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Historical Sunshine and Cloud Data in the United States

P. M. Steurer
T. R. Karl

Environmental Sciences Division
Publication No. 3689

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ORNL/CDIAC-43

Environmental Sciences Division

HISTORICAL SUNSHINE AND CLOUD DATA IN THE UNITED STATES

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CONTENTS

Page

LIST OF FIGURES v

LIST OF TABLES vii

ABSTRACT ix

PART 1: INFORMATION ABOUT THE DATA PACKAGE 1

1. NAME OF THE NUMERIC DATA PACKAGE 3

2. CONTRIBUTORS 3

3. KEYWORDS 3

4. BACKGROUND INFORMATION 3

5. SOURCE AND SCOPE OF THE DATA 18

6. APPLICATIONS OF THE DATA 39

7. LIMITATIONS AND RESTRICTIONS 39

8. REFERENCES 42

9. QUALITY ASSURANCE OF THE SUNSHINE AND CLOUD DATA BASE . 45

10. HOW TO OBTAIN THE DATA PACKAGE 47

PART 2: INFORMATION ABOUT THE MAGNETIC TAPE 49

11. CONTENTS OF THE MAGNETIC TAPE 51

12. DESCRIPTIVE FILE ON THE MAGNETIC TAPE 53

13. LISTINGS OF THE FORTRAN IV DATA RETRIEVAL PROGRAMS 69

14. LISTINGS OF THE SAS™ INPUT/OUTPUT RETRIEVAL PROGRAMS 77

CONTENTS (continued)

Page

15. VERIFICATION OF DATA TRANSPORT 83

APPENDIX A. SUNSHINE AND CLOUD NETWORK STATION INVENTORIES A-1

APPENDIX B. HISTORICAL DESCRIPTION AND ASSESSMENT OF SUNSHINE MEASUREMENT PROCEDURES AND DATA SOURCES B-1

APPENDIX C. HISTORICAL DESCRIPTION AND ASSESSMENT OF CLOUD AMOUNT ESTIMATION PROCEDURES AND DATA SOURCES C-1

APPENDIX D. MAXIMUM POSSIBLE HOURS OF SUNSHINE AT STATIONS IN THE U.S. SUNSHINE RECORDER NETWORK D-1

APPENDIX E. REPRINTS OF PERTINENT LITERATURE E-1

Increased cloudiness in the United States during the first half of the twentieth century: Fact or fiction? by T. R. Karl and P. M. Steurer. 1990.

LIST OF FIGURES

Figure		Page
1a	U.S. sunshine and cloud reporting stations, 1891	5
1b	U.S. sunshine and cloud reporting stations, 1910	6
1c	U.S. sunshine and cloud reporting stations, 1930	7
1d	U.S. sunshine and cloud reporting stations, 1950	8
1e	U.S. sunshine and cloud reporting stations, 1970	9
1f	U.S. sunshine and cloud reporting stations, 1987	10
2	Evolution of the number of stations in the U.S. sunshine recording network	11
3	Evolution of the number of stations in the U.S. cloud observing network	13
4a	Correlation coefficients for seasonally averaged clouds and sunshine: spring	14
4b	Correlation coefficients for seasonally averaged clouds and sunshine: summer	15
4c	Correlation coefficients for seasonally averaged clouds and sunshine: fall	16
4d	Correlation coefficients for seasonally averaged clouds and sunshine: winter	17
5	Distribution of station history lengths from the U.S. sunshine observing network	29
6	Distribution of station history lengths from the U.S. cloud observing network	36
7	The rate of change from thermometric to photoelectric sunshine switches in the 1950s and 1960s	38
8	Annual percentage of possible sunshine and annual cloud amount (percentage of total sky cover) for Hartford, Connecticut, 1905-1987	41

LIST OF TABLES

Table		Page
1	Inventory of stations in the U.S. sunshine recording network showing beginning dates (month/day/year) of use for the different types of recorders	19
2	Inventory of stations in the U.S. cloud observing network	30
3	Characteristics of numeric variables from the measured hours of sunshine file (File 10)	84
4	Characteristics of numeric variables from the maximum possible hours of sunshine file (File 11)	85
5	Characteristics of numeric variables from the percentage of possible sunshine file (File 12)	86
6	Characteristics of numeric variables from the cloud amount file (File 13)	87
7	Sample listing of the measured hours of sunshine file	88
8	Sample listing of the maximum possible hours of sunshine file	91
9	Sample listing of the percentage of possible sunshine file	92
10	Sample listing of the cloud amount file	96

ABSTRACT

STEURER, P.M., and T. R. KARL. 1991. Historical Sunshine and Cloud Data in the United States. ORNL/CDIAC-43, NDP-021/R1. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee. 154 pp.

This document describes a data base containing United States monthly and annual historical time series of sunshine duration (observed hours of sunshine, maximum possible hours of sunshine, and percentage of possible sunshine) and mean sunrise to sunset fractional cloud amount. These data were assembled by the National Climatic Data Center (Asheville, N.C.) and the U.S. Department of Energy in response to the need for regional historical sunshine and cloud amount data sets for use in the study of climate change. A total of 240 sunshine time series (longest period of record, 1891–1987) and 197 cloud amount time series (longest period of record, 1871–1987) have been assembled. The high correlation between these two data sets has allowed for an independent method of quality assurance and the development of a procedure for producing estimates when data are missing in either of the two time series. These new data sets contain the most complete and highest quality cloud and sunshine time series available to the research community and should prove invaluable in the assessment of climate change in the United States over the last century.

These data are available free of charge as a numeric data package (NDP) from the Carbon Dioxide Information Analysis Center. The NDP consists of this document and a magnetic tape containing machine-readable data files, a descriptive file, and computer access codes. This document defines limitations and restrictions of the data, describes the format and contents of the magnetic tape, and provides a reprint of a pertinent journal article.

PART 1

INFORMATION ABOUT THE DATA PACKAGE

1. NAME OF THE NUMERIC DATA PACKAGE

Historical Sunshine and Cloud Data in the United States

2. CONTRIBUTORS

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National Climatic Data Center
Asheville, North Carolina 28801

3. KEYWORDS

Sunshine duration; percent of possible sunshine; maximum possible sunshine; fractional cloud amount; estimates; global warming; climate change.

4. BACKGROUND INFORMATION

An understanding of the roles played by cloud cover and solar insolation has become increasingly important in the study of climate change induced by greenhouse gases. Increases in the concentrations of greenhouse gases over the last century have commonly been linked to increasing global temperature. A major uncertainty regarding the magnitude of this warming relates to associated changes in cloudiness. Ramanathan et al. (1989) found that global warming would probably lead to increasing cloudiness, which would tend to decrease the amount of solar insolation reaching the earth's surface, but would also decrease the amount of outgoing longwave radiation. Depending on the cloud characteristics, such as type and height, an increase in cloudiness could cool the earth through decreased absorption of shortwave radiation or warm it via the trapping of outgoing longwave radiation. For current cloud distributions, an increase in global fractional cloud amount (hereafter referred to simply as cloud amount) would likely cool the earth (Ramanathan 1989).

Several articles have reported on the changes of cloudiness and sunshine in the United States during the twentieth century. Henderson-Sellers (1986, 1988) analyzed cloud cover for 77 stations in the United States and 66 stations in Canada since 1900 and found a tendency toward increases in total cloud amount, with the largest increases occurring between the 1930s and 1950. Angell et al. (1984) found a 3.7% increase in cloudiness since 1950 but only a 0.9% corresponding decrease in sunshine, while Angell and Korshover (1987) reported that cloudiness has increased 0.8% per decade since 1950. Changnon (1981) also found long-term increases in cloud amount for the midwestern United States since 1960, potentially because of to jet contrail effects. A recent detailed investigation into U.S. Weather Bureau observing practices since 1891 has revealed that these reported increases in cloudiness may have been exaggerated as a result of significant changes in cloud-observing techniques (Karl and Steurer 1990). In addition, changes in instrumentation from the thermometric to the more sensitive photoelectric sunshine recorders did not occur at all stations in the early 1950s, as previously assumed [e.g.,

Doehring and Karl (1981) and Quinlan (1985)], but occurred gradually from 1952 through the mid-1960s. It is quite possible that serious biases were introduced into the historical time series of sunshine and cloud amount.

The need for regional historical sunshine and cloud amount data sets for use in the study of climate change has led the National Climatic Data Center (NCDC), in conjunction with the U.S. Department of Energy, to improve and expand the United States monthly and annual historical time series of sunshine duration (observed hours of sunshine and percentage of possible sunshine) and mean sunrise to sunset fractional cloud amount. Altogether 240 sunshine time series and 197 cloud amount time series have been assembled, which span a period from the late 1800s through 1987. The sunshine data (through 1984) were originally documented by Young et al. (1987). Maps depicting the sunshine and cloud observing networks for selected years are presented in Figs. 1a-f. Specific historical information for each data set is presented in the following, along with information regarding the method by which estimates for missing data were made for each data set.

a) Sunshine

Automatic recordings of the number of hours in which the sun is visible each day have been made in the United States since the 1880s. Possible sunshine duration is considered to be the time between sunrise and sunset assuming a smooth, spherical earth. Sunrise and sunset, are defined by the National Weather Service as the time when the sun's upper disc appears in the morning and disappears in the evening on a sea-level horizon. On a smooth, spherical earth, possible sunshine duration is dependent only on latitude and time of year.

Official sunshine duration data were first published for the year 1891 in the *Report of the Chief of the Weather Bureau*. At the time of the report, only 20 stations existed in the U.S. Weather Bureau network, but the network expanded rapidly to 82 stations by 1900 and to a high of 184 stations in 1948. Since 1948 there has been a small decline in the number of stations because of station closings and movement of station offices to airports. In 1987, 154 stations were operating, and altogether, over the past 97 years, 240 sunshine recording stations have been instrumented at one time or another. A time series of the number of stations in the sunshine recording network from 1891–1987 is shown in Fig. 2.

Since 1888, three automatic instruments with completely different sensing characteristics have been used to record sunshine duration in the United States. These were the Jordan Photographic Sunshine recorder used from 1888 through 1907, the Maring-Marvin Thermometric Sunshine recorder used from 1893 through the mid-1960s, and the Foster Photoelectric Sunswitch used from 1952 to the present. Although different instruments were used, all three types were designed to record the duration of sunshine without regard to the degree of intensity. Further details pertaining to the sunshine recorders and the sunshine recording network are provided in the appendices and in the journal article included in this package.

Fig. 1a. U.S. sunshine and cloud reporting stations, 1891.

Fig. 1b. U.S. sunshine and cloud reporting stations, 1910.

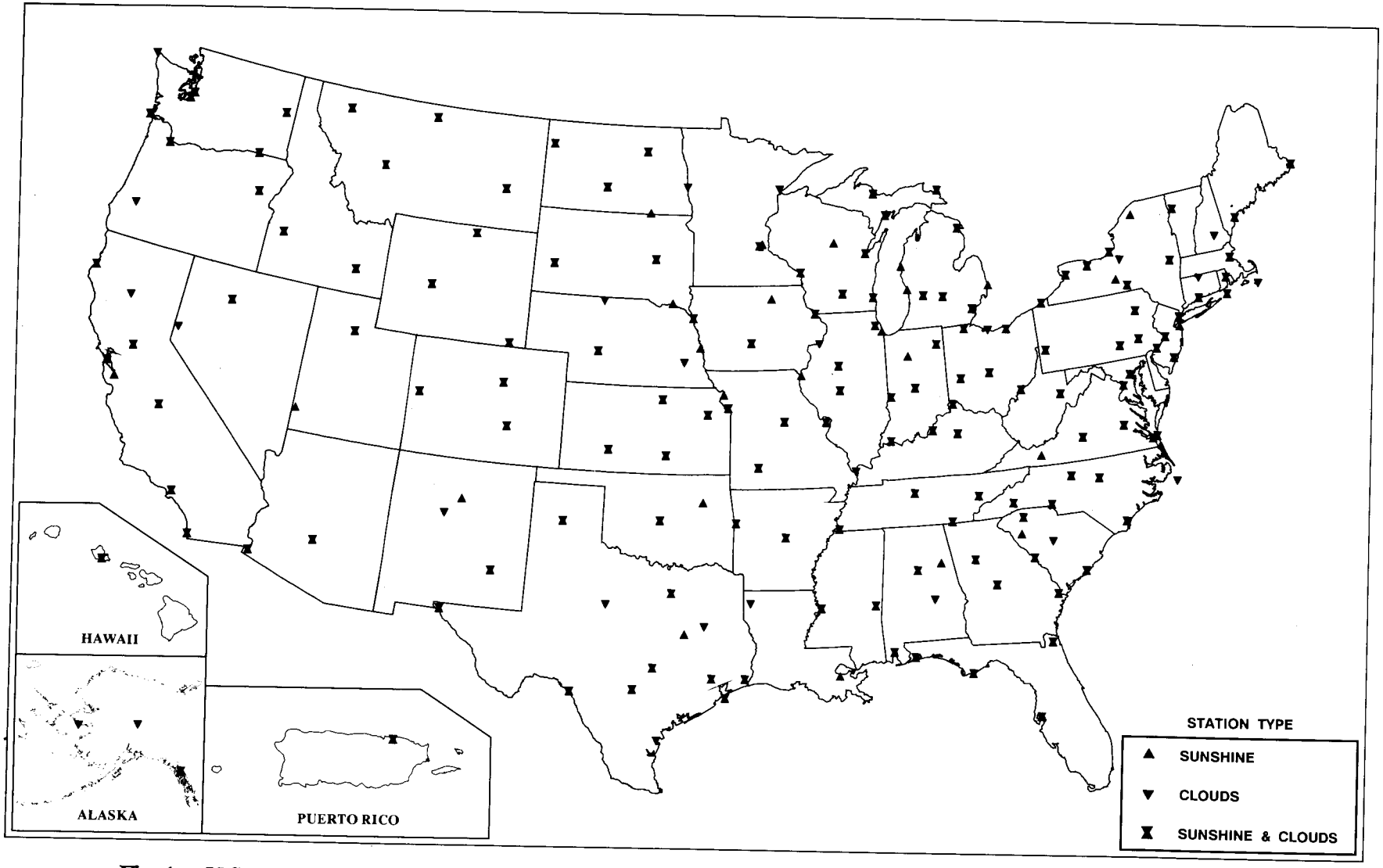

Fig. 1c. U.S. sunshine and cloud reporting stations, 1930.

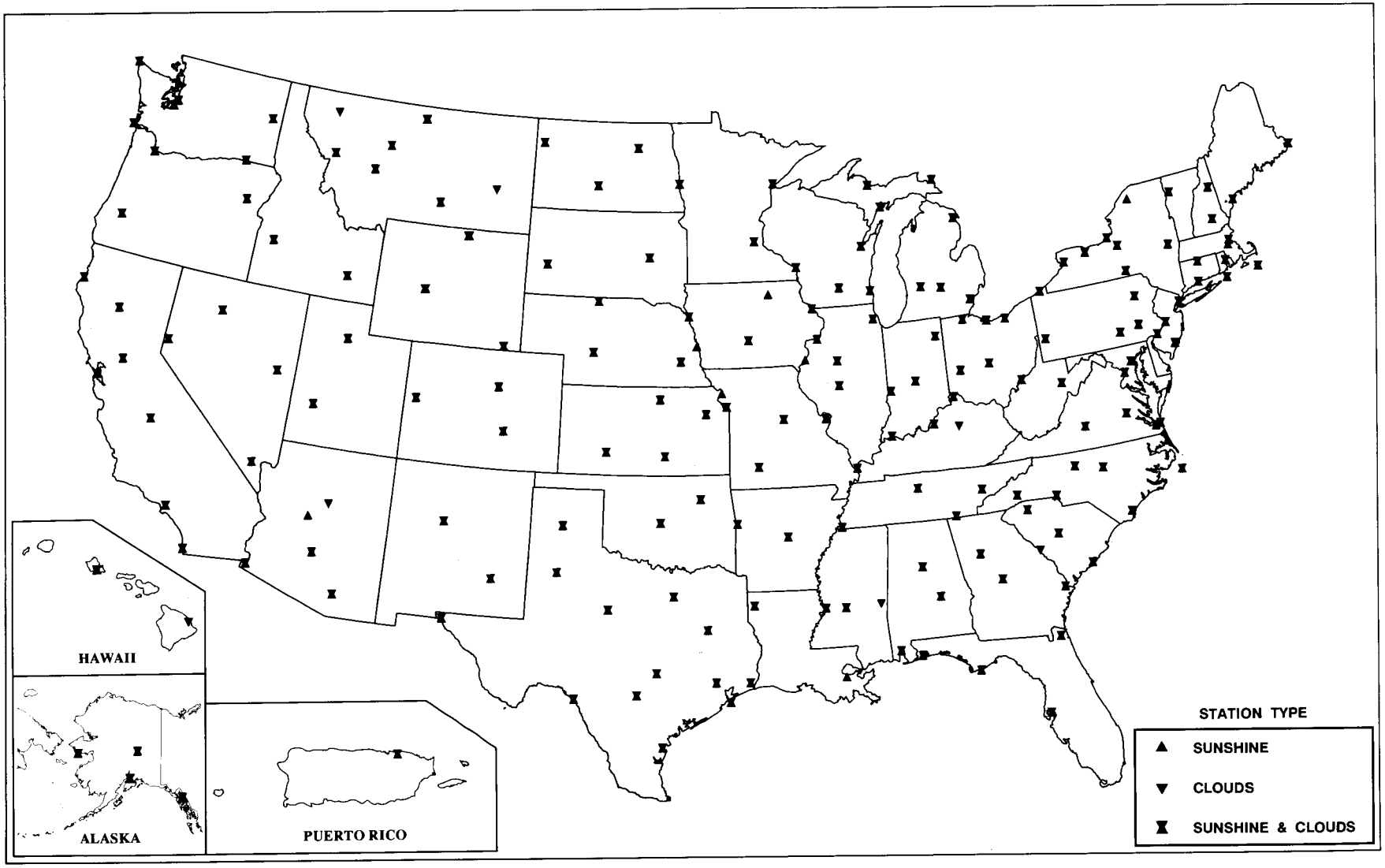

Fig. 1d. U.S. sunshine and cloud reporting stations, 1950.

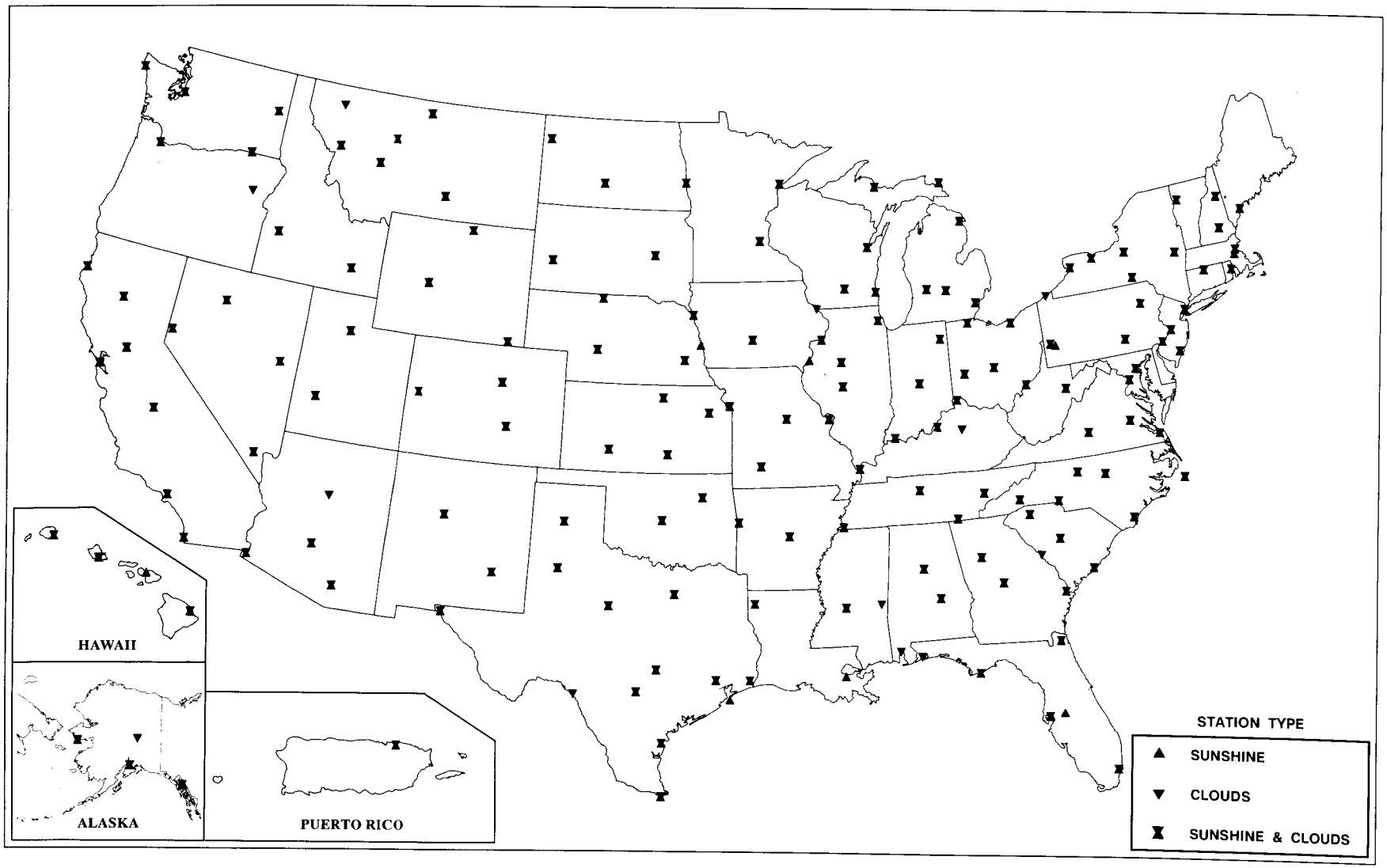

Fig. 1e. U.S. sunshine and cloud reporting stations, 1970.

Fig. 1f. U.S. sunshine and cloud reporting stations, 1987.

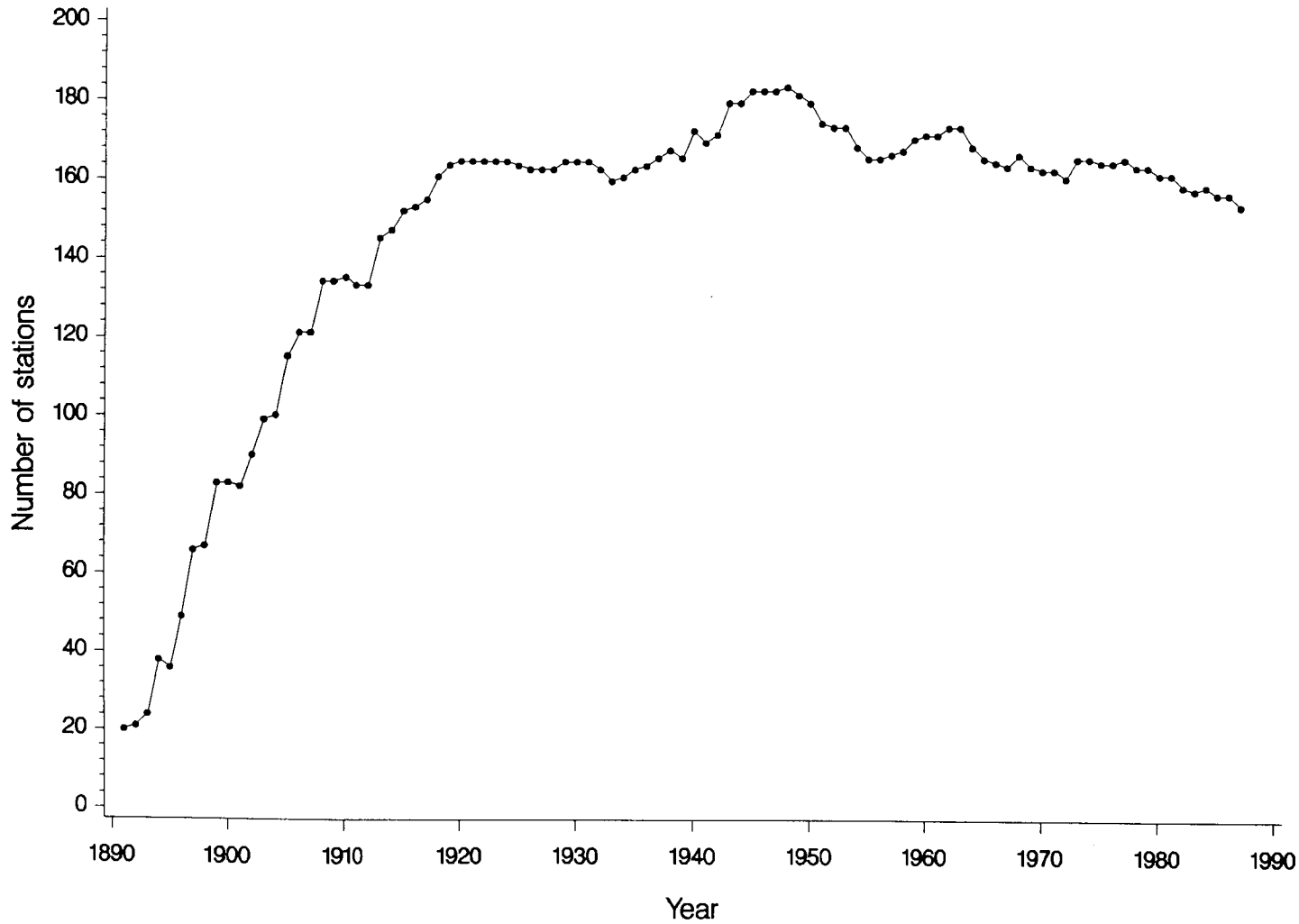

Fig. 2. Evolution of the number of stations in the U.S. sunshine recording network.

b) Clouds

Land-based estimates of cloud amount in tenths of sky cover have been routinely made in the United States since the 19th century. Cloud measurements from the ground are subjective, compared with more objective satellite techniques and are based on observer competence, the method of observation, and viewing conditions.

In 1948 the definition of average sunrise to sunset cloud amount was broadened to include all obstructions to the sky such as fog, haze, smoke, and dust. Before 1948, observers were explicitly instructed to not include these phenomena in the sums and averages of cloud amount. In 1949 this new observing technique was reflected in a change in official U.S. Weather Bureau terminology; estimates were now to be made of total sky cover, not just cloud cover. For simplicity, henceforth in this document the terms cloud cover or cloud amount will be used in lieu of sky cover. A more detailed history of cloud measurement procedures may be found in Appendix C, which describes additional changes in cloud observing practices that may have biased the historical record.

Official monthly mean cloud amounts were available in 1871 at just three U.S. cities: Chicago, Illinois; Toledo, Ohio; and Baltimore, Maryland. By 1900, these data were being provided by 134 stations, with the network reaching a high of 195 stations in 1951. In 1987, 162 stations were operating. As noted in the preceding, maps depicting the station network for selected years are presented in Figs. 1a-f. A time series of the number of stations in the cloud observing network from 1871–1987 is shown in Fig. 3.

c) Estimation of Missing Data and Quality Control

A high inverse correlation is commonly known to exist between monthly sunrise to sunset cloud cover and monthly percentage of possible sunshine. Angell et al. (1984) found a correlation of
-0.92 between annual values in the contiguous United States, with seasonal values ranging from -0.78 in spring to -0.98 in autumn. The data contained in this package have been found to confirm the correlation between clouds and sunshine as depicted in Figs. 4a-d. Although highly correlated, the two data sets are not exactly complementary because sunshine, for the most part, is observed by instruments and cloudiness is subjectively measured by ground-based observers. Especially in the case of cumulus-type clouds, measurements of clouds are frequently overestimated because observers view the sides as well as the bases of clouds (Hughes 1984). Also, cirrus or altostratus clouds can be simultaneously recorded as cloud cover and sunshine when they are not thick enough to turn off the sunshine recorder.

The high correlation between clouds and sunshine has led to an independent method of quality control (see Sect. 9) and also to the development of a procedure that produces an estimate when data are missing in either of the two data sets (see Sects. 5 and 7).

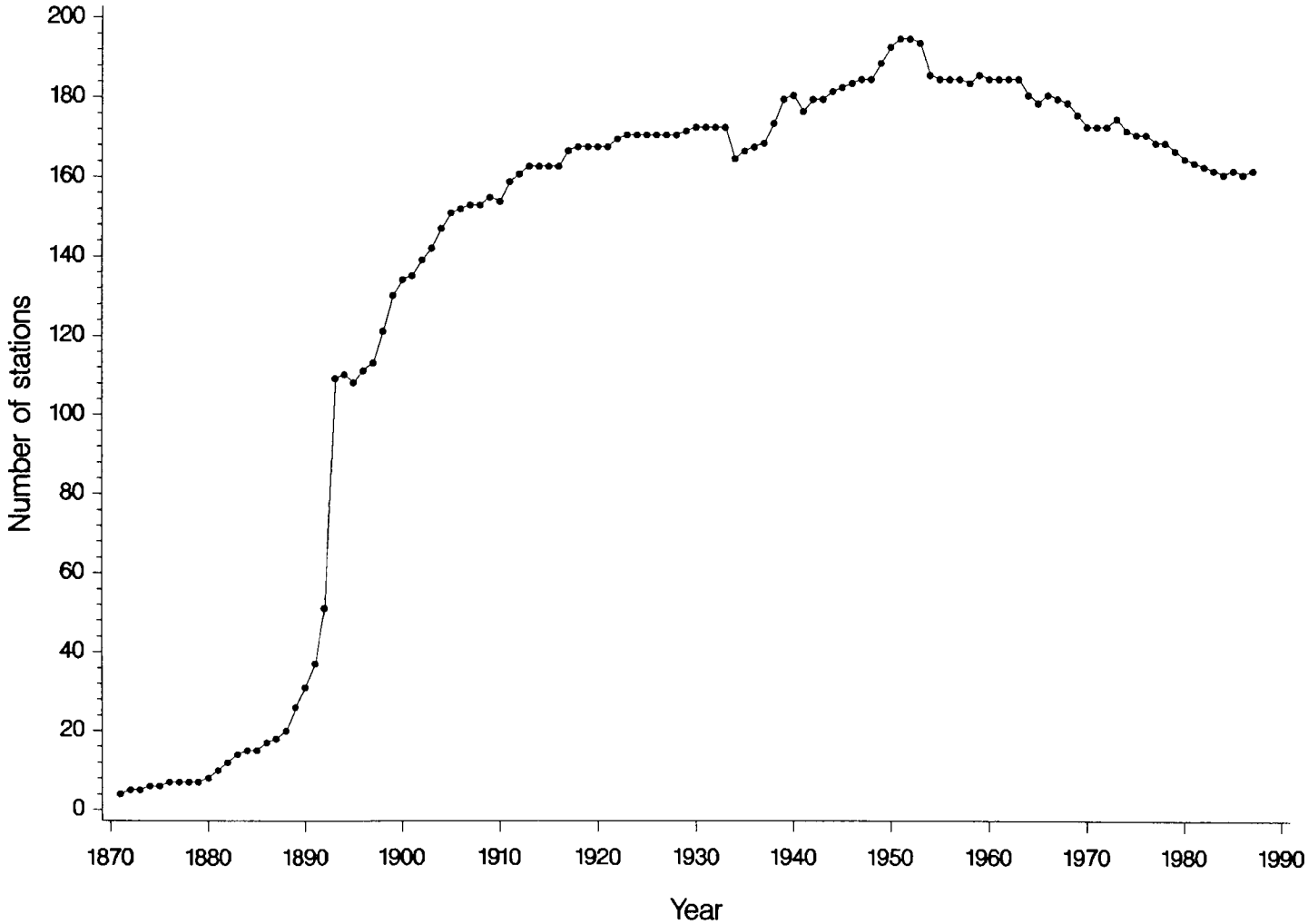

Fig. 3. Evolution of the number of stations in the U.S. cloud observing network.

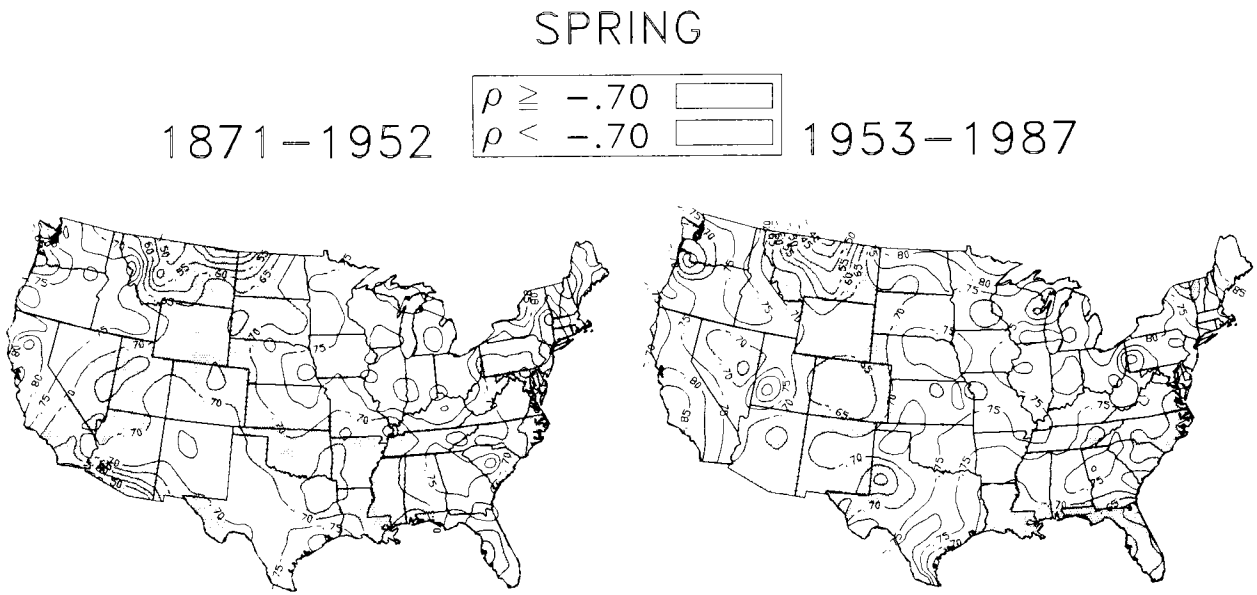

Fig. 4a. Correlation coefficients for seasonally averaged clouds and sunshine: spring.

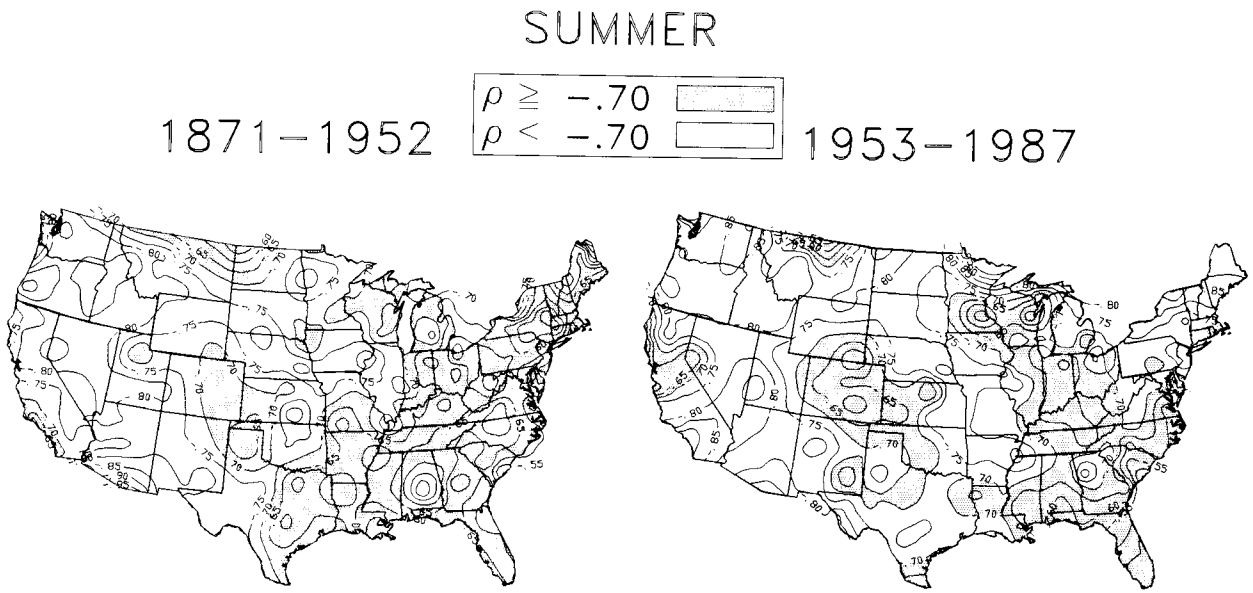

Fig. 4b. Correlation coefficients for seasonally averaged clouds and sunshine: summer.

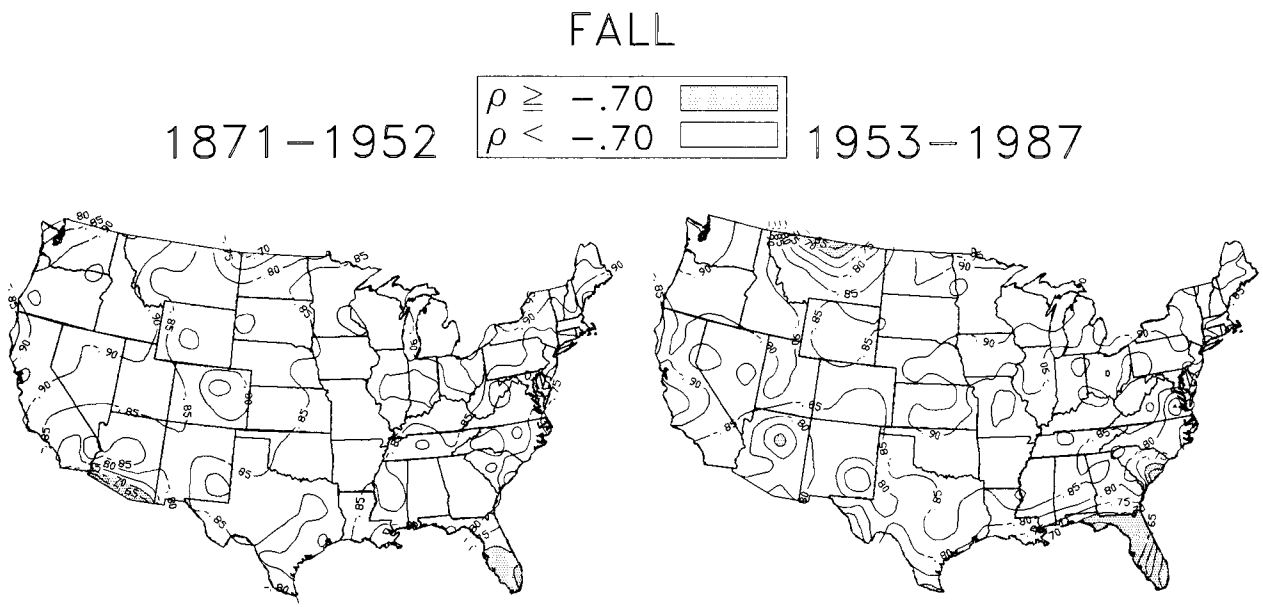

Fig. 4c. Correlation coefficients for seasonally averaged clouds and sunshine: fall.

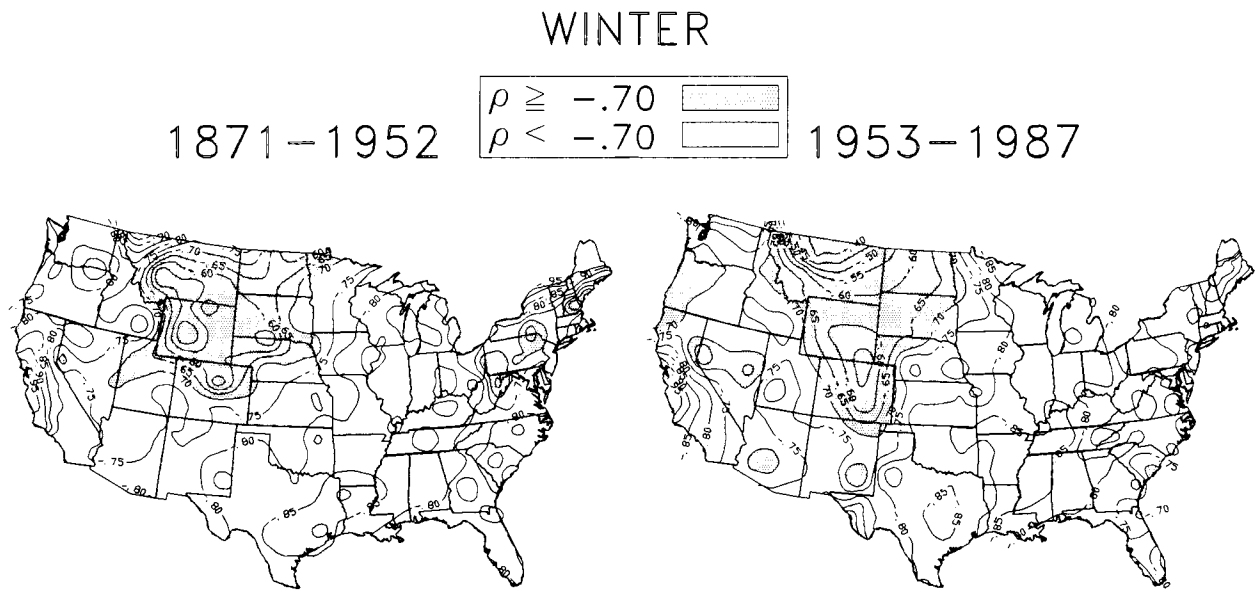

Fig. 4d. Correlation coefficients for seasonally averaged clouds and sunshine: winter.

5. SOURCE AND SCOPE OF THE DATA

a) Sunshine

Sunshine data for 240 U.S. stations (including Puerto Rico and nine Pacific islands) are presented for the years 1891–1987. An inventory of these stations, giving dates when each began using a particular model of sunshine recorder, is presented in Table 1. The stations' periods of record vary greatly. Many of the stations have discontinuous sampling periods and only 49 (20%) have periods of record equal to or greater than 90 years. However, 192 stations (80%) have periods of record equal to or greater than 30 years. More detailed information on the lengths of station records is given in Fig. 5 and Appendix A.

In addition to the total monthly and annual measurements of sunshine duration, total monthly and annual maximum possible sunshine duration and monthly and annual percentages of possible sunshine duration are also provided. Maximum possible sunshine values for the 240-station recording network range from a minimum of 4418 h at the southernmost station (Tafuna, Pacific Ocean) to a maximum of 4591 h at the northernmost station (Fairbanks, Alaska). The highest annual amount of sunshine ever recorded in the United States was at Yuma, Arizona, with 4272 h (96% of possible) in 1958, and the lowest ever recorded was at Mt. Washington, New Hampshire, with 1181 h (26% of possible) in 1943.

In terms of annual percentage of possible sunshine, the highest amount ever recorded was 96% at Yuma, Arizona, in 1958, and the lowest amount ever recorded was 18% at Juneau, Alaska, in 1939. In the contiguous United States, the lowest annual percentage of possible sunshine ever recorded was 23% at Quillayute, Washington, in 1986.

b) Clouds

Cloud amount data for 197 U.S. stations are presented for the years 1871–1987. An inventory of these stations along with the dates of city to airport station moves is presented in Table 2. Most of the stations in the cloud observing network are also present in the sunshine recorder network; however, the earlier opening of several stations only measured cloud amount upon opening, and this, coupled with a higher percentage of stations remaining open through 1987 to measure cloud amount, has resulted in the cloud data set being longer and more complete than the sunshine data set. For example, 100 stations (51%) have periods of record at least 90 years in length and 194 stations (98%) have records for at least 30 years. More-detailed information on the lengths of station records is given in Fig. 6 and Appendix A.

In compiling the cloud amount data set, only monthly sunrise to sunset cloud amount averages (percentages) were used. This eliminated problems associated with nighttime measurements and also maintained consistency in any comparisons with the monthly sunshine data.

Table 1. Inventory of stations in the U.S. sunshine recording network showing beginning dates of use (month/day/year) for the different types of recorders (A blank entry for recorder type indicates the recorder was not used at that station.)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
33	39	85	50	93865	AL	ANNISTON		01/01/14	
33	28	86	50	03883	AL	BIRMINGHAM		01/01/05[c]	05/08/64
30	42	88	02	93855	AL	MOBILE		01/01/08	
32	18	86	24	13895	AL	MONTGOMERY		01/01/43	12/01/56
61	10	150	01	26451	AK	ANCHORAGE		01/01/42	10/30/53[c]
64	49	147	52	26411	AK	FAIRBANKS		01/01/31	
58	22	134	35	25309	AK	JUNEAU		01/01/17	04/28/53[c]
55	21	131	42	25325	AK	KETCHIKAN		01/01/43	
64	30	165	26	26617	AK	NOME		01/01/34	12/27/54
35	08	111	40	03103	AZ	FLAGSTAFF		01/01/08	01/01/73
33	26	112	01	23183	AZ	PHOENIX	08/01/95	(unknown)	10/22/53
34	39	112	26	23184	AZ	PRESCOTT		01/01/47	(unknown)
32	08	110	56	23160	AZ	TUCSON	06/01/92	01/01/48	01/01/54
32	40	114	36	23195	AZ	YUMA		01/01/08	04/01/57
36	22	94	12	93925	AR	BENTONVILLE		04/01/06	
35	20	94	22	13964	AR	FORT SMITH		01/01/05	12/01/64
34	50	92	16	03952	AR	NORTH LITTLE ROCK		02/01/94	06/01/63[c]
40	48	124	10	24213	CA	EUREKA	01/01/96	01/01/08	07/10/57[c]
36	46	119	43	93193	CA	FRESNO		07/01/96	03/23/55
36	48	118	12	93164	CA	INDEPENDENCE		06/01/18	
34	03	118	14	93134	CA	LOS ANGELES	10/01/96	01/01/07	02/20/58[c]
37	56	122	35	23262	CA	MT. TAMALPAIS	01/01/99	10/01/05	
40	09	122	15	24216	CA	RED BLUFF		01/01/33	11/10/52[c]
38	31	121	30	23232	CA	SACRAMENTO		01/01/05	05/17/56
32	44	117	10	23188	CA	SAN DIEGO	01/01/91	04/01/07	12/01/56[c]
37	47	122	25	23272	CA	SAN FRANCISCO	01/01/91	11/14/94	10/05/53

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
37	22	121	55	23293	CA	SAN JOSE		01/01/08	
35	15	120	40	93206	CA	SAN LUIS OBISPO		07/01/04	
39	46	104	52	23062	CO	DENVER	04/01/91	01/01/07	02/01/57
37	17	107	53	93004	CO	DURANGO		01/01/05	
39	07	108	32	23066	CO	GRAND JUNCTION	01/01/99	07/01/07	06/26/61[c]
38	17	104	31	93058	CO	PUEBLO		10/01/99	06/01/54[c]
41	56	72	41	14740	CT	HARTFORD		01/01/05	05/24/56
41	16	72	53	14758	CT	NEW HAVEN		02/01/94	12/01/58[c]
38	51	77	02	13743	DC	WASHINGTON	01/01/91	02/01/04	12/01/53
29	44	85	02	12832	FL	APALACHICOLA		01/01/24	09/15/59[c]
30	30	81	42	13889	FL	JACKSONVILLE		11/01/97	10/01/62
26	57	80	07	12893	FL	JUPITER		10/01/99	
24	33	81	45	12836	FL	KEY WEST		01/01/94	09/13/62[c]
28	02	81	57	12883	FL	LAKELAND		01/01/54	09/29/60
25	48	80	18	12839	FL	MIAMI		01/01/13	12/01/53
30	28	87	12	13899	FL	PENSACOLA		01/01/18	01/27/58
27	58	82	32	12842	FL	TAMPA		11/01/96	08/25/52[c]
33	39	84	26	13874	GA	ATLANTA		01/01/95	06/12/56
33	28	81	58	93848	GA	AUGUSTA		05/01/02	
32	42	83	39	03813	GA	MACON		04/01/99	05/01/55[c]
32	08	81	12	03822	GA	SAVANNAH	01/01/91	10/01/98	06/14/54
19	43	155	04	21504	HI	HILO			08/20/53
21	20	157	55	22521	HI	HONOLULU		01/01/08	08/01/56[c]
20	54	156	26	22516	HI	KAHULUI			03/01/62

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
21	59	159	21	22536	HI	LIHUE		01/01/51	03/12/57[c]
43	34	116	13	24131	ID	BOISE	01/01/99	11/22/07	12/05/53
42	55	112	36	24156	ID	POCATELLO		07/01/99	06/01/55[c]
37	00	89	10	93809	IL	CAIRO		01/01/43	04/23/65
41	59	87	54	94846	IL	CHICAGO		09/01/93	??/??/58
41	47	87	36	14892	IL	CHICAGO UNIVERSITY		01/01/19	
41	27	90	30	14923	IL	MOLINE		01/01/43	06/01/55
40	40	89	41	14842	IL	PEORIA		01/01/06	10/01/59[c]
39	51	89	41	93822	IL	SPRINGFIELD		01/01/02	12/18/56[c]
38	03	87	32	93817	IN	EVANSVILLE		01/01/13	03/13/64
41	00	85	12	14827	IN	FORT WAYNE		01/01/13	04/17/64
39	44	86	16	93819	IN	INDIANAPOLIS		11/01/96	07/01/55
40	53	86	29	94881	IN	ROYAL CENTER		04/01/18	
39	27	87	18	93823	IN	TERRE HAUTE		01/01/13	
40	47	91	07	14931	IA	BURLINGTON		01/01/42	09/15/55
43	04	92	40	14966	IA	CHARLES CITY		01/01/05	
41	31	90	34	14932	IA	DAVENPORT		01/01/33	
41	32	93	39	14933	IA	DES MOINES		01/01/94	08/13/54
42	30	90	40	14934	IA	DUBUQUE		06/01/96	
40	24	91	24	14969	IA	KEOKUK		01/01/21	
42	24	96	23	14943	IA	SIOUX CITY		01/01/08	01/29/54
39	33	97	39	13984	KS	CONCORDIA		01/01/08	07/08/55
37	46	99	58	13985	KS	DODGE CITY	03/01/91	01/01/03	12/19/58[c]
39	04	95	38	13996	KS	TOPEKA		01/01/99	10/16/57[c]
37	39	97	26	03928	KS	WICHITA		04/01/13	12/01/53[c]

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
39	03	84	40	93814	KY	COVINGTON	01/01/91	05/01/95[c]	12/09/53[c]
38	02	84	36	93820	KY	LEXINGTON		01/01/99	
38	11	85	44	93821	KY	LOUISVILLE		01/01/94	04/26/56[c]
29	59	90	15	12916	LA	NEW ORLEANS		01/01/91	10/01/62[c]
32	28	93	49	13957	LA	SHREVEPORT		01/01/43	07/06/52[c]
44	55	67	00	14608	ME	EASTPORT	01/01/91	10/22/02	
43	39	70	19	14764	ME	PORTLAND		01/01/94	(unknown)
39	11	76	40	93721	MD	BALTIMORE		01/01/94	03/10/53[c]
42	13	71	07	14753	MA	BLUE HILL		09/01/49	
42	22	71	02	14739	MA	BOSTON		01/01/93	06/04/53
41	15	70	04	14756	MA	NANTUCKET		01/01/40	04/28/52
45	04	83	34	94849	MI	ALPENA		01/01/18	08/25/59[c]
42	14	83	20	94847	MI	DETROIT		02/01/91	05/01/52[c]
45	45	87	03	14824	MI	ESCANABA		01/01/99	
43	05	86	14	94879	MI	GRAND HAVEN		01/01/02	
42	53	85	31	94860	MI	GRAND RAPIDS		01/01/04	05/29/59[c]
42	46	84	36	14836	MI	LANSING		01/01/13	05/14/61
43	57	86	28	94816	MI	LUDINGTON		01/01/13	
46	32	87	34	94850	MI	MARQUETTE		01/01/95	07/26/55
43	00	82	26	94880	MI	PORT HURON		01/01/03	
43	26	83	52	14845	MI	SAGINAW		01/01/13	
46	28	84	21	14847	MI	SAULT STE. MARIE		10/01/99	08/05/53
46	50	92	11	14913	MN	DULUTH		01/01/33	05/05/65[c]
44	53	93	13	14922	MN	MINNEAPOLIS		06/01/96	09/18/58

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
44	56	93	04	14927	MN	ST. PAUL	01/01/97	01/23/06	
32	19	90	05	03940	MS	JACKSON		06/01/48	01/01/65
32	21	88	40	93854	MS	MERIDIAN		01/01/99	
32	21	90	53	93917	MS	VICKSBURG		02/01/94	05/19/55
38	49	92	13	03945	MO	COLUMBIA		02/01/98	01/27/54
39	19	94	43	03947	MO	KANSAS CITY	01/01/91	10/15/02	04/03/58
37	14	93	23	13995	MO	SPRINGFIELD		01/01/15	10/20/55
39	46	94	55	13993	MO	ST. JOSEPH		01/01/13	
38	45	90	22	13994	MO	ST. LOUIS		01/01/91	06/25/54[c]
45	48	108	32	24033	MT	BILLINGS		01/01/40	09/01/55
47	29	111	22	24143	MT	GREAT FALLS		01/01/42	08/01/59[c]
48	33	109	46	94012	MT	HAVRE		01/01/05	01/25/61[c]
46	36	112	00	24144	MT	HELENA	04/01/94	12/21/02	03/11/58
48	18	114	16	24146	MT	KALISPELL		06/01/99	
46	26	105	52	24037	MT	MILES CITY		01/01/24	
46	55	114	05	24153	MT	MISSOULA		01/01/36	09/04/53[c]
41	20	96	16	94941	NE	DREXEL		06/01/15	
40	51	96	45	14939	NE	LINCOLN		01/01/33	09/09/55[c]
41	22	96	01	94918	NE	NORTH OMAHA	08/01/96	12/20/99	03/14/55
41	08	100	41	24023	NE	NORTH PLATTE		01/01/08	11/07/56
42	52	100	33	24032	NE	VALENTINE		01/01/33	09/01/54[c]
39	17	114	51	23154	NV	ELY		01/01/40	09/10/61[c]
36	05	115	10	23169	NV	LAS VEGAS		01/01/53	05/19/61[c]
39	30	119	47	23185	NV	RENO		01/01/43	11/03/59[c]
38	04	117	14	93142	NV	TONOPAH		01/01/08	

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
40	54	117	48	24128	NV	WINNEMUCCA		01/01/08	03/04/61[c]
43	12	71	30	14745	NH	CONCORD		01/01/38	03/15/65[c]
44	16	71	18	14755	NH	MT. WASHINGTON		01/01/43	(unknown)
39	27	74	34	93730	NJ	ATLANTIC CITY	01/01/97	11/01/99	08/10/58
40	28	74	1	94739	NJ	SANDY HOOK		01/01/15	
40	13	74	46	14773	NJ	TRENTON		05/01/13	06/19/57[c]
35	03	106	37	23050	NM	ALBUQUERQUE		01/01/33	09/18/59[c]
33	18	104	32	23009	NM	ROSWELL		01/01/05	03/01/62[c]
35	37	106	05	23049	NM	SANTA FE	01/01/91	03/01/08	
42	45	73	48	14735	NY	ALBANY		01/01/97	10/23/57[c]
42	13	75	59	04725	NY	BINGHAMTON		10/01/96	(unknown)
42	56	78	44	14733	NY	BUFFALO		01/01/91	08/23/60[c]
44	35	75	10	14743	NY	CANTON		01/01/08	
42	29	76	28	94761	NY	ITHACA		01/01/00	
40	47	73	58	94728	NY	NY CENTRAL PARK		08/01/93	12/31/58[c]
43	27	76	32	14759	NY	OSWEGO		01/01/29	
43	07	77	40	14768	NY	ROCHESTER		01/01/94	05/29/53
43	07	76	07	14771	NY	SYRACUSE		01/01/33	08/28/62[c]
35	26	82	33	03812	NC	ASHEVILLE		01/01/03	09/01/64[c]
35	16	75	33	93729	NC	CAPE HATTERAS		08/01/45	10/12/55[c]
35	13	80	56	13881	NC	CHARLOTTE		10/01/19	(unknown)
36	05	79	57	13723	NC	GREENSBORO		01/01/30	10/06/54
35	52	78	47	13722	NC	RALEIGH/DURHAM		11/01/96	05/17/54
34	16	77	54	13748	NC	WILMINGTON		01/01/94	12/16/53

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
46	46	100	45	24011	ND	BISMARK	04/01/94	01/01/07	05/02/53
48	07	98	52	14912	ND	DEVILS LAKE		01/01/05	
45	59	98	34	94942	ND	ELLENDALE		12/01/17	
46	54	96	48	14914	ND	FARGO		01/01/42	11/01/53[c]
48	11	103	38	94014	ND	WILLISTON		01/01/03	09/15/54[c]
41	25	81	52	14820	OH	CLEVELAND	01/01/91	10/17/96	04/27/53
40	00	82	53	14821	OH	COLUMBUS		01/01/94	06/19/55
39	54	84	12	93815	OH	DAYTON		01/01/13	12/27/53
41	27	82	43	14846	OH	SANDUSKY		01/01/43	
41	36	83	48	94830	OH	TOLEDO		11/01/99	01/12/55[c]
36	02	95	49	03955	OK	BROKEN ARROW		06/01/18	
35	24	97	36	13967	OK	OKLAHOMA CITY		12/01/97	(unknown)
36	12	95	54	13968	OK	TULSA		01/01/43	12/24/56[c]
44	46	117	51	24199	OR	BAKER		02/01/06	
45	36	122	36	24229	OR	PORTLAND	01/01/91	(unknown)	04/22/57[c]
43	14	123	22	24231	OR	ROSEBURG		01/01/31	12/12/55[c]
42	07	80	05	14893	PA	ERIE		03/01/97	
40	13	76	51	14751	PA	HARRISBURG		05/01/97	12/01/54
39	53	75	15	13739	PA	PHILADELPHIA		01/01/91	(unknown)
40	30	80	13	94823	PA	PITTSBURGH		01/01/97	10/16/52
40	27	80	00	14861	PA	PITTSBURGH WSO			10/05/55
40	20	75	58	14767	PA	READING		01/01/13	11/17/65
41	20	75	44	14777	PA	WILKES-BARRE/SCRANTON		01/01/26	07/01/57[c]
41	10	71	34	14799	RI	BLOCK ISLAND		01/01/03	
41	44	71	26	14765	RI	PROVIDENCE		01/01/05	05/20/53[c]

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
32	54	80	02	13880	SC	CHARLESTON		01/01/97	04/13/54
33	57	81	07	13883	SC	COLUMBIA		01/01/38	12/20/53
34	21	82	22	93871	SC	DUE WEST		01/01/21	
34	54	82	13	03870	SC	GREENVILLE/SPAR.		11/01/17	05/03/55
44	23	98	13	14936	SD	HURON		10/01/97	04/10/65
44	03	103	04	24090	SD	RAPID CITY		01/01/08	03/12/57[c]
42	55	97	23	94911	SD	YANKTON		10/01/97	
35	02	85	12	13882	TN	CHATTANOOGA		11/01/96	10/18/56[c]
35	48	84	00	13891	TN	KNOXVILLE		11/01/97	02/23/61[c]
35	03	90	00	13893	TN	MEMPHIS	01/01/91	01/01/02	08/06/54[c]
36	07	86	41	13897	TN	NASHVILLE		01/01/97	11/21/56[c]
32	25	99	41	13962	TX	ABILENE		01/01/45	02/08/54
35	14	101	42	23047	TX	AMARILLO		01/01/05	04/21/55
30	17	97	42	13958	TX	AUSTIN		01/01/27	10/16/53
25	54	97	26	12919	TX	BROWNSVILLE		01/01/23	05/20/54[c]
27	46	97	30	12924	TX	CORPUS CHRISTI		01/01/43	06/01/54
32	54	97	02	03927	TX	DALLAS/FORT WORTH		01/01/14	04/29/58[c]
29	22	100	55	22010	TX	DEL RIO		08/01/18	
31	48	106	24	23044	TX	EL PASO		01/01/08	04/11/53
32	49	97	21	13961	TX	FORT WORTH		01/01/22	
29	18	94	48	12944	TX	GALVESTON	01/01/91	05/21/02	05/10/60
31	30	96	28	13924	TX	GROESBECK		07/01/18	
29	58	95	21	12960	TX	HOUSTON		01/01/10	02/15/54[c]
33	39	101	49	23042	TX	LUBBOCK			01/01/73
31	45	95	40	93914	TX	PALESTINE		01/01/40	
29	57	94	01	12917	TX	PORT ARTHUR		02/01/17	03/12/62[c]
29	32	98	28	12921	TX	SAN ANTONIO		01/01/03	02/28/57[c]

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
38	26	113	01	23176	UT	MILFORD			01/01/73
37	48	113	54	23177	UT	MODENA	05/01/02	10/07/03	
40	47	111	57	24127	UT	SALT LAKE CITY	01/01/91	01/01/00	01/22/54
44	28	73	09	14742	VT	BURLINGTON		04/01/06	04/19/54
44	10	72	41	04721	VT	NORTHFIELD	02/01/96	01/01/03	
36	56	76	00	13727	VA	CAPE HENRY		01/01/26	
37	20	79	12	13733	VA	LYNCHBURG		01/01/03	02/06/63
36	54	76	12	13737	VA	NORFOLK		01/01/02	04/08/55
37	30	77	20	13740	VA	RICHMOND		01/01/03	11/19/63[c]
36	56	81	05	03806	VA	WYTHEVILLE		01/01/03	
46	18	124	05	24226	WA	NORTH HEAD		01/01/04	
48	08	123	24	24228	WA	PORT ANGELES		06/01/16	
47	57	124	33	94240	WA	QUILLAYUTE			01/01/67
47	27	122	18	24233	WA	SEATTLE		11/01/96	09/21/55
47	38	117	32	24157	WA	SPOKANE	07/01/94	11/01/97[c]	02/01/53[c]
47	15	122	26	24239	WA	TACOMA		10/01/97	
48	23	124	44	24240	WA	TATOOSH ISLAND		01/01/34	(unknown)
46	02	118	20	94103	WA	WALLA WALLA		01/01/06	06/01/55[c]
46	34	120	32	24243	WA	YAKIMA		01/01/31	
38	53	79	51	13729	WV	ELKINS		03/01/99	07/01/83[d]
39	16	81	34	13867	WV	PARKERSBURG		08/01/97	07/13/60[e]
44	29	88	08	14898	WI	GREEN BAY		02/01/02	06/01/53[c]
43	52	91	15	14920	WI	LA CROSSE		03/01/02	
43	08	89	20	14837	WI	MADISON		01/01/05	03/01/53[c]
42	57	87	54	14839	WI	MILWAUKEE		01/01/02	03/23/53

Table 1. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE[a] deg.	LONGITUDE[a] min.	WBAN[b] Sta. No.	STATE	STATION NAME	PHOTO-GRAPHIC	THERMO-METRIC	PHOTO-ELECTRIC
44	55	89	37	14897	WI	WAUSAU		01/01/29	
41	09	104	49	24018	WY	CHEYENNE	08/01/96	02/12/08	10/08/53
42	49	108	44	24021	WY	LANDER		01/01/03	11/26/53
44	46	106	58	24029	WY	SHERIDAN		01/01/08	06/12/58[c]
44	58	110	42	24169	WY	YELLOWSTONE		01/01/04	
18	26	66	00	11641	PR	SAN JUAN		01/01/03	01/30/54[c]
13	33	-144	50	41415	PI	GUAM			01/01/57
16	44	169	31	21603	PI	JOHNSTON ISLAND			01/01/59
7	20	-134	29	40309	PI	KOROR			09/01/59
7	05	-171	23	40710	PI	MAJURO			04/01/58
6	58	-158	13	40504	PI	PONAPE			05/01/58
14	20	170	43	61705	PI	TAFUNA			01/01/67
7	27	-151	50	40505	PI	TRUK ISLAND			12/01/59
19	17	-166	39	41606	PI	WAKE ISLAND			01/01/68
9	29	-138	05	40308	PI	YAP ISLAND			12/01/59

[a] Negative values denote east longitude.
[b] Weather Bureau Army Navy
[c] There is uncertainty regarding this date.
[d] Station ceased recording in 1954 but resumed on this date with a photoelectric recorder.

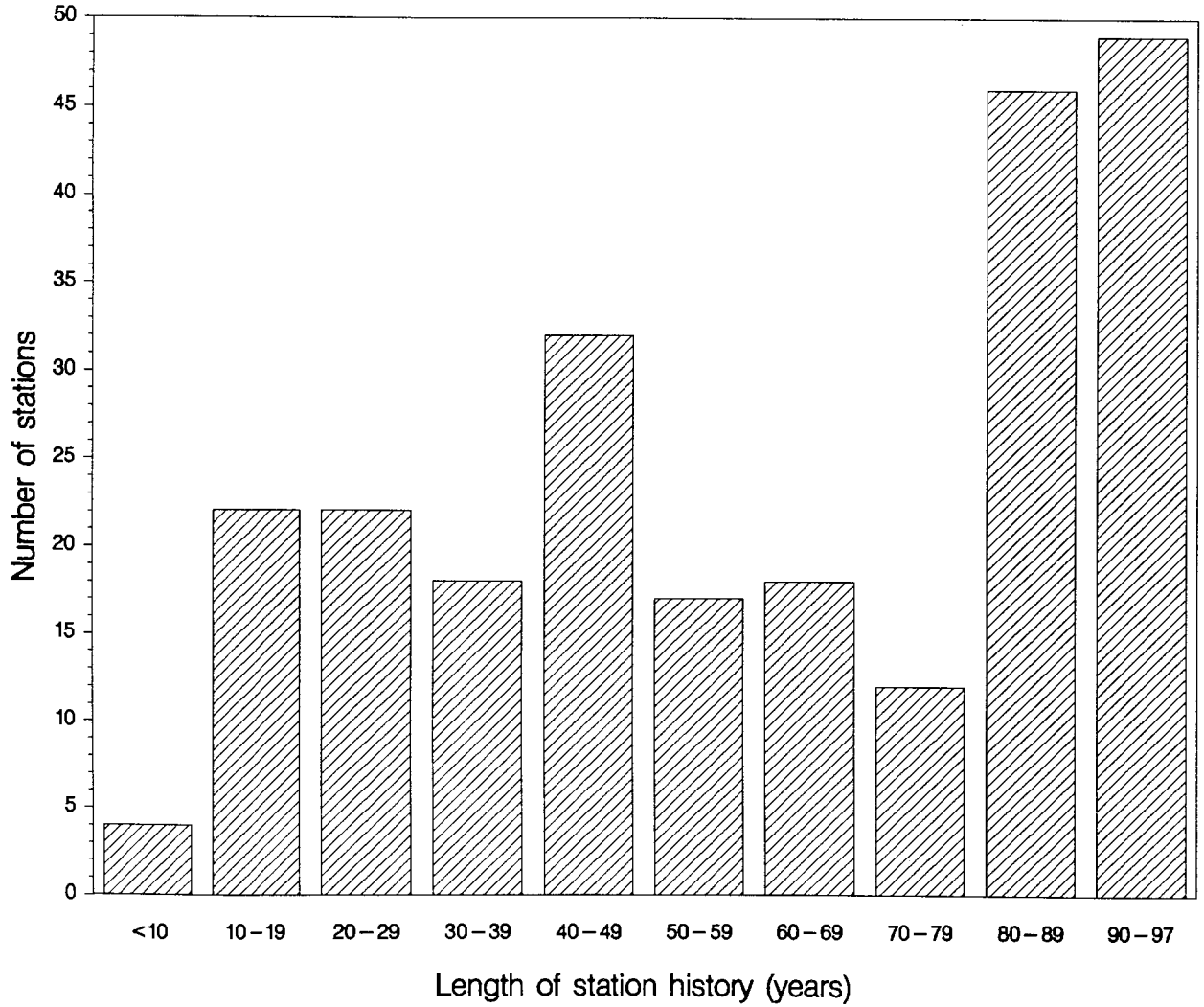

Fig. 5. Distribution of station history lengths from the U.S. sunshine observing network.

Table 2. Inventory of stations in the U.S. cloud observing network, including the date (month/year) on which cloud observing responsibilities moved from city to airport

LATITUDE deg.	LATITUDE min.	LONGITUDE deg.	LONGITUDE min.	WBAN[a] Sta. No.	STATE	STATION	MOVE DATE[b]
33	34	86	45	13876	AL	BIRMINGHAM	07/43
30	41	88	15	13894	AL	MOBILE	01/53
32	18	86	24	13895	AL	MONTGOMERY	09/50
61	10	150	01	26451	AK	ANCHORAGE	02/43
64	49	147	52	26411	AK	FAIRBANKS	07/43
58	22	134	35	25309	AK	JUNEAU	07/43
64	30	165	26	26617	AK	NOME	04/46
35	08	111	40	03103	AZ	FLAGSTAFF	01/50
33	26	112	01	23183	AZ	PHOENIX	02/48
32	08	110	56	23160	AZ	TUCSON	
32	40	114	36	23195	AZ	YUMA	01/49
35	20	94	22	13964	AR	FORT SMITH	10/45
34	44	92	14	13963	AR	LITTLE ROCK	08/42
39	17	120	42	23225	CA	BLUE CANYON	
40	48	124	10	24213	CA	EUREKA	
36	46	119	43	93193	CA	FRESNO	07/39
33	56	118	24	23174	CA	LOS ANGELES	01/50
40	09	122	15	24216	CA	RED BLUFF	08/44
38	31	121	30	23232	CA	SACRAMENTO	02/50
32	44	117	10	23188	CA	SAN DIEGO	02/40
37	37	122	23	23234	CA	SAN FRANCISCO	01/49
39	46	104	52	23062	CO	DENVER	01/49
39	07	108	32	23066	CO	GRAND JUNCTION	08/46
38	17	104	31	93058	CO	PUEBLO	07/40
41	56	72	41	14740	CT	HARTFORD	01/40
41	16	72	53	14758	CT	NEW HAVEN	07/43
38	51	77	02	13743	DC	WASHINGTON	01/49
29	44	85	02	12832	FL	APALACHICOLA	05/75
30	30	81	42	13889	FL	JACKSONVILLE	06/49
24	33	81	45	12836	FL	KEY WEST	07/57
25	48	80	18	12839	FL	MIAMI	01/49
30	28	87	12	13899	FL	PENSACOLA	11/66
27	58	82	32	12842	FL	TAMPA	05/41

Table 2. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE deg.	LONGITUDE min.	WBAN[a] Sta. No.	STATE	STATION	MOVE DATE[b]
33	39	84	26	13874	GA	ATLANTA	12/34
33	22	81	58	03820	GA	AUGUSTA	06/49
32	42	83	39	03813	GA	MACON	10/49
32	08	81	12	03822	GA	SAVANNAH	01/46
19	43	155	04	21504	HI	HILO	
21	20	157	55	22521	HI	HONOLULU	03/51
20	54	156	26	22544	HI	KAHULUI	
21	59	159	21	22536	HI	LIHUE	
43	34	116	13	24131	ID	BOISE	07/39
46	23	117	01	24149	ID	LEWISTON	01/47
42	55	112	36	24156	ID	POCATELLO	09/38
37	00	89	10	93809	IL	CAIRO	
41	59	87	54	94846	IL	CHICAGO	07/42
41	27	90	30	14923	IL	MOLINE	01/44
40	40	89	41	14842	IL	PEORIA	01/42
39	51	89	41	93822	IL	SPRINGFIELD	01/49
38	03	87	32	93817	IN	EVANSVILLE	09/40
41	00	85	12	14827	IN	FORT WAYNE	04/41
39	44	86	16	93819	IN	INDIANAPOLIS	01/43
39	27	87	18	93823	IN	TERRE HAUTE	02/47
40	47	91	07	14931	IA	BURLINGTON	
41	32	93	39	14933	IA	DES MOINES	10/48
42	24	90	42	94908	IA	DUBUQUE	02/51
42	24	96	23	14943	IA	SIOUX CITY	
39	33	97	39	13984	KS	CONCORDIA	06/62
37	46	99	58	13985	KS	DODGE CITY	07/42
39	22	101	42	23065	KS	GOODLAND	
39	04	95	38	13996	KS	TOPEKA	06/49
37	39	97	26	03928	KS	WICHITA	12/40
39	03	84	40	93814	KY	COVINGTON	02/46
38	02	84	36	93820	KY	LEXINGTON	08/44
38	11	85	44	93821	KY	LOUISVILLE	07/45
29	59	90	15	12916	LA	NEW ORLEANS	01/47
32	28	93	49	13957	LA	SHREVEPORT	10/41
44	55	67	00	14608	ME	EASTPORT	

Table 2. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE deg.	LONGITUDE min.	WBAN[a] Sta. No.	STATE	STATION	MOVE DATE[b]
43	39	70	19	14764	ME	PORTLAND	12/40
39	11	76	40	93721	MD	BALTIMORE	08/50
42	22	71	02	14739	MA	BOSTON	01/36
41	15	70	04	14756	MA	NANTUCKET	04/46
45	04	83	34	94849	MI	ALPENA	09/59
42	14	83	20	94847	MI	DETROIT	01/34
45	45	87	03	14824	MI	ESCANABA	
42	53	85	31	94860	MI	GRAND RAPIDS	01/49
42	46	84	36	14836	MI	LANSING	07/54
46	32	87	34	94850	MI	MARQUETTE	01/79
46	28	84	21	14847	MI	SAULT STE. MARIE	07/41
46	50	92	11	14913	MN	DULUTH	01/49
44	53	93	13	14922	MN	MINNEAPOLIS	04/38
43	55	92	30	14925	MN	ROCHESTER	
32	19	90	05	03940	MS	JACKSON	01/46
32	20	88	45	13865	MS	MERIDIAN WSO	10/48
32	21	90	53	93917	MS	VICKSBURG	
38	49	92	13	03945	MO	COLUMBIA	01/40
39	19	94	43	03947	MO	KANSAS CITY	01/34
37	14	93	23	13995	MO	SPRINGFIELD	08/40
38	45	90	22	13994	MO	ST. LOUIS	01/57
45	48	108	32	24033	MT	BILLINGS	
47	29	111	22	24143	MT	GREAT FALLS	
48	33	109	46	94012	MT	HAVRE	01/61
46	36	112	00	24144	MT	HELENA	05/40
48	18	114	16	24146	MT	KALISPELL	05/49
46	26	105	52	24037	MT	MILES CITY	06/43
46	55	114	05	24153	MT	MISSOULA	12/44
40	58	98	19	14935	NE	GRAND ISLAND	
40	51	96	45	14939	NE	LINCOLN	01/51
41	22	96	01	94918	NE	NORTH OMAHA	06/35
41	08	100	41	24023	NE	NORTH PLATTE	01/44
41	52	103	36	24028	NE	SCOTTSBLUFF	
42	52	100	33	24032	NE	VALENTINE	08/55
39	17	114	51	23154	NV	ELY	

Table 2. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE deg.	LONGITUDE min.	WBAN[a] Sta. No.	STATE	STATION	MOVE DATE[b]
36	05	115	10	23169	NV	LAS VEGAS	01/49
39	30	119	47	23185	NV	RENO	09/42
40	54	117	48	24128	NV	WINNEMUCCA	01/51
43	12	71	30	14745	NH	CONCORD	05/41
44	16	71	18	14755	NH	MT. WASHINGTON	
39	27	74	34	93730	NJ	ATLANTIC CITY	08/58
40	13	74	46	14773	NJ	TRENTON	
35	03	106	37	23050	NM	ALBUQUERQUE	01/33
33	18	104	32	23009	NM	ROSWELL	06/47
42	45	73	48	14735	NY	ALBANY	06/38
42	13	75	59	04725	NY	BINGHAMTON	06/51
42	56	78	44	14733	NY	BUFFALO	07/43
40	46	73	54	14732	NY	LA GUARDIA WSO	01/60
43	27	76	32	14759	NY	OSWEGO	
43	07	77	40	14768	NY	ROCHESTER	11/40
43	07	76	07	14771	NY	SYRACUSE	08/40
35	26	82	33	03812	NC	ASHEVILLE	01/65
35	16	75	33	93729	NC	CAPE HATTERAS	
35	13	80	56	13881	NC	CHARLOTTE	05/51
36	05	79	57	13723	NC	GREENSBORO	
35	52	78	47	13722	NC	RALEIGH/DURHAM	01/41
34	16	77	54	13748	NC	WILMINGTON	10/51
46	46	100	45	24011	ND	BISMARK	01/40
48	07	98	52	14912	ND	DEVILS LAKE	
46	54	96	48	14914	ND	FARGO	11/41
48	11	103	38	94014	ND	WILLISTON	01/62
40	55	81	26	14895	OH	AKRON-CANTON	07/48
41	25	81	52	14820	OH	CLEVELAND	06/41
40	00	82	53	14821	OH	COLUMBUS	01/52
39	54	84	12	93815	OH	DAYTON	01/43
41	27	82	43	14846	OH	SANDUSKY	
41	36	83	48	94830	OH	TOLEDO	02/43
35	24	97	36	13967	OK	OKLAHOMA CITY	05/49
36	12	95	54	13968	OK	TULSA	
44	50	117	49	24130	OR	BAKER	

Table 2. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE deg.	LONGITUDE min.	WBAN[a] Sta. No.	STATE	STATION	MOVE DATE[b]
42	23	122	53	24225	OR	MEDFORD	11/29
45	36	122	36	24229	OR	PORTLAND	07/49
43	14	123	22	24231	OR	ROSEBURG	12/52
42	05	80	11	14860	PA	ERIE	09/55
40	13	76	51	14751	PA	HARRISBURG	01/39
39	53	75	15	13739	PA	PHILADELPHIA	01/43
40	30	80	13	94823	PA	PITTSBURGH	06/37
40	20	75	58	14767	PA	READING	
41	20	75	44	14777	PA	WILKES-BARRE/SC	04/55
41	10	71	35	94793	RI	BLOCK ISLAND	11/50
41	44	71	26	14765	RI	PROVIDENCE	11/41
32	54	80	02	13880	SC	CHARLESTON	01/57
33	57	81	07	13883	SC	COLUMBIA	01/49
34	54	82	13	03870	SC	GREENVILLE/SPAR.	01/52
44	23	98	13	14936	SD	HURON	03/39
44	03	103	04	24090	SD	RAPID CITY	01/43
35	02	85	12	13882	TN	CHATTANOOGA	07/40
35	48	84	00	13891	TN	KNOXVILLE	02/42
35	03	90	00	13893	TN	MEMPHIS	01/49
36	07	86	41	13897	TN	NASHVILLE	01/42
32	25	99	41	13962	TX	ABILENE	03/44
35	14	101	42	23047	TX	AMARILLO	04/41
30	17	97	42	13958	TX	AUSTIN	08/42
25	54	97	26	12919	TX	BROWNSVILLE	04/42
27	46	97	30	12924	TX	CORPUS CHRISTI	01/42
32	51	96	51	13960	TX	DALLAS	09/40
32	54	97	02	03927	TX	DALLAS/FORT WORTH	07/39
29	22	100	55	22010	TX	DEL RIO	01/65
31	48	106	24	23044	TX	EL PASO	01/43
29	16	94	52	12923	TX	GALVESTON	05/49
29	58	95	21	12960	TX	HOUSTON	04/61
33	39	101	49	23042	TX	LUBBOCK	
31	45	95	40	93914	TX	PALESTINE	
29	57	94	01	12917	TX	PORT ARTHUR	01/51
29	32	98	28	12921	TX	SAN ANTONIO	01/41
38	26	113	01	23176	UT	MILFORD	
40	47	111	57	24127	UT	SALT LAKE CITY	07/35

Table 2. (continued)

LATITUDE deg.	LATITUDE min.	LONGITUDE deg.	LONGITUDE min.	WBAN[a] Sta. No.	STATE	STATION	MOVE DATE[b]
44	28	73	09	14742	VT	BURLINGTON	06/43
36	56	76	00	13727	VA	CAPE HENRY	
37	20	79	12	13733	VA	LYNCHBURG	08/44
36	54	76	12	13737	VA	NORFOLK	01/50
37	30	77	20	13740	VA	RICHMOND	06/50
46	18	124	05	24226	WA	NORTH HEAD	
47	57	124	33	94240	WA	QUILLAYUTE	
47	27	122	18	24233	WA	SEATTLE	01/54
47	38	117	32	24157	WA	SPOKANE	01/41
47	15	122	26	24239	WA	TACOMA	
48	23	124	44	24240	WA	TATOOSH ISLAND	
46	02	118	20	94103	WA	WALLA WALLA	
38	53	79	51	13729	WV	ELKINS	09/44
39	16	81	34	13867	WV	PARKERSBURG	
44	29	88	08	14898	WI	GREEN BAY	01/51
43	52	91	15	14920	WI	LA CROSSE	02/43
43	08	89	20	14837	WI	MADISON	01/49
42	57	87	54	14839	WI	MILWAUKEE	03/41
41	09	104	49	24018	WY	CHEYENNE	09/35
42	49	108	44	24021	WY	LANDER	06/46
44	46	106	58	24029	WY	SHERIDAN	01/41
18	26	66	00	11641	PR	SAN JUAN	11/49

[a] Weather Bureau Army Navy
[b] The absence of a move date indicates a station in its original location.

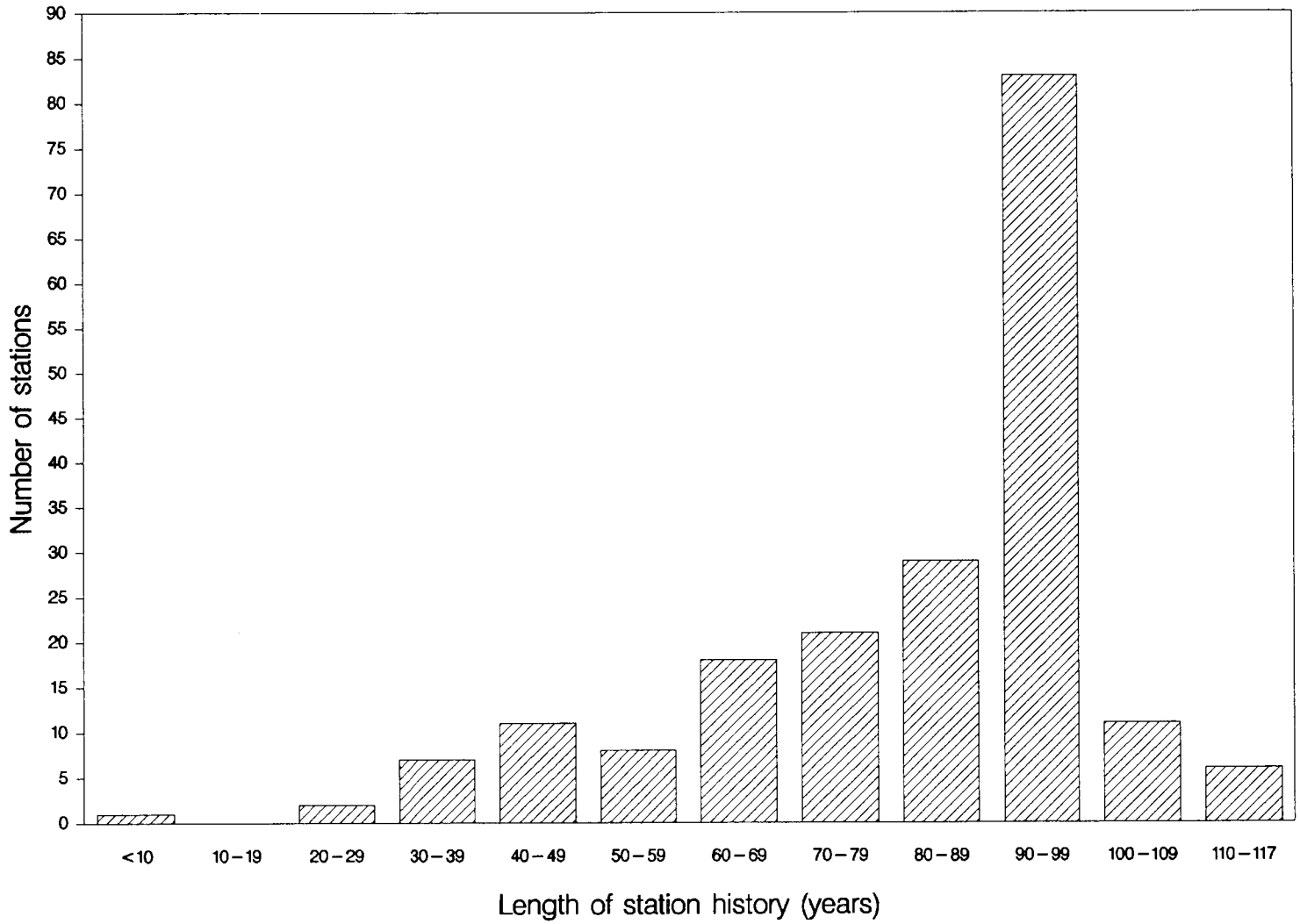

Fig. 6. Distribution of station history lengths from the U.S. cloud observing network.

c) Estimates for Missing Data

The high correlation between clouds and sunshine has led to the development of a procedure that produces an estimate when data are missing in either of the two data sets. Usually, data are fitted to a least-squares regression line, where a slope and y-intercept are computed. A given value in one series can then be used to predict a missing value in the other series. Similarly, suspect values can be flagged for inspection if the value falls outside of some arbitrary range. Unfortunately, these suspect values can seize control of the best-fit line and give totally misleading regression line statistics. Preprocessing of the data by eliminating all extreme values is one method of avoiding this difficulty. Another method is the resistant regression (Emerson and Hoaglin 1983). Resistant regression essentially provides resistance against unusual data points so that these points will have only a small effect on the fitted line. This is done by sorting the predictor variable (values of x) in ascending order and then dividing the data points into three groups. Within each group, the median of the x and y values are determined. A slope and y-intercept is then found using these median values. This initial line is then adjusted by an iterative process using the actual data points. The iterations continue until the adjustments cause a $<1\%$ change in the slope. The resulting line provides resistance to those unusual data points that depart substantially from the primary pattern. It is important to note that the fewer the number of extraneous points, the closer the regression and resistant lines become in regard to slope and y-intercept.

Seasonal and annual resistant line statistics were computed for all stations that recorded at least 10 years of simultaneous monthly cloud and sunshine data during the 1953–1987 period. This reference period was chosen because of the impression that from 1953 onward, all stations in the sunshine recording network were using the photoelectric type of sunshine recorder. Because the performance characteristics of the three types of sunshine recorders used through the years are known to vary (see Appendix B), only the modern-day instrument period was desired for deriving the resistant line statistics. Subsequent to the calculation of these statistics, it was realized through detailed inspections of station histories that most stations had not implemented the photoelectric recorders by 1953. Many did so through the latter years of that decade, and some stations did not switch over until the mid-1960s. Figure 7 depicts the rate of change from the thermometric to photoelectric recorder over this period. The potential impacts of instrumental variations on the quality of the estimates for missing data are discussed in Sect. 7 of this package.

Two sets of seasonal and annual statistics were computed: one using clouds and the other using sunshine as the predictor variable. The seasons were based on the standard climatological periods (i.e., winter being December, January, and February; spring being March, April and May; etc.). An estimate for a missing value in one series was produced by using the corresponding monthly value and seasonal predictor statistics of the other series. If, at a given point, a city had differing station numbers in the sun and cloud data sets, estimates for missing observations were not produced from the corresponding sun or cloud amounts that may have been present. The cloud amount data set has far fewer missing observations than the sunshine data set, which in the case of some stations, has blocks of several years in which estimates were substituted.

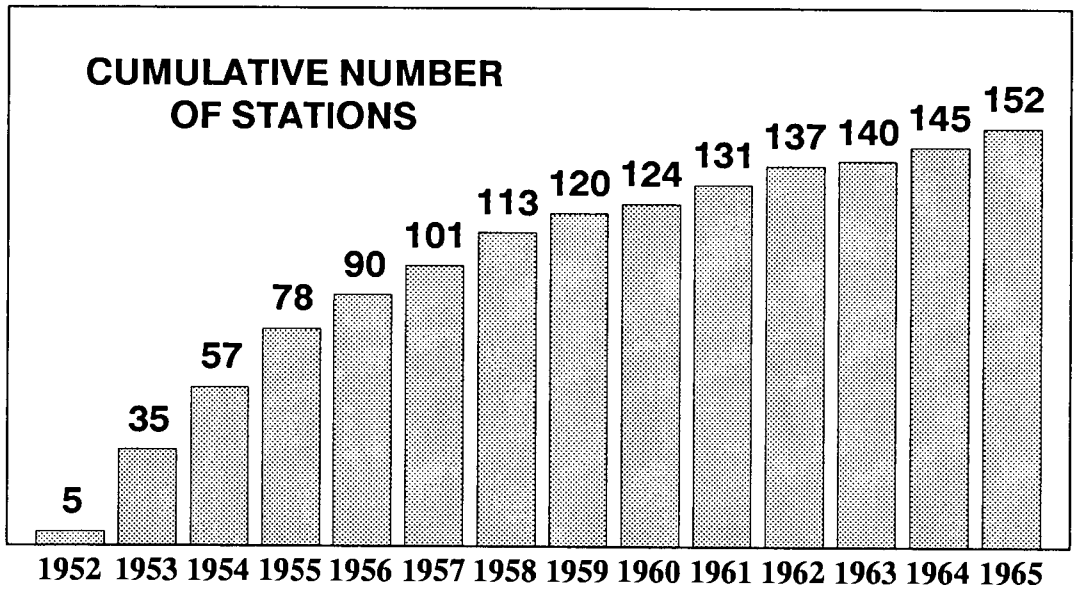

Fig. 7. The rate of change from thermometric to photoelectric sunshine switches in the 1950s and 1960s.

6. APPLICATIONS OF THE DATA

Historical sunshine and cloud data are useful in identifying patterns of spatial and temporal variability in each and in understanding past climatic conditions. As noted in the preceding, for a location in which observations of one of the two variables are missing for a given period, it is possible to produce useful estimates using regression analysis of a period when both variables were observed.

Sunshine duration measurements are useful for examining the availability of sunshine and can be used indirectly to determine average insolation. Historical cloud amount data, coupled with that on cloud type and height, could be useful in conducting earth-atmosphere temperature sensitivity studies.

These new data sets contain the most complete and highest-quality cloud and sunshine time series available to the research community and should prove invaluable in the assessment of climate change in the United States over the last century.

7. LIMITATIONS AND RESTRICTIONS

Inhomogeneities have been created in the sunshine and cloud amount data sets through the evolution of sunshine recorder instrumentation and cloud measurement procedures. These factors and the limitations of the procedure for producing estimates for missing data are discussed separately in the following.

a) Sunshine

Significant differences are known to exist in the sensitivity and responsiveness of the three sunshine recorders used over the years, Specifically, recorders were activated/deactivated at different solar radiation flux density thresholds and by different types of radiation (i.e., by both direct and diffuse radiation or by direct radiation alone). Also, the recorders vary in their ability to activate when the sun is close to the horizon. Observers have been instructed to include the observed but unrecorded sunshine associated with clear sunrise or sunset in the daily totals for sunshine duration. Complex terrain, such as in mountainous regions, can lead to underestimates of measured sunshine. To standardize measurements, all stations correct the recorded sunshine duration by adding the minutes of sunshine considered to be lost to permanent obstructions.

Final factors that must be considered when comparing sunshine measurements are the instrument installation, calibration, and maintenance procedures at all the stations in the network over the period of record. The likelihood that comparable or identical procedures exist for all stations within the network is remote. Because of the subjectivity in some of the corrections and inconsistencies in the sampling methods over time and among stations, caution should be used in any intrastation or interstation comparisons. Basically, the sunshine data recorded with each type of instrument should be treated separately for each station, taking into account the information on dates of usage contained in Table 1.

b) Clouds

Several changes have been made to the cloud measurement procedures used over the period of the historical cloud record; these changes may have introduced serious biases into the data. Cloud measurements were not made at regular observing times until the 1890s, when three official observations were to be made per day (near sunrise and sunset and at 12 noon). However, an estimate of the average cloud cover for the period sunrise to sunset was also determined from frequent personal observations. Hourly observations were supposed to be the rule starting in 1939, but U.S. Weather Bureau instructions through 1948 still contained references to less frequent observations. Through 1934 these observations were made for the most part in urban areas, where observation sites consisted largely of rooftop exposures. With the advent of commercial aviation, increasing numbers of new observation sites were opened at airports, which in many cases undoubtedly resulted in better viewing conditions. These types of changes, coupled with the change in 1949 to observing total "sky cover" (described in Sect. 4 and Appendix C), have probably imparted nonphysical trends on the historical cloud record.

To determine the magnitude of these potential biases, an intercomparison between the independently observed, but highly correlated, cloud and sunshine data was performed for each station. This cross check determined the veracity of reported fluctuations in the cloud and sunshine time series. The results are described in detail by Karl and Steurer (1990). In summary, as cloud cover increases, a corresponding decrease in sunshine is expected, and vice versa. However, as cloudiness increased during the wet 1940s, sunshine only decreased approximately half as much. This change in the relationship between cloud and sunshine amount has occurred several times during the century. The abrupt change in the cloud-sunshine relationship that occurred in the late 1930s and steadily increased through the mid-1950s coincides with the period when cloud observing practices were changing significantly.

c) Estimates for missing data

As described in Sect. 5, estimates of missing sun or cloud data were made using resistant/regression statistics for stations that recorded at least 10 years of simultaneous monthly cloud and sunshine data during the 1953–1987 period. These estimates should prove very useful because they often create continuous monthly and annual records for many stations that would otherwise suffer from numerous gaps. However, some caution should be used with these data because for some stations they were derived from regression statistics that may have been adversely affected by using sunshine data from both a thermometric recorder and a photoelectric recorder. This effect is the likely cause of erroneous estimates of percentage of possible sunshine produced for Hartford, Connecticut, from 1924 through 1934. The history of annual sun and cloud amount for Hartford (including these estimates) is shown in Fig. 8. The large spike which the estimates have produced in the sunshine curve is thought to be erroneous because no observed sunshine amounts of this magnitude are found outside the estimate period, even though similar cloud amounts were observed both before and after this period. These 11 years of estimates for Hartford have been removed from the percentage of possible sunshine file. Other multiyear periods of sunshine estimates, inserted prior to the onset of actual measurements at many stations, were also removed as they too contained especially high values when compared with these stations' subsequent measured data.

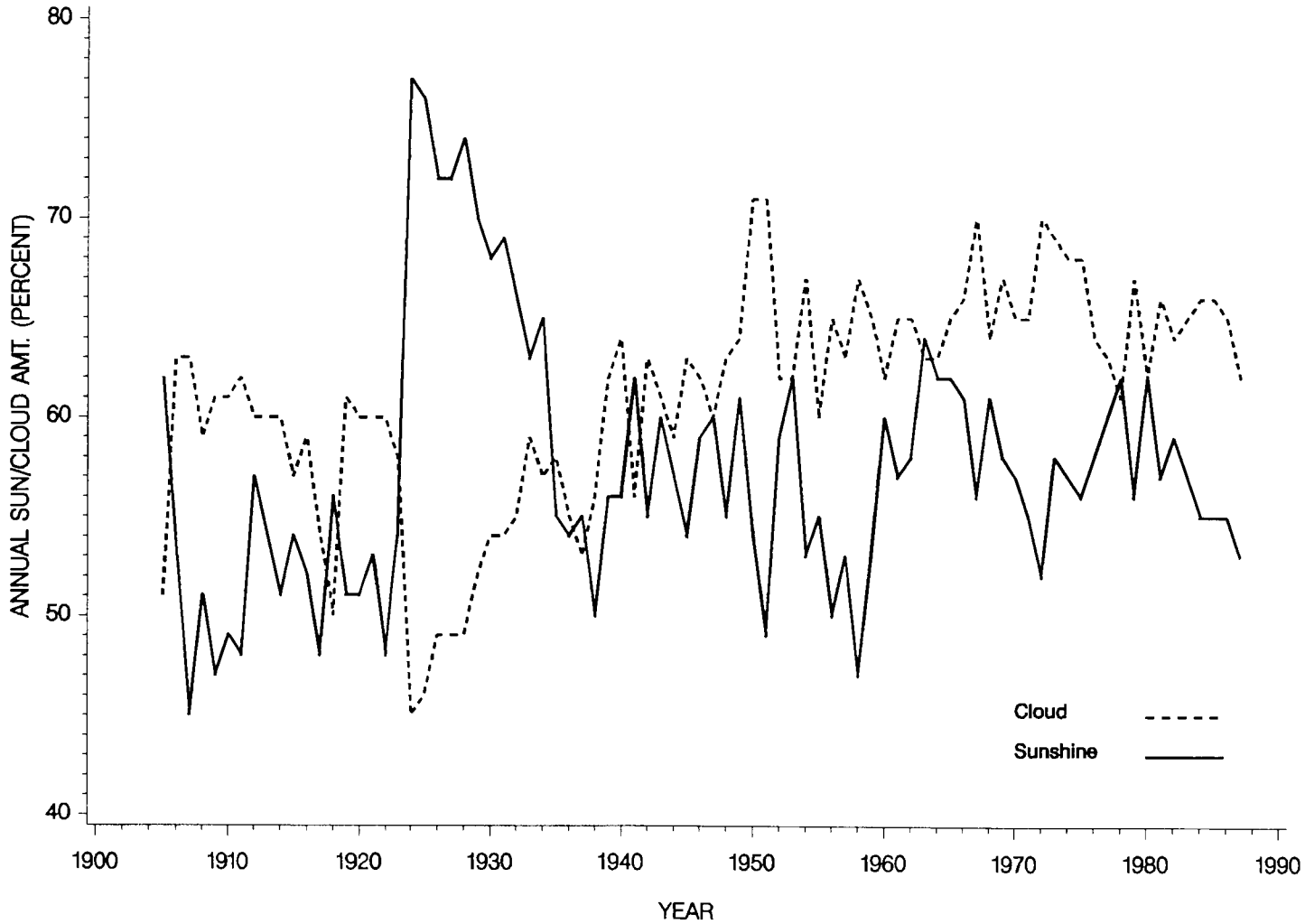

Fig. 8. Annual percentage of possible sunshine and annual cloud amount (percentage) for Hartford, Connecticut, 1905–1987

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9. QUALITY ASSURANCE OF THE SUNSHINE AND CLOUD DATA BASE

An important part of the numeric data package process at CDIAC is the quality assurance (QA) of data before distribution. Data received at CDIAC are rarely in perfect condition for immediate distribution, regardless of the source. To guarantee data of the highest possible quality, CDIAC conducts extensive QA reviews. Reviews involve examining the data for completeness, reasonableness, and accuracy. Although they have common objectives, these reviews are tailored to each data set, often requiring extensive programming efforts. Although time-consuming, the QA process is an important component in the value-added concept of assuring accurate, usable data for researchers.

NCDC examined the sunshine and cloud time series after inserting estimates for missing data where possible. Simple differences for both sunshine and cloud amounts were computed between the actual monthly values and the corresponding values predicted through the use of seasonal resistant line statistics described in Sect. 5. Seasonal means and standard deviations of these errors or deviations from the resistant line were then computed. Standard Z-scores were computed and values greater than 2 or less than -2 were flagged for inspection. These inspections involved comparisons with values from the original observation forms.

Thorough QA checks were conducted by CDIAC on receiving the sunshine and cloud data sets. These checks are described in the following.

QA Checks

1. All files were checked for erroneous WBAN (Weather Bureau Army Navy) station numbers, missing value codes (other than -9999 and -99), and dates outside the maximum periods of record.

2. The percentage of possible sunshine file and the cloud amount file were checked for values less than 0% and greater than 100%. These files were also checked for data flags that were not included in NCDC documentation.

3. The maximum possible hours of sunshine file was checked to make sure that February and annual values of possible sunshine were a reasonable number of hours higher in leap years than in non-leap years.

4. Mean, minimum, and maximum values were determined from the monthly time series of sunshine and cloud amount at each station. Inspection of monthly series statistics was critical in determining the reasonableness of data from each station. Several outliers were identified, and in consultation with NCDC these were researched and subsequently verified or corrected.

5. To assess the reasonableness of estimated values, plots of monthly and annual sunshine and cloud amounts were made for stations that had several years of estimated data that happened to contain outliers. Some periods of multiyear estimated sunshine data were deemed unreasonable and removed from the record.

Modifications

1. The maximum possible hours of sunshine file received from NCDC had two records for each station: one containing monthly and annual values for non-leap years and one containing monthly and annual values for leap years. A new file was created by CDIAC having one record per station containing non-leap-year monthly and annual values and the appropriate adjustment factor for February and annual values in a leap year.

2. All files received from NCDC identified stations via WBAN number. CDIAC chose to regenerate the files, adding state and station name to each record.

10. HOW TO OBTAIN THE DATA PACKAGE

This document contains listings of the stations in the U.S. sunshine and cloud observing networks (Tables 1 and 2), listings of the monthly and annual maximum possible hours of sunshine for stations in the sunshine network (Appendix D), and a set of microfiche (inside the back cover of this document) containing the three sunshine files (measured hours of sunshine, maximum possible hours of sunshine, and percentage of possible sunshine) and the one cloudiness file [fractional cloud amount (percentage)].

These U.S. sunshine and cloudiness files are available on request on a nine-track, magnetic tape or IBM-formatted diskettes from CDIAC. Requests for the magnetic tape should include any specific instructions for transmitting the data required by the user to access the data. Requests not accompanied by specific instructions will be filled on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC (Extended Binary Codes Decimal Interchange Code), and files will be formatted as shown in Sect. 11. Requests for the data on floppy diskettes should specify preferences for 5.25 or 3.5 inch diskettes and high or low density. Requests should be addressed to:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, Tennessee 37831-6335
U.S.A.

The tape and documentation can be ordered by telephone, fax, or through electronic mail.

Telephone:	(615)	574-0390
	FTS	624-0390
Fax:	(615)	574-2232
	FTS	624-2232

Electronic Mail: BITNET: CDP@ORNLSTC
OMNET: CDIAC
INTERNET: CDP@STC10.CTD.ORNL.GOV

PART 2

INFORMATION ABOUT THE MAGNETIC TAPE

11. CONTENTS OF THE MAGNETIC TAPE

The following is a list of files distributed on magnetic tape by CDIAC along with this documentation.

File number and description	Logical records	Record format[a]	Block size	Record length
1. General descriptive information file	602	FB	6160	110
2. FORTRAN IV data retrieval code to read and print the measured hours of sunshine file (File 10)	32	FB	8000	80
3. FORTRAN IV data retrieval code to read and print the maximum possible hours of sunshine file (File 11)	30	FB	8000	80
4. FORTRAN IV data retrieval code to read and print the percentage of possible sunshine file (File 12)	43	FB	8300	83
5. FORTRAN IV data retrieval code to read and print the cloud amount file (File 13)	43	FB	8300	83
6. SAS™ input/output routine to read and print the measured hours of sunshine file (File 10)	16	FB	8800	88
7. SAS™ input/output routine to read and print the maximum possible hours of sunshine file (File 11)	19	FB	8000	80

File number and description	Logical records	Record format[a]	Block size	Record length
8. SAS™ input/output routine to read and print the percentage of possible sunshine file (File 12)	41	FB	8,000	80
9. SAS™ input/output routine to read and print the cloud amount file (File 13)	41	FB	8,000	80
10. Monthly and annual measured hours of sunshine	14,355	FB	5,600	112
11. Monthly and annual maximum possible hours of sunshine	240	FB	8,900	89
12. Monthly and annual percentage of possible sunshine	14,582	FB	7,400	148
13. Monthly and annual cloud amounts (%)	16,272	FB	7,400	148
Total records	46,316			

[a]FB = fixed block.

12. DESCRIPTIVE FILE ON THE MAGNETIC TAPE

The following is a listing of the first file on the magnetic tape distributed by CDIAC. This file is intended to provide the details (i.e., variable descriptions, formats, and units) about each file associated with this numeric data package.

TITLE OF THE DATA SET

Historical Sunshine and Cloud Data in the United States

DATA CONTRIBUTORS

Peter M. Steurer and Thomas R. Karl
National Oceanic and Atmospheric Administration
National Climatic Data Center
Asheville, North Carolina 28801

SOURCE AND SCOPE OF THE DATA

a) Sunshine

Sunshine data for 240 U.S. stations (including Puerto Rico and nine islands in the Pacific Ocean) are presented for the years 1891–1987. The periods of record of monthly and annual total hours of sunshine vary widely from station to station. Many of the stations have discontinuous sampling periods and only 49 (20%) have periods of record equal to or greater than 90 years. However, 192 stations (80%) have periods of record equal to or greater than 30 years.

In addition to the total monthly and annual measurements of sunshine duration, total monthly and annual maximum possible sunshine duration and monthly and annual percentages of possible sunshine duration are also provided. Maximum possible sunshine values for the 240-station recording network range from a minimum of 4418 h at the southernmost station (Tofuna, Pacific Ocean) to a maximum of 4591 h at the northernmost station (Fairbanks, Alaska). The highest annual sunshine amount ever recorded in the United States was at Yuma, Arizona, with 4272 h (96% of possible) in 1958, and the lowest ever recorded was at Mt. Washington, New Hampshire, with 1181 h (26% of possible) in 1943.

In terms of annual percentage of possible sunshine, the highest amount ever recorded was 96% at Yuma, Arizona, in 1958 and the lowest amount ever recorded was 18% at Juneau, Alaska, in 1939. In the continental United States, the lowest annual percentage of possible sunshine ever recorded was 23% at Quillayute, Washington, in 1986.

b) Clouds

Cloud amount data for 197 U.S. stations are presented for the years 1871–1987. Most of the stations in the cloud observing network are also present in the sunshine recorder network, but the earlier opening of several stations for cloud observing purposes, coupled with a higher percentage of stations remaining open through 1987 to measure cloud amount, has resulted in the cloud amount data set being longer and more complete than the sunshine data set. For example, 100 stations (51%) have periods of record at least 90 years in length and 194 stations (98%) have records for at least 30 years.

In compiling the cloud amount data set, only monthly sunrise to sunset cloud amount averages (percentages) were used. This eliminated problems associated with nighttime measurements and also maintained consistency in any comparisons with the monthly sunshine data.

c) Estimates for Missing Data

The high correlation between clouds and sunshine has led to the development of a procedure that produces an estimate when data are missing in either of the two data sets. Usually, data are fitted to a least-squares regression line where a slope and y-intercept are computed. A given value in one series can then be used to predict a missing value in the other series. Similarly, suspect values can be flagged for inspection if the value falls outside of some arbitrary range. Unfortunately, these suspect values can seize control of the best-fit line and give totally misleading regression line statistics. Preprocessing of the data by eliminating all extreme values is one method of avoiding this difficulty. Another method is the resistant regression (Emerson and Hoaglin 1983). Resistant regression essentially provides resistance against unusual data points so that these points will have only a small effect on the fitted line. This is done by sorting the predictor variable (values of x) in ascending order and then dividing the data points into three groups. Within each group, the median of the x and y values are determined. A slope and y-intercept is then found using these median values. This initial line is then adjusted by an iterative process using the actual data points. The iterations continue until the adjustments cause less than a 1% change in the slope. The resulting line provides resistance to those unusual data points that depart substantially from the primary pattern. It is important to note that the fewer the number of extraneous points, the closer the regression and resistant lines become with regard to slope and y-intercept.

Seasonal and annual resistant line statistics were computed for all stations that recorded at least 10 years of simultaneous monthly cloud and sunshine data during the 1953–1987 period. This reference period was chosen because of the impression that from 1953 onward, all stations in the sunshine recording network were using the photoelectric type of sunshine recorder. Because the performance characteristics of the three types of sunshine recorders used through the years are known to vary, only the modern-day instrument period was desired for deriving the resistant line statistics. Subsequent to the calculation of these statistics, it was realized through detailed inspection of station histories that most stations had not implemented the photoelectric recorders by 1953. Many did so through the latter years of that decade, and some stations did not switch over until the mid-1960s (see Table 1 of the accompanying documentation).

Two sets of seasonal and annual statistics were computed: one using clouds and the other using sunshine as the predictor variable. The seasons were based on the standard climatological periods (i.e., winter being December, January, and February; spring being March, April, and May; etc). An estimate for a missing value in one series was produced by using the corresponding monthly value and seasonal predictor statistics of the other series when both were available for a given month. The cloud amount data set has far fewer missing observations than does the sunshine data set, which in the case of some stations, has blocks of several years in which estimates were substituted. These estimates should prove very useful, as they often create continuous monthly and annual records for many stations that would otherwise suffer from numerous gaps. However, some caution should be used with these data, since, in the case of some stations, they were derived from regression statistics that may have been adversely affected by using sunshine data from a thermometric recorder together with those from a photoelectric recorder.

DATA FORMAT

Thirteen files are provided on this tape including this descriptive file: four FORTRAN IV input/output routines; four SAS™ input/output routines; one file containing monthly and annual values of measured hours of sunshine; one file containing monthly and annual values of the maximum possible hours of sunshine; one file containing monthly and annual values of measured sunshine expressed as a percentage of that possible; and one file containing monthly and annual cloud amounts (percentage).

MEASURED HOURS OF SUNSHINE FILE

The measured hours of sunshine file (File 10 on the magnetic tape) contains monthly and annual hours of sunshine for each year from each of the 240 sunshine stations. The data are sorted by WBAN (Weather Bureau Army Navy) station number, with each record containing the WBAN station number, information on any previous WBAN station number, state name and station name, monthly values of hours of sunshine, and an annual value of hours of sunshine. Missing sunshine amounts are set to -99.

The file may be read using the following FORTRAN format:

```
      INTEGER WBAN, PWBAN, MON, YEAR, HRSSUN(12), TOTAL
      CHARACTER*18 STNAME

      READ (5,100,END=99)WBAN,PWBAN,MON,STNAME,YEAR,(HRSSUN(I),I=1,12),
     + TOTAL
100   FORMAT(2(1X,I5),1X,I2,2X,A18,2X,I4,12(2X,I3),3X,I4)
```

or by using the SAS format:

```
INPUT WBAN 2-6 PWBAN 8-12 MON 14-15
    STNAME $ 18-35 YEAR 38-41
    JAN 44-46 FEB 49-51 MAR 54-56 APR 59-61
    MAY 64-66 JUN 69-71 JUL 74-76 AUG 79-81
    SEP 84-86 OCT 89-91 NOV 94-96 DEC 99-101 TOTAL 105-108;
```

Stated in tabular form, the contents include the following.

Variable	Variable type	Variable width	Starting column	Ending column
WBAN	Numeric	5	2	6
PWBAN	Numeric	5	8	12
MON	Numeric	2	14	15
STNAME	Character	18	18	35
YEAR	Numeric	4	38	41
JAN	Numeric	3	44	46
FEB	Numeric	3	49	51
MAR	Numeric	3	54	56
APR	Numeric	3	59	61
MAY	Numeric	3	64	66
JUN	Numeric	3	69	71
JUL	Numeric	3	74	76
AUG	Numeric	3	79	81
SEP	Numeric	3	84	86
OCT	Numeric	3	89	91
NOV	Numeric	3	94	96
DEC	Numeric	3	99	101
TOTAL	Numeric	4	105	108

where

WBAN is the 1987 WBAN station number or the number during the final year of a station's record;

PWBAN is the actual WBAN number that was assigned during that year in the record (set to 0 after the first year in which the latest WBAN number was assigned, set to 99999 for years in which the WBAN number was not known or not assigned);

MON is the month when a new WBAN number went into effect (set to 0 for years when no change took place);

STNAME is the state abbreviation and station name;

YEAR is the year of the data;

JAN-DEC are the monthly measured hours of sunshine values (nearest whole hour); and

TOTAL is the total hours of sunshine recorded in that year (nearest whole hour).

MAXIMUM POSSIBLE HOURS OF SUNSHINE FILE

The maximum possible hours of sunshine file (File 11 on the magnetic tape) contains monthly and annual values for the maximum hours of sunshine that could be received at each station. The file is sorted by WBAN station number, with each record containing WBAN station number, state and station name, monthly and annual maximum possible sunshine amounts (hours) for non-leap years, and an adjustment factor (hours) to be added to the February and annual values in leap years.

The file may be read using the following FORTRAN format:

```
      INTEGER WBAN, MAXSUN(12)
      REAL TOTAL, ADJ
      CHARACTER*18 STNAME
      READ (5,100,END=99) WBAN, STNAME, (MAXSUN(I),I=1,12), TOTAL, ADJUST
  100 FORMAT(1X,I5,1X,A18,12(1X,I3),1X,F6.1,1X,F4.1)
```

or by using the SAS format:

```
INPUT WBAN 2-6  STNAME $ 8-25
      JAN 27-29 FEB 31-33 MAR 35-37 APR 39-41 MAY 43-45 JUN 47-49 JUL 51-53
      AUG 55-57 SEP 59-61 OCT 63-65 NOV 67-69 DEC 71-73 TOTAL 75-80
      ADJUST 82-85;
```

Stated in tabular form, the contents include the following.

Variable	Variable type	Variable width	Starting column	Ending column
WBAN	Numeric	5	2	6
STNAME	Character	18	8	25
JAN	Numeric	3	27	29
FEB	Numeric	3	31	33
MAR	Numeric	3	35	37
APR	Numeric	3	39	41
MAY	Numeric	3	43	45
JUN	Numeric	3	47	49
JUL	Numeric	3	51	53
AUG	Numeric	3	55	57
SEP	Numeric	3	59	61
OCT	Numeric	3	63	65
NOV	Numeric	3	67	69
DEC	Numeric	3	71	73
TOTAL	Numeric	6	75	80
ADJUST	Numeric	4	82	85

where

WBAN is the WBAN station number;

STNAME is the state abbreviation and station name;

JAN-DEC are the monthly values of the maximum hours of sunshine possible at that station (nearest whole hour);

TOTAL is the maximum hours of sunshine possible at that station in a non-leap year (given to the nearest tenth of an hour, e.g., 4447.3); and

ADJUST is the number of hours to add to FEB and TOTAL for leap years (also given to the nearest tenth of an hour, e.g., 11.4).

PERCENTAGE OF POSSIBLE SUNSHINE FILE

The percentage of possible sunshine file (File 12 on the magnetic tape) contains monthly and annual values of percentage of possible sunshine for each year from each of the 240 sunshine stations. The file is sorted by WBAN station number, with each record containing WBAN station number, state and station name, monthly sunshine percentages (missing values are set to -9999) with each month's four respective data flags, and an

annual sunshine percentage (the mean of the monthly values, if none are set to missing; otherwise set to the missing indicator -9999).

The file may be read using the following FORTRAN format:

```
      INTEGER WBAN, YEAR, SUNPCT(12), MEANC
      CHARACTER FLAG1(12), FLAG2(12), FLAG3(12), FLAG4(12)
      CHARACTER*18 STNAME
      READ (5,100,END=99) WBAN, STNAME, YEAR,
     + (SUNPCT(I),FLAG1(I),FLAG2(I),FLAG3(I),FLAG4(I),I=1,12), MEAN
100   FORMAT(1X,I5,1X,A18,1X,I4,12(I5,4(A1)),1X,I5)
```

or by using the SAS format:

```
INPUT WBAN 2-6 STNAME $ 8-25 YEAR 27-30
 JAN 31-35 JANFL1 $ 36 JANFL2 $ 37 JANFL3 $ 38 JANFL4 $ 39
 FEB 40-44 FEBFL1 $ 45 FEBFL2 $ 46 FEBFL3 $ 47 FEBFL4 $ 48
 MAR 49-53 MARFL1 $ 54 MARFL2 $ 55 MARFL3 $ 56 MARFL4 $ 57
 APR 58-62 APRFL1 $ 63 APRFL2 $ 64 APRFL3 $ 65 APRFL4 $ 66
 MAY 67-71 MAYFL1 $ 72 MAYFL2 $ 73 MAYFL3 $ 74 MAYFL4 $ 75
 JUN 76-80 JUNFL1 $ 81 JUNFL2 $ 82 JUNFL3 $ 83 JUNFL4 $ 84
 JUL 85-89 JULFL1 $ 90 JULFL2 $ 91 JULFL3 $ 92 JULFL4 $ 93
 AUG 94-98 AUGFL1 $ 99 AUGFL2 $ 100 AUGFL3 $ 101 FEBFL4 $ 102
 SEP 103-107 SEPFL1 $ 108 SEPFL2 $ 109 SEPFL3 $ 110 MARFL4 $ 111
 OCT 112-111 OCTFL1 $ 117 OCTFL2 $ 118 OCTFL3 $ 119 OCTFL4 $ 120
 NOV 121-125 NOVFL1 $ 126 NOVFL2 $ 127 NOVFL3 $ 128 NOVFL4 $ 129
 DEC 130-134 DECFL1 $ 135 DECFL2 $ 136 DECFL3 $ 137 DECFL4 $ 138
 MEAN 140-144;
```

Stated in tabular form, the contents include the following.

Variable	Variable type	Variable width	Starting column	Ending column
WBAN	Numeric	5	2	6
STNAME	Character	18	8	25
YEAR	Numeric	4	27	30
JAN	Numeric	5	31	35
JANFL1	Alphanumeric	1	36	36
JANFL2	Alphanumeric	1	37	37
JANFL3	Alphanumeric	1	38	38
JANFL4	Alphanumeric	1	39	39
FEB	Numeric	5	40	44
FEBFL1	Alphanumeric	1	45	45
FEBFL2	Alphanumeric	1	46	46
FEBFL3	Alphanumeric	1	47	47
FEBFL4	Alphanumeric	1	48	48
MAR	Numeric	5	49	53
MARFL1	Alphanumeric	1	54	54
MARFL2	Alphanumeric	1	55	55
MARFL3	Alphanumeric	1	56	56
MARFL4	Alphanumeric	1	57	57
APR	Numeric	5	58	62
APRFL1	Alphanumeric	1	63	63
APRFL2	Alphanumeric	1	64	64
APRFL3	Alphanumeric	1	65	65
APRFL4	Alphanumeric	1	66	66
MAY	Numeric	5	67	71
MAYFL1	Alphanumeric	1	72	72
MAYFL2	Alphanumeric	1	73	73
MAYFL3	Alphanumeric	1	74	74
MAYFL4	Alphanumeric	1	75	75
JUN	Numeric	5	76	80
JUNFL1	Alphanumeric	1	81	81
JUNFL2	Alphanumeric	1	82	82
JUNFL3	Alphanumeric	1	83	83
JUNFL4	Alphanumeric	1	84	84
JUL	Numeric	5	85	89
JULFL1	Alphanumeric	1	90	90
JULFL2	Alphanumeric	1	91	91
JULFL3	Alphanumeric	1	92	92
JULFL4	Alphanumeric	1	93	93
AUG	Numeric	5	94	98
AUGFL1	Alphanumeric	1	99	99
AUGFL2	Alphanumeric	1	100	100

Variable	Variable type	Variable width	Starting column	Ending column
AUGFL3	Alphanumeric	1	101	101
AUGFL4	Alphanumeric	1	102	102
SEP	Numeric	5	103	107
SEPFL1	Alphanumeric	1	108	108
SEPFL2	Alphanumeric	1	109	109
SEPFL3	Alphanumeric	1	110	110
SEPFL4	Alphanumeric	1	111	111
OCT	Numeric	5	112	116
OCTFL1	Alphanumeric	1	117	117
OCTFL2	Alphanumeric	1	118	118
OCTFL3	Alphanumeric	1	119	119
OCTFL4	Alphanumeric	1	120	120
NOV	Numeric	5	121	125
NOVFL1	Alphanumeric	1	126	126
NOVFL2	Alphanumeric	1	127	127
NOVFL3	Alphanumeric	1	128	128
NOVFL4	Alphanumeric	1	129	129
DEC	Numeric	5	130	134
DECFL1	Alphanumeric	1	135	135
DECFL2	Alphanumeric	1	136	136
DECFL3	Alphanumeric	1	137	137
DECFL4	Alphanumeric	1	138	138
MEAN	Numeric	5	140	144

where

WBAN is the WBAN station number;

STNAME is the state abbreviation and station name;

YEAR is the year of the data;

JAN-DEC are the monthly percentages of possible sunshine (nearest whole percent), with missing values set to -9999; and

MEAN is the mean of the monthly sunshine percentages, if all 12 are available; otherwise set to the missing indicator -9999.

Flag codes for the data

The use of flags in the percentage of possible sunshine file was generally modeled after the U.S. Historical Climatology Network (HCN) format, examples of which may be found in Karl et al. (1990). This meant that each monthly data value had four flag positions. For consistency, these flag positions are retained in the percentage of possible sunshine file, but their use has been simplified as follows.

(JAN-DEC) FL1 is a general data type flag. The codes are as follows:

Z = value has been estimated by resistant regression on cloud data, and

Blank = value based on observations (see Flag 2 for details).

(JAN-DEC) FL2 is the data source code. The codes are as follows:

3 = Manuscript—Original National Climatic Data Center Records;
7 = LCD—*Local Climatological Data*, published monthly by the National Climatic Data Center (NCDC), Asheville, North Carolina;
T = NCDC Tape Deck 9788;
I = NCDC Tape Deck 9788—value is an estimate because of incomplete data for the month [i.e., at least one missing day (actual number not available)];
C = NCDC Tape Deck 9788—value from deck has been edited after comparison with the monthly cloud amount from the station; and
Z = value has been estimated by resistant regression on cloud amount.

(JAN-DEC) FL3 has the same meaning as Flag 1.

(JAN-DEC) FL4 has the same meaning as Flag 1.

CLOUD AMOUNT FILE

The cloud amount file (File 13 on the magnetic tape) contains monthly and annual cloud amounts (percentage of sky cover) for each year from each of 197 stations. The file is sorted by WBAN station number, with each record containing WBAN station number, state and station name, monthly cloud amounts (missing values are set to -9999) with each month's 4 respective data flags, and an annual cloud amount (the mean of the monthly values if none are set to missing; otherwise set to the missing indicator -9999).

The file may be read using the following FORTRAN format:

```
      INTEGER WBAN, YEAR, CLDPCT(12), MEAN
      CHARACTER FLAG1(12), FLAG2(12), FLAG3(12), FLAG4(12)
      CHARACTER*18 STNAME
      READ (5,100,END=99) WBAN, STNAME, YEAR,
     + (CLDPCT(I),FLAG1(I),FLAG2(I),FLAG3(I),FLAG4(I),I=1,12), MEAN
100   FORMAT(1X,I5,1X,A18,1X,I4,12(I5,4(A1)),1X,I5)
```

or by using the SAS format:

```
INPUT WBAN 2-6 STNAME $ 8-25 YEAR 27-30
 JAN 31-35 JANFL1 $ 36 JANFL2 $ 37 JANFL3 $ 38 JANFL4 $ 39
 FEB 40-44 FEBFL1 $ 45 FEBFL2 $ 46 FEBFL3 $ 47 FEBFL4 $ 48
 MAR 49-53 MARFL1 $ 54 MARFL2 $ 55 MARFL3 $ 56 MARFL4 $ 57
 APR 58-62 APRFL1 $ 63 APRFL2 $ 64 APRFL3 $ 65 APRFL4 $ 66
 MAY 67-71 MAYFL1 $ 72 MAYFL2 $ 73 MAYFL3 $ 74 MAYFL4 $ 75
 JUN 76-80 JUNFL1 $ 81 JUNFL2 $ 82 JUNFL3 $ 83 JUNFL4 $ 84
 JUL 85-89 JULFL1 $ 90 JULFL2 $ 91 JULFL3 $ 92 JULFL4 $ 93
 AUG 94-98 AUGFL1 $ 99 AUGFL2 $ 100 AUGFL3 $ 101 FEBFL4 $ 102
 SEP 103-107 SEPFL1 $ 108 SEPFL2 $ 109 SEPFL3 $ 110 MARFL4 $ 111
 OCT 112-111 OCTFL1 $ 117 OCTFL2 $ 118 OCTFL3 $ 119 OCTFL4 $ 120
 NOV 121-125 NOVFL1 $ 126 NOVFL2 $ 127 NOVFL3 $ 128 NOVFL4 $ 129
 DEC 130-134 DECFL1 $ 135 DECFL2 $ 136 DECFL3 $ 137 DECFL4 $ 138
 MEAN 140-144;
```

Stated in tabular form, the contents include the following.

Variable	Variable type	Variable width	Starting column	Ending column
WBAN	Numeric	5	2	6
STNAME	Character	18	8	25
YEAR	Numeric	4	27	30
JAN	Numeric	5	31	35
JANFL1	Alphanumeric	1	36	36
JANFL2	Alphanumeric	1	37	37
JANFL3	Alphanumeric	1	38	38
JANFL4	Alphanumeric	1	39	39
FEB	Numeric	5	40	44
FEBFL1	Alphanumeric	1	45	45
FEBFL2	Alphanumeric	1	46	46
FEBFL3	Alphanumeric	1	47	47
FEBFL4	Alphanumeric	1	48	48
MAR	Numeric	5	49	53
MARFL1	Alphanumeric	1	54	54
MARFL2	Alphanumeric	1	55	55
MARFL3	Alphanumeric	1	56	56
MARFL4	Alphanumeric	1	57	57
APR	Numeric	5	58	62
APRFL1	Alphanumeric	1	63	63
APRFL2	Alphanumeric	1	64	64
APRFL3	Alphanumeric	1	65	65
APRFL4	Alphanumeric	1	66	66
MAY	Numeric	5	67	71
MAYFL1	Alphanumeric	1	72	72
MAYFL2	Alphanumeric	1	73	73
MAYFL3	Alphanumeric	1	74	74
MAYFL4	Alphanumeric	1	75	75
JUN	Numeric	5	76	80
JUNFL1	Alphanumeric	1	81	81
JUNFL2	Alphanumeric	1	82	82
JUNFL3	Alphanumeric	1	83	83
JUNFL4	Alphanumeric	1	84	84
JUL	Numeric	5	85	89
JULFL1	Alphanumeric	1	90	90
JULFL2	Alphanumeric	1	91	91
JULFL3	Alphanumeric	1	92	92
JULFL4	Alphanumeric	1	93	93
AUG	Numeric	5	94	98
AUGFL1	Alphanumeric	1	99	99

Variable	Variable type	Variable width	Starting column	Ending column
AUGFL2	Alphanumeric	1	100	100
AUGFL3	Alphanumeric	1	101	101
AUGFL4	Alphanumeric	1	102	102
SEP	Numeric	5	103	107
SEPFL1	Alphanumeric	1	108	108
SEPFL2	Alphanumeric	1	109	109
SEPFL3	Alphanumeric	1	110	110
SEPFL4	Alphanumeric	1	111	111
OCT	Numeric	5	112	116
OCTFL1	Alphanumeric	1	117	117
OCTFL2	Alphanumeric	1	118	118
OCTFL3	Alphanumeric	1	119	119
OCTFL4	Alphanumeric	1	120	120
NOV	Numeric	5	121	125
NOVFL1	Alphanumeric	1	126	126
NOVFL2	Alphanumeric	1	127	127
NOVFL3	Alphanumeric	1	128	128
NOVFL4	Alphanumeric	1	129	129
DEC	Numeric	5	130	134
DECFL1	Alphanumeric	1	135	135
DECFL2	Alphanumeric	1	136	136
DECFL3	Alphanumeric	1	137	137
DECFL4	Alphanumeric	1	138	138
MEAN	Numeric	5	140	144

where

WBAN is the WBAN station number;

STNAME is the state abbreviation and station name;

YEAR is the year of the data;

JAN-DEC are the monthly cloud amounts (nearest whole percent of sky cover); and

MEAN is the mean of the monthly cloud amounts, if all 12 are present; otherwise set to the missing indicator -9999.

Flag codes for the data

The use of flags in the cloud amount file was also generally modeled after the U.S. HCN format (Karl et al. 1990). The four flag positions normally associated with each monthly value are retained in the file, but their use has been customized as follows.

(JAN-DEC) FL1 is a dual purpose code pertaining to either (1) the number of daily values not available in computing the monthly mean cloud amount or (2) how an estimate of the monthly mean cloud amount has been produced. The codes and their meanings are as follows:

A,B,C, . . . I corresponds to 1,2,3 . . . 9 days missing;
Blank = no missing days;
X = value has been estimated from manuscript entries (see Flag 2); and
Z = value has been estimated by resistant regression on percentage of possible sunshine.

(JAN-DEC) FL2 is the data source code. The codes and their meanings are as follows:

1 = NCDC Tape Deck 3210, Summary of the Day, First Order;
3 = Manuscript—Original National Climatic Data Center Records;
5 = Climate Record Book—for a description, see *History of Climatological Record Books*, U.S. Department of Commerce, Weather Bureau, U.S.G.P.O., 1960;
7 = LCD—*Local Climatological Data*, published monthly by NCDC;
M = *Monthly Weather Review*, U.S. Weather Bureau, U.S.G.P.O., 1872–1966;
R = *Report of the Chief of the Weather Bureau*, U.S. Weather Bureau, U.S.G.P.O., 1891–1934;
United States Meteorological Yearbook, U.S.G.P.O., 1935–1949; or
Climatological Data, National Summary, U.S. Weather Bureau, Asheville, North Carolina, 1950–1980; and
Z = value has been estimated by resistant regression on percentage of possible sunshine.

(JAN-DEC) FL3 is the location code. The codes and their meanings are as follows:

0 = primary station location is current;
U = previous station number unknown;
1 = prior city or airport location;
2 = second city or airport location;
3 = third airport location; and
Z = value has been estimated by resistant regression on percentage of possible sunshine.

(JAN-DEC) FL4 is an additional source qualifier. The codes and their meanings are as follows:

C = computed by technician from data available in the nondigital source specified by Flag 2;
Blank = data are directly from the source specified by Flag 2; and
Z = value has been estimated by resistant regression on percent of possible sunshine.

REFERENCES

Emerson, J. D., and D. C. Hoaglin. 1983. Resistant lines for y versus x. pp. 129-65. IN D. C. Hoaglin, F. Mosteller, and J. W. Tukey, eds., *Understanding Robust and Exploratory Data Analysis*. John Wiley & Sons.

Karl, T. R., C. N. Williams, Jr., and F. T. Quinlan. 1990. United States Historical Climatology Network (HCN) serial temperature and precipitation data. ORNL/CDIAC-30, NDP-019/R1. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

13. LISTINGS OF THE FORTRAN IV DATA RETRIEVAL PROGRAMS

The following is a listing of the FORTRAN IV data retrieval program provided on magnetic tape (File 2 on the tape) by CDIAC for reading and printing the measured hours of sunshine file (File 10 on the tape). The job control language (JCL) statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDMAX JOB(12345,TAPE,IO10),'USER ADDRESS',TIME=(,30)
// EXEC FORTQCLG
//FORT.SYSIN DD *
C
C FORTRAN RETRIEVAL CODE TO READ AND PRINT THE MEASURED
C HOURS OF SUNSHINE FILE (FILE 10 ON THE MAGNETIC TAPE).
C
      INTEGER WBAN, PWBAN, MON, YEAR, HRSSUN(12), TOTAL
      CHARACTER*18 STNAME
C
C INITIALIZE A COUNTER FOR THE NUMBER OF RECORDS OUTPUT.
      NREC = 0
C
    1 CONTINUE
       READ (5,100,END=99) WBAN, PWBAN, MON, STNAME, YEAR,
     + (HRSSUN(I),I=1,12), TOTAL
  100 FORMAT(2(1X,I5),1X,I2,2X,A18,2X,I4,12(2X,I3),3X,I4)
C
C WRITE OUT A HEADER ON EACH PAGE OF THE LISTING.
      IF (MOD(NREC,56).EQ.0) WRITE(6,200)
C
      WRITE(6,100) WBAN, PWBAN, MON, STNAME, YEAR, (HRSSUN(I),I=1,12),
TOTAL
C
      NREC = NREC + 1
C
  200 FORMAT('1','WBAN# PREV# MO  STATE AND STATION   YEAR  JAN  ',
     + 'FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  ',
     + 'TOTAL',/)
C
      GO TO 1
C
   99 CONTINUE
      STOP
      END
```

```
/*
//GO.FT05F001 DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
//   DSN=TAB.NDP021R1.OBSHRS.DATA,LABEL=(10,SL,EXPDT=98000)
//GO.FT06F001 DD *
//
```

The following is a listing of the FORTRAN IV data retrieval program provided on magnetic tape (File 3 on the tape) by CDIAC for reading and printing the maximum possible hours of sunshine file (File 11 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements shown in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDMAX JOB(12345,TAPE,IO10),'USER ADDRESS',TIME=(,30)
// EXEC FORTQCLG
//FORT.SYSIN DD *
C
C FORTRAN RETRIEVAL CODE TO READ AND PRINT THE MAXIMUM
POSSIBLE
C HOURS OF SUNSHINE FILE (FILE 11 ON THE MAGNETIC TAPE)
C
      INTEGER WBAN, MAXSUN(12)
      REAL TOTAL, ADJUST
      CHARACTER*18 STNAME
C
C INITIALIZE A COUNTER FOR THE NUMBER OF RECORDS OUTPUT.
      NREC = 0
C
    1 CONTINUE
      READ (5,100,END=99) WBAN, STNAME, (MAXSUN(I),I=1,12), TOTAL,
      ADJUST
C
  100 FORMAT(1X,I5,1X,A18,12(1X,I3),1X,F6.1,1X,F4.1)
C
C WRITE OUT A HEADER ON EACH PAGE OF THE LISTING.
      IF (MOD(NREC,56).EQ.0) WRITE(6,200)
C
      WRITE(6,100) WBAN, STNAME, (MAXSUN(I),I=1,12), TOTAL, ADJUST
C
      NREC = NREC + 1
C
  200 FORMAT('1',79X,'LEAPYR',/,1X,'WBAN  STATE AND STATION  JAN ',
     + 'FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC  TOTAL ADJ.',/)
C
      GO TO 1
   99 CONTINUE
      STOP
      END
/*
//GO.FT05F001 DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
```

```
//   DSN=TAB.NDP021R1.MAXSUN.DATA,LABEL=(11,SL,EXPDT=98000)
//GO.FT06F001 DD *
//
```

The following is a listing of the FORTRAN IV data retrieval program provided on magnetic tape (File 4 on the tape) by CDIAC for reading and printing the percentage of possible sunshine file (File 12 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDSUN JOB (12345,TAPE,IO10),'USER ADDRESS',TIME=(1,00)
//   EXEC FORTQCLG
//FORT.SYSIN DD *
C
C FORTRAN RETRIEVAL CODE TO READ AND PRINT THE PERCENTAGE OF
C POSSIBLE SUNSHINE FILE (FILE 12 ON THE MAGNETIC TAPE).
C
      INTEGER WBAN, YEAR, SUNPCT(12), MEAN
C
      CHARACTER FLAG1(12), FLAG2(12), FLAG3(12), FLAG4(12)
      CHARACTER*18 STNAME
C
C INITIALIZE A COUNTER FOR THE NUMBER OF RECORDS PRINTED.
      NREC = 0
C
    1 CONTINUE
      READ (5,100,END=99) WBAN, STNAME, YEAR,
     + (SUNPCT(I),FLAG1(I),FLAG2(I),FLAG3(I),FLAG4(I),I=1,12), MEAN
C
  100 FORMAT(1X,I5,1X,A18,1X,I4,12(I5,4(A1)),1X,I5)
C
C WRITE OUT A HEADER ON EACH PAGE OF THE LISTING.
      IF (MOD(NREC,28).EQ.0) WRITE(6,200)
C
      WRITE(6,201) WBAN, STNAME, YEAR,
     + (SUNPCT(I),FLAG1(I),FLAG2(I),FLAG3(I),FLAG4(I),I=1,12), MEAN
C
      NREC = NREC + 1
C
  200 FORMAT('1','WBAN  STATE AND STATION',/,2X,'YEAR    JAN',
     + '      FEB      MAR      APR      MAY      JUN',
     + '      JUL      AUG      SEP      OCT      NOV',
     + '      DEC     MEAN',/)
C
  201 FORMAT(1X,I5,1X,A18,/,2X,I4,12(1X,I5,4(A1)),1X,I5)
C
      GO TO 1
```

```
C
  99 CONTINUE
     STOP
     END
/*
//GO.FT05F001 DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
//   DSN=TAB.NDP021R1.PCTSUN.DATA,LABEL=(12,SL,EXPDT=98000)
//GO.FT06F001 DD *
//
```

The following is a listing of the FORTRAN IV data retrieval program provided on magnetic tape (File 5 on the tape) by CDIAC for reading and printing the cloud amount file (File 13 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements shown in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDCLD JOB (12345,TAPE,IO10),'USER ADDRESS',TIME=(1,00)
//   EXEC FORTQCLG
//FORT.SYSIN DD *
C
C FORTRAN RETRIEVAL CODE TO READ AND PRINT THE CLOUD AMOUNT
C FILE (FILE 13 ON THE MAGNETIC TAPE).
C
      INTEGER WBAN, YEAR, CLDPCT(12), MEAN
C
      CHARACTER FLAG1(12), FLAG2(12), FLAG3(12), FLAG4(12)
      CHARACTER*18 STNAME
C
C INITIALIZE A COUNTER FOR THE NUMBER OF RECORDS OUTPUT.
      NREC = 0
C
    1 CONTINUE
      READ (5,100,END=99) WBAN, STNAME, YEAR,
     + (CLDPCT(I),FLAG1(I),FLAG2(I),FLAG3(I),FLAG4(I),I=1,12), MEAN
C
  100 FORMAT(1X,I5,1X,A18,1X,I4,12(I5,4(A1)),1X,I5)
C
C WRITE OUT A HEADER ON EACH PAGE OF THE LISTING.
      IF (MOD(NREC,28).EQ.0) WRITE(6,200)
C
      WRITE(6,201) WBAN, STNAME, YEAR,
     + (CLDPCT(I),FLAG1(I),FLAG2(I),FLAG3(I),FLAG4(I),I=1,12), MEAN
C
      NREC = NREC + 1
C
  200 FORMAT('1','WBAN  STATE AND STATION',/,2X,'YEAR    JAN',
     + '      FEB      MAR      APR      MAY      JUN',
     + '      JUL      AUG      SEP      OCT      NOV',
     + '      DEC     MEAN',/)
C
  201 FORMAT(1X,I5,1X,A18,/,2X,I4,12(1X,I5,4(A1)),1X,I5)
C
      GO TO 1
```

```
C
  99 CONTINUE
     STOP
     END
/*
//GO.FT05F001 DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
//   DSN=TAB.NDP021R1.PCTCLD.DATA,LABEL=(13,SL,EXPDT=98000)
//GO.FT06F001 DD *
//
```

14. LISTINGS OF THE SAS™ INPUT/OUTPUT RETRIEVAL PROGRAMS

The following is a listing of the SAS™ data retrieval program provided on magnetic tape (File 6 on the tape) by CDIAC for reading and printing the measured hours of sunshine file (File 10 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements shown in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDHRS JOB (12345,TAPE,IO10),'USER ADDRESS',TIME=(,30)
// EXEC SAS,SASRGN=4096K,WORK=1600
//IN DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
// DSN=TAB.NDP021R1.OBSHRS.DATA,LABEL=(10,SL,EXPDT=98000)
//FT06F001 DD SYSOUT=A
//SYSIN DD *
* SAS RETRIEVAL CODE TO READ AND PRINT THE MEASURED HOURS OF
SUNSHINE FILE (FILE 10 ON THE MAGNETIC TAPE);
DATA HRSSUN;
 INFILE IN;
  INPUT WBAN 2-6 PWBAN 8-12 MON 14-15
  STATION $ 18-35 YEAR 38-41
  JAN 44-46 FEB 49-51 MAR 54-56 APR 59-61 MAY 64-66 JUN 69-71 JUL 74-76 AUG 79-81
  SEP 84-86 OCT 89-91 NOV 94-96 DEC 99-101 TOTAL 105-108;
 FILE PRINT NOTITLE HEADER=NEWPAGE;
 PUT _INFILE_;
 RETURN;
 NEWPAGE:
 PUT @2 'WBAN# PREV# MO  STATE & STATION     YEAR  JAN  FEB'
 ' MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  TOTAL'/;
RETURN;
RUN;
/*
//
```

The following is a listing of the SAS™ data retrieval program provided on magnetic tape (File 7 on the tape) by CDIAC for reading and printing the maximum possible hours of sunshine file (File 11 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements shown in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDMAX JOB (12345,TAPE,IO10),'USER ADDRESS',TIME=(,30)
//   EXEC SAS,SASRGN=4096K,WORK=1600
//IN DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
//  DSN=TAB.NDP021R1.MAXSUN.DATA,LABEL=(11,SL,EXPDT=98000)
//FT06F001 DD SYSOUT=A
//SYSIN DD *

* SAS RETRIEVAL CODE TO READ AND PRINT THE MAXIMUM POSSIBLE
  HOURS OF SUNSHINE FILE (FILE 11 ON THE MAGNETIC TAPE);

DATA MAXSUN;

 INFILE IN;
 INPUT WBAN 2-6  STATION $ 8-25
      JAN 27-29 FEB 31-33 MAR 35-37 APR 39-41
      MAY 43-45 JUN 47-49 JUL 51-53 AUG 55-57
      SEP 59-61 OCT 63-65 NOV 67-69 DEC 71-73
      TOTAL 75-80  ADJUST 82-85;

 FILE PRINT NOTITLE HEADER=NEWPAGE;
 PUT _INFILE_;
 RETURN;

 NEWPAGE:
 PUT @81 'LEAPYR' /
 @2  'WBAN  STATE & STATION    JAN FEB MAR APR MAY'
    ' JUN JUL AUG SEP OCT NOV DEC  TOTAL ADJ.'/;
 RETURN;

RUN;
/*
//
```

The following is a listing of the SAS™ data retrieval program provided on magnetic tape (File 8 on the tape) by CDIAC for reading and printing the percentage of possible sunshine file (File 12 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements shown in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDMAX JOB (12345,TAPE,IO10),'USER ADDRESS',TIME=(,30)
//   EXEC SAS,SASRGN=4096K,WORK=1600
//IN DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
//   DSN=TAB.NDP021R1.PCTSUN.DATA,LABEL=(12,SL,EXPDT=98000)
//FT06F001 DD SYSOUT=A
//SYSIN DD *

* SAS RETRIEVAL CODE TO READ AND PRINT THE PERCENTAGE OF
POSSIBLE    SUNSHINE FILE (FILE 12 ON THE MAGNETIC TAPE);

DATA PCTSUN;

INFILE IN;
INPUT WBAN 2-6 STATE $ 8-9 STANAME $ 11-25 YEAR 27-30
 JAN 31-35 JANFL1 $ 36 JANFL2 $ 37 JANFL3 $ 38 JANFL4 $ 39
 FEB 40-44 FEBFL1 $ 45 FEBFL2 $ 46 FEBFL3 $ 47 FEBFL4 $ 48
 MAR 49-53 MARFL1 $ 54 MARFL2 $ 55 MARFL3 $ 56 MARFL4 $ 57
 APR 58-62 APRFL1 $ 63 APRFL2 $ 64 APRFL3 $ 65 APRFL4 $ 66
 MAY 67-71 MAYFL1 $ 72 MAYFL2 $ 73 MAYFL3 $ 74 MAYFL4 $ 75
 JUN 76-80 JUNFL1 $ 81 JUNFL2 $ 82 JUNFL3 $ 83 JUNFL4 $ 84
 JUL 85-89 JULFL1 $ 90 JULFL2 $ 91 JULFL3 $ 92 JULFL4 $ 93
 AUG 94-98 AUGFL1 $ 99 AUGFL2 $ 100 AUGFL3 $ 101 FEBFL4 $ 102
 SEP 103-107 SEPFL1 $ 108 SEPFL2 $ 109 SEPFL3 $ 110 MARFL4 $ 111
 OCT 112-116 OCTFL1 $ 117 OCTFL2 $ 118 OCTFL3 $ 119 OCTFL4 $ 120
 NOV 121-125 NOVFL1 $ 126 NOVFL2 $ 127 NOVFL3 $ 128 NOVFL4 $ 129
 DEC 130-134 DECFL1 $ 135 DECFL2 $ 136 DECFL3 $ 137 DECFL4 $ 138
 MEAN 140-144;

 FILE PRINT NOTITLE HEADER=NEWPAGE;

 PUT WBAN 2-6 STATE $ 8-9 STANAME $ 11-25 / YEAR 3-6
  JAN 8-12  JANFL1 $ 13 JANFL2 $ 14 JANFL3 $ 15 JANFL4 $ 16
  FEB 18-22 FEBFL1 $ 23 FEBFL2 $ 24 FEBFL3 $ 25 FEBFL4 $ 26
  MAR 28-32 MARFL1 $ 33 MARFL2 $ 34 MARFL3 $ 35 MARFL4 $ 36
  APR 38-42 APRFL1 $ 43 APRFL2 $ 44 APRFL3 $ 45 APRFL4 $ 46
  MAY 48-52 MAYFL1 $ 53 MAYFL2 $ 54 MAYFL3 $ 55 MAYFL4 $ 56
  JUN 58-62 JUNFL1 $ 63 JUNFL2 $ 64 JUNFL3 $ 65 JUNFL4 $ 66
```

```
 JUL 68-72 JULFL1 $ 73 JULFL2 $ 74 JULFL3 $ 75 JULFL4 $ 76
 AUG 78-82 AUGFL1 $ 83 AUGFL2 $ 84 AUGFL3 $ 85 FEBFL4 $ 86
 SEP 88-92 SEPFL1 $ 93 SEPFL2 $ 94 SEPFL3 $ 95 MARFL4 $ 96
 OCT 98-102 OCTFL1 $ 103 OCTFL2 $ 104 OCTFL3 $ 105 OCTFL4 $ 106
 NOV 108-112 NOVFL1 $ 113 NOVFL2 $ 114 NOVFL3 $ 115 NOVFL4 $ 116
 DEC 118-122 DECFL1 $ 123 DECFL2 $ 124 DECFL3 $ 125 DECFL4 $ 126
 MEAN 128-132;
RETURN;

NEWPAGE:
PUT @2 'WBAN  STATE & STATION'/
@3 'YEAR    JAN      FEB      MAR      APR      MAY      JUN'
'     JUL      AUG      SEP      OCT      NOV      DEC'
'    MEAN'/;
RETURN;

RUN;
/*
//
```

The following is a listing of the SAS™ data retrieval program provided on magnetic tape (File 9 on the tape) by CDIAC for reading and printing the cloud amount file (File 13 on the tape). The JCL statements (preceded by // or /*) shown in the following are not provided in the file on the magnetic tape. The JCL statements required will vary for each operating system. The JCL statements shown in the following are provided to illustrate the statements that would be required by an individual at ORNL who has requested these data on a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC and who is attempting to read the tape on an IBM mainframe (e.g., IBM 3090).

```
//UIDMAX JOB (12345,TAPE,IO10),'USER ADDRESS',TIME=(,30)
//   EXEC SAS,SASRGN=4096K,WORK=1600
//IN DD UNIT=TAPE62,VOL=SER=TAPENUMB,DISP=(,PASS),
//   DSN=TAB.NDP021R1.PCTCLD.DATA,LABEL=(13,SL,EXPDT=98000)
//FT06F001 DD SYSOUT=A
//SYSIN DD *

* SAS RETRIEVAL CODE TO READ AND PRINT THE CLOUD AMOUNT FILE
(FILE    13 ON THE MAGNETIC TAPE);

DATA PCTCLD;

INFILE IN;
INPUT WBAN 2-6 STATE $ 8-9 STANAME $ 11-25 YEAR 27-30
 JAN 31-35 JANFL1 $ 36 JANFL2 $ 37 JANFL3 $ 38 JANFL4 $ 39
 FEB 40-44 FEBFL1 $ 45 FEBFL2 $ 46 FEBFL3 $ 47 FEBFL4 $ 48
 MAR 49-53 MARFL1 $ 54 MARFL2 $ 55 MARFL3 $ 56 MARFL4 $ 57
 APR 58-62 APRFL1 $ 63 APRFL2 $ 64 APRFL3 $ 65 APRFL4 $ 66
 MAY 67-71 MAYFL1 $ 72 MAYFL2 $ 73 MAYFL3 $ 74 MAYFL4 $ 75
 JUN 76-80 JUNFL1 $ 81 JUNFL2 $ 82 JUNFL3 $ 83 JUNFL4 $ 84
 JUL 85-89 JULFL1 $ 90 JULFL2 $ 91 JULFL3 $ 92 JULFL4 $ 93
 AUG 94-98 AUGFL1 $ 99 AUGFL2 $ 100 AUGFL3 $ 101 FEBFL4 $ 102
 SEP 103-107 SEPFL1 $ 108 SEPFL2 $ 109 SEPFL3 $ 110 MARFL4 $ 111
 OCT 112-116 OCTFL1 $ 117 OCTFL2 $ 118 OCTFL3 $ 119 OCTFL4 $ 120
 NOV 121-125 NOVFL1 $ 126 NOVFL2 $ 127 NOVFL3 $ 128 NOVFL4 $ 129
 DEC 130-134 DECFL1 $ 135 DECFL2 $ 136 DECFL3 $ 137 DECFL4 $ 138
 MEAN 140-144;

 FILE PRINT NOTITLE HEADER=NEWPAGE;

 PUT WBAN 2-6 STATE $ 8-9 STANAME $ 11-25 / YEAR 3-6
  JAN 8-12  JANFL1 $ 13 JANFL2 $ 14 JANFL3 $ 15 JANFL4 $ 16
  FEB 18-22 FEBFL1 $ 23 FEBFL2 $ 24 FEBFL3 $ 25 FEBFL4 $ 26
  MAR 28-32 MARFL1 $ 33 MARFL2 $ 34 MARFL3 $ 35 MARFL4 $ 36
  APR 38-42 APRFL1 $ 43 APRFL2 $ 44 APRFL3 $ 45 APRFL4 $ 46
  MAY 48-52 MAYFL1 $ 53 MAYFL2 $ 54 MAYFL3 $ 55 MAYFL4 $ 56
  JUN 58-62 JUNFL1 $ 63 JUNFL2 $ 64 JUNFL3 $ 65 JUNFL4 $ 66
```

```
 JUL 68-72 JULFL1 $ 73 JULFL2 $ 74 JULFL3 $ 75 JULFL4 $ 76
 AUG 78-82 AUGFL1 $ 83 AUGFL2 $ 84 AUGFL3 $ 85 FEBFL4 $ 86
 SEP 88-92 SEPFL1 $ 93 SEPFL2 $ 94 SEPFL3 $ 95 MARFL4 $ 96
 OCT 98-102 OCTFL1 $ 103 OCTFL2 $ 104 OCTFL3 $ 105 OCTFL4 $ 106
 NOV 108-112 NOVFL1 $ 113 NOVFL2 $ 114 NOVFL3 $ 115 NOVFL4 $ 116
 DEC 118-122 DECFL1 $ 123 DECFL2 $ 124 DECFL3 $ 125 DECFL4 $ 126
 MEAN 128-132;
RETURN;

NEWPAGE:
PUT @2 'WBAN  STATE & STATION'/
@3 'YEAR    JAN      FEB      MAR      APR      MAY      JUN'
'     JUL      AUG      SEP      OCT      NOV      DEC'
'    MEAN'/;
RETURN;

RUN;
/*
//
```

15. VERIFICATION OF DATA TRANSPORT

The four sunshine/cloudiness data files described herein may be read using the FORTRAN or SAS™ input/output routines provided. Users should verify that the files have been correctly transported to their systems by generating some or all of the statistics presented in Tables 3 through 6. These statistics were generated in SAS™ (PROC MEANS) but can be duplicated in other statistical packages or languages. If the statistics generated by the user differ from those presented here, the files may have been corrupted in transport.

These statistics are presented only as a tool to ensure proper reading of the data files. They are not to be construed as either a summary of the sunshine and cloud data or an indicator of trends in these data.

Table 3. Characteristics of numeric variables from the measured hours of sunshine file (File 10)

Variable	Number of observations	Mean	Minimum value	Maximum value
WBAN	14,355	31,231.225496	3,103.000000	94,942.000000
PWBAN	14,355	19,015.446116	0.000000	99,999.000000
MON	14,355	0.066388	0.000000	12.000000
YEAR	14,355	1,944.120376	1,891.000000	1,987.000000
JAN	14,355	146.623615	-99.000000	321.000000
FEB	14,355	161.070289	-99.000000	318.000000
MAR	14,355	211.587809	-99.000000	367.000000
APR	14,355	239.066318	-99.000000	391.000000
MAY	14,355	278.802926	-99.000000	473.000000
JUN	14,355	295.445768	-99.000000	488.000000
JUL	14,355	311.755277	-99.000000	465.000000
AUG	14,355	284.495367	-99.000000	431.000000
SEP	14,355	239.653501	-99.000000	374.000000
OCT	14,355	210.249112	-99.000000	349.000000
NOV	14,355	153.570603	-99.000000	310.000000
DEC	14,355	134.841310	-99.000000	320.000000
TOTAL	14,355	2,624.442564	-99.000000	4,272.000000

Table 4. Characteristics of numeric variables from the maximum possible hours of sunshine file (File 11)

Variable	Number of observations	Mean	Minimum value	Maximum value
WBAN	240	33,327.104167	3,103.000000	94,942.000000
JAN	240	302.933333	164.000000	399.000000
FEB	240	300.766667	236.000000	352.000000
MAR	240	370.733333	365.000000	377.000000
APR	240	397.045833	353.000000	457.000000
MAY	240	444.116667	355.000000	581.000000
JUN	240	446.808333	339.000000	643.000000
JUL	240	453.254167	352.000000	619.000000
AUG	240	423.700000	361.000000	511.000000
SEP	240	373.429167	361.000000	392.000000
OCT	240	346.529167	300.000000	385.000000
NOV	240	301.691667	189.000000	383.000000
DEC	240	293.245833	124.000000	402.000000
TOTAL	240	4,454.301667	4,418.500000	4581.50000
ADJUST	240	11.329167	10.100000	12.40000

Table 5. Characteristics of numeric variables from the percentage of possible sunshine file (File 12)

Variable	Number of observations	Mean	Minimum value	Maximum value
WBAN	14,582	31,091.606913	3,103.000000	94,942.000000
YEAR	14,582	1,944.263818	1,891.000000	1,987.000000
JAN	14,582	2.189412	-9,999.000000	100.000000
FEB	14,582	11.736319	-9,999.000000	100.000000
MAR	14,582	12.390893	-9,999.000000	99.000000
APR	14,582	18.932382	-9,999.000000	99.000000
MAY	14,582	18.739542	-9,999.000000	100.000000
JUN	14,582	19.481964	-9,999.000000	100.000000
JUL	14,582	26.811548	-9,999.000000	100.000000
AUG	14,582	24.528597	-9,999.000000	100.000000
SEP	14,582	18.804074	-9,999.000000	100.000000
OCT	14,582	13.825538	-9,999.000000	99.000000
NOV	14,582	3.130503	-9,999.000000	99.000000
DEC	14,582	1.596077	-9,999.000000	99.000000
MEAN	14,582	-66.662872	-9,999.000000	96.000000

Table 6. Characteristics of numeric variables from the cloud amount file (File 13)

Variable	Number of observations	Mean	Minimum value	Maximum value
WBAN	16,272	29,316.541114	3,103.000000	94,918.000000
YEAR	16,272	1,940.868424	1,871.000000	1,987.000000
JAN	16,272	-13.491273	-9,999.000000	98.000000
FEB	16,272	-11.667650	-9,999.000000	99.000000
MAR	16,272	-15.791114	-9,999.000000	95.000000
APR	16,272	-15.841323	-9,999.000000	96.000000
MAY	16,272	-14.908985	-9,999.000000	95.000000
JUN	16,272	-17.427114	-9,999.000000	97.000000
JUL	16,272	-17.116212	-9,999.000000	96.000000
AUG	16,272	-16.701696	-9,999.000000	98.000000
SEP	16,272	-8.511431	-9,999.000000	97.000000
OCT	16,272	-3.891900	-9,999.000000	99.000000
NOV	16,272	13.602692	-9,999.000000	99.000000
DEC	16,272	20.115782	-9,999.000000	99.000000
MEAN	16,272	-78.865782	-9,999.000000	89.000000

Table 7. Sample listing of the measured hours of sunshine file[a]

3103	23166	1	AZ	FLAGSTAFF	1908	237	249	326	343	399	423	325	298	308	298	279	233	3717
3103	23166	0	AZ	FLAGSTAFF	1909	235	241	300	348	385	404	302	181	299	344	256	196	3493
3103	23166	0	AZ	FLAGSTAFF	1910	232	265	314	329	401	398	303	279	313	305	259	243	3641
3103	23166	0	AZ	FLAGSTAFF	1911	178	229	229	314	420	348	241	279	241	283	268	265	3295
3103	23166	0	AZ	FLAGSTAFF	1912	274	276	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99	-99
3103	3103	1	AZ	FLAGSTAFF	1973	228	167	170	295	363	381	317	286	344	321	216	238	3327
3103	0	0	AZ	FLAGSTAFF	1974	160	250	313	370	419	402	328	383	331	268	239	257	3719
3103	0	0	AZ	FLAGSTAFF	1975	270	256	257	290	391	415	329	338	264	310	267	249	3634
3103	0	0	AZ	FLAGSTAFF	1976	284	212	281	332	371	412	313	359	273	293	275	258	3662
3103	0	0	AZ	FLAGSTAFF	1977	210	262	314	332	353	305	264	245	283	-99	-99	-99	-99
3103	0	0	AZ	FLAGSTAFF	1978	-99	-99	-99	288	373	400	354	297	304	250	174	219	-99
3103	0	0	AZ	FLAGSTAFF	1979	135	208	-99	326	282	382	385	392	368	327	295	245	-99
3103	0	0	AZ	FLAGSTAFF	1980	206	237	307	364	346	409	376	337	-99	-99	-99	-99	-99
3103	0	0	AZ	FLAGSTAFF	1981	266	283	323	334	361	390	294	-99	220	221	-99	-99	-99
3103	0	0	AZ	FLAGSTAFF	1982	-99	194	221	316	329	337	281	221	-99	286	128	-99	-99
3103	0	0	AZ	FLAGSTAFF	1983	238	167	212	281	368	360	288	251	248	251	204	153	3021
3103	0	0	AZ	FLAGSTAFF	1984	242	237	315	297	387	354	241	-99	-99	249	223	118	-99
3103	0	0	AZ	FLAGSTAFF	1985	222	247	289	282	364	338	-99	-99	-99	-99	192	259	-99
3103	0	0	AZ	FLAGSTAFF	1986	278	235	304	348	-99	286	309	195	264	245	204	-99	-99
3103	0	0	AZ	FLAGSTAFF	1987	-99	208	281	309	394	412	402	-99	-99	-99	244	216	-99
3806	0	0	VA	WYTHEVILLE	1903	130	171	139	194	326	244	342	270	270	230	176	167	2660
3806	0	0	VA	WYTHEVILLE	1904	151	142	143	168	238	304	262	211	232	267	164	130	2412
3806	0	0	VA	WYTHEVILLE	1905	127	116	194	206	227	228	223	216	234	201	158	114	2243
3806	0	0	VA	WYTHEVILLE	1906	151	193	108	269	278	268	215	174	149	138	183	93	2217
3806	0	0	VA	WYTHEVILLE	1907	140	143	197	163	237	216	292	249	252	208	132	99	2329
3806	0	0	VA	WYTHEVILLE	1908	139	116	161	240	246	267	359	201	271	222	176	114	2512
3806	0	0	VA	WYTHEVILLE	1909	134	163	210	260	313	283	303	303	228	261	194	156	2808
3806	0	0	VA	WYTHEVILLE	1910	108	159	256	180	248	212	262	235	193	213	153	127	2347
3806	0	0	VA	WYTHEVILLE	1911	113	130	216	176	329	298	302	277	244	190	148	111	2535
3806	0	0	VA	WYTHEVILLE	1912	141	157	180	250	317	299	257	201	211	229	219	140	2600
3806	0	0	VA	WYTHEVILLE	1913	151	186	177	212	283	284	271	244	200	204	176	159	2546
3806	0	0	VA	WYTHEVILLE	1914	126	158	197	248	347	322	305	285	267	198	224	105	2782
3806	0	0	VA	WYTHEVILLE	1915	125	180	231	269	294	300	311	230	210	197	153	112	2613
3806	0	0	VA	WYTHEVILLE	1916	129	150	192	200	324	327	203	184	227	219	206	168	2528
3806	0	0	VA	WYTHEVILLE	1917	139	117	206	253	247	259	210	261	182	230	164	145	2412
3806	0	0	VA	WYTHEVILLE	1918	126	152	192	146	254	240	217	250	225	184	175	95	2256
3806	0	0	VA	WYTHEVILLE	1919	180	132	205	235	210	237	258	241	267	138	171	144	2418
3806	0	0	VA	WYTHEVILLE	1920	108	94	214	214	281	288	331	196	210	303	134	125	2497
3806	0	0	VA	WYTHEVILLE	1921	136	124	225	215	216	288	282	248	227	245	129	103	2440
3806	0	0	VA	WYTHEVILLE	1922	89	76	137	207	249	223	221	207	246	237	170	101	2163
3806	0	0	VA	WYTHEVILLE	1923	133	143	224	255	228	294	285	272	228	228	135	121	2546
3806	0	0	VA	WYTHEVILLE	1924	154	91	156	203	224	238	215	260	156	280	157	142	2277
3806	0	0	VA	WYTHEVILLE	1925	118	136	210	251	275	299	287	276	204	128	153	150	2488
3806	0	0	VA	WYTHEVILLE	1926	127	166	200	231	287	246	282	242	174	170	148	120	2392
3806	0	0	VA	WYTHEVILLE	1927	121	149	194	207	251	270	322	226	270	225	138	150	2524
3806	0	0	VA	WYTHEVILLE	1928	173	153	208	175	270	209	277	210	188	192	129	161	2346
3806	0	0	VA	WYTHEVILLE	1929	127	136	180	236	208	245	264	257	190	187	87	142	2259
3806	0	0	VA	WYTHEVILLE	1930	122	197	216	247	268	287	267	251	169	193	118	120	2456
3806	0	0	VA	WYTHEVILLE	1931	166	159	100	192	225	254	218	207	246	206	170	105	2248
3806	0	0	VA	WYTHEVILLE	1932	128	172	183	232	239	263	284	237	210	188	158	115	2409
3806	0	0	VA	WYTHEVILLE	1933	119	136	162	202	235	313	238	210	223	241	152	133	2364
3806	0	0	VA	WYTHEVILLE	1934	156	152	168	192	292	267	232	125	175	253	162	131	2305
3806	0	0	VA	WYTHEVILLE	1935	123	128	146	161	224	275	208	229	218	242	122	103	2179
3806	0	0	VA	WYTHEVILLE	1936	130	168	191	184	339	275	228	217	197	163	177	95	2365
3806	0	0	VA	WYTHEVILLE	1937	70	121	178	192	297	236	224	190	209	130	138	121	2106
3806	0	0	VA	WYTHEVILLE	1938	124	90	149	231	186	220	186	274	126	281	176	141	2184
3806	0	0	VA	WYTHEVILLE	1939	144	148	175	219	250	251	184	193	264	214	155	132	2329
3806	0	0	VA	WYTHEVILLE	1940	141	98	155	186	215	240	189	136	295	240	147	113	2155
3812	13872	1	NC	ASHEVILLE	1903	171	175	166	213	272	256	329	331	294	276	207	211	2900
3812	13872	0	NC	ASHEVILLE	1905	148	119	200	231	256	258	248	229	277	209	178	124	2477
3812	13872	0	NC	ASHEVILLE	1906	163	215	182	279	248	248	249	210	174	230	206	139	2542

Table 7. (continued)

3812	13872	0	NC	ASHEVILLE	1907	181	155	272	256	353	306	312	291	283	225	155	139	2927
3812	13872	0	NC	ASHEVILLE	1908	143	144	201	250	238	263	276	200	257	247	205	136	2559
3812	13872	0	NC	ASHEVILLE	1909	138	184	191	239	252	229	247	285	190	252	219	156	2580
3812	13872	0	NC	ASHEVILLE	1910	173	178	242	208	271	211	266	246	216	216	235	174	2637
3812	13872	0	NC	ASHEVILLE	1911	155	164	214	198	301	248	197	203	201	160	184	141	2367
3812	13872	0	NC	ASHEVILLE	1912	161	172	215	285	284	268	262	277	252	247	222	131	2776
3812	13872	0	NC	ASHEVILLE	1913	165	185	226	227	302	327	321	276	220	258	231	155	2893
3812	13872	0	NC	ASHEVILLE	1914	191	165	196	272	358	316	328	266	243	168	197	78	2778
3812	13872	0	NC	ASHEVILLE	1915	137	177	201	268	280	270	288	227	243	192	204	163	2648
3812	13872	0	NC	ASHEVILLE	1916	108	168	225	199	265	205	137	162	230	223	215	163	2299
3812	13872	0	NC	ASHEVILLE	1917	140	168	190	268	250	258	243	257	171	212	184	139	2480
3812	13872	0	NC	ASHEVILLE	1918	116	159	172	154	222	206	216	221	174	159	186	111	2096
3812	13872	0	NC	ASHEVILLE	1919	195	143	236	268	248	243	256	232	309	152	173	178	2633
3812	13872	0	NC	ASHEVILLE	1920	138	123	213	251	257	293	261	136	185	262	152	136	2407
3812	13872	0	NC	ASHEVILLE	1921	118	129	208	253	239	256	242	254	236	267	147	157	2507
3812	13872	0	NC	ASHEVILLE	1922	104	128	170	240	220	270	238	228	259	224	215	98	2393
3812	13872	0	NC	ASHEVILLE	1923	147	151	204	235	214	270	273	272	240	224	188	143	2561
3812	13872	0	NC	ASHEVILLE	1924	195	161	189	222	265	297	220	258	154	268	224	162	2616
3812	13872	0	NC	ASHEVILLE	1925	143	194	269	262	279	269	258	262	200	155	141	151	2582
3812	13872	0	NC	ASHEVILLE	1926	143	171	208	260	296	248	257	194	149	177	166	126	2394
3812	13872	0	NC	ASHEVILLE	1927	111	120	149	210	220	174	211	211	232	248	133	169	2188
3812	13872	0	NC	ASHEVILLE	1928	191	182	226	188	250	181	222	196	198	189	166	168	2358
3812	13872	0	NC	ASHEVILLE	1929	158	145	216	256	226	276	249	246	153	201	120	175	2421
3812	13872	0	NC	ASHEVILLE	1930	130	215	206	247	219	270	269	283	168	209	137	125	2476
3812	13872	0	NC	ASHEVILLE	1931	196	158	181	203	238	318	281	218	267	228	160	146	2596
3812	13872	0	NC	ASHEVILLE	1932	142	169	214	256	284	319	320	265	215	196	182	95	2657
3812	13872	0	NC	ASHEVILLE	1933	141	131	217	255	299	311	239	176	234	233	188	152	2575
3812	13872	0	NC	ASHEVILLE	1934	177	168	192	201	283	267	271	198	235	247	188	129	2556
3812	13872	0	NC	ASHEVILLE	1935	130	141	175	174	253	308	274	278	249	256	154	146	2538
3812	13872	0	NC	ASHEVILLE	1936	174	182	182	246	357	331	267	268	209	153	159	109	2639
3812	13872	0	NC	ASHEVILLE	1937	66	133	250	235	340	311	322	276	261	151	180	117	2642
3812	13872	0	NC	ASHEVILLE	1938	161	118	175	248	224	248	199	233	156	310	208	170	2450
3812	13872	0	NC	ASHEVILLE	1939	158	146	235	259	235	256	234	183	222	235	189	178	2530
3812	13872	0	NC	ASHEVILLE	1940	158	130	172	191	271	245	190	146	283	267	124	124	2301
3812	13872	0	NC	ASHEVILLE	1941	138	178	213	243	345	224	196	270	309	222	200	131	2669
3812	13872	0	NC	ASHEVILLE	1942	138	142	243	313	295	311	262	222	239	218	198	123	2704
3812	13872	0	NC	ASHEVILLE	1943	174	196	196	241	287	306	258	292	259	233	234	150	2826
3812	13872	0	NC	ASHEVILLE	1944	138	134	231	254	298	317	302	266	194	228	155	137	2654
3812	13872	0	NC	ASHEVILLE	1945	164	170	245	263	283	262	227	250	239	255	180	108	2646
3812	13872	0	NC	ASHEVILLE	1946	131	178	233	264	230	308	281	258	212	227	155	153	2630
3812	13872	0	NC	ASHEVILLE	1947	112	181	205	245	326	280	313	249	232	155	138	152	2588
3812	13872	0	NC	ASHEVILLE	1948	138	124	218	312	339	331	276	245	209	227	145	154	2718
3812	13872	0	NC	ASHEVILLE	1949	146	181	244	240	341	298	279	254	256	174	206	156	2775
3812	13872	0	NC	ASHEVILLE	1950	134	172	213	273	303	345	307	290	210	253	161	139	2800
3812	13872	0	NC	ASHEVILLE	1951	151	187	193	226	318	281	304	306	250	244	155	183	2798
3812	13872	0	NC	ASHEVILLE	1952	170	188	252	263	350	365	341	230	267	270	160	177	3033
3812	13872	0	NC	ASHEVILLE	1953	163	181	218	283	327	327	325	307	270	290	226	139	3056
3812	13872	0	NC	ASHEVILLE	1954	155	194	244	261	287	326	327	299	301	267	183	164	3008
3812	13872	0	NC	ASHEVILLE	1955	164	183	216	258	311	275	237	256	243	252	217	168	2780
3812	13872	0	NC	ASHEVILLE	1956	128	138	246	283	271	287	272	317	240	186	222	165	2755
3812	13872	0	NC	ASHEVILLE	1957	85	151	179	217	237	146	296	295	172	155	146	130	2209
3812	13872	0	NC	ASHEVILLE	1958	136	179	113	179	220	314	236	239	273	227	210	182	2508
3812	13872	0	NC	ASHEVILLE	1959	185	131	242	259	237	315	198	209	170	186	173	111	2416
3812	13872	0	NC	ASHEVILLE	1960	136	165	195	260	288	231	193	190	191	154	177	190	2370
3812	13872	0	NC	ASHEVILLE	1961	206	136	156	191	234	105	228	219	259	249	132	115	2230
3812	13872	0	NC	ASHEVILLE	1962	161	171	175	230	268	214	312	281	220	253	138	182	2605
3812	13872	0	NC	ASHEVILLE	1963	202	200	254	277	281	213	255	262	217	323	172	157	2813
3812	3812	9	NC	ASHEVILLE	1964	203	151	223	193	289	307	236	224	227	248	239	150	2690
3812	0	0	NC	ASHEVILLE	1965	192	178	193	265	278	227	235	265	209	248	191	204	2684
3812	0	0	NC	ASHEVILLE	1966	157	128	294	211	246	290	298	208	187	221	153	167	2560
3812	0	0	NC	ASHEVILLE	1967	211	202	305	295	254	295	249	192	238	223	199	149	2810
3812	0	0	NC	ASHEVILLE	1968	140	225	278	250	283	298	248	293	222	183	132	189	2741
3812	0	0	NC	ASHEVILLE	1969	154	162	275	287	324	291	315	298	213	224	212	178	2932
3812	0	0	NC	ASHEVILLE	1970	201	233	248	268	288	292	318	202	214	142	226	209	2840
3812	0	0	NC	ASHEVILLE	1971	156	198	275	344	316	308	280	276	211	187	235	189	2973
3812	0	0	NC	ASHEVILLE	1972	189	212	262	295	278	346	247	247	276	264	172	135	2923

Table 7. (continued)

3812	0	0	NC ASHEVILLE	1973	189	226	187	181	264	211	213	191	218	216	209	153	2457
3812	0	0	NC ASHEVILLE	1974	136	195	220	266	234	281	277	165	139	319	246	176	2653
3812	0	0	NC ASHEVILLE	1975	185	163	223	236	235	337	226	217	206	212	185	171	2595
3812	0	0	NC ASHEVILLE	1976	193	211	196	340	290	240	250	249	243	179	189	200	2779
3812	0	0	NC ASHEVILLE	1977	188	237	204	236	256	290	278	191	152	194	114	134	2472
3812	0	0	NC ASHEVILLE	1978	146	170	227	294	239	302	254	201	195	288	154	171	2641
3812	0	0	NC ASHEVILLE	1979	179	167	219	244	229	233	189	221	107	223	179	196	2386
3812	0	0	NC ASHEVILLE	1980	132	218	185	284	299	301	313	259	188	201	185	183	2748
3812	0	0	NC ASHEVILLE	1981	210	191	232	246	245	283	229	191	261	200	193	148	2629
3812	0	0	NC ASHEVILLE	1982	143	129	167	217	235	234	217	232	186	172	147	131	2211
3812	0	0	NC ASHEVILLE	1983	168	136	163	198	265	244	364	287	202	182	176	179	2565
3812	0	0	NC ASHEVILLE	1984	196	216	219	157	296	271	212	207	250	142	186	182	2534
3812	0	0	NC ASHEVILLE	1985	174	155	241	302	247	287	194	183	249	157	108	228	2525
3812	0	0	NC ASHEVILLE	1986	221	167	263	286	230	282	296	162	178	203	96	161	2545
3812	0	0	NC ASHEVILLE	1987	171	137	211	235	217	234	292	221	200	269	198	115	2500

[a] Missing values are represented by -99.

Table 8. Sample listing of the maximum possible hours of sunshine file

3103	AZ	FLAGSTAFF	313	306	371	392	434	434	442	417	372	350	310	305	4447.3	11.4
3806	VA	WYTHEVILLE	309	304	371	394	439	439	447	420	373	349	306	300	4449.8	11.3
3812	NC	ASHEVILLE	312	305	371	393	435	435	443	417	372	350	310	304	4447.7	11.5
3813	GA	MACON	319	309	372	390	429	428	436	413	371	352	315	311	4444.3	11.5
3822	GA	SAVANNAH	320	309	372	389	428	427	435	412	371	353	316	313	4443.6	11.5
3870	SC	GREENVILLE/SPAR	313	306	371	392	434	434	441	417	372	351	310	306	4447.1	11.4
3883	AL	BIRMINGHAM	317	308	371	391	431	430	438	415	371	352	313	309	4445.3	11.5
3927	TX	DALLAS/FORT WOR	318	308	372	390	429	429	436	414	371	352	314	311	4444.6	11.4
3928	KS	WICHITA	307	303	371	395	440	442	449	421	373	348	305	298	4450.8	11.3
3940	MS	JACKSON	319	309	372	389	428	427	435	413	371	353	315	312	4443.9	11.5
3945	MO	COLUMBIA	304	301	371	397	443	445	452	423	373	347	302	295	4452.6	11.3
3947	MO	KANSAS CITY	303	300	371	397	444	447	453	424	374	346	301	293	4453.3	11.3
3952	AR	NORTH LITTLE RO	314	306	371	392	433	433	441	416	372	351	311	306	4446.8	11.4
3955	OK	BROKEN ARROW	311	305	371	393	436	437	444	418	372	349	308	302	4448.5	11.4
4721	VT	NORTHFIELD	289	293	370	404	458	463	469	433	376	341	290	277	4461.8	11.2
4725	NY	BINGHAMTON	294	296	370	401	452	456	462	429	375	343	294	284	4458.2	11.2
11641	PR	SAN JUAN	346	323	373	377	403	397	407	395	367	363	338	342	4431.5	11.8
12832	FL	APALACHICOLA	325	312	372	387	423	421	429	409	370	355	320	318	4441.1	11.6
12836	FL	KEY WEST	335	317	373	382	413	409	418	402	369	359	329	330	4436.3	11.6
12839	FL	MIAMI	333	316	372	383	416	412	421	404	369	358	327	327	4437.3	11.7
12842	FL	TAMPA	328	314	372	385	420	417	425	407	370	356	323	322	4439.3	11.6
12883	FL	LAKELAND	328	314	372	385	420	417	425	407	370	356	323	322	4439.3	11.6
12893	FL	JUPITER	330	315	372	384	418	414	423	405	369	357	325	325	4438.2	11.6
12916	LA	NEW ORLEANS	324	312	372	387	423	421	430	409	370	355	320	318	4441.3	11.6
12917	TX	PORT ARTHUR	324	312	372	387	423	421	430	409	370	355	320	318	4441.4	11.5
12919	TX	BROWNSVILLE	332	316	372	383	416	412	421	404	369	358	327	327	4437.3	11.7
12921	TX	SAN ANTONIO	325	312	372	387	423	420	429	409	370	355	321	319	4440.9	11.5
12924	TX	CORPUS CHRISTI	329	314	372	385	419	416	425	406	370	356	324	323	4439.1	11.6
12944	TX	GALVESTON	326	312	372	386	422	420	428	408	370	355	321	319	4440.8	11.5
12960	TX	HOUSTON	324	312	372	387	423	421	430	409	370	355	320	318	4441.3	11.6
13722	NC	RALEIGH/DURHAM	311	305	371	393	436	436	444	418	372	350	309	303	4448.3	11.4
13723	NC	GREENSBORO	311	305	371	393	437	437	444	419	372	349	308	302	4448.7	11.4
13727	VA	CAPE HENRY	309	303	371	394	438	440	447	420	373	349	306	300	4449.8	11.3
13729	WV	ELKINS	304	301	371	397	443	445	452	423	373	347	302	294	4452.6	11.3
13733	VA	LYNCHBURG	308	303	371	395	439	441	448	421	373	348	306	299	4450.4	11.3
13737	VA	NORFOLK	309	304	371	394	438	439	447	420	373	349	306	300	4449.7	11.3
13739	PA	PHILADELPHIA	301	299	371	398	446	448	455	425	374	346	300	291	4454.0	11.3
13740	VA	RICHMOND	307	303	371	395	440	441	448	421	373	348	305	298	4450.5	11.4
13743	DC	WASHINGTON	304	301	371	397	443	445	452	423	373	347	302	294	4452.5	11.3
13748	NC	WILMINGTON	315	307	371	391	432	432	440	416	372	351	312	307	4446.2	11.4
13867	WV	PARKERSBURG	303	300	371	397	444	447	453	424	373	346	301	293	4453.1	11.3
13874	GA	ATLANTA	316	308	371	391	431	430	438	415	371	352	313	309	4445.4	11.5
13880	SC	CHARLESTON	318	308	372	390	429	429	436	414	371	352	314	311	4444.7	11.5
13881	NC	CHARLOTTE	313	306	371	392	435	435	442	417	372	350	310	305	4447.5	11.4
13882	TN	CHATTANOOGA	313	306	371	392	434	434	442	417	372	350	310	305	4447.1	11.5
13883	SC	COLUMBIA	316	307	371	391	432	431	439	415	372	351	312	308	4445.9	11.4
13889	FL	JACKSONVILLE	323	311	372	388	425	423	431	410	370	354	319	317	4442.1	11.5
13891	TN	KNOXVILLE	311	305	371	393	436	436	444	418	372	350	309	303	4448.3	11.4
13893	TN	MEMPHIS	313	306	371	392	434	434	442	417	372	350	310	305	4447.2	11.5
13895	AL	MONTGOMERY	319	309	372	389	428	427	435	413	371	353	316	312	4443.9	11.5
13897	TN	NASHVILLE	311	305	371	393	437	437	444	419	372	349	308	302	4448.6	11.4
13899	FL	PENSACOLA	323	311	372	388	424	422	431	410	370	354	319	317	4441.8	11.5
13924	TX	GROESBECK	321	310	372	389	427	425	433	411	371	353	317	314	4443.0	11.5
13957	LA	SHREVEPORT	319	309	372	390	429	427	435	413	371	353	315	312	4444.1	11.5
13958	TX	AUSTIN	324	311	372	387	424	422	430	410	370	354	319	317	4441.7	11.5
13961	TX	FORT WORTH	318	309	372	390	429	428	436	413	371	352	315	311	4444.4	11.5
13962	TX	ABILENE	319	309	372	390	428	427	435	413	371	353	315	312	4444.0	11.5
13964	AR	FORT SMITH	313	306	371	393	435	435	442	417	372	350	310	304	4447.6	11.4
13967	OK	OKLAHOMA CITY	312	305	371	393	435	435	443	417	372	350	310	304	4447.7	11.5
13968	OK	TULSA	310	304	371	394	437	437	445	419	372	349	308	302	4448.8	11.4

Table 9. Sample listing of the percentage of possible sunshine file

3103	AZ	FLAGSTAFF	1908	76 T	78 T	88 T	87 T	92 T	97 T	74 T	71 T	83 T	85 T	90 T	76 T	83
3103	AZ	FLAGSTAFF	1909	75 T	79 T	81 T	89 T	89 T	93 T	68 T	43 T	80 T	98 T	83 T	64 T	79
3103	AZ	FLAGSTAFF	1910	74 T	87 T	85 T	84 T	92 T	92 T	69 T	67 T	84 T	87 T	84 T	80 T	82
3103	AZ	FLAGSTAFF	1911	57 T	75 T	62 T	80 T	97 T	80 T	55 T	67 T	65 T	81 T	86 T	87 T	74
3103	AZ	FLAGSTAFF	1912	88 T	87 T	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3103	AZ	FLAGSTAFF	1973	73 T	55 T	46 T	75 T	84 T	88 T	72 T	69 T	92 T	92 T	70 T	78 T	75
3103	AZ	FLAGSTAFF	1974	51 T	82 T	84 T	94 T	96 T	93 T	74 T	92 T	89 T	77 T	77 T	84 T	83
3103	AZ	FLAGSTAFF	1975	86 T	84 T	69 T	74 T	90 T	96 T	74 T	81 T	71 T	88 T	86 T	82 T	82
3103	AZ	FLAGSTAFF	1976	91 T	67 T	76 T	85 T	85 T	95 T	71 T	86 T	73 T	84 T	89 T	85 T	82
3103	AZ	FLAGSTAFF	1977	67 T	86 T	85 T	85 T	81 T	70 T	60 T	59 T	76 T	83ZZZZ	74ZZZZ	71ZZZZ	75
3103	AZ	FLAGSTAFF	1978	63ZZZZ	74ZZZZ	74ZZZZ	73 T	86 T	92 T	80 T	71 T	82 T	71 T	56 T	72 T	75
3103	AZ	FLAGSTAFF	1979	43 T	68 T	75ZZZZ	83 T	65 T	88 T	87 T	94 T	99 T	93 T	95 T	80 T	81
3103	AZ	FLAGSTAFF	1980	66 T	75 T	83 T	93 T	80 T	94 T	85 T	81 T	81ZZZZ	86ZZZZ	80ZZZZ	75ZZZZ	82
3103	AZ	FLAGSTAFF	1981	85 7	93 7	87 7	85 7	83 7	90 7	67 7	-9999	59 7	63 7	-9999	-9999	-9999
3103	AZ	FLAGSTAFF	1982	-9999	64 7	60 7	80 7	76 7	90 7	66 7	59 7	67ZZZZ	82 7	41 7	75ZZZZ	-9999
3103	AZ	FLAGSTAFF	1983	76 7	56 7	57 7	72 7	85 7	83 7	65 7	60 7	67 7	72 7	66 7	50 7	67
3103	AZ	FLAGSTAFF	1984	77 7	84 7	85 7	76 7	89 7	81 7	55 7	66ZZZZ	78ZZZZ	71 7	72 7	39 7	73
3103	AZ	FLAGSTAFF	1985	71 7	81 7	78 7	72 7	84 7	78 7	63ZZZZ	79ZZZZ	78ZZZZ	72ZZZZ	62 7	85 7	75
3103	AZ	FLAGSTAFF	1986	89 7	77 7	82 7	89 7	81ZZZZ	66 7	70 7	47 7	71 7	70 7	66 7	75ZZZZ	74
3103	AZ	FLAGSTAFF	1987	74ZZZZ	68 7	76 7	79 7	91 7	95 7	91 7	-9999	-9999	73ZZZZ	79 7	71 7	-9999
3806	VA	WYTHEVILLE	1903	42 T	56 T	37 T	49 T	74 T	56 T	77 T	64 T	72 T	66 T	57 T	56 T	59
3806	VA	WYTHEVILLE	1904	49 T	45 T	39 T	43 T	54 T	69 T	59 T	50 T	62 T	77 T	54 T	43 T	54
3806	VA	WYTHEVILLE	1905	41 T	38 T	52 T	52 T	52 T	52 T	50 T	51 T	63 T	58 T	52 T	38 T	50
3806	VA	WYTHEVILLE	1906	49 T	64 T	29 T	68 T	63 T	61 T	48 T	41 T	40 T	40 T	60 T	31 T	50
3806	VA	WYTHEVILLE	1907	45 T	47 T	53 T	41 T	54 T	49 T	65 T	59 T	68 T	60 T	43 T	33 T	51
3806	VA	WYTHEVILLE	1908	45 T	37 T	43 T	61 T	56 T	61 T	80 T	48 T	73 T	64 T	57 T	38 T	55
3806	VA	WYTHEVILLE	1909	43 T	54 T	57 T	66 T	71 T	64 T	68 T	72 T	61 T	75 T	63 T	52 T	62
3806	VA	WYTHEVILLE	1910	35 T	52 T	69 T	46 T	57 T	48 T	59 T	56 T	52 T	61 T	50 T	42 T	52
3806	VA	WYTHEVILLE	1911	37 T	43 T	58 T	45 T	75 T	68 T	68 T	66 T	65 T	55 T	48 T	37 T	55
3806	VA	WYTHEVILLE	1912	46 T	50 T	49 T	63 T	72 T	68 T	58 T	48 T	57 T	66 T	71 T	47 T	58
3806	VA	WYTHEVILLE	1913	49 T	61 T	48 T	54 T	65 T	65 T	61 T	58 T	54 T	59 T	57 T	53 T	57
3806	VA	WYTHEVILLE	1914	41 T	52 T	53 T	63 T	79 T	73 T	68 T	68 T	72 T	57 T	73 T	35 T	61
3806	VA	WYTHEVILLE	1915	41 T	59 T	62 T	68 T	67 T	68 T	70 T	55 T	56 T	57 T	50 T	37 T	58
3806	VA	WYTHEVILLE	1916	42 T	48 T	52 T	51 T	74 T	74 T	45 T	44 T	61 T	63 T	67 T	56 T	56
3806	VA	WYTHEVILLE	1917	45 T	39 T	56 T	64 T	56 T	59 T	47 T	62 T	49 T	66 T	54 T	48 T	54
3806	VA	WYTHEVILLE	1918	41 T	50 T	52 T	37 T	58 T	55 T	49 T	60 T	60 T	53 T	57 T	32 T	50
3806	VA	WYTHEVILLE	1919	58 T	43 T	55 T	60 T	48 T	54 T	58 T	57 T	72 T	40 T	56 T	48 T	54
3806	VA	WYTHEVILLE	1920	35 T	30 T	58 T	54 T	64 T	66 T	74 T	47 T	56 T	87 T	44 T	42 T	55
3806	VA	WYTHEVILLE	1921	44 T	41 T	61 T	55 T	49 T	66 T	63 T	59 T	61 T	70 T	42 T	34 T	54
3806	VA	WYTHEVILLE	1922	29 T	25 T	37 T	52 T	57 T	51 T	49 T	49 T	66 T	68 T	55 T	34 T	48
3806	VA	WYTHEVILLE	1923	43 T	47 T	60 T	65 T	52 T	67 T	64 T	65 T	61 T	65 T	44 T	40 T	56
3806	VA	WYTHEVILLE	1924	50 T	29 T	42 T	51 T	51 T	54 T	48 T	62 T	42 T	80 T	51 T	47 T	51
3806	VA	WYTHEVILLE	1925	38 T	45 T	57 T	64 T	63 T	68 T	64 T	66 T	55 T	37 T	50 T	50 T	55
3806	VA	WYTHEVILLE	1926	41 T	55 T	54 T	59 T	65 T	56 T	63 T	58 T	47 T	49 T	48 T	40 T	53
3806	VA	WYTHEVILLE	1927	39 T	49 T	52 T	52 T	57 T	61 T	72 T	54 T	72 T	65 T	45 T	50 T	56

Table 9. (continued)

3806 VA WYTHEVILLE	1928	56 T	49 T	56 T	44 T	62 T	48 T	62 T	50 T	50 T	55 T	42 T	54 T	52
3806 VA WYTHEVILLE	1929	41 T	45 T	49 T	60 T	47 T	56 T	59 T	61 T	51 T	54 T	28 T	47 T	50
3806 VA WYTHEVILLE	1930	40 T	65 T	58 T	63 T	61 T	65 T	60 T	60 T	45 T	55 T	39 T	40 T	54
3806 VA WYTHEVILLE	1931	54 T	52 T	27 T	49 T	51 T	58 T	49 T	49 T	66 T	59 T	55 T	35 T	50
3806 VA WYTHEVILLE	1932	41 T	55 T	49 T	59 T	55 T	60 T	64 T	56 T	56 T	54 T	52 T	38 T	53
3806 VA WYTHEVILLE	1933	39 T	45 T	44 T	51 T	54 T	71 T	53 T	50 T	60 T	69 T	50 T	44 T	53
3806 VA WYTHEVILLE	1934	51 T	50 T	45 T	49 T	67 T	61 T	52 T	30 T	47 T	73 T	53 T	44 T	52
3806 VA WYTHEVILLE	1935	40 T	42 T	39 T	41 T	51 T	63 T	47 T	55 T	59 T	69 T	40 T	34 T	48
3806 VA WYTHEVILLE	1936	42 T	53 T	51 T	47 T	77 T	63 T	51 T	52 T	53 T	47 T	58 T	32 T	52
3806 VA WYTHEVILLE	1937	23 T	40 T	48 T	49 T	68 T	54 T	50 T	45 T	56 T	37 T	45 T	40 T	46
3806 VA WYTHEVILLE	1938	40 T	30 T	40 T	59 T	42 T	50 T	42 T	65 T	34 T	81 T	57 T	47 T	49
3806 VA WYTHEVILLE	1939	47 T	49 T	47 T	56 T	57 T	57 T	41 T	46 T	71 T	61 T	51 T	44 T	52
3806 VA WYTHEVILLE	1940	46 T	31 T	42 T	47 T	49 T	55 T	42 T	32 T	79 T	69 T	48 T	38 T	48
3812 NC ASHEVILLE	1902	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	60ZZZZ	75ZZZZ	61ZZZZ	56ZZZZ	-9999
3812 NC ASHEVILLE	1903	55 T	57 T	45 T	54 T	63 T	59 T	74 T	79 T	79 T	79 T	67 T	69 T	65
3812 NC ASHEVILLE	1904	58ZZZZ	56ZZZZ	56ZZZZ	59ZZZZ	74ZZZZ	68ZZZZ	62ZZZZ	60ZZZZ	65ZZZZ	84ZZZZ	67ZZZZ	58ZZZZ	64
3812 NC ASHEVILLE	1905	47 T	39 T	54 T	59 T	59 T	59 T	56 T	55 T	74 T	60 T	58 T	41 T	55
3812 NC ASHEVILLE	1906	52 T	70 T	49 T	71 T	57 T	57 T	56 T	50 T	47 T	66 T	67 T	46 T	57
3812 NC ASHEVILLE	1907	58 T	51 T	73 T	65 T	81 T	70 T	70 T	70 T	76 T	64 T	50 T	46 T	65
3812 NC ASHEVILLE	1908	46 T	45 T	54 T	64 T	55 T	60 T	62 T	48 T	69 T	71 T	66 T	45 T	57
3812 NC ASHEVILLE	1909	44 T	60 T	51 T	61 T	58 T	53 T	56 T	68 T	51 T	72 T	71 T	51 T	58
3812 NC ASHEVILLE	1910	55 T	58 T	65 T	53 T	62 T	48 T	60 T	59 T	58 T	62 T	76 T	57 T	59
3812 NC ASHEVILLE	1911	50 T	54 T	58 T	50 T	69 T	57 T	44 T	49 T	54 T	46 T	59 T	46 T	53
3812 NC ASHEVILLE	1912	52 T	54 T	58 T	73 T	65 T	62 T	59 T	66 T	68 T	71 T	72 T	43 T	62
3812 NC ASHEVILLE	1913	53 T	61 T	61 T	58 T	69 T	75 T	73 T	66 T	59 T	74 T	75 T	51 T	65
3812 NC ASHEVILLE	1914	61 T	54 T	53 T	69 T	82 T	73 T	74 T	64 T	65 T	48 T	64 T	26 T	61
3812 NC ASHEVILLE	1915	44 T	58 T	54 T	68 T	64 T	62 T	65 T	54 T	65 T	55 T	66 T	54 T	59
3812 NC ASHEVILLE	1916	35 T	53 T	61 T	51 T	61 T	47 T	31 T	39 T	62 T	64 T	69 T	54 T	52
3812 NC ASHEVILLE	1917	45 T	55 T	51 T	68 T	57 T	59 T	55 T	62 T	46 T	61 T	59 T	46 T	55
3812 NC ASHEVILLE	1918	37 T	52 T	46 T	39 T	51 T	47 T	49 T	53 T	47 T	45 T	60 T	37 T	47
3812 NC ASHEVILLE	1919	62 T	47 T	64 T	68 T	57 T	56 T	58 T	56 T	83 T	43 T	56 T	59 T	59
3812 NC ASHEVILLE	1920	44 T	39 T	57 T	64 T	59 T	67 T	59 T	33 T	50 T	75 T	49 T	45 T	53
3812 NC ASHEVILLE	1921	38 T	42 T	56 T	64 T	55 T	59 T	55 T	61 T	63 T	76 T	47 T	52 T	56
3812 NC ASHEVILLE	1922	33 T	42 T	46 T	61 T	51 T	62 T	54 T	55 T	70 T	64 T	69 T	32 T	53
3812 NC ASHEVILLE	1923	47 T	49 T	55 T	60 T	49 T	62 T	62 T	65 T	65 T	64 T	61 T	47 T	57
3812 NC ASHEVILLE	1924	62 T	51 T	51 T	57 T	61 T	68 T	50 T	62 T	41 T	77 T	72 T	53 T	59
3812 NC ASHEVILLE	1925	46 T	64 T	72 T	67 T	64 T	62 T	58 T	63 T	54 T	44 T	46 T	50 T	58
3812 NC ASHEVILLE	1926	46 T	56 T	56 T	66 T	68 T	57 T	58 T	46 T	40 T	51 T	54 T	41 T	53
3812 NC ASHEVILLE	1927	36 T	39 T	40 T	53 T	51 T	40 T	48 T	51 T	62 T	71 T	43 T	56 T	49
3812 NC ASHEVILLE	1928	61 T	57 T	61 T	48 T	57 T	42 T	50 T	47 T	53 T	54 T	54 T	55 T	53
3812 NC ASHEVILLE	1929	51 T	47 T	58 T	65 T	52 T	63 T	56 T	59 T	41 T	57 T	39 T	58 T	54
3812 NC ASHEVILLE	1930	42 T	70 T	55 T	63 T	50 T	62 T	61 T	68 T	45 T	60 T	44 T	41 T	55
3812 NC ASHEVILLE	1931	63 T	52 T	49 T	52 T	55 T	73 T	63 T	52 T	72 T	65 T	52 T	48 T	58
3812 NC ASHEVILLE	1932	45 T	53 T	58 T	65 T	65 T	73 T	72 T	63 T	58 T	56 T	59 T	31 T	58
3812 NC ASHEVILLE	1933	45 T	43 T	58 T	65 T	69 T	71 T	54 T	42 T	63 T	67 T	61 T	50 T	57
3812 NC ASHEVILLE	1934	57 T	55 T	52 T	51 T	65 T	61 T	61 T	47 T	63 T	71 T	61 T	42 T	57
3812 NC ASHEVILLE	1935	42 T	46 T	47 T	44 T	58 T	71 T	62 T	67 T	67 T	73 T	50 T	48 T	56
3812 NC ASHEVILLE	1936	56 T	57 T	49 T	63 T	82 T	76 T	60 T	64 T	56 T	44 T	51 T	36 T	58

Table 9. (continued)

3812	NC	ASHEVILLE	1937	21	T	44	T	67	T	60	T	78	T	71	T	73	T	66	T	70	T	43	T	58	T	38	T	57
3812	NC	ASHEVILLE	1938	52	T	39	T	47	T	63	T	51	T	57	T	45	T	56	T	42	T	89	T	67	T	56	T	55
3812	NC	ASHEVILLE	1939	51	T	48	T	63	T	66	T	54	T	59	T	53	T	44	T	60	T	67	T	61	T	59	T	57
3812	NC	ASHEVILLE	1940	51	T	41	T	46	T	49	T	62	T	56	T	43	T	35	T	76	T	76	T	40	T	41	T	51
3812	NC	ASHEVILLE	1941	44	T	58	T	57	T	62	T	79	T	51	T	44	T	65	T	83	T	63	T	65	T	43	T	60
3812	NC	ASHEVILLE	1942	44	T	46	T	65	T	80	T	68	T	71	T	59	T	53	T	64	T	62	T	64	T	40	T	60
3812	NC	ASHEVILLE	1943	56	T	64	T	53	T	61	T	66	T	70	T	58	T	70	T	70	T	67	T	76	T	49	T	63
3812	NC	ASHEVILLE	1944	44	T	42	T	62	T	65	T	69	T	73	T	68	T	64	T	52	T	65	T	50	T	45	T	58
3812	NC	ASHEVILLE	1945	53	T	56	T	66	T	67	T	65	T	60	T	51	T	60	T	64	T	73	T	58	T	36	T	59
3812	NC	ASHEVILLE	1946	42	T	58	T	63	T	67	T	53	T	71	T	63	T	62	T	57	T	65	T	50	T	50	T	58
3812	NC	ASHEVILLE	1947	36	T	59	T	55	T	62	T	75	T	64	T	71	T	60	T	62	T	44	T	45	T	50	T	57
3812	NC	ASHEVILLE	1948	44	T	39	T	59	T	79	T	78	T	76	T	62	T	59	T	56	T	65	T	47	T	51	T	60
3812	NC	ASHEVILLE	1949	47	T	59	T	66	T	61	T	78	T	68	T	63	T	61	T	69	T	50	T	67	T	51	T	62
3812	NC	ASHEVILLE	1950	43	T	56	T	57	T	70	T	70	T	79	T	69	T	69	T	56	T	72	T	52	T	46	T	62
3812	NC	ASHEVILLE	1951	48	T	61	T	52	T	58	T	73	T	65	T	69	T	73	T	67	T	70	T	50	T	60	T	62
3812	NC	ASHEVILLE	1952	54	T	59	T	68	T	67	T	80	T	84	T	77	T	55	T	72	T	77	T	52	T	58	T	67
3812	NC	ASHEVILLE	1953	52	T	59	T	59	T	72	T	75	T	75	T	73	T	74	T	73	T	83	T	73	T	46	T	68
3812	NC	ASHEVILLE	1954	50	T	64	T	66	T	66	T	66	T	75	T	74	T	72	T	81	T	76	T	59	T	54	T	67
3812	NC	ASHEVILLE	1955	53	T	60	T	58	T	66	T	71	T	63	T	54	T	61	T	65	T	72	T	70	T	55	T	62
3812	NC	ASHEVILLE	1956	41	T	44	T	66	T	72	T	62	T	66	T	61	T	76	T	65	T	53	T	72	T	54	T	61
3812	NC	ASHEVILLE	1957	27	T	49	T	48	T	55	T	54	T	34	T	67	T	71	T	46	T	44	T	47	T	43	T	49
3812	NC	ASHEVILLE	1958	44	T	59	T	30	T	46	T	51	T	72	T	53	T	57	T	73	T	65	T	68	T	60	T	57
3812	NC	ASHEVILLE	1959	59	T	43	T	65	T	66	T	54	T	72	T	45	T	50	T	46	T	53	T	56	T	37	T	54
3812	NC	ASHEVILLE	1960	44	T	52	T	53	T	66	T	66	T	53	T	44	T	46	T	51	T	44	T	57	T	62	T	53
3812	NC	ASHEVILLE	1961	66	T	45	T	42	T	49	T	54	T	24	T	51	T	52	T	70	T	71	T	43	T	38	T	50
3812	NC	ASHEVILLE	1962	52	T	56	T	47	T	59	T	62	T	49	T	70	T	67	T	59	T	72	T	45	T	60	T	58
3812	NC	ASHEVILLE	1963	65	T	65	T	68	T	71	T	65	T	49	T	58	T	63	T	58	T	92	T	56	T	52	T	64
3812	NC	ASHEVILLE	1964	65	T	48	T	60	T	49	T	66	T	71	T	53	T	54	T	61	T	71	T	77	T	49	T	60
3812	NC	ASHEVILLE	1965	61	T	58	T	52	T	67	T	64	T	52	T	53	T	63	T	56	T	71	T	62	T	67	T	61
3812	NC	ASHEVILLE	1966	50	T	42	T	79	T	54	T	57	T	67	T	67	T	50	T	50	T	63	T	49	T	55	T	57
3812	NC	ASHEVILLE	1967	68	T	66	T	82	T	75	T	58	T	68	T	56	T	46	T	64	T	64	T	64	T	49	T	63
3812	NC	ASHEVILLE	1968	45	T	71	T	75	T	64	T	65	T	68	T	56	T	70	T	60	T	52	T	43	T	62	T	61
3812	NC	ASHEVILLE	1969	49	T	53	T	74	T	73	T	74	T	67	T	71	T	71	T	57	T	64	T	68	T	59	T	65
3812	NC	ASHEVILLE	1970	64	T	76	T	67	T	68	T	66	T	67	T	72	T	48	T	58	T	41	T	73	T	69	T	64
3812	NC	ASHEVILLE	1971	50	T	65	T	74	T	88	T	73	T	71	T	63	T	66	T	57	T	53	T	76	T	62	T	67
3812	NC	ASHEVILLE	1972	61	T	67	T	71	T	75	T	64	T	79	T	56	T	59	T	74	T	75	T	56	T	44	T	65
3812	NC	ASHEVILLE	1973	61	T	74	T	50	T	46	T	61	T	48	T	48	T	46	T	59	T	62	T	68	T	50	T	56
3812	NC	ASHEVILLE	1974	44	T	64	T	59	T	68	T	54	T	65	T	63	T	40	T	37	T	91	T	79	T	58	T	60
3812	NC	ASHEVILLE	1975	59	T	53	T	60	T	60	T	54	T	77	T	51	T	52	T	55	T	61	T	60	T	56	T	58
3812	NC	ASHEVILLE	1976	62	T	67	T	53	T	87	T	67	T	55	T	56	T	60	T	65	T	51	T	61	T	66	T	63
3812	NC	ASHEVILLE	1977	60	T	78	T	55	T	60	T	59	T	67	T	63	T	46	T	41	T	55	T	37	T	44	T	55
3812	NC	ASHEVILLE	1978	47	T	56	T	61	T	75	T	55	T	69	T	57	T	48	T	52	T	82	T	50	T	56	T	59
3812	NC	ASHEVILLE	1979	57	T	55	T	59	T	62	T	53	T	54	T	43	T	53	T	29	T	64	T	58	T	64	T	54
3812	NC	ASHEVILLE	1980	42	T	69	T	50	T	72	T	69	T	69	T	71	T	62	T	51	T	57	T	60	T	60	T	61
3812	NC	ASHEVILLE	1981	67	7	62	7	63	7	63	7	56	7	65	7	52	7	46	7	70	7	57	7	62	7	49	7	59
3812	NC	ASHEVILLE	1982	46	7	42	7	45	7	55	7	54	7	54	7	49	7	55	7	50	7	49	7	47	7	43	7	49
3812	NC	ASHEVILLE	1983	54	7	44	7	44	7	50	7	61	7	56	7	82	7	69	7	54	7	52	7	57	7	59	7	57
3812	NC	ASHEVILLE	1984	63	7	68	7	59	7	40	7	68	7	62	7	48	7	50	7	67	7	41	7	60	7	60	7	57
3812	NC	ASHEVILLE	1985	56	7	51	7	65	7	77	7	57	7	66	7	44	7	44	7	67	7	45	7	35	7	75	7	57

Table 9. (continued)

3812 NC ASHEVILLE	1986	71 7	55 7	71 7	73 7	53 7	65 7	67 7	39 7	48 7	58 7	31 7	53 7	57
3812 NC ASHEVILLE	1987	55 7	45 7	57 7	60 7	50 7	54 7	66 7	53 7	54 7	77 7	64 7	38 7	56

Table 10. Sample listing of the cloud amount file

3103 AZ FLAGSTAFF	1901	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	19 31	46 31	35 31	27 31	-9999
3103 AZ FLAGSTAFF	1902	52 31	36 31	51 31	33 31	32 31	20 31	35 31	56 31	33 31	27 31	39 31	38 31	38
3103 AZ FLAGSTAFF	1903	37 31	36 31	54 31	35 31	48 31	43 31	48 31	53 31	50 31	11 31	30 31	18 31	39
3103 AZ FLAGSTAFF	1904	21 31	47 31	57 31	21 31	43 31	44 31	43 31	69 31	37 31	15 31	15 31	44 31	38
3103 AZ FLAGSTAFF	1905	54 31	78 31	66 31	53 31	31 31	16 31	34 31	42 31	39 31	14 31	59 31	42 31	44
3103 AZ FLAGSTAFF	1906	45 31	65 31	63 31	43 31	29 31	20 31	55 31	58 31	30 31	25 31	36 31	53 31	44
3103 AZ FLAGSTAFF	1907	61 31	52 31	60 31	41 31	44 31	25 31	52 31	59 31	33 31	60 31	35 31	43 31	47
3103 AZ FLAGSTAFF	1908	49 31	53 31	48 31	34 31	30 31	16 31	55 31	57 31	31 31	24 31	44 31	50 31	41
3103 AZ FLAGSTAFF	1909	65 31	56 31	50 31	23 31	26 31	13 31	39 31	70 31	32 31	16 31	40 31	53 31	40
3103 AZ FLAGSTAFF	1910	45 31	45 31	38 31	41 31	32 31	15 31	49 31	57 31	27 31	29 31	34 31	53 31	39
3103 AZ FLAGSTAFF	1911	62 31	50 31	48 31	35 31	17 31	40 31	64 31	45 31	53 31	31 31	21 31	26 31	41
3103 AZ FLAGSTAFF	1912	33 31	28 31	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3103 AZ FLAGSTAFF	1918	-9999	-9999	-9999	-9999	-9999	-9999	45 31	-9999	26 31	-9999	-9999	-9999	-9999
3103 AZ FLAGSTAFF	1940	62 31	56 31	42 31	55 31	49 31	45 31	49 31	59 31	59 31	33 31	41 31	55 31	50
3103 AZ FLAGSTAFF	1941	59 31	63 31	53 31	60 31	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
3103 AZ FLAGSTAFF	1944	55 31	62 31	48 31	59 31	40 31	20 31	41 31	32 31	38 31	45 31	53 31	44 31	45
3103 AZ FLAGSTAFF	1945	49 31	60 31	53 31	35 31	40 31	25 31	59 31	52 31	31 31	43 31	35 31	59 31	45
3103 AZ FLAGSTAFF	1946	42 31	38 31	46 31	43 31	35 31	17 31	58 31	63 31	40 31	41 31	50 31	58 31	44
3103 AZ FLAGSTAFF	1947	34 31	51 31	58 31	50 31	53 31	38 31	57 31	65 31	50 31	37 31	44 31	45 31	49
3103 AZ FLAGSTAFF	1948	37 31	67 31	55 31	56 31	38 31	27 31	44 31	55 31	35 31	46 31	28 31	57 31	45
3103 AZ FLAGSTAFF	1949	69 71	58 71	64 71	53 71	41 71	47 71	65 71	31 71	47 71	46 71	37 71	40 71	50
3103 AZ FLAGSTAFF	1950	66 50	51 50	51 50	37 50	38 50	15 50	75 50	49 50	40 50	19 50	43 50	52 50	45
3103 AZ FLAGSTAFF	1951	64 50	65 50	45 50	62 50	45 50	25 50	42 50	42 50	15 50	30 50	37 50	56 50	44
3103 AZ FLAGSTAFF	1952	58 50	47 50	60 50	62 50	31 50	21 50	45 50	64 50	38 50	28 50	40 50	56 50	46
3103 AZ FLAGSTAFF	1953	49 50	38 50	49 50	53 50	42 50	21 50	76 50	47 50	23 50	23 50	44 50	42 50	42
3103 AZ FLAGSTAFF	1954	62 50	19 50	64 50	39 50	40 50	24 50	61 50	46 50	33 50	19 50	26 50	44 50	40
3103 AZ FLAGSTAFF	1955	55 50	44 50	30 50	30 50	41 50	24 50	37 50	58 50	16 50	24 50	33 50	50 50	37
3103 AZ FLAGSTAFF	1956	67 50	39 50	22 50	51 50	32 50	25 50	55 50	40 50	21 50	34 50	9 50	21 50	35
3103 AZ FLAGSTAFF	1957	73 50	68 50	70 50	56 50	54 50	26 50	59 50	63 50	26 50	65 50	40 50	47 50	54
3103 AZ FLAGSTAFF	1958	48 50	60 50	66 50	46 50	43 50	27 50	32 50	55 50	42 50	34 50	35 50	17 70	42
3103 AZ FLAGSTAFF	1959	44 50	54 50	25 50	52 50	46 50	36 50	57 50	61 50	31 50	30 50	32 50	58 50	44
3103 AZ FLAGSTAFF	1960	53 50	57 50	45 50	51 50	39 50	40 50	48 50	43 50	37 50	47 50	41 50	50 50	46
3103 AZ FLAGSTAFF	1961	43 50	48 50	59 50	35 50	30 50	38 50	53 50	68 50	36 50	37 50	46 70	55 50	46
3103 AZ FLAGSTAFF	1962	50 50	61 50	49 50	46 50	35 50	25 50	47 50	42 50	45 50	24 50	44 50	32 50	42
3103 AZ FLAGSTAFF	1963	35 50	56 50	52 50	54 50	40 50	17 50	47 50	75 50	39 50	39 50	52 50	26 50	44
3103 AZ FLAGSTAFF	1964	37 50	20 50	49 50	44 50	42 50	28 50	65 50	54 50	45 50	24 50	50 50	55 50	43
3103 AZ FLAGSTAFF	1965	59 10	41 10	54 10	61 10	44 10	42 10	68 10	39 10	37 10	20 10	71 10	60 10	50
3103 AZ FLAGSTAFF	1966	47 10	49 10	59 10	44 10	33 10	38 10	59 10	49 10	51 10	41 10	39 10	45 10	46
3103 AZ FLAGSTAFF	1967	51 10	37 10	64 10	44 10	46 10	30 10	77 10	60 10	53 10	28 10	49 10	42 10	48
3103 AZ FLAGSTAFF	1968	47 10	69 10	55 10	46 10	40A10	28 10	49 10	50 10	24 10	31 10	41 10	59 10	45
3103 AZ FLAGSTAFF	1969	72 10	64 10	46 10	37 10	33 10	30 10	59 10	62 10	41 10	45 10	36 10	50 10	48
3103 AZ FLAGSTAFF	1970	65 10	59 10	48 10	40 10	28 10	29 10	59 10	61 10	27 10	38 10	45 10	59 10	47
3103 AZ FLAGSTAFF	1971	33 10	45 10	36 10	35 10	37 10	24 10	47 10	66 10	25 10	39 10	43 10	60 10	41
3103 AZ FLAGSTAFF	1972	35 10	43 10	32 10	38 10	29 10	45 10	41 10	43 10	44 10	70 10	46 10	48 10	43
3103 AZ FLAGSTAFF	1973	56 10	74 10	71 10	41 10	43 10	34 10	41 10	40 10	10 10	20 10	50 10	45 10	44

Table 10. (continued)

3103 AZ FLAGSTAFF	1974	61 10	34 10	53 10	31 10	25 10	33 10	56 10	36 10	41 10	50 10	44 10	44 10	42
3103 AZ FLAGSTAFF	1975	49 10	54 10	63 10	43 10	41 10	22 10	53 10	31 10	40 10	20 10	30 10	35 10	40
3103 AZ FLAGSTAFF	1976	34 10	61 10	56 10	45 10	43 10	17 10	54 10	32 10	60 10	40 10	19 10	31 10	41
3103 AZ FLAGSTAFF	1977	59 10	50 10	41 10	41 10	41 10	52 10	59 10	53 10	42 10	33 10	46 10	58 10	48
3103 AZ FLAGSTAFF	1978	68 10	53 10	60 10	52 10	35 10	21 10	50 10	37 10	38 10	45 10	56 10	41 10	46
3103 AZ FLAGSTAFF	1979	68 10	59 10	59 10	37 10	56 10	33 10	36 10	38 10	41 10	48 10	40 10	45 10	47
3103 AZ FLAGSTAFF	1980	74 10	65 10	57 10	51 10	48 10	31 10	52 10	36 10	35 10	28 10	37 10	52 10	47
3103 AZ FLAGSTAFF	1981	55 10	55 10	63 10	45ZZZZ	46ZZZZ	33ZZZZ	49ZZZZ	-9999	58ZZZZ	54ZZZZ	-9999	-9999	-9999
3103 AZ FLAGSTAFF	1982	-9999	61ZZZZ	61ZZZZ	48ZZZZ	50ZZZZ	33ZZZZ	50ZZZZ	70 10	57 10	42 10	71 10	52 10	-9999
3103 AZ FLAGSTAFF	1983	45 10	69 10	66 10	49 10	29 10	29 10	51 10	55 10	52 10	47 10	55 10	75 10	52
3103 AZ FLAGSTAFF	1984	36 10	43 10	44 10	50 10	42ZZZZ	39ZZZZ	73 10	56 10	40 10	52 10	52 10	81 10	51
3103 AZ FLAGSTAFF	1985	47 10	54 10	59 10	49 10	49 10	25 10	60 10	40 10	41 10	49 10	53 10	38 10	47
3103 AZ FLAGSTAFF	1986	44 10	58 10	52 10	51 10	48 10	41 10	47 10	65 10	54 10	46 10	37 10	52 10	50
3103 AZ FLAGSTAFF	1987	53 10	63 10	55 10	49 10	53 10	32 10	39 10	-9999	-9999	48 10	47 10	58 10	-9999

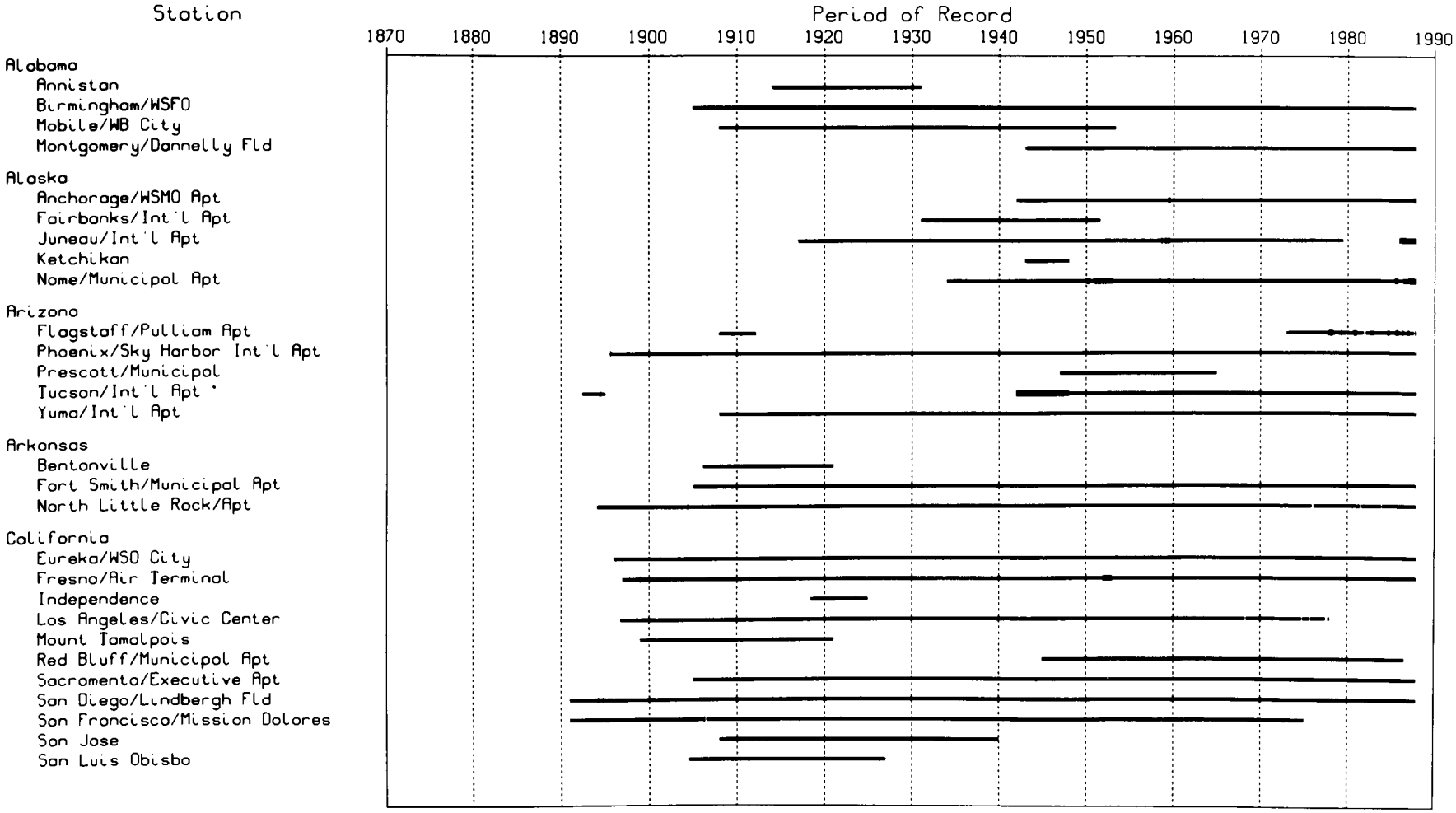
APPENDICES

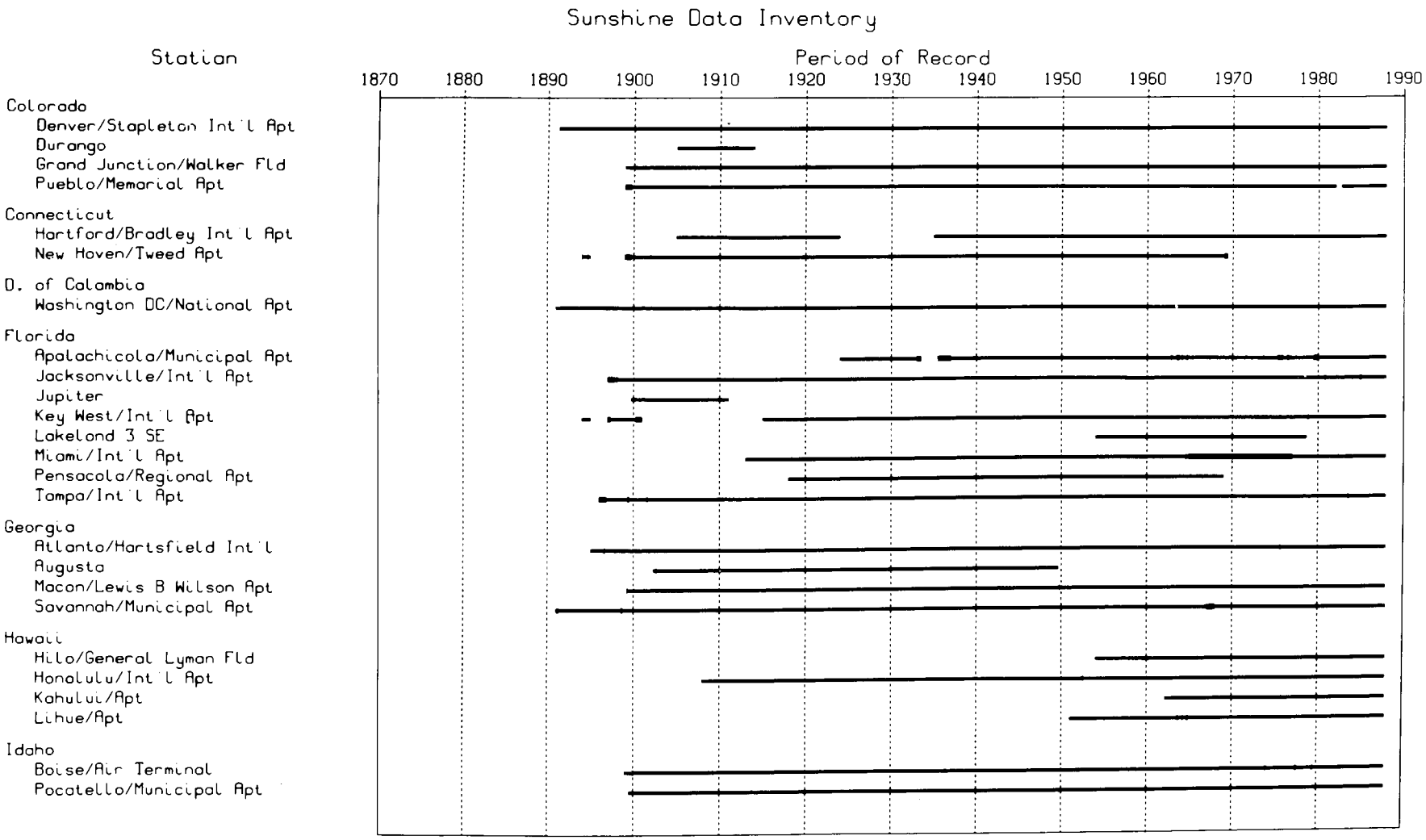
APPENDIX A

Sunshine and Cloud Network Station Inventories

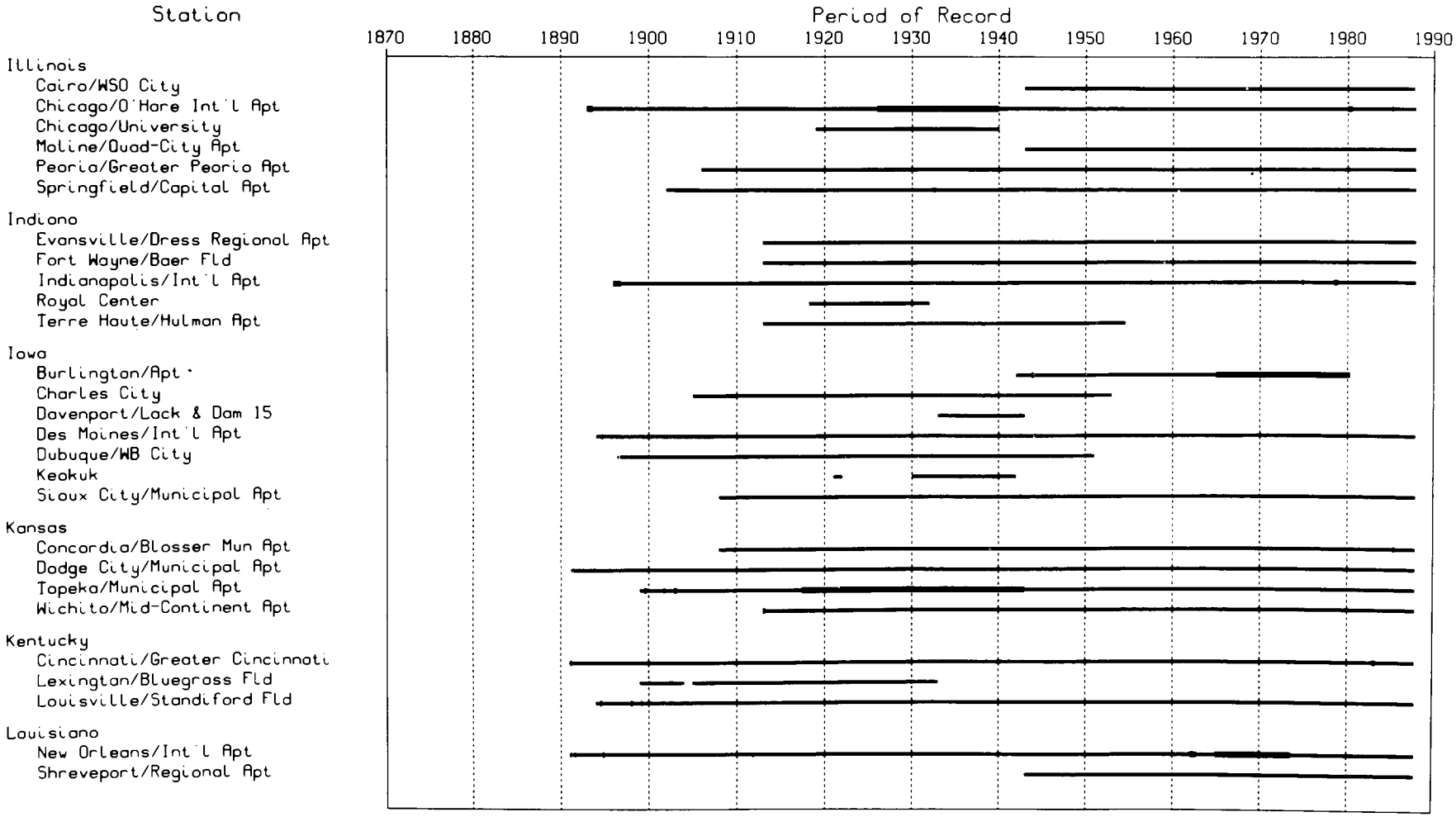
Periods of record are illustrated, with thin lines representing periods of observed values and thick lines representing periods of estimates.

Sunshine Data Inventory

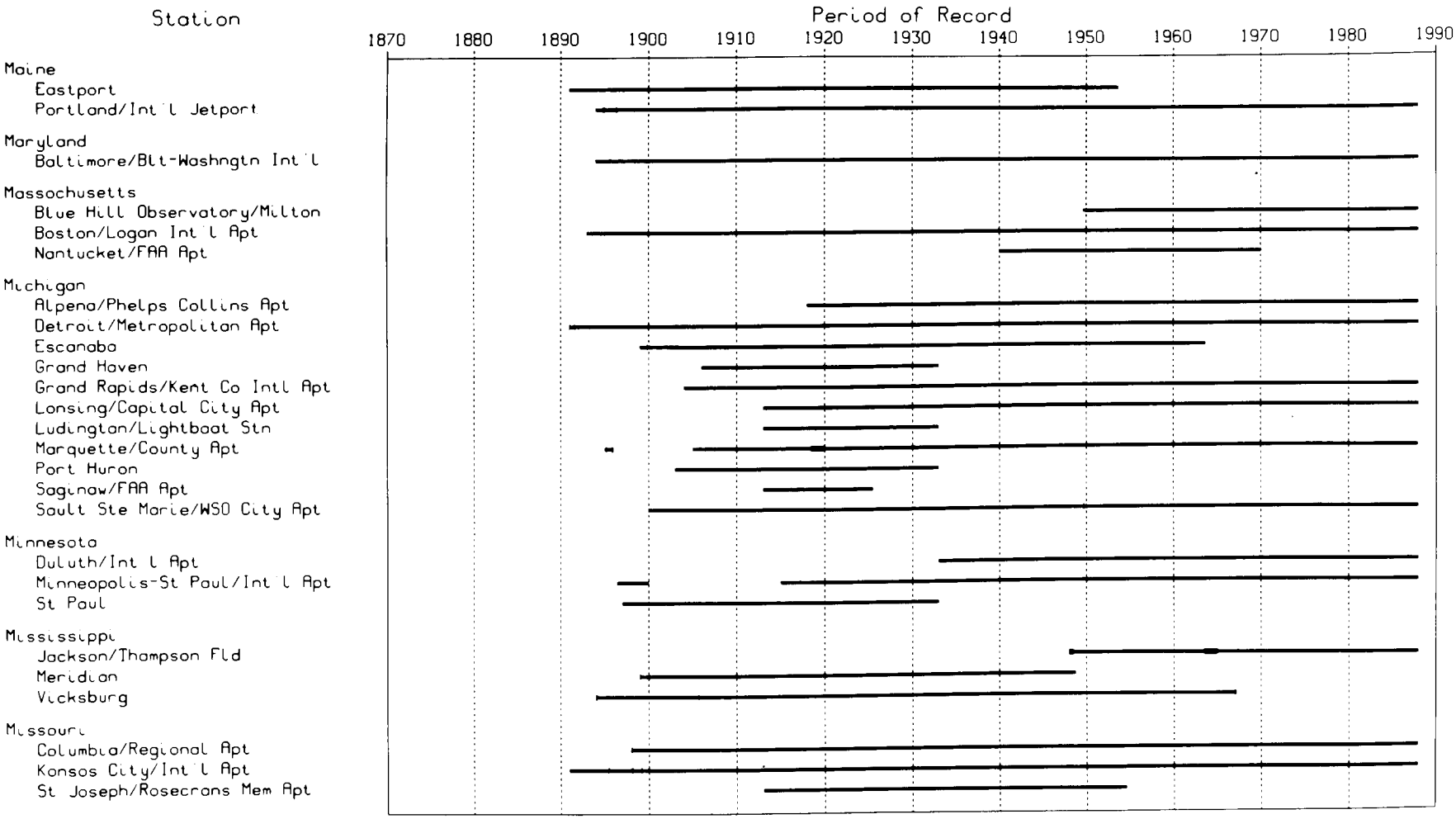



Sunshine Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Colorado
Denver/Stapleton Int'l Apt
Durango
Grand Junction/Walker Fld
Pueblo/Memorial Apt
Connecticut
Hartford/Bradley Int'l Apt
New Haven/Tweed Apt
D. of Colombia
Washington DC/National Apt
Florida
Apalachicola/Municipal Apt
Jacksonville/Int'l Apt
Jupiter
Key West/Int'l Apt
Lakeland 3 SE
Miami/Int'l Apt
Pensacola/Regional Apt
Tampa/Int'l Apt
Georgia
Atlanta/Hartsfield Int'l
Augusta
Macon/Lewis B Wilson Apt
Savannah/Municipal Apt
Hawaii
Hilo/General Lyman Fld
Honolulu/Int'l Apt
Kahului/Apt
Lihue/Apt
Idaho
Boise/Air Terminal
Pocatello/Municipal Apt

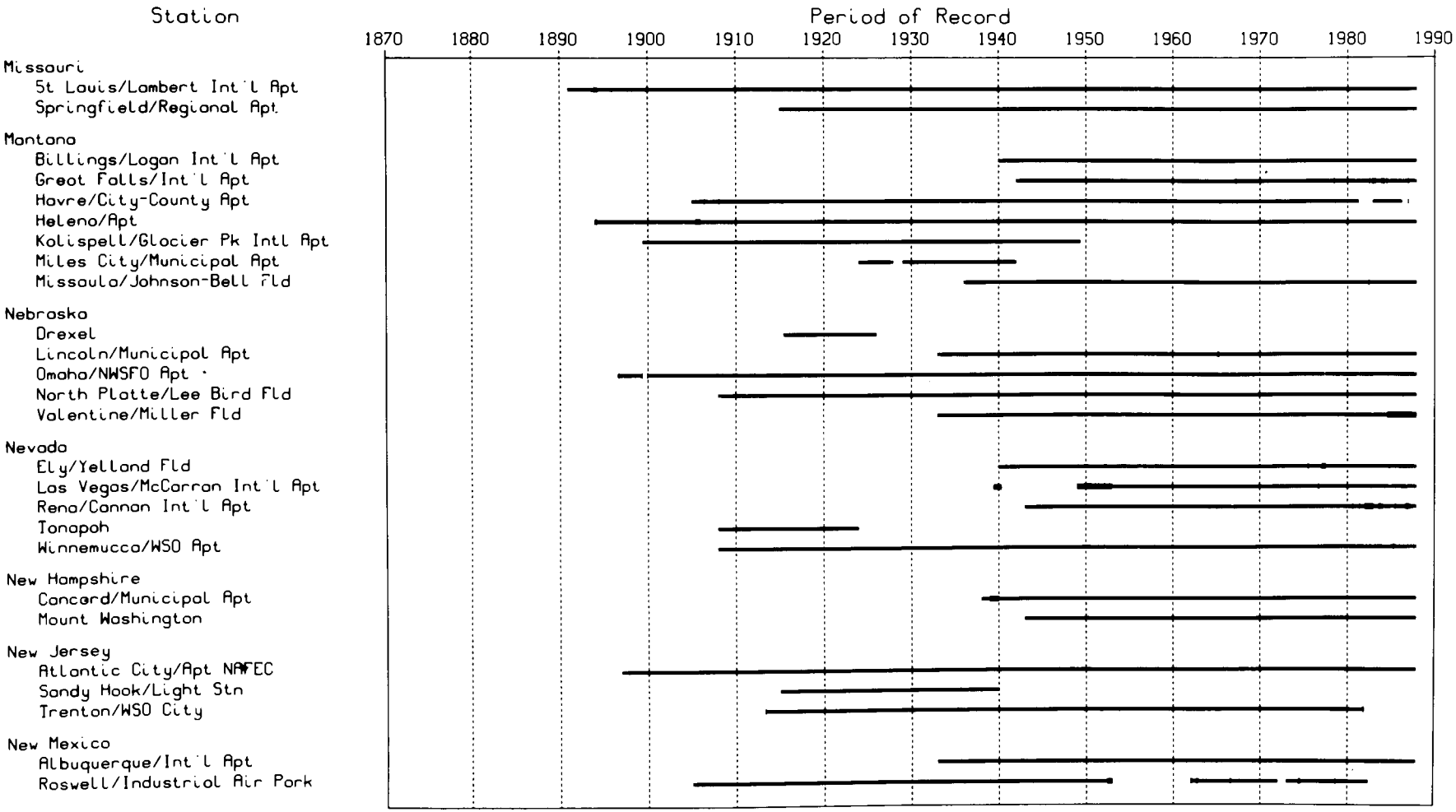
Sunshine Data Inventory

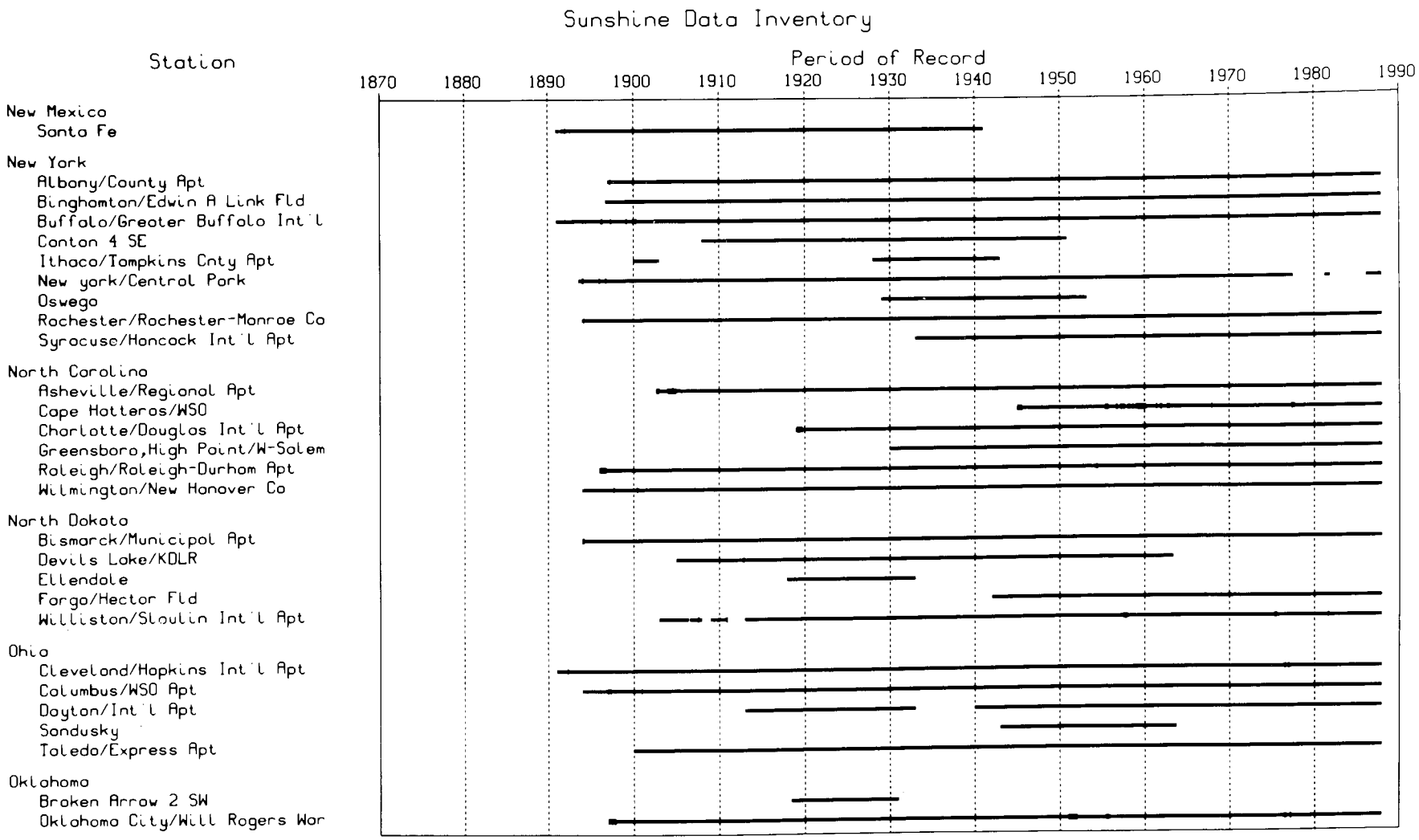


Sunshine Data Inventory

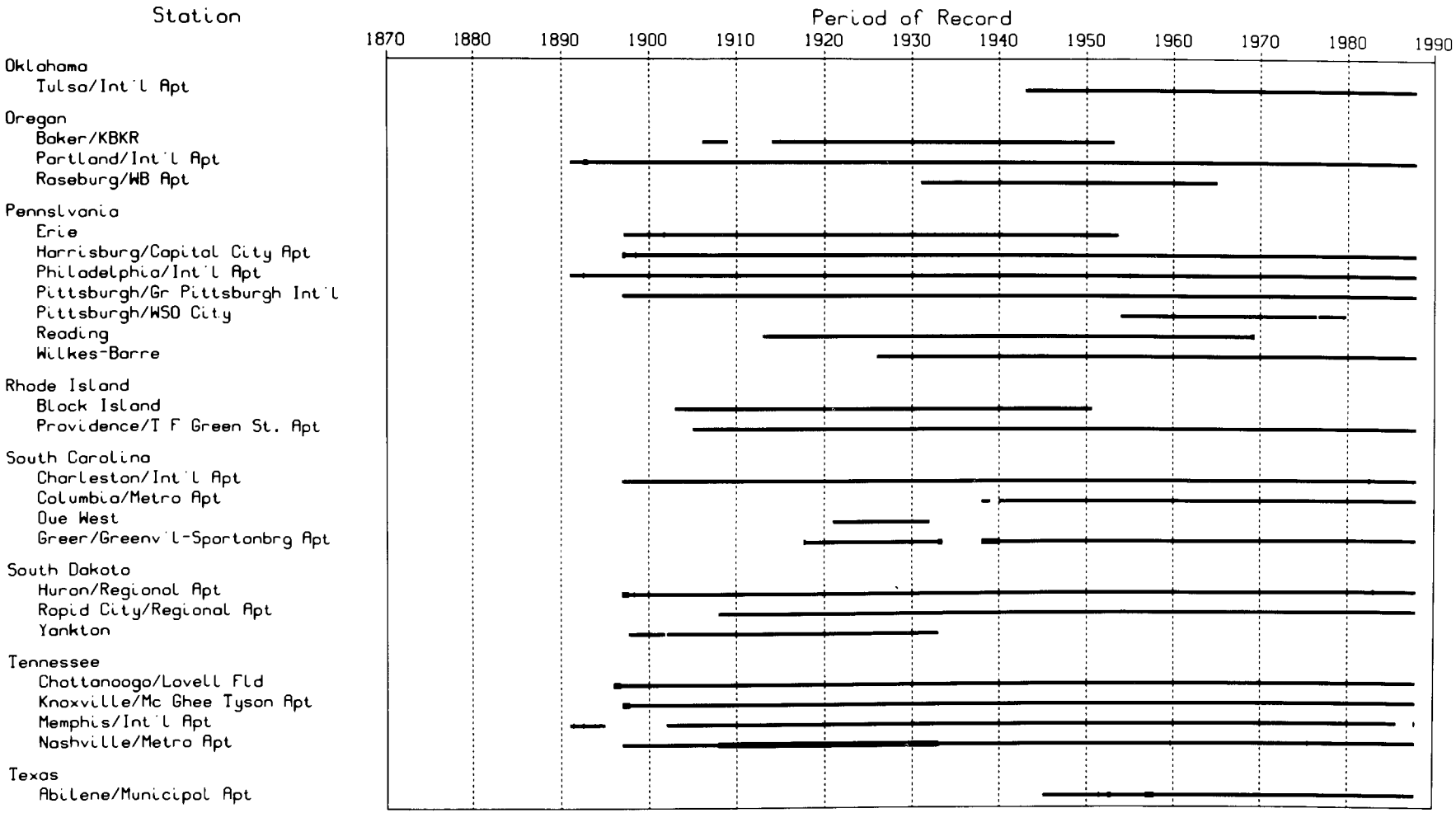


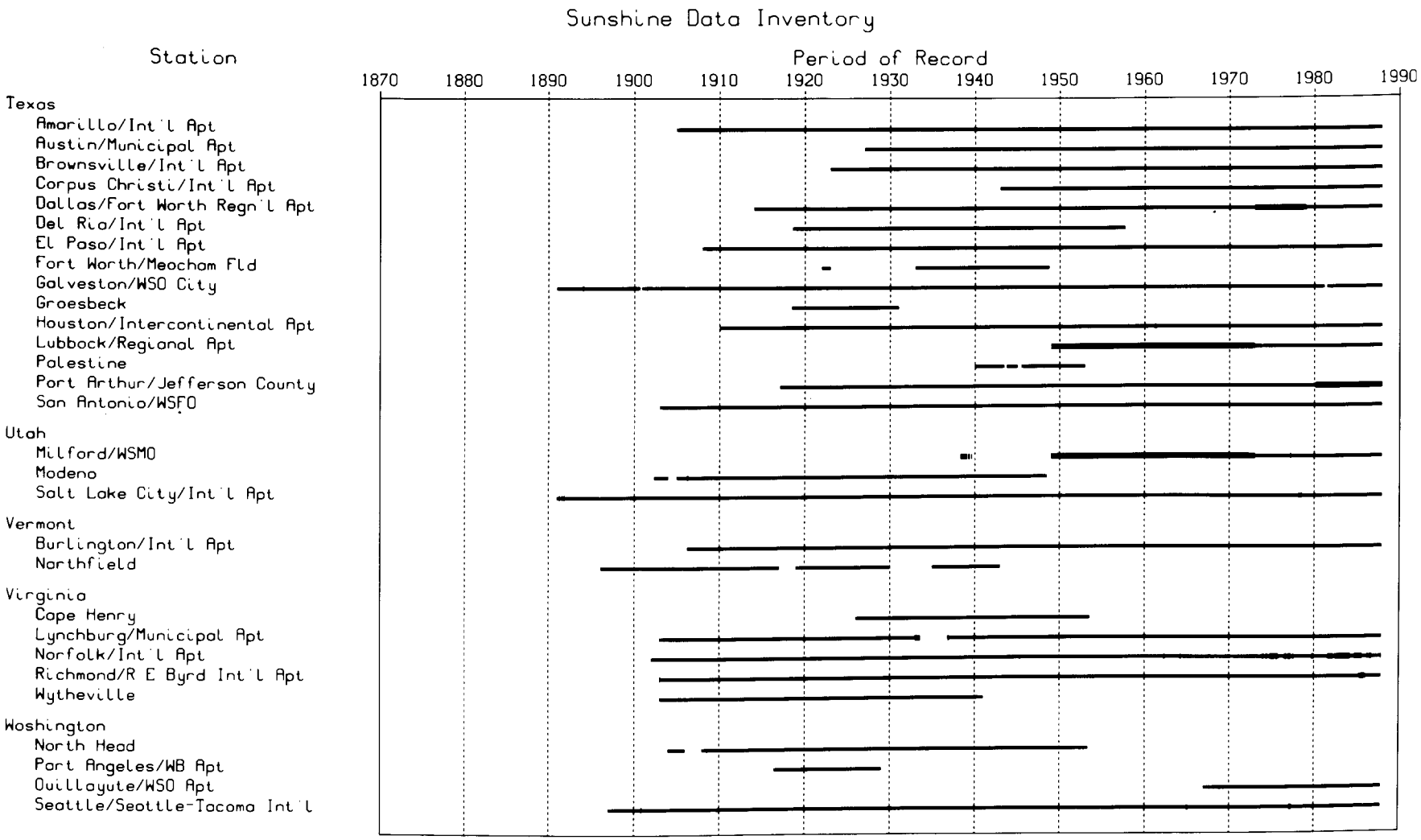
Sunshine Data Inventory

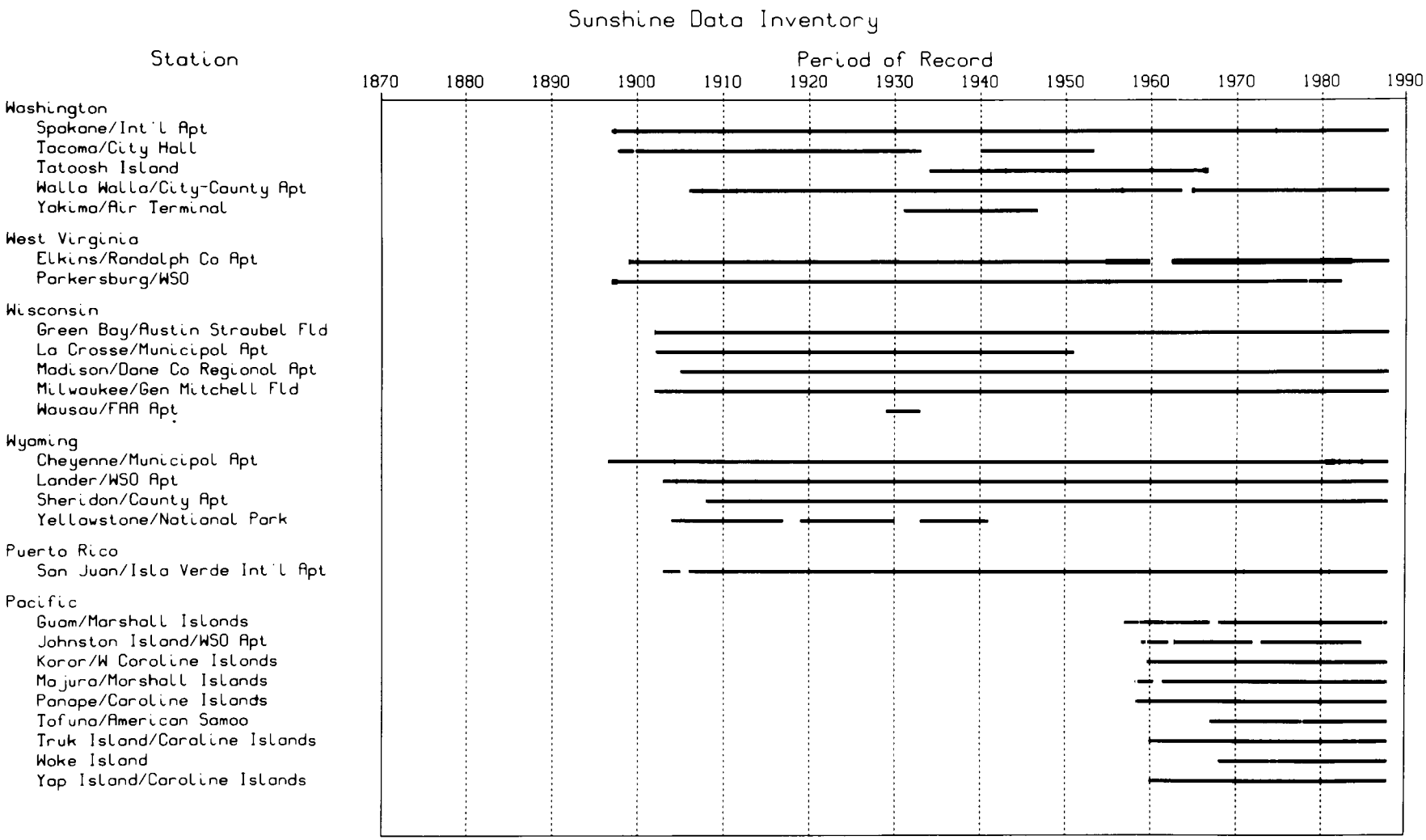


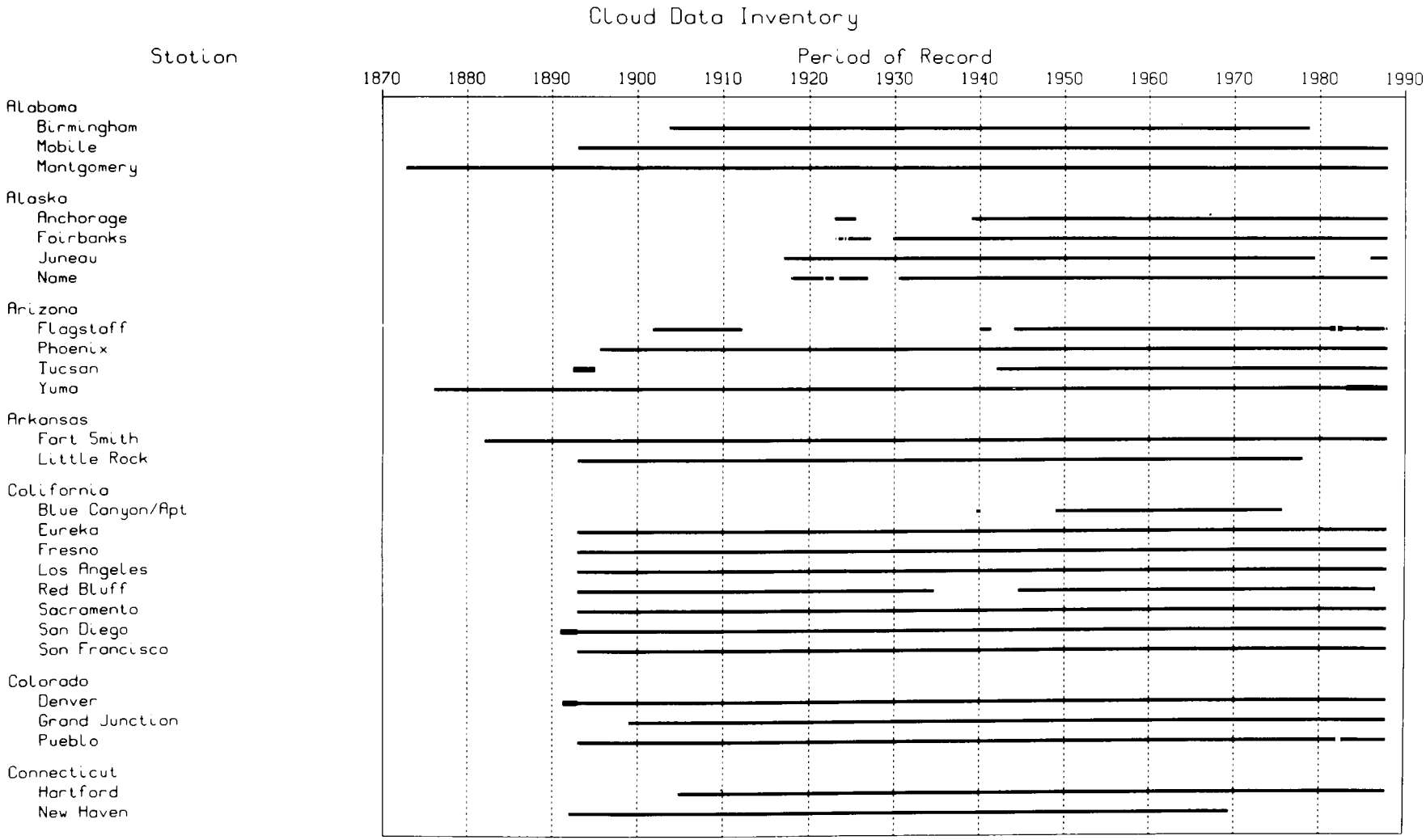

Sunshine Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
New Mexico
Santa Fe
New York
Albany/County Apt
Binghamton/Edwin A Link Fld
Buffalo/Greater Buffalo Int'l
Canton 4 SE
Ithaca/Tompkins Cnty Apt
New york/Central Park
Oswego
Rochester/Rochester-Monroe Co
Syracuse/Hancock Int'l Apt
North Carolina
Asheville/Regional Apt
Cape Hatteras/WSO
Charlotte/Douglas Int'l Apt
Greensboro,High Point/W-Salem
Raleigh/Raleigh-Durham Apt
Wilmington/New Hanover Co
North Dakota
Bismarck/Municipal Apt
Devils Lake/KDLR
Ellendale
Fargo/Hector Fld
Williston/Sloulin Int'l Apt
Ohio
Cleveland/Hopkins Int'l Apt
Columbus/WSO Apt
Dayton/Int'l Apt
Sandusky
Toledo/Express Apt
Oklahoma
Broken Arrow 2 SW
Oklahoma City/Will Rogers War

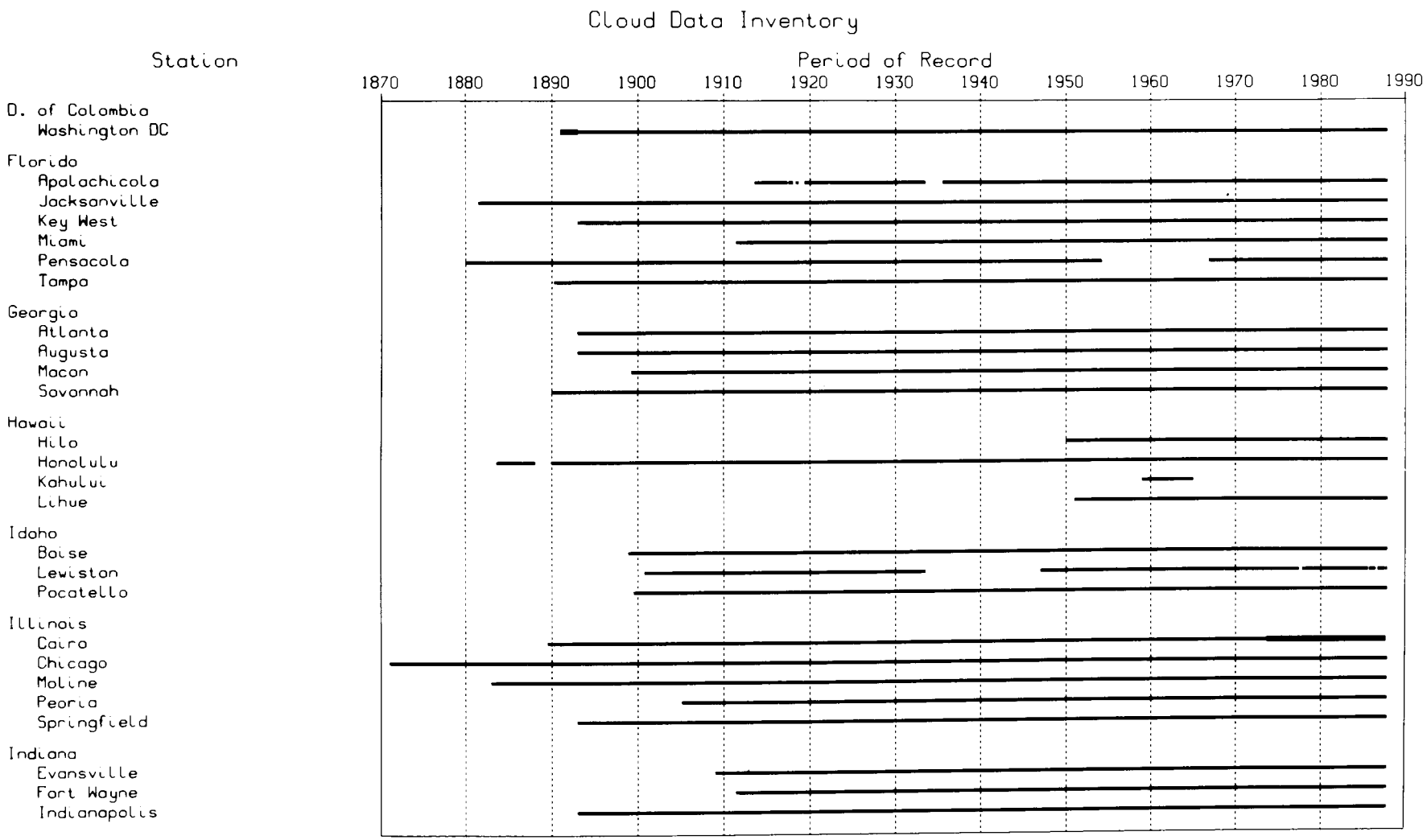
Sunshine Data Inventory

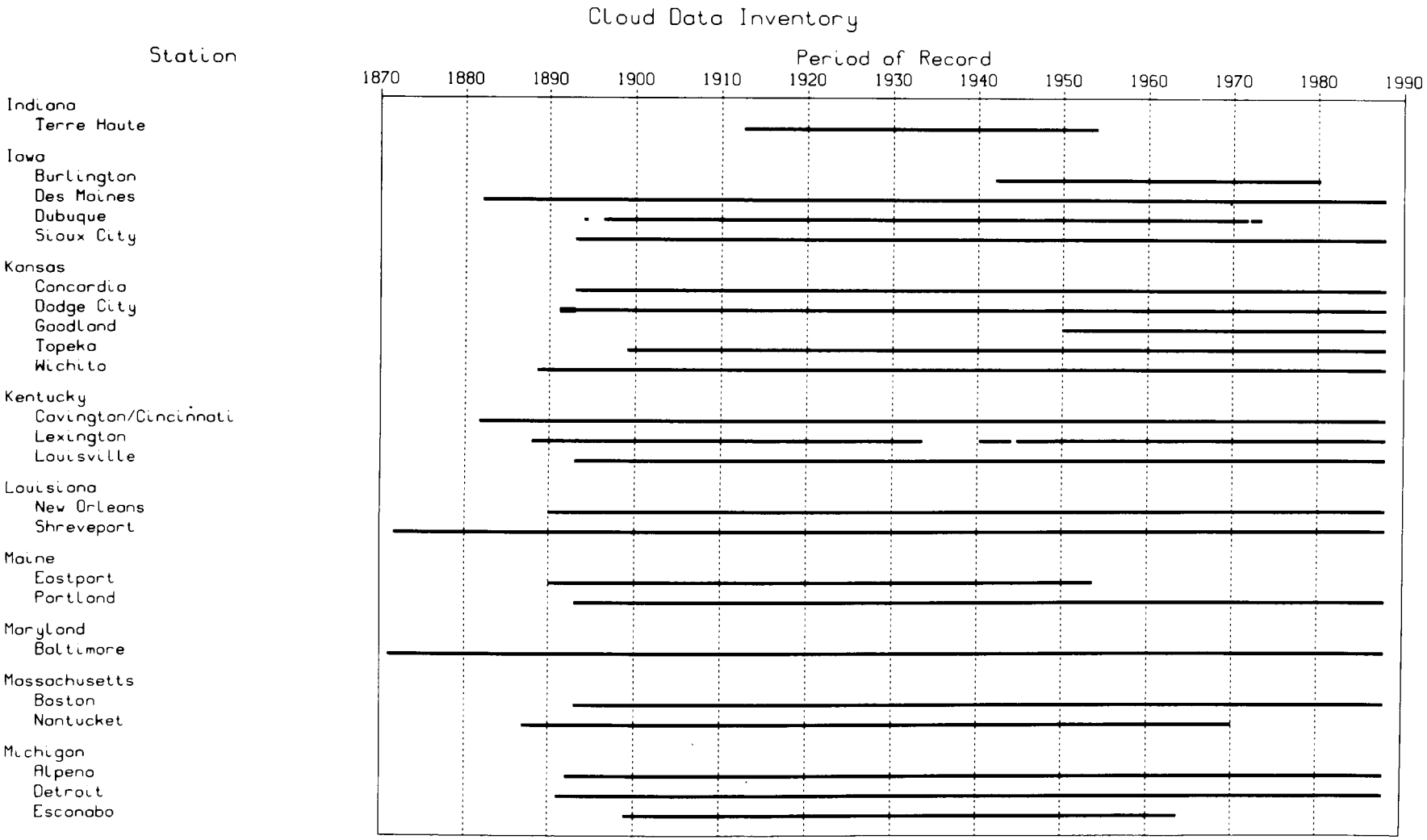


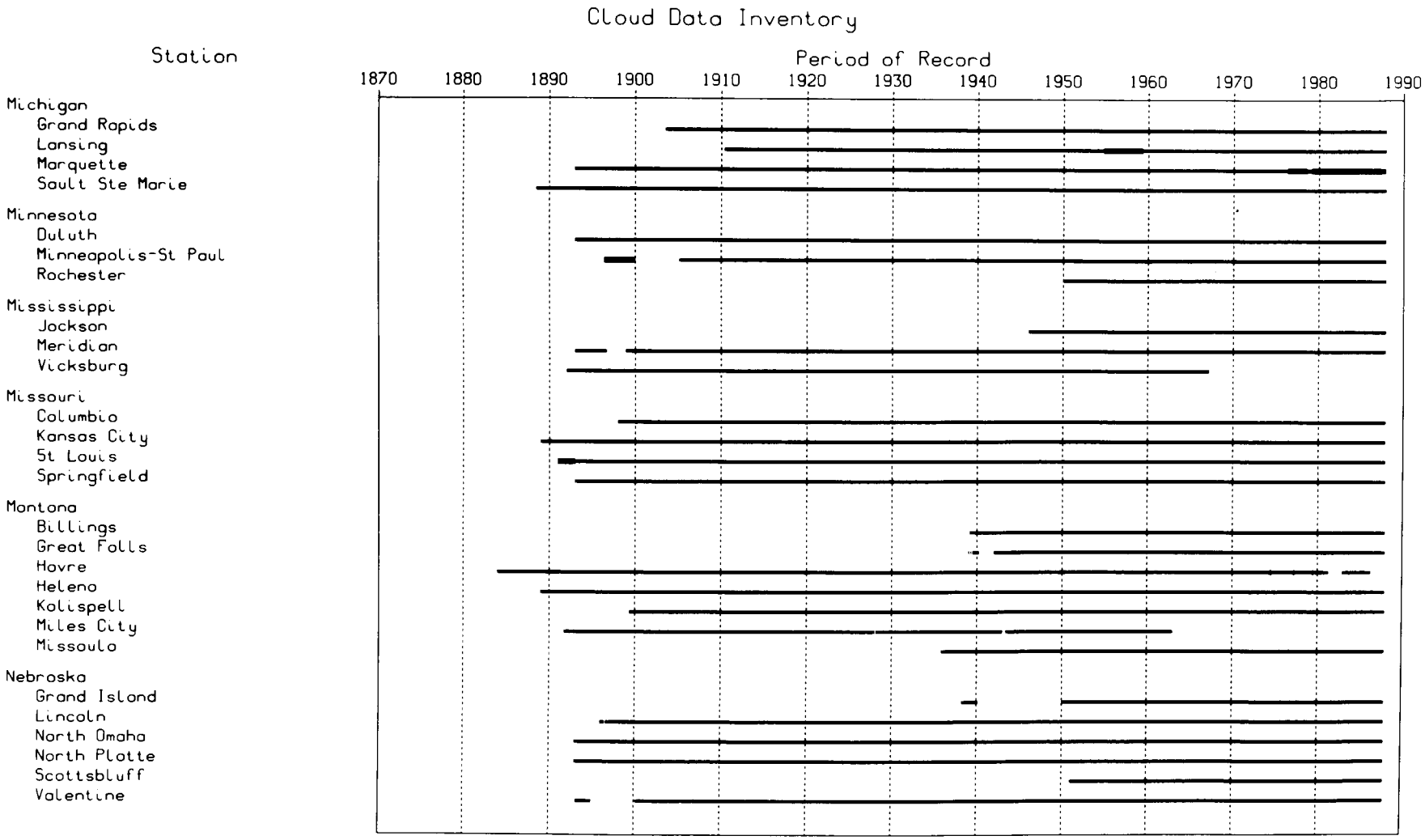

Sunshine Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Texas
Amarillo/Int'l Apt
Austin/Municipal Apt
Brownsville/Int'l Apt
Corpus Christi/Int'l Apt
Dallas/Fort Worth Regn'l Apt
Del Rio/Int'l Apt
El Paso/Int'l Apt
Fort Worth/Meacham Fld
Galveston/WSO City
Groesbeck
Houston/Intercontinental Apt
Lubbock/Regional Apt
Palestine
Port Arthur/Jefferson County
San Antonio/WSFO
Utah
Milford/WSMO
Modena
Salt Lake City/Int'l Apt
Vermont
Burlington/Int'l Apt
Northfield
Virginia
Cape Henry
Lynchburg/Municipal Apt
Norfolk/Int'l Apt
Richmond/R E Byrd Int'l Apt
Wytheville
Washington
North Head
Port Angeles/WB Apt
Quillayute/WSO Apt
Seattle/Seattle-Tacoma Int'l

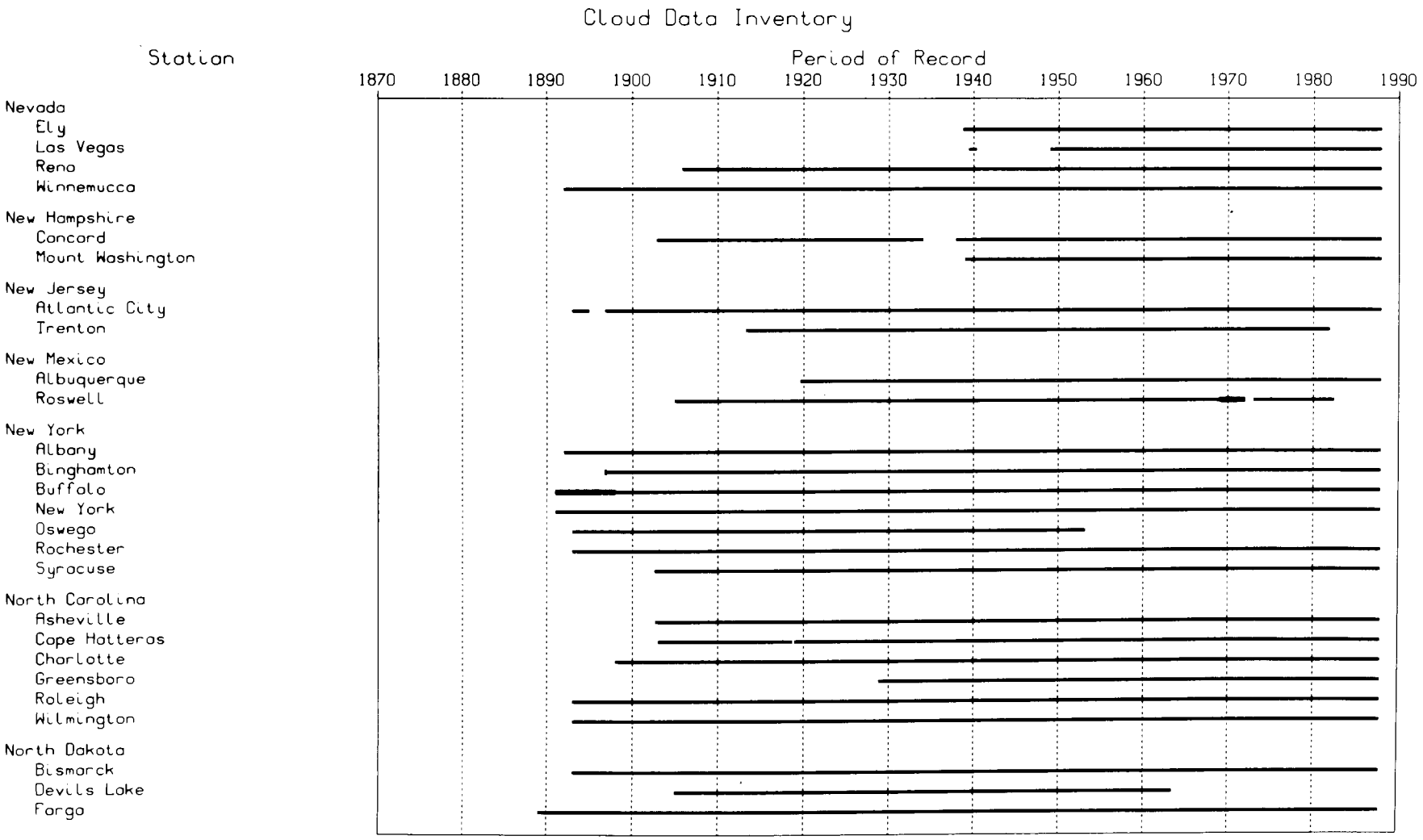

Sunshine Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Washington
Spokane/Int'l Apt
Tacoma/City Hall
Tatoosh Island
Walla Walla/City-County Apt
Yakima/Air Terminal
West Virginia
Elkins/Randolph Co Apt
Parkersburg/WSO
Wisconsin
Green Bay/Austin Straubel Fld
La Crosse/Municipal Apt
Madison/Dane Co Regional Apt
Milwaukee/Gen Mitchell Fld
Wausau/FAA Apt
Wyoming
Cheyenne/Municipal Apt
Lander/WSO Apt
Sheridan/County Apt
Yellowstone/National Park
Puerto Rico
San Juan/Isla Verde Int'l Apt
Pacific
Guam/Marshall Islands
Johnston Island/WSO Apt
Koror/W Caroline Islands
Majuro/Marshall Islands
Ponape/Caroline Islands
Tafuna/American Samoa
Truk Island/Caroline Islands
Wake Island
Yap Island/Caroline Islands

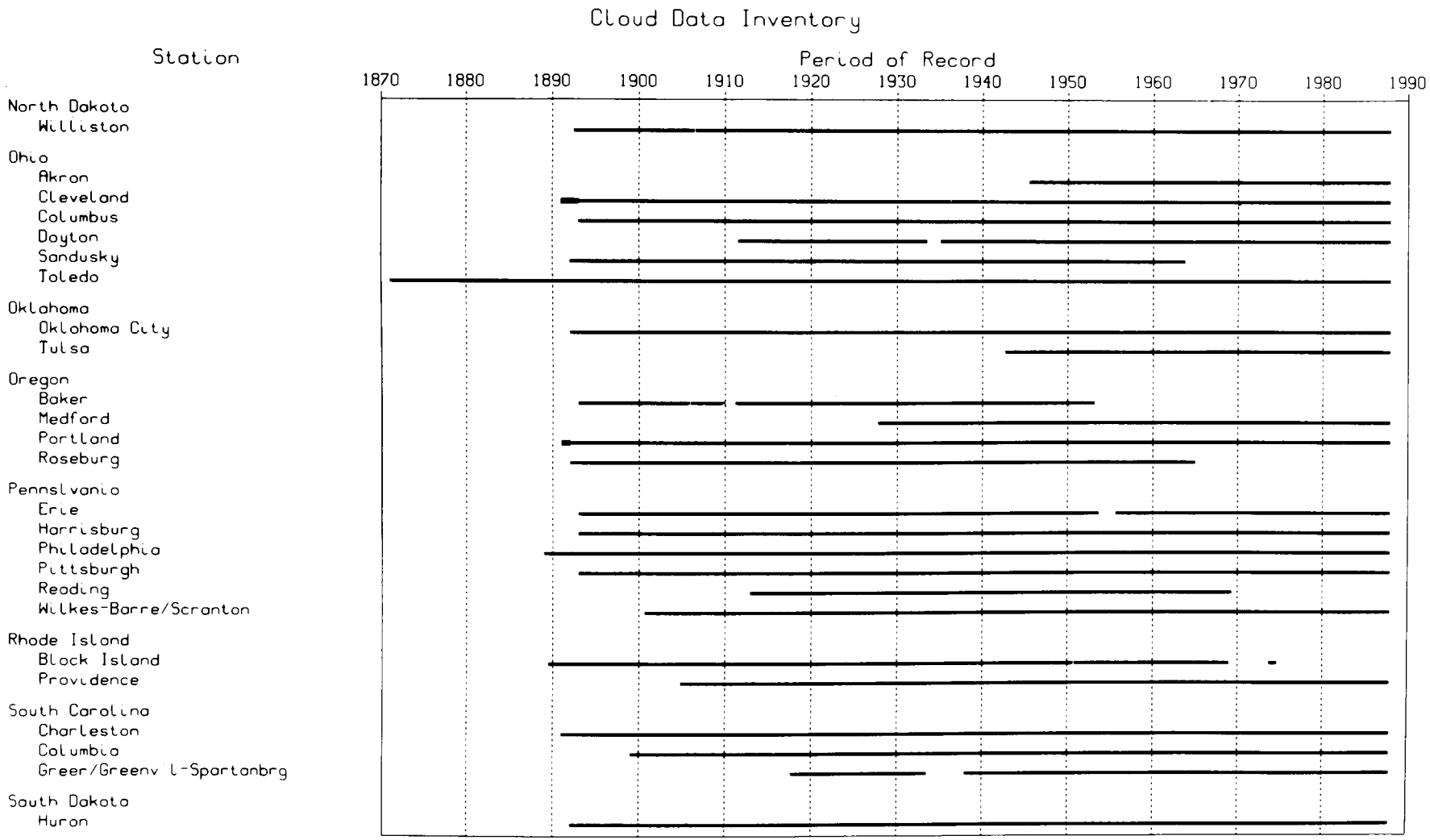

Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Alabama
Birmingham
Mobile
Montgomery
Alaska
Anchorage
Fairbanks
Juneau
Nome
Arizona
Flagstaff
Phoenix
Tucson
Yuma
Arkansas
Fort Smith
Little Rock
California
Blue Canyon/Apt
Eureka
Fresno
Los Angeles
Red Bluff
Sacramento
San Diego
San Francisco
Colorado
Denver
Grand Junction
Pueblo
Connecticut
Hartford
New Haven

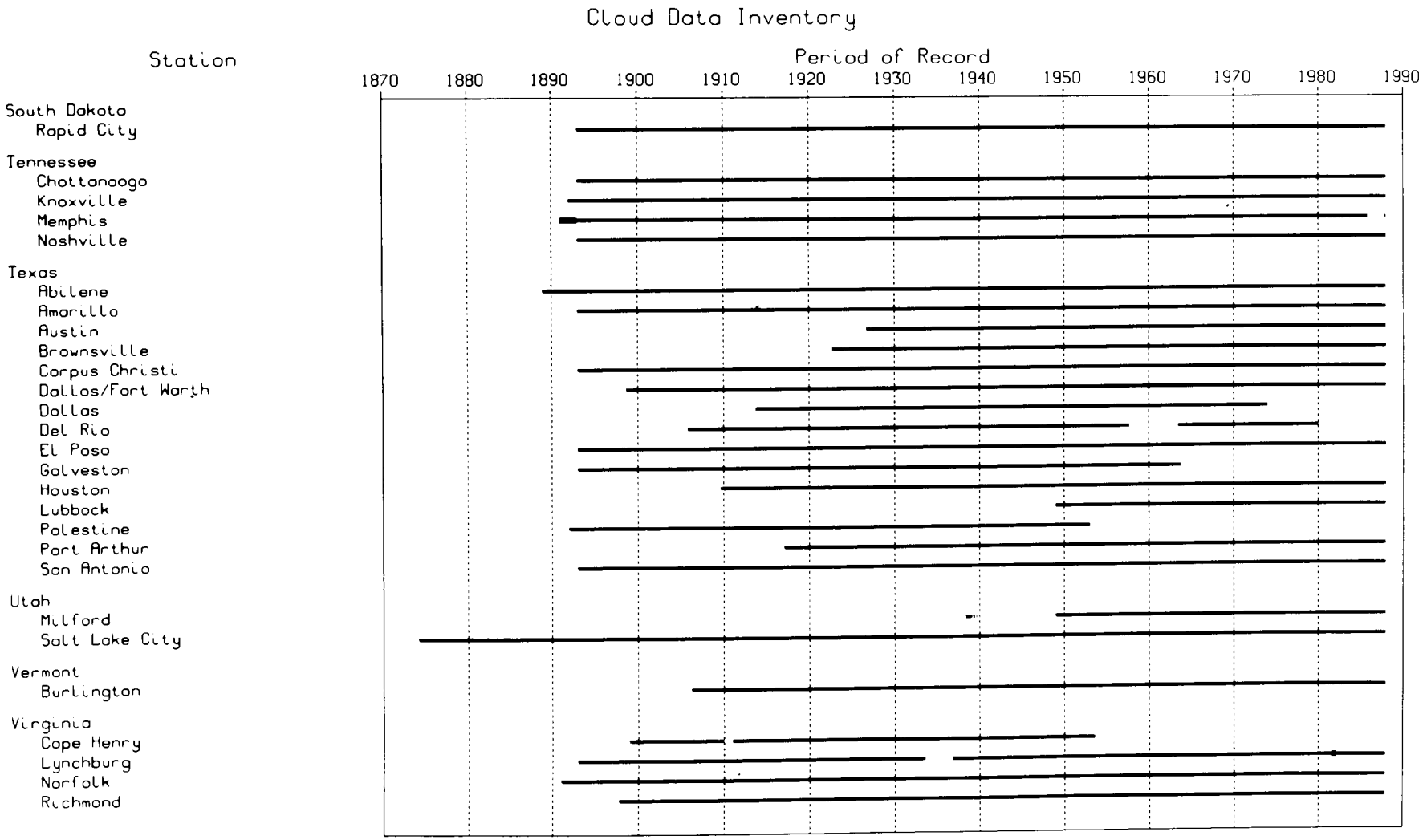

Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
D. of Colombia
Washington DC
Florida
Apalachicola
Jacksonville
Key West
Miami
Pensacola
Tampa
Georgia
Atlanta
Augusta
Macon
Savannah
Hawaii
Hilo
Honolulu
Kahului
Lihue
Idaho
Boise
Lewiston
Pocatello
Illinois
Cairo
Chicago
Moline
Peoria
Springfield
Indiana
Evansville
Fort Wayne
Indianapolis

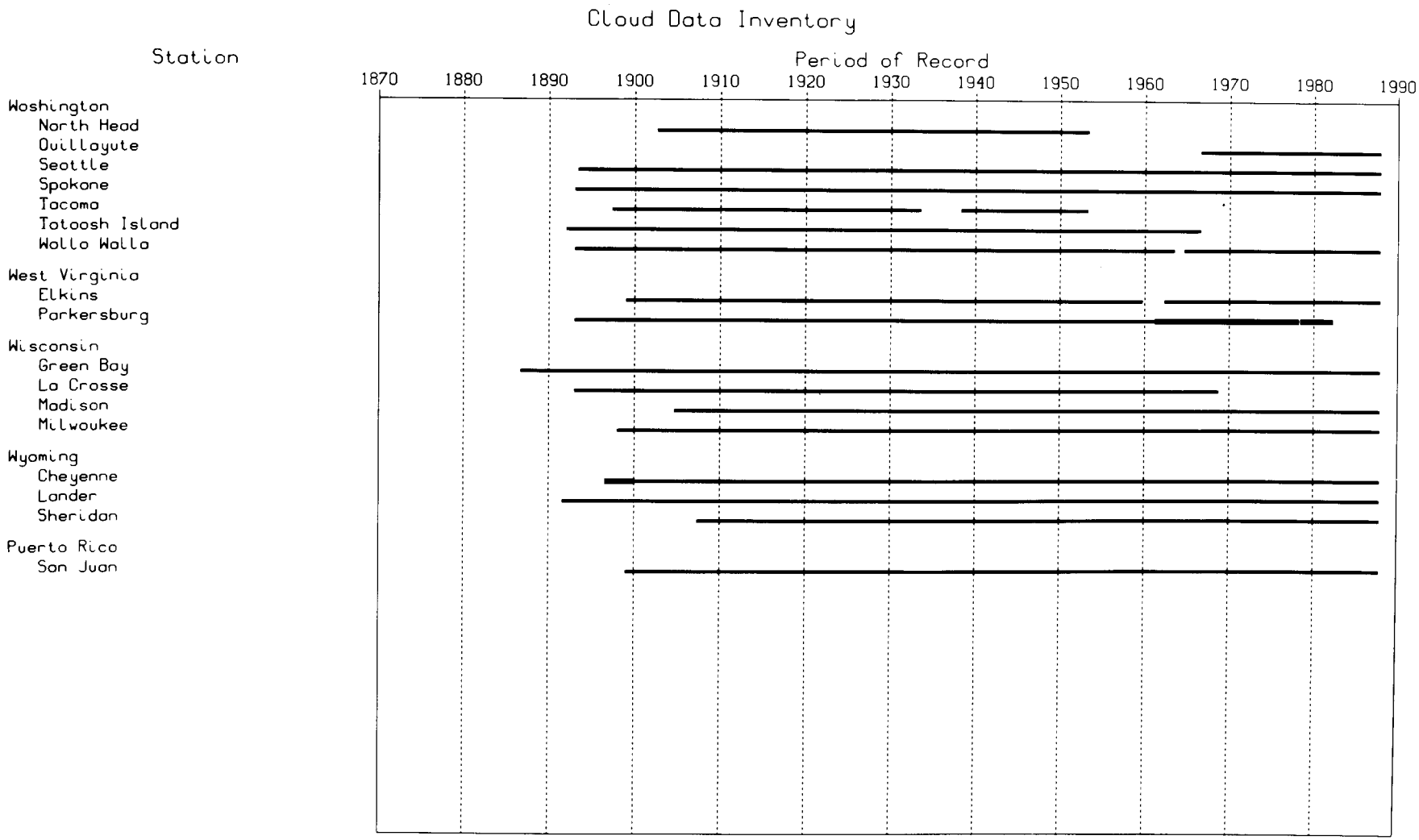

Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Indiana
Terre Haute
Iowa
Burlington
Des Moines
Dubuque
Sioux City
Kansas
Concordia
Dodge City
Goodland
Topeka
Wichita
Kentucky
Covington/Cincinnati
Lexington
Louisville
Louisiana
New Orleans
Shreveport
Maine
Eastport
Portland
Maryland
Baltimore
Massachusetts
Boston
Nantucket
Michigan
Alpena
Detroit
Escanaba


Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Michigan
Grand Rapids
Lansing
Marquette
Sault Ste Marie
Minnesota
Duluth
Minneapolis-St Paul
Rochester
Mississippi
Jackson
Meridian
Vicksburg
Missouri
Columbia
Kansas City
St Louis
Springfield
Montana
Billings
Great Falls
Havre
Helena
Kalispell
Miles City
Missoula
Nebraska
Grand Island
Lincoln
North Omaha
North Platte
Scottsbluff
Valentine


Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Nevada
Ely
Las Vegas
Reno
Winnemucca
New Hampshire
Concord
Mount Washington
New Jersey
Atlantic City
Trenton
New Mexico
Albuquerque
Roswell
New York
Albany
Binghamton
Buffalo
New York
Oswego
Rochester
Syracuse
North Carolina
Asheville
Cape Hatteras
Charlotte
Greensboro
Raleigh
Wilmington
North Dakota
Bismarck
Devils Lake
Fargo


Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
North Dakota
Williston
Ohio
Akron
Cleveland
Columbus
Dayton
Sandusky
Toledo
Oklahoma
Oklahoma City
Tulsa
Oregon
Baker
Medford
Portland
Roseburg
Pennsylvania
Erie
Harrisburg
Philadelphia
Pittsburgh
Reading
Wilkes-Barre/Scranton
Rhode Island
Block Island
Providence
South Carolina
Charleston
Columbia
Greer/Greenv l-Spartanbrg
South Dakota
Huron


Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
South Dakota
Rapid City
Tennessee
Chattanooga
Knoxville
Memphis
Nashville
Texas
Abilene
Amarillo
Austin
Brownsville
Corpus Christi
Dallas/Fort Worth
Dallas
Del Rio
El Paso
Galveston
Houston
Lubbock
Palestine
Port Arthur
San Antonio
Utah
Milford
Salt Lake City
Vermont
Burlington
Virginia
Cape Henry
Lynchburg
Norfolk
Richmond


Cloud Data Inventory
Station
Period of Record
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Washington
North Head
Quillayute
Seattle
Spokane
Tacoma
Tatoosh Island
Walla Walla
West Virginia
Elkins
Parkersburg
Wisconsin
Green Bay
La Crosse
Madison
Milwaukee
Wyoming
Cheyenne
Lander
Sheridan
Puerto Rico
San Juan

APPENDIX B

Historical Description and Assessment of Sunshine Measurement Procedures and Data Sources

Automatic recordings of the number of hours in which the sun is visible each day have been made in the United States since the 1880s. Possible sunshine duration (SD) is simply the time between sunrise and sunset, assuming a smooth, spherical earth not obstructed by natural or man-made obstructions. Sunrise and sunset are defined by the National Weather Service as the time when the sun's upper disc appears in the morning and disappears in the evening on a sea-level horizon.

Since 1888, three automatic instruments with completely different sensing characteristics have been used to record SD in the United States. These were the Jordan Photographic Sunshine recorder used from 1888–1907, the Maring-Marvin Thermometric Sunshine recorder used from 1893 through the middle 1960s, and the Foster Photoelectric Sunswitch used from 1952 to the present. Although different instruments have been used, all three sunshine recorders were designed to record the duration of sunshine without regard to the degree of intensity.

Detailed descriptions of the three sunshine recorders are given by Maring (1897), Brooks and Brooks (1947), and Foster and Foskett (1953). Briefly, the photographic instrument used light-sensitive sheets of paper that traced SD. A disadvantage was that records from this instrument required manual extractions before they could be used for study. SD data from the photographic instrument were first published in the 1891 edition of the *Report of Chief of the Weather Bureau* (RCWB) for twenty stations. That year, a differential thermometer was also devised as a sunshine recorder (Maring 1897). The advantage of this instrument was that SD could be recorded automatically and electronically using a triple register at a distance from the recorder. Beginning in 1893, the photographic sunshine recorders were gradually replaced by thermometric sunshine recorders as they became available. By 1908, all 130 stations in the rapidly expanding station network were using the thermometric recorders. Because this instrument was relatively simple and inexpensive, it remained in use at U.S. Weather Bureau stations through the 1950s and 1960s. In the early 1950s, a new sunshine recorder was designed using advancing technology in electronics and photoelectric cells. The photoelectric sunshine switch was introduced into the network in 1952 (Foster and Foskett 1953) and replaced the thermometric recorders as fast as the equipment could be made available. A recent detailed investigation of the station history records has revealed that the change from the thermometric to the photoelectric sunshine switch did not occur at all stations in the early 1950s as previously assumed by many researchers. Rather, the change was more gradual, with the thermometric recorder still in use at about a third of the stations in 1960. Figure 7 indicates that the most rapid rate of change was during the early 1950s, with the last conversion taking place in the mid-1960s. Table 1 (pp. 18–27 of this document) delineates the time periods in which the photographic, thermometric, and photoelectric sunshine recorders were used at each observation site.

The three instruments described differ with regard to their sensitivity and responsiveness to different types of radiation, this being a potential source of inhomogeneity when considering a station's entire period of record. The photographic and thermometric recorders responded to both direct and diffuse radiation, but the photoelectric recorder responds only to direct radiation. In addition, the photoelectric recorder was reported by Baker and Haines (1969) to be activated when exposed to a solar flux density of about 0.12 cal cm^{-2} min^{-1}. Brooks and Brooks (1947) reported that the average insolation value for which the thermometric recorder began and ceased recording was 0.37 cal cm^{-2} min^{-1}. The response time of the photoelectric recorder is also much quicker than that of the thermometric recorder, especially when the sky has broken clouds. Concerning the thermometric recorder, the fourth edition of *Weather Bureau Circular G* (Marvin 1914) states that " . . . this sunshine recorder is somewhat sluggish . . . " and " . . . small clouds and a few moments of sunshine may, therefore, escape being recorded." Foster and Foskett (1953) found the thermometric recorder to be so sluggish that it would take 5 to 10 minutes to respond to the appearance or disappearance of the sun. No references were found that compared the sensitivity of the photographic recorder with the other sunshine recorders. However, the 1891 issue of RCWB did state that "the use of this recorder has not been attended with much satisfaction, owing wholly to the

imperfect and irregular action of the photographic paper."

Exposure, calibration, and maintenance of the sunshine recorder are also of utmost importance in maintaining a homogeneous record. The first edition of Circular G (Marvin 1896) stated, "It need scarcely be said that the point selected for the exposure of a sunshine recorder should command an uninterrupted view of the sun at all hours of the day and all seasons of the year." Subjective corrections (described in the following) were required when obstructions caused breaks in the daily sunshine record. Also, extensive but subjective instructions on the calibration of the recorders were provided by the U.S. Weather Bureau. For example, Marvin (1896 and 1914) states, "The inclination of the (thermometric) recorder will be adjusted at such an angle that the mercury column will just close the electric circuit during the time when the disk of the sun can just be faintly seen through the clouds." Similar subjective instructions are given for the photoelectric switch, making the sensitivity of the sunshine recorders somewhat dependent on the observer or electronics technician. Lack of maintenance of the sunshine recorders could also lead to potential inhomogeneity. Although the fourth edition of Circular G (Marvin 1914) stated " . . . it will rarely be necessary to examine or readjust this instrument (thermometric recorder), and it is not, therefore, so important that it be of easy access," the third edition of Circular A (Marvin 1913) stated, "The glass jacket of the sunshine recorder should be cleaned once a week or as often as necessary, especially in dirty, smoky cities so as to maintain high transparency of the glass and prevent accumulation of dust and soot that will impair the sensitivity of the instrument."

Another problem associated with SD is that sunshine instruments do not start recording until the sun angle is well above the horizon. This is complicated by complex terrain (buildings, mountains, etc.) and smoky and foggy conditions that would obstruct visibility during low sun angles. To compensate for complex terrain, instrument failure, and the lack of instrument sensitivity, observers from 1893 to the present have been instructed to include the observed but unrecorded sunshine in the daily totals of sunshine duration. These correction factors introduce subjectivity into the data, especially when skies at sunrise and sunset are partly cloudy, and require a low sun correction of something other than 0 or 100%. Also, observers at many city offices were not always on duty at sunrise, requiring an educated guess of the low-sun-angle correction. In addition, station moves from urban to airport locations in the 1930s and 1940s would presumably require smaller low sun corrections (less subjectivity) because of less obstruction of vision caused by buildings and smoke.

Total sunshine duration data (TSDD) were assembled from four data sources. From 1981 to the current time, TSDD were extracted from digital files used in the publication *Local Climatological Data* (LCD). The digital LCD work files are retained at the National Climatic Data Center (NCDC) until the data are merged into the historical sunshine data base (TD9788). Before 1981, three related manuscript sources of sunshine data were consulted and digitized by Doehring and Karl (1981).

The annual *Report of the Chief of the Weather Bureau* was published from 1891–1934. The yearly reports contained monthly and annual totals of the hours of sunshine and also the percentage of possible sunshine. Starting in 1935, these annual meteorological statistics were transferred to a separate volume entitled the *United States Meteorological Yearbook*. This continued each year until 1949, when the publication was discontinued. In 1950, the *Climatological Data, National Summary* (CDNS) publication began. In each annual issue of CDNS, monthly sunshine data were available in the same format as prior years. This publication was discontinued in 1980. Monthly data for all years prior to 1981 were extracted from these publications and merged with the post-1980 digital data.

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APPENDIX C

Historical Description and Assessment of Cloud Measurement Procedures and Data Sources

Estimates of the total amount of clouds in tenths of sky cover have been routinely made in the United States since the 19th century. Cloud measurements from the ground are subjective, compared with the more objective satellite techniques, and are based on observer competence, the method of observation, and viewing conditions. Since the 1890s, cloud measurements in the United States have been made at regular observing times. Through the 1930s, three official observations were required by a station each day. The observations were made near sunrise and sunset and also at 12 noon; however, an estimate of the average cloud cover for the period sunrise to sunset was also made as determined from frequent personal observations. Up until 1934, these cloud observations were made for the most part in urban areas largely consisting of rooftop exposures. With the advent of commercial aviation, an increasing number of new observation sites were opened at airports. Many city offices were closed or coexisted with airport offices usually within a few miles of each other.

The change from city to airport represented a significant change in cloud observing practice. Because of the operational requirements of aviation, cloud observations were regularly taken at airports every hour. In contrast, city offices were required to " . . . record in whole numbers the average amount of clouds during the day (sunrise to sunset) on a scale of 0 to 10, as determined from frequent personal observations." This probably involved the city observer, or in many cases observers, keeping track of the cloud amounts throughout the day on a note sheet at irregular intervals and then subjectively combining these amounts to produce an average daily sunrise to sunset cloud cover. Although official documentation has not been located, it would be logical that the hourly cloud amounts recorded at airports were used to calculate the daily cloud cover. If this is true, a potential bias was created when stations moved from the city to the airport. Not only were observations being recorded at a different location, with probable better viewing conditions compared with the city, but these observations were recorded on a systematic basis compared with an irregular schedule. It is quite possible that airport observers would have found more clouds than those city observers who did not have to be as rigorous. Furthermore, observers at city offices were not always present during all daylight hours. Marvin (1913) stated, "It is not intended that observers shall go on duty at unreasonably early hours in order that the character of sunrise may be determined, but it is believed that, without much inconvenience, sufficiently accurate data can be obtained by noticing the character of weather, immediately upon rising and by inquiry of persons who may have occasion to be up at the time of sunrise." This could also have resulted in a bias toward lower cloud amounts because observers would not be searching the sky for clouds at this early hour.

In 1939, a major change in observing practices was initiated by the U.S. Weather Bureau. Cloud forms were now identified according to an international classification system, and observations at both city and airport sites were made on a more systematic basis. The March, 1939 issue of the U.S. Weather Bureau's *Topics and Personnel* stated that the observer was to record on U.S. Weather Bureau Form 1014 " . . . the amount of cloudiness for each hour. The cloudiness for the day is then determined by adding the hourly figures and dividing by the number of hours." This method was probably used by all airport stations and most large city offices at the start of 1939; however, it appears that the smaller city offices did not have sufficient personnel to perform hourly observations. The 1939 through 1941 issues of *Topics and Personnel* frequently commented on the serious loss of personnel to the military in preparation for the impending world war. Also, the last year in which the annual instructions were issued (1948) had references pertaining to computing sunrise to sunset cloudiness based on 3-hourly, 6-hourly, and only one or two observations per day. This obviously implies that some stations were not recording on an hourly basis as late as 1948.

Another major change in observing practice occurred in 1948. The definition of average sunrise to sunset cloudiness was broadened to include all obstructions to the sky such as fog, haze, smoke, and dust. In 1949, this was reflected in the change of terminology from cloud cover to sky cover. Prior to 1948, only clouds were used and observers were explicitly instructed not to include these obstructions in their sums and averages of cloudiness. This is a significant change in observing

practice. If, for example, five-tenths of the sky was obscured by fog and the remaining unobscured sky had one-tenth cloud cover, current observing practice would record six-tenths sky cover. However, prior to 1948, cloudiness was determined by the proportion of the sky covered with clouds, exclusive of obstructions. Because, in this example, the five-tenths of unobscured sky had one-tenth clouds, pre-1948 observing practices would record two-tenths cloud cover.

Changes in cloud observing practices suggest that the historical cloud record underwent significant changes. This is especially true during the 1930s and 1940s, when stations were relocating to airports and major changes were occurring in observing practice.

Total monthly mean cloud amounts for the period sunrise to sunset (TCSS) were assembled from four compatible data sources. From 1965 to the present, TCSS has been extracted from the digital file, Summary of the Day (TD3210). Prior to 1965, these data were unavailable in digital form and were assembled from three manuscript sources.

The Climate Record Book (CRB) and U.S. Weather Bureau Form 1001 (WB1001) both contain monthly mean cloud amounts from the beginning of record through 1970 and 1948, respectively. The *Local Climatological Data* (LCD) publication contains TCSS from 1949 to the present. WB1001 is the original weather form on which observers recorded their hourly and daily observations. All entries in the CRB and LCD are special monthly summaries created from WB1001 [or earlier/subsequent original weather forms (e.g., WBAN 10)].

Because of the ease of data extraction (30 years of a station's monthly data on a page), the CRB was first examined for TCSS. Unfortunately, much of the CRB cloud data contained three monthly values, which represented averages for observations made at 12 noon local time and 8 a.m. and p.m. (7:30 a.m. and p.m. after 1936) 75th Meridian time (now eastern time). Depending on the station location and/or time of year, the 8/7:30 a.m. and/or p.m. observation(s) might not occur during the sunrise to sunset period. Because the cloud data were to be compared with sunshine data and, also required to be compatible with the post-1964 TCSS data, the WB1001 and LCD were then consulted.

WB1001 contains observations recorded at the same hours as the CRB but also contains a summary page in which the monthly mean cloud amounts were based on the period sunrise to sunset. Data extracted from WB1001 was a much more laborious task because each monthly cloud amount was on a separate sheet of paper. Similarly, the LCD contained 12 monthly mean TCSS values in the annual issue.

In summary, monthly mean sunrise to sunset cloud amounts are a combination of four compatible data sources. From 1965 to the present, all data are from the TD3210 digital file. Before 1965, the CRB was first consulted to determine whether observations were TCSS or an hourly mean. All observations in the CRB that were TCSS were extracted. The remaining data obtained before 1949, which were not extracted from the CRB, were obtained from WB1001. From 1949 to 1964, the remaining data came from the LCD. The resulting digital file of TCSS contains a code identifying which of the four data sources was used for each monthly value.

REFERENCES

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APPENDIX D

Maximum Possible Hours of Sunshine at Stations in the U.S. Sunshine Recorder Network

STATE & STATION	WBAN#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	LEAPYR ADJ.
AL ANNISTON	93865	316	308	371	391	431	430	438	415	371	352	313	309	4445.4	11.5
AL BIRMINGHAM	3883	317	308	371	391	431	430	438	415	371	352	313	309	4445.3	11.5
AL MOBILE	93855	323	311	372	388	425	423	431	410	371	354	318	316	4442.0	11.5
AL MONTGOMERY	13895	319	309	372	389	428	427	435	413	371	353	316	312	4443.9	11.5
AK ANCHORAGE	26451	203	252	366	442	542	575	568	489	387	311	219	175	4530.0	10.4
AK FAIRBANKS	26411	164	236	365	457	581	643	619	511	392	300	189	124	4581.5	10.1
AK JUNEAU	25309	224	262	367	433	521	545	542	476	385	318	236	201	4510.2	10.5
AK KETCHIKAN	25325	243	270	368	425	503	520	521	464	382	324	251	224	4494.4	10.8
AK NOME	26617	168	238	365	455	577	634	614	509	392	301	192	129	4574.1	10.1
AZ FLAGSTAFF	3103	313	306	371	392	434	434	442	417	372	350	310	305	4447.3	11.4
AZ PHOENIX	23183	317	308	371	391	431	430	438	414	371	352	313	309	4445.2	11.4
AZ PRESCOTT	23184	314	306	371	392	433	433	441	416	372	351	311	306	4446.7	11.4
AZ TUCSON	23160	320	309	372	389	428	426	435	412	371	353	316	313	4443.6	11.5
AZ YUMA	23195	319	309	372	390	429	428	436	413	371	352	315	311	4444.3	11.5
AR BENTONVILLE	93925	310	304	371	394	437	438	445	419	372	349	308	302	4448.9	11.4
AR FORT SMITH	13964	313	306	371	393	435	435	442	417	372	350	310	304	4447.6	11.4
AR NORTH LITTLE RO	3952	314	306	371	392	433	433	441	416	372	351	311	306	4446.8	11.4
CA EUREKA	24213	299	298	370	399	448	451	458	427	374	345	298	288	4455.7	11.3
CA FRESNO	93193	309	304	371	394	438	439	446	420	373	349	307	300	4449.5	11.4
CA INDEPENDENCE	93164	309	304	371	394	438	439	446	420	373	349	307	300	4449.5	11.4
CA LOS ANGELES	93134	316	307	371	391	432	431	439	415	372	351	312	308	4445.9	11.4
CA MT TAMALPAIS	23262	306	302	371	396	441	443	449	422	373	348	304	297	4451.3	11.4
CA RED BLUFF	24216	300	299	371	398	447	449	456	426	374	345	299	290	4454.7	11.3
CA SACRAMENTO	23232	305	301	371	396	442	444	451	423	373	347	303	295	4452.0	11.3
CA SAN DIEGO	23188	318	309	372	390	429	428	436	413	371	352	315	311	4444.4	11.5
CA SAN FRANCISCO	23272	307	302	371	395	441	442	449	421	373	348	305	298	4450.9	11.4
CA SAN JOSE	23293	308	303	371	395	439	441	448	421	373	348	306	299	4450.4	11.4
CA SAN LUIS OBISPO	93206	313	306	371	393	435	435	442	417	372	350	310	305	4447.6	11.4
CO DENVER	23062	301	300	371	398	445	448	455	425	374	346	300	292	4453.8	11.3
CO DURANGO	93004	308	303	371	395	439	441	448	420	373	348	306	299	4450.2	11.4
CO GRAND JUNCTION	23066	303	301	371	397	444	446	453	424	373	346	302	294	4452.9	11.3
CO PUEBLO	93058	305	302	371	396	442	444	450	422	373	347	304	296	4451.6	11.4
CT HARTFORD	14740	295	297	370	401	451	455	461	429	375	343	295	285	4457.6	11.3
CT NEW HAVEN	14758	297	298	370	400	449	453	459	428	374	344	297	287	4456.3	11.3
DC WASHINGTON	13743	304	301	371	397	443	445	452	423	373	347	302	294	4452.5	11.3
FL APALACHICOLA	12832	325	312	372	387	423	421	429	409	370	355	320	318	4441.1	11.6
FL JACKSONVILLE	13889	323	311	372	388	425	423	431	410	370	354	319	317	4442.1	11.5
FL JUPITER	12893	330	315	372	384	418	414	423	405	369	357	325	325	4438.2	11.6
FL KEY WEST	12836	335	317	373	382	413	409	418	402	369	359	329	330	4436.3	11.6
FL LAKELAND	12883	328	314	372	385	420	417	425	407	370	356	323	322	4439.3	11.6
FL MIAMI	12839	333	316	372	383	416	412	421	404	369	358	327	327	4437.3	11.7
FL PENSACOLA	13899	323	311	372	388	424	422	431	410	370	354	319	317	4441.8	11.5
FL TAMPA	12842	328	314	372	385	420	417	425	407	370	356	323	322	4439.3	11.6
GA ATLANTA	13874	316	308	371	391	431	430	438	415	371	352	313	309	4445.4	11.5
GA AUGUSTA	93848	317	308	371	391	431	430	438	414	371	352	313	309	4445.2	11.5
GA MACON	3813	319	309	372	390	429	428	436	413	371	352	315	311	4444.3	11.5
GA SAVANNAH	3822	320	309	372	389	428	427	435	412	371	353	316	313	4443.6	11.5
HI HILO	21504	344	322	373	378	405	399	409	396	368	362	336	340	4432.5	11.8
HI HONOLULU	22521	341	321	373	379	408	402	412	398	368	361	334	337	4433.8	11.7
HI KAHULUI	22516	342	321	373	379	407	401	411	398	368	362	335	337	4433.2	11.7
HI LIHUE	22536	340	320	373	380	409	404	413	399	368	361	333	335	4434.1	11.7
ID BOISE	24131	290	294	370	403	456	461	467	432	375	342	291	279	4460.7	11.2
ID POCATELLO	24156	292	295	370	402	454	459	465	431	375	342	293	281	4459.3	11.2

STATE & STATION	WBAN#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	LEAPYR ADJ.
IL CAIRO	93809	308	303	371	395	439	440	447	420	373	348	306	300	4449.8	11.4
IL CHICAGO	94846	295	296	370	401	452	455	461	429	375	343	295	285	4457.8	11.2
IL CHICAGO UNIVERS	14892	296	297	370	401	451	455	461	429	374	344	295	285	4457.4	11.3
IL MOLINE	14923	297	297	370	400	450	454	460	428	374	344	296	286	4456.9	11.3
IL PEORIA	14842	299	298	370	399	448	451	457	426	374	345	298	289	4455.4	11.3
IL SPRINGFIELD	93822	301	300	371	398	446	448	455	425	374	346	300	291	4454.1	11.3
IN EVANSVILLE	93817	306	302	371	396	441	443	450	422	373	347	304	297	4451.4	11.4
IN FORT WAYNE	14827	298	298	370	399	449	452	458	427	374	344	297	288	4456.0	11.2
IN INDIANAPOLIS	93819	301	300	371	398	445	448	455	425	374	346	300	292	4453.7	11.3
IN ROYAL CENTER	94881	298	298	370	399	448	452	458	427	374	345	298	288	4455.8	11.3
IN TERRE HAUTE	93823	302	300	371	397	445	447	454	424	374	346	301	293	4453.4	11.3
IA BURLINGTON	14931	299	298	370	399	448	451	458	427	374	345	298	288	4455.7	11.2
IA CHARLES CITY	14966	292	295	370	402	455	459	465	431	375	342	292	281	4459.7	11.3
IA DAVENPORT	14932	297	297	370	400	450	454	460	428	374	344	296	286	4456.9	11.2
IA DES MOINES	14933	296	297	370	400	450	454	460	428	374	344	296	286	4456.8	11.3
IA DUBUQUE	14934	294	296	370	402	453	457	463	430	375	343	294	283	4458.7	11.2
IA KEOKUK	14969	300	299	370	399	447	450	457	426	374	345	299	290	4455.1	11.3
IA SIOUX CITY	14943	294	296	370	401	453	457	463	430	375	343	294	283	4458.5	11.3
KS CONCORDIA	13984	302	300	371	398	445	447	454	424	374	346	301	292	4453.7	11.3
KS DODGE CITY	13985	307	302	371	395	440	442	449	421	373	348	305	298	4450.9	11.3
KS TOPEKA	13996	303	301	371	397	444	446	453	424	373	346	302	294	4452.9	11.3
KS WICHITA	3928	307	303	371	395	440	442	449	421	373	348	305	298	4450.8	11.3
KY COVINGTON	93814	303	301	371	397	444	446	453	424	373	346	302	293	4453.1	11.3
KY LEXINGTON	93820	306	302	371	396	441	443	450	422	373	348	304	297	4451.3	11.4
KY LOUISVILLE	93821	305	302	371	396	442	443	450	422	373	347	304	296	4451.5	11.4
LA NEW ORLEANS	12916	324	312	372	387	423	421	430	409	370	355	320	318	4441.3	11.6
LA SHREVEPORT	13957	319	309	372	390	429	427	435	413	371	353	315	312	4444.1	11.5
ME EASTPORT	14608	286	292	370	405	460	466	471	435	376	340	287	274	4463.3	11.2
ME PORTLAND	14764	290	294	370	403	456	461	467	432	375	342	291	279	4460.9	11.2
MD BALTIMORE	93721	303	301	371	397	444	446	453	424	373	346	302	293	4453.0	11.4
MA BLUE HILL	14753	294	296	370	401	452	456	462	429	375	343	294	284	4458.1	11.2
MA BOSTON	14739	294	296	370	401	453	457	463	430	375	343	294	283	4458.4	11.2
MA NANTUCKET	14756	297	298	370	400	449	453	459	428	374	344	297	287	4456.5	11.3
MI ALPENA	94849	286	292	370	405	461	467	472	435	376	340	287	274	4463.7	11.1
MI DETROIT	94847	294	296	370	401	452	456	462	429	375	343	294	284	4458.2	11.2
MI ESCANABA	14824	283	291	370	406	463	470	474	437	376	339	285	271	4465.1	11.1
MI GRAND HAVEN	94879	292	295	370	402	455	459	465	431	375	342	292	281	4459.6	11.2
MI GRAND RAPIDS	94860	292	295	370	402	454	459	464	431	375	342	293	282	4459.3	11.3
MI LANSING	14836	293	295	370	402	454	458	464	431	375	342	293	282	4459.0	11.2
MI LUDINGTON	94816	289	293	370	403	457	463	468	433	375	341	290	278	4461.5	11.2
MI MARQUETTE	94850	281	289	370	408	466	473	478	439	377	338	283	268	4467.0	11.1
MI PORT HURON	94880	292	295	370	402	454	459	465	431	375	342	292	281	4459.7	11.2
MI SAGINAW	14845	291	294	370	403	456	461	466	432	375	342	291	280	4460.4	11.2
MI SAULT STE MARIE	14847	281	289	370	407	465	473	477	438	377	338	283	268	4466.8	11.1
MN DULUTH	14913	280	289	369	408	466	474	479	439	377	338	282	267	4467.6	11.1
MN MINNEAPOLIS	14922	286	292	370	405	460	466	471	435	376	340	288	274	4463.3	11.1
MN ST PAUL	14927	286	292	370	405	460	466	471	435	376	340	287	274	4463.4	11.1
MS JACKSON	3940	319	309	372	389	428	427	435	413	371	353	315	312	4443.9	11.5
MS MERIDIAN	93854	319	309	372	389	428	427	435	413	371	353	315	312	4443.9	11.5
MS VICKSBURG	93917	319	309	372	389	428	427	435	413	371	353	315	312	4443.9	11.5
MO COLUMBIA	3945	304	301	371	397	443	445	452	423	373	347	302	295	4452.6	11.3
MO KANSAS CITY	3947	303	300	371	397	444	447	453	424	374	346	301	293	4453.3	11.3
MO SPRINGFIELD	13995	308	303	371	395	439	440	447	420	373	348	306	299	4450.2	11.4
MO ST JOSEPH	13993	301	300	371	398	445	448	455	425	374	346	300	292	4454.0	11.3
MO ST LOUIS	13994	304	301	371	397	443	445	452	423	373	347	302	295	4452.3	11.4

STATE & STATION	WBAN#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	LEAPYR ADJ.
MT BILLINGS	24033	283	290	370	406	463	470	475	437	376	339	285	271	4465.3	11.1
MT GREAT FALLS	24143	277	288	369	409	469	477	481	441	377	337	280	264	4469.2	11.1
MT HAVRE	94012	273	286	369	411	473	482	486	443	378	335	277	260	4471.8	11.0
MT HELENA	24144	280	289	370	408	466	473	478	439	377	338	283	268	4467.0	11.1
MT KALISPELL	24146	274	286	369	410	472	481	485	443	378	336	278	261	4471.3	11.0
MT MILES CITY	24037	281	289	370	407	465	472	477	438	377	338	283	268	4466.6	11.1
MT MISSOULA	24153	279	289	369	408	467	474	479	440	377	337	282	266	4467.8	11.1
NE DREXEL	94941	297	297	370	400	450	453	459	428	374	344	297	287	4456.6	11.3
NE LINCOLN	14939	298	298	370	399	448	452	458	427	374	345	298	288	4455.7	11.3
NE NORTH OMAHA	94918	297	298	370	400	450	453	459	428	374	344	297	287	4456.5	11.2
NE NORTH PLATTE	24023	298	298	370	400	449	453	459	427	374	344	297	287	4456.3	11.3
NE VALENTINE	24032	293	295	370	402	454	459	464	431	375	342	293	282	4459.3	11.2
NV ELY	23154	303	300	371	397	444	447	453	424	373	346	301	293	4453.2	11.3
NV LAS VEGAS	23169	311	305	371	393	437	437	444	419	372	349	308	302	4448.5	11.4
NV RENO	23185	302	300	371	398	445	447	454	424	374	346	301	292	4453.7	11.3
NV TONOPAH	93142	306	302	371	396	441	443	450	422	373	347	304	297	4451.4	11.4
NV WINNEMUCCA	24128	298	298	370	399	449	452	458	427	374	345	298	288	4455.8	11.3
NH CONCORD	14745	292	295	370	402	455	460	465	431	375	342	292	280	4460.0	11.2
NH MT WASHINGTON	14755	288	293	370	404	458	464	469	434	376	341	289	277	4461.9	11.1
NJ ATLANTIC CITY	93730	302	300	371	397	445	447	454	424	373	346	301	293	4453.4	11.3
NJ SANDY HOOK	94739	299	299	370	399	447	450	457	426	374	345	299	289	4455.2	11.2
NJ TRENTON	14773	300	299	371	398	447	450	456	426	374	345	299	290	4454.6	11.3
NM ALBUQUERQUE	23050	313	306	371	392	434	434	442	417	372	350	310	305	4447.2	11.5
NM ROSWELL	23009	317	308	371	390	430	430	437	414	371	352	314	310	4445.0	11.5
NM SANTA FE	23049	312	305	371	393	435	436	443	418	372	350	309	304	4447.9	11.4
NY ALBANY	14735	293	295	370	402	454	458	464	430	375	343	293	282	4459.2	11.2
NY BINGHAMTON	4725	294	296	370	401	452	456	462	429	375	343	294	284	4458.2	11.2
NY BUFFALO	14733	292	295	370	402	454	459	465	431	375	342	293	281	4459.4	11.2
NY CANTON	14743	287	292	370	404	459	465	470	434	376	340	288	275	4462.7	11.2
NY ITHACA	94761	294	307	370	401	453	457	463	430	375	343	294	283	4469.8	11.2
NY NY CENTRAL PARK	94728	299	298	370	399	448	451	458	427	374	345	298	288	4455.6	11.3
NY OSWEGO	14759	291	294	370	403	456	461	466	432	375	342	291	280	4460.3	11.2
NY ROCHESTER	14768	292	295	370	402	455	459	465	431	375	342	292	281	4459.7	11.2
NY SYRACUSE	14771	292	295	370	402	455	459	465	431	375	342	292	281	4459.9	11.2
NC ASHEVILLE	3812	312	305	371	393	435	435	443	417	372	350	310	304	4447.7	11.5
NC CAPE HATTERAS	93729	313	306	371	393	435	435	442	417	372	350	310	305	4447.5	11.4
NC CHARLOTTE	13881	313	306	371	392	435	435	442	417	372	350	310	305	4447.5	11.4
NC GREENSBORO	13723	311	305	371	393	437	437	444	419	372	349	308	302	4448.7	11.4
NC RALEIGH/DURHAM	13722	311	305	371	393	436	436	444	418	372	350	309	303	4448.3	11.4
NC WILMINGTON	13748	315	307	371	391	432	432	440	416	372	351	312	307	4446.2	11.4
ND BISMARK	24011	280	289	370	408	466	474	478	439	377	338	282	267	4467.5	11.1
ND DEVILS LAKE	14912	275	286	369	410	471	480	484	442	378	336	278	261	4470.7	11.0
ND ELLENDALE	94942	283	290	370	407	464	471	475	437	376	339	284	270	4465.6	11.2
ND FARGO	14914	279	289	369	408	467	474	479	440	377	338	282	266	4467.9	11.0
ND WILLISTON	94014	275	286	369	410	471	480	484	443	378	336	278	261	4470.8	11.1
OH CLEVELAND	14820	297	297	370	400	450	454	460	428	374	344	296	286	4456.7	11.3
OH COLUMBUS	14821	301	299	371	398	446	449	455	425	374	346	300	291	4454.5	11.3
OH DAYTON	93815	301	300	371	398	446	449	455	425	374	346	300	291	4454.2	11.3
OH SANDUSKY	14846	297	297	370	400	450	454	460	428	374	344	296	286	4456.9	11.3
OH TOLEDO	94830	296	297	370	400	450	454	460	428	374	344	296	286	4457.0	11.3
OK BROKEN ARROW	3955	311	305	371	393	436	437	444	418	372	349	308	302	4448.5	11.4
OK OKLAHOMA CITY	13967	312	305	371	393	435	435	443	417	372	350	310	304	4447.7	11.5
OK TULSA	13968	310	304	371	394	437	437	445	419	372	349	308	302	4448.8	11.4
OR BAKER	24199	287	292	370	405	460	466	471	435	376	340	288	275	4463.2	11.2
OR PORTLAND	24229	284	291	370	406	462	469	474	437	376	339	286	272	4465.0	11.1
OR ROSEBURG	24231	291	295	370	403	455	460	466	431	375	342	292	280	4460.0	11.2

STATE & STATION	WBAN#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	LEAPYR ADJ.
PA ERIE	14893	295	296	370	401	452	456	462	429	375	343	295	284	4458.1	11.2
PA HARRISBURG	14751	300	299	371	398	447	450	456	426	374	345	299	290	4454.6	11.3
PA PHILADELPHIA	13739	301	299	371	398	446	448	455	425	374	346	300	291	4454.0	11.3
PA PITTSBURGH	94823	299	299	370	399	447	451	457	426	374	345	299	289	4455.3	11.3
PA PITTSBURGH WSO	14861	299	299	370	399	447	450	457	426	374	345	299	289	4455.1	11.3
PA READING	14767	300	299	370	399	447	450	457	426	374	345	299	290	4455.0	11.3
PA WILKES-BARRE/SC	14777	297	297	370	400	450	453	459	428	374	344	297	287	4456.6	11.3
RI BLOCK ISLAND	14799	297	298	370	400	449	453	459	427	374	344	297	287	4456.4	11.2
RI PROVIDENCE	14765	296	297	370	400	451	455	461	429	374	344	296	285	4457.2	11.3
SC CHARLESTON	13880	318	308	372	390	429	429	436	414	371	352	314	311	4444.7	11.5
SC COLUMBIA	13883	316	307	371	391	432	431	439	415	372	351	312	308	4445.9	11.4
SC DUE WEST	93871	315	307	371	392	433	432	440	416	372	351	312	307	4446.3	11.5
SC GREENVILLE/SPAR	3870	313	306	371	392	434	434	441	417	372	351	310	306	4447.1	11.4
SD HURON	14936	288	293	370	404	459	464	470	434	376	341	289	276	4462.3	11.2
SD RAPID CITY	24090	289	293	370	404	457	463	468	433	376	341	290	277	4461.4	11.2
SD YANKTON	94911	292	295	370	402	454	459	465	431	375	342	293	281	4459.6	11.2
TN CHATTANOOGA	13882	313	306	371	392	434	434	442	417	372	350	310	305	4447.1	11.5
TN KNOXVILLE	13891	311	305	371	393	436	436	444	418	372	350	309	303	4448.3	11.4
TN MEMPHIS	13893	313	306	371	392	434	434	442	417	372	350	310	305	4447.2	11.5
TN NASHVILLE	13897	311	305	371	393	437	437	444	419	372	349	308	302	4448.6	11.4
TX ABILENE	13962	319	309	372	390	428	427	435	413	371	353	315	312	4444.0	11.5
TX AMARILLO	23047	313	306	371	393	435	435	442	417	372	350	310	305	4447.5	11.4
TX AUSTIN	13958	324	311	372	387	424	422	430	410	370	354	319	317	4441.7	11.5
TX BROWNSVILLE	12919	332	316	372	383	416	412	421	404	369	358	327	327	4437.3	11.7
TX CORPUS CHRISTI	12924	329	314	372	385	419	416	425	406	370	356	324	323	4439.1	11.6
TX DALLAS/FORT WOR	3927	318	308	372	390	429	429	436	414	371	352	314	311	4444.6	11.4
TX DEL RIO	22010	326	312	372	387	422	420	428	408	370	355	321	319	4440.7	11.6
TX EL PASO	23044	320	310	372	389	427	426	434	412	371	353	316	313	4443.2	11.5
TX FORT WORTH	13961	318	309	372	390	429	428	436	413	371	352	315	311	4444.4	11.5
TX GALVESTON	12944	326	312	372	386	422	420	428	408	370	355	321	319	4440.8	11.5
TX GROESBECK	13924	321	310	372	389	427	425	433	411	371	353	317	314	4443.0	11.5
TX HOUSTON	12960	324	312	372	387	423	421	430	409	370	355	320	318	4441.3	11.6
TX LUBBOCK	23042	316	308	371	391	431	430	438	415	371	352	313	309	4445.5	11.5
TX PALESTINE	93914	321	310	372	389	427	426	434	412	371	353	317	314	4443.2	11.5
TX PORT ARTHUR	12917	324	312	372	387	423	421	430	409	370	355	320	318	4441.4	11.5
TX SAN ANTONIO	12921	325	312	372	387	423	420	429	409	370	355	321	319	4440.9	11.5
UT MILFORD	23176	305	302	371	396	442	444	451	422	373	347	303	296	4451.9	11.4
UT MODENA	23177	306	302	371	395	441	442	449	421	373	348	305	297	4451.0	11.4
UT SALT LAKE CITY	24127	299	298	370	399	448	451	458	427	374	345	298	288	4455.5	11.3
VT BURLINGTON	14742	288	293	370	404	459	464	470	434	376	341	289	276	4462.3	11.2
VT NORTHFIELD	4721	289	293	370	404	458	463	469	433	376	341	290	277	4461.8	11.2
VA CAPE HENRY	13727	309	303	371	394	438	440	447	420	373	349	306	300	4449.8	11.3
VA LYNCHBURG	13733	308	303	371	395	439	441	448	421	373	348	306	299	4450.4	11.3
VA NORFOLK	13737	309	304	371	394	438	439	447	420	373	349	306	300	4449.7	11.3
VA RICHMOND	13740	307	303	371	395	440	441	448	421	373	348	305	298	4450.5	11.4
VA WYTHEVILLE	3806	309	304	371	394	439	439	447	420	373	349	306	300	4449.8	11.3
WA NORTH HEAD	24226	282	290	370	407	465	472	477	438	377	338	284	269	4466.3	11.1
WA PORT ANGELES	24228	275	286	369	410	471	480	484	442	377	336	278	261	4470.8	11.0
WA QUILLAYUTE	94240	276	287	369	410	470	479	483	442	377	336	279	262	4470.2	11.1
WA SEATTLE	24233	278	288	369	409	469	477	481	441	377	337	280	264	4469.2	11.0
WA SPOKANE	24157	277	287	369	409	469	478	482	441	377	337	280	263	4469.5	11.0
WA TACOMA	24239	278	288	369	409	468	476	480	440	377	337	281	265	4468.6	11.1
WA TATOOSH ISLAND	24240	274	286	369	411	472	481	485	443	378	336	277	260	4471.4	11.0
WA WALLA WALLA	94103	282	290	370	407	464	471	476	437	376	339	284	270	4465.5	11.2
WA YAKIMA	24243	281	289	370	408	466	473	478	439	377	338	283	268	4466.9	11.1
WV ELKINS	13729	304	301	371	397	443	445	452	423	373	347	302	294	4452.6	11.3
WV PARKERSBURG	13867	303	300	371	397	444	447	453	424	373	346	301	293	4453.1	11.3

STATE & STATION	WBAN#	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	LEAPYR ADJ.
WI GREEN BAY	14898	288	293	370	404	459	465	470	434	376	340	289	276	4462.4	11.2
WI LA CROSSE	14920	289	294	370	403	457	462	468	433	375	341	290	278	4461.2	11.2
WI MADISON	14837	292	295	370	402	455	460	465	431	375	342	292	281	4459.9	11.2
WI MILWAUKEE	14839	292	295	370	402	454	459	465	431	375	342	293	281	4459.5	11.2
WI WAUSAU	14897	286	292	370	405	460	466	471	435	376	340	287	274	4463.3	11.1
WY CHEYENNE	24018	298	298	370	400	449	453	459	427	374	344	297	287	4456.1	11.3
WY LANDER	24021	293	295	370	402	454	458	464	431	375	342	293	282	4459.3	11.3
WY SHERIDAN	24029	287	292	370	405	460	466	471	435	376	340	288	275	4463.0	11.1
WY YELLOWSTONE	24169	286	292	370	405	460	466	472	435	376	340	287	274	4463.4	11.2
PI GUAM	41415	354	328	374	373	395	387	398	389	366	367	345	352	4428.5	11.9
PI JOHNSTON ISLAND	21603	349	325	373	376	400	393	403	393	367	365	341	346	4430.3	11.9
PI KOROR	40309	364	333	375	369	386	376	388	383	365	371	354	363	4425.4	11.9
PI MAJURO	40710	365	333	375	368	386	376	387	383	365	371	354	363	4425.1	12.0
PI PONAPE	40504	365	333	375	368	386	376	387	383	365	371	354	363	4425.0	12.0
PI TOFUNA	61705	399	352	377	353	355	339	352	361	361	385	383	402	4418.5	12.4
PI TRUK ISLAND	40505	364	333	375	369	386	376	388	383	365	371	354	363	4425.4	11.9
PI WAKE ISLAND	41606	345	322	373	378	404	398	408	396	367	363	337	341	4432.1	11.8
PI YAP ISLAND	40308	361	331	374	370	389	380	391	385	365	369	351	359	4426.3	12.0
PR SAN JUAN	11641	346	323	373	377	403	397	407	395	367	363	338	342	4431.5	11.8

APPENDIX E

Reprints of Pertinent Literature

GEOPHYSICAL RESEARCH LETTERS, VOL. 17, NO. 11, PAGES 1925-1928, OCTOBER 1990

INCREASED CLOUDINESS IN THE UNITED STATES DURING THE FIRST HALF OF THE TWENTIETH CENTURY: FACT OR FICTION?

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NOAA/National Climatic Data Center

Abstract. A new source of cloud and sunshine data, in conjunction with an inspection of the observing practices, instruments, and daily temperature range over the United States, are used to confirm or contradict the large increases of cloudiness previously reported. This analysis indicates that changes in observing practices are primarily responsible for the reported increase of cloudiness during the first half of the this Century. The response of the sunshine instruments and the surface daily temperature range over the United States are not consistent with the reported increases during the first half of this Century. Since the late 1940s however, the increase of cloud cover is confirmed by an inspection of the sunshine data, daily temperature range, changes in instruments, and the instructions to the observers. The types of changes in the cloud observing practices during the late 1930s and 1940s would tend to lead to increases in reported cloud amounts. Although we have not yet produced a combined sunshine/cloudiness index of cloud cover over the Twentieth Century, some cogent inferences can be made at this time:

1) Monotonic trends of cloudiness on the Century time-scale do not exist in the United States.
2) Fewer clouds were present during the 1930s and early 1950s.
3) There has been a tendency toward increased cloudiness since 1948.

Background

Several articles have reported on the changes of cloudiness over the Twentieth Century in the United States and Canada. Angell and Korshover [1986] and Angell [1990] found a general increase in cloud cover over the United States since 1953 with a concomitant decrease of sunshine. The rate of change associated with the decrease of sunshine however, was only about half that compared with the increase observed from cloud observations. Seaver and Lee [1987] analyzed the changes in the number of clear days at several dozen stations across the United States and found a decrease in the number of clear days over the 1900-1984 period. Henderson-Sellers [1986, 1988] analyzed cloud cover data from over 77 stations in the United States (and 66 stations in Canada) during the period from 1900 to 1980 and found a significant increase in cloudiness which was primarily the result of an increase in cloudiness during the late 1930s to 1950.

The importance of changes in regional cloudiness to temperature changes is well known. Figure 1 provides an example of the relationship between annual mean maximum temperature across the United States and annual mean cloudiness from sunrise to sunset over a recent 40-year period. The importance of changes in cloud cover over the United States may be especially significant given its lower rate of temperature increase compared to the rest of the Hemisphere and the decrease in the daily temperature range (daily maximum minus daily minimum) as reflected in Figure 2. Recently, Ramanathan et al. [1989] have demonstrated the importance of cloud cover as related to the global energy balance. It is apparent that a comprehensive understanding of how regional and global temperatures have changed over the Twentieth Century must include information on both regional and global scale changes in cloudiness (the latter may only be possible for the most recent decade).

All of the United States stations which have recorded sunrise to sunset cloud cover and/or sunshine since the 1890s have recently been expanded and improved and transferred to computer media [Steurer et al., 1990]. A subset of this network was used in this analysis in order to represent only those stations which had continuous and long-term records. Such a data set makes it possible to perform a rigorous cross-check of the cloud and sunshine data. Such a cross-check is necessary because there have been several changes in cloud observing practices over

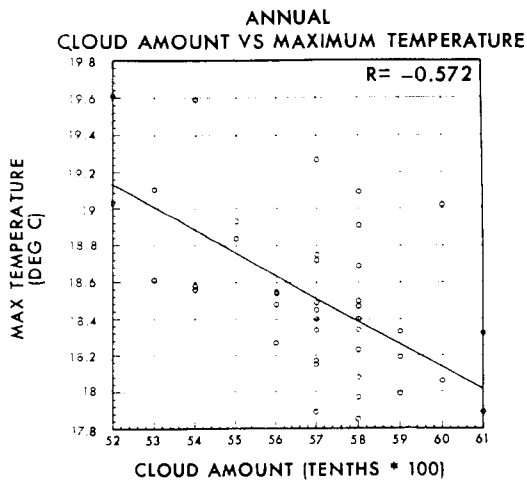

Fig. 1. Correlation of mean annual maximum temperature over the United States and sky cover.

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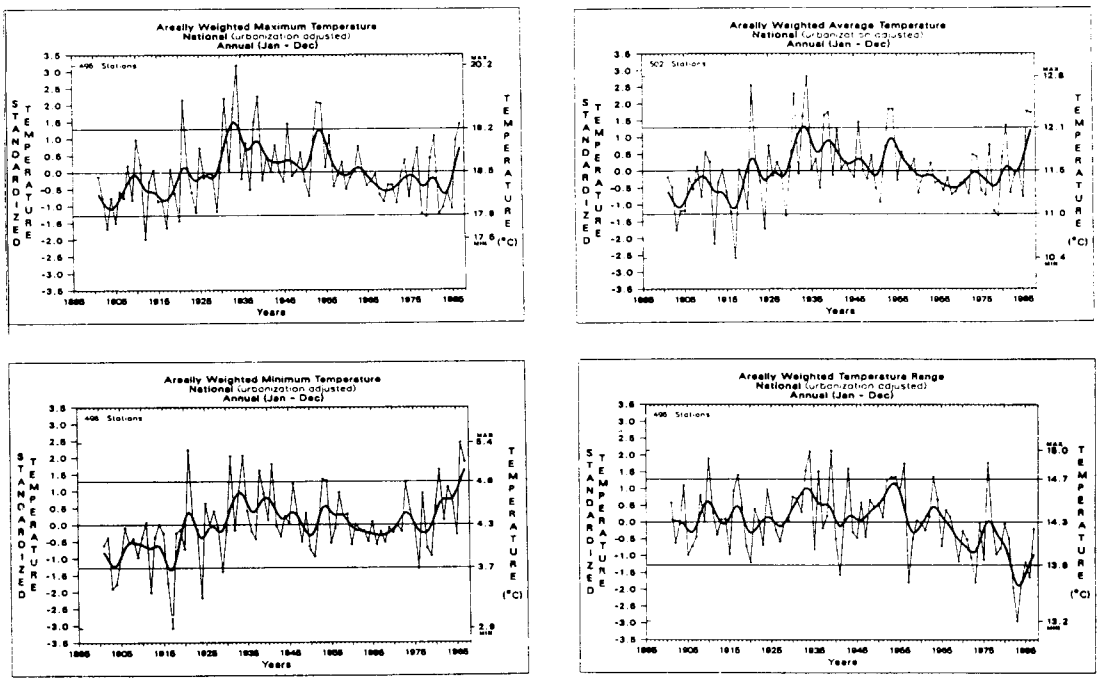

Fig. 2. Annual change of the maximum, minimum, and mean temperature as well as the daily temperature range over the United States.

the Twentieth Century. Additionally, three different sunshine instruments have been used to measure sunshine over the Twentieth Century. Consistency of the changes observed between these two data sets, after consideration of the changes in instruments and observing practices, would confirm the veracity of the previously reported increases of cloudiness.

Data Characteristics

a) Sunshine

The percent of possible sunshine has been recorded using three different instruments, a photographic recorder, a thermometric recorder, and a photoelectric recorder. The characteristics of these instruments are summarized elsewhere [Quinlan, 1985]. Since the response function of each instrument is different as well as their sensitivity to direct and diffuse sky radiation, the Twentieth Century record of sunshine cannot be considered homogeneous. The measurements are not totally automated as an observer estimates the amount of sunshine that would have been recorded to compensate for lack of instrument sensitivity and also complex terrain. This has been especially important near times of sunrise and sunset.

In 1893 the thermometric sunshine switch began to replace the photographic recorder. According to station history notes, by 1907 all but 14 of the 125 stations in the total network of stations operating at that time had converted to the thermometric recorder. The conversion of all stations to the thermometric recorder must have been somewhat later however, since the annual Weather Bureau manual entitled Instructions for Preparing Meteorological Forms continued to include instructions for photographic observations until 1917. A recent detailed investigation of the station history records has revealed that the change from the thermometric sunshine switch to the photoelectric sunshine switch indicates that the conversion was not immediate. In 1952 the changeover began, and by 1960 22 of the 92 stations in our sub-network still used the thermometric switch. The last conversion took place as late as the mid-1960s. Figure 3 indicates that the rate of change was most rapid during the early 1950s as about half of the network had changed by 1955. Clearly, however, the sunshine record during the 1950s must be treated with caution.

b) Cloudiness

All of the cloudiness information reported here pertains to both thin and opaque cloudiness observed between sunrise and sunset. Prior to 1934 the cloud cover information was based on frequent personal observations of cloud cover. There were only three required observations -- one near sunrise, one near sunset, and one at noon. It was left to the judgement of the observers to estimate the cloud cover the rest of the day and produce an average sunrise to sunset cloud cover amount. This average and the three required observations were entered on Weather Bureau 1001 forms. In 1934 stations began to relocate to airport locations where hourly observations (1 observation per hour) were required. It would be logical that these hourly values were used to calculate the sunrise to sunset cloud cover. By 1939, 25 stations in the total station

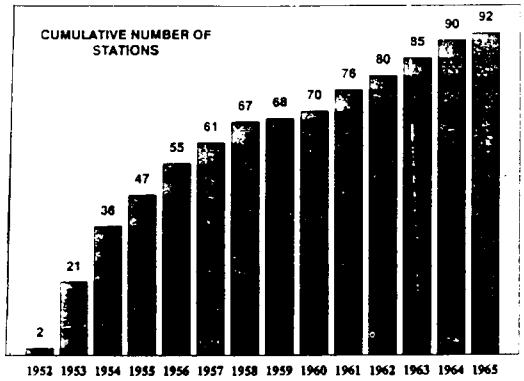

Fig. 3. The rate of change of thermometric sunshine switches to photoelectric switches.

network were reporting from the airport. In 1939, a major change in observing practice took place. Hourly cloud observations in tenths were recorded directly on Weather Bureau Form 1014 and were averaged to produce daytime cloud cover. Just how rapidly this practice took hold at city stations cannot be stated with certainty. It is a significant change in practice, not because the cloud cover information would be more precise, but because of the bias this may have introduced. When observers were required to write down and look for clouds each hour, it is quite possible that they would have found more clouds than those observers who did not have to be so rigorous. Furthermore, observers at city offices were not always present during all daylight hours. Official Weather Bureau instructions stated that observers were not expected to go on duty at unreasonably early hours just to ascertain the extent of cloudiness at sunrise. This would also result in a bias toward lower cloud amounts at city offices since observers would not be searching the sky for clouds at this early hour.

By 1948 another major change in observing practice had taken place. Observers were instructed to incorporate all obstructions to the sky in their observations of cloud cover. This included fog, haze, smoke, and dust. This is reflected in the change of terminology from cloud cover to sky cover. Such a change would, of course, lead to an apparent increase in cloud cover. Once again however, we are not certain of the exact date of the changeover or whether all observers immediately began this practice once it was announced. Instructions to the observers during the World War II years of 1939-1943 could not be located and possibly were never formally issued since references in 1940 have been found referring to the 1938 annual instructions and not the 1940 instructions.

These changes in cloud observing practices suggest that the cloud record during the late 1930s and 1940s underwent significant changes. It is quite possible that these changes have introduced serious biases in the cloud record.

Cross Comparisons of the Cloud/Sunshine Network

A network of 127 cloud and 92 sunshine stations was used in this analysis. This network was based upon stations having 75 or more years of monthly cloud and/or sunshine data since 1900. Monthly data were averaged across the standard climatological seasons (Winter - December, January, February; Spring - March, April, May, etc.) and sunshine was converted to the percent of possible sunshine. Regional means of sunshine and cloudiness were calculated for 23 regions depicted in Plantico et al. [1989] using arithmetic averages for all stations available in each region. These regions were then area-averaged to obtain the contiguous United States area-average cloudiness and percent of possible sunshine for the period 1900-1986. Long-term means were substituted for missing observations for about 1% of the cloud data and 3% of the sunshine data. Most stations simultaneously measured both cloudiness and sunshine.

The time series of seasonal and annual cloudiness and the percent of possible sunshine reveal some general similarities, but they also contain some glaring inconsistencies. For example, on an annual basis (Figure 4) cloudiness (sunshine) increases (decreases) during the wet decade of the 1940s and decrease (increase) during the dry 1930s and 1950s. Although not depicted, this characteristic is also generally reflected in the seasonal time series plots as well. But, there is also an apparent change in the relationship between the amount of cloudiness and sunshine several times during the Century

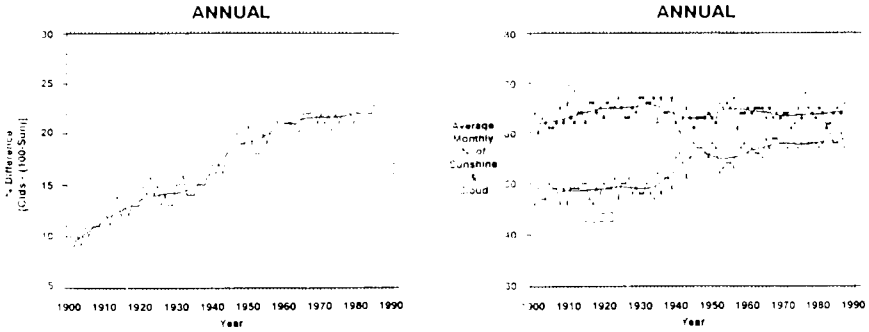

Fig. 4. Annual difference between sky cover and 100% minus the percent of possible sunshine over the United States (left). Time series of sky cover and percent of possible sunshine over the United States on an annual basis (right).

(Figure 4). An abrupt change in the amount of cloudiness relative to the sunshine occurs in the late 1930s and steadily increases through the mid-1950s, and somewhat less so during the first part of the Century. Although not shown, this characteristic is also prevalent in every season.

Discussion

What could have caused the change in relationship between cloudiness and sunshine? Based on our information, the sunshine network should be nearly homogeneous from 1917 to 1952. The cloudiness information is not homogeneous from the late 1930s to the late 1940s. A logical conclusion would be that the change in the relationship between cloudiness and sunshine is at least partially, if not totally, due to biases in the sunshine network during the early part of the Century and during the 1950s, but the biases in the cloud observations affected the relationship during the late 1930s and 1940s.

Such a scenario has some important implications which would explain some inconsistencies reported in the literature. First, the large increase in cloudiness reported to have occurred during the 1940s may be considerably exaggerated. Second, the apparent increase of cloudiness since 1948, relative to the decrease in sunshine reported by Angell [1990] and Plantico et al. [1989], may be the result of the change in sunshine instruments from the thermometric sunshine switch to the more sensitive photoelectric switch [Quinlan, 1985]. Additionally, there is not a corresponding decrease of the daily temperature range during the 1940s in conjunction with the apparent large increase in cloudiness. There is however a decrease in the temperature range since the mid-1950s, consistent with the increase of cloudiness over the last 40 years. Plantico et al. [1989] report an increase of cloudiness of about 4%. Their analysis suggests that much of this may be due to an increase of low cloud ceilings.

Some have suggested [Changnon, 1981] that increases in high-level cloud cover have occurred due to contrails from high-flying aircraft. If these high-level cirrus are too thin to trigger the sunshine switch, then this could lead to a change in the relationship between the cloud cover and sunshine. The timing of increased high-flying jet traffic over the United States however, does not seem to support such a scenario as the cause of the change in relationship between cloudiness and sunshine which occurred before the 1960s. Since the mid 1960s, however, the increase in contrails associated with high-flying aircraft does support the 1 to 2% increase which has occurred in the relationship between clouds and sunshine depicted in Figure 4.

Conclusion

The previously reported large increase of cloudiness observed during the 1940s may be exaggerated. The sunshine measurements and the surface daily temperature range over the United States did not respond to such an increase. The types of changes in the cloud observing practices during the late 1930s and 1940s would tend to lead to an apparent increase of cloud amounts. Although we have not yet produced a combined sunshine/cloudiness index of cloud cover over the Twentieth Century, some cogent inferences can be made at this time:

1) Monotonic trends of cloudiness on the Century time-scale do not exist in the United States.
2) Fewer clouds were present during the 1930s and early 1950s.
3) There has been a tendency toward increased cloudiness since 1948.

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