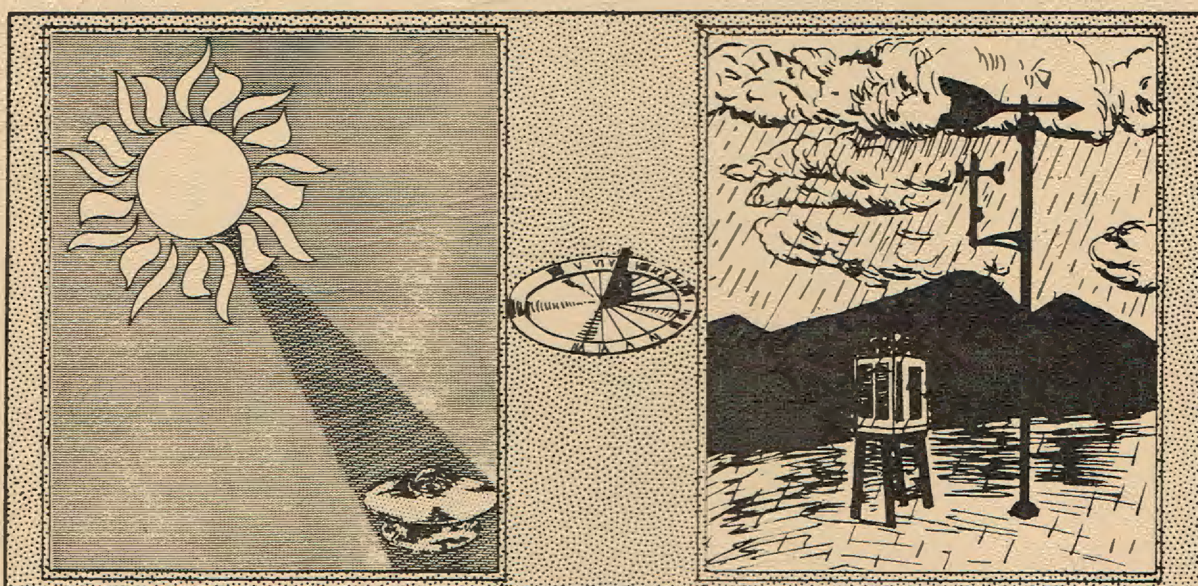
TYPICAL METEOROLOGICAL YEAR

USER'S MANUAL

TD - 9734



Hourly Solar Radiation-Surface Meteorological Observations

TYPICAL

METEOROLOGICAL YEAR

USER'S MANUAL

TD - 9734

HOURLY SOLAR RADIATION - SURFACE

METEOROLOGICAL OBSERVATIONS

National Climatic Center

Asheville, North Carolina

May 1981

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CONTENTS

ACKNOWLEDGEMENTS

The Typical Meteorological Year (TMY) data described in this manual were produced under contract to the Department of Energy by a number of organizations. The rehabilitated solar radiation data for 26 locations and all meteorological data were supplied by the National Climatic Center, the modeled (ERSATZ) solar radiation data were developed by the Air Resources Laboratory of the National Oceanic and Atmospheric Administration, the TMY data for the 26 "rehabilitated" locations were developed by the Sandia Laboratories, and the TMY data for all other locations were produced by EG & G, Inc. of Los Alamos, New Mexico.

I particularly want to thank I. J. Hall, R. R. Prairie, H. E. Anderson and E. C. Boes of Sandia Laboratories for their development of the TMY selection procedures and processing programs. Special acknowledgement is made to Miriam Provine of EG & G for supplying the TMY tapes for 208 locations and to Devoyd Ezell of the National Climatic Center for his efforts in assembling the data into regional tapes and development of the inventory program.

Frank T. Quinlan

Chief, Climatological Analysis Division

INTRODUCTION

The requirement for weather data collections suitable for use with building energy-load computer programs has resulted in a class of data sets known as "typical," "representative," or "reference" years. The goal is to produce a full set of 8,760 hourly weather observations containing real weather sequences that represent the long-term climatic mean conditions for a particular location. Typical Meteorological Year (TMY) data have been selected from SOLMET data (Tape Deck 9724) for use with computer programs to assess solar system performance. The TMY tapes contain only global and direct solar radiation estimates and the collateral meteorological data for 234 locations in the United States; it is recommended that Field 108 (Standard Year Corrected data) be used for best estimates of global radiation on a horizontal surface.

The Tape Deck contains nine (9) tapes with each tape containing all available TMY locations for a particular region of the United States (see Figures 1 and 2). Each logical record is 132 bytes long. The files on each tape are arranged in station number order with the data for each station in chronological sort, blocked by day in 24 logical records (3168 bytes) per physical tape record on 1600 bpi, 9 track, EBCDIC mode, odd parity tapes. Each station contains 365 blocks (see Figure 3 for record layout). NOTE: There is no tape mark between stations.

Users should refer to the following publications for details about the individual elements contained in these tape records and the procedures used to assemble the basic SOLMET data sets:

SOLMET: Volume 1 - User's Manual (TD-9724)

SOLMET: Volume 2 - Final Report (TD-9724)

Long-term monthly averages of solar radiation, temperature, degree days and global K_T values may be obtained in the INSOLATION DATA MANUAL published by the Solar Energy Research Institute (SERI). This publication (SERI/SP-755-789) dated October 1980 is available through the Superintendent of Documents.

ORDERING INFORMATION

Address requests to Director, National Climatic Center, Federal Building, Asheville, NC 28801; or call our Digital Products Section at 704-258-2850, extension 203 (FTS 672-0203).

DISCLAIMER

The National Climatic Center has agreed to service requests for tape copies of Typical Meteorological Year (TMY) tapes that were derived from the "Regression Modeled Solar Radiation Stations" described in SOLMET: Volume 1 - User's Manual. The "Regression Modeled Solar Radiation Station" SOLMET tapes and the TMY tapes derived from them were developed by contractors to the Department of Energy and have not received an independent review for accuracy or completeness.

Therefore, NATIONAL CLIMATIC CENTER ASSUMES NO RESPONSIBILITY FOR THE ACCURACY OR COMPLETENESS OF THE ENCLOSED TAPE(S). We do, however, guarantee that the tape is readable. We anticipate that these tapes will be quality controlled by a contractor at some future date so we would appreciate any positive or negative comments from users. Please forward these comments to:

Solar Energy Research Institute
1617 Cole Blvd.
Golden, CO 80401

Attn: Tom Stoffel 642 16/3

Please identify the station by name and number, make your comments as specific as possible, and indicate the date on the tape copy.

NINE TYPICAL METEOROLOGICAL YEAR REGIONS

(ONE MAGNETIC TAPE PER REGION)

TYPICAL METEOROLOGICAL YEAR NETWORK

IDENTIFICATION						SOLAR RADIATION OBSERVATION										
WBAN STN #	SOLAR TIME				LST TIME	ETR KJ/m^2	RADIATION VALUES KJ/m^2									SUNSHINE MIN
											GLOBAL			A	B	
	YR	MO	DY	HRMN			DIRECT	DIFFUSE	NET	TILTED	OBS	ENG COR	STD YR COR			
XXXXX	XX	XX	XX	XXXX	XXXX	XXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	XX
002	003				004	101	102	103	104	105	106	107	108	109	110	111

FIELD NUMBER

SURFACE METEOROLOGICAL OBSERVATION														
OB TIME LST	CEILING dam	SKY COND	VSBY hm	WEATHER	PRESSURE kPa		TEMP °C		WIND		CLOUDS		SNOW COVER	
					SEA LEVEL	STATION	DRY BULB	DEW-PT.	DIR deg	SPD m/s	TOTAL	OPAQUE		
XX	XXXX	iXXXX	XXXX	XXXXXXXX	XXXXX	XXXXX	XXXX	XXXX	XXX	XXXX	XX	XX	X	XXXXXXXXXX
201	202	203	204	205	206		207		208		209		210	211

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT
002	001 - 005	WBAN STATION NUMBER
003	006 - 015	SOLAR TIME (YR, MO, DAY, HOUR, MINUTE)
004	016 - 019	LOCAL STANDARD TIME (HOUR AND MINUTE)
101	020 - 023	EXTRATERRESTRIAL RADIATION
102	024 - 028	DIRECT RADIATION
103	029 - 033	DIFFUSE RADIATION
104	034 - 038	NET RADIATION
105	039 - 043	GLOBAL RADIATION ON A TILTED SURFACE
106	044 - 048	GLOBAL RADIATION ON A HORIZONTAL SURFACE – OBSERVED DATA
107	049 - 053	GLOBAL RADIATION ON A HORIZONTAL SURFACE – ENGINEERING CORRECTED DATA
108	054 - 058	GLOBAL RADIATION ON A HORIZONTAL SURFACE – STANDARD YEAR CORRECTED DATA
109,110	059 - 068	ADDITIONAL RADIATION MEASUREMENTS
111	069 - 070	MINUTES OF SUNSHINE
201	071 - 072	TIME OF COLLATERAL SURFACE OBSERVATION (LST)
202	073 - 076	CEILING HEIGHT (DEKAMETERS)
203	077 - 081	SKY CONDITION
204	082 - 085	VISIBILITY (HECTOMETERS)
205	086 - 093	WEATHER
206	094 - 103	PRESSURE (KILOPASCALS)
207	104 - 111	TEMPERATURE (DEGREES CELSIUS TO TENTHS)
208	112 - 118	WIND (SPEED IN METERS PER SECOND)
209	119 - 122	CLOUDS
210	123	SNOW COVER INDICATOR
211	124 - 132	BLANK (UNUSED)

NOTE: Except for tape positions 001-023 in fields 002-101, elements with a tape configuration of 9's indicate missing or unknown data.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
002	001-005	WBAN STATION NUMBER	01001 - 98999	Unique number used to identify each station.
003	006-015	SOLAR TIME		
	006-007	YEAR	00 - 99	Year of observation, 00 - 99 = 1900 - 1999
	008-009	MONTH	01 - 12	Month of observation, 01 - 12 = Jan. - Dec.
	010-011	DAY	01 - 31	Day of month
	012-015	HOUR	0001 - 2400	End of the hour of observation in solar time (hours and minutes)
004	016-019	LOCAL STANDARD TIME	0000 - 2359	Local Standard Time in hours and minutes corresponding to end of solar hour indicated in field 003. For Appendix A.2 listed stations, add 30 minutes to the local standard time on tape.
101	020-023	EXTRATERRESTRIAL RADIATION	0000 - 4957	Amount of solar energy in kJ/m^2 received at top of atmosphere during solar hour ending at time indicated in field 003, based on solar constant = $1377J/(m^2 \cdot s)$. 0000 = nightime values for extraterrestrial radiation, and 80000 = corresponding nighttime value in Field 108. For stations noted as "rehabilitated" in the station list, 99999 = nighttime values defined as zero kJ/m^2.
102	024-028	DIRECT RADIATION		Portion of radiant energy in kJ/m^2 received at the pyrheliometer directly from the sun during solar hour ending at time indicated in field 003. 99999 = nighttime values defined as zero kJ/m^2.
	024	DATA CODE INDICATOR	0 - 9	
	025-028	DATA	0000 - 4957	

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
103		DIFFUSE RADIATION		Amount of radiant energy in kJ/m^2 received at the instrument indirectly from reflection, scattering, etc., during the solar hour ending at the time indicated in field 003. NOTE: DIFFUSE DATA NOT AVAILABLE.
	029	DATA CODE INDICATOR	0 - 9	
	030-033	DATA	0000 - 4957	
104	034-038	NET RADIATION		Difference between the incoming and outgoing radiant energy in kJ/m^2 during the solar hour ending at the time indicated in field 003. A constant of 5000 has been added to all net radiation data. NOTE: NET RADIATION DATA NOT AVAILABLE
	034	DATA CODE INDICATOR	0 - 9	
	035-038	DATA	2000 - 8000	
105	039-043	GLOBAL RADIATION ON A TILTED SURFACE		Total of direct and diffuse radiant energy in kJ/m^2 received on a tilted surface (tilt angle indicated in station - period of record list) during solar hour ending at the time indicated in field 003. NOTE: DATA NOT AVAILABLE
	039	DATA CODE INDICATOR	0 - 9	
	040-043	DATA	0000 - 4957	
	044-058	GLOBAL RADIATION ON A HORIZONTAL SURFACE		Total of direct and diffuse radiant energy in kJ/m^2 received on a horizontal surface by a pyranometer during solar hour ending at the time indicated in field 003.
106	044-048	OBSERVED DATA		
	044	DATA CODE INDICATOR	0 - 9	
	045-048	DATA	0000 - 4957	Observed value. NOTE: THESE DATA ARE NOT CORRECTED. RECOMMEND USE OF DATA IN FIELD 108.
107	049-053	ENGINEERING CORRECTED DATA		NOTE: RECOMMEND USE OF DATA IN FIELD 108.
	049	DATA CODE INDICATOR	0 - 9	
	050-053	DATA	0000 - 4957	Observed value corrected for known scale changes, station moves, recorder and sensor calibration changes, etc.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
108	054-058	STANDARD YEAR CORRECTED DATA		
	054	DATA CODE INDICATOR	0 - 9	
	055-058	DATA	0000 - 4957	Observed value adjusted to Standard Year Model. This model yields expected sky irradiance received on a horizontal surface at the elevation of the station. NOTE: All nighttime values coded as 80000 except stations noted as rehabilitated in the station list; for those stations nighttime values are coded 99999.
109, 110	059-068	ADDITIONAL RADIATION MEASUREMENTS		Supplemental Fields A and B for additional radiation measurements; type of measurement specified in station-period of record list.
	059-064	DATA CODE INDICATORS	0 - 9	
	060-063	DATA		
	065-068	DATA		

NOTE FOR FIELDS 102-110: Data code indicators are:

- 0 Observed data
- 1 Estimated from model using sunshine and cloud data
- 2 Estimated from model using cloud data
- 3 Estimated from model using sunshine data
- 4 Estimated from model using sky condition data
- 5 Estimated from linear interpolation
- 6 Reserved for future use
- 7 Estimated from other model (see individual station notes in SOLMET: Volume 1.)
- 8 Estimated without use of a model
- 9 Missing data follows

(See model description in SOLMET: Volume 2.)

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
111	069-070	MINUTES OF SUNSHINE	00 - 60	For Local Standard Hour most closely matching solar hour. NOTE: Data available only for when observations were made.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
201	071-072	TIME OF TD 1440 OBSERVATIONS	00 - 23	Local Standard Hour of TD 1440 Meteorological Observation that comes closest to midpoint of the solar hour for which solar data are recorded.
202	073-076	CEILING HEIGHT	0000 - 3000	Ceiling height in dekameters (dam = m x 10^1); ceiling is defined as opaque sky cover of .6 or greater. 0000 - 3000 = 0 to 30,000 meters
			7777	7777 = unlimited; clear
			8888	8888 = unknown height of cirroform ceiling
203	077-081	SKY CONDITION		
	077	INDICATOR	0	Identifies observations after 1 June 51.
	078-081	SKY CONDITION	0000 - 8888	Coded by layer in ascending order; four layers are described; if less than 4 layers are present the remaining positions are coded 0. The code for each layer is: 0 = Clear or less than .1 cover 1 = Thin scattered (.1 - .5 cover) 2 = Opaque scattered (.1 - .5 cover) 3 = Thin broken (.6 - .9 cover) 4 = Opaque broken (.6 - .9 cover) 5 = Thin overcast (1.0 cover) 6 = Opaque overcast (1.0 cover) 7 = Obscuration 8 = Partial obscuration
204	082-085	VISIBILITY	0000 - 1600	Prevailing horizontal visibility in hectometers (hm = m x 10^2). 0000 - 1600 = 0 to 160 kilometers
			8888	8888 = unlimited

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
205	086-093	WEATHER		
	086	OCCURRENCE OF THUNDERSTORM, TORNADO OR SQUALL	0 - 4	0 = None 1 = Thunderstorm - lightning and thunder. Wind gusts less than 50 knots, and hail, if any, less than 3/4 inch diameter. 2 = Heavy or severe thunderstorm - frequent intense lightning and thunder. Wind gusts 50 knots or greater and hail, if any, 3/4 inch or greater diameter. 3 = Report of tornado or waterspout. 4 = Squall (sudden increase of wind speed by at least 16 knots, reaching 22 knots or more and lasting for at least one minute).
	087	OCCURRENCE OF RAIN, RAIN SHOWERS OR FREEZING RAIN	0 - 8	0 = None 1 = Light rain 2 = Moderate rain 3 = Heavy rain 4 = Light rain showers 5 = Moderate rain showers 6 = Heavy rain showers 7 = Light freezing rain 8 = Moderate or heavy freezing rain
	088	OCCURRENCE OF DRIZZLE, FREEZING DRIZZLE	0 - 6	0 = None 1 = Light drizzle 2 = Moderate drizzle 3 = Heavy drizzle 4 = Light freezing drizzle 5 = Moderate freezing drizzle 6 = Heavy freezing drizzle

TAPE FIELD NUMBER	TAPE POSITION	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
	089	OCCURRENCE OF SNOW, SNOW PELLETS OR ICE CRYSTALS	0 - 8	0 = None 1 = Light snow 2 = Moderate snow 3 = Heavy snow 4 = Light snow pellets 5 = Moderate snow pellets 6 = Heavy snow pellets 7 = Light ice crystals 8 = Moderate ice crystals Beginning April 1963 intensities of ice crystals were discontinued. All occurrences since this date are recorded as an 8.
	090	OCCURRENCE OF SNOW SHOWERS OR SNOW GRAINS	0 - 6	0 = None 1 = Light snow showers 2 = Moderate snow showers 3 = Heavy snow showers 4 = Light snow grains 5 = Moderate snow grains 6 = Heavy snow grains Beginning April 1963 intensities of snow grains were discontinued. All occurrences since this date are recorded as a 5.
	091	OCCURRENCE OF SLEET (ICE PELLETS), SLEET SHOWERS OR HAIL	0 - 8	0 = None 1 = Light sleet or sleet showers (ice pellets) 2 = Moderate sleet or sleet showers (ice pellets) 3 = Heavy sleet or sleet showers (ice pellets) 4 = Light hail 5 = Moderate hail 6 = Heavy hail

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
	091 (Continued)			7 = Light small hail 8 = Moderate or heavy small hail Prior to April 1970 ice pellets were coded as sleet. Beginning April 1970 sleet and small hail were redefined as ice pellets and are coded as a 1, 2 or 3 in this position. Beginning September 1956 intensities of hail were no longer reported and all occurrences were recorded as a 5.
	092	OCCURRENCE OF FOG, BLOWING DUST OR BLOWING SAND	0 - 5	0 = None 1 = Fog 2 = Ice fog 3 = Ground fog 4 = Blowing dust 5 = Blowing sand These values recorded only when visibility less than 7 miles.
	093	OCCURRENCE OF SMOKE, HAZE, DUST, BLOWING SNOW OR BLOWING SPRAY	0 - 6	0 = None 1 = Smoke 2 = Haze 3 = Smoke and haze 4 = Dust 5 = Blowing snow 6 = Blowing spray These values recorded only when visibility less than 7 miles.
206	094-103	PRESSURE		
	094-098	SEA LEVEL PRESSURE	08000 - 10999	Pressure, reduced to sea level, in kilopascals (kPa) and hundredths.
	099-103	STATION PRESSURE	08000 - 10999	Pressure at station level in kilopascals (kPa) and hundredths. 08000 - 10999 = 80 to 109.99 kPa

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
207	104-111	TEMPERATURE		
	104-107	DRY BULB	-700 to 0600	°C and tenths
	108-111	DEW POINT	-700 to 0600	°C and tenths -700 to 0600 = -70.0 to +60.0°C
208	112-118	WIND		
	112-114	WIND DIRECTION	000 - 360	Degrees
	115-118	WIND SPEED	0000 - 1500	m/s and tenths; 0000 with 000 direction indicates calm. 0000 - 1500 = 0 to 150.0 m/s
209	119-122	CLOUDS		
	119-120	TOTAL SKY COVER	00 - 10	Amount of celestial dome in tenths covered by clouds or obscuring phenomena. Opaque means clouds or obscuration through which the sky or higher cloud layers cannot be seen.
	121-122	TOTAL OPAQUE SKY COVER	00 - 10	
210	123	SNOW COVER INDICATOR	0 - 1	0 indicates no snow or trace of snow. 1 indicates more than a trace of snow on the ground.
211	124-132	BLANK		

TMY REGION 1 - NORTHEASTERN U. S.

CT

14740 Hartford/Bradley Intl

DC

*93734 Washington/Dulles Intl, Sterling VA

DE

13781 Wilmington/Gtr Wilmington

MA

*94701 Boston/Logan Intl

MD

93721 Baltimore/Balto-Wash Intl
13721 Patuxent River/NAS

ME

14601 Bangor/Intl
*14607 Caribou/Muni
14764 Portland/Intl Jetport

NH

14745 Concord/Muni

NJ

14780 Lakehurst/NAS
14734 Newark/Intl

NY

14735 Albany/County
04725 Binghamton/Broome County
14733 Buffalo/Gtr Buffalo Intl
94725 Massena/Richards Field
14732 New York City/La Guardia
*94728 New York City/Central Park
14768 Rochester/Monroe County
14771 Syracuse/Hancock Intl

PA

14737 Allentown/A-B-E
14777 Avoca/Wilkes Barre-Scranton
14860 Erie/Intl
14751 Harrisburg/Capital City
13739 Philadelphia/Intl
94823 Pittsburgh/Gtr Pittsburgh Intl

RI

14765 Providence/T F Green State

VT

14742 Burlington/Intl

* Rehabilitated Solar Radiation Data

TMY REGION 2 - SOUTHEASTERN U. S.

FL

*12832 Apalachicola/Muni
12834 Daytona Beach/Regional
13889 Jacksonville/Intl
*12839 Miami/Intl
12841 Orlando/Herndon
93805 Tallahassee/Muni
12842 Tampa/Intl
12844 West Palm Beach/Palm Beach Intl

GA

13874 Atlanta/Hartsfield Intl
03820 Augusta/Bush Field
03813 Macon/Lewis B. Wilson
03822 Savannah/Muni

NC

03812 Asheville/Muni
*93729 Cape Hatteras
13881 Charlotte/Douglas Muni
13754 Cherry Point/MCAS
13723 Greensboro/Regional
13722 Raleigh/Raleigh-Durham

SC

*13880 Charleston/Intl
13883 Columbia/Metro
03870 Greer/Greenville-Spartanburg

VA

13737 Norfolk/Intl
13740 Richmond/R E Byrd Intl
13741 Roanoke/Muni-Woodrum

WV

13866 Charleston/Kanawha

* Rehabilitated Solar Radiation Data

TMY REGION 3 - LOWER MISSISSIPPI VALLEY

AL

13876 Birmingham/Muni
13894 Mobile/Bates Field
13895 Montgomery/Dannelley Field

AR

13964 Fort Smith/Muni
13963 Little Rock/Adams Field

KS

*13985 Dodge City/Muni
23065 Goodland/Muni-Renner Field
13996 Topeka/Muni-Billard

KY

93820 Lexington/Blue Grass
93821 Louisville/Standiford Field

LA

13970 Baton Rouge/Ryan
*03937 Lake Charles/Muni
12916 New Orleans/Intl-Moisant
13957 Shreveport/Regional

MS

03940 Jackson/Allen C. Thompson Field
13865 Meridian/Key Field

MO

*03945 Columbia/Regional
13995 Springfield/Regional
13994 St Louis/Lambert Intl

OK

13967 Oklahoma City/Will Rogers World
13968 Tulsa/Intl

TN

13882 Chattanooga/Lovell Field
13891 Knoxville/McGhee Tyson
13893 Memphis/Intl
*13897 Nashville/Metro

* Rehabilitated Solar Radiation Data

TMY REGION 4 - GREAT LAKES AREA

IL

14819 Chicago/Midway
14923 Moline/Quad City
93822 Springfield/Capital

IN

93817 Evansville/Dress Regional
14827 Fort Wayne/Baer Muni
93819 Indianapolis/Weir Cook Intl
14848 South Bend/Michiana Regional

MI

94849 Alpena/Phelps Collins
14822 Detroit/City
14826 Flint/Bishop
94860 Grand Rapids/Kent County Intl
14847 Sault Ste Marie/County Intl
14850 Traverse City/Cherry Capital

OH

14895 Akron/Akron-Canton
93814 Cincinnati/Gtr Cincinnati, Covington KY
14821 Columbus/Port Columbus Intl
93815 Dayton/James M. Cox
94830 Toledo/Express
14852 Youngstown/Muni

WI

14991 Eau Claire/Muni
14898 Green Bay/Austin Straubel
14920 La Crosse/Muni
*14837 Madison/Truax Field
14839 Milwaukee/Gen Mitchell

* Rehabilitated Solar Radiation Data

TMY REGION 5 - UPPER MISSISSIPPI VALLEY/GREAT PLAINS

IA

- **14931 Burlington/Muni
- 14933 Des Moines/Muni
- 14940 Mason City/Muni
- 14943 Sioux City/Muni

MN

- 14913 Duluth/Intl
- 14918 International Falls/Falls Intl
- 14922 Minneapolis-St Paul/Intl
- 14925 Rochester/Muni

MT

- 24033 Billings/Logan
- 24137 Cut Bank/Muni
- 24138 Dillon/FAA
- 94008 Glasgow/Intl
- *24143 Great Falls/Intl
- 24144 Helena/Helena
- 24036 Lewistown/Muni
- 24037 Miles City/Muni
- 24153 Missoula/Johnson-Bell

NE

- 14935 Grand Island/Air Park
- *94918 Omaha/North Omaha Arpt
- 24023 North Platte/Lee Byrd
- 24028 Scottsbluff/County

ND

- *24011 Bismarck/Muni
- 14914 Fargo/Hector
- 24013 Minot/Intl

SD

- 14936 Huron/W W Howes Muni
- 24025 Pierre/Muni
- 24090 Rapid City/Regional
- 14944 Sioux Falls/Foss

* Rehabilitated Solar Radiation Data
** Do not use station and sea level pressure fields.

TMY REGION 6 - TEXAS AND NEW MEXICO

NM

*23050 Albuquerque/Intl
23051 Clayton/Muni
23043 Roswell/Muni
93045 Truth or Consequences/Muni
23048 Tucumcari/Muni

TX

13962 Abilene/Muni
23047 Amarillo/Air Terminal
13958 Austin/Muni
*12919 Brownsville/Intl
12924 Corpus Christi/Intl
22010 Del Rio/Intl
23044 El Paso/Intl
*03927 Fort Worth/Stephenville
*12960 Houston/Intercontinental
12928 Kingsville/NAS
12907 Laredo/Laredo AFB
23042 Lubbock/Regional
93987 Lufkin/Angelina County
23023 Midland-Odessa/Regional
12917 Port Arthur/Jefferson County
23034 San Angelo/Mathis
12921 San Antonio/Intl
13923 Sherman/Perrin
13959 Waco/Madison Cooper
13966 Wichita Falls/Muni

* Rehabilitated Solar Radiation Data

TMY REGION 7 - ROCKIES and DESERT SOUTHWEST

AZ

*23183 Phoenix/Sky Harbor Intl
23184 Prescott/Muni
23160 Tucson/Intl
23194 Winslow/Muni
23195 Yuma/MCAS-Yuma Intl

CO

93037 Colorado Springs/Muni
23062 Denver/Stapleton Intl
23063 Eagle/Eagle County
23066 Grand Junction/Walker
93058 Pueblo/Memorial

ID

24131 Boise/Boise Air Terminal
24149 Lewiston/Nez Perce County
24156 Pocatello/Muni

NV

24121 Elko/Muni
*23154 Ely/Yelland Field
23169 Las Vegas/McCarran Intl
24172 Lovelock/Derby
23185 Reno/Intl
23153 Tonopah/Tonopah
24128 Winnemucca/Muni
03133 Yucca Flats/Test Site

UT

23159 Bryce Canton/Bryce Canton
93129 Cedar City/Muni
24127 Salt Lake City/Intl

WY

24089 Casper/Natrona County Intl
24018 Cheyenne/Muni
24027 Rock Springs/Muni
24029 Sheridan/Sheridan County

* Rehabilitated Solar Radiation Data

TMY REGION 8 - WEST COAST STATES

CA

24283 Arcata/FAA
23155 Bakersfield/Kern County
93104 China Lake/NAF
23161 Daggett/San Bernardino County
93101 El Toro/MCAS
*93193 Fresno/Air Terminal
23129 Long Beach/Long Beach
23174 Los Angeles/Intl
24215 Mount Shasta/City Office
23230 Oakland/Intl
93111 Point Mugu/Pacific Missile Range
24216 Red Bluff/Muni
23232 Sacramento/Executive
23188 San Diego/Lindbergh
23234 San Francisco/Intl
*23273 Santa Maria/Public
23244 Sunnyvale/Moffett NAS

OR

94224 Astoria/Clatsop County
*24225 Medford/Jackson County
24284 North Bend/Muni
24229 Portland/Intl
24230 Redmon/Roberts
24232 Salem/McNary

WA

24227 Olympia/Olympia
*24233 Seattle-Tacoma/Intl
24157 Spokane/Intl
24255 Whidbey Island/NAS
24243 Yakima/Muni

* Rehabilitated Solar Radiation Data

TMY REGION 9 - ALASKA and ISLANDS

AK

25704 Adak/Naval Station
25308 Annette/FAA
26615 Bethel/Muni
26415 Big Delta/Big Delta
26411 Fairbanks/Intl
26425 Gulkana/Intermediate
25507 Homer/Muni
25309 Juneau/Muni
25503 King Salmon/King Salmon
25501 Kodiak/USCG Base
26510 McGrath/McGrath
26617 Nome/Muni
26414 Summit/Summit
25339 Yakutat/State

HI

22514 Barbers Point/NAS
21504 Hilo/Gen Lyman
22521 Honolulu/Intl
22536 Lihue/Lihue

CU

11706 Guantanamo Bay

PN

40309 Koror Island
40604 Kwajalein Island
41606 Wake Island

PR

11641 San Juan/Isla Verde

SOLMET STATIONS FOR WHICH TMY DATA WERE NOT PROCESSED

AK
27502 Barrow/W Rogers-W Post
26533 Bettles/Bettles Field
26616 Kotzebue/Ralph Wien

CA
23179 Needles/FAA

KS
03928 Wichita/Mid-Continent

MI
14858 Houghton/FAA

MO
03947 Kansas City/Intl

NM
23090 Farmington/Muni
93044 Zuni/Intermediate

OH
14820 Cleveland/Hopkins Intl

OR
24134 Burns/City Office
24155 Pendleton/Muni

TX
13960 Dallas/Love Field

WV
03860 Huntington/Tri State

HOURLY TMY OBSERVATIONS WBAN STATION NR: 03812

		LST TIME	DRY BULB	WET BULB	ETR	RADIATION FIELDS GLOBAL	DIRECT	DIFFUSE	SUNSHINE	TOTAL CLOUD	SNOW COVER	WIND SPEED	STATION PRESSURE
JAN		00744	00744	00744	00744	00744	00326			00744		00744	00744
	MAX	02314	00200	00133	03037	02120	03183			00010		00154	09538
	MIN	00004	-0078	-0128	00000	00000	00000			00000		00000	09253
FEB		00672	00672	00672	00672	00672	00336			00224		00672	00672
	MAX	02314	00167	00133	03622	02583	03231			00010		00144	09517
	MIN	00013	-0117	-0172	00000	00000	00000			00000		00000	09273
MAR		00744	00744	00744	00744	00744	00390			00248		00744	00744
	MAX	02313	00211	00161	04189	03145	03234			00010		00129	09497
	MIN	00004	-0078	-0122	00000	00000	00000			00000		00000	09182
APR		00720	00720	00720	00720	00720	00420			00240		00720	00720
	MAX	02359	00283	00172	04525	03395	03191			00010		00118	09490
	MIN	00000	-0011	-0056	00000	00000	00000			00000		00000	09287
MAY		00744	00744	00744	00744	00744	00452			00744		00744	00744
	MAX	02358	00317	00228	04646	03448	03008			00010		00103	09565
	MIN	00056	00022	-0033	00000	00000	00000			00000		00000	09358
JUN		00720	00720	00720	00720	00720	00480			00240		00720	00720
	MAX	02359	00339	00217	04656	03475	03007			00010		00118	09490
	MIN	00000	00094	00061	00000	00000	00000			00000		00000	09341
JUL		00744	00744	00744	00744	00744	00474			00744		00744	00744
	MAX	02307	00317	00244	04644	03317	03010			00010		00077	09514
	MIN	00004	00111	00100	00000	00000	00000			00000		00000	09372
AUG		00744	00744	00744	00744	00744	00434			00248		00744	00744
	MAX	02306	00300	00222	04553	03168	02949			00010		00077	09494
	MIN	00000	00128	00128	00000	00000	00000			00000		00000	09368
SEP		00720	00720	00720	00720	00720	00402			00240		00720	00720
	MAX	02359	00322	00206	04294	03116	03047			00010		00103	09527
	MIN	00000	00067	00056	00000	00000	00000			00000		00000	09284
OCT		00744	00744	00744	00744	00744	00372			00248		00744	00744
	MAX	02359	00283	00200	03821	02741	03114			00010		00103	09571
	MIN	00044	-0033	-0050	00000	00000	00000			00000		00000	09341
NOV		00720	00720	00720	00720	00720	00338			00240		00720	00720
	MAX	02349	00217	00159	03206	02227	03147			00010		00134	09504
	MIN	00044	-0128	-0161	00000	00000	00000			00000		00000	09304
DEC		00744	00744	00744	00744	00744	00310			00744		00744	00744
	MAX	02359	00183	00150	02714	01856	03081			00010		00165	09615
	MIN	00000	-0128	-0200	00000	00000	00002			00000		00000	09280
ANNUAL		08760	08760	08760	08760	08760	04734	00000	00000	04904	00000	08760	08760

APPENDIX

GENERATION

OF

TYPICAL METEOROLOGICAL YEARS

FOR

26 SOLMET STATIONS

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GENERATION OF TYPICAL METEOROLOGICAL YEARS FOR 26 SOLMET STATIONS

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ABSTRACT

Typical meteorological years (TMY) are defined, and a methodology for their selection for given geographical locations for which long term weather data bases exist is described. The TMYs thus selected are given, and magnetic tapes containing the TMY data bases have been created.

TABLE OF CONTENTS

TABLES

FIGURES

MICROFICHE

TABLE OF CONTENTS (Con't)

GENERATION OF TYPICAL METEOROLOGICAL YEARS FOR 26 SOLMET STATIONS

I. INTRODUCTION

Problems with which designers of solar systems are faced include determining the efficiency of a system and evaluating the performance of different system designs. To address such problems designers usually use computer codes which simulate or predict the energy output of the actual hardware. Such codes require meteorological inputs. At present there is no agreed upon meteorological data base to be used for inputs. The predicted performance of a system will, of course, depend on the meteorological inputs. A system which performs well for one set of inputs may perform poorly for another set.

The value of a standard data base which is representative of a given area is quite apparent. For example, it would help engineers design and evaluate energy systems and would aid them in making comparisons between different systems. To be most useful to system designers, this data base should possess several characteristics. It should consist of hourly solar radiation and weather readings for a network of representative sites across the U.S. It should in some sense be "typical" of the long term data base and it should be of a year's duration. For a given site this data base could be reasonably called a "typical meteorological year" (TMY).

Defining the characteristics of a meteorological year which make it "typical" is difficult; however, sensible properties of a TMY would seem to include the following:

(a) The meteorological measures of the TMY, i.e., temperature, solar radiation, and wind, should have frequency distributions which are "close" to the long term distributions.

(b) The sequences of the daily measures for the TMY should in some sense be "like" the sequences often registered at a given location.

(c) The relationships among the different measures for the TMY should be "like" the relationships observed in nature.

This document describes a procedure for obtaining a TMY of hourly data with properties (a)-(c) and presents the results of using the procedure for 26 U.S. sites.

Other efforts have been devoted to developing common weather bases. A brief history of some of the efforts is given in reference [4]. One of the procedures described in reference [4] was developed in a joint effort by members of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, the National Bureau of Standards, the National Oceanic and Atmospheric Administration, and the Federal Energy Administration. The principle of that procedure is to eliminate years in the period of record containing months with extremely high or low mean temperatures until only one year remains. The period of record for 60 U.S. stations was about 27 years. In another effort, described in reference [1], typical years are computer generated via mathematical models.

The method described and used in this report for generating TMY's is referred to as the empirical approach. Briefly, the empirical approach adopted for selecting TMYs for a given station is as follows: a typical month for each of the twelve calendar months from the long term data base (23 years for most stations) was chosen and then these twelve months were catenated to form TMYs. The data set generated to form the basis for the selection of a typical month consisted of the thirteen daily indices calculated from the hourly values of dry bulb temperature, dew point temperature, wind velocity, and solar radiation. Monthly statistics were calculated for each index. Month/year combinations which had statistics that were "close" to the long term statistics were candidates for typical months. Final selection of a typical month included consideration of persistence of weather patterns.

It should be emphasized that the selection methodology described herein is not limited to the 26 SOLMET sites, but is applicable to any geographic location for which a long term weather data base exists.

II. DATA BASE

The long term data base used was that for the 26 SOLMET sites maintained by the National Climatic Center (NCC) in Asheville, NC. (See Figure 1 for the location of the sites. Table I lists the stations, station numbers, and periods of record.) The NCC has "rehabilitated" the meteorological data and stored the data using the SOLMET format on magnetic tapes. The tapes were rehabilitated in two ways. The existing global horizontal solar radiation data were corrected by applying a Standard Year Clear Solar Noon Model. See reference [6]. Also, gaps in the hourly solar radiation data tapes were filled by using the Total-Horizontal Solar Radiation Model. See reference [6]. The SOLMET format and the information recorded on the SOLMET tapes are described in the SOLMET manual.* Table II, seven pages from the SOLMET manual, lists the weather variables and describes the format of the SOLMET tapes. In addition, Aerospace Corporation has augmented the tapes by adding direct insolation estimates. See reference [5].

The four meteorological measures that were used in the selection of the TMY were:

1. Dry bulb temperature
2. Dew point temperature
3. Wind velocity
4. Global solar radiation on a horizontal surface - standard year corrected.

III. INITIAL APPROACH

The initial phase of the project consisted of searching the meteorological literature and contacting meteorological experts for ideas and comments on the generation of TMYs. From this it was learned that considerable effort has been expended in constructing mathematical weather models. The derivation of mathematical models commonly involves using time series techniques to fit the data with stochastic models. Extensive efforts were made to fit a part of the data from one of the SOLMET tapes with stochastic models. It was found for example, that the dry bulb temperature data could be fit quite well with the following model:

$$x_t = \alpha + \sum_{j=1}^{4} (a_j \cos w_j t + b_j \sin w_j t)$$

$$+ B_1 X_{t-1} + B_2 X_{t-2} + B_3 X_{t-3}$$

$$+ B_4 X_{t-23} + B_5 X_{t-24} + B_6 X_{t-25} + \varepsilon_t$$

$$\text{for } w_j = \frac{2\pi}{24}, \frac{2\pi}{12}, \frac{2\pi}{6}, \frac{2\pi}{3}$$

*SOLMET Volume 1 - User's Manual
Hourly Solar Radiation - Surface Meteorological Observations
U. S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Data Service
National Climatic Center
Asheville, NC

where x_{t-i} is the dry bulb temperature at hour t-i (i=0,1, 2,3...)

α, a's, b's, and B's are constants to be determined

ε_t is a random error term at hour t.

Once the data on a meteorological measure are fitted with a stochastic model one can generate data for this measure using computer simulation. A question which arises from using this procedure for generating TMYs is how one can decide that a given set of generated data is "typical."

Although the data for each of the meteorological measures perhaps could be individually fitted with a stochastic model, the models would in a sense still not be realistic because they would not account for the interrelationship among the variables. Weather data are actually a multivariate stochastic process with complex interrelationships among the variables. Fitting multivariate stochastic processes with mathematical models is somewhat difficult. Also, even if such models could be derived and a computer simulation performed to generate meteorological data, one would still be faced with the problem of deciding about the typicalness of a set of generated data.

These problems plus time constraints (both chronological and computational) suggested that a more empirical approach for obtaining TMYs might be better. The approach adopted is discussed in Section IV.

IV. EMPIRICAL APPROACH

1. Method of Generating Typical Years

It was decided to construct typical years for each site by first dividing the year into calendar months. Typical meteorological months (TMMs) were chosen by statistical methods from the period of record (23 years in most cases - see Table I) and the twelve TMMs were catenated to form a TMY. Some of the variables were smoothed between adjacent months to avoid abrupt changes from the last hour of one month to the first hour of the next. Thus the typical year for each station consists of 12 months of actual meteorological data which are selected from the long term data base for that station. A TMY at a given station could, for example, consist of January 1955, February 1966, March 1962, ... December 1973.

2. Meteorological Measures Involved for Selecting TMY

As mentioned above, the meteorological measures involved in the selection are dry bulb temperature, dew point temperature, wind velocity, and global solar radiation. From these four measures, thirteen daily indices were generated. These indices are daily total global solar radiation, and daily maximum, mean, minimum and range for each of dry bulb temperature, dew point temperature, and wind velocity. For example, for the month of May there are 31 numerical values for each index for each year at a given station. For stations with 23 years of data there are a total of 23 x 31 = 713 values for each index for the long term May composite.

For each individual month of each year there is a distribution associated with each of the daily indices - for example, the distribution of daily maximums of dry bulb temperatures for May of 1961. In addition, for each month there is a long term distribution associated with each of the daily indices - for example, the distribution of daily maximums of dry bulb temperatures for all days in May in the entire data base. Ideally, one would pick for a TMM a particular month whose individual distributions for all of the 13 daily indices are close to the 13 corresponding long term indices. Usually it will be impossible to find such a combination. For different applications of a TMY the indices will take on different levels of importance. Thus, one would attempt to pick as candidates for the TMM the month/year combinations in which the distributions of the important indices are close, and be less concerned with matching distributions of less important indices. Further discussion regarding the importance assigned to the various indices is given in the next section.

3. Selection Procedure

The procedure for selecting a TMM consisted of two steps. The first step was to select five candidate years. The second step was to select the TMM from the five candidate years.

In the succeeding discussion the term "year" refers to a month/year combination. That is, if May is the month under consideration, 1966 refers to May, 1966.

a. Selection of five candidate years

For each of the twelve calendar months the procedure involved selecting the five years that were "closest" to the composite of all 23 years. This was done by comparing the cumulative distribution function (CDF) for each year with the CDF for the long term composite of all 23 years for each of the 13 indices. (The CDF gives the proportion of values which are less than or equal to a specified value of an index.) Many statistics are available for comparing CDFs. Reference [3] lists six of them and gives some of the properties of the statistics. The statistic selected to measure the closeness of each year's CDF to the long term composite for a given index was the Finkelstein-Schafer (FS) statistic. See reference [2]. The CDF for the variable X is estimated by $S_n(x)$ where

$$S_n(x) = \begin{cases} 0 \text{ for } x < x_{(1)} \\ (k - .5)/n \text{ for } x_{(k)} \leq x \leq x_{(k+1)} \\ 1 \text{ for } x > x_{(n)}, \end{cases}$$

Where $x_{(k)}$ is the k^{th} ordered (from smallest to largest) observation and n is the number of observations on the variable x, (if the month is May, n = 31). $S_n(x)$ is a monotonically increasing step function which is bounded by zero and one. The steps are of size 1/n and occur at the values of $x_{(k)}$. See Figure 2 for a plot of typical CDFs for mean daily wind velocity. The station is Albuquerque and the month is May. The long term CDF is based on 23 years of data - 713 daily observations. The CDFs labeled 1958 and 1953 are each based on 31 daily observations. The FS statistic for comparing the long term CDF and the month/year CDF for the variable x is given by

$$FS = \frac{1}{n} \sum_{i=1}^{n} \delta_i$$

Where:

δ_i = the absolute difference between the long term CDF and the month/year CDF at $x_{(i)}$ (i = 1, ..., n).

n = the number of daily readings in the month.

The closer the two CDFs the smaller the value of FS.

It is noted in passing that some solar practitioners have attempted to pick representative months by matching the mean and standard deviation of a month/year combination to the long term mean and standard deviation. It is felt that using the CDF and a statistic such as FS is a better selection procedure because the first two moments of two distributions can be close and yet the distributions can be quite different. A statistic such as FS is more sensitive to differences.

For each year, thirteen FS statistics were computed, one for each index. As mentioned above, the matching of certain distributions of some indices is more important than matching those of other indices. How to order groups (the years) of thirteen FS statistics in which some statistics are more important than others is an open question. One way to perform the ordering is with a weighted sum of the thirteen FS statistics,

$$WS = \sum w_i \, FS_i$$

where the FS values associated with important statistics would receive relatively larger weights than the less important statistics. Choosing these weights (w_i) is not clear cut but would depend on the ultimate application of the generated typical year.

In the generation of these TMY's, it was determined that the three range statistics and the minimum of wind velocity were of little or no value in the selection process, so these statistics were omitted, i.e., assigned zero weight. The maxima and minima of dry bulb and dew point temperatures were assigned the minimum non-zero weight, the means of those statistics and the mean and maximum of wind velocity a weight twice that minimum, and daily total global solar radiation was assigned the maximum weight. The actual weighting scheme used for the TMY's follows:

	Temperature						Wind Velocity		Solar Radiation
	Dry Bulb			Dew Point					
	Max	Min	Mean	Max	Min	Mean	Max	Mean	
W_i:	1/24	1/24	2/24	1/24	1/24	2/24	2/24	2/24	12/24

A value for WS was computed for each year and the five years with the smallest values for WS were selected as candidate years for the month in question.

b. Final Selection of TMM

The final selection of the TMM from the five candidate years involved examining statistics and persistence structure associated with mean daily dry bulb temperature and daily total global solar radiation. The statistics examined were the FS statistic and the deviations of the monthly mean and median from the long term mean and median. Persistence was characterized by frequency and run length (RL) above and below fixed long term percentiles. For mean daily dry bulb temperature the frequency and run length above the 67th (consecutive warm days) and below the 33rd (consecutive cool days) long term percentile were computed. For solar radiation the frequency and run length below the 33rd long term percentile (consecutive days with low radiation) were computed. Table A-III in Appendix A is an example of the runs information calculated for daily total global solar radiation. Persistence was considered important because it was thought that in some cases a given year's CDF could be quite close to that for the long term composite yet there still could be atypically long runs of cloudy or warm or cool days. An unusual run structure is of particular importance with regard to solar energy systems.

The final selection of a TMM was somewhat subjective. However, an attempt was made to select years with small WS values, small deviations, and "typical" run structures.

The summary statistics calculated for each month/year combination are included with this report on microfiche. Appendix A describes the computer output that was generated and gives some examples of output.

Typical wind years (TWY) were also characterized. Maximum and mean daily wind velocity were the only indices used in the selection of the TWY. The selection of the five candidate years for the TWY was similar to that used for the TMY. These may be found in Appendix Table A-I. It should be noted that no adjustments were made in the wind velocity data due to changes in anemometer heights during the period of record. If appropriate adjustments were made to compensate for anemometer height changes, different TWYs would probably have been chosen.

V. RESULTS

The methodology previously described was applied to the 26 SOLMET sites. Table III lists the TMY for each station. The meteorological data corresponding to each TMY for each station have been recorded on magnetic tape and are available from the National Climatic Center at Asheville. The tape is FORTRAN formatted into 132 character BCD records. (Tapes are also available in blocked format.) Each record represents one hourly SOLMET recording of solar and meteorological data for that station, and the entire file represents the typical year for that station. There are 365 x 24 = 8760 formatted physical records in the file. (If a leap year February were chosen it was truncated to 28 days.) The data in these records are exactly as described in Volume 1 - SOLMET User's Manual, with two exceptions: field number 1, the tape deck number is omitted; and in field number 209, clouds, only total sky cover and total opaque sky cover are included. In addition, for meteorological data recorded after 1964 when recordings were made on a three-hourly basis, missing data have been filled in by linear interpolation for the following fields:

Number 206 - Pressure (sea level/station)
Number 207 - Temperature (dry bulb/dew point)
Number 208 - Wind (direction/speed)

Since the TMY is created by catenating typical months, discontinuities between the end of one month and the beginning of the next were ameliorated by cubic spline smoothing for pressure, temperature, and wind velocity.

VI. VALIDATION

No extensive validation has been performed to assess the typicality of the years generated by the procedure described in this report. However, P. J. Hughes, formerly at the University of Wisconsin Solar Energy Laboratory, has assessed the TMY for Madison, Wisconsin by simulating (using TRNSYS*) the solar heating system shown in Figure 3 over the period 1953-1974. In Table IV the TRNSYS output is given for each of the 22 years and for the TMY. The mean and standard deviation of the 22 year data base is given for each column. Note that the results for the TMY are all within one standard deviation of the data base mean, a result which is supportive of the TMY.

Further validation of the TMY's is presently being conducted by Science Applications, Inc., McLean, VA.

*TRaNsient SYstem Simulation - See Reference [7].

TABLE I

SOLMET WEATHER STATIONS AND PERIODS OF RECORD AVAILABLE

Station	Station Number	First Year	Last Year	Period of Record, Yrs
Albuquerque	23050	53	75	23
Apalachicola	12832	53	70	18
Bismarck	24011	53	75	23
Boston	94701	53	67	15
Brownsville	12919	53	75	23
Cape Hatteras	93729	53	75	23
Caribou	14607	53	75	23
Charleston	13880	53	75	23
Columbia	03945	53	75	23
Dodge City	13985	53	75	23
El Paso	23044	53	75	23
Ely	23154	54	75	22
Fort Worth	03927	53	73	21
Fresno	93193	53	75	23
Great Falls	24143	53	75	23
Lake Charles	03937	53	75	23
Madison	14837	53	75	23
*Medford	24225	52	75	24
Miami	12839	53	75	23
Nashville	13897	53	75	23
New York	94728	53	75	23
Omaha	94918	58	75	18
Phoenix	23183	53	75	23
Santa Maria	23273	53	68	16
*Seattle	24233	52	75	24
Wash., D.C.	93734	54	75	22

*1952 not used; December data omitted 1968-1975 due to bad or missing data.

SOLMET DATA FORMAT

IDENTIFICATION							SOLAR RADIATION OBSERVATION											
TAPE DECK #	WBAN STN #	SOLAR TIME				LST TIME	ETR KJ/m^2	RADIATION VALUES KJ/m^2										SUNSHINE MIN
								DIRECT	DIFFUSE	NET	TILTED	GLOBAL			A	B		
		YR	MO	DY	HRMN							OBS	ENG COR	STD YR COR				
9724	XXXXX	XX	XX	XX	XXXX	XXXX	XXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX	iXXXX		XX
FIELD NUMBER: 001	002	003				004	101	102	103	104	105	106	107	108	109	110		111

SURFACE METEOROLOGICAL OBSERVATION																												
OB TIME LST	CEILING dam	SKY COND	VSBY hm	WEATHER	PRESSURE kPa		TEMP °C		WIND		CLOUDS																	SNOW COVER
											TOTAL	LOWEST			SECOND				THIRD				FOURTH			OPAQUE		
					SEA LEVEL	STATION	DRY BULB	DEW-PT.	DIR deg	SPD m/s		AMOUNT	TYPE	HEIGHT dam	AMOUNT	TYPE	HEIGHT dam	SUM AMT	AMOUNT	TYPE	HEIGHT dam	SUM AMT	AMOUNT	TYPE	HEIGHT dam			
XX	XXXX	iXXXX	XXXX	XXXXXXXX	XXXXX	XXXXX	XXXX	XXXX	XXX	XXXX	XX	XX	XX	XXXX	XX	XX	XXXX	XX	XX	XX	XXXX	XX	XX	XX	XXXX	XX		X
201	202	203	204	205	206		207		208		209																	210

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT
001	001 - 004	TAPE DECK NUMBER
002	005 - 009	WBAN STATION NUMBER
003	010 - 019	SOLAR TIME
004	020 - 023	LOCAL STANDARD TIME
101	024 - 027	EXTRATERRESTRIAL RADIATION
102	028 - 032	DIRECT RADIATION
103	033 - 037	DIFFUSE RADIATION
104	038 - 042	NET RADIATION
105	043 - 047	GLOBAL RADIATION ON A TILTED SURFACE
106	048 - 052	GLOBAL RADIATION ON A HORIZONTAL SURFACE - OBSERVED DATA
107	053 - 057	GLOBAL RADIATION ON A HORIZONTAL SURFACE - ENGINEERING CORRECTED DATA
108	058 - 062	GLOBAL RADIATION ON A HORIZONTAL SURFACE - STANDARD YEAR CORRECTED DATA
109, 110	063 - 072	ADDITIONAL RADIATION MEASUREMENTS
111	073 - 074	MINUTES OF SUNSHINE
201	075 - 076	TIME OF TD 1440 OBSERVATION
202	077 - 080	CEILING HEIGHT
203	081 - 085	SKY CONDITION
204	086 - 089	VISIBILITY
205	090 - 097	WEATHER
206	098 - 107	PRESSURE
207	108 - 115	TEMPERATURE
208	116 - 122	WIND
209	123 - 162	CLOUDS
210	163	SNOW COVER INDICATOR

TABLE II-1

NOTE: Except for tape positions 001-027 in fields 001-101, elements with a tape configuration of 9's indicate missing or unknown data.

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
001	001 - 004	TAPE DECK NUMBER	9724	
002	005 - 009	WBAN STATION NUMBER	01001 - 98999	Unique number used to identify each station.
003	010 - 019	SOLAR TIME		
	010 - 011	YEAR	00 - 99	Year of observation, 00 - 99 = 1900 - 1999
	012 - 013	MONTH	01 - 12	Month of observation, 01 - 12 = Jan. - Dec.
	014 - 015	DAY	01 - 31	Day of month
	016 - 019	HOUR	0001 - 2400	End of the hour of observation in solar time (hours and minutes)
004	020 - 023	LOCAL STANDARD TIME	0000 - 2359	Local Standard Time in hours and minutes corresponding to end of solar hour indicated in field 003.
101	024 - 027	EXTRATERRESTRIAL RADIATION	0000 - 4957	Amount of solar energy in kJ/m^2 received at top of atmosphere during solar hour ending at time indicated in field 003, based on solar constant = $1377J/(m^2.s)$ 9999 = nighttime values defined as zero kJ/m^2
102	028 - 032	DIRECT RADIATION		Portion of radiant energy in kJ/m^2 received at the pyrheliometer directly from the sun during solar hour ending at time indicated in field 003.
	028	DATA CODE INDICATOR	0 - 8	
	029 - 032	DATA	0000 - 4957	
103	033 - 037	DIFFUSE RADIATION		Amount of radiant energy in kJ/m^2 received at the instrument indirectly from reflection, scattering, etc., during the solar hour ending at the time indicated in field 003.
	033	DATA CODE INDICATOR	0 - 8	
	034 - 037	DATA	0000 - 4957	
104	038 - 042	NET RADIATION		Difference between the incoming and outgoing radiant energy in kJ/m^2 during the solar hour ending at the time indicated in field 003. A constant of 5000 has been added to all net radiation data.
	038	DATA CODE INDICATOR	0 - 8	
	039 - 042	DATA	2000 - 8000	
105	043 - 047	GLOBAL RADIATION ON A TILTED SURFACE		Total of direct and diffuse radiant energy in kJ/m^2 received on a tilted surface (tilt angle indicated in station - period of record list) during solar hour ending at the time indicated in field 003.
	043	DATA CODE INDICATOR	0 - 8	
	044 - 047	DATA	0000 - 4957	
	048 - 062	GLOBAL RADIATION ON A HORIZONTAL SURFACE		Total of direct and diffuse radiant energy in kJ/m^2 received on a horizontal surface by a pyranometer during the solar hour ending at the time indicated in field 003.
106	048 - 052	OBSERVED DATA		
	048	DATA CODE INDICATOR	0 - 8	
	049 - 052	DATA	0000 - 4957	Observed value.
107	053 - 057	ENGINEERING CORRECTED DATA		
	053	DATA CODE INDICATOR	0 - 8	
	054-057	DATA	0000 - 4957	Observed value corrected for known scale changes, station moves, recorder and sensor calibration changes, etc.

TABLE II-2

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
108	058 - 062	STANDARD YEAR CORRECTED DATA		
	058	DATA CODE INDICATOR	0 - 8	
	059 - 062	DATA	0000 - 4957	Observed value adjusted to Standard Year Model. This model yields expected clear sky irradiance received on a horizontal surface at the elevation of the station.
109, 110	063 - 072	ADDITIONAL RADIATION MEASUREMENTS		Supplemental Fields A and B for additional radiation measurements; type of measurement specified in station-period of record list.
	063, 068	DATA CODE INDICATORS	0 - 8	
	064-067	DATA		
	069-072	DATA		

NOTE FOR FIELDS 102-110: Data code indicators are:

- 0 Observed data
- 1 Estimated from model using sunshine and cloud data
- 2 Estimated from model using cloud data
- 3 Estimated from model using sunshine data
- 4 Estimated from model using sky condition data
- 5 Estimated from linear interpolation
- 6 Reserved for future use
- 7 Estimated from other model (see individual station notes at end of manual)
- 8 Estimated without use of a model

(See model description in Volume 2.)

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
111	073 - 074	MINUTES OF SUNSHINE	00 - 60	For Local Standard Hour most closely matching solar hour.
201	075 - 076	TIME OF TD 1440 OBSERVATION	00 - 23	Local Standard Hour of TD 1440 Meteorological Observation that comes closest to midpoint of the solar hour for which solar data are recorded.
202	077 - 080	CEILING HEIGHT	0000 - 3000	Ceiling height in dekameters (dam = m x 10^1); ceiling is defined as sky cover of .6 or greater. 0000 - 3000 = 0 to 30,000 meters
			7777	7777 = unlimited; clear
			8888	8888 = unknown height of cirroform ceiling
203	081 - 085	SKY CONDITION		
	081	INDICATOR	0	Identifies observations after 1 June 51.
	082 - 085	SKY CONDITION	0000 - 8888	Coded by layer in ascending order; four layers are described; if less than 4 layers are present the remaining positions are coded 0. The code for each layer is: 0 = Clear or less than .1 cover 1 = Thin scattered (.1 - .5 cover) 2 = Opaque scattered (.1 - .5 cover) 3 = Thin broken (.6 - .9 cover) 4 = Opaque broken (.6 - .9 cover) 5 = Thin overcast (1.0 cover) 6 = Opaque overcast (1.0 cover) 7 = Obscuration 8 = Partial obscuration
204	086 - 089	VISIBILITY	0000 - 1600	Prevailing horizontal visibility in hectometers (hm = m x 10^2). 0000 - 1600 = 0 to 160 kilometers
			8888	8888 = unlimited

TABLE II-3

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
205	090 - 097	WEATHER		
	090	OCCURRENCE OF THUNDERSTORM, TORNADO OR SQUALL	0 - 4	0 = None 1 = Thunderstorm - lightning and thunder. Wind gusts less than 50 knots, and hail, if any, less than 3/4 inch diameter. 2 = Heavy or severe thunderstorm - frequent intense lightning and thunder. Wind gusts 50 knots or greater and hail, if any, 3/4 inch or greater diameter. 3 = Report of tornado or waterspout. 4 = Squall (sudden increase of wind speed by at least 16 knots, reaching 22 knots or more and lasting for at least one minute).
	091	OCCURRENCE OF RAIN, RAIN SHOWERS OR FREEZING RAIN	0 - 8	0 = None 1 = Light rain 2 = Moderate rain 3 = Heavy rain 4 = Light rain showers 5 = Moderate rain showers 6 = Heavy rain showers 7 = Light freezing rain 8 = Moderate or heavy freezing rain
	092	OCCURRENCE OF DRIZZLE, FREEZING DRIZZLE	0 - 6	0 = None 1 = Light Drizzle 2 = Moderate drizzle 3 = Heavy drizzle 4 = Light freezing drizzle 5 = Moderate freezing drizzle 6 = Heavy freezing drizzle
	093	OCCURRENCE OF SNOW, SNOW PELLETS OR ICE CRYSTALS	0 - 8	0 = None 1 = Light snow 2 = Moderate snow 3 = Heavy snow 4 = Light snow pellets 5 = Moderate snow pellets 6 = Heavy snow pellets 7 = Light ice crystals 8 = Moderate ice crystals Beginning April 1963 intensities of ice crystals were discontinued. All occurrences since this date are recorded as an 8.
	094	OCCURRENCE OF SNOW SHOWERS AND SNOW GRAINS	0 - 6	0 = None 1 = Light snow showers 2 = Moderate snow showers 3 = Heavy snow showers 4 = Light snow grains 5 = Moderate snow grains 6 = Heavy snow grains Beginning April 1963 intensities of snow grains were discontinued. All occurrences since this date are recorded as a 5.

TABLE II-4

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
	095	OCCURRENCE OF SLEET (ICE PELLETS), SLEET SHOWERS OR HAIL	0 - 8	0 = None 1 = Light sleet or sleet showers (ice pellets) 2 = Moderate sleet or sleet showers (ice pellets) 3 = Heavy sleet or sleet showers (ice pellets) 4 = Light hail 5 = Moderate hail 6 = Heavy hail 7 = Light small hail 8 = Moderate or heavy small hail Prior to April 1970 ice pellets were coded as sleet. Beginning April 1970 sleet and small hail were redefined as ice pellets and are coded as a 1, 2 or 3 in this position. Beginning September 1956 intensities of hail were no longer reported and all occurrences were recorded as a 5.
	096	OCCURRENCE OF FOG, BLOWING DUST OR BLOWING SAND	0 - 5	0 = None 1 = Fog 2 = Ice fog 3 = Ground fog 4 = Blowing dust 5 = Blowing sand These values recorded only when visibility less than 7 miles.
	097	OCCURRENCE OF SMOKE, HAZE, DUST, BLOWING SNOW, BLOWING SPRAY	0 - 6	0 = None 1 = Smoke 2 = Haze 3 = Smoke and haze 4 = Dust 5 = Blowing snow 6 = Blowing spray These values recorded only when visibility less than 7 miles.
206	098 - 107	PRESSURE		
	098 - 102	SEA LEVEL PRESSURE	08000 - 10999	Pressure, reduced to sea level, in kilopascals (kPa) and hundredths.
	103 - 107	STATION PRESSURE	08000 - 10999	Pressure at station level in kilopascals (kPa) and hundredths. 08000 - 10999 = 80 to 109.99 kPa
207	108 - 115	TEMPERATURE		
	108 - 111	DRY BULB	-700 to 0600	°C and tenths
	112 - 115	DEW POINT	-700 to 0600	°C and tenths -700 to 0600 = -70.0 to +60.0°C
208	116 - 122	WIND		
	116 - 118	WIND DIRECTION	000 - 360	Degrees
	119 - 122	WIND SPEED	0000 - 1500	m/s and tenths; 0000 with 000 direction indicates calm. 0000 - 1500 = 0 to 150.0 m/s

TABLE II-5

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
209	123 - 162	CLOUDS		See following explanatory "NOTES."
	123 - 124	TOTAL SKY COVER		
	125 - 126	LOWEST CLOUD LAYER AMOUNT		
	127 - 128	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA		
	129 - 132	HEIGHT OF BASE OF LOWEST CLOUD LAYER OR OBSCURING PHENOMENA		
	133 - 134	SECOND LAYER AMOUNT		
	135 - 136	TYPE OF SECOND CLOUD LAYER		
	137 - 140	HEIGHT OF BASE OF SECOND CLOUD LAYER		
	141 - 142	SUMMATION OF FIRST 2 LAYERS		
	143 - 144	THIRD LAYER AMOUNT		
	145 - 146	TYPE OF THIRD CLOUD LAYER		
	147 - 150	HEIGHT OF BASE OF THIRD CLOUD LAYER		
	151 - 152	SUMMATION OF FIRST 3 LAYERS		
	153 - 154	FOURTH LAYER AMOUNT		
	155 - 156	TYPE OF FOURTH CLOUD LAYER		
	157 - 160	HEIGHT OF BASE OF FOURTH CLOUD LAYER		
	161 - 162	TOTAL OPAQUE SKY COVER		

NOTES: (1) Tape Configuration and Remarks for Total Sky Cover, Cloud Layer Amount, Summation of Cloud Layers and Total Opaque Sky Cover

Configuration	Remarks
00 - 10	Amount of celestial dome in tenths covered by clouds or obscuring phenomena. Opaque means clouds or obscuration through which the sky or higher cloud layers cannot be seen.

(2) Tape Configuration and Remarks for Type of Cloud or Obscuring Phenomena.

Configuration	Remarks
00 - 16	Generic cloud type or obscuring phenomena. 0 = None 1 = Fog 2 = Stratus 3 = Stratocumulus 4 = Cumulus 5 = Cumulonimbus 6 = Altostratus 7 = Altocumulus 8 = Cirrus 9 = Cirrostratus 10 = Stratus Fractus 11 = Cumulus Fractus 12 = Cumulonimbus Mamma 13 = Nimbostratus 14 = Altocumulus Castellanus 15 = Cirrocumulus 16 = Obscuring phenomena other than fog

TABLE II-6

(3) Tape Configuration and Remarks for Height of Base of Cloud Layer or Obscuring Phenomena.

Configuration	Remarks
0000 - 3000	Dekameters
7777	7777 = Unlimited, clear
8888	8888 = Unknown height or cirroform layer

210	163	SNOW COVER INDICATOR	0 - 1	0 indicates no snow or trace of snow on ground; 1 indicates more than trace of snow on ground.

TABLE II-7

TABLE III

TYPICAL METEOROLOGICAL YEARS FOR EACH OF THE SOLMET STATIONS

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Albuquerque	58	53	65	66	64	69	57	54	67	65	59	54
Apalachicola	60	60	64	63	67	63	58	55	66	55	59	65
Bismarck	60	71	57	54	57	75	69	55	57	68	67	67
Boston	66	53	61	60	62	65	53	56	62	57	61	61
Brownsville	64	61	56	65	71	64	61	66	68	53	68	75
Cape Hatteras	65	55	56	69	54	69	68	71	64	66	74	66
Caribou	59	70	70	69	71	53	74	53	72	73	74	60
Charleston	60	60	75	59	73	61	53	67	60	65	71	75
Columbia	65	55	54	70	58	64	62	63	67	74	71	64
Dodge City	60	73	54	62	55	63	61	60	66	54	71	67
El Paso	74	67	75	74	54	61	71	61	71	67	71	56
Ely	74	71	71	71	56	75	58	73	66	66	63	65
Fort Worth	72	61	62	66	66	59	65	55	57	68	71	62
Fresno	64	75	68	53	68	62	54	73	68	66	74	68
Great Falls	68	65	71	63	70	59	54	62	73	71	71	65
Lake Charles	67	72	56	74	64	59	63	66	64	75	58	62
Madison	65	60	72	64	53	57	73	63	58	74	65	54
Medford	66	62	53	69	64	59	69	63	62	60	62	61
Miami	62	74	67	59	64	53	57	63	57	65	61	68
Nashville	54	59	64	74	63	68	75	73	58	69	66	66
New York	58	59	59	74	74	61	60	72	58	56	71	67
Omaha	72	59	59	63	58	72	61	60	66	68	74	62
Phoenix	68	75	63	57	68	56	74	72	72	68	59	66
Santa Maria	63	59	57	57	56	64	53	62	61	62	53	62
Seattle	75	71	62	72	61	59	62	70	62	66	68	56
Wash., D.C.	65	70	64	67	56	68	73	65	73	75	73	61

TABLE IV-1

TRNSYS RESULTS FOR TMY AND TWENTY-TWO YEAR DATA BASE*
(MADISON, WISCONSIN)

YEAR	QCOL (GJ)	HCOL (GJ)	COL EFFIC	AVG.TANK TEMP (C)	SHAUX (GJ)	TOTAUX (GJ)	SHLOAD (GJ)	TOTLOAD (GJ)	FRACTION BY SOLAR
1953	85.69	283.80	.302	63.7	49.54	55.99	104.60	134.40	.583
1954	88.72	263.10	.337	61.7	47.74	54.06	107.10	135.90	.602
1955	88.69	287.10	.309	63.7	55.87	62.21	113.90	143.60	.567
1956	89.20	271.20	.329	63.2	53.27	59.76	112.30	142.00	.579
1957	88.57	262.30	.338	59.7	53.74	60.88	114.20	143.00	.574
1958	95.16	295.80	.322	65.4	51.82	57.63	115.10	145.10	.603
1959	88.83	272.70	.326	60.4	60.64	67.67	120.90	149.90	.548
1960	93.85	284.90	.329	61.2	54.95	61.81	119.70	148.90	.585
1961	90.45	282.30	.320	60.1	54.66	61.87	116.70	145.70	.575
1962	89.29	276.70	.323	60.8	62.14	68.92	122.60	151.50	.545
1963	88.08	292.70	.301	65.0	66.37	72.56	123.00	153.20	.526
1964	97.94	297.80	.329	64.8	45.23	50.85	111.70	141.30	.640
1965	95.80	284.90	.336	60.5	53.78	60.62	121.00	149.80	.595
1966	100.50	298.40	.337	61.0	51.80	58.48	123.20	152.20	.616
1967	93.18	270.20	.345	59.2	57.04	64.21	122.50	151.10	.575
1968	94.99	296.50	.320	64.5	48.06	53.75	111.90	141.40	.620
1969	98.18	282.70	.347	61.2	54.33	60.86	123.30	152.20	.600
1970	96.30	292.50	.329	62.4	52.07	58.51	118.40	147.70	.604
1971	93.39	294.20	.317	64.5	55.85	61.94	118.10	148.00	.581
1972	91.91	265.50	.346	59.2	65.90	73.12	130.10	158.70	.539
1973	87.00	264.20	.329	61.3	47.08	53.57	105.10	133.90	.600
1974	89.57	268.40	.334	61.4	55.31	62.06	115.70	144.90	.572
1953-1974									
Average	92.06	281.27	.328	62.0	54.42	60.97	116.87	146.11	.583
Std.Dev.	4.09	12.38	.013	2.0	5.58	5.83	6.48	6.36	.028
TMY	93.00	279.70	.333	62.9	52.30	58.50	115.20	144.60	.595

*See Table IV-2 for column heading explanations

TABLE IV-2

COLUMN HEADING EXPLANATIONS

QCOL	Useful Solar Energy Collected
HCOL	Amount of Solar Energy on Collector Surface
COL EFFIC	Collector Efficiency (QCOL/HCOL)
AVG. TANK TEMP	Average Tank Temperature per Year
SHAUX	Space Heating Auxiliary Energy
TOTAUX	SHAUX plus Domestic Heating Auxiliary Energy
SHLOAD	Space Heating Load
TOTLOAD	SHLOAD plus Water Heating Load
FRACTION BY SOLAR	1.-(TOTAUX/TOTLOAD)
GJ	Gigajoules
C	Celsius

FIGURE 1. Solar Radiation Data Rehabilitation Stations

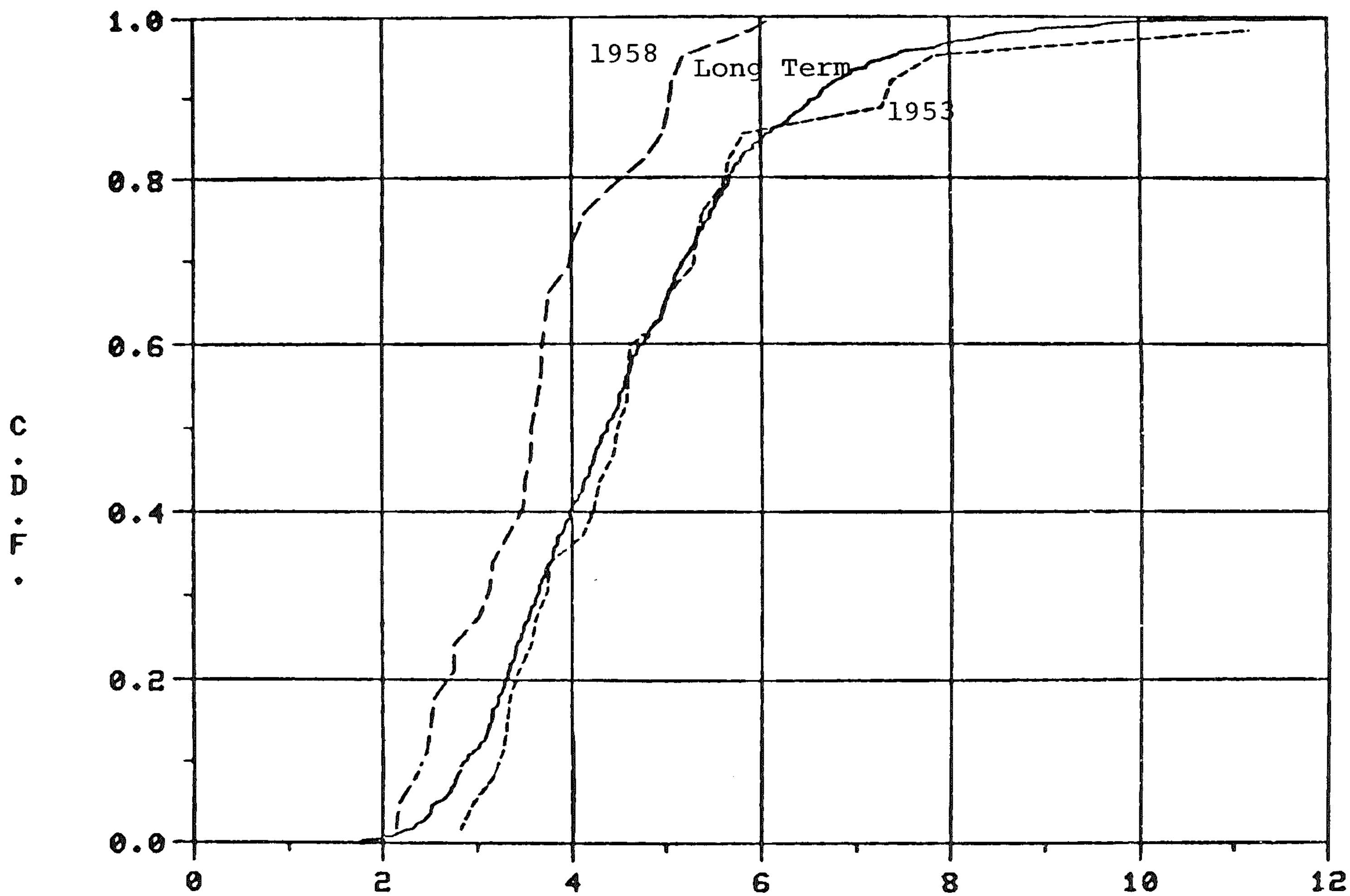

FIGURE 2. Cumulative Distribution Functions for Mean Daily Wind Velocity

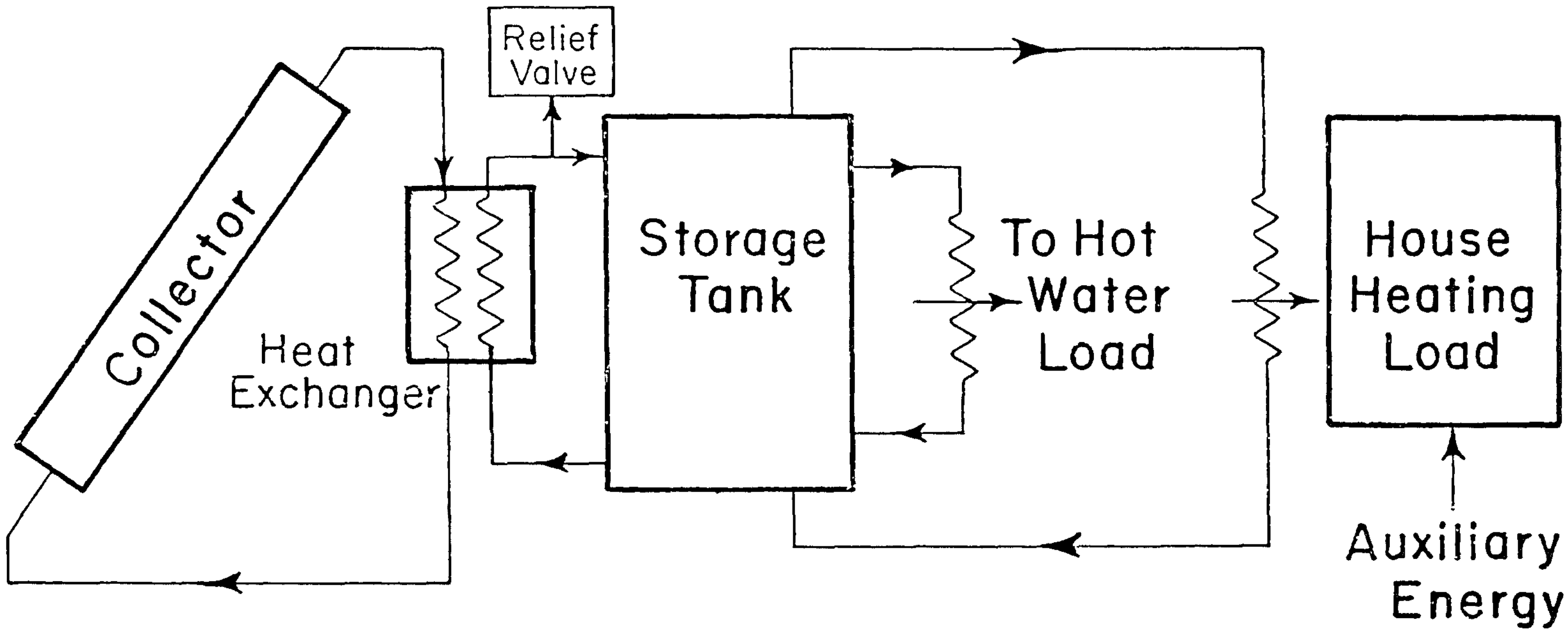

FIGURE 3. Solar Heating System Schematic

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APPENDIX A

INTRODUCTION

This Appendix describes in detail the enclosed microfiche reproductions of the computer output used in the determination of the Typical Meteorological Years, as well as the computer-generated empirical cumulative distribution functions of the nine principal indices used in the selection process.

The statistics described herein should be of value to researchers in subsequent validation studies, as a capsulation of historical weather data, and as an aid to determination of solar energy system requirements.

MICROFICHE DESCRIPTION

The microfiche package comprises 26 sets representing the 26 solar rehabilitation stations. Each set consists of three separate sections and a total of five fiche per set. The following detailed descriptions of the three sections apply to each of the sets, but actual data from Set 1 (Albuquerque) are used to illustrate the discussion.

Section I. Long Term and Yearly Statistics

This section contains twelve sets of tabular computer output, one set for each month, which provides summary information for each individual year and for the composite of all years. Three types of information are provided:

1. Summary information on the 13 indices: daily maximum, mean, minimum, and range for dry bulb temperature, dew point temperature, and wind velocity; and daily total global solar radiation. The summary statistics provided are the mean, median, and standard deviation of each of the 13 indices.

2. Finkelstein-Schafer (FS) statistics on the 13 indices and weighted sums of the 13 FS statistics. The FS statistic is a measure of the closeness of two distributions. An explanation of the FS statistic and the specific weighting used is given in the main body of this report.

3. The top five typical year candidates as selected by the FS statistic for solar and wind. The five years with the smallest values for FS were selected.

The first page of each set contains summary statistics of the indices over the composite of all years; solar and wind weighted FS statistics for each year; and five candidate years as selected by the FS criterion for solar and five for wind.

The remaining pages of each set give FS statistics, summary statistics, and absolute error from the composite for the mean and median for each of the individual years.

Some results from Station 23050 for January are included in order to illustrate the information provided. Note that the statistics computed for each of the indices are based on 31 daily values for January for each individual year and 713 values for the composite of all years.

In Table A-I, summary statistics on the 13 indices based on all 23 years data are provided. Also, the solar weighted and wind weighted sum of FS statistics are given for each year and the five candidate years for solar and wind are given. For example, the following information is available for daily maximum dry bulb temperature over all 23 years of January data.

a. Mean of 713 daily maximum temperatures is 7.5°C.
b. Median of 713 daily maximum temperature is 7.8°C.
c. Average of 23 standard deviations is 4.8°C.

The solar weighted FS statistic for 1953 is .155 and the top five January solar year candidates are 1958, 1960, 1970, 1955, and 1968.

In Table A-II, FS statistics, means, absolute error in means, medians, absolute error in medians, and standard deviations are given for each of the 13 indices for each of the individual years. (Table A-II shows only the first 6 of the 23 years represented). For example, for maximum daily dry bulb temperature for January 1953, the following information is available:

a. FS is .252
b. Mean of 31 daily maximum temperatures is 12.2°C.
c. Absolute deviation of the 1953 mean of daily maximums from mean of daily maximums over all 23 years is 4.6°C.
d. Median of 31 daily maximum temperatures is 12.8°C.
e. Absolute deviation of the 1953 median of daily maximums from median of daily maximums over all 23 years is 5.0°C.
f. Standard deviation of 31 daily maximum temperatures is 3.6°C.

Section II. Frequencies and Run Lengths

This section contains information on weather continuity, or persistence, as measured by run length and run frequency for daily mean dry bulb temperature and daily total global solar radiation in three tables per month. The first and second tables give year by year information on the number and length of runs (consecutive days) for daily mean dry bulb temperature. The first table gives the number of runs and run length (RL) for a given year which are greater than the 67th percentile of the long term distribution. The second table gives similar information on runs below the 33rd percentile. In these tables a run length of 10 includes lengths of 10 and greater. The first table gives information on the number of relatively "warm" days in a row and the second table on the number of relatively "cold" days in a row. The third table gives the number and run length of days where the daily total global solar radiation is less than the 33rd percentile of the long term distribution.

In order to understand more easily the information provided, results from Station 23050 for January are again used. Results are given in Table A-III for daily total solar radiation. For example, from Table A-III it is seen that for 1956 there were two runs of length 1, three runs of length 2, and one run of length 6 where the daily total global solar radiation was less than the 33rd percentile for the composite of 23 years. The tables also give the average number of runs per year and the average run length. For example, from Table A-III we find

$$\text{Ave. No. of runs/year} = \frac{127}{23} = 5.5$$

$$\text{Ave. Run Length} = [(1x75)+(2x29)+...+(10x1)]/127 = 1.9$$

Section III. Empirical Cumulative Distribution Functions

This section consists of nine graphs of the empirical cumulative distribution function (CDF) for each of the twelve months. The nine graphs are computed from the long term data for the nine indices: daily maximum, mean, and minimum for dry bulb and dew point temperature, daily maximum and mean wind velocity, and daily total global solar radiation.

Figure A1 is an example of an empirical CDF. Again, it is the CDF for Station 23050 for January. From this table one can determine, for example, that twenty percent of the January days have a daily total global solar radiation of less than 9500 kJ/m^2.

TABLE A-I

STATION 23050 JANUARY

DAILY LONG TERM STATISTICS

	DRY BULB				DEW POINT				WIND VELOCITY				RADIATION
	MAX	MIN	MEAN	RANGE	MAX	MIN	MEAN	RANGE	MAX	MIN	MEAN	RANGE	DAILY TOTAL
MEAN	7.5	-4.3	1.2	11.9	-5.3	-10.9	-8.1	5.6	6.4	1.1	3.4	5.3	11537.
MEDIAN	7.8	-3.9	1.7	12.2	-5.0	-10.0	-7.7	5.0	5.7	1.0	3.0	4.7	12422.
AVE. STD. DEV.	4.8	4.1	4.0	3.3	4.4	4.8	4.4	2.9	2.6	.9	1.4	2.4	2891.

SUMMARY OF SUM OF F - S STATISTICS FOR YEARS 1953 - 1964

	53	54	55	56	57	58	59	60	61	62	63	64
SOLAR WEIGHTED SUM	.135	.061	.056	.127	.136	.054	.068	.054	.096	.065	.086	.134
WIND WEIGHTED SUM	.107	.101	.057	.053	.040	.045	.050	.103	.115	.045	.043	.068

SUMMARY OF SUM OF F - S STATISTICS FOR YEARS 1965 - 1975

	65	66	67	68	69	70	71	72	73	74	75
SOLAR WEIGHTED SUM	.108	.123	.104	.057	.105	.055	.095	.079	.086	.065	.118
WIND WEIGHTED SUM	.125	.126	.064	.079	.070	.082	.086	.073	.095	.050	.293

YEARS ORDERED BY F - S STATISTICS

FIRST FIVE YEARS (SOLAR) 58 60 70 55 68

FIRST FIVE YEARS (WIND) 57 63 62 58 59

TABLE A-II

YEARLY STATISTICS FOR JANUARY

	DRY BULB				DEW POINT				WIND VELOCITY				RADIATION
	MAX	MIN	MEAN	RANGE	MAX	MIN	MEAN	RANGE	MAX	MIN	MEAN	RANGE	DAILY TOTAL
1953													
F - S	.252	.248	.275	.088	.131	.086	.115	.044	.125	.125	.088	.116	.109
MEAN	12.2	-.5	5.2	12.7	-3.3	-9.2	-6.3	6.0	8.2	1.5	3.9	6.7	12712.
ABS. ERROR	4.6	3.8	4.0	.8	2.1	1.7	1.8	.4	1.0	.4	.5	1.4	1176.
MEDIAN	12.8	0.0	6.0	13.4	-2.8	-9.4	-6.9	4.5	8.8	1.5	3.5	7.3	12805.
ABS. ERROR	5.0	3.9	4.2	1.2	2.2	.6	.9	.5	3.1	.5	.5	2.6	383.
STD. DEV.	3.6	2.6	2.9	2.9	3.4	5.2	3.8	3.7	3.4	.9	1.8	3.1	2086.
1954													
F - S	.121	.082	.115	.057	.107	.089	.112	.113	.067	.178	.134	.035	.016
MEAN	10.0	-2.5	3.1	12.5	-3.3	-9.3	-6.5	6.0	6.3	1.0	2.9	5.3	11551.
ABS. ERROR	2.5	1.9	1.9	.6	2.0	1.6	1.6	.4	.1	.1	.5	.0	15.
MEDIAN	10.6	-3.3	2.8	13.3	-3.9	-8.3	-6.2	5.6	5.1	1.0	2.5	4.6	12407.
ABS. ERROR	2.8	.6	1.1	1.1	1.1	1.7	1.5	.6	.6	0.0	.5	.1	15.
STD. DEV.	4.1	3.3	3.3	3.2	3.1	3.5	3.4	1.7	2.4	.5	1.3	2.3	3037.
1955													
F - S	.108	.085	.096	.088	.041	.058	.042	.067	.053	.126	.061	.050	.045
MEAN	6.5	-4.5	.7	11.0	-4.4	-10.4	-7.3	5.9	7.1	1.2	3.4	5.9	11257.
ABS. ERROR	1.0	.2	.5	.8	.9	.6	.8	.3	.7	.1	.0	.6	279.
MEDIAN	7.2	-4.4	.8	10.6	-5.6	-10.6	-8.1	5.0	6.7	1.5	3.3	5.1	12280.
ABS. ERROR	.6	.5	1.0	1.6	.6	.6	.4	.0	1.0	.5	.3	.4	142.
STD. DEV.	3.5	3.2	2.9	3.2	4.7	4.3	4.5	2.4	2.9	.6	1.1	2.9	3328.
1956													
F - S	.186	.213	.255	.059	.122	.062	.112	.104	.046	.251	.060	.047	.127
MEAN	11.0	-.8	4.7	11.8	-2.7	-9.1	-6.0	6.3	6.3	.7	3.1	5.6	10437.
ABS. ERROR	3.5	3.5	3.5	.0	2.6	1.9	2.1	.8	.1	.4	.3	.3	1100.
MEDIAN	12.2	-.6	4.6	12.7	-2.2	-10.0	-6.2	6.1	5.7	0.0	2.8	5.1	11884.
ABS. ERROR	4.4	3.3	2.9	.5	2.8	0.0	1.6	1.1	0.0	1.0	.3	.4	538.
STD. DEV.	3.6	3.2	2.5	4.3	4.4	4.3	4.2	2.7	2.6	1.0	1.2	2.1	3208.
1957													
F - S	.086	.232	.187	.210	.172	.146	.182	.037	.030	.272	.049	.071	.144
MEAN	9.3	-.4	4.2	9.7	-1.8	-7.4	-4.6	5.6	6.4	.6	3.2	5.8	9854.
ABS. ERROR	1.8	3.9	3.0	2.1	3.5	3.5	3.5	.0	.0	.5	.2	.5	1683.
MEDIAN	9.4	-.6	3.9	9.4	-1.1	-8.9	-5.8	5.0	6.2	0.0	2.9	5.7	11070.
ABS. ERROR	1.6	3.3	2.2	2.8	3.9	1.1	2.0	.0	.5	1.0	.1	1.0	1352.
STD. DEV.	3.4	3.7	3.2	2.4	4.4	4.5	4.5	2.4	2.5	.9	1.5	2.1	3810.
1958													
F - S	.075	.040	.100	.054	.063	.071	.060	.107	.044	.363	.047	.108	.045
MEAN	7.4	-3.7	1.4	11.1	-4.2	-10.5	-7.2	6.3	6.7	.4	3.2	6.3	11116.
ABS. ERROR	.1	.6	.2	.7	1.1	.4	.9	.7	.2	.8	.2	1.0	420.
MEDIAN	7.8	-3.9	2.0	11.7	-4.4	-10.6	-7.8	6.1	6.7	0.0	2.9	6.2	12288.
ABS. ERROR	0.0	0.0	.3	.5	.5	.6	.0	1.1	1.0	1.0	.2	1.5	134.
STD. DEV.	3.7	3.3	2.7	3.9	3.0	3.5	2.9	2.6	2.6	.7	1.3	2.4	3174.

STATION 23050 JANUARY

SOLAR RAD.<=33 PERCENTILE

R.L.	YEAR 53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	
1	3	6	4	2	1	3	5	2	4	3	1	6	2	3	4	4	3	6	1	3	4	2	3	75
2	1	2	0	3	0	0	1	1	0	4	1	0	2	0	1	1	1	2	0	1	3	4	1	29
3	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	2	0	1	0	1	0	1	8
4	0	0	2	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	6
5	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	6
6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	4	8	6	6	4	5	6	4	5	8	3	6	5	4	5	6	7	8	2	4	8	7	6	127

AVE. NO. OF RUNS/YEAR 5.5

AVE. RUN LENGTH 1.9

TABLE A-III

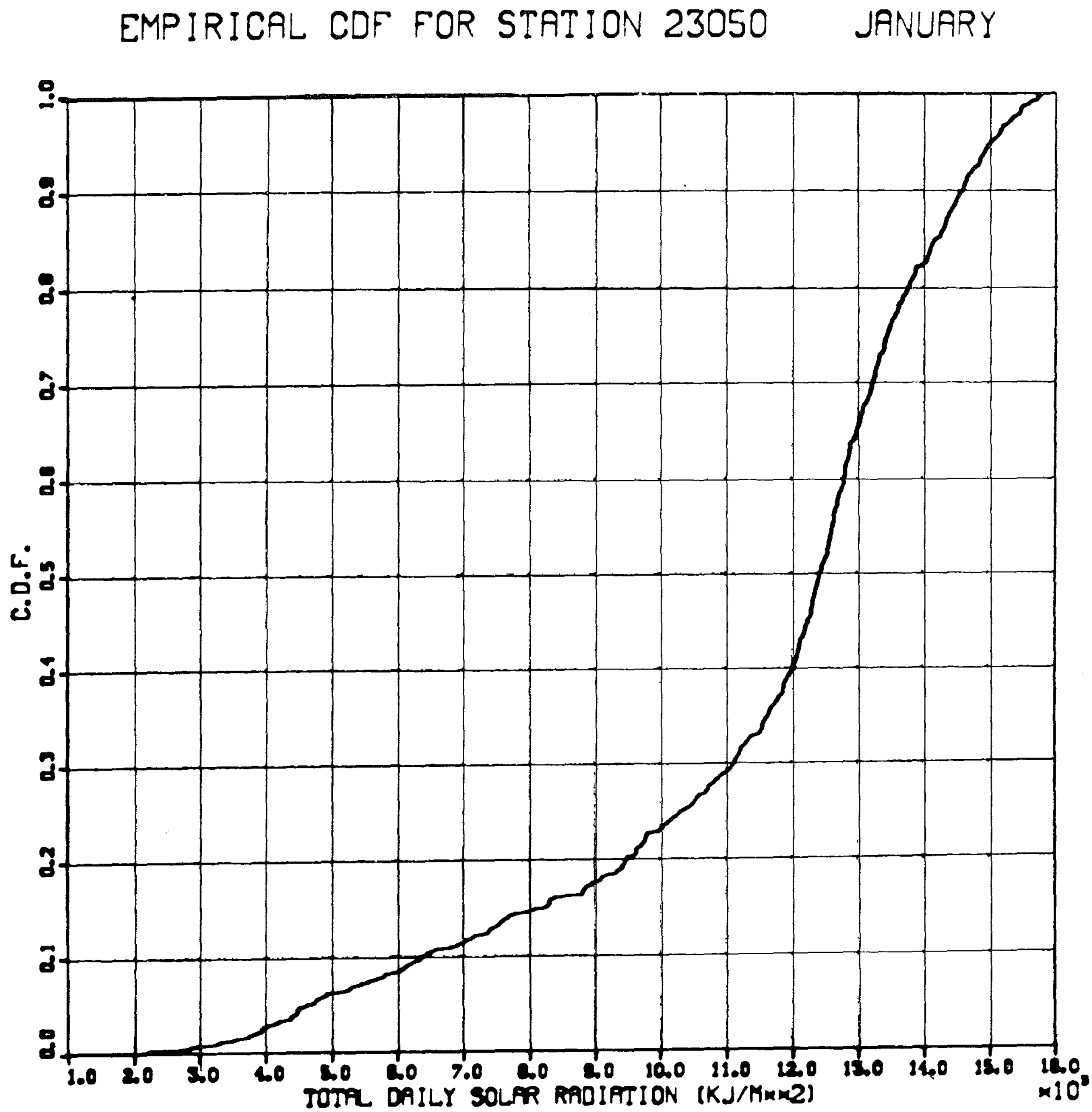

FIGURE A-1

USCOMM - NOAA - ASHEVILLE, N.C. 7/81/200