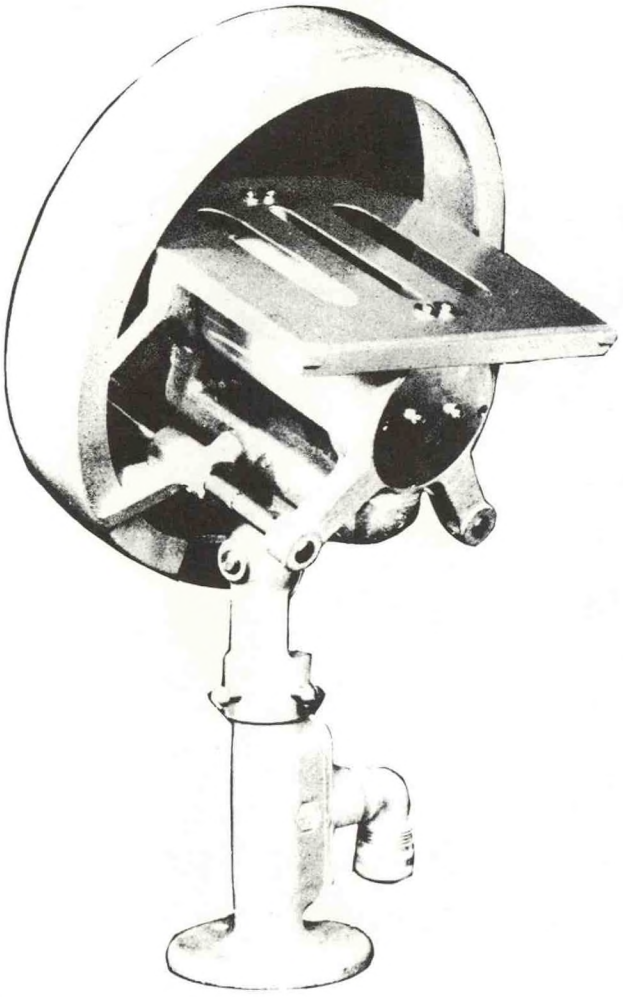
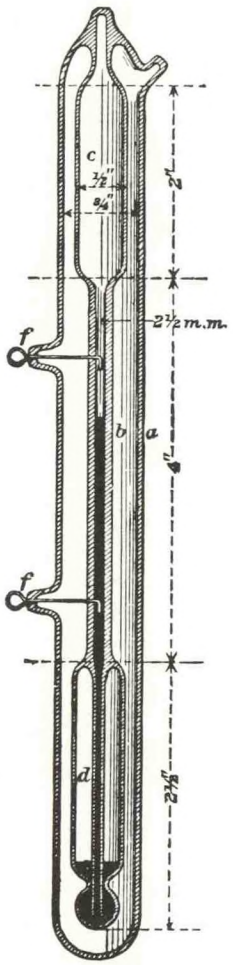
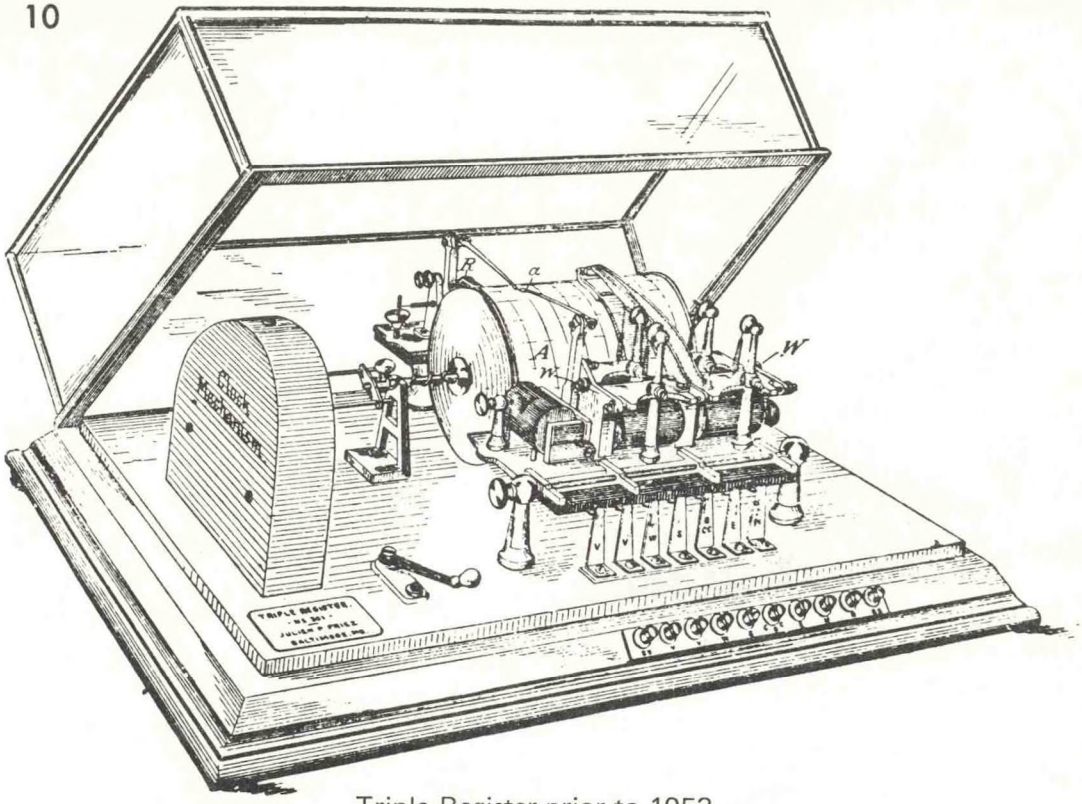


Photo Electric Sunshine Recorder 1953 to Present.

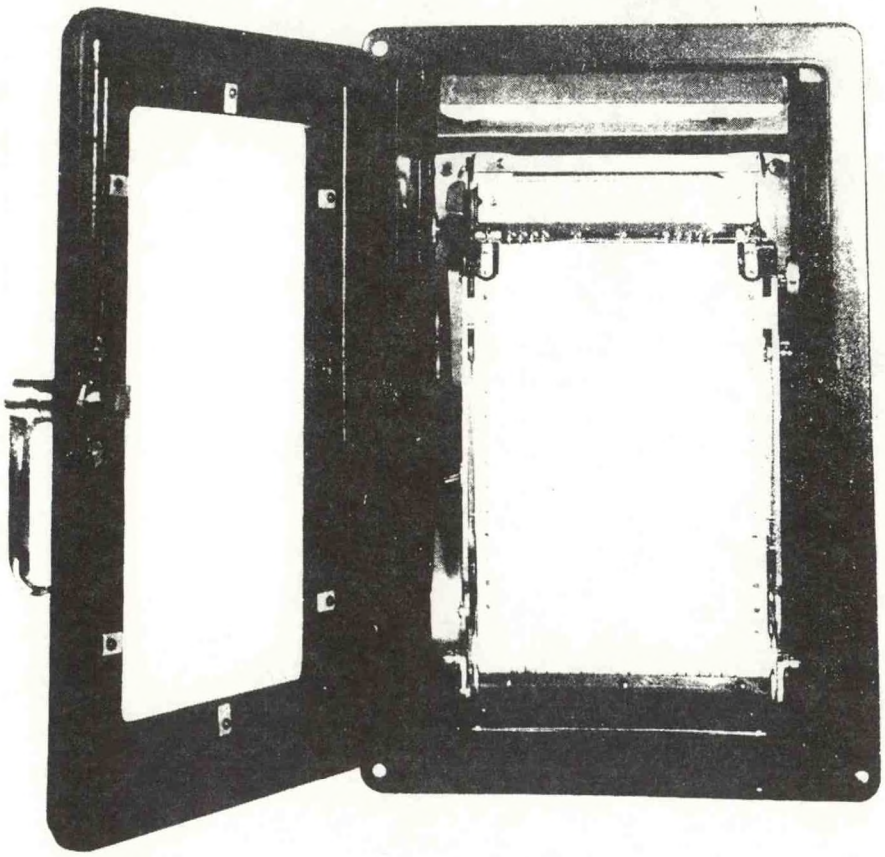


Thermometric Sunshine Recorder 1893 – 1952.

FIG. 10



Triple Register prior to 1953.



Triple Register 1953 to Present.

FIG. 11

STATION LOCATION

EL PASO, TEXAS

Location	Occupied from	Occupied to	Airline distance and direction from previous location	Latitude North	Longitude West	Elevation above Sea level	Elevation above Ground								Automatic Observing Equipment *	Remarks
						Ground at temperature site	Wind instruments	Extreme thermometers	Psychrometer	Sunshine Switch	Tipping bucket rain gage	Weighing rain gage	8" rain gage	Hygrothermometer		
CITY																
San Francisco Street between Santa Fe and El Paso Streets	11/06/77	8/12/80		31° 47'	106° 30'	3720	22	17	17				11			
One door east of above office	8/12/80	11/01/81	1 door E	31° 47'	106° 30'	3720	27									
Corner San Francisco and Santa Fe Streets	11/01/81	11/01/82	1/2 block W	31° 47'	106° 30'	3720	21	5	5				2			
State National Bank Building, 1 door W of SW corner San Antonio and Oregon Streets	11/01/82	4/01/88	700 ft. E	31° 47'	106° 30'	3720	37	21	21				34			Maximum temperature too high in early years, due to exposure of thermometers on northwest wall of building.
Sheldon Hotel, SW corner St. Louis (later Mills) and Oregon Streets	4/01/88	8/08/94	400 ft. NW	31° 47'	106° 30'	3720	80	68	68		62		62			
Government Building SE corner St. Louis and Oregon Streets	8/08/94	12/29/07	100 ft. NE	31° 47'	106° 30'	3720	110	10	10		2		2			Thermometer shelter and rain gages in San Jacinto Plaza.
El Paso & Southwestern Building, SE corner Stanton & Franklin Sts.	12/29/07	6/30/25	1100 ft.NNE	31° 47'	106° 30'	3731	133	111	110		102		102			
Mills Building, NW corner Oregon and Mills Streets	7/01/25	4/28/36	1100 ft.SSW	31° 47'	106° 30'	3720	175	153	152		145		145			
U. S. Court House, NE corner San Antonio and Kansas Streets	4/28/36	12/19/42	1500 ft. E	31° 47'	106° 30'	3711	101	82	82		75		75			
AIRPORT																
American Airlines Adm. Building, Municipal AP	11/20/31	12/14/42		31° 48'	106° 24'	3913	54	6	6			3	3			
Administration Building International Airport (formerly Municipal AP)	12/14/42	4/01/64	2000 ft. E	31° 48'	106° 24'	a3918	b20	c32	c31		29	30	29	d5		Ground exposure for temperature and precipitation instruments to 5/17/44.
FAA-WB Building International Airport	4/01/64	Present	.3 mi. SE	31° 48'	106° 24'	3918	f20 h32	NA	27	%27	25	26	25	f5 h5	NA	

* Type
M = AMOS
T = AUTOB

a - 3920 feet to 9/1/60.
b - 85 feet to 5/1/61.
c - 37 feet 5/17/44 to 4/23/59.
d - Commissioned 4000 feet N of thermometer site 9/1/60.
f - Not moved.
h - Moved 1.6 miles West 9/20/78.
% - Commissioned 4/10/78.

Subscription Price: $3.30 per year for monthly data and annual summary. Foreign mailing $1.95 extra. Single copy: 25 cents for monthly and 30 cents for annual issue. There is a minimum charge of $3.00 for each order of shelf-stocked issues of publications. Make checks payable to Department of Commerce, NOAA. Send payments, orders, and inquiries to Publications, National Climatic Center, Federal Building, Asheville, N. C. 28801.

I certify that this is an official publication of the National Oceanic and Atmospheric Administration, and is compiled from records on file at the National Climatic Center, Asheville, North Carolina 28801.

Daniel B. Mitchell
Director, National Climatic Center

USCOMM-NOAA-ASHEVILLE - 1225

FIG. 12

LIST OF OBSERVING STATIONS.

The following table contains the geographical coordinates of the several stations whose summaries are published in Part III, the height of the barometer cistern above mean sea level, and of other instruments above ground, the difference between local and standard time, and the date on which observations began. The standard time used by the Weather Bureau in all of its synchronous work is that of the seventy-fifth meridian (Eastern time), which standard is always understood unless otherwise expressed.

The elevations given are for January 1, 1895, except at stations established subsequent to that date. (See Table II.) Elevations preceded by the letter "B" have been determined by the barometer; all others are the results of precise levels. Changes made during 1895 are given in the second or third set of figures, as the case may be.

The significance of the bold-face letter or letters following the name of station is as follows:

P=continuous records of pressure (on December 31, 1895);

T=continuous records of temperature (on December 31, 1895);

W=continuous records of wind (direction and velocity) (on December 31, 1895);

V=continuous records of wind (velocity only) (on December 31, 1895);

R=continuous records of rainfall (on December 31, 1895);

S=continuous records of sunshine (on December 31, 1895).

Stations having no letter make an observation of temperature, precipitation, direction of the wind, and the state of the weather daily at 8 p. m.

TABLE I.—LATITUDE, LONGITUDE, ELEVATION, ETC., OF WEATHER BUREAU STATIONS.

Stations.	Latitude.	Longitude.	Local meridian time faster or slower than 75th meridian.	Elevation December 31, 1895.				Observations began.	Date of changes in elevation.
				Barometer above sea.	Thermometer above ground.	Rain gauge above ground.	Anemometer above ground.		
	° ′	° ′	*h.* *m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
Abilene, **P T W**	32 23	99 40	1 39 S.	1,749	47	36	54	Sept. 14, 1885	
Albany, **P T W**	42 39	73 45	05 F.	85	84	99	113	Dec. 22, 1873	
Alpena, **P T W**	45 05	83 30	34 S.	609	61	54	65	Sept. 10, 1872	
Amarillo, **T V**	35 13	101 50	1 47 S.	3,691	53	46	61	Jan. 1, 1892	
Astoria	46 57	124 00	3 15 S.	41	39	56	60	Nov. 1, 1883	
Atlanta, **P T W R**	33 45	84 23	37 S.	1,131	92	85	126	Sept. 25, 1878	
Augusta, **P T W**	33 28	81 54	27 S.	*a* 180	89	54	103	Nov. 2, 1870	
Baker City, **T V**	44 50	117 50	2 51 S.	3,430	49	38	53	July 9, 1889	
Baltimore, **P T W R S**	39 18	76 37	06 S.	179	87	80	100	Jan. 1, 1871	
				142	120	116	136	.....	Sept. 7.
Bismarck, **P T W R**	46 47	100 38	1 42 S.	1,681	16	3	29	Sept. 15, 1874	
Block Island, **V**	41 10	71 36	14 F.	27	39	3	48	Sept. 1, 1880	
Boston, **P T W R S**	42 21	71 04	16 F.	125	115	154	181	Nov. 1, 1870	
Buffalo, **P T W R S**	42 53	78 53	15 S.	690	103	93	108	.....do.....	
Cairo, **V**	37 00	89 10	56 S.	359	87	78	93	June 1, 1871	
Canby, Fort, **V**	46 16	124 04	3 16 S.	179	10	2	34	Sept. 1, 1883	

a Redetermined.

FIG. 13

Time Series of Annual Sunshine Data

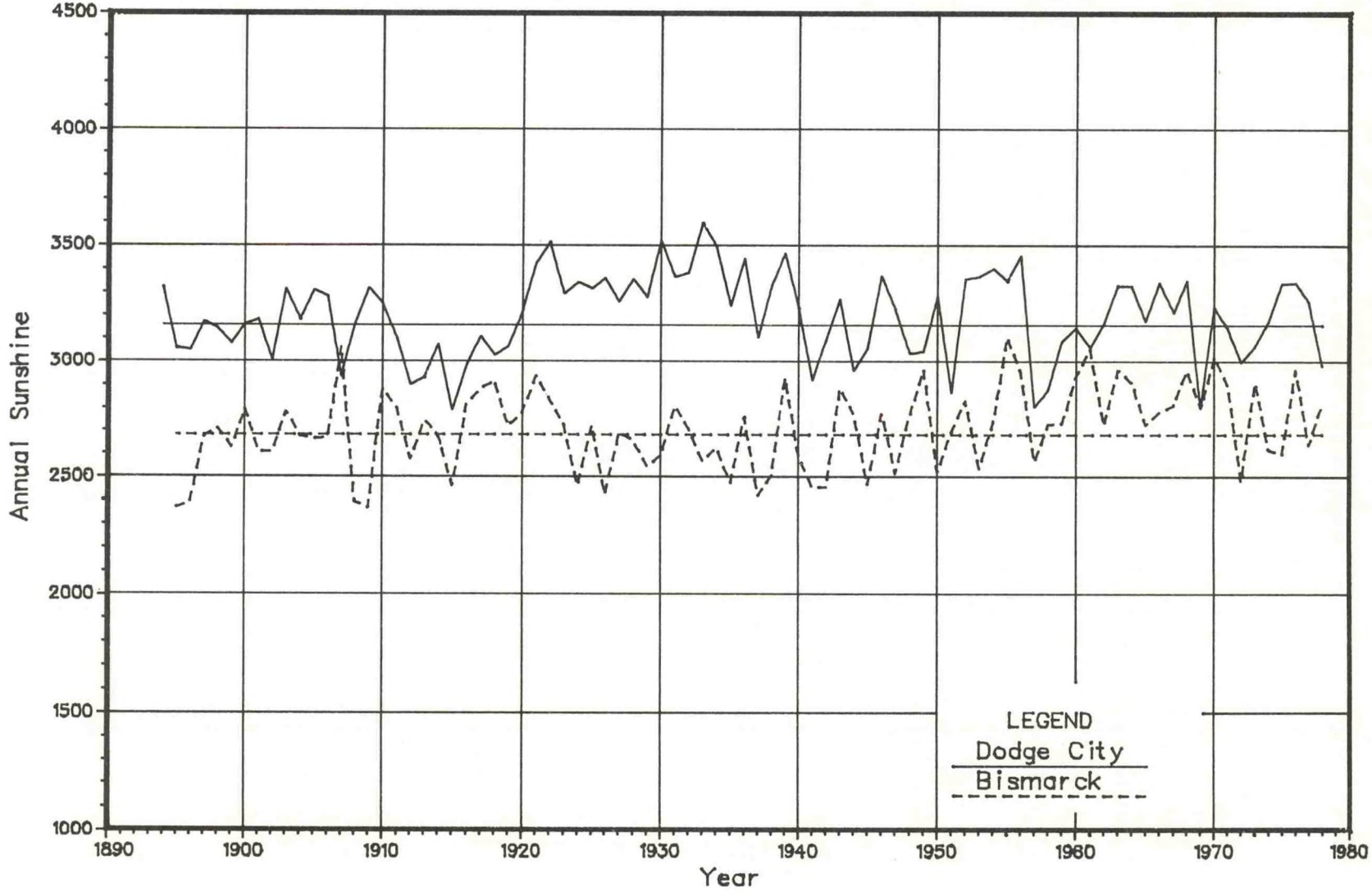


FIG. 13 (Con't) Time Series of Annual Sunshine Data

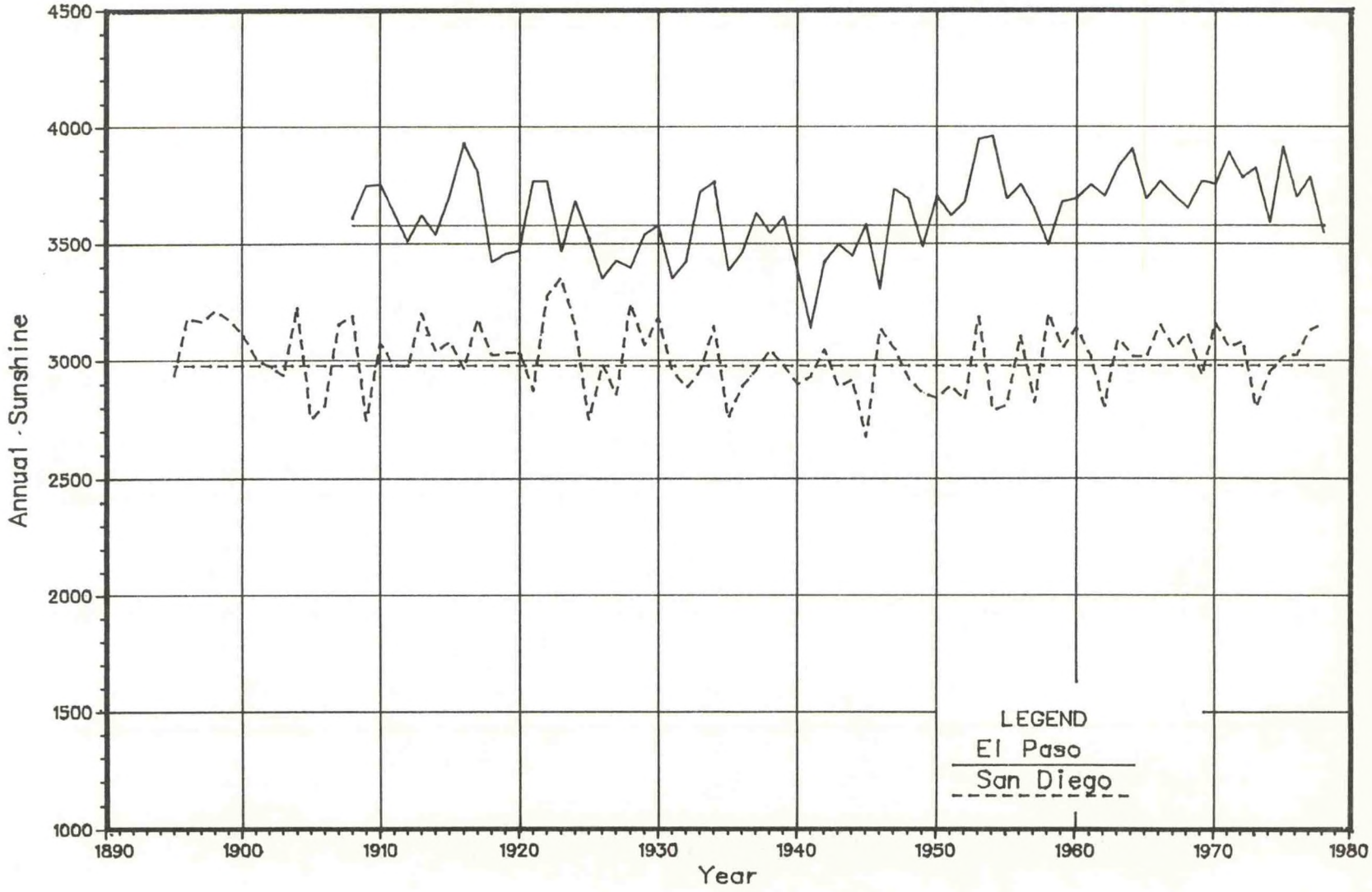


FIG. 13 (Con't) Time Series of Annual Sunshine Data

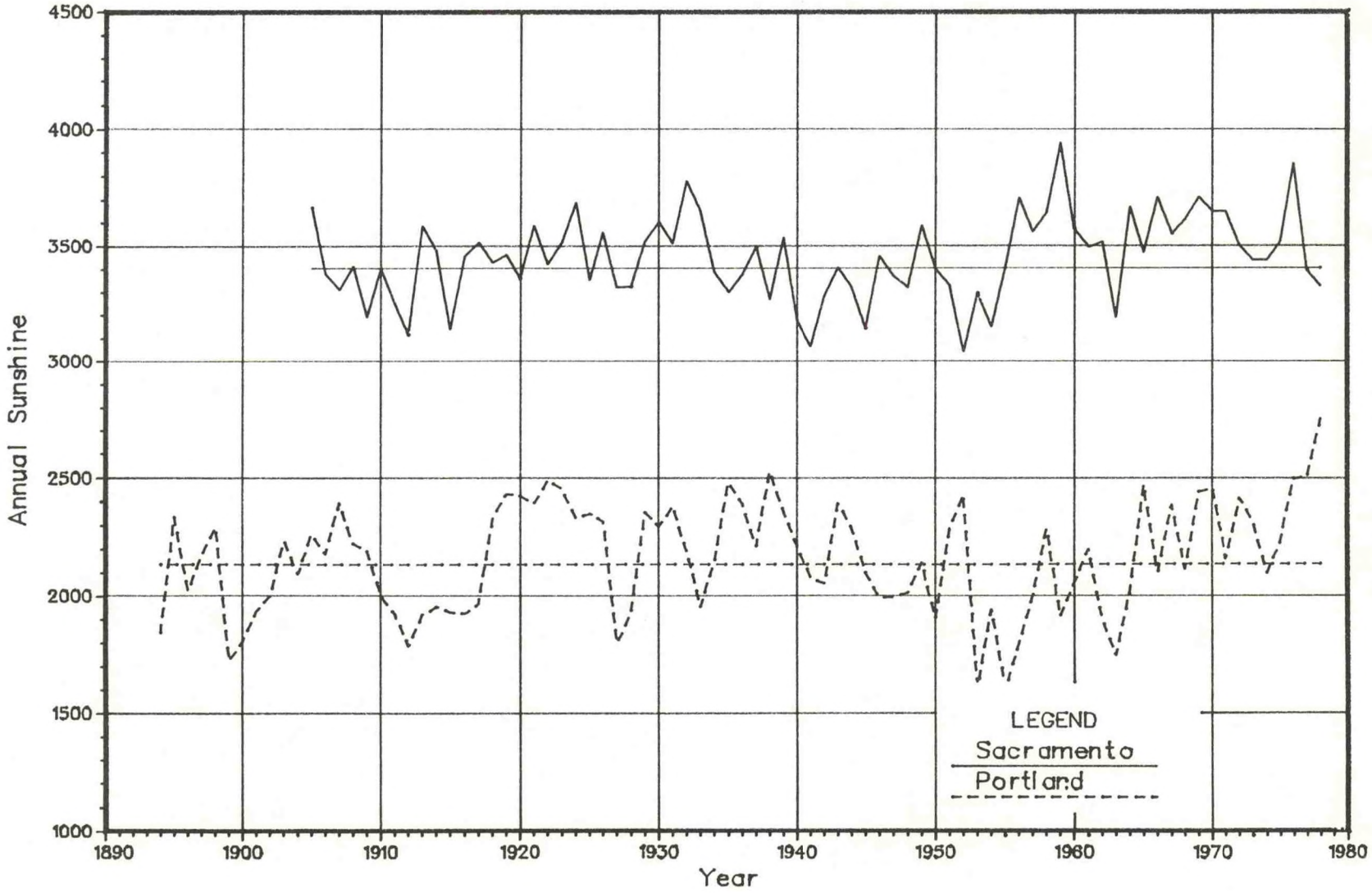
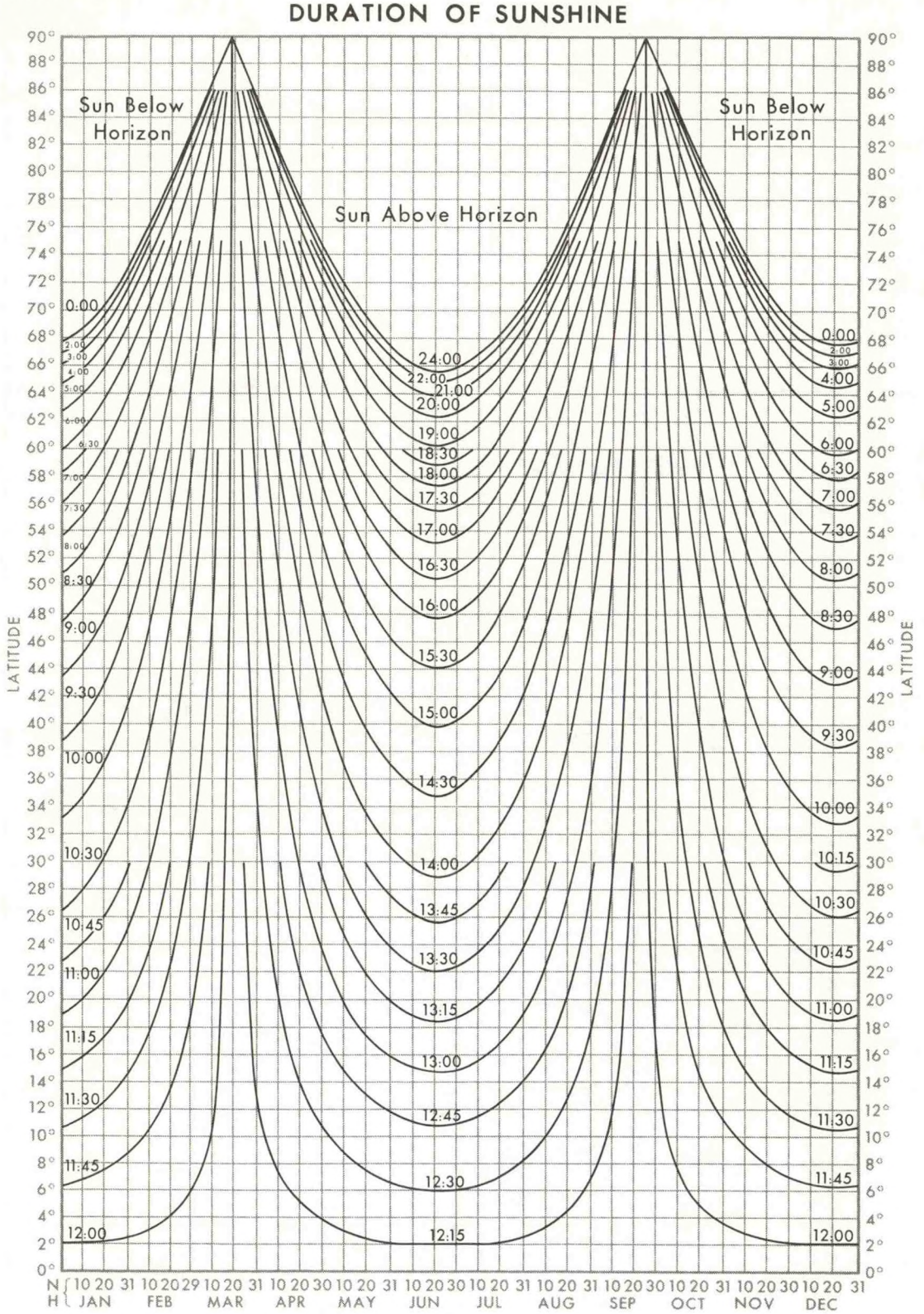


FIG. 14


DURATION OF SUNSHINE
Sun Below Horizon
Sun Above Horizon
Sun Below Horizon
LATITUDE
LATITUDE
90° 88° 86° 84° 82° 80° 78° 76° 74° 72° 70° 68° 66° 64° 62° 60° 58° 56° 54° 52° 50° 48° 46° 44° 42° 40° 38° 36° 34° 32° 30° 28° 26° 24° 22° 20° 18° 16° 14° 12° 10° 8° 6° 4° 2° 0°
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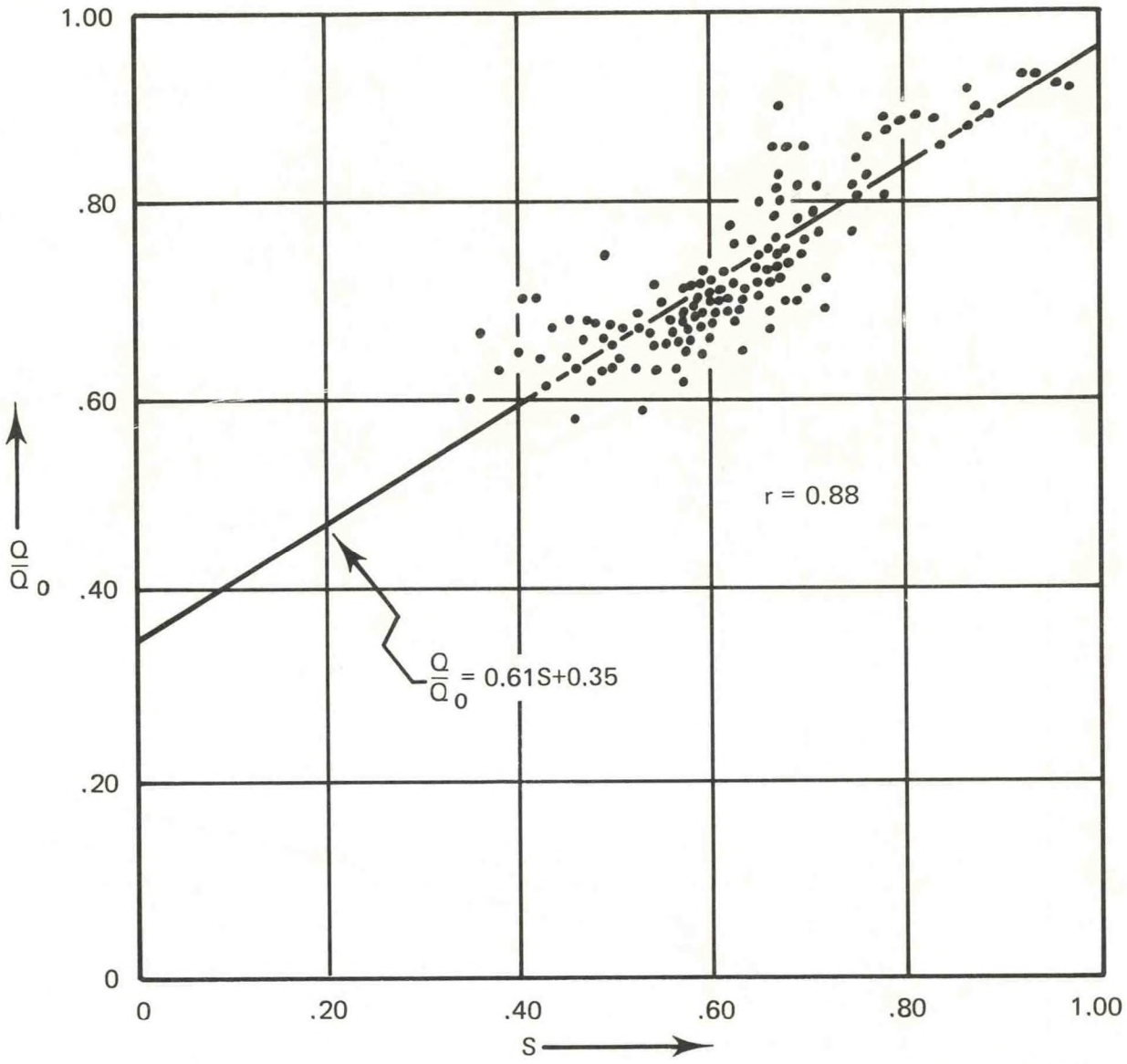
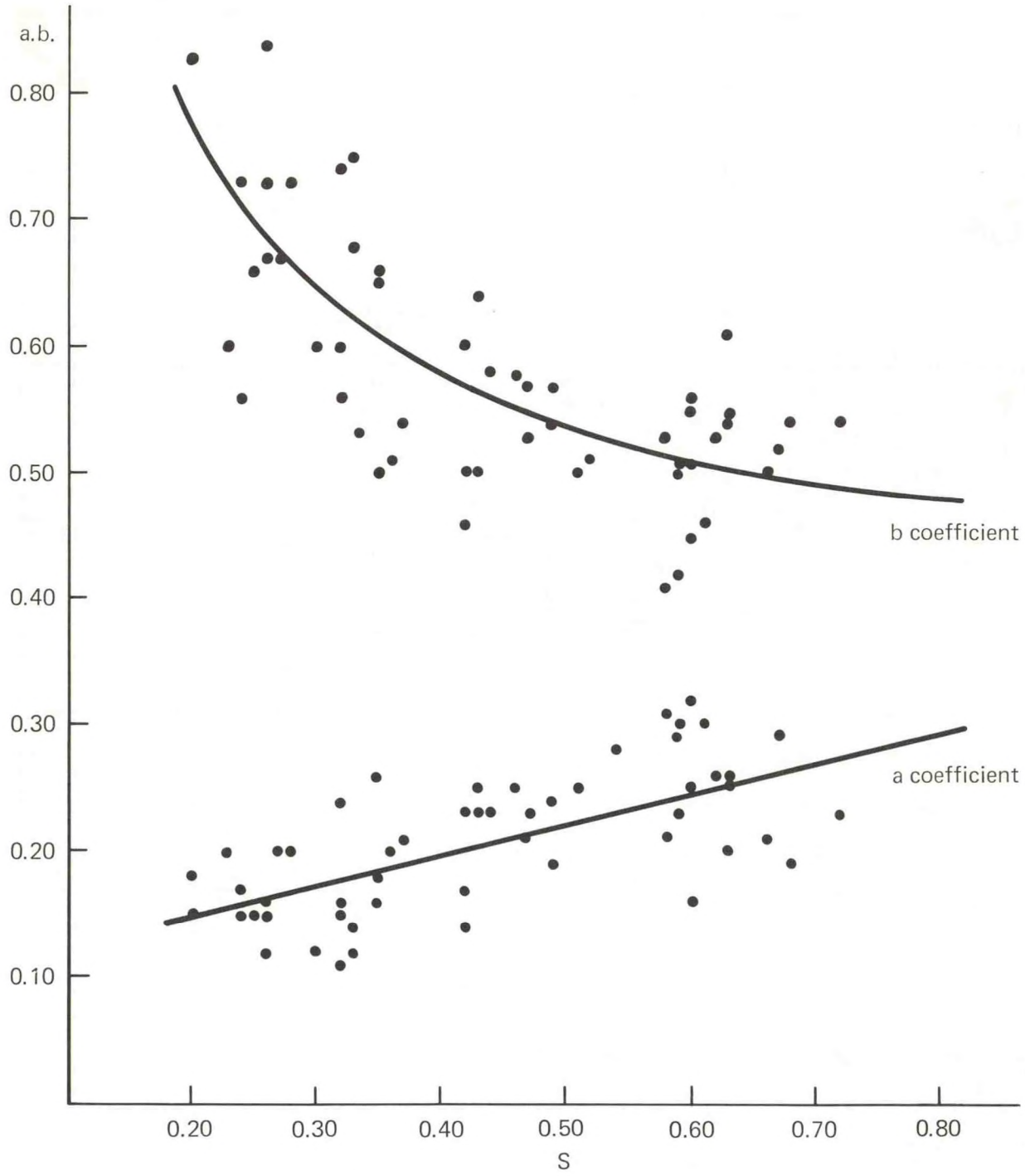
N H
10 20 31 JAN
10 20 29 FEB
10 20 31 MAR
10 20 30 APR
10 20 31 MAY
10 20 30 JUN
10 20 31 JUL
10 20 31 AUG
10 20 30 SEP
10 20 31 OCT
10 20 30 NOV
10 20 31 DEC

FIG. 15



Relation between average sunshine and solar radiation on a horizontal surface
(Smithsonian meteorological tables)

FIG. 16



Dependence of the *a* and *b* coefficients on the relative sunshine duration (after Rietveld, 1978)

TABLE 1 LOCATION OF SUNSHINE RECORDING STATIONS WHICH CLOSED PRIOR TO 1949

STATION	STATE	WBAN #	LAT	LONG	STATION ELEV (FT)	LOCATION	FROM:	TO:	REMARKS
ANNISTON	AL	13871	33 39N	85 50W	724	Weather Bureau Building 720 Quintard Avenue	1/1914	12/1930	
BENTONVILLE	AR	93925	36 22N	94 12W	1303	Exact location unknown	3/1906	12/1920	No station history
INDEPENDENCE	CA	93164	36 48N	118 12W	3921	Given House Jackson Street	6/1918	6/1923	
"	"	"	"	"	3939	Austin House 123 Market Street	7/1923	11/1924	
MT. TAMALPAIS	CA	23262	37 56N	122 35W	2375	Weather Bureau Building	1/1899	12/1920	or 2.3 miles NW of Mill Valley P.O.
SAN JOSE	CA	23293	37 20N	121 53W	95	In park, front of City Hall	1/1908	12/1939	
SAN LUIS OBISPO	CA	93206	35 17N	120 40W	193	Crocker Building, Corner Hisuera and Garden Streets	7/1904	6/1914	
" " "	"	"	"	"	194	1131 Chorro Street adjacent to Raekliff House	7/1914	12/1926	
DURANGO	CO	93004	37 16N	107 53W	6546	683 4th Avenue	1/1905	12/1913	
JUPITER	FL	None	26 57N	80 07W	28	Exact location unknown	10/1899	12/1910	Data not digitized No station history
CHICAGO UNIV.	IL	14892	41 47N	87 35W	594	Rosenwald Hall, 58th Street & University Ave.	1/1919	12/1939	Missing years 1934, 1935
ROYAL CENTER	IN	94881	40 53N	86 29W	736	Exact location unknown	4/1918	12/1931	No station history
DAVENPORT	IA	14932	41 31N	90 34W	579	131 East 4th Street New Post Office Building	1/1933	12/1942	Records moved to Moline 1/1/1943

TABLE 1 (Con't) LOCATION OF SUNSHINE RECORDING STATIONS WHICH CLOSED PRIOR TO 1949

STATION	STATE	WBAN #	LAT	LONG	STATION ELEV (FT)	LOCATION	FROM:	TO:	REMARKS
KEOKUK	IA	14969	40 22N	91 26W	574	Federal Building	1/1921	12/1941	Missing years 1922, 1929
GRAND HAVEN	MT	94879	43 05N	86 13W	632	Exact location unknown no station history folder	1/1902	12/1932	July 1902 missing; missing years 1903-06
LUDINGTON	MI	94816	43 57N	86 27W	637	Exact location unknown	1/1913	12/1932	No station history
PORT HURON	MI	94880	43 00N	82 26W	638	Exact location unknown	1/1903	12/1932	No station history
SAGINAW	MI	14845	43 26N	83 57W	637	Arthur Hill Trade School Michigan Ave. & Mackinaw St.	1/1913	7/1919	
"	"	"	"	"	"	Miller Building, corner of Court & Hamilton St.	8/1919	6/1925	
ST. PAUL	MN	14927	44 57N	93 05W	758	Chamber of Commerce Bldg.	1/1897	6/1904	(All buildings down-town St. Paul - longest move: 1,600 ft)
" "	"	"	"	"	"	Pioneer Building	7/1904	6/1918	" " "
" "	"	"	"	"	"	Merchants National Bank Building	7/1918	3/1931	" " "
" "	"	"	"	"	787	Hamm Building	4/1931	12/1932	" " "
DREXEL	NB	94941	41 20N	96 16W	1299	Exact location unknown	6/1915	12/1925	No station history
TONOPAH	NV	23153	38 04N	117 14W	6101	Richards Cottage 0.7 mile West of P.O.	1/1908	12/1923	
SANDY HOOK	NJ	94739	40 28N	74 01W	15	Weather Bureau Building near extreme end of Hook	1/1915	12/1939	

TABLE 1 (Con't) LOCATION OF SUNSHINE RECORDING STATIONS WHICH CLOSED PRIOR TO 1949

STATION	STATE	WBAN #	LAT	LONG	STATION ELEV (FT)	LOCATION	FROM:	TO:	REMARKS
SANTA FE	NM	23049	35 41N	105 57W	7013	Exact location unknown	1/1891	12/1940	No station history
ITHACA	NY	94761	42 27N	76 29W	836	Lincoln Hall Cornell University	1/1900	12/1942	Missing years 1/1903-12/1927
BROKEN ARROW	OK	03955	36 02N	95 49W	765	Exact location unknown	6/1918	12/1930	No station history
DUE WEST	SC	93871	34 21N	82 22W	711	Exact location unknown	1/1921	12/1931	No station history
YAULTON	SD	94911	42 52N	97 24W	1231	Post Office Building 4th & Walnut	10/1897	12/2932	
GROESBECK	TX	13924	31 30N	96 28W	461	Exact location unknown	7/1918	12/1930	No station history
MODENA	UT	23117	37 48N	113 54W	5460	1000 ft. West of Union Pacific Depot	5/1902	1/1948	
NORTHFIELD	VT	04721	44 08N	72 40W	840	Weather Bureau Building Central Street	2/1896	12/1942	Missing years 1917, 1918, 1930-1934
WYTHEVILLE	VA	03806	36 56N	91 05W	2304	Exact location unknown	1/1903	12/1940	No station history
PORT ANGELES	WA	24228	48 06N	123 25W	29	Weather Bureau Building 1st & Laurel Streets	6/1916	12/1928	
WAUSAU	WI	14897	44 57N	89 35W	1247	Exact location unknown	1/1929	12/1932	No station history
YELLOWSTONE	WY	24169	44 58N	110 42W	6200	Exact location unknown	1/1904	12/1940	No station history Missing years 1917, 1918, 1930-1932
KETCHIKAN	AK	25325	55 21N	131 39W	15	Federal Building	1/1943	12/1947	

TABLE 2

SUNSHINE STATION NETWORK (1979)
TOTAL POSSIBLE SUNSHINE IN HOURS & TENTHS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ALABAMA													
BIRMINGHAM	316.6	307.7	371.4	390.8	430.9	430.3	438.0	414.5	371.3	351.6	313.1	309.1	4445.5
MONTGOMERY	319.5	309.1	371.6	389.4	428.2	427.0	435.0	412.6	370.9	352.7	315.6	312.3	4443.9
ARIZONA													
FLAGSTAFF	313.1	305.8	371.1	392.3	434.3	434.5	442.0	416.9	371.9	350.3	310.2	305.0	4447.4
PHOENIX	317.0	307.8	371.4	390.5	430.6	429.9	437.8	414.4	371.4	351.8	313.5	309.4	4445.5
TUCSON	319.8	309.3	371.5	389.1	427.8	426.6	434.7	412.4	370.9	352.9	315.9	312.7	4443.7
YUMA	318.8	308.8	371.6	389.7	429.0	427.7	435.9	413.1	371.0	352.4	314.8	311.4	4444.3
ARKANSAS													
FORT SMITH	312.5	305.6	371.1	392.6	434.9	435.0	442.5	417.2	372.0	350.0	309.8	304.5	4447.6
LITTLE ROCK	314.0	306.3	371.2	391.9	433.4	433.5	441.0	416.4	371.7	350.6	310.9	306.1	4446.8
CALIFORNIA													
EUREKA	298.7	298.4	370.5	399.3	448.4	451.6	457.8	426.6	373.8	344.5	297.8	288.5	4455.8
FRESNO	309.1	303.8	371.1	394.3	438.2	439.2	446.2	419.4	372.4	348.6	306.7	300.5	4449.4
RED BLUFF	300.4	299.3	370.7	398.4	480.0	449.4	455.7	425.3	373.6	345.2	299.3	290.5	4487.8
SACRAMENTO	304.7	301.5	370.9	396.5	442.6	444.4	451.2	422.6	373.0	346.8	302.8	295.3	4452.1
SAN DIEGO	319.6	308.7	371.6	389.9	429.1	428.2	436.0	413.2	371.0	352.3	314.7	311.2	4444.4
COLORADO													
DENVER	301.5	299.7	370.6	397.9	445.5	448.2	454.6	424.7	373.6	345.7	300.3	291.8	4454.0
PUEBLO	305.4	301.7	370.8	395.9	441.8	443.6	450.4	422.2	373.0	347.2	303.6	296.2	4451.7
CONNECTICUT													
HARTFORD	295.4	296.7	370.3	400.7	451.5	455.4	461.4	428.7	374.4	343.3	295.1	284.8	4457.8
DIST./COL.													
WASHINGTON	303.9	301.0	370.8	396.7	443.2	445.4	452.0	423.0	373.2	346.7	302.4	294.5	4453.7
FLORIDA													
APPALACHICOLA	325.1	312.1	371.9	386.8	423.0	420.7	429.1	409.0	370.1	354.9	320.2	318.5	4441.3
JACKSONVILLE	323.5	311.2	371.8	387.5	424.3	422.4	430.7	409.9	370.3	354.3	319.0	316.9	4441.1
KEY WEST	335.2	317.4	372.7	382.0	413.3	409.0	418.2	402.1	368.7	358.9	328.9	330.0	4436.7
MIAMI	332.8	316.2	372.5	383.1	415.5	411.6	420.7	403.6	369.0	358.0	326.8	327.4	4437.2
TAMPA	328.6	313.9	372.1	385.0	419.6	416.6	425.2	406.5	369.6	356.3	323.2	322.6	4439.4
GEORGIA													
ATLANTA	316.5	307.5	371.4	390.7	431.1	430.5	438.2	414.6	371.4	351.6	313.0	308.8	4445.4
MACON	318.6	308.7	371.5	389.8	429.1	428.0	435.9	413.3	371.0	352.4	314.8	311.3	4444.5
SAVANNAH	319.9	309.3	371.6	389.2	427.9	426.6	434.6	412.3	370.9	352.9	315.8	312.7	4443.7
IDAHO													
BOISE	290.6	294.2	370.1	403.1	456.2	461.2	466.6	432.0	375.1	341.4	291.0	279.2	4460.7
POCATELLO	292.5	295.2	370.2	402.1	454.2	458.8	464.5	430.7	374.8	342.2	292.6	281.4	4459.2
ILLINOIS													
CAIRO	308.6	303.5	371.0	394.5	438.7	439.8	480.2	420.0	372.5	348.5	306.3	299.9	4483.5
CHICAGO	296.0	296.9	370.3	400.4	450.8	454.7	460.7	428.4	374.4	343.7	295.6	285.5	4456.5
MOLINE	296.8	297.3	370.3	400.0	450.1	453.7	459.8	427.9	374.3	343.9	296.3	286.3	4456.7
PEORIA	299.0	298.5	370.5	399.0	448.0	451.2	457.4	426.3	373.9	344.8	298.2	288.9	4455.6
SPRINGFIELD	301.3	299.7	370.5	398.1	445.8	448.4	454.9	424.9	373.5	345.7	300.1	291.5	4454.4
INDIANA													
EVANSVILLE	305.9	302.1	370.8	395.8	441.2	442.9	449.8	421.8	372.9	347.6	304.0	296.8	4451.3
FORT WAYNE	298.1	298.0	370.4	399.5	448.8	452.3	458.4	427.0	374.0	344.4	297.4	287.5	4456.0
INDIANAPOLIS	301.6	299.9	372.3	397.9	445.5	448.1	454.6	424.7	373.6	345.7	300.3	291.7	4455.9
IOWA													
DES MOINES	296.5	297.1	370.3	400.3	450.5	454.2	460.2	428.1	374.4	343.8	296.0	286.0	4457.2
SIOUX CITY	294.0	295.9	370.1	401.3	452.8	457.0	462.9	429.7	374.7	342.9	294.0	283.3	4458.6
KANSAS													
CONCORDIA	302.0	299.9	370.5	397.5	445.0	447.6	454.1	424.4	373.5	346.1	300.7	292.4	4453.5
DODGE CITY	306.7	302.4	370.8	395.3	440.5	442.1	449.0	421.3	372.9	347.7	304.8	297.7	4451.1
TOPEKA	303.3	300.6	370.6	397.0	443.8	446.0	452.6	423.5	373.0	346.4	301.9	293.9	4452.7
WICHITA	307.0	302.6	370.8	395.2	440.2	441.7	448.7	421.0	372.8	347.9	304.9	298.0	4450.9
KENTUCKY													
LOUISVILLE	305.6	302.0	370.8	395.9	441.6	443.3	450.2	422.0	373.0	347.4	303.8	296.5	4452.0
LOUISIANA													
NEW ORLEANS	325.0	311.7	371.9	387.0	423.4	421.5	429.6	409.3	370.2	354.7	319.8	318.0	4442.1
SHREVEPORT	319.1	309.0	371.5	389.5	428.6	427.4	435.4	412.9	371.0	352.6	315.2	311.9	4444.1

TABLE 2 (Con't)

SUNSHINE STATION NETWORK (1979)
TOTAL POSSIBLE SUNSHINE IN HOURS & TENTHS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MAINE													
PORTLAND	290.3	294.1	370.1	403.2	456.4	461.5	466.9	432.2	375.1	341.4	290.9	278.8	4461.1
MARYLAND													
BALTIMORE	303.1	300.6	370.6	397.2	444.0	446.4	453.0	423.7	373.3	346.3	301.6	293.5	4453.2
MASSACHUSETTS													
BLUE HILL	294.2	296.0	370.3	401.4	452.7	456.8	462.7	429.6	374.6	342.9	294.1	283.4	4458.7
BOSTON	294.2	296.0	370.3	401.4	452.7	456.8	462.7	429.6	374.6	342.9	294.1	283.4	4458.7
MICHIGAN													
ALPENA	285.8	291.7	369.8	405.2	460.7	466.9	472.0	435.2	375.8	339.7	287.0	273.8	4463.6
DETROIT	294.7	296.2	370.2	401.1	452.1	456.4	462.2	429.4	374.6	343.0	294.4	283.8	4458.1
GRAND RAPIDS	292.6	295.2	370.1	402.0	454.2	458.8	464.5	430.8	374.9	342.3	292.8	281.5	4459.5
LANSING	293.0	295.4	370.1	401.8	453.6	458.2	463.9	430.4	374.8	342.5	293.1	282.1	4459.0
MARQUETTE	280.7	289.1	369.5	407.6	465.7	473.0	477.6	438.6	376.6	337.9	282.9	267.9	4467.1
SAULT STE MARIE	294.0	295.9	370.1	401.3	452.8	457.0	462.9	429.7	374.7	342.9	294.0	283.3	4458.6
MINNESOTA													
DULUTH	279.8	288.7	369.5	408.0	466.4	294.7	478.7	439.3	376.7	337.5	282.0	266.9	4288.2
MINNEAPOLIS	286.0	291.8	369.8	405.1	460.5	466.6	471.7	435.1	375.8	339.9	287.4	274.1	4463.7
MISSISSIPPI													
JACKSON	319.4	309.1	371.6	389.3	428.3	427.2	435.1	412.7	371.0	352.8	315.5	312.2	4444.2
MISSOURI													
COLUMBIA	303.9	301.1	370.8	396.7	443.1	445.3	451.9	423.0	373.2	346.7	302.4	294.6	4452.5
KANSAS CITY	303.2	300.6	370.6	397.0	443.9	446.1	452.8	423.6	373.3	346.3	301.7	293.8	4452.9
ST. LOUIS	304.4	301.2	370.8	396.5	442.7	444.6	451.4	422.7	373.1	346.8	302.8	295.1	4452.1
SPRINGFIELD	308.0	303.1	370.9	394.8	439.2	440.5	447.5	420.3	372.6	348.2	305.7	299.2	4450.0
MONTANA													
BILLINGS	283.2	290.4	369.6	406.3	463.0	469.8	474.8	436.9	376.3	338.9	285.1	271.0	4465.3
GREAT FALLS	277.5	287.5	369.3	409.0	468.6	477.0	481.3	440.9	377.2	336.8	280.2	264.2	4469.4
HAVRE	273.5	285.4	369.0	410.8	472.6	481.8	485.8	443.5	377.8	335.2	276.8	259.6	4471.1
HELENA	280.7	289.2	369.6	407.7	465.8	473.1	477.7	438.6	376.5	337.7	282.7	267.8	4467.8
MISSOULA	279.6	288.7	369.5	408.2	466.8	474.5	478.9	439.3	376.8	337.3	281.7	266.6	4468.1
NEBRASKA													
LINCOLN	298.6	298.3	370.4	399.2	448.3	451.6	457.9	426.8	374.0	344.6	297.4	288.4	4455.9
NORTH PLATTE	297.6	297.7	370.3	399.6	449.2	452.6	458.9	427.2	374.1	344.4	297.1	287.4	4456.1
OMAHA	297.2	297.6	370.3	399.8	449.7	453.2	459.4	427.8	374.1	344.1	296.7	286.8	4456.6
VALENTINE	292.7	295.2	370.1	401.9	454.0	458.6	464.4	430.5	374.9	342.4	292.9	281.7	4459.2
NEVADA													
ELY	302.8	300.5	370.7	397.4	444.3	446.7	452.7	423.8	373.3	346.1	301.2	293.1	4453.1
LAS VEGAS	310.9	304.7	371.2	393.5	436.6	437.2	444.4	418.4	372.1	349.3	308.2	302.4	4448.7
RENO	302.1	300.2	370.8	397.7	445.0	447.4	453.9	424.2	373.4	345.8	300.8	292.5	4453.8
WINNEMUCCA	298.4	298.2	370.5	399.4	448.7	451.9	458.0	426.7	374.0	344.4	297.6	288.1	4455.9
NEW HAMPSHIRE													
CONCORD	291.7	294.8	370.1	402.5	455.1	459.9	465.4	431.3	374.9	341.9	291.9	280.5	4460.0
MT. WASHINGTON	294.3	298.4	376.1	410.1	464.6	469.9	475.5	440.0	381.4	346.8	294.9	282.8	4534.8
NEW JERSEY													
ATLANTIC CITY	302.5	300.3	370.5	397.3	444.6	447.0	453.5	424.0	373.3	346.1	301.1	293.0	4453.2
TRENTON	300.2	299.2	370.6	398.5	446.8	449.7	456.0	425.5	373.7	345.2	299.2	290.3	4454.9
NEW MEXICO													
ALBUQUERQUE	313.3	305.8	371.2	392.2	434.1	434.2	441.7	416.9	371.9	350.4	310.3	305.3	4447.3
ROSWELL	317.1	307.9	371.4	390.5	430.5	429.9	437.7	414.3	371.3	351.8	313.5	309.5	4445.3
NEW YORK													
ALBANY	293.3	295.6	370.2	401.7	453.5	458.0	463.7	430.2	374.7	342.5	293.3	282.4	4458.9
BINGHAMTON	294.5	296.2	370.2	401.1	452.3	456.3	462.3	429.3	374.5	343.0	294.4	283.8	4458.0
BUFFALO	292.5	295.1	370.2	402.1	454.3	459.0	464.7	430.7	374.9	342.2	292.7	281.4	4459.7
ROCHESTER	291.9	294.9	370.1	402.4	454.8	459.6	465.2	431.1	374.9	342.0	292.1	280.9	4459.8
SYRACUSE	292.0	294.9	370.1	402.4	454.9	459.6	465.3	431.1	374.9	342.0	292.2	280.8	4460.2
NORTH CAROLINA													
ASHEVILLE	311.9	305.3	371.1	392.9	435.5	435.9	443.2	417.7	372.1	349.7	309.0	303.7	4448.1
CAPE HATTERAS	312.7	305.5	371.2	392.6	434.7	434.9	442.3	417.1	371.9	350.0	309.8	304.7	4447.5
CHARLOTTE	312.9	305.8	371.1	392.5	434.5	434.7	442.2	417.0	371.9	350.1	310.0	304.8	4447.3
GREENSBORO	310.9	304.7	371.1	393.4	436.6	437.2	444.5	418.4	372.2	349.3	308.2	302.4	4448.6
RALEIGH	311.4	304.8	371.2	393.2	436.1	436.5	443.8	417.5	372.1	349.5	308.7	303.0	4448.2
WILMINGTON	315.2	306.9	371.4	391.4	432.5	432.2	439.8	415.6	371.5	351.0	311.8	307.3	4446.5

TABLE 2 (Con't)

SUNSHINE STATION NETWORK (1979)
TOTAL POSSIBLE SUNSHINE IN HOURS & TENTHS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
NORTH DAKOTA													
BISMARCK	280.0	288.8	369.4	407.9	466.3	473.9	478.3	439.1	376.6	337.7	282.2	267.1	4467.3
FARGO	279.6	288.5	369.4	408.0	466.7	474.4	478.9	439.4	377.0	337.5	281.9	266.6	4468.0
WILLISTON	275.0	286.2	369.1	410.2	471.1	480.0	484.0	442.5	377.5	335.8	278.2	261.4	4470.8
OHIO													
CINCINNATI	303.1	300.7	370.8	397.0	443.9	446.2	452.7	423.6	373.3	346.4	301.7	293.7	4453.0
CLEVELAND	296.9	298.1	370.4	400.0	450.0	453.6	459.7	427.8	374.3	343.9	296.4	286.5	4456.7
COLUMBUS	300.8	299.5	370.5	398.3	446.2	449.0	455.4	425.1	373.6	345.5	299.7	291.0	4454.4
DAYTON	301.1	299.6	370.6	398.1	446.0	448.6	455.1	425.0	373.6	345.5	299.9	291.3	4454.1
TOLEDO	296.4	297.2	370.3	400.3	450.4	454.3	460.3	428.2	374.3	343.7	295.9	285.9	4457.2
OKLAHOMA													
OKLAHOMA CITY	312.5	305.4	371.1	392.7	435.0	435.2	442.7	417.3	372.0	350.0	309.6	304.3	4447.0
TULSA	310.6	304.4	371.1	393.6	436.8	437.5	444.7	418.6	372.2	349.2	308.1	302.1	4448.8
OREGON													
PORTLAND	284.4	291.1	369.8	406.0	462.2	468.8	473.6	436.2	375.9	339.0	285.7	271.9	4464.7
PENNSYLVANIA													
HARRISBURG	300.2	299.0	370.4	398.5	446.7	449.7	456.1	425.6	373.8	345.3	299.3	290.3	4454.7
PHILADELPHIA	301.0	299.5	370.6	398.0	445.9	448.5	455.1	425.0	373.7	345.6	300.0	291.4	4454.3
PITTSBURGH	299.6	298.8	370.5	398.7	447.3	450.4	456.7	426.0	373.8	345.0	298.6	289.5	4455.3
SCRANTON	297.1	308.6	370.3	400.0	449.6	453.3	459.4	427.7	374.2	344.1	296.7	286.8	4467.8
RHODE ISLAND													
PROVIDENCE	295.9	296.9	370.2	400.3	450.8	454.7	460.7	428.5	374.5	343.7	295.7	285.5	4457.3
SOUTH CAROLINA													
CHARLESTON	318.2	308.4	371.5	389.9	429.5	428.5	436.4	413.6	371.2	352.2	314.4	310.8	4444.5
COLUMBIA	315.8	307.2	371.3	391.1	431.7	431.3	439.0	415.1	371.5	351.3	312.5	308.1	4445.7
GREENVILLE	309.6	306.0	371.2	392.0	433.8	433.8	441.3	416.4	371.8	350.5	310.7	305.8	4442.9
SOUTH DAKOTA													
HURON	288.0	292.9	369.9	404.1	458.5	464.2	469.5	433.7	375.5	340.6	288.9	276.3	4462.1
RAPID CITY	289.1	293.5	370.0	403.7	457.6	463.0	468.3	433.0	375.3	341.0	289.8	277.5	4461.7
TENNESSEE													
CHATTANOOGA	313.2	305.8	371.2	392.2	434.2	434.3	441.7	416.8	371.9	350.3	310.4	305.3	4447.1
KNOXVILLE	311.5	304.8	371.1	393.1	435.9	436.5	443.7	418.1	372.1	349.6	308.7	303.1	4448.1
MEMPHIS	313.0	305.8	371.2	392.4	434.4	434.6	442.0	417.0	371.9	350.2	310.0	304.9	4447.3
NASHVILLE	310.8	304.6	371.2	393.5	436.6	437.3	444.5	418.5	372.2	349.3	308.2	302.3	4448.9
TEXAS													
ABILENE	319.2	309.0	371.6	389.5	428.5	427.4	435.3	412.8	370.9	352.5	315.3	311.9	4443.9
AMARILLO	312.9	305.7	371.2	392.5	434.6	434.7	442.2	417.1	371.9	350.1	309.9	304.7	4447.4
AUSTIN	323.8	311.3	371.8	387.4	424.1	422.1	430.4	413.7	370.3	354.4	319.2	317.2	4445.7
BROWNSVILLE	332.6	316.1	372.4	383.2	415.8	412.0	420.8	403.8	369.0	357.9	326.7	327.1	4437.3
CORPUS CHRISTI	329.0	314.1	372.1	384.9	419.2	416.1	424.9	406.3	369.6	356.4	323.6	323.0	4439.2
EL PASO	320.6	309.7	371.7	388.9	427.2	425.8	433.8	411.8	370.7	353.1	316.4	313.5	4443.2
GALVESTON	325.8	312.5	371.9	386.4	422.2	419.7	428.2	408.4	370.0	355.2	320.9	319.6	4441.0
HOUSTON	324.9	311.9	371.9	386.8	423.1	420.8	429.2	408.9	370.2	354.8	320.1	318.4	4441.1
LUBBOCK	316.5	307.5	371.4	390.8	431.1	430.6	438.2	414.6	371.3	351.5	313.0	308.9	4445.4
PORT ARTHUR	324.5	311.7	371.9	387.1	423.5	421.3	429.7	409.2	370.2	354.7	319.8	316.8	4440.4
SAN ANTONIO	325.4	312.2	371.9	386.5	422.6	420.3	428.7	408.7	370.1	355.1	320.5	319.0	4441.0
UTAH													
MILFORD	304.9	301.6	370.8	396.3	442.6	444.1	450.7	422.3	373.0	347.0	303.2	295.7	4452.2
SALT LAKE CITY	298.8	298.4	370.5	399.2	448.3	451.4	457.7	426.4	374.0	344.6	297.9	288.5	4455.7
VERMONT													
BURLINGTON	287.6	292.3	369.8	404.2	458.9	464.6	470.0	434.0	375.7	340.6	288.8	276.1	4462.6
VIRGINIA													
LYNCHBURG	307.8	302.8	370.9	394.8	439.4	440.7	447.8	420.6	372.7	348.2	305.6	298.9	4450.3
NORFOLK	308.9	303.6	370.9	394.3	438.4	439.5	446.6	419.8	372.5	348.6	306.6	300.2	4449.9
RICHMOND	307.3	302.7	370.9	395.0	439.9	441.2	448.3	420.8	372.7	348.0	305.3	298.4	4450.5
WASHINGTON													
QUILLAYUTE	274.3	286.3	369.3	410.8	472.1	481.0	484.9	442.9	377.4	335.3	277.2	260.4	4471.6
SEATTLE	277.7	287.7	369.4	409.0	468.7	476.7	481.0	440.5	376.9	336.5	280.1	264.3	4468.7
SPOKANE	277.1	287.4	369.5	409.4	469.4	477.5	481.7	441.0	377.0	336.4	279.6	263.7	4469.5
WALLA WALLA	282.6	290.0	369.8	406.8	463.9	470.8	475.5	437.3	376.2	338.4	284.3	270.1	4465.6
WEST VIRGINIA													
PARKERSBURG	302.7	300.4	370.6	397.2	444.3	446.7	453.3	423.9	373.4	346.2	301.4	293.2	4453.3

TABLE 2 (Con't)

SUNSHINE STATION NETWORK (1979)
TOTAL POSSIBLE SUNSHINE IN HOURS & TENTHS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
WISCONSIN													
GREEN BAY	287.5	292.6	369.8	404.3	458.9	464.6	470.0	434.0	375.6	340.5	288.6	275.9	4462.5
MADISON	291.9	294.4	370.1	402.3	454.9	459.7	466.3	431.2	375.0	342.1	292.2	280.7	4460.1
MILWAUKEE	292.3	295.0	370.1	402.1	454.3	459.0	464.6	430.9	374.9	342.3	292.6	281.3	4459.4
WYOMING													
CHEYENNE	297.7	297.8	370.4	399.7	449.3	452.7	458.9	427.5	374.2	344.1	297.0	287.3	4456.6
LANDER	292.8	295.4	370.2	401.9	453.9	458.4	464.1	430.5	374.8	342.4	293.0	281.8	4459.0
SHERIDAN	286.8	292.3	369.9	404.8	459.8	465.8	470.8	434.6	375.6	340.1	287.8	274.9	4463.1
ALASKA													
ANCHORAGE	203.1	252.7	366.7	442.3	542.5	575.4	567.9	488.3	386.9	310.7	218.7	175.1	4530.1
NOME	168.5	238.7	365.8	455.8	577.5	634.8	613.0	508.3	390.7	300.4	191.5	129.2	4574.2
HAWAII													
HILO	343.9	322.1	373.2	378.0	405.2	399.1	408.9	396.2	367.4	362.3	336.3	339.9	4432.5
HONOLULU	341.1	320.7	373.0	379.3	407.9	402.3	411.9	398.1	367.8	361.2	333.9	336.7	4433.8
KAHULUI	341.8	320.1	373.0	379.0	407.2	401.4	411.1	397.6	367.7	361.5	334.4	337.6	4433.3
LIHUE	339.9	320.0	373.0	379.9	408.9	403.7	413.1	398.9	368.0	360.7	332.9	335.3	4434.3
PACIFIC ISLANDS													
GUAM	354.2	327.4	373.5	372.9	395.2	387.4	398.1	389.7	366.3	366.9	345.3	351.7	4428.5
JOHNSTON	348.6	324.6	373.4	375.7	400.7	393.8	404.0	393.2	366.9	364.3	340.3	345.2	4430.7
KOROR	364.2	332.9	374.4	368.4	386.1	376.3	387.6	383.0	364.8	370.9	353.8	362.9	4425.3
MAJURO	364.6	333.1	374.4	368.3	385.7	375.8	387.2	382.9	364.8	371.1	354.2	363.4	4425.4
PAGO PAGO	399.2	351.9	377.4	353.0	355.3	338.7	352.4	361.3	360.4	385.4	383.2	402.2	4419.4
PONAPE	364.8	333.2	374.4	368.1	385.4	375.6	387.0	382.7	364.8	371.4	354.3	363.6	4424.9
TRUK	363.9	332.7	374.3	368.4	386.3	376.5	387.9	382.8	364.9	370.7	353.7	362.7	4425.3
WAKE	344.4	322.2	372.7	377.1	404.1	398.2	408.3	396.2	367.7	363.1	337.3	340.8	4432.0
YAP	360.7	331.0	373.9	370.1	389.2	380.1	391.2	385.2	365.4	369.4	350.9	359.0	4426.1
PUERTO RICO													
SAN JUAN	346.2	323.2	373.2	376.8	403.0	396.5	406.5	394.8	367.2	363.4	338.3	342.4	4430.7

TABLE 3

Some radiation data of several meteorological stations in the USA (after Baker and Haines, 1969)

Place	Latitude	a coeff.	b coeff.	S	Corr. coeff. r
Dodge City	37°46'	0.23	0.54	0.72	0.89
Columbia	38°58'	0.20	0.54	0.63	0.90
Indianapolis	39°44'	0.16	0.56	0.60	0.90
Lincoln	40°49'	0.19	0.54	0.68	0.92
Cleveland	41°24'	0.19	0.54	0.49	0.85
Madison	43°08'	0.21	0.53	0.58	0.87
Rapid City	44°02'	0.32	0.45	0.60	0.84
Sault Ste. Marie	46°20'	0.25	0.58	0.46	0.90
Bismarck	46°46'	0.26	0.53	0.62	0.89

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