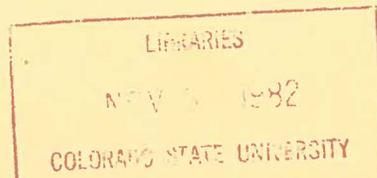


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COLORADO
SOLAR RADIATION DATA
With Supplemental Climatic Data

NOLAN J. DOESKEN
THOMAS B. McKEE
DAVID M. EBEL



Climatology Report No. 82-2

DEPARTMENT OF ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO

COLORADO SOLAR RADIATION DATA
With Supplemental Climatic Data

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I. INTRODUCTION

In 1979 the Colorado Climate Center, in conjunction with the Colorado Office of Energy Conservation and the Western Solar Utilization Network, published a solar radiation and climatic data manual entitled Colorado Solar Radiation Data (Doesken et al., 1979). High quality measured solar radiation data from several Colorado locations collected by several sources, federal, state, and private, were published along with other summarized climatic data such as wind, temperature, and heating degree days. Many copies of this report have been distributed, and user response has been favorable.

The 1979 report had several weaknesses. The most serious weakness was the small amount of solar data available at that time. Several stations had a total of only one or two years of solar measurements. Another problem was the lack of data in mountain and foothill locations. A new effort to locate high quality, long duration, solar data in mountainous areas turned up very few additional stations. However, where data have been collected we now have 4 or more years of continuous solar observations. This gives a much better solar climatology for the state.

Some sections of our previous report are not repeated here. For example, the general description of solar radiation processes and measurements is omitted. Many textbooks are available which treat those subjects in great detail.

Some new information has been added. For example, outdoor relative humidity data appear in the climatic data tables at stations where the data were available. Also, more analyses are shown describing various characteristics of the solar radiation climate of Colorado.

This publication should not be considered the ultimate source of climate information in addition to solar data. Many summaries and data sets exist, especially pertaining to temperature and precipitation data, which are not mentioned here. Contact the Colorado Climate Center for more information.

It is also important to remember that most of the raw data, both of solar measurements and other climatic data, are maintained in computerized forms. If existing summaries do not meet your specific needs, the raw daily (and in some cases hourly) data are available.

Finally, we reiterate that solar information summarized in this report is entirely based on actual measured data. We want to clarify this point since much of the widely used and currently available information is derived from the SOLMET data set (U.S. Department of Commerce, 1978 and 1979). The SOLMET solar data were frequently derived from observed cloud cover data using regression model estimates. This information is summarized for the entire United States in a recent publication of the Solar Energy Research Institute (SERI, 1981).

II. LOCATION OF COLORADO SITES

Solar radiation measurements in Colorado are being taken by several interested groups including the federal government, universities, utilities, and private industry. Measurements taken by these various groups are not coordinated, and the data are being used for several different purposes. There are no universal standards for the collection of solar radiation, and consequently a variety of instruments are in use, different maintenance and calibration procedures are employed, and the data appear in several formats. These inconsistencies, especially when it is impossible to verify the accuracy of a given data set, present serious problems to users of the data. To minimize the effects of the various inconsistencies, this report presents data from only those locations which meet the following requirements:

- 1) Data collected with an instrument of similar quality to those used in the National Solar Radiation Network (Flowers, 1979).
- 2) A routine maintenance and calibration schedule is maintained.
- 3) Data pass data quality control standards established by the Colorado Climate Center.

Eight sites in Colorado satisfy the above requirements at this time. Two additional sites, Akron and Center, do not meet the instrument quality requirement, but they have long data records and the data quality is adequate. The Golden site does not meet the instrument requirement, but is rigorously monitored and calibrated. The Buena Vista site also fails to meet the instrument quality requirement, but the instrument was calibrated, the data look good, and the site is a good one in close proximity to high mountains. Three stations outside of Colorado: Albuquerque, New Mexico, Cheyenne, Wyoming, and Dodge City, Kansas, were

added to show variations across the state line. Table 1 lists the selected stations, and their locations are shown on Figure 1. Earlier solar data from Boulder, Grand Junction, and Grand Lake have been summarized by the U.S. Department of Commerce (1968). These earlier observations, which were frequently used and referenced prior to the completion of the SOLMET data set, fail to meet all of the requirements put forth in this manual, and the data quality is still in doubt.

Climatic data are included for 4 stations with no solar radiation data. This was done to present at least a limited climatic description for areas that were otherwise not represented but which are likely to have an interest and need for solar radiation and other climatic information. The stations Colorado Springs, Durango, Eagle, and La Junta, were chosen because relatively detailed climatic summaries including wind data are available for those stations.

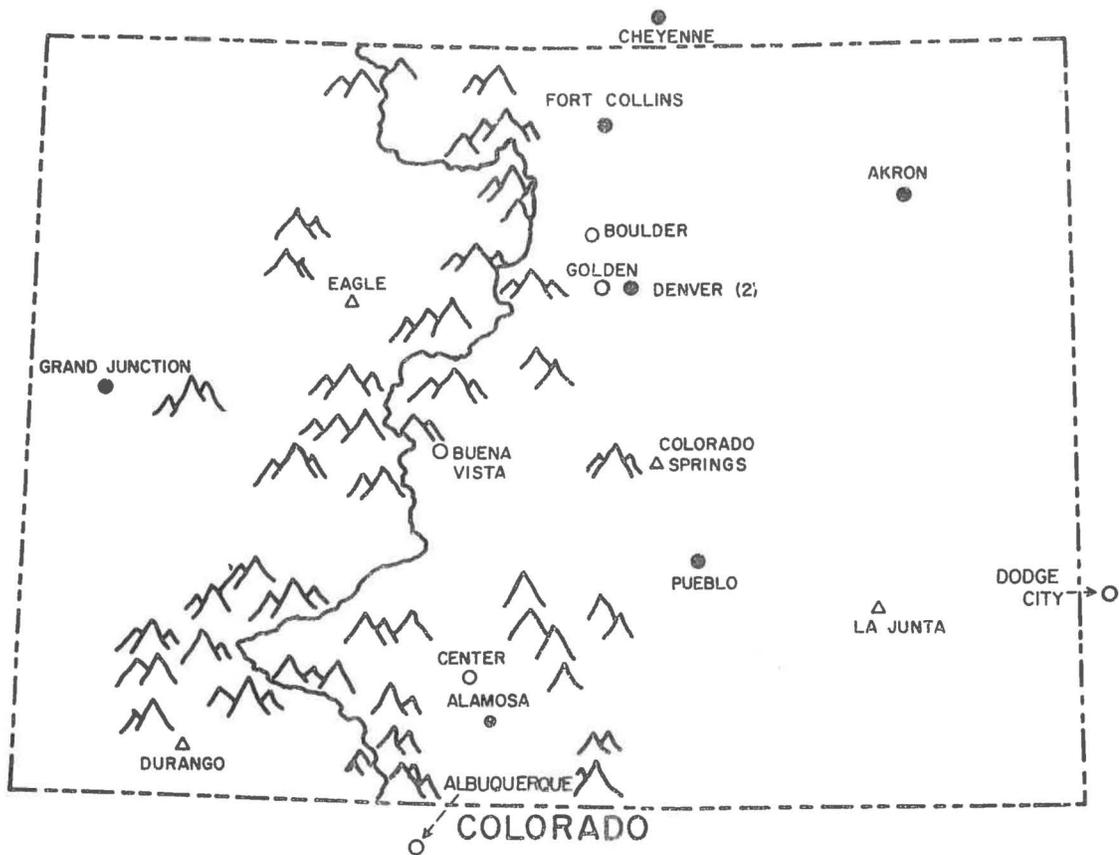
Table 1.

Stations and Data Contained in this Report*

	LATITUDE		LONGITUDE		ELEVATION	Observed Hemi - spheric Radiation	Calculated Tilted Surface Radiation	General Climatic Information	Wind Summary
	(DEG	MIN)	(DEG	MIN)	(FEET)				
Akron	40	9	103	9	4540	X	X	X	X
Alamosa	37	29	105	52	7560	X	X	X	X
Albuquerque (New Mexico)	35	2	106	37	5311	X	X	X	
Boulder	40	1	105	15	5360	X	X	X	
Buena Vista	38	51	106	8	7950	X	X	X	
Center	37	44	106	8	7683	X	X	X	
Cheyenne (Wyoming)	41	8	104	49	6155	X	X	X	X
Colorado Springs	38	49	104	43	6145			X	X
Denver 1	39	39	104	51	5340	X	X	X	X
Denver 2	39	45	104	54	5330	X	X	X	X
Dodge City (Kansas)	37	46	99	58	2582	X	X	X	
Durango	37	17	107	53	6550			X	X
Eagle	39	39	106	55	6497			X	X
Fort Collins	40	35	105	8	5279	X	X	X	X
Golden	39	44	105	9	5705	X	X	X	
Grand Junction	39	7	108	32	4833	X	X	X	X
La Junta	38	3	103	31	4196			X	X
Pueblo	38	16	104	37	4860	X	X	X	X

* Additional data for these stations may exist which are not contained in this report.

FIGURE I. STATION LOCATIONS



- △ CLIMATIC DATA AND WIND SUMMARY
- HEMISPHERIC SOLAR RADIATION, LIMITED CLIMATIC DATA
- HEMISPHERIC SOLAR RADIATION, CLIMATIC DATA INCLUDING WIND SUMMARY

III. SOLAR RADIATION AND CLIMATIC DATA

Hemispheric Radiation and Climatic Data

The following pages contain detailed summaries of hemispheric solar radiation and other climatic data at 11 locations in Colorado, one site in Wyoming, one in Kansas, and one in New Mexico. Information for each location is presented according to the following format.

1. Introductory page
 - station name
 - climatic description
 - discussion of quantity and quality of solar data
2. Summary table
 - station and location
 - data description
 - observed hemispheric data
 - ratio of hemispheric to extraterrestrial radiation
 - calculated tilted surface radiation
 - available climatic data (temperature, degree days, precipitation, etc.)
3. Wind summary (if available)
 - data description
 - seasonal wind characteristics
 - annual wind rose

The summary tables are the most important and most useful portion of this manual. Basic station information, average solar radiation information, and averages of other climatic variables are all combined in a single table for each station. The tables should be self-explanatory,

but there are several items the reader should be aware of when using the data:

- 1) The elevation, latitude, and longitude given at the top of the table are for the radiation measurement sites except for those sites without solar data. The other climatic data may or may not have been collected at the same site. The closest source of additional climatic data was generally chosen. If the location was significantly different from the solar site, special comment is made in the data description section above the data tables.
- 2) Observed solar radiation averages (total solar irradiance on an upward-facing horizontal surface) are average daily values. They are displayed in megajoules per square meter (MJ/SQM) and in BTU's per square foot (BTU/SQFT) on a per day basis. Other units may be obtained by applying appropriate conversion factors shown in Appendix A.
- 3) Averages are calculated and displayed regardless of how much or how little data was available. The period of record is indicated in the far right-hand column. For example, the number 4 means that the averages were based on approximately four years of data. When averages at different stations are based on different periods of record it may not be wise to make comparisons. More specific information on available and missing radiation data are contained in the monthly data table in Appendix B.
- 4) The ratio of observed average hemispheric radiation to calculated extraterrestrial radiation (ETR -- solar radiation

available at the top of the atmosphere on a surface parallel to the earth's surface) indicates how much of the radiation arriving at the top of the atmosphere penetrates to the earth's surface. A value of 0.61 indicates that an average of 61% of the ETR is reaching the surface for that month.

- 5) Radiation on tilted surfaces are calculated and displayed in the units of MJ/SQM also on a per day basis. The calculated values were obtained from the observed hemispheric data by a method explained in Appendix C. The calculation was made for a south-facing surface, and a reflectivity for the surroundings was assumed to be 0.2, a typical value for grassy surfaces. Values of tilted surface radiation are strongly affected by the reflectivity of the surroundings. Appendix C in the previous solar radiation report (Doesken et al., 1979) shows how the radiation differs for varying reflectivities. Radiation values were calculated for four commonly used tilted surfaces. Figure 2 shows an example of the orientation of these tilted surfaces for a station at a latitude of 39° North.
- 6) The remaining portion of the table contains climatic averages. Temperature, precipitation, and degree day (base 65° F) information are shown for each station. Heating degree days to other bases, cloud cover, possible sunshine, wind, relative humidity, and barometric pressure averages are also shown for a limited number of stations. The averages may be based on different periods of record. The number of years of record appear in the right-hand column after each variable, and the actual years that were averaged are listed in the heading

information above the table. Specific month by month climatic data corresponding to the available radiation data are displayed in Appendix B.

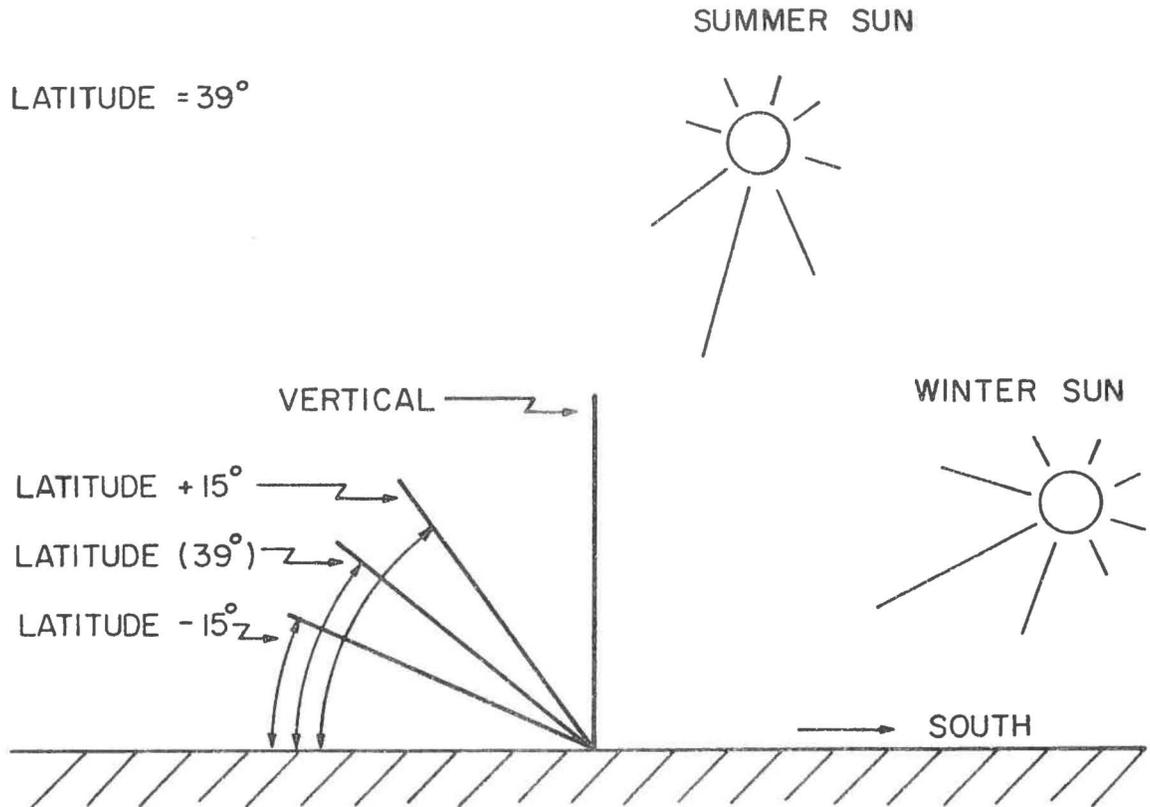


Figure 2. Tilt angles for tilted surfaces.

Following the summary tables, general descriptions of the wind characteristics near each site are presented for the locations where summarized wind data are available. The diagram at the bottom of each wind summary page is an annual wind rose. These wind roses are used to display the average percentage of winds coming from each of the principal compass directions in each of several wind speed categories.

The annual wind rose for Denver Stapleton International Airport appears in Figure 3 on the next page as an example. The features of the

wind rose are 1) the concentric circles which are scaled to represent percentages, and 2) the telescoping bars radiating outward from the center of the diagram in 8 compass directions. The total length of each telescoping bar is related to the percentage frequency that the wind blows from that direction. The sum of the lengths of all 8 bars, plus the percentage of calm winds (upper right-hand corner of the wind rose), equals 100%.

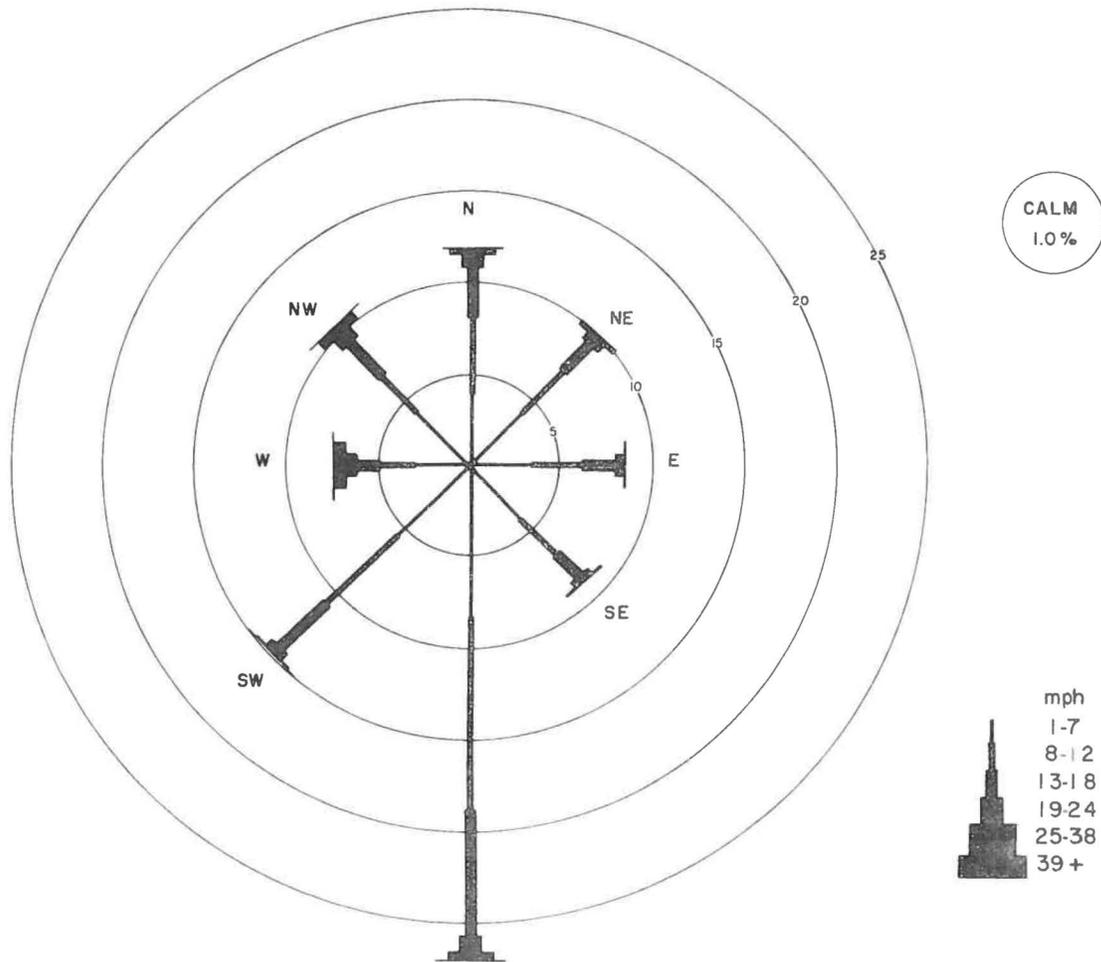


Figure 3. Denver Annual Wind Rose

From the Denver wind rose it is apparent that South (wind blowing from the south toward the north) is the most common wind direction.

The total length of the bar shows that south winds occur nearly 27% of the time. Winds blow least frequently from the west, only about 7.5% of the time.

Wind speeds are divided into several categories shown in the lower right-hand corner of the figure. Low wind speeds are represented by thin lines. Higher speeds are indicated by wider bars. The length of each segment is related to the percentage of winds in that speed category. For example, at Denver winds from the south at speeds between 1 and 7 mph (the thinnest line) occur about 8% of the time, and southerly winds at speeds from 8 to 12 mph (the next thicker line) occur 10% of the time. Winds greater than 18 mph from the south occur only about 1.3% of the time.

The annual wind rose displays both wind speed and direction information on a single diagram. However, since it is a composite of all observations taken over a several year period, it does not specifically show seasonal and diurnal wind characteristics. Therefore, a very general description of those characteristics are given above each wind rose for sites where more specific information is available.

AKRON

CLIMATE

Akron is located in the dryland wheat-growing area on the plains of northeastern Colorado. The climate is characterized by low relative humidity, moderate and persistent winds, large temperature variations, and light precipitation. The average monthly temperature varies from 26° F in January to 74° in July. The diurnal temperature range (difference between the daily maximum and minimum temperatures) is large and often exceeds 30 degrees. The average annual precipitation is about 16 inches, much of which is produced by heavy and sometimes severe thunderstorms which occur most frequently in May, June, and July. Winter precipitation is scarce, but ferocious blizzards occasionally sweep across the area. Winter snowfall averages about 40 inches with March typically being the snowiest month.

DESCRIPTION OF SOLAR RADIATION DATA

Collection of solar radiation data began in 1971 at the U.S. Department of Agriculture Central Great Plains Research Station (4 miles east of Akron) in support of agricultural research activities. The data set is continuous for 10 years with almost no missing data. The instrument, a Kipp and Zonen solarimeter, is checked and read daily. The instrument does not undergo frequent calibration, but side-by-side tests with a more sensitive Eppley instrument have shown it to be quite accurate. Examination of the data indicated a distinct calibration shift upward of about 5% in early 1979 when a new sensor was installed.

AKRON

ELEVATION 4540 FEET MSL LATITUDE 40 DEG 9 MIN LONGITUDE 103 DEG 9 MIN

SOURCE OF SOLAR RADIATION DATA -- U.S. DEPARTMENT OF AGRICULTURE, CENTRAL GREAT PLAINS FIELD STATION.

INSTRUMENTATION -- KIPP AND ZONEN SOLARIMETER (SWITCHED TO DIFFERENT SENSOR OF THE SAME MODEL MARCH 29, 1979)

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, JANUARY 1971-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT THE AKRON AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA.

SOLAR RADIATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD
*****														(YEARS)
HEMISPHERIC (MJ/SQM DAY)	9.23	12.40	15.83	19.57	22.10	24.90	23.77	20.97	18.01	14.03	9.47	8.08	16.53	10
HEMISPHERIC (BTU/SQFT DAY)	813	1093	1394	1723	1947	2194	2094	1847	1586	1236	834	711	1456	10
(HEMISPHERIC / ETR) RATIO	.60	.60	.56	.56	.55	.59	.58	.57	.59	.61	.57	.59	.58	
COMPUTED TILTED SURFACES														
(MJ/SQM DAY)														
LATITUDE - 15 DEG.	15.12	17.46	19.07	20.69	21.52	23.34	22.59	21.24	20.43	18.53	14.48	13.72		
LATITUDE	17.53	19.22	19.68	20.00	19.91	21.12	20.60	20.06	20.45	19.88	16.43	16.08		
LATITUDE + 15 DEG.	18.90	19.89	19.23	18.32	17.45	18.07	17.78	17.94	19.39	20.11	17.43	17.49		
VERTICAL	17.71	17.09	14.41	11.44	9.61	9.25	9.33	10.42	13.29	16.38	15.82	16.66		
CLIMATE														

EXTREME MAXIMUM TEMP. (DEG F)	71.0	77.0	85.0	87.0	93.0	105.0	105.0	102.0	99.0	91.0	76.0	73.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	38.1	43.4	48.8	60.1	70.1	81.7	88.2	86.2	77.3	65.7	49.3	41.3		30
MEAN TEMP.	25.6	30.5	35.5	46.1	56.4	67.0	73.5	71.5	62.2	50.8	36.2	28.8	48.7	30
AVERAGE MINIMUM TEMP. (DEG F)	13.0	17.5	22.2	32.1	42.6	52.3	58.7	56.7	47.2	35.9	23.2	16.1		30
EXTREME MINIMUM TEMP. (DEG F)	-28.0	-29.0	-20.0	-3.0	19.0	28.0	38.0	40.0	27.0	7.0	-11.0	-20.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1203	983	942	558	286	93	0	6	143	446	846	1119	6625	30
COOLING(65 DEG. BASE)	0	0	0	0	15	123	258	217	56	9	0	0	678	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	.33	.30	.93	1.27	3.08	2.44	2.75	1.79	1.03	.78	.59	.37	15.66	30
	5.6	4.6	9.5	4.3	.9	0.0	0.0	0.0	.5	3.2	6.0	5.3	39.9	30

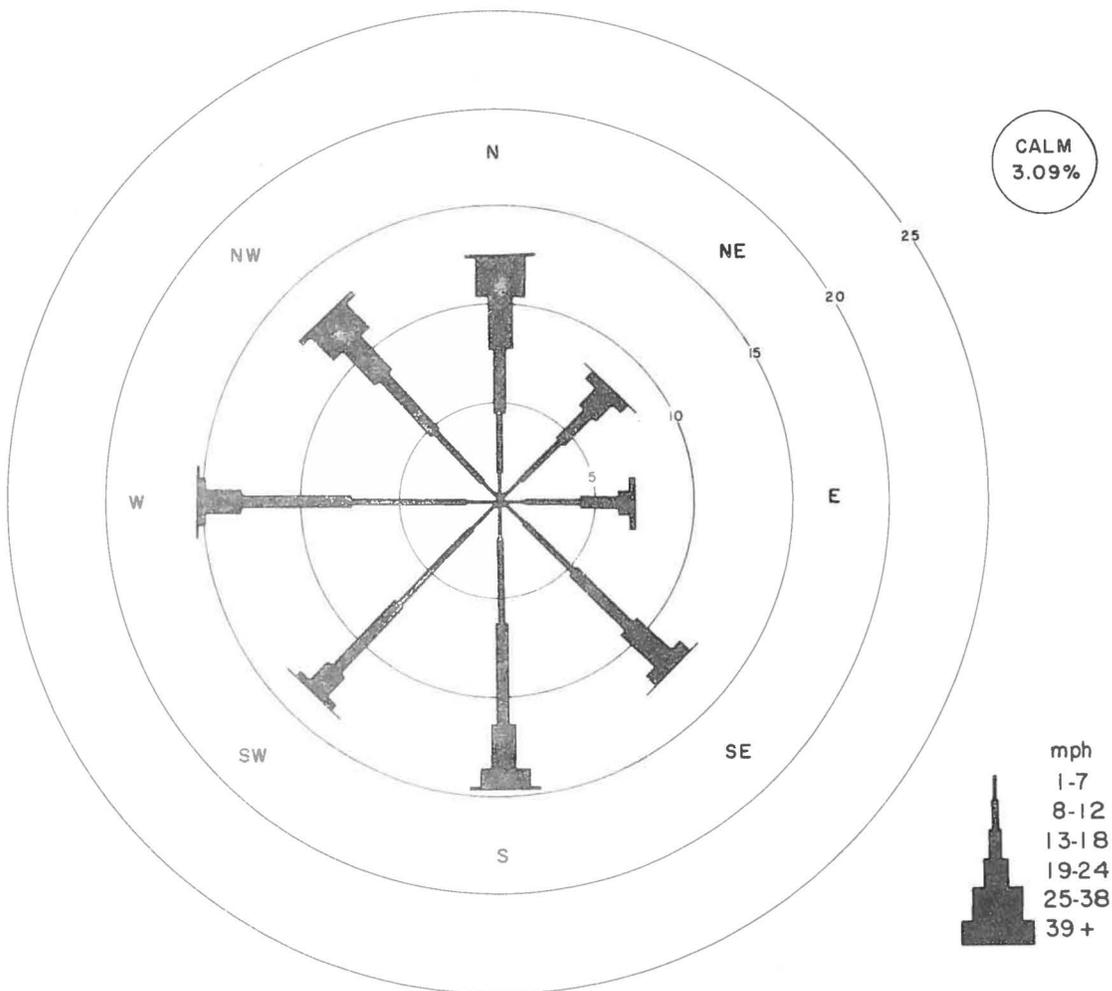
AKRON, COLORADO - - WIND SUMMARY

Summary period: November 1949 - October 1954. Summary based on 43,758 hourly observations, 24 observations per day.

Location: Akron Airport (located about 5 miles SE of town at that time).
Ground elevation 4582 feet.

Anemometer height: 27 feet 11/49 - 1/50
(above ground) 30 feet 2/50 - 10/54

Seasonal variations: Akron, on the Eastern Plains of Colorado, experiences brisk winds much of the time. Early spring is the windiest period of year and wind speeds taper off to a minimum in late summer and fall. The prevailing wind direction in winter is from the WSW although the strongest winter winds are from the NW. The prevailing wind direction in summer is from the SSE.



Annual Wind Rose

ALAMOSA

CLIMATE

Alamosa is located on the Rio Grande River near the center of the broad, flat San Luis Valley. The climate is characterized by abundant sunshine, low relative humidity, light to moderate winds, large day to night temperature variations, and very light precipitation. The average monthly temperature varies from 16° F in January to 65° in July. Winters are very cold, and temperatures drop to 0° F or colder an average of about 50 nights per year. Summer temperatures are pleasant, and daytime temperatures rarely exceed 90°. Precipitation is very light averaging only about 7 inches annually. Light summer thunderstorms, which move in from the surrounding mountains, account for much of the precipitation. Winter snowfall is quite light (38 inches per year on the average), but because of the cold temperatures it often remains on the ground for many weeks.

DESCRIPTION OF SOLAR RADIATION DATA

The Public Service Company of Colorado established a solar radiation measurement site in Alamosa early in 1977. It is a part of an extensive network in the Southwest established for the purpose of supplying solar radiation data to public utilities who use the information for heating load calculations and for design and evaluation of solar energy projects. A Spectrolab SR-75 pyranometer is used to measure hemispheric radiation. A regular maintenance schedule is employed and thorough calibrations have been scheduled at 6-month intervals (Yinger, 1978). The overall data quality appears to be good at this site. However, there seemed to be some sort of upward calibration shift which occurred during 1978. Data since then seemed to be as much as 5% too high.

ALAMOSA

ELEVATION 7560 FEET MSL LATITUDE 37 DEG 29 MIN LONGITUDE 105 DEG 52 MIN

SOURCE OF SOLAR RADIATION DATA -- PUBLIC SERVICE COMPANY OF COLORADO

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, MAY 1977-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT THE ALAMOSA MUNICIPAL AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN WIND SPEEDS OBTAINED FROM HOURLY OBSERVATIONS, 1948-1972. MEAN CLOUD COVER BASED ON 1948-1980 DATA. AVERAGE STATION PRESSURE AT ELEVATION OF 7541 FEET BASED ON 1973-1977 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1946-1980 DATA.

SOLAR RADIATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)

HEMISPHERIC (MJ/SQM DAY)	11.09	15.31	20.99	23.38	25.25	28.69	27.00	23.57	21.23	16.93	12.28	10.23	19.66	4
HEMISPHERIC (BTU/SQFT DAY)	977	1349	1849	2059	2225	2527	2378	2076	1870	1491	1081	901	1731	4
(HEMISPHERIC / ETR) RATIO	.65	.69	.72	.65	.63	.68	.66	.63	.68	.69	.67	.66	.67	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	17.12	20.99	25.30	24.62	24.56	26.87	25.64	23.77	23.83	21.82	18.17	16.46		
LATITUDE	19.95	23.32	26.42	23.86	22.70	24.22	23.33	22.46	23.96	23.58	20.84	19.46		
LATITUDE + 15 DEG.	21.60	24.29	26.03	21.89	19.83	20.57	20.03	20.09	22.78	23.98	22.27	21.29		
VERTICAL	20.02	20.55	18.86	12.71	9.91	9.25	9.39	10.78	14.84	19.08	20.06	20.16		
CLIMATE														

EXTREME MAXIMUM TEMP. (DEG F)	62.0	64.0	73.0	75.0	85.0	91.0	93.0	90.0	87.0	81.0	71.0	61.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	34.5	40.2	48.1	57.9	67.7	78.2	82.0	79.4	73.8	62.9	47.2	36.4		30
MEAN TEMP.	16.3	22.8	31.6	40.8	50.5	59.8	65.0	62.5	55.0	43.8	29.3	18.2	41.3	30
AVERAGE MINIMUM TEMP. (DEG F)	-2.0	5.4	15.0	23.6	33.2	41.4	48.0	45.6	36.1	24.6	11.5	-2		30
EXTREME MINIMUM TEMP. (DEG F)	-41.0	-30.0	-20.0	-6.0	11.0	25.0	34.0	29.0	17.0	-2.0	-30.0	-42.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1482	1182	1054	714	440	171	55	96	294	648	1053	1420	8609	30
HEATING(60 DEG. BASE)	1327	1042	899	564	289	67	7	21	152	493	903	1265	7029	30
HEATING(55 DEG. BASE)	1172	902	744	414	153	12	0	0	52	342	753	1110	5654	30
COOLING(65 DEG. BASE)	0	0	0	0	0	9	55	24	0	0	0	0	88	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	4.6	4.6	6.5	4.7	2.2	0.0	0.0	0.0	.4	3.9	4.4	6.2	37.5	30
MEAN CLOUD COVER (PERCENT)	47	49	51	51	53	39	51	48	38	37	42	44	45	33
AVERAGE WIND SPEED (MPH)	5.9	6.7	9.2	10.3	9.8	9.0	6.8	6.3	6.7	6.4	5.7	5.4	7.4	25
AVERAGE STATION PRESSURE (MB)	770.2	770.4	765.7	768.5	770.5	773.9	777.0	777.0	775.4	774.2	771.6	771.0	772.1	5
AVG. REL. HUMID. (PERCENT) 5AM	78	78	74	71	73	75	84	85	81	76	78	77		35
AVG. REL. HUMID. (PERCENT) 5PM	59	50	37	30	28	25	36	38	33	34	48	58		35

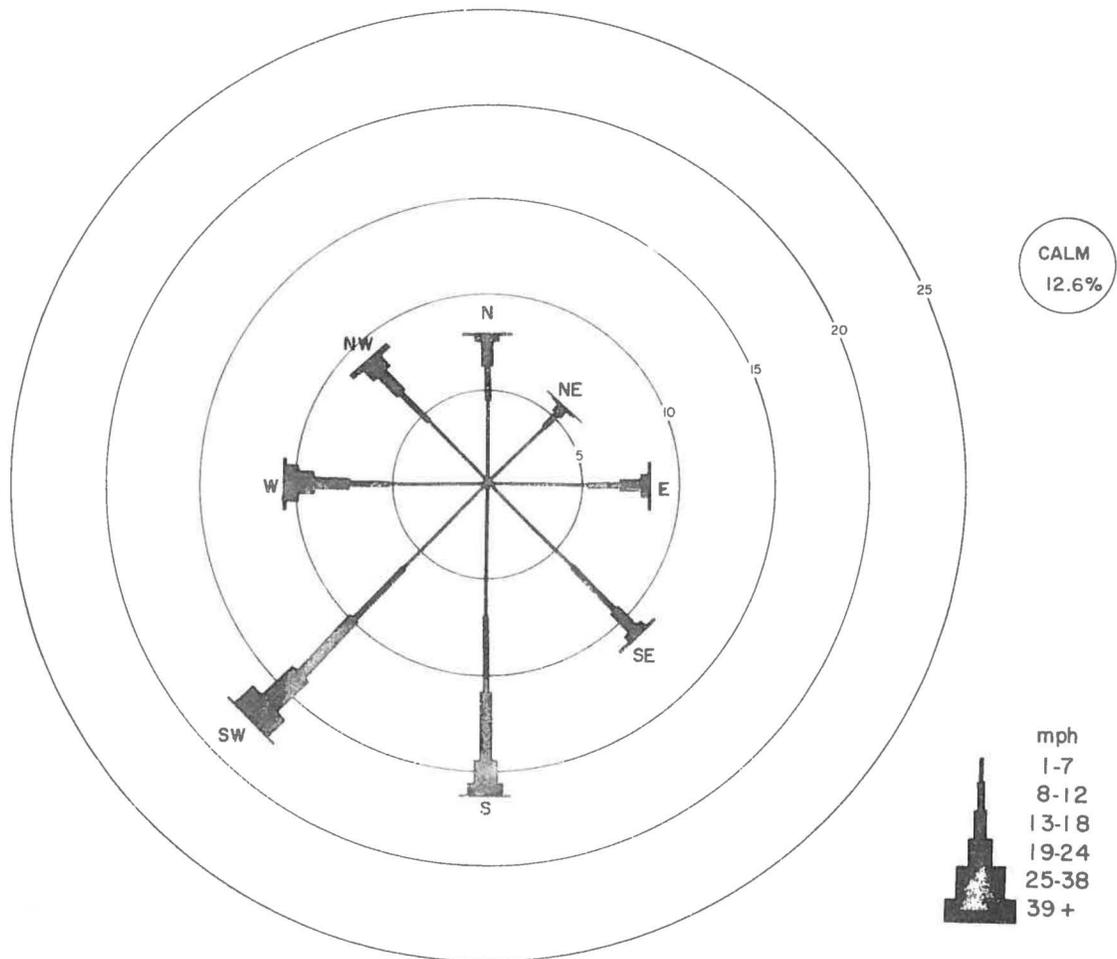
ALAMOSA, COLORADO - - WIND SUMMARY

Summary period: January 1948 - December 1972. Summary based on 128,505 hourly observations, generally 16 observations per day from 6 A.M. to 10 P.M.

Locations: Alamosa Municipal Airport located on the SSE side of the city. Ground elevation 7536 feet.

Anemometer height: 33 feet 1/48 - 10/54
 25 feet 10/54 - 10/59
 33 feet 10/59 - 12/72

Seasonal variations: Spring is the windiest time of year with average wind speeds of about 10 mph. There are frequent periods of calm winds in late fall and winter. The prevailing wind direction is from the SW in all seasons except for a slight tendency toward E winds in midsummer. The strongest winds blow from the SW.



Annual Wind Rose

ALBUQUERQUE

CLIMATE

Albuquerque lies in the valley of the Rio Grande about 150 miles south of the Colorado border. The climate is arid with mild winters, hot summers, light to moderate winds, and plenty of sunshine year around. The average monthly temperature varies from 35° F in January to 79° in July. Extreme temperatures have ranged from -17° F to 105° F.

The average annual precipitation is less than 8 inches with July and August typically being the wettest months of the year. Average winter snowfall is only 11 inches, and snow rarely stays on the ground in the valley for more than a day or two at a time. Stormy weather of any kind is quite rare with the possible exception of occasional late winter and early spring dust storms.

DESCRIPTION OF SOLAR RADIATION DATA

The Albuquerque station is a part of the National Oceanic and Atmospheric Administration national solar radiation network which began operation in 1977. The calibration standards and the data quality at this station appear to be very good, and the data are consistent with other national network stations.

ALBUQUERQUE

ELEVATION 5311 FEET MSL LATITUDE 35 DEG 3 MIN LONGITUDE 106 DEG 37 MIN

SOURCE OF SOLAR RADIATION DATA -- NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL WEATHER SERVICE. NATIONAL NETWORK

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, JANUARY 1977-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT ALBUQUERQUE INTERNATIONAL AIRPORT-KIRKLAND AFB. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1941-1970 PERIOD. TEMPERATURE EXTREMES, AVERAGE SNOWFALL, MEAN WIND SPEED, CLOUD COVER, AND POSSIBLE SUNSHINE OBTAINED FROM HOURLY OBSERVATIONS, 1940-1980. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. AVERAGE STATION PRESSURE AT ELEVATION 5314 FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1961-1980 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	10.09	14.45	18.59	24.65	26.14	28.36	27.35	24.76	20.55	17.58	11.67	10.43	19.55	4
HEMISPHERIC (BTU/SQFT DAY)	888	1273	1637	2172	2303	2498	2410	2181	1811	1548	1028	918	1722	4
(HEMISPHERIC / ETR) RATIO	.54	.61	.61	.68	.65	.68	.67	.66	.64	.68	.59	.61	.64	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	14.06	18.53	21.39	25.72	25.39	26.64	26.01	24.85	22.53	21.77	15.89	15.33		
LATITUDE	16.16	20.42	22.15	24.95	23.46	24.02	23.66	23.49	22.61	23.50	18.04	18.01		
LATITUDE + 15 DEG.	17.35	21.15	21.72	22.89	20.48	20.42	20.31	21.00	21.49	23.89	19.17	19.64		
VERTICAL	15.63	17.37	15.18	12.50	9.46	8.55	8.30	10.49	13.44	18.48	16.81	18.24		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	69.0	75.0	85.0	89.0	95.0	105.0	105.0	101.0	100.0	91.0	77.0	72.0		41
AVERAGE MAXIMUM TEMP. (DEG F)	46.9	52.6	59.2	70.1	79.9	89.5	92.2	89.7	83.4	71.1	57.1	47.5		30
MEAN TEMP.	35.2	40.0	45.8	55.8	65.3	74.6	78.7	76.6	70.1	58.2	44.5	36.2	56.8	30
AVERAGE MINIMUM TEMP. (DEG F)	23.5	27.4	32.3	41.4	50.7	59.7	65.2	63.4	56.7	44.7	31.8	24.9		30
EXTREME MINIMUM TEMP. (DEG F)	-17.0	-5.0	8.0	19.0	28.0	40.0	54.0	52.0	37.0	25.0	-7.0	3.0		41
DEGREE DAYS														
HEATING(65 DEG. BASE)	924	700	595	282	58	0	0	0	7	218	615	893	4292	30
COOLING(65 DEG. BASE)	0	0	0	6	67	291	425	360	160	7	0	0	1316	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	.30	.39	.47	.48	.53	.50	1.39	1.34	.77	.79	.29	.52	7.77	30
MEAN CLOUD COVER (PERCENT)	2.4	2.0	2.0	.5	.1	0.0	0.0	0.0	.1	.1	1.2	2.7	11.1	41
POSSIBLE SUNSHINE (PERCENT)	49	49	50	45	41	32	45	42	34	34	39	45	42	41
AVERAGE WIND SPEED (MPH)	72	73	73	77	79	83	76	76	80	80	77	72	76	41
AVERAGE STATION PRESSURE (MB)	8.0	8.8	10.1	11.0	10.5	10.0	9.1	8.2	8.6	8.3	7.9	7.7	9.0	41
AVG. REL. HUMID. (PERCENT) 5AM	838.1	838.1	834.6	835.5	835.9	838.4	840.4	840.4	840.3	840.2	839.4	839.7	838.4	8
AVG. REL. HUMID. (PERCENT) 5PM	70	64	55	47	46	44	60	65	61	59	65	70		20
	39	32	24	18	17	16	27	29	31	28	35	42		20

BOULDER

CLIMATE

Boulder is located on the eastern slope of the Rocky Mountains nestled tightly against steep foothills. The climate is characterized by light precipitation, surprisingly mild temperatures, and light winds punctuated by occasional very strong chinook winds. The average monthly temperature varies from 33° F in January to 74° in July. Average winter temperatures are relatively warm due to occurrences of warm chinook winds. Boulder averages more than 80 inches of snow annually, but prolonged snowcover is unusual. March is by far the snowiest month. The average annual precipitation is about 18 inches. Light afternoon thundershowers occur frequently throughout the summer, but May is the wettest month.

DESCRIPTION OF SOLAR RADIATION DATA

The National Oceanic and Atmospheric Administration maintains a solar radiation calibration facility at the Environmental Research Laboratories in Boulder. Data are collected by several independent instruments, but the data displayed here come from the National Network instrument, a Spectrolab SR-75 pyranometer. High calibration standards and frequent maintenance assures good quality data at this site.

BOULDER

ELEVATION 5360 FEET MSL LATITUDE 40 DEG 1 MIN LONGITUDE 105 DEG 15 MIN

SOURCE OF SOLAR RADIATION DATA -- NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, ENVIRONMENTAL RESEARCH LABORATORIES. NATIONAL NETWORK

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, JANUARY 1977-DECEMBER 1981.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- TEMPERATURE AND PRECIPITATION DATA FROM NATIONAL WEATHER SERVICE COOPERATIVE OBSERVER RECORDS. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. NO WIND SUMMARY AVAILABLE AT THIS TIME.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.25	11.26	15.38	19.28	20.15	24.95	23.00	19.65	18.35	13.12	9.00	7.20	15.80	5
HEMISPHERIC (BTU/SQF DAY)	726	991	1355	1699	1775	2198	2026	1731	1616	1156	793	634	1391	5
(HEMISPHERIC / ETR) RATIO	.53	.54	.55	.55	.50	.59	.56	.53	.60	.57	.53	.52	.55	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	13.05	15.50	18.45	20.36	19.61	23.39	21.87	19.85	20.82	17.07	13.52	11.78		
LATITUDE	15.01	16.96	19.02	19.68	18.16	21.16	19.96	18.75	20.85	18.23	15.27	13.69		
LATITUDE + 15 DEG.	16.09	17.48	18.57	18.04	15.95	18.10	17.24	16.79	19.77	18.39	16.15	14.80		
VERTICAL	14.95	14.92	13.89	11.24	8.93	9.23	9.10	9.82	13.51	14.91	14.60	13.99		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	72.0	79.0	79.0	83.0	93.0	104.0	104.0	101.0	97.0	90.0	79.0	76.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	45.0	48.5	52.8	62.2	71.9	82.4	88.1	85.7	78.2	68.0	53.6	48.0		30
MEAN TEMP.	32.6	36.3	40.0	48.9	58.6	68.2	74.0	71.9	63.8	54.0	41.2	36.0	52.1	30
AVERAGE MINIMUM TEMP. (DEG F)	20.1	24.0	27.1	35.5	45.3	54.0	59.8	57.9	49.4	40.0	28.7	23.9		30
EXTREME MINIMUM TEMP. (DEG F)	-22.0	-15.0	-3.0	-3.0	22.0	30.0	42.0	43.0	22.0	10.0	-7.0	-16.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	992	826	809	482	236	88	6	0	139	367	690	905	5540	30
COOLING(65 DEG. BASE)	0	0	0	8	29	154	282	234	109	26	0	0	842	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	10.2	11.2	18.3	11.7	2.0	.1	0.0	0.0	1.4	5.0	11.5	10.2	81.6	30

BUENA VISTA

CLIMATE

Buena Vista is located in the upper valley of the Arkansas River in central Colorado in the immediate vicinity of some of the highest mountains in the country. Despite the relatively high elevation and proximity to high mountains, the climate is quite hospitable. General characteristics of the climate are light precipitation, low humidities, light winds, lots of sunshine, and moderate temperatures. The average monthly temperature varies from 26° F in January to 65° in July. Extreme temperatures have ranged from -37° F to 97° F.

Average annual precipitation is only about 10 inches due to the shadowing effect of the surrounding mountains. The majority falls during the summer months from frequent light afternoon thundershowers. Average winter snowfall is 51 inches but is distributed over a long snowfall season (September - May).

DESCRIPTION OF SOLAR RADIATION DATA

A special field site was established by the Colorado Climate Center near Buena Vista in 1980 to monitor solar radiation in the upper Arkansas Valley. A mechanical integrator processed data from a LICOR-200S sensor and was read daily by a cooperative observer. The instrument was calibrated at Colorado State University prior to installation and at the close of the observation period in May 1982. The data quality from this station appears to be good.

BUENA VISTA

ELEVATION 7950 FEET MSL LATITUDE 38 DEG 51 MIN LONGITUDE 106 DEG 8 MIN

SOURCE OF SOLAR RADIATION DATA -- COLORADO CLIMATE CENTER, COLORADO STATE UNIVERSITY, SPECIAL FIELD SITE, BUENA VISTA, COLORADO.

INSTRUMENTATION -- LICOR LI-200S

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, OCTOBER 1980 - MAY 1982.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA TAKEN FROM NATIONAL WEATHER SERVICE COOPERATIVE OBSERVER RECORDS AT BUENA VISTA, COLORADO (ELEV. 7930 FT.). TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES ARE BASED ON 1941-1970 DATA. THERE IS NO WIND SUMMARY FOR THIS LOCATION.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	10.20	14.42	17.89	23.34	21.91	25.10	21.88	19.22	16.82	16.36	11.58	9.17	17.32	2
HEMISPHERIC (BTU/SQFT DAY)	899	1270	1576	2056	1930	2211	1927	1693	1481	1441	1020	807	1525	2
(HEMISPHERIC / ETR) RATIO	.63	.67	.62	.66	.54	.60	.53	.52	.55	.69	.66	.63	.61	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	16.24	20.21	21.51	24.75	21.31	23.55	20.81	19.35	18.74	21.59	17.72	15.18		
LATITUDE	18.88	22.41	22.30	23.99	19.73	21.31	19.02	18.28	18.71	23.34	20.32	17.88		
LATITUDE + 15 DEG.	20.41	23.31	21.86	22.00	17.30	18.23	16.48	16.38	17.72	23.73	21.71	19.51		
VERTICAL	19.02	19.92	16.12	13.15	9.27	9.00	8.56	9.39	11.92	19.17	19.72	18.55		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	61.0	64.0	71.0	77.0	83.0	95.0	95.0	92.0	88.0	79.0	69.0	62.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	40.4	43.1	48.0	56.3	66.1	77.0	82.0	78.8	73.2	63.6	49.0	41.6		30
MEAN TEMP.	26.1	28.5	33.5	41.2	50.1	59.1	64.7	62.2	55.6	46.4	34.1	26.9	44.0	30
AVERAGE MINIMUM TEMP. (DEG F)	11.5	13.8	19.1	26.0	34.1	41.3	47.5	45.6	38.0	29.2	19.3	12.1		30
EXTREME MINIMUM TEMP. (DEG F)	-32.0	-30.0	-13.0	-9.0	6.0	26.0	34.0	32.0	19.0	3.0	-19.0	-25.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1221	1033	1008	717	462	203	63	108	273	549	906	1172	7715	30
COOLING(65 DEG. BASE)	0	0	0	0	0	14	41	28	0	0	0	0	83	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	6.7	6.2	8.5	5.2	2.5	.3	0.0	0.0	1.7	4.6	8.1	7.0	50.8	30

CENTER

CLIMATE

Center is located in the San Luis Valley about 20 miles northwest of Alamosa. The climate is characterized by abundant sunshine, low relative humidity, light to moderate winds, large day to night temperature variations, and very light precipitation. The average monthly temperature varies from about 16° F in January to 63° in July. Winters are very cold, and temperatures frequently drop below 0° F at night. Summer temperatures are pleasant and daytime temperatures rarely exceed 90°. Precipitation is very light, averaging only about 7 inches annually. Light summer thundershowers, which move in from the surrounding mountains, account for much of the precipitation. Winter snowfall is quite light (annual average of 25 inches), but because of the cold temperatures the snow often remains on the ground for many weeks.

DESCRIPTION OF SOLAR RADIATION DATA

The San Luis Valley Experiment Station, located 4 miles south-southwest of Center began collecting solar radiation data in 1967, in support of agricultural research activities. The data set is nearly continuous for 13 years. The instrument, a Solameter, is not particularly sensitive, and calibrations (side-by-side tests with an Eppley) have been performed infrequently. However, the instrument is checked and read daily, and the data quality appears to be adequate. A thorough examination of the data suggests that the observations from this site are reading about 5% lower than they should be. The data from this station are of particular interest due to the relatively long period of record.

CENTER

ELEVATION 7683 FEET MSL LATITUDE 37 DEG 44 MIN LONGITUDE 106 DEG 8 MIN

SOURCE OF SOLAR RADIATION DATA -- COLORADO STATE UNIVERSITY, SAN LUIS VALLEY RESEARCH CENTER.

INSTRUMENTATION -- SOLAMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, JANUARY 1968-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- DATA COLLECTED AT THE SAN LUIS VALLEY RESEARCH CENTER. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. NO WIND SUMMARY FOR THIS STATION. CLIMATE STATION MOVED 4 MILES TO CURRENT LOCATION IN 1970. TEMPERATURES WERE WARMER AT PREVIOUS SITE.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	9.89	13.58	17.75	20.80	23.70	25.94	23.98	21.70	18.91	14.26	10.33	8.78	17.47	13
HEMISPHERIC (BTU/SQFT DAY)	871	1196	1563	1832	2088	2285	2112	1911	1666	1256	909	773	1538	13
(HEMISPHERIC / ETR) RATIO	.58	.61	.61	.58	.59	.62	.59	.58	.60	.59	.57	.57	.59	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	15.00	18.30	21.00	21.80	23.05	24.35	22.80	21.85	21.07	17.98	14.84	13.73		
LATITUDE	17.34	20.17	21.75	21.10	21.32	22.02	20.81	20.65	21.11	19.24	16.83	16.05		
LATITUDE + 15 DEG.	18.68	20.89	21.31	19.35	18.66	18.81	17.96	18.49	20.03	19.44	17.84	17.44		
VERTICAL	17.22	17.60	15.47	11.47	9.55	8.90	8.84	10.14	13.18	15.40	15.93	16.38		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	59.0	63.0	74.0	77.0	87.0	95.0	94.0	90.0	89.0	79.0	68.0	61.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	33.8	40.0	48.6	58.4	68.0	77.3	80.8	78.5	73.4	63.3	47.0	36.4		30
MEAN TEMP.	16.2	22.9	32.2	41.2	50.6	58.7	63.2	60.8	54.6	44.4	29.8	19.2	41.2	30
AVERAGE MINIMUM TEMP. (DEG F)	-1.5	5.8	15.7	23.9	33.1	40.0	45.4	43.2	35.7	25.5	12.6	2.0		30
EXTREME MINIMUM TEMP. (DEG F)	-38.0	-30.0	-16.0	-4.0	12.0	26.0	33.0	28.0	17.0	-4.0	-25.0	-41.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1476	1165	1029	687	419	184	67	113	300	636	1035	1383	8494	30
COOLING(65 DEG. BASE)	0	0	0	0	0	10	36	14	0	0	0	0	60	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	3.4	3.7	4.0	2.5	.7	0.0	0.0	0.0	.4	2.4	3.5	4.5	25.1	30

CHEYENNE

CLIMATE

Cheyenne is located in an area of rolling prairie in southeastern Wyoming on a ridge between the North Platte and South Platte Rivers. The climate is characterized by low relative humidity, light precipitation, large temperature variations, and strong, persistent winds. The average monthly temperature varies from about 27° F in January to 69° in July. Winter temperatures would be considerably colder were it not for the frequent occurrences of warm chinook winds. The average annual precipitation is about 15 inches, most of which falls during the growing season. Thunderstorms occur frequently during the summer months and often produce hail. Annual snowfall averages 51 inches and March and April are typically the snowiest months.

DESCRIPTION OF SOLAR RADIATION DATA

The Public Service Company of Colorado established a solar radiation measurement site in Cheyenne early in 1977. It is part of an extensive network in the Southwest established for the purpose of supplying solar radiation data to public utilities who use the information for heating load calculations and for design and evaluation of solar energy projects. A Spectrolab SR-75 pyranometer is used to measure hemispheric radiation. A regular maintenance schedule is employed and thorough calibrations are scheduled at 6-month intervals (Yinger, 1978). The data quality appears to be excellent at this site.

CHEYENNE

ELEVATION 6155 FEET MSL LATITUDE 41 DEG 8 MIN LONGITUDE 104 DEG 49 MIN

SOURCE OF SOLAR RADIATION DATA -- PUBLIC SERVICE COMPANY OF COLORADO

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, MARCH 1977-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT CHEYENNE MUNICIPAL AIRPORT. TEMPERATURE, PRECIPITATION, AND DEGREE DAY AVERAGES ARE FOR THE 1941-1970 PERIOD. TEMPERATURE EXTREMES, MEAN CLOUD COVER AND POSSIBLE SUNSHINE BASED ON 1936-1980 DATA. MEAN WIND SPEEDS OBTAINED FROM HOURLY OBSERVATIONS 1958-1980. AVERAGE STATION PRESSURE AT ELEVATION OF 6141 FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1960-1980 DATA.

SOLAR RADIATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD
*****														(YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.31	11.67	16.29	20.47	21.94	24.94	23.83	20.33	19.10	13.96	8.68	7.46	16.42	4
HEMISPHERIC (BTU/SQFT DAY)	732	1028	1435	1803	1932	2197	2099	1791	1682	1231	764	657	1445	4
(HEMISPHERIC / ETR) RATIO	.56	.58	.59	.59	.55	.59	.58	.56	.63	.62	.53	.56	.58	
COMPUTED TILTED SURFACES														
(MJ/SQM DAY)														
LATITUDE - 15 DEG.	13.79	16.67	20.01	21.83	21.38	23.36	22.64	20.63	22.01	18.82	13.43	12.98		
LATITUDE	15.92	18.33	20.69	21.11	19.77	21.13	20.64	19.47	22.06	20.22	15.18	15.18		
LATITUDE + 15 DEG.	17.11	18.94	20.25	19.34	17.32	18.07	17.80	17.42	20.95	20.46	16.06	16.48		
VERTICAL	16.06	16.38	15.38	12.24	9.77	9.48	9.57	10.37	14.56	16.84	14.63	15.75		
CLIMATE														

EXTREME MAXIMUM TEMP. (DEG F)	63.0	71.0	73.0	82.0	90.0	100.0	100.0	96.0	93.0	83.0	73.0	69.0		45
AVERAGE MAXIMUM TEMP. (DEG F)	38.2	40.7	43.5	55.4	65.1	74.4	83.7	81.9	72.8	61.8	47.5	40.3		30
MEAN TEMP.	26.6	29.0	31.6	42.7	52.4	61.3	69.1	67.6	58.2	47.9	35.5	29.2	45.9	30
AVERAGE MINIMUM TEMP. (DEG F)	14.9	17.3	19.6	30.0	39.7	48.1	54.5	53.2	43.5	33.9	23.5	18.1		30
EXTREME MINIMUM TEMP. (DEG F)	-27.0	-34.0	-21.0	-8.0	16.0	25.0	38.0	36.0	18.0	2.0	-13.0	-24.0		45
DEGREE DAYS														
HEATING(65 DEG. BASE)	1190	1008	1035	669	394	156	22	31	225	530	885	1110	7255	30
COOLING(65 DEG. BASE)	0	0	0	0	0	45	149	112	21	0	0	0	327	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	.46	.46	1.05	1.57	2.52	2.41	1.82	1.45	1.03	.95	.58	.35	14.65	30
MEAN CLOUD COVER (PERCENT)	5.8	5.5	11.9	9.3	3.1	.3	0.0	.7	3.4	6.0	5.2	51.2		30
POSSIBLE SUNSHINE (PERCENT)	59	62	62	65	66	55	50	51	45	47	55	58	56	45
AVERAGE WIND SPEED (MPH)	62	65	65	61	59	65	68	67	69	69	60	59	64	44
AVERAGE STATION PRESSURE (MB)	15.4	15.1	14.8	14.5	12.9	11.6	10.5	10.6	11.3	12.4	13.4	15.0	13.1	23
AVG. REL. HUMID. (PERCENT) 5AM	807.8	808.7	806.1	808.6	809.8	812.7	815.3	814.6	814.6	813.4	810.7	809.3	811.0	8
AVG. REL. HUMID. (PERCENT) 5PM	55	58	62	65	68	68	67	65	62	57	57	55		21
	49	46	45	39	41	39	37	35	36	38	48	49		21

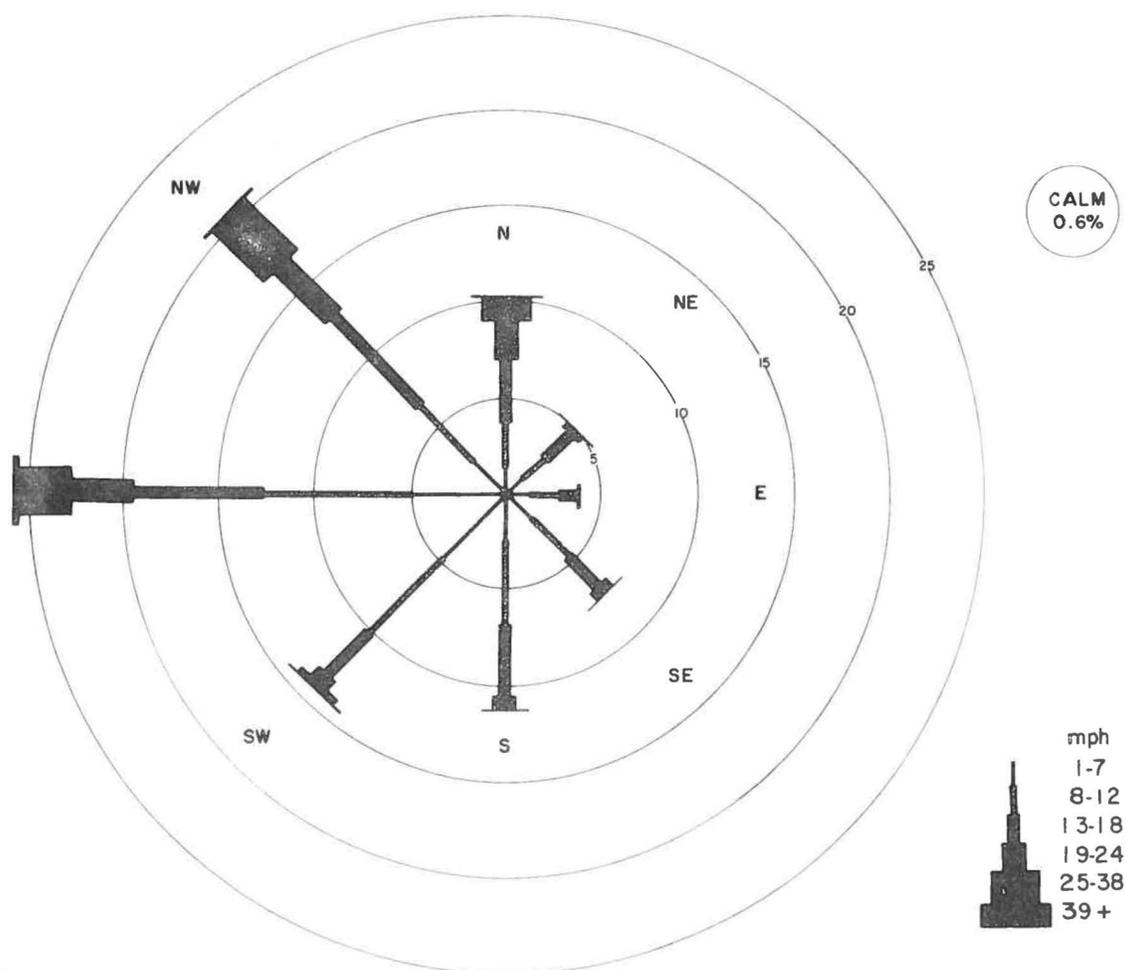
CHEYENNE, WYOMING - - WIND SUMMARY

Summary period: January 1948 - May 1967. Summary based on 155,922 hourly observations, 24 observations per day.

Location: Cheyenne Airport, National Weather Service Office (NE edge of Cheyenne). Ground elevation 6144 feet.

Anemometer height: 40 feet 1/48 - 8/54 73 feet 8/54 - 10/57
(above ground) 33 feet 10/57 - 5/67

Seasonal variation: Cheyenne is a very windy location. Average wind speeds vary from 11 mph in August to 16 mph in March. The prevailing wind direction is from the WNW throughout the year, but WNW winds are particularly dominant during winter. Wind speeds above 50 mph from the W - NW are not uncommon during winter and early spring.



Annual Wind Rose

COLORADO SPRINGS

CLIMATE

Colorado Springs is located on the eastern slope of the Rocky Mountains only 12 air-miles from the 14,110 foot summit of Pikes Peak. The climate is characterized by low relative humidity, light to moderate winds, and fairly comfortable temperatures. The average monthly temperature varies from 29° F in January to 71° in July. Occasional chinook winds help to keep winter temperatures relatively mild. Uncomfortable temperature extremes occur infrequently. Precipitation averages about 15 inches per year. Most of the precipitation falls from scattered thunderstorms that develop over the mountains on most summer afternoons. Snowfall varies greatly with elevation but averages 43 inches at the airport. March and April are typically the snowiest months.

COLORADO SPRINGS

ELEVATION 6090 FEET MSL LATITUDE 38 DEG 49 MIN LONGITUDE 104 DEG 43 MIN

NO OBSERVED SOLAR RADIATION DATA AT THIS TIME.

CLIMATIC DATA -- ALL DATA COLLECTED AT PETERSON FIELD. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN WIND SPEEDS AND MEAN CLOUD COVER OBTAINED FROM HOURLY OBSERVATION, 1949-1980. AVERAGE STATION PRESSURE AT ELEVATION 6170 FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1961-1980 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	72.0	76.0	81.0	81.0	92.0	100.0	100.0	99.0	94.0	86.0	77.0	77.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	41.9	45.3	49.1	59.2	68.7	79.7	85.0	82.4	74.8	64.4	50.4	44.5		30
MEAN TEMP.	28.8	32.3	36.2	45.8	55.5	65.5	71.1	68.9	61.0	50.6	37.5	31.5	48.7	30
AVERAGE MINIMUM TEMP. (DEG F)	15.7	19.2	23.3	32.4	42.3	51.3	57.2	55.3	47.1	36.7	24.4	18.4		30
EXTREME MINIMUM TEMP. (DEG F)	-26.0	-27.0	-11.0	-3.0	21.0	32.0	42.0	43.0	25.0	5.0	-8.0	-16.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1128	944	921	564	301	103	9	13	155	456	825	1054	6473	30
HEATING(60 DEG. BASE)	973	804	766	422	169	39	0	0	70	314	675	899	5131	30
HEATING(55 DEG. BASE)	813	644	611	288	78	11	0	0	19	196	525	744	3929	30
COOLING(65 DEG. BASE)	0	0	0	0	6	91	186	140	32	6	0	0	461	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	4.5	4.7	9.2	7.5	1.8	0.0	0.0	0.0	1.5	3.0	5.5	5.0	42.7	30
MEAN CLOUD COVER (PERCENT)	53	55	58	58	60	48	50	49	41	41	49	50	51	32
AVERAGE WIND SPEED (MPH)	9.8	10.5	11.6	12.1	11.6	10.8	9.5	9.2	9.6	9.7	9.6	9.8	10.3	32
AVERAGE STATION PRESSURE (MB)	808.0	808.6	805.8	808.1	809.2	812.4	815.0	814.5	814.3	813.1	810.7	809.5	810.8	8
AVG. REL. HUMID. (PERCENT) 5AM	58	59	60	61	64	65	69	69	66	56	60	55	62	20
AVG. REL. HUMID. (PERCENT) 5PM	47	39	38	33	36	34	41	40	37	35	46	47	39	20

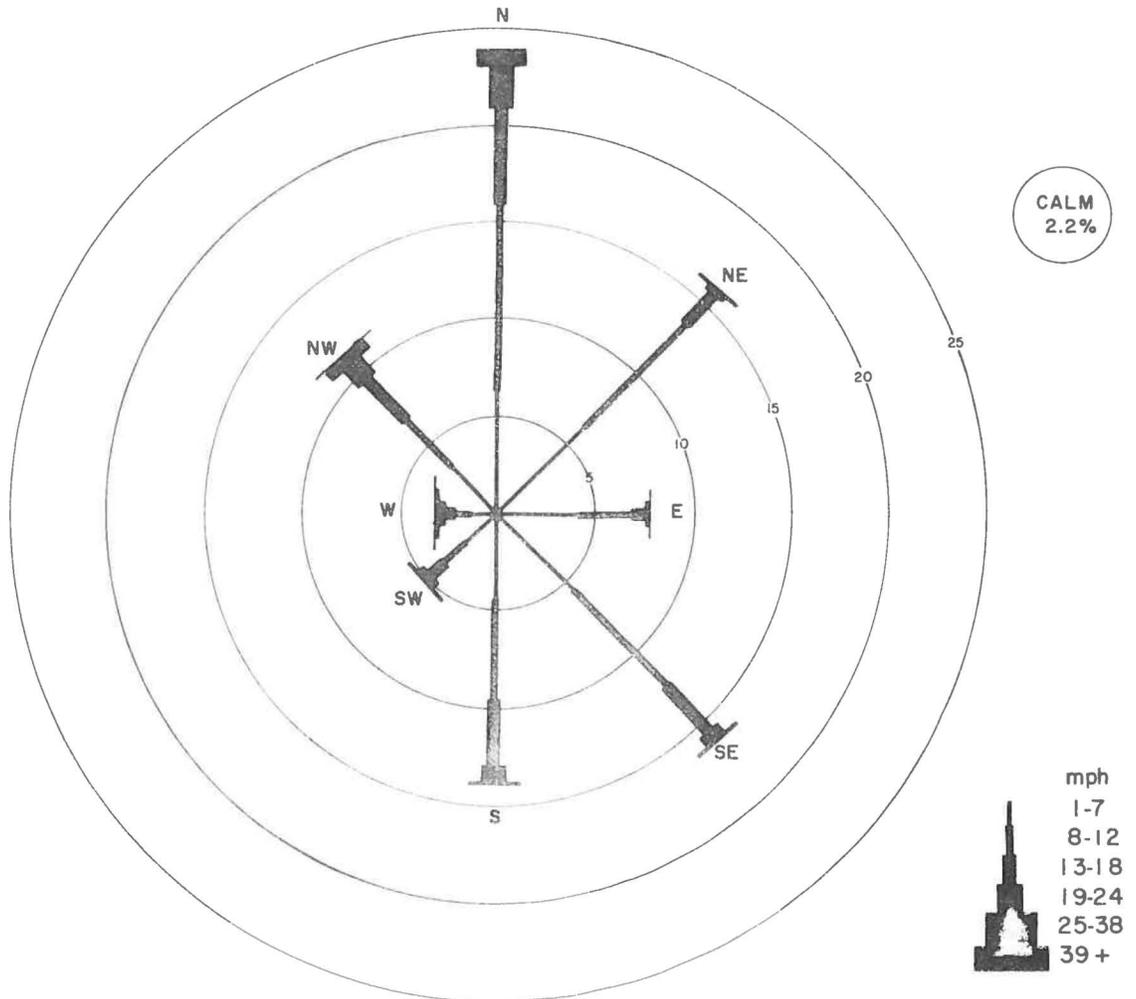
COLORADO SPRINGS, COLORADO - - WIND SUMMARY

Summary period: January 1956 - December 1960. Summary based on 43,848 hourly observations, 24 observations per day.

Location: Colorado Springs Peterson Field (airport located about 6 miles ESE of downtown Colorado Springs). Ground elevation 6173 feet.

Anemometer height: 67 feet 1/56 - 5/56 76 feet 5/56 - 2/58
 (above ground) 22 feet 2/58 - 12/60

Seasonal variation: Average wind speeds at Colorado Springs vary from 9 mph in October to 12 mph in April. There is a distinct diurnal variation in wind direction throughout the year with N winds prevailing at night while SSE winds prevail during the day. Most of the strong winds usually blow from the N and are most likely during the winter. WNW winds (downslope winds) occur infrequently but can be very strong (greater than 40 mph).



Annual Wind Rose

DENVER

CLIMATE

Denver is located on the South Platte River on the eastern slope of the Rocky Mountains. The climate is characterized by low relative humidity, light to moderate winds, mild temperatures, and light precipitation. The average monthly temperature varies from 30° F in January to 73° in July. Occasional chinook winds help to moderate winter temperatures. Annual snowfall averages 63 inches but persistent snowcover is unusual. March is typically the snowiest month. Precipitation averages a little more than 15.5 inches per year, most of which falls during the growing season. Thundershowers occur fairly frequently on summer afternoons.

DESCRIPTION OF SOLAR RADIATION DATA

The Public Service Company of Colorado established two solar radiation measurement sites in Denver early in 1977. These two sites are a part of an extensive network in the Southwest established for the purpose of supplying solar radiation data to public utilities who use the information for heating load calculations and for design and evaluation of solar energy projects. Spectrolab SR-75 pyranometers are used to measure hemispheric radiation. A regular maintenance schedule is employed and thorough calibrations are scheduled at 6-month intervals (Yinger, 1978). The data quality at these stations appear to be excellent, although some inconsistencies appear which make high resolution comparison between the two stations risky.

DENVER (SOUTHEAST)

ELEVATION 5340 FEET MSL LATITUDE 39 DEG 39 MIN LONGITUDE 104 DEG 51 MIN

SOURCE OF SOLAR RADIATION DATA -- PUBLIC SERVICE COMPANY OF COLORADO

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE,
MARCH 1977-AUGUST 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU
AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT DENVER STAPLETON AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE
FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN WIND SPEEDS, CLOUD COVER, AND
POSSIBLE SUNSHINE OBTAINED FROM HOURLY OBSERVATIONS, 1949-1980. AVERAGE STATION PRESSURE AT ELEVATION 5332
FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1961-1980 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.64	11.92	16.08	19.79	21.95	25.64	24.32	21.27	19.79	13.99	9.50	7.74	16.72	4
HEMISPHERIC (BTU/SQFT DAY)	760	1049	1417	1743	1934	2259	2143	1874	1743	1232	836	691	1472	4
(HEMISPHERIC / ETR) RATIO	.55	.56	.57	.56	.55	.61	.59	.58	.65	.60	.56	.55	.58	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	13.62	16.43	19.30	20.89	21.37	24.03	23.11	21.52	22.54	18.25	14.27	12.70		
LATITUDE	15.68	18.03	19.92	20.19	19.77	21.73	21.07	20.33	22.63	19.56	16.16	14.81		
LATITUDE + 15 DEG.	16.84	18.61	19.48	18.51	17.33	18.56	18.17	18.19	21.49	19.78	17.13	16.06		
VERTICAL	15.64	15.87	14.50	11.43	9.45	9.29	9.36	10.43	14.57	16.01	15.48	15.21		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	72.0	76.0	84.0	85.0	93.0	102.0	103.0	100.0	97.0	87.0	78.0	75.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	43.1	46.9	51.2	61.0	70.7	81.6	88.0	85.8	77.5	66.8	52.4	46.1		30
MEAN TEMP.	29.5	33.6	38.0	47.4	57.2	67.0	73.3	71.4	62.6	51.9	38.7	32.6	50.3	30
AVERAGE MINIMUM TEMP. (DEG F)	15.9	20.2	24.7	33.7	43.6	52.4	58.7	57.0	47.7	36.9	25.1	18.9		30
EXTREME MINIMUM TEMP. (DEG F)	-25.0	-25.0	-8.0	-2.0	22.0	30.0	43.0	41.0	20.0	3.0	-7.0	-18.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1088	902	868	525	253	80	0	0	120	408	768	1004	6016	30
HEATING(60 DEG. BASE)	933	762	713	386	123	26	0	0	47	266	618	849	4723	30
HEATING(55 DEG. BASE)	778	622	565	256	41	7	0	0	12	153	473	694	3601	30
COOLING(65 DEG. BASE)	0	0	0	0	0	110	248	208	54	5	0	0	625	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	.51	.69	1.21	1.81	2.47	1.58	1.93	1.53	1.23	.98	.82	.55	15.31	30
MEAN CLOUD COVER (PERCENT)	7.2	8.7	13.9	9.5	1.8	0.0	0.0	0.0	1.8	4.3	8.6	7.2	63.0	30
POSSIBLE SUNSHINE (PERCENT)	56	59	61	61	62	50	49	49	43	44	54	53	53	32
AVERAGE WIND SPEED (MPH)	72	71	71	67	65	71	71	73	75	73	65	68	70	31
AVERAGE STATION PRESSURE (MB)	9.0	9.2	9.9	10.3	9.5	9.1	8.5	8.2	8.2	8.1	8.6	8.9	9.0	32
AVG. REL. HUMID. (PERCENT) 5AM	833.8	834.2	831.2	833.2	834.0	836.5	839.0	838.4	838.7	837.9	836.0	834.8	835.6	8
AVG. REL. HUMID. (PERCENT) 5PM	64	66	67	68	70	69	69	68	68	63	69	64		20
	49	43	40	35	37	35	34	34	34	34	50	50		20

DENVER (HOLLY)

ELEVATION 5330 FEET MSL LATITUDE 39 DEG 45 MIN LONGITUDE 104 DEG 54 MIN

SOURCE OF SOLAR RADIATION DATA -- PUBLIC SERVICE COMPANY OF COLORADO

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, MARCH 1977-SEPTEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT DENVER STAPLETON AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN WIND SPEEDS, CLOUD COVER, AND POSSIBLE SUNSHINE OBTAINED FROM HOURLY OBSERVATIONS, 1949-1980. AVERAGE STATION PRESSURE AT ELEVATION 5332 FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1961-1980 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.19	11.25	15.28	19.10	21.24	24.25	24.07	20.98	19.05	13.41	9.00	7.34	16.10	4
HEMISPHERIC (BTU/SQFT DAY)	721	991	1345	1682	1871	2136	2120	1848	1678	1181	792	646	1417	4
(HEMISPHERIC / ETR) RATIO	.52	.54	.54	.54	.53	.58	.59	.57	.62	.57	.53	.52	.55	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	12.81	15.39	18.24	20.13	20.68	22.75	22.87	21.23	21.64	17.41	13.39	11.92		
LATITUDE	14.71	16.83	18.79	19.45	19.14	20.60	20.86	20.05	21.69	18.62	15.11	13.86		
LATITUDE + 15 DEG.	15.76	17.34	18.35	17.83	16.79	17.64	17.99	17.94	20.58	18.79	15.97	14.99		
VERTICAL	14.60	14.76	13.67	11.07	9.24	9.01	9.32	10.34	13.99	15.20	14.40	14.16		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	72.0	76.0	84.0	85.0	93.0	102.0	103.0	100.0	97.0	87.0	78.0	75.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	43.1	46.9	51.2	61.0	70.7	81.6	88.0	85.8	77.5	66.8	52.4	46.1		30
MEAN TEMP.	29.5	33.6	38.0	47.4	57.2	67.0	73.3	71.4	62.6	51.9	38.7	32.6	50.3	30
AVERAGE MINIMUM TEMP. (DEG F)	15.9	20.2	24.7	33.7	43.6	52.4	58.7	57.0	47.7	36.9	25.1	18.9		30
EXTREME MINIMUM TEMP. (DEG F)	-25.0	-25.0	-8.0	-2.0	22.0	30.0	43.0	41.0	20.0	3.0	-7.0	-18.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1088	902	868	525	253	80	0	0	120	408	768	1004	6016	30
HEATING(60 DEG. BASE)	933	762	713	386	123	26	0	0	47	266	618	849	4723	30
HEATING(55 DEG. BASE)	778	622	565	256	41	7	0	0	12	153	473	694	3601	30
COOLING(65 DEG. BASE)	0	0	0	0	0	110	248	208	54	5	0	0	625	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	.51	.69	1.21	1.81	2.47	1.58	1.93	1.53	1.23	.98	.82	.55	15.31	30
MEAN CLOUD COVER (PERCENT)	7.2	8.7	13.9	9.5	1.8	0.0	0.0	0.0	1.8	4.3	8.6	7.2	63.0	30
POSSIBLE SUNSHINE (PERCENT)	56	59	61	61	62	50	49	49	43	44	54	53	53	32
AVERAGE WIND SPEED (MPH)	72	71	71	67	65	71	71	73	75	73	65	68	70	31
AVERAGE STATION PRESSURE (MB)	9.0	9.2	9.9	10.3	9.5	9.1	8.5	8.2	8.2	8.1	8.6	8.9	9.0	32
AVG. REL. HUMID. (PERCENT) 5AM	833.8	834.2	831.2	833.2	834.0	836.5	839.0	838.4	838.7	837.9	836.0	834.8	835.6	8
AVG. REL. HUMID. (PERCENT) 5PM	64	66	67	68	70	69	69	68	68	63	69	64	64	20
AVG. REL. HUMID. (PERCENT) 5PM	49	43	40	35	37	35	34	34	34	34	50	50	50	20

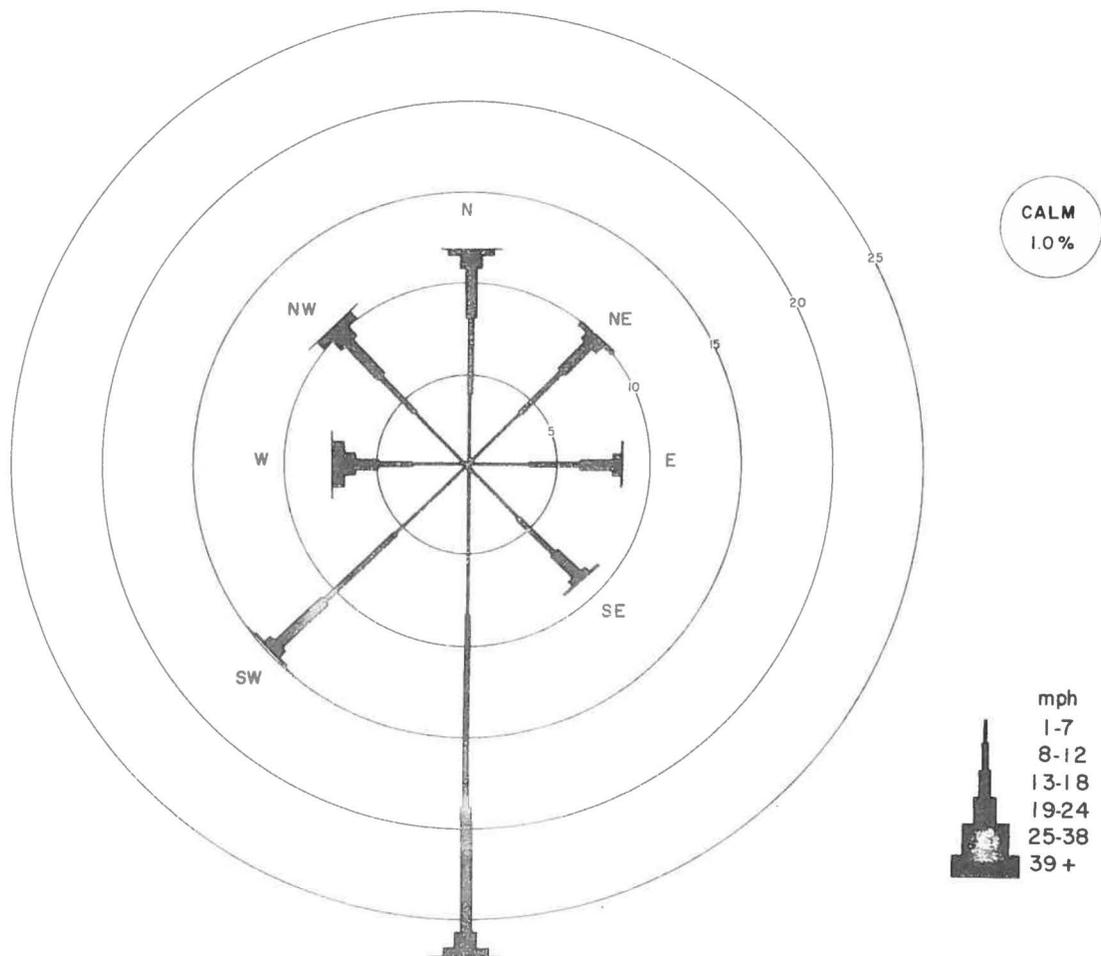
DENVER, COLORADO - - WIND SUMMARY

Summary period: January 1951 - December 1960. Summary based on 87,672 hourly observations, 24 observations per day.

Location: Denver Stapleton Airport. Ground elevation 5292 feet.

Anemometer height: 72 feet 1/51 - 7/60
(above ground) 20 feet 7/60 - 12/60

Seasonal variations: Average wind speeds vary from about 8 mph in early autumn to 11 mph in April. There is a distinct diurnal variation in wind direction throughout the year with S winds prevailing at night while NW - NE winds prevail during the day. S winds dominate throughout the year but especially during late fall and winter. The strongest winds are the mountain induced downslope winds from the WNW and occur most frequently during winter and early spring.



Annual Wind Rose

DODGE CITY

CLIMATE

Dodge City is located in southwestern Kansas about 125 miles east of the Colorado border and nearly 300 miles east of the Rocky Mountains. The climate is similar to parts of southeastern Colorado and is characterized by moderate to strong winds, mild temperatures, light precipitation, fairly low humidity, and plenty of sunshine. The average monthly temperature varies from about 31° F in January to 79° F in July. Extreme temperatures have ranged from -26° F to 109° F.

The annual average precipitation is about 20 inches. About 60 percent of the annual total falls in May - August produced mostly by scattered thunderstorms, some of which are quite severe. Winter precipitation is light, and average winter snowfall is only 19 inches. A few strong blizzards occasionally sweep across the area.

DESCRIPTION OF SOLAR RADIATION DATA

The Dodge City station is a part of the National Oceanic and Atmospheric Administration national solar radiation network which began operation in 1977. The calibration standards and the data quality at this station appear to be very good, and the data are consistent with other national network stations.

DODGE CITY

ELEVATION 2582 FEET MSL LATITUDE 37 DEG 46 MIN LONGITUDE 99 DEG 58 MIN

SOURCE OF SOLAR RADIATION DATA -- NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL WEATHER SERVICE, NATIONAL NETWORK

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, JANUARY 1977-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT DODGE CITY MUNICIPAL AIRPORT. TEMPERATURE, PRECIPITATION, AND DEGREE DAY AVERAGES ARE FOR THE 1941-1970 PERIOD. SNOWFALL, TEMPERATURE EXTREMES, MEAN CLOUD COVER AND POSSIBLE SUNSHINE BASED ON 1943-1980 DATA. MEAN WIND SPEEDS OBTAINED FROM HOURLY OBSERVATIONS 1945-1980. AVERAGE STATION PRESSURE AT ELEVATION OF 2592 FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1964-1980 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.76	12.62	16.40	19.76	21.27	25.63	25.83	22.50	19.46	15.65	9.23	8.19	17.11	4
HEMISPHERIC (BTU/SQFT DAY)	772	1112	1444	1740	1874	2258	2276	1982	1714	1378	813	721	1507	4
(HEMISPHERIC / ETR) RATIO	.52	.57	.56	.55	.53	.61	.63	.60	.62	.64	.51	.54	.57	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	12.95	16.81	19.24	20.66	20.68	24.06	24.55	22.68	21.73	20.02	12.98	12.61		
LATITUDE	14.84	18.45	19.86	19.99	19.16	21.77	22.36	21.43	21.79	21.54	14.59	14.68		
LATITUDE + 15 DEG.	15.89	19.05	19.42	18.33	16.83	18.60	19.24	19.18	20.68	21.83	15.39	15.90		
VERTICAL	14.54	15.99	14.10	10.93	8.85	8.85	9.25	10.46	13.60	17.37	13.65	14.87		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	78.0	85.0	93.0	94.0	102.0	108.0	109.0	107.0	106.0	96.0	91.0	86.0		38
AVERAGE MAXIMUM TEMP. (DEG F)	42.6	47.1	53.9	66.9	76.2	86.0	91.4	90.4	81.4	70.7	55.2	44.6		30
MEAN TEMP.	30.8	35.2	41.2	54.0	64.0	73.7	79.2	78.1	68.9	57.9	42.8	33.4	54.9	30
AVERAGE MINIMUM TEMP. (DEG F)	19.0	23.2	28.4	41.1	51.7	61.4	66.9	65.7	56.3	45.0	30.4	22.2		30
EXTREME MINIMUM TEMP. (DEG F)	-12.0	-15.0	-15.0	15.0	26.0	41.0	47.0	47.0	31.0	20.0	0.0	-7.0		38
DEGREE DAYS														
HEATING(65 DEG. BASE)	1060	834	738	344	115	21	0	0	41	247	666	980	5046	30
COOLING(65 DEG. BASE)	0	0	0	14	84	282	440	406	158	27	0	0	1411	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	4.2	3.8	4.8	.8	.1	0.0	0.0	0.0	.1	.2	1.9	3.4	19.3	38
MEAN CLOUD COVER (PERCENT)	57	57	59	58	57	48	47	45	44	42	51	54	51	38
POSSIBLE SUNSHINE (PERCENT)	67	65	66	68	68	76	78	77	74	75	67	65	70	38
AVERAGE WIND SPEED (MPH)	13.6	14.1	15.9	15.6	14.6	14.3	13.0	12.7	13.6	13.5	13.7	13.5	14.0	36
AVERAGE STATION PRESSURE (MB)	926.2	925.3	921.2	922.2	921.8	923.1	924.9	924.9	925.8	925.8	926.2	925.6	924.4	8
AVG. REL. HUMID. (PERCENT) 5AM	77	76	75	74	78	77	74	78	80	71	77	76		17
AVG. REL. HUMID. (PERCENT) 5PM	60	53	44	42	46	42	38	42	46	45	57	60		17

DURANGO

CLIMATE

Durango is located on the Animas River on the south slope of the San Juan Mountain Range in southwestern Colorado. The climate is characterized by light winds, relatively light precipitation, and large day to night temperature variations. The average monthly temperature varies from about 26° F in January to 68° in July. Winter temperatures occasionally fall below 0° F and summer temperatures in the low 90's are not uncommon. The diurnal temperature range (difference between the daily maximum and minimum temperatures) is very large and often exceeds 40 degrees, especially in late summer and early fall.

A characteristic of precipitation in Durango and much of southwestern Colorado is the great year to year variability in annual precipitation totals. Very dry and very wet years both occur with some regularity. On the average, Durango receives about 19 inches of precipitation annually, but this increases rapidly as you move into the San Juans. Maximum precipitation occurs in late summer and early fall and again in December and January. August is typically the wettest month. Annual snowfall averages about 71 inches with December and January usually being the snowiest months.

DURANGO

ELEVATION 6600 FEET MSL LATITUDE 37 DEG 17 MIN LONGITUDE 107 DEG 53 MIN

NO SOLAR RADIATION DATA AT THIS TIME.

CLIMATIC DATA -- TEMPERATURE AND PRECIPITATION DATA FROM NATIONAL WEATHER SERVICE COOPERATIVE OBSERVER RECORDS
 TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970
 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	65.0	68.0	78.0	82.0	92.0	97.0	98.0	96.0	92.0	87.0	74.0	64.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	40.9	46.6	53.1	62.2	71.7	81.8	86.8	84.2	77.9	67.9	53.4	43.0		30
MEAN TEMP.	25.7	30.8	37.2	45.0	53.2	61.5	68.3	66.2	58.8	49.1	37.1	27.8	46.7	30
AVERAGE MINIMUM TEMP. (DEG F)	10.4	15.0	21.3	27.7	34.7	41.2	49.7	48.1	39.5	30.2	20.7	12.6		30
EXTREME MINIMUM TEMP. (DEG F)	-30.0	-18.0	-7.0	6.0	18.0	23.0	35.0	33.0	20.0	10.0	-9.0	-18.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1212	958	880	597	375	161	20	37	198	502	843	1147	6930	30
COOLING(65 DEG. BASE)	0	0	0	0	0	17	97	68	6	0	0	0	188	30
PRECIPITATION (INCHES)	1.95	1.29	1.52	1.21	1.08	.59	1.70	2.38	1.52	2.07	1.34	1.96	18.61	30
SNOWFALL (INCHES)	19.8	12.3	12.0	4.0	.6	0.0	0.0	0.0	0.0	.5	4.8	17.2	71.2	30

DURANGO, COLORADO - - WIND SUMMARY

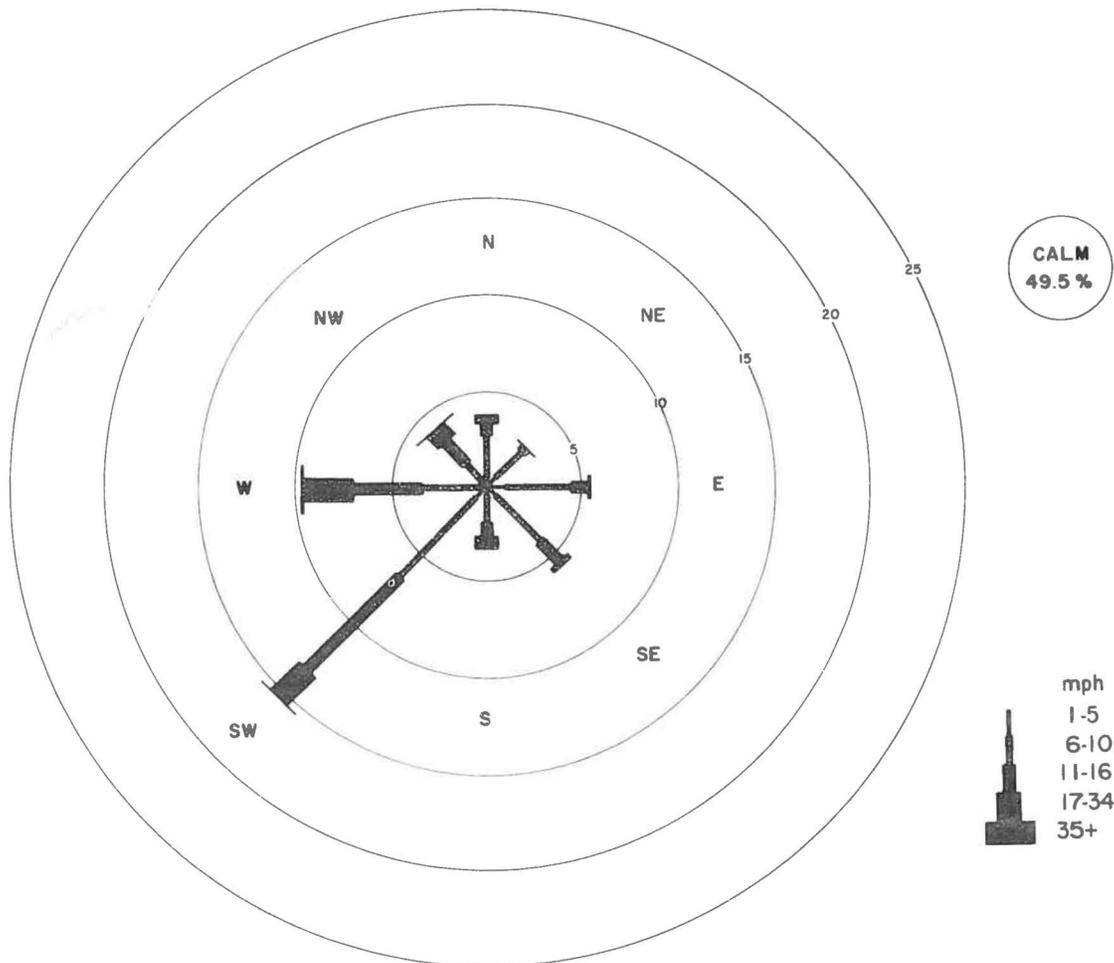
Summary period: July 1959 - June 1964. Summary based on 31,412 hourly observations per day from 5 A.M. to 9 P.M.

Location: Durango Airport located about 12 miles SE of Durango. Ground elevation 6660 feet.

Anemometer height: 32 feet 7/59 - 6/64
(above ground)

Seasonal variations: No month by month summaries are available at this time, but average wind speeds appear to be quite low throughout the year. Calms occur practically every night but are most persistent during winter. The prevailing daytime wind direction is from the SW.

Note: Anemometer may have been insensitive to wind speeds below about 5 mph, thus explaining the high frequency of calms.



EAGLE

CLIMATE

Eagle is located in the valley of the Eagle River in the mountains of central Colorado. The climate is characterized by low relative humidity, light winds, light precipitation, and large diurnal and seasonal temperature variations. The average monthly temperature varies from about 18° F in January to 66° in July. The diurnal temperature range (difference between the daily maximum and minimum temperatures) is very large and often exceeds 40 degrees. Afternoon temperatures in the low 90's are not unusual during the summer months, but nighttime temperatures are always cool, usually dropping into the 40's. During the winter, temperatures below zero occur frequently as cold air settles into the valley.

Annual precipitation in the valley bottom near Eagle averages only about 10 inches, but precipitation increases rapidly as you move to higher elevations in the nearby mountains. Precipitation is distributed fairly evenly throughout the year. Light afternoon thundershowers account for the summer precipitation, while most winter precipitation falls as snow. Annual snowfall averages 48 inches near Eagle but increases rapidly with elevation. December and January are typically the snowiest months and snowcover often persists throughout the mid-winter months.

EAGLE

ELEVATION 6497 FEET MSL LATITUDE 39 DEG 39 MIN LONGITUDE 106 DEG 55 MIN

NO SOLAR RADIATION DATA AT THIS TIME.

CLIMATIC DATA -- ALL DATA COLLECTED AT EAGLE COUNTY AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	58.0	62.0	71.0	80.0	90.0	99.0	98.0	95.0	93.0	84.0	69.0	61.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	33.8	39.7	46.9	57.8	69.3	80.8	86.4	83.2	75.9	64.3	46.9	35.1		30
MEAN TEMP.	18.3	24.0	32.3	41.5	51.1	59.6	66.2	63.7	55.5	44.8	30.8	19.6	42.3	30
AVERAGE MINIMUM TEMP. (DEG F)	2.8	8.3	17.6	25.2	32.9	39.1	45.9	44.2	35.0	25.1	14.6	4.0		30
EXTREME MINIMUM TEMP. (DEG F)	-51.0	-46.0	-20.0	-8.0	12.0	23.0	29.0	27.0	18.0	2.0	-29.0	-33.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1457	1168	1051	693	425	190	43	79	285	626	1023	1386	8426	30
HEATING(60 DEG. BASE)	1302	1028	896	543	273	80	0	15	152	471	873	1231	6864	30
HEATING(55 DEG. BASE)	1147	888	741	393	138	17	0	0	62	320	723	1076	5505	30
COOLING(65 DEG. BASE)	0	0	0	0	0	7	71	39	0	0	0	0	117	30
PRECIPITATION (INCHES)	.92	.62	.79	.77	.79	.82	1.04	1.03	1.04	.84	.66	.92	10.24	30
SNOWFALL (INCHES)	11.2	6.2	7.3	3.8	1.3	.1	0.0	0.0	.6	1.9	5.8	10.0	48.2	30

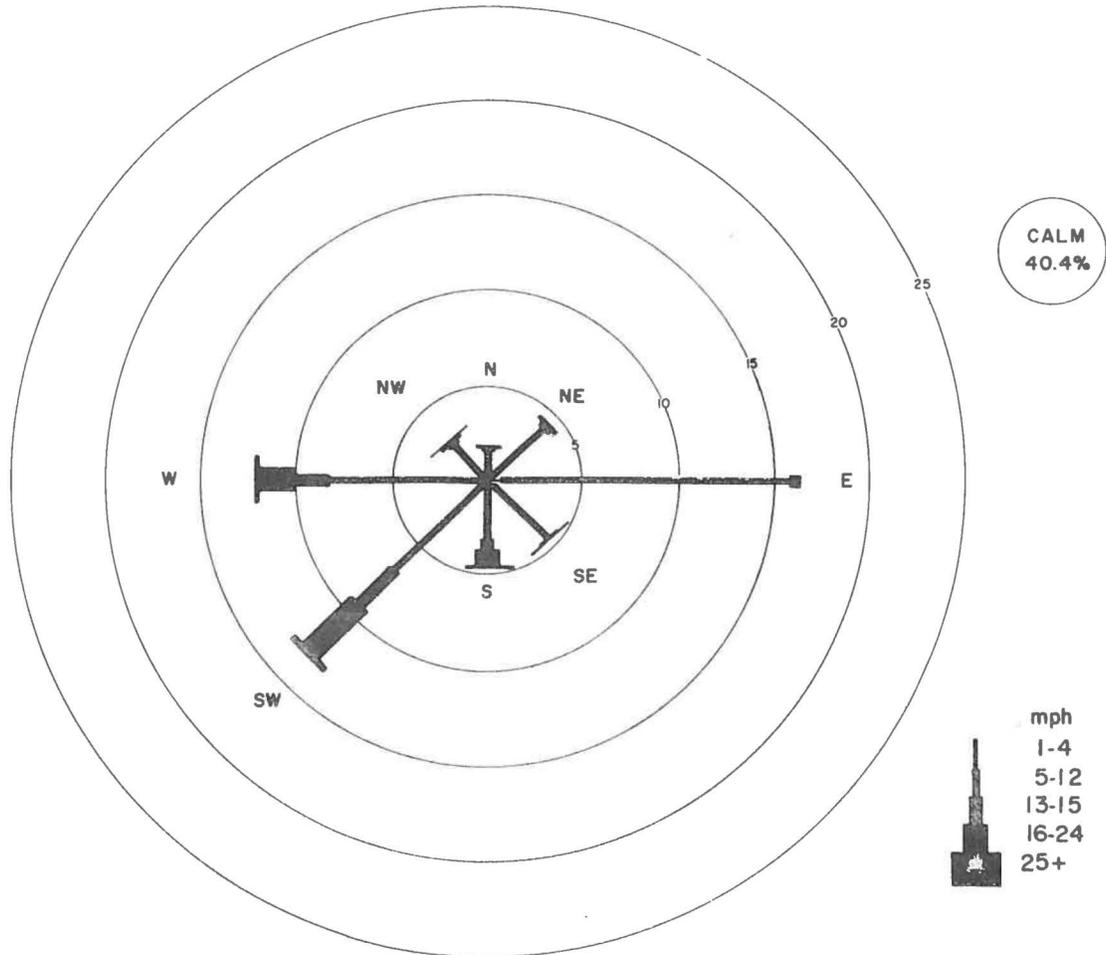
EAGLE, COLORADO - - WIND SUMMARY

Summary period: January 1969 - December 1973. Summary based on 14,608 observations, 8 observations per day at 3-hour intervals.

Location: Eagle County Airport located 5 miles W of Eagle on mesa 200 feet above river. Ground elevation 6497 feet.

Anemometer height: estimated at 50 feet
(above ground)

Seasonal variations: No month by month summaries are available at this time. However, the dominant characteristic of wind in the Eagle area is the distinct diurnal variation of wind direction. At night the winds typically blow from the E (down the valley) while during the day W or SW winds prevail (up the Eagle River valley).



Annual Wind Rose

FORT COLLINS

CLIMATE

Fort Collins is located in north central Colorado near the foothills on the eastern slope of the Rocky Mountains. The climate is characterized by moderate temperatures, light precipitation, and light winds interrupted occasionally by strong chinook winds. The average monthly temperature varies from 27° F in January to 71° in July. Winter temperatures are moderated by the sporadic occurrences of warm chinook winds. The average annual precipitation is 14.47 inches, most of which falls during the growing season. Afternoon thundershowers occur frequently during the summer months but they are usually quite light. Seasonal snowfall averages about 51 inches, but persistent snowcover is unusual. March is typically the snowiest month.

DESCRIPTION OF SOLAR RADIATION DATA

Measurements of solar radiation have been made since 1975 in support of research activities at the Colorado State University Department of Atmospheric Science. Instrument calibrations are performed annually at the National Calibration Facility in Boulder and maintenance is performed regularly. Problems with the data storage/recovery system have resulted in some missing data, but the overall data quality is excellent.

FORT COLLINS

ELEVATION 5279 FEET MSL LATITUDE 40 DEG 35 MIN LONGITUDE 105 DEG 8 MIN

SOURCE OF SOLAR RADIATION DATA -- COLORADO STATE UNIVERSITY, DEPARTMENT OF ATMOSPHERIC SCIENCE

INSTRUMENTATION -- EPPLEY PRECISION SPECTRAL PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, MAY 1975-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT COLORADO STATE UNIVERSITY MAIN CAMPUS WEATHER STATION. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN WIND SPEED OBTAINED FROM 1893-1957 DATA. AVERAGE STATION PRESSURE AT ELEVATION 5004 FEET BASED ON 1887-1957 DATA.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.69	11.39	16.64	19.56	20.98	25.01	23.30	20.58	18.04	13.79	9.12	7.65	16.23	6
HEMISPHERIC (BTU/SQFT DAY)	765	1003	1466	1723	1848	2203	2052	1813	1589	1215	803	674	1429	6
(HEMISPHERIC / ETR) RATIO	.57	.55	.60	.56	.52	.59	.57	.56	.60	.60	.55	.56	.57	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	14.26	15.95	20.32	20.74	20.43	23.43	22.14	20.86	20.56	18.31	14.02	13.05		
LATITUDE	16.48	17.48	21.03	20.04	18.91	21.20	20.20	19.69	20.58	19.63	15.88	15.26		
LATITUDE + 15 DEG.	17.73	18.03	20.59	18.36	16.59	18.13	17.44	17.62	19.51	19.85	16.82	16.57		
VERTICAL	16.60	15.49	15.53	11.55	9.32	9.37	9.30	10.36	13.46	16.24	15.29	15.79		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	68.0	75.0	80.0	84.0	90.0	102.0	102.0	99.0	95.0	87.0	77.0	73.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	40.6	45.1	50.2	60.1	69.5	80.0	85.8	83.3	75.4	64.9	50.4	43.7		30
MEAN TEMP.	26.9	31.8	36.7	46.4	56.1	65.6	71.4	68.9	60.3	49.9	36.8	30.4	48.4	30
AVERAGE MINIMUM TEMP. (DEG F)	13.2	18.5	23.3	32.7	42.7	51.2	56.9	54.5	45.2	34.8	23.2	17.1		30
EXTREME MINIMUM TEMP. (DEG F)	-32.0	-41.0	-23.0	-8.0	25.0	33.0	40.0	39.0	21.0	8.0	-17.0	-18.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1184	960	918	558	297	101	7	12	175	477	834	1076	6599	30
COOLING(65 DEG. BASE)	0	0	0	0	5	80	187	133	25	0	0	0	430	30
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	7.3	6.3	12.2	6.5	1.5	0.0	0.0	0.0	.6	2.9	6.9	6.7	50.9	30
AVERAGE WIND SPEED (MPH)	6.4	6.6	7.5	7.8	6.6	5.4	4.7	4.6	4.9	5.3	5.9	5.9	6.0	65
AVERAGE STATION PRESSURE (MB)	844.5	844.4	843.4	844.2	844.8	849.1	849.2	848.3	847.8	847.1	845.4	846.2	846.2	71

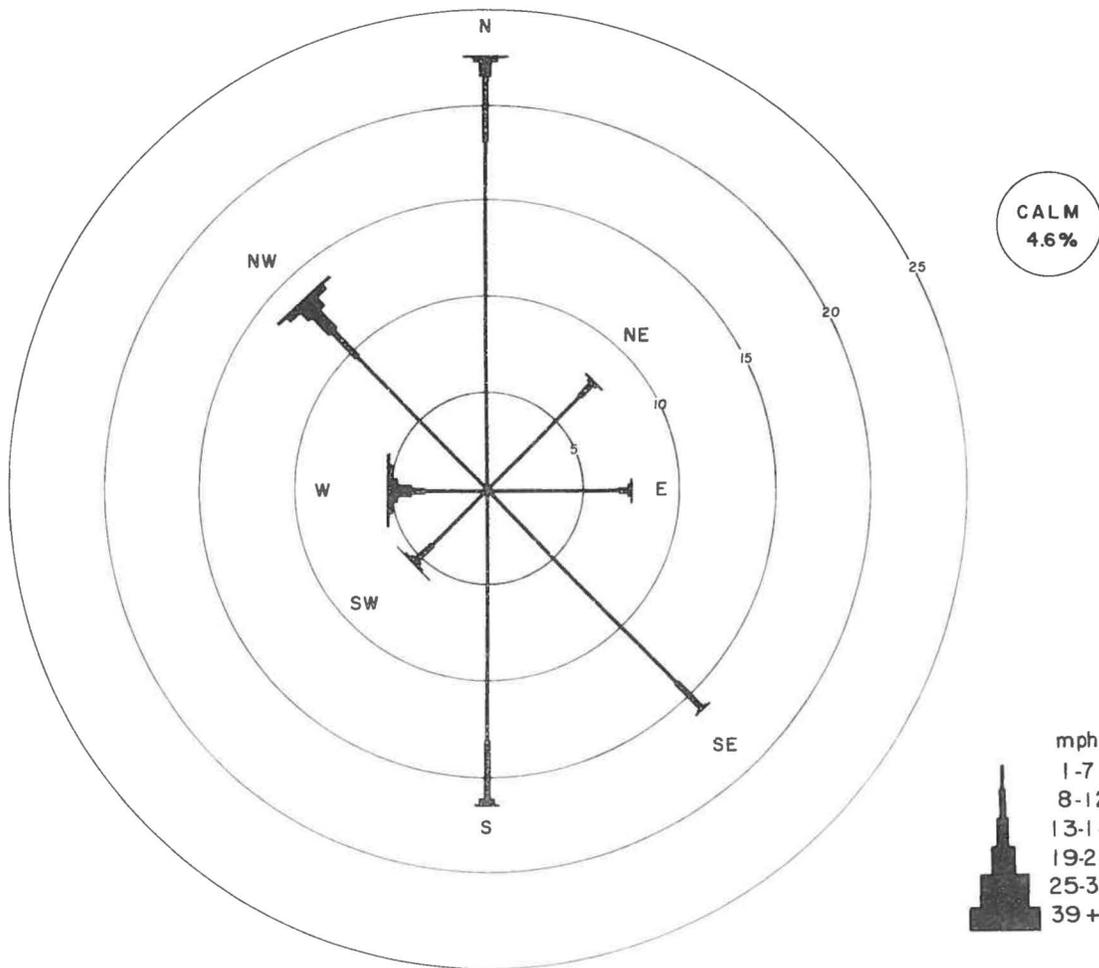
FORT COLLINS, COLORADO - - WIND SUMMARY

Summary period: January 1954 - December 1963. Summary based on 42,510 observations, 12 observations per day at 2-hour intervals.

Location: Colorado State University main campus weather station. Ground elevation 5004 feet.

Anemometer height: 65 feet 1/54 - 12/63
(above ground)

Seasonal variations: Average wind speeds vary from about 5 mph in August to 8 mph in April. Although average wind speeds are quite light, strong W-NW winds (downslope winds) occur occasionally, particularly during winter and early spring. There is a distinct diurnal variation in wind direction throughout the year with NNW winds prevailing at night while SE winds prevail during the day.



Annual Wind Rose

GOLDEN

CLIMATE

Golden is located 12 miles west of downtown Denver nestled tightly against the eastern foothills of the Rocky Mountains. The climate is characterized by light precipitation, mild temperatures, and mostly light winds punctuated by occasional very strong chinook wind storms. The average monthly temperature varies from about 30° F in January to 72° in July. Occasional chinook winds help to moderate winter temperatures. Golden averages 62 inches of snowfall annually, but prolonged snowcover is unusual. March is typically the snowiest month. The average annual precipitation is about 15 inches with most of that occurring from April to September. Afternoon thunderstorms occur frequently throughout the summer, but May is typically the wettest month of the year.

DESCRIPTION OF SOLAR RADIATION DATA

A group within the Solar Energy Research Institute (U.S. Department of Energy) maintains solar monitoring facilities at its headquarters in Golden, Colorado. A LICOR-200S sensor is used, calibrated regularly at the National Calibration Facility in Boulder. Data quality are monitored closely and data summaries are prepared regularly. The period of record is short at this site, but the calibration standards and data quality are very good.

GOLDEN

ELEVATION 5705 FEET MSL LATITUDE 39 DEG 44 MIN LONGITUDE 105 DEG 9 MIN-

SOURCE OF SOLAR RADIATION DATA -- SOLAR ENERGY RESEARCH INSTITUTE, GOLDEN, COLORADO.

INSTRUMENTATION -- LICOR LI-200S

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, JANUARY 1980-DECEMBER 1981.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2.

CLIMATIC DATA -- ALL DATA TAKEN FROM NATIONAL WEATHER SERVICE COOPERATIVE OBSERVER RECORDS AT LAKEWOOD, COLORADO (ELEV. 5640). TEMPERATURE, PRECIPITATION, AND DEGREE DAY AVERAGES ARE FOR THE 1962-1980 PERIOD.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
HEMISPHERIC (MJ/SQM DAY)	8.00	10.95	14.18	18.74	18.21	24.99	22.58	19.18	16.95	13.28	8.96	5.92	15.16	2
HEMISPHERIC (BTU/SQFT DAY)	704	964	1249	1650	1604	2201	1989	1689	1493	1170	789	521	1335	2
(HEMISPHERIC / ETR) RATIO	.51	.52	.50	.53	.45	.59	.55	.52	.56	.57	.53	.42	.52	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	12.41	14.87	16.77	19.72	17.70	23.43	21.47	19.35	19.05	17.23	13.33	9.06		
LATITUDE	14.22	16.23	17.21	19.05	16.42	21.20	19.61	18.27	19.03	18.42	15.05	10.36		
LATITUDE + 15 DEG.	15.21	16.69	16.77	17.46	14.47	18.13	16.95	16.37	18.02	18.58	15.91	11.08		
VERTICAL	14.07	14.19	12.48	10.86	8.22	9.17	8.92	9.56	12.29	15.03	14.35	10.31		
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	67.0	74.0	84.0	86.0	92.0	98.0	100.0	98.0	94.0	89.0	79.0	74.0		19
AVERAGE MAXIMUM TEMP. (DEG F)	42.5	46.8	51.2	59.8	69.1	79.4	86.0	83.7	75.5	66.0	52.0	46.1		19
MEAN TEMP.	29.8	34.1	38.4	46.7	56.1	65.8	72.2	69.9	61.5	52.1	39.5	33.3	50.0	19
AVERAGE MINIMUM TEMP. (DEG F)	16.9	21.4	25.5	33.6	43.0	52.1	58.5	56.1	47.4	38.3	26.9	20.6		19
EXTREME MINIMUM TEMP. (DEG F)	-26.0	-6.0	-11.0	-1.0	12.0	27.0	37.0	41.0	20.0	7.0	-5.0	-17.0		19
DEGREE DAYS														
HEATING(65 DEG. BASE)	1087	866	819	542	284	76	9	15	147	397	758	977	5977	19
PRECIPITATION (INCHES)														
SNOWFALL (INCHES)	.47	.46	1.10	1.71	2.43	2.04	1.76	1.24	1.50	.92	.83	.48	14.94	19
	7.1	7.4	12.9	9.9	1.6	0.0	0.0	0.0	.5	4.4	10.0	9.0	62.8	19

GRAND JUNCTION

CLIMATE

Grand Junction is located in west central Colorado in a large valley at the junction of the Colorado and Gunnison Rivers. The climate is characterized by abundant sunshine, very low relative humidity, light precipitation, and large seasonal temperature variations. The average monthly temperature varies from 26° F in January to 79° in July. Summer temperatures in the 90's are very common, but winter temperatures below zero occur infrequently. Despite its interior continental location, Grand Junction has a long growing season averaging about 191 days. Average annual precipitation is only about 8 inches, and annual average snowfall is 26 inches. Precipitation is distributed quite evenly through the year. Heavy snowstorms and heavy thunderstorms are both quite rare.

DESCRIPTION OF SOLAR RADIATION DATA

The current Grand Junction station is part of the National Oceanic and Atmospheric Administration national solar radiation network which began operation in 1977. There has been a substantial amount of missing data from this station due to data recorder problems. However, the calibration standards and the data quality appear to be excellent.

GRAND JUNCTION

ELEVATION 4833 FEET MSL LATITUDE 39 DEG 7 MIN LONGITUDE 108 DEG 32 MIN

SOURCE OF SOLAR RADIATION DATA -- NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL WEATHER SERVICE. NATIONAL NETWORK

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, APRIL 1977 -JULY 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT GRAND JUNCTION WALKER FIELD. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN WIND SPEED, CLOUD COVER, AND POSSIBLE SUNSHINE OBTAINED FROM HOURLY OBSERVATIONS, 1947-1980. AVERAGE STATION PRESSURE AT ELEVATION 4839 FEET BASED ON 1973-1980 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1964-1980 DATA.

SOLAR RADIATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)

HEMISPHERIC (MJ/SQM DAY)	7.09	11.66	15.72	21.73	24.41	29.59	26.02	23.34	21.50	16.24	9.78	7.57	17.89	4
HEMISPHERIC (BTU/SQFT DAY)	625	1027	1385	1914	2150	2607	2292	2056	1894	1431	861	667	1575	4
(HEMISPHERIC / ETR) RATIO	.44	.55	.55	.61	.61	.70	.64	.63	.70	.69	.56	.52	.60	
COMPUTED TILTED SURFACES (MJ/SQM DAY)														
LATITUDE - 15 DEG.	10.45	15.81	18.68	22.99	23.76	27.67	24.71	23.64	24.56	21.51	14.51	12.08		
LATITUDE	11.84	17.30	19.26	22.26	21.96	24.90	22.50	22.34	24.73	23.24	16.45	14.04		
LATITUDE + 15 DEG.	12.58	17.84	18.81	20.40	19.20	21.11	19.35	19.96	23.52	23.63	17.44	15.19		
VERTICAL	11.48	15.12	13.90	12.36	10.09	9.84	9.63	11.14	15.75	19.13	15.71	14.30		
CLIMATE														

EXTREME MAXIMUM TEMP. (DEG F)	60.0	67.0	81.0	86.0	95.0	103.0	105.0	103.0	98.0	88.0	75.0	64.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	35.4	44.1	53.7	64.6	75.7	87.4	93.5	89.7	81.4	68.1	50.6	38.4		30
MEAN TEMP.	25.5	33.5	41.7	51.5	61.9	72.3	78.9	75.6	67.0	54.9	39.5	28.3	52.6	30
AVERAGE MINIMUM TEMP. (DEG F)	15.5	22.7	29.8	38.3	48.1	57.1	64.3	61.5	52.7	41.6	28.4	18.2		30
EXTREME MINIMUM TEMP. (DEG F)	-23.0	-14.0	6.0	11.0	26.0	34.0	48.0	43.0	29.0	18.0	-2.0	-12.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1190	879	738	404	133	20	0	0	60	324	756	1101	5605	30
HEATING(60 DEG. BASE)	1035	739	583	266	54	0	0	0	17	195	606	946	4441	30
HEATING(55 DEG. BASE)	880	599	428	155	13	0	0	0	0	103	456	791	3425	30
COOLING(65 DEG. BASE)	0	0	0	0	47	209	425	322	126	11	0	0	1140	30
PRECIPITATION (INCHES)	.64	.54	.75	.71	.76	.44	.47	.91	.70	.87	.63	.58	8.00	30
SNOWFALL (INCHES)	7.2	4.0	3.9	1.3	.2	0.0	0.0	0.0	.1	.7	3.0	5.5	25.9	30
MEAN CLOUD COVER (PERCENT)	63	62	61	59	54	34	42	43	35	41	53	58	50	34
POSSIBLE SUNSHINE (PERCENT)	58	64	64	67	71	79	78	76	79	74	63	60	69	34
AVERAGE WIND SPEED (MPH)	5.5	6.6	8.3	9.6	9.6	9.8	9.3	9.0	9.0	7.9	6.6	5.8	8.1	34
AVERAGE STATION PRESSURE (MB)	854.2	853.7	848.8	849.3	849.2	851.2	853.1	852.8	853.4	854.4	854.5	855.6	852.5	8
AVG. REL. HUMID. (PERCENT) 5AM	78	71	61	54	51	43	47	49	50	55	68	76		17
AVG. REL. HUMID. (PERCENT) 5PM	65	46	34	27	24	19	21	22	24	32	46	60		17

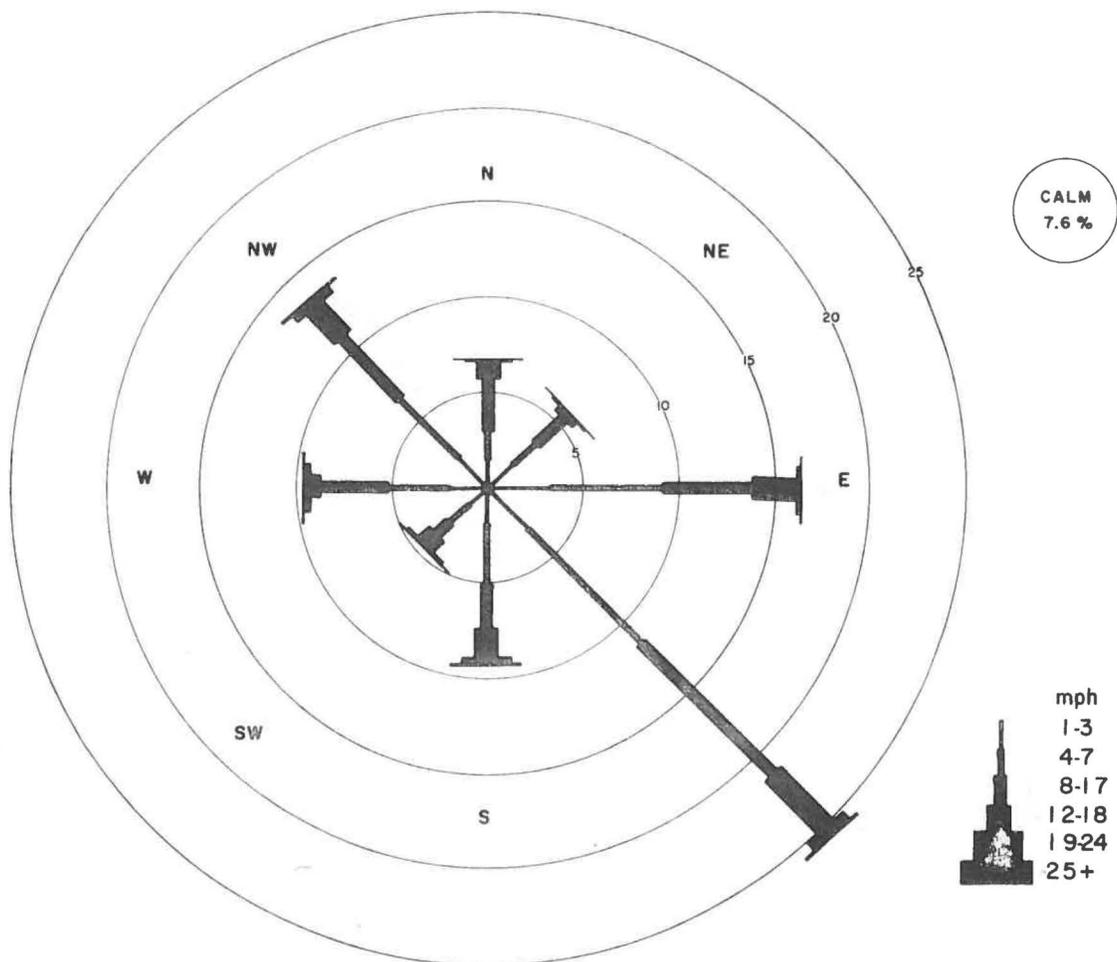
GRAND JUNCTION, COLORADO - - WIND SUMMARY

Summary period: January 1960 - December 1964. Summary based on 43,795 hourly observations, 24 observations per day.

Location: Grand Junction Walker Field (airport located on the NE edge of Grand Junction). Ground elevations 4825 feet.

Anemometer height: 59 feet 1/60 - 9/63
(above ground) 22 feet 9/63 - 12/64

Seasonal variations: Average wind speeds vary from about 6 mph during the winter to about 10 mph during spring and early summer. Wind speeds greater than 25 mph occur infrequently but are most likely in spring and summer. The prevailing wind direction is from the SE throughout the year, but a diurnal variation in wind direction is often observed. SE winds prevail at night, while NW winds prevail during the afternoon.



Annual Wind Rose

LA JUNTA

CLIMATE

La Junta is located along the Arkansas River on the plains of southeastern Colorado. The climate is characterized by abundant sunshine, light precipitation, low relative humidity, and large temperature variations. The average monthly temperature varies from 29° F in January to 79° in July. The diurnal temperature range (difference between the daily maximum and minimum temperature) is large and often exceeds 30 degrees throughout the year. Winter temperatures are relatively mild despite occasional invasions of Arctic air which sweep down across the Great Plains. Summer temperatures are hot and daytime temperatures above 100° are common.

Annual precipitation averages about 11 inches, most of which falls during the growing season. May and July are typically the wettest months. Thunderstorms account for much of the summer precipitation. Winter precipitation is scant and the seasonal snowfall averages 25 inches.

LA JUNTA

ELEVATION 4190 FEET MSL LATITUDE 38 DEG 3 MIN LONGITUDE 103 DEG 31 MIN

NO SOLAR RADIATION DATA AT THIS TIME.

CLIMATIC DATA -- ALL DATA COLLECTED AT LA JUNTA AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1951-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1951-1980 DATA. MEAN WIND SPEEDS OBTAINED FROM 1942-1970 HOURLY OBSERVATIONS.

SOLAR RADIATION *****	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD (YEARS)
CLIMATE *****														
EXTREME MAXIMUM TEMP. (DEG F)	76.0	80.0	90.0	92.0	100.0	108.0	109.0	106.0	103.0	95.0	85.0	81.0		30
AVERAGE MAXIMUM TEMP. (DEG F)	43.4	50.0	56.5	68.1	78.0	89.6	94.3	91.6	83.0	71.8	55.1	46.6		30
MEAN TEMP.	29.2	35.4	41.5	52.9	63.0	73.9	79.1	76.5	67.6	55.7	40.5	32.4	54.0	30
AVERAGE MINIMUM TEMP. (DEG F)	14.9	20.8	26.5	37.6	48.0	58.1	63.9	61.4	52.2	39.6	25.9	18.1		30
EXTREME MINIMUM TEMP. (DEG F)	-22.0	-19.0	-17.0	10.0	22.0	39.0	48.0	48.0	30.0	14.0	-11.0	-20.0		30
DEGREE DAYS														
HEATING(65 DEG. BASE)	1103	831	721	365	129	15	1	2	63	298	727	1005	5260	30
PRECIPITATION (INCHES)														
PRECIPITATION (INCHES)	.31	.26	.63	1.06	1.80	1.10	2.12	1.42	.84	.71	.50	.27	11.02	30
SNOWFALL (INCHES)														
SNOWFALL (INCHES)	4.9	3.9	5.5	2.0	.1	0.0	0.0	0.0	0.0	1.1	3.0	4.3	24.8	30
AVERAGE WIND SPEED (MPH)														
AVERAGE WIND SPEED (MPH)	8.0	8.6	9.9	9.8	9.3	9.4	7.8	7.6	7.6	7.2	7.8	7.7	8.4	29

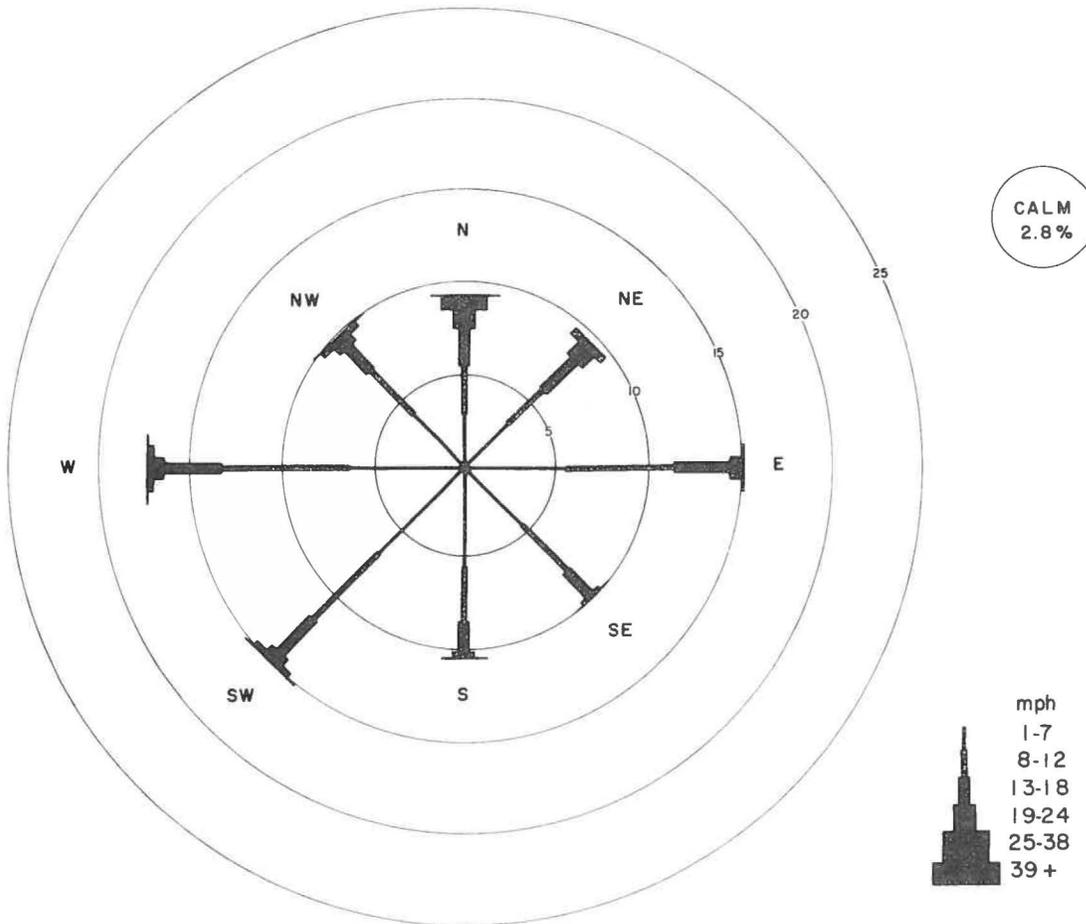
LA JUNTA, COLORADO - - WIND SUMMARY

Summary period: November 1942 - June 1945, June 1948 - December 1954.
 Summary based on 80,713 hourly observations, 24 observations per day.

Location: La Junta Airport (located 5 miles NE of La Junta). Ground elevation 4190 feet.

Anemometer height:	81 feet	11/42 - 4/43	96 feet	5/43 - 1/54
(above ground)	15 feet	1/48 - 8/50	40 feet	8/50 - 12/54

Seasonal variations: Average monthly wind speeds vary from 7 mph in October to 10 mph in March and April. Strong winds occur most frequently during the spring and mostly blow from W-N. The prevailing wind direction during the winter is from the WSW and is especially dominant during December and January. Wind direction is more variable during the summer, but ESE winds prevail.



Annual Wind Rose

PUEBLO

CLIMATE

Pueblo is located east of the Rocky Mountains at the junction of the Arkansas and Fountain Rivers. The climate is characterized by abundant sunshine, low relative humidity, light to moderate winds, large day to night temperature variations, and light precipitation. The average monthly temperature varies from 29° F in January to 77° in July. The diurnal temperature range is large and often exceeds 30 degrees throughout the year. The average annual precipitation is only about 11 inches, most of which falls during the growing season. Afternoon thundershowers account for much of the summer precipitation. Winter precipitation is scant and falls mostly as snow. The average annual snowfall is about 30 inches. Persistent snowcover is rare.

DESCRIPTION OF SOLAR RADIATION DATA

The Public Service Company of Colorado established a solar radiation measurement site in Pueblo early in 1977. It is a part of an extensive network in the Southwest established for the purpose of supplying solar radiation data to public utilities who use the information for heating load calculations and for design and evaluation of solar energy projects. A spectrolab SR-75 pyranometer is used to measure hemispheric radiation. A regular maintenance schedule is employed and thorough calibrations have been scheduled at 6-month intervals (Yinger, 1978). The data quality at this station appears to be excellent.

PUEBLO

ELEVATION 4860 FEET MSL LATITUDE 38 DEG 16 MIN LONGITUDE 104 DEG 37 MIN

SOURCE OF SOLAR RADIATION DATA -- PUBLIC SERVICE COMPANY OF COLORADO

INSTRUMENTATION -- SPECTROLAB MODEL SR-75 PYRANOMETER

OBSERVED SOLAR RADIATION DATA -- AVERAGE DAILY TOTAL HEMISPHERIC RADIATION ON A HORIZONTAL SURFACE, MARCH 1977-DECEMBER 1980.

TILTED SURFACE RADIATION DATA -- CALCULATED FROM THE OBSERVED HORIZONTAL DATA USING THE METHOD DEvised BY LIU AND JORDAN (1960). VALID FOR SOUTH-FACING SURFACES. REFLECTIVITY = 0.2

CLIMATIC DATA -- ALL DATA COLLECTED AT PUEBLO MEMORIAL AIRPORT. TEMPERATURE AND PRECIPITATION AVERAGES ARE FOR THE 1954-1980 PERIOD. DEGREE DAY AVERAGES BASED ON 1941-1970 DATA. MEAN CLOUD COVER AND POSSIBLE SUNSHINE OBTAINED FROM HOURLY OBSERVATIONS 1941-1980. MEAN WIND SPEED BASED ON 1944-1980 DATA. AVERAGE STATION PRESSURE AT ELEVATION 4720 FEET BASED ON 1972-1977 DATA. RELATIVE HUMIDITY AVERAGES BASED ON 1965-1980 DATA.

SOLAR RADIATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	RECORD
*****														(YEARS)
HEMISPHERIC (MJ/SQM DAY)	9.67	12.36	17.02	21.16	23.32	26.04	25.49	22.96	20.33	15.32	9.99	8.78	17.70	4
HEMISPHERIC (BTU/SQFT DAY)	851	1089	1499	1864	2054	2294	2245	2023	1791	1349	879	773	1559	4
(HEMISPHERIC / ETR) RATIO	.58	.57	.59	.59	.58	.62	.62	.62	.65	.64	.56	.59	.60	
COMPUTED TILTED SURFACES														
(MJ/SQM DAY)														
LATITUDE - 15 DEG.	14.86	16.60	20.19	22.25	22.69	24.43	24.22	23.19	22.90	19.73	14.49	14.02		
LATITUDE	17.19	18.21	20.87	21.54	20.99	22.09	22.07	21.92	23.00	21.21	16.41	16.43		
LATITUDE + 15 DEG.	18.51	18.80	20.43	19.76	18.38	18.86	18.99	19.60	21.85	21.49	17.38	17.86		
VERTICAL	17.11	15.84	14.94	11.80	9.57	9.04	9.30	10.77	14.46	17.19	15.56	16.85		
CLIMATE														

EXTREME MAXIMUM TEMP. (DEG F)	78.0	81.0	84.0	89.0	98.0	106.0	106.0	104.0	99.0	92.0	84.0	82.0		27
AVERAGE MAXIMUM TEMP. (DEG F)	44.4	50.1	55.8	66.3	76.3	87.4	92.3	89.5	81.4	70.7	55.9	48.6		27
MEAN TEMP.	28.9	34.7	40.5	50.9	61.2	71.1	76.9	74.3	65.9	54.1	40.3	32.9	52.6	27
AVERAGE MINIMUM TEMP. (DEG F)	13.3	19.2	25.1	35.5	46.0	54.8	61.4	59.1	50.2	37.5	24.6	17.1		27
EXTREME MINIMUM TEMP. (DEG F)	-28.0	-31.0	-10.0	2.0	26.0	39.0	50.0	40.0	29.0	14.0	-14.0	-28.0		27
DEGREE DAYS														
HEATING(65 DEG. BASE)	1082	848	775	405	148	28	0	0	55	335	726	992	5394	30
HEATING(60 DEG. BASE)	927	708	620	270	60	7	0	0	11	205	576	837	4221	30
HEATING(55 DEG. BASE)	772	577	473	161	13	0	0	0	0	110	432	682	3220	30
COOLING(65 DEG. BASE)	0	0	0	6	27	199	353	295	91	10	0	0	981	30
PRECIPITATION (INCHES)	.28	.28	.69	1.00	1.45	1.23	1.86	1.83	.87	.82	.48	.31	11.10	27
SNOWFALL (INCHES)	5.4	4.1	6.9	3.1	.2	0.0	0.0	0.0	.8	1.3	3.4	4.5	29.7	27
MEAN CLOUD COVER (PERCENT)	52	55	54	57	57	45	47	47	39	40	48	50	49	40
POSSIBLE SUNSHINE (PERCENT)	75	74	75	74	73	79	78	78	80	79	74	73	76	40
AVERAGE WIND SPEED (MPH)	8.0	8.6	9.8	10.5	9.8	9.4	8.7	8.0	8.0	7.5	7.6	7.9	8.7	37
AVERAGE STATION PRESSURE (MB)	854.1	854.4	849.8	852.1	852.6	854.4	857.0	856.9	857.3	856.8	855.3	854.1	854.6	6
AVG. REL. HUMID. (PERCENT) 5AM	66	63	63	65	65	68	72	73	70	66	73	67		16
AVG. REL. HUMID. (PERCENT) 5PM	49	37	33	29	32	27	33	34	32	32	44	48		16

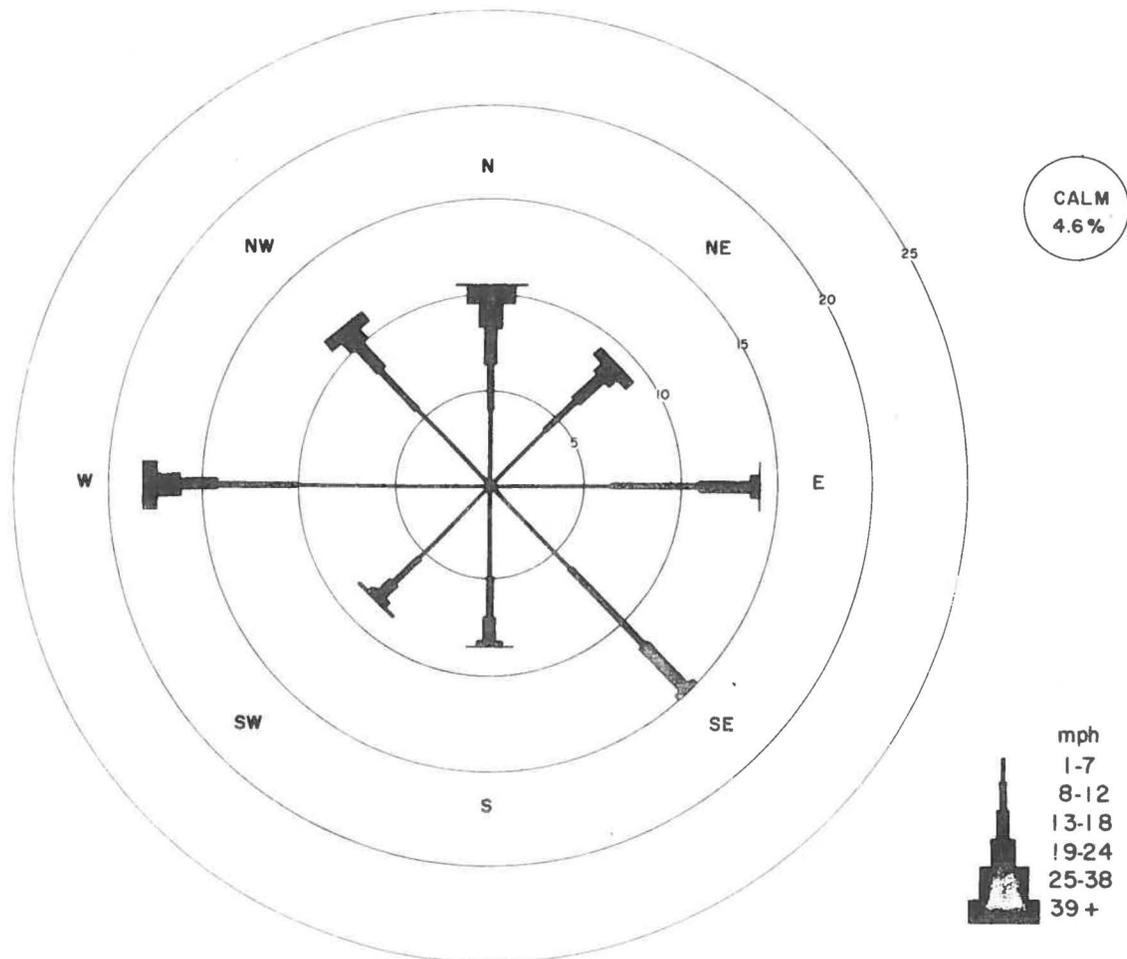
PUEBLO, COLORADO - - WIND SUMMARY

Summary period: July 1954 - February 1971. Summary based on 110,014 hourly observations, 24 observations per day through 1964 and 8 observations per day since then.

Location: Pueblo Memorial Airport (located along the Arkansas River about 6 miles E of downtown Pueblo). Ground elevation 4720 feet.

Anemometer height: 34 feet 6/54 - 3/62
(above ground) 22 feet 3/62 - 2/71

Seasonal variations: Average wind speeds vary from about 7 mph in fall and early winter to 11 mph in spring. Strong winds are most common in late winter and spring and usually blow from the W-N. There is a distinct diurnal variation in wind direction throughout the year. During the day, ESE (up valley) winds prevail, while at night W (down valley) winds usually occur.



Annual Wind Rose

IV. SOLAR CHARACTERISTICS IN COLORADO

In this section, most people would love to see beautiful contour maps of average solar radiation by month across Colorado. That would be possible if we had more data and if we knew exactly how total hemispheric radiation varied with elevation all across Colorado. Unfortunately, we don't. Drawing such maps without that additional information would almost certainly lead to misrepresentation. However, there are other important characteristics which can be examined using available data which lead to a better knowledge of Colorado's solar climate.

A. Seasonal Variations

Solar radiation variations can best be viewed and explained in comparison to the extraterrestrial radiation (ETR). ETR is related to the earth-sun geometry and is a direct function of latitude and calendar date. A solar constant of 1377 joules per meter² second was used for all calculations in this report. Seasonal and latitudinal variations of ETR over Colorado are shown in Figure 4. Conley (1982) presents an algorithm for calculating ETR which is adaptable to programmable calculators.

The solar radiation arriving at the top of the earth's atmosphere is reflected, scattered, and absorbed on its way through the atmosphere. The length of the path through the atmosphere (dependent on elevation, latitude, and time of day), the amount of gaseous absorbers of radiation in the atmosphere (water vapor, ozone, and carbon dioxide), and the amount of clouds and dust all control the portion of incoming energy which penetrates to the ground. The ratio of the average hemispheric radiation measured at the earth's surface divided by the ETR is commonly called the clearness index or factor.

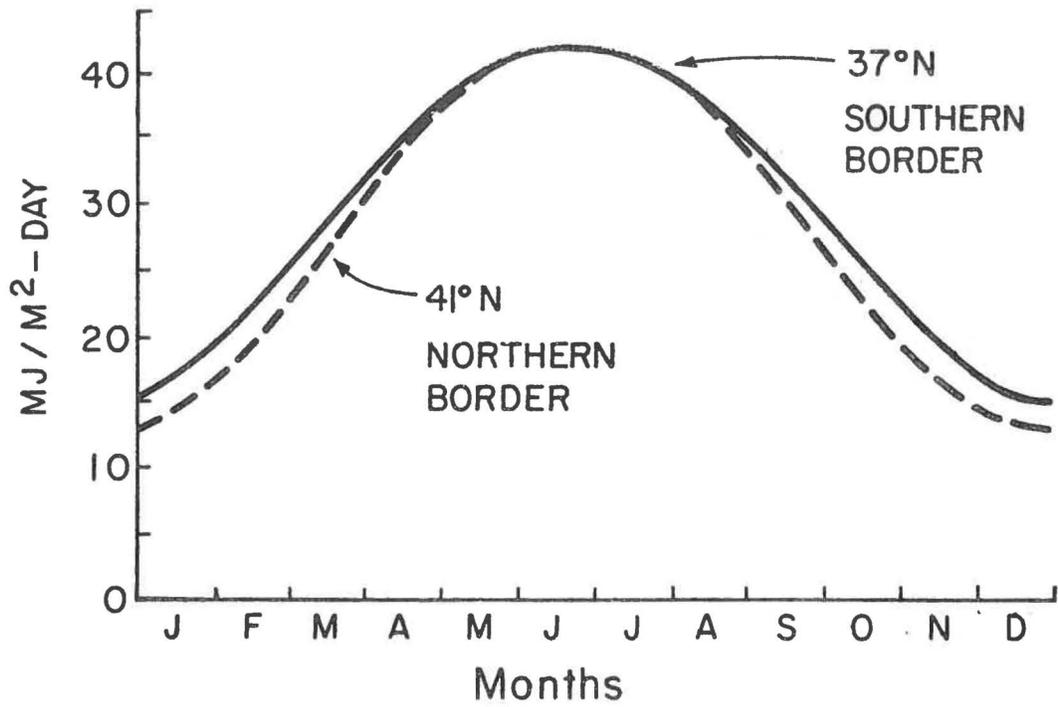


Figure 4. Extraterrestrial Radiation over Colorado.

Monthly average clearness index values based on existing observed solar radiation data for selected Colorado stations are shown in Figure 5. Not all areas of the state are represented and no data for high mountain areas are available. Nevertheless, significant seasonal and spatial variations are apparent.

The clearness index is closely correlated with mean cloud cover over the state. The clearness index, averaged over the state, generally increases slightly from midwinter to late winter - early spring. It then decreases to a low in May before rebounding rapidly in June to a state-wide peak between 0.6 and 0.7. It decreases again during July and August, the summer convection season. A sudden increase occurs from August to September as the state experiences its normal September - October clear period. The index then drops off again in November and December as winter sets in.

While this is the general pattern statewide, there are distinct spatial differences. Grand Junction, Alamosa - Center, and Buena Vista make an interesting comparative example. Grand Junction, which lies west of the mountain barrier, experiences low clearness index values during midwinter (less than 0.5 in January) as Pacific air masses bring abundant cloud cover and moisture to the mountains and western valleys. Meanwhile, the interior mountain valleys represented by Alamosa, Center, and Buena Vista are shielded by surrounding mountains and experience high midwinter clearness indexes in excess of 0.6. As summer arrives and moist air masses become a rarity from the mountain barrier westward, Grand Junction experiences the highest clearness index values in the state. Alamosa - Center show values which are almost as high. However, the Buena Vista area, adjacent to some of the highest mountains in the

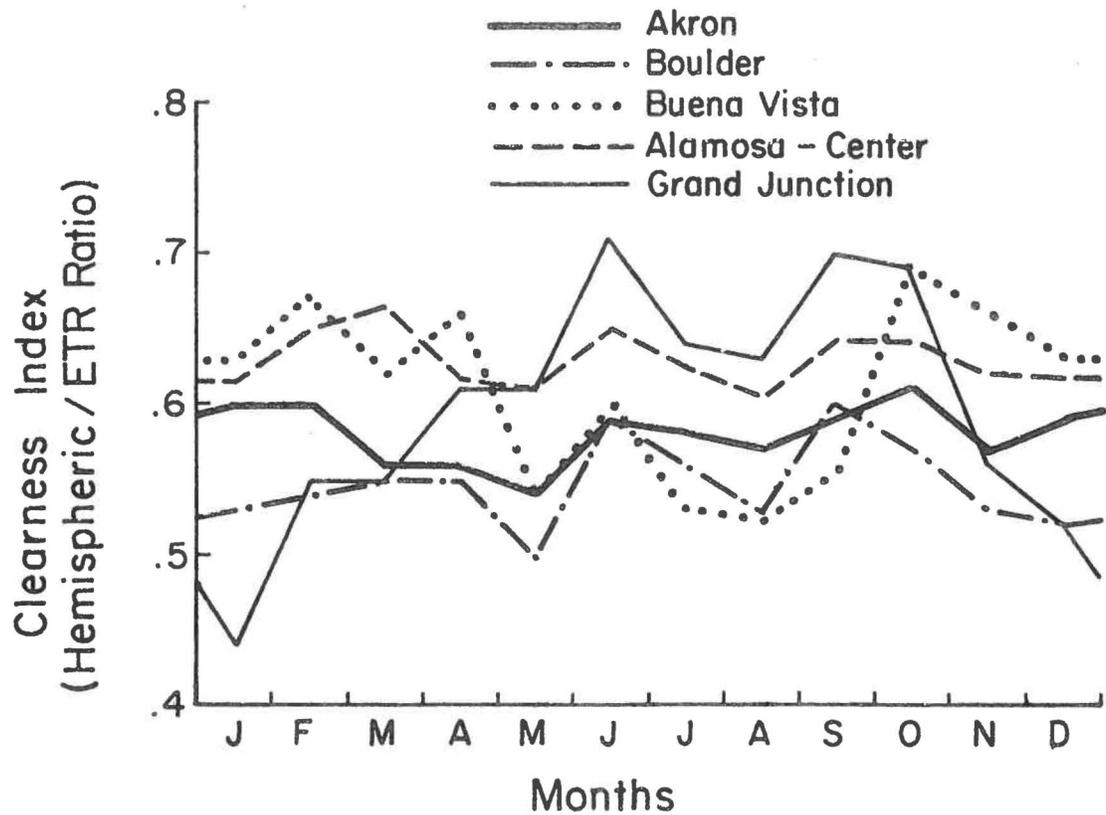


Figure 5. Monthly clearness index values (average monthly observed hemispheric radiation divided by the average monthly extraterrestrial radiation) for selected Colorado locations.

state where daytime thundershower activity is the rule in July and August, simultaneously see low index values (less than 0.55).

B. Daily Distributions of Hemispheric to ETR Ratios

Distributions of daily values of the hemispheric/ETR ratio for several stations in Colorado are shown in Figure 6. The general shape of these distributions are similar statewide. All stations show a peak somewhere from 0.65 to 0.75 corresponding to cloud free or nearly cloud free days. The distributions then end abruptly (limited by normal clear air attenuation) with very few days experiencing 80% or more of the ETR.

There are subtle differences between distributions. Alamosa - Center and Grand Junction, representative of the interior mountain valley and western slope valley locations, see more high hemispheric/ETR daily ratios than locations east of the mountains. Grand Junction, for example, averages 38% of the days annually with hemispheric/ETR ratios of 0.7 or higher compared to only 13% at Boulder. This is probably best explained by the fact that air masses, even during clear weather, generally contain less water vapor west of the mountain barrier than east, especially during the warm season.

A second interesting feature to compare is the relative frequencies of overcast days with dense cloud cover (days with hemispheric/ETR ratios less than 0.3). An average of 8 percent (29 days) of the days each year at Akron fall into this category. This compares to 9 percent at Grand Junction, 12 percent at Boulder, and only 2 percent at Alamosa - Center. The increase from Akron to Boulder is related to Boulder's proximity to the mountains. Easterly "upslope" winds, which usually accompany overcast conditions east of the mountains, are more likely to produce

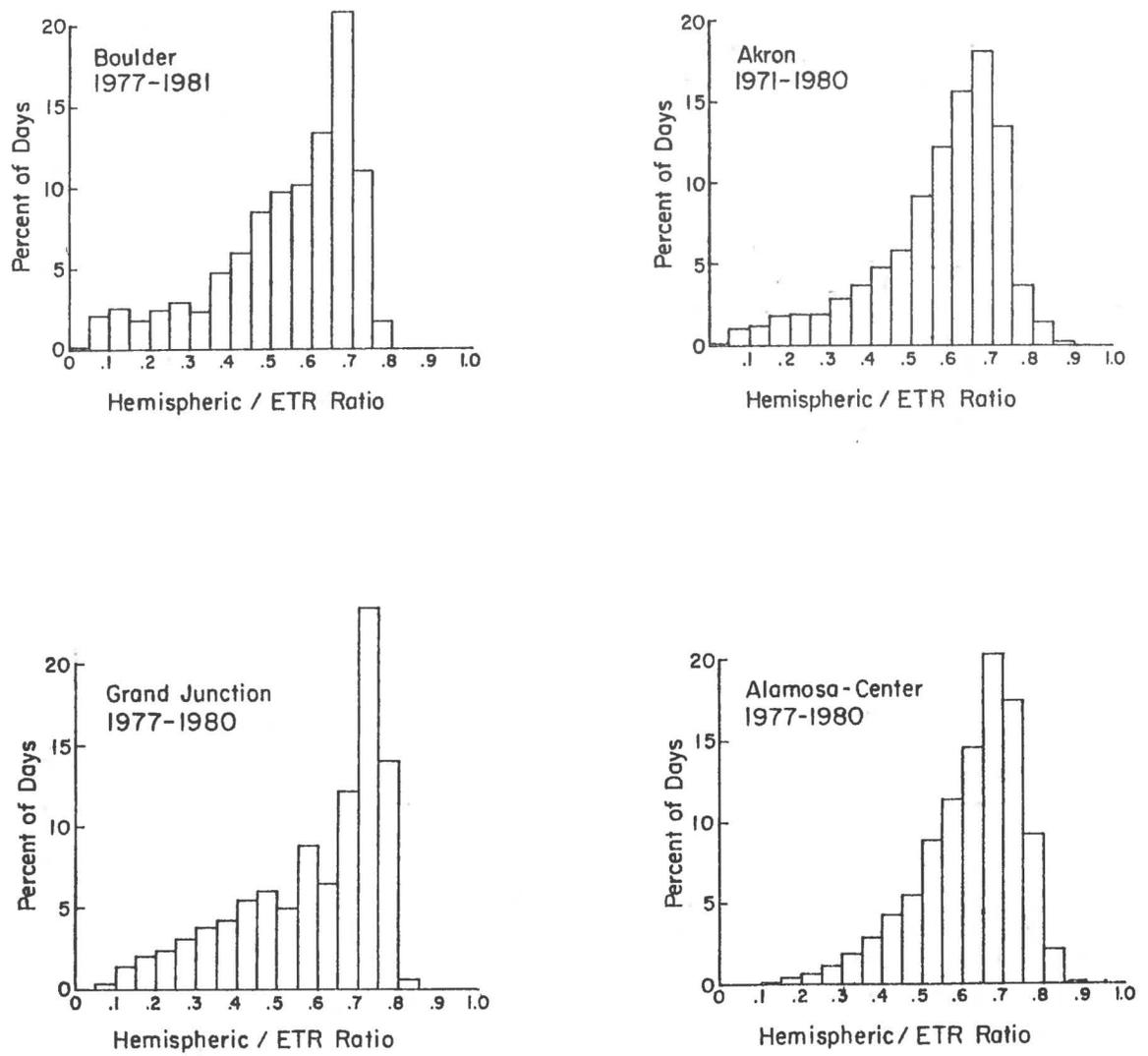


Figure 6. Frequency distributions of daily hemispheric solar radiation as a fraction of extraterrestrial radiation at selected Colorado locations.

heavy overcast conditions at the immediate base of the mountains than farther east on the plains or to the west in the foothills and mountains. These conditions occur most often in winter and spring but can occur any time throughout the year. The occurrences of dense cloud cover at Grand Junction are confined mostly to the midwinter period and correspond to occurrences of moist Pacific air masses and storm systems pushing eastward against the mountain barrier. High interior valleys surrounded by high mountains, such as the San Luis Valley (site of Alamosa and Center) are usually not greatly affected by either cloud producing situation, and occurrences of dense, prolonged cloud cover are rare.

C. Daily Distributions of Total Hemispheric Radiation

Distributions of actual daily total hemispheric radiation on a horizontal surface are perhaps more useful in determining the feasibility of harnessing solar energy. Figure 7 shows annual average distributions based on 3 years of daily data for selected stations.

At the Colorado locations shown, the majority of daily totals fall into the 8-24 mj/m^2 category. These locations all show a peak in the 8-12 mj/m^2 range which corresponds to clear winter days as well as some partly cloudy fall and spring days and cloudy summer days. The major differences in solar climates indicated by these graphs are: 1) More days with high daily totals at Alamosa - Center (13% of days with 28 mj/m^2 or more compared to 9% at Akron and 8% at Boulder), 2) More days with low daily totals at Boulder (19% of days with less than 8 mj/m^2 compared to 15% at Akron and 6% at Alamosa - Center).

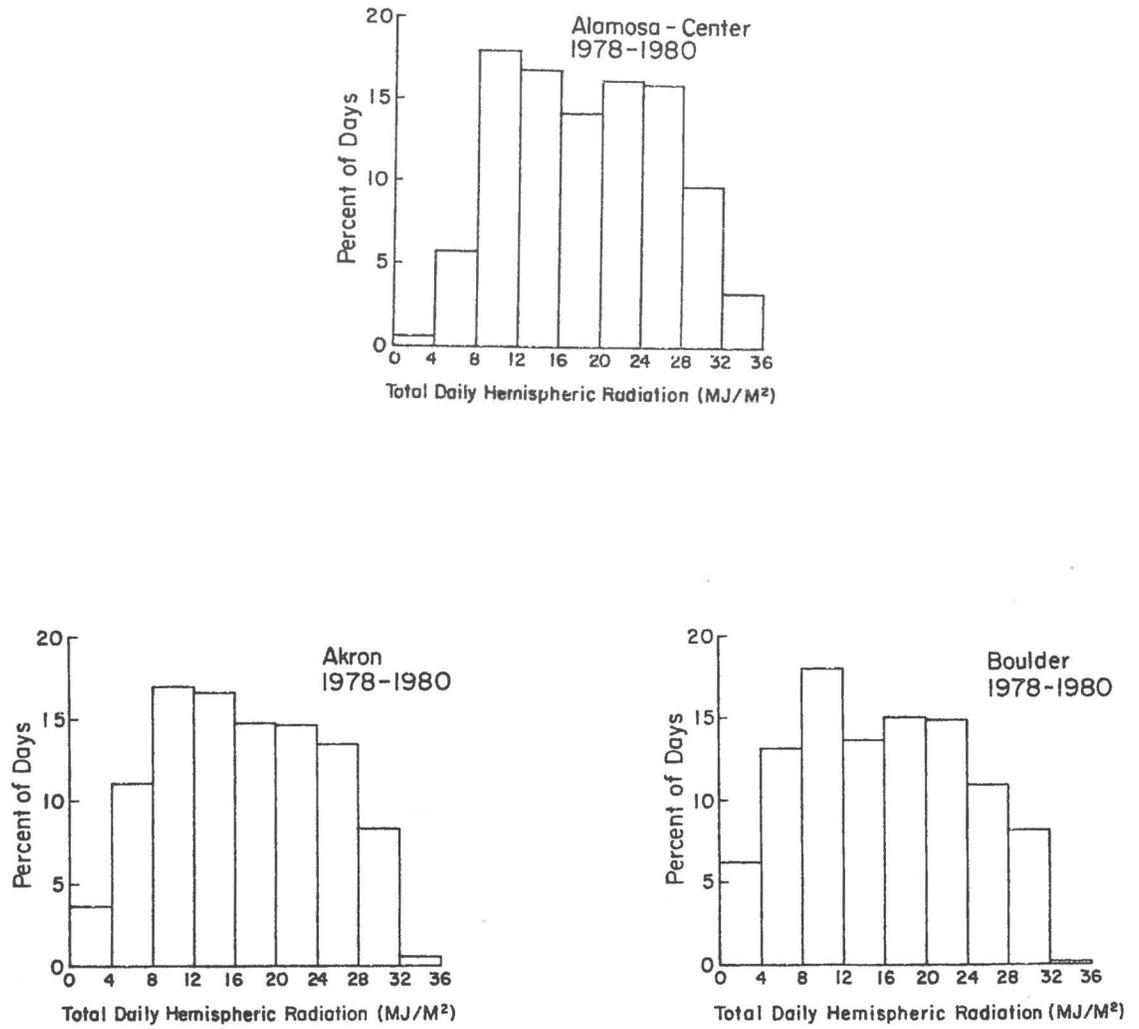


Figure 7. Annual frequency distributions of daily hemispheric radiation at selected Colorado locations based on 1978-1980 data.

D. Characteristic Energy Distribution Throughout the Day

Hourly totals of hemispheric radiation at Grand Junction and Boulder were compared, and the results are shown in Figure 8. The average daily distribution of energy for a typical winter month, January, shows no significant difference between the two sites other than a minor shift due to the difference in longitude between the two stations. The midsummer pattern is quite different, however. The average hourly radiation during the morning hours (sunrise to 1000 MST) is nearly identical at the two stations. Boulder reaches their midday peak prior to local solar noon and more than an hour before Grand Junction. The afternoon hourly solar radiation totals are all considerably lower at Boulder than at Grand Junction. The reason for this difference is the high frequency of midday and afternoon cloud cover in and near the mountains during the summer. Grand Junction is too far west to experience this afternoon phenomenon.

E. Conclusions

This section has attempted to describe some of the general characteristics and the variable nature of the solar radiation climate in Colorado based on available data. While variations obviously occur as a result of climatic differences, solar radiation is quite stable compared to other climatic elements. With only 4 years of high quality solar measurements for a few locations in Colorado, a good climatology can already be formed.

It must be remembered, however, that incoming solar radiation at the earth's surface remains one of the most difficult and expensive climatic elements to measure accurately. Despite our best efforts,

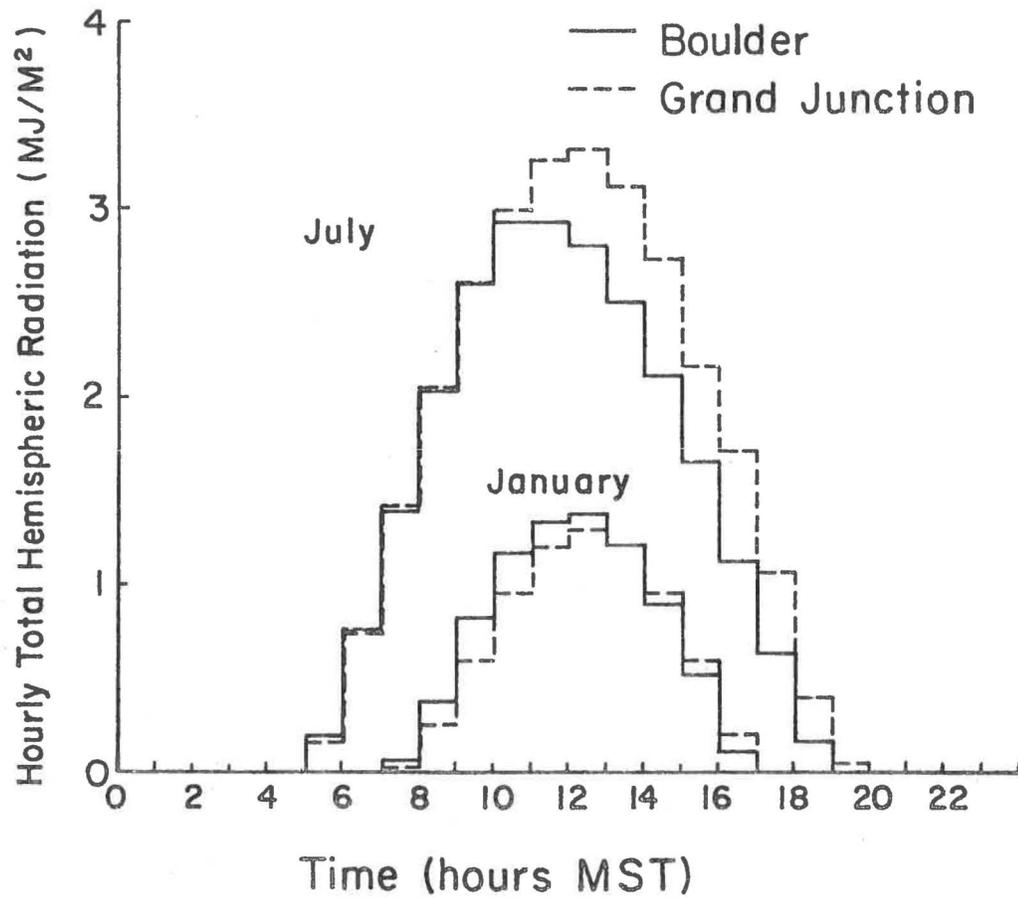


Figure 8. Comparison of average hourly hemispheric radiation for Boulder and Grand Junction, Colorado. Data are for January and July based on 1978-1980 hourly values.

questionable and inconsistent data may still be a part of this published summary. It is the best available data, however, and is likely to remain so for some time. Current attitudes among those groups who have been collecting data indicate that data collection may be halted or, at best, data quality will be compromised. We hope this will not be the case. We also will continue to push for more data sources in the foothills, mountains, and western valleys of Colorado. Measurements of solar radiation as a function of elevation would allow a much more complete description of the solar resource of this state.

V. APPENDICES

- A. Conversion Factors
- B. Monthly Solar Data
- C. Method for Estimating Tilted Surface Radiation
- D. Sun-Path Diagrams

Appendix A. CONVERSION FACTORS

	<u>To convert from</u>	<u>to</u>	<u>Multiply by</u>
Time:	years	hours	8,760
	days	seconds	86,400
Length:	miles (statute)	miles (nautical)	0.8684
	miles (statute)	kilometers	1.6093
	feet	meters	0.3048
	inches	centimeters	2.540
Area:	foot ²	meter ²	0.09290
	mile ²	kilometer ²	2.5898
	meter ²	centimeter ²	10 ⁴
Speed:	miles per hour	meters per second	0.4470
	knots	meters per second	0.5147
Pressure:	millibars	pounds per inch ²	0.0145
	millibars	kilograms per meter ²	10.19
	millibars	pascals	10 ²
Temperature:	degrees Fahrenheit (°F)	degrees Celsius (°C)	$T_{(°C)} = [T_{(°F)} - 32] / 1.8$
Energy:	BTU (thermochemical)	kilowatt-hour	2.9288×10^{-4}
	BTU	kilojoule	1.0544
	BTU	calorie	252.0
	kilowatt-hour	kilojoule	3600.
	kilowatt-hour	calorie	8.604×10^5
	kilojoule	calorie	239.0
Energy Density:	BTU per foot ²	kilowatt-hour per meter ²	3.1525×10^{-3}
	BTU per foot ²	kilojoule per meter ²	11.349
	BTU per foot ²	calorie per centimeter ² (langley)	0.27125
	Kilowatt-hour per meter ²	kilojoule per meter ²	3600.
	Kilowatt-hour per meter ²	calorie per centimeter ² (langley)	86.04
	Kilojoule per meter ²	calorie per centimeter ² (langley)	0.02390
	<u>To derive</u>	<u>from</u>	<u>Divide by</u>

Appendix B. MONTHLY SOLAR DATA

Actual monthly values of average daily hemispheric radiation for the period of record at each site are shown in the following tables. The hemispheric data are displayed in megajoules per meter² day. Beneath each radiation value is the number of days of data which were averaged to obtain that value. Average daily values, by month, are displayed regardless of how many days of data were missing.

Corresponding temperature, heating degree day, and cloud cover data (where available) are shown for all months having solar radiation measurements. This will facilitate actual month to month comparisons of solar data with some of the other climatic factors.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1971	AKRON												1971
HEMISPHERIC (MJ/SQM DAY)	9.39	11.80	17.19	21.24	22.00	26.07	23.92	22.39	18.26	14.57	10.04	7.52	17.03
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	38.4	39.1	48.3	59.2	64.5	85.3	85.5	88.1	72.8	63.5	49.9	42.4	61.4
AVERAGE MINIMUM TEMP. (DEG F)	15.2	17.4	23.2	34.2	41.1	52.9	55.9	58.4	44.8	34.3	25.2	17.3	35.0
HEATING DEGREE DAYS(65 BASE)	1178	1024	899	541	369	29	19	0	256	493	815	1083	6706
1972	AKRON												1972
HEMISPHERIC (MJ/SQM DAY)	9.05	12.99	16.04	19.21	22.59	25.28	22.56	21.16	17.98	11.18	10.00	8.76	16.40
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	38.1	49.1	58.7	61.9	69.8	82.3	83.8	83.8	75.3	61.3	34.7	26.8	60.5
AVERAGE MINIMUM TEMP. (DEG F)	12.0	21.1	27.6	32.6	43.5	55.0	55.2	57.2	47.4	36.4	18.5	8.0	34.5
HEATING DEGREE DAYS(65 BASE)	1229	859	671	522	281	13	50	24	145	494	1145	1469	6902
1973	AKRON												1973
HEMISPHERIC (MJ/SQM DAY)	9.73	13.73	14.78	19.09	22.33	24.76	21.56	20.70	14.92	13.98	8.54	7.98	16.01
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	29.8	37.4	45.3	52.9	66.4	81.3	84.2	89.9	71.7	66.1	47.7	39.6	59.4
AVERAGE MINIMUM TEMP. (DEG F)	12.3	16.4	27.1	30.2	41.7	52.9	56.8	58.8	46.0	38.0	25.0	16.4	35.1
HEATING DEGREE DAYS(65 BASE)	1352	1060	884	697	332	60	17	0	203	392	852	1140	6989
1974	AKRON												1974
HEMISPHERIC (MJ/SQM DAY)	9.91	12.86	15.36	20.10	23.91	23.73	22.94	20.45	16.87	12.72	9.19	8.01	16.34
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	31.0	44.1	52.9	60.3	76.0	83.0	91.4	81.9	74.6	67.4	49.3	42.3	62.9
AVERAGE MINIMUM TEMP. (DEG F)	10.5	20.3	26.8	33.4	43.3	53.1	60.3	53.9	44.1	38.0	24.0	15.9	35.3
HEATING DEGREE DAYS(65 BASE)	1368	911	772	539	186	66	0	21	209	375	847	1107	6401
1975	AKRON												1975
HEMISPHERIC (MJ/SQM DAY)	7.98	12.27	14.43	19.40	21.24	23.48	24.99	21.91	17.90	14.77	9.78	7.91	16.34
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	41.0	42.1	47.3	58.0	67.4	78.2	88.5	88.2	74.3	69.3	48.7	42.1	62.1
AVERAGE MINIMUM TEMP. (DEG F)	15.7	13.5	20.1	30.3	41.7	50.1	58.5	56.3	44.7	36.3	20.2	21.4	34.1
HEATING DEGREE DAYS(65 BASE)	1129	1032	962	621	320	95	0	14	201	381	910	1026	6691

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1976	AKRON												1976
HEMISPHERIC (MJ/SQM DAY)	9.16	12.47	16.81	17.29	21.64	24.72	23.84	19.40	16.25	14.48	9.63	8.20	16.16
NUMBER OF DAYS WITH DATA	30	27	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	41.9	50.9	51.3	60.9	69.4	81.3	89.0	86.8	75.1	61.3	49.2	45.9	63.6
AVERAGE MINIMUM TEMP. (DEG F)	16.3	23.6	20.2	34.7	41.8	51.5	59.9	55.9	49.0	31.9	21.9	18.7	35.5
HEATING DEGREE DAYS(65 BASE)	1106	801	898	509	291	63	0	18	145	566	874	1007	6278
1977	AKRON												1977
HEMISPHERIC (MJ/SQM DAY)	9.57	11.80	17.44	18.66	23.06	24.00	23.03	19.02	18.35	14.55	9.45	7.91	16.40
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	34.3	49.0	49.5	62.2	74.0	85.7	89.0	83.5	82.7	67.7	49.8	44.8	64.4
AVERAGE MINIMUM TEMP. (DEG F)	8.7	22.0	22.4	37.2	46.8	56.4	60.6	56.5	50.9	36.6	24.4	17.6	36.7
HEATING DEGREE DAYS(65 BASE)	1339	819	899	455	145	4	8	19	43	390	831	1040	5992
1978	AKRON												1978
HEMISPHERIC (MJ/SQM DAY)	8.84	10.60	16.61	18.19	19.75	23.04	23.03	19.66	19.34	14.53	7.97	8.95	15.87
NUMBER OF DAYS WITH DATA	31	26	31	30	31	30	31	31	30	31	30	27	
AVERAGE MAXIMUM TEMP. (DEG F)	31.5	32.8	54.9	61.1	67.0	81.5	90.8	84.1	80.6	66.9	46.5	31.1	60.7
AVERAGE MINIMUM TEMP. (DEG F)	9.5	13.0	26.3	34.6	42.1	53.8	59.5	54.7	49.6	36.9	24.1	9.0	34.4
HEATING DEGREE DAYS(65 BASE)	1372	1172	748	505	338	77	4	42	96	403	883	1387	7027
1979	AKRON												1979
HEMISPHERIC (MJ/SQM DAY)	9.58	13.00	14.28	22.08	21.44	25.67	24.83	22.73	20.24	14.45	10.61	8.40	17.28
NUMBER OF DAYS WITH DATA	30	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	26.0	43.0	50.2	61.6	64.8	78.7	85.7	82.2	79.8	66.3	41.2	42.1	60.9
AVERAGE MINIMUM TEMP. (DEG F)	4.0	18.5	27.3	35.2	42.0	52.1	58.5	54.8	51.9	38.3	19.5	20.3	35.9
HEATING DEGREE DAYS(65 BASE)	1545	951	809	488	357	91	1	36	71	393	1031	1040	6807
1980	AKRON												1980
HEMISPHERIC (MJ/SQM DAY)	9.11	12.42	15.33	20.40	23.07	28.25	27.03	22.25	19.98	15.10	9.53	7.28	17.48
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	32.3	42.3	45.5	56.8	67.4	86.0	90.3	86.5	79.7	64.8	52.0	50.4	62.8
AVERAGE MINIMUM TEMP. (DEG F)	12.2	19.4	22.3	33.0	42.7	54.3	61.6	56.6	49.7	35.4	27.1	23.4	36.5
HEATING DEGREE DAYS(65 BASE)	1319	982	957	598	306	30	0	9	93	456	756	866	6372

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN																									
1977													ALAMOSA													1977												
HEMISPHERIC (MJ/SQM DAY)					25.76	24.99	23.90	21.17	19.48	16.63	11.72	9.37																										
NUMBER OF DAYS WITH DATA	0	0	0	0	25	30	31	31	29	31	30	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	32.9	43.0	47.4	60.8	69.2	81.2	81.2	80.2	74.4	65.8	49.9	43.5	60.8																									
AVERAGE MINIMUM TEMP. (DEG F)	-6.6	4.0	11.2	25.1	32.0	41.5	49.3	47.5	38.9	23.8	16.1	5.4	24.0																									
HEATING DEGREE DAYS(65 BASE)	1598	1155	1097	655	440	104	19	51	246	621	951	1252	8189																									
MEAN CLOUD COVER (PERCENT)	46	52	48	59	43	58	53	59	39	26	45	53	48																									
1978													ALAMOSA													1978												
HEMISPHERIC (MJ/SQM DAY)	10.20	13.80	24.72	23.58	24.61	29.48	29.42	24.93	22.15	19.53	11.64	10.83	20.41																									
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	20	31	30	2	24	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	39.6	42.8	55.0	62.0	65.0	80.9	83.6	80.4	75.2	65.4	46.8	25.0	60.1																									
AVERAGE MINIMUM TEMP. (DEG F)	5.9	7.8	16.8	24.5	31.1	40.7	47.1	40.0	35.8	23.3	18.4	-9.0	23.5																									
HEATING DEGREE DAYS(65 BASE)	1302	1103	900	647	516	126	18	141	278	632	966	1762	8391																									
MEAN CLOUD COVER (PERCENT)	59	50	53	50	49		41	42	30	35	56	43	0																									
1979													ALAMOSA													1979												
HEMISPHERIC (MJ/SQM DAY)	11.27	16.23	19.12	23.53	24.70	28.77	27.55	24.62	21.47	16.76	12.60	10.91	19.79																									
NUMBER OF DAYS WITH DATA	31	28	31	30	30	30	31	30	30	31	28	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	24.2	30.8	44.2	59.0	66.8	76.7	82.9	78.4	76.5	66.2	39.5	37.6	56.9																									
AVERAGE MINIMUM TEMP. (DEG F)	-12.3	-9.6	16.5	23.7	34.6	39.3	44.2	43.8	35.3	25.2	2.4	.6	20.3																									
HEATING DEGREE DAYS(65 BASE)	1827	1518	1069	704	438	203	57	127	267	590	1312	1438	9550																									
MEAN CLOUD COVER (PERCENT)	56	48	58	53	67	37	44	38	29	51	40	42	46																									
1980													ALAMOSA													1980												
HEMISPHERIC (MJ/SQM DAY)	11.82	15.92	19.14	23.02	26.03	31.51	28.04	23.59	21.78	17.22	13.04	9.83	20.08																									
NUMBER OF DAYS WITH DATA	30	27	31	30	31	30	29	30	29	31	30	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	36.6	46.0	46.9	55.8	64.0	82.8	85.8	80.5	76.1	60.6	51.8	48.6	61.3																									
AVERAGE MINIMUM TEMP. (DEG F)	4.9	12.7	13.5	20.6	32.9	41.0	48.1	43.3	35.9	20.2	8.9	7.6	24.1																									
HEATING DEGREE DAYS(65 BASE)	1363	1029	1071	798	504	107	5	102	263	757	1031	1136	8166																									
MEAN CLOUD COVER (PERCENT)	56	49	54	49	58	28	39	46	29	33	39	54	44																									

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1977	ALBUQUERQUE												1977
HEMISPHERIC (MJ/SQM DAY)	10.85	15.16	19.63	24.11	27.67	27.38	27.27	24.46	19.36	17.11	12.81	10.32	19.68
NUMBER OF DAYS WITH DATA	30	26	30	30	31	30	30	29	29	29	30	27	
AVERAGE MAXIMUM TEMP. (DEG F)	41.6	55.1	57.9	70.5	79.1	91.4	91.9	89.8	82.4	73.8	61.0	53.5	70.7
AVERAGE MINIMUM TEMP. (DEG F)	18.0	26.2	28.4	42.5	49.2	59.6	65.2	65.0	56.3	44.0	31.8	27.2	42.8
HEATING DEGREE DAYS(65 BASE)	1084	675	669	250	61	0	0	0	1	192	551	757	4240
MEAN CLOUD COVER (PERCENT)	47	44	45	46	37	53	47	54	45	26	39	50	44
POSSIBLE SUNSHINE (PERCENT)	64	79	70	71	75	72	81	69	73	85	79	65	73
1978	ALBUQUERQUE												1978
HEMISPHERIC (MJ/SQM DAY)		13.78	18.55	26.04	25.52	29.52	28.15	25.26	21.20	16.96	10.10	9.84	
NUMBER OF DAYS WITH DATA	0	27	30	30	31	30	31	31	30	30	30	30	
AVERAGE MAXIMUM TEMP. (DEG F)	46.4	51.6	65.4	75.0	76.6	91.9	96.8	89.9	83.2	75.3	59.3	46.0	71.5
AVERAGE MINIMUM TEMP. (DEG F)	27.1	26.9	34.9	40.4	44.3	59.0	66.3	61.0	55.0	45.3	35.7	22.5	43.2
HEATING DEGREE DAYS(65 BASE)	870	713	454	215	175	2	0	0	20	167	521	945	4082
MEAN CLOUD COVER (PERCENT)	67	52	53	35	41	28	33	39	28	27	55	43	41
POSSIBLE SUNSHINE (PERCENT)	54	61	67	86	73	86	80	82	80	84	51	64	72
1979	ALBUQUERQUE												1979
HEMISPHERIC (MJ/SQM DAY)	10.31	15.00	18.17	24.04	24.97	27.68	26.68	24.84	20.96	17.91	12.35	10.95	19.49
NUMBER OF DAYS WITH DATA	28	24	29	26	30	30	31	31	30	29	29	27	
AVERAGE MAXIMUM TEMP. (DEG F)	43.2	55.2	64.2	73.5	78.5	89.1	96.1	90.9	87.3	78.1	53.8	52.4	71.9
AVERAGE MINIMUM TEMP. (DEG F)	22.5	27.0	32.6	40.2	48.8	57.5	65.0	63.2	57.3	44.8	28.1	22.9	42.5
HEATING DEGREE DAYS(65 BASE)	988	665	509	241	100	12	0	0	23	148	715	840	4241
MEAN CLOUD COVER (PERCENT)	57	49	48	45	53	34	42	36	34	40	36	38	42
POSSIBLE SUNSHINE (PERCENT)	58	73	66	70	68	79	79	79	78	84	75	80	74
1980	ALBUQUERQUE												1980
HEMISPHERIC (MJ/SQM DAY)	9.08	13.95	17.95	24.33	26.36	28.86	27.31	24.45	20.66	19.08	10.79	10.69	19.46
NUMBER OF DAYS WITH DATA	29	26	28	26	29	30	31	31	29	15	8	23	
AVERAGE MAXIMUM TEMP. (DEG F)	51.5	58.1	60.9	68.9	78.2	96.3	99.1	91.5	84.1	70.3	59.0	54.9	72.7
AVERAGE MINIMUM TEMP. (DEG F)	28.8	30.3	31.3	35.3	44.0	58.0	66.2	63.2	55.7	38.7	28.0	26.0	42.1
HEATING DEGREE DAYS(65 BASE)	763	595	577	379	139	2	0	0	6	335	640	752	4188
MEAN CLOUD COVER (PERCENT)	66	56	54	46	47	37	45	43	37	24	38	40	44
POSSIBLE SUNSHINE (PERCENT)	54	72	67	80	78	83	79	74	78	86	86	86	76

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN																									
1977													BOULDER													1977												
HEMISPHERIC (MJ/SQM DAY)	8.58	12.16	16.71	17.76	23.19	24.44	21.94	19.06	18.98	13.94	9.17	7.88	16.15																									
NUMBER OF DAYS WITH DATA	31	28	31	29	31	30	31	31	30	31	30	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	42.3	51.4	53.7	63.1	74.5	86.7	88.2	82.1	81.5	69.1	53.7	49.8	66.3																									
AVERAGE MINIMUM TEMP. (DEG F)	14.0	26.5	25.2	35.9	44.6	55.6	59.1	55.1	49.5	38.5	29.4	26.2	38.3																									
HEATING DEGREE DAYS(65 BASE)	1134	722	785	461	165	0	0	13	45	340	694	826	5185																									
1978													BOULDER													1978												
HEMISPHERIC (MJ/SQM DAY)	7.51	9.96	16.32	19.21	21.26	23.71	23.80	20.80	19.39	13.59	8.31	7.63	15.96																									
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	29																										
AVERAGE MAXIMUM TEMP. (DEG F)	38.6	39.9	56.6	62.8	70.6	81.4	89.4	85.4	81.1	69.5	52.4	40.7	64.0																									
AVERAGE MINIMUM TEMP. (DEG F)	15.7	19.6	29.9	35.6	41.9	51.0	57.9	53.6	48.8	38.5	28.0	16.3	36.4																									
HEATING DEGREE DAYS(65 BASE)	1165	980	669	469	284	91	0	4	86	332	737	1118	5935																									
1979													BOULDER													1979												
HEMISPHERIC (MJ/SQM DAY)	8.27	11.06	13.85	20.45	18.17	24.74	23.33	19.53	18.51	12.98	9.16	7.06	15.59																									
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	35.7	50.5	54.3	63.9			87.7	81.1	81.0	70.9	46.9	52.3																										
AVERAGE MINIMUM TEMP. (DEG F)	9.5	22.3	30.8	36.2			59.8	54.7	48.8	41.3	23.2	25.5																										
HEATING DEGREE DAYS(65 BASE)	1305	809	690	442	278	75	2	44	85	279	890	802	5701																									
1980													BOULDER													1980												
HEMISPHERIC (MJ/SQM DAY)	8.02	11.50	14.48	19.35	20.24	26.91	24.11	20.26	18.56	13.82	8.64	6.23	16.01																									
NUMBER OF DAYS WITH DATA	31	27	30	30	31	30	31	31	30	31	30	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	40.8	49.2	51.5	61.5	68.8	89.5	90.9	87.1	81.4	67.1	56.5	57.2	66.8																									
AVERAGE MINIMUM TEMP. (DEG F)	18.1	23.7	26.2	33.9	42.3	53.9	58.4	56.7	50.0	38.0	31.1	31.0	38.6																									
HEATING DEGREE DAYS(65 BASE)	1094	820	803	513	287	8	0	1	61	384	630	644	5245																									
1981													BOULDER													1981												
HEMISPHERIC (MJ/SQM DAY)	8.85	11.60	15.52	19.60	17.87	24.93	21.84	18.59	16.31	11.29	9.72	7.23	15.28																									
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31																										
AVERAGE MAXIMUM TEMP. (DEG F)	52.2	53.8	55.1	71.2	67.0	84.9	87.6	82.5	76.5	62.7	57.3	48.2	66.6																									
AVERAGE MINIMUM TEMP. (DEG F)	25.7	24.8	29.3	42.1	43.2	53.2	55.7	54.9	48.5	38.6	34.6	25.5	39.7																									
HEATING DEGREE DAYS(65 BASE)	800	714	702	252	306	27	4	14	34	436	563	866	4718																									

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1980	BUENA VISTA												1980
HEMISPHERIC (MJ/SQM DAY)										14.75	11.82	9.33	
NUMBER OF DAYS WITH DATA	0	0	0	0	0	0	0	0	0	14	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	38.1	43.3	43.6	51.6	61.0	79.4	83.7	79.6	72.8	60.7	48.2	49.9	59.3
AVERAGE MINIMUM TEMP. (DEG F)	10.0	15.3	17.6	25.4	34.2	42.4	48.9	46.0	40.2	27.2	16.3	22.4	28.8
HEATING DEGREE DAYS(65 BASE)	1260	1027	1058	786	533	133	19	84	246	645	976	886	7653
1981	BUENA VISTA												1981
HEMISPHERIC (MJ/SQM DAY)	10.24	13.79	18.11	23.05	21.84	25.10	21.88	19.22	16.82	17.09	11.33	9.00	17.29
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	45.1	45.7	45.9	62.3	62.4	79.9	78.5	76.8	72.2	58.8	52.5	41.6	60.1
AVERAGE MINIMUM TEMP. (DEG F)	13.3	13.3	20.8	31.9	35.6	45.8	50.2	47.2	40.9	31.5	22.6	12.9	30.5
HEATING DEGREE DAYS(65 BASE)	1102	983	975	529	487	88	38	111	248	611	817	1162	7151
1982	BUENA VISTA												1982
HEMISPHERIC (MJ/SQM DAY)	10.17	15.06	17.68	23.62	22.00								
NUMBER OF DAYS WITH DATA	30	28	31	30	21	0	0	0	0	0	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	38.0	38.9	46.3	56.6	61.7								
AVERAGE MINIMUM TEMP. (DEG F)	12.8	11.8	22.0	26.0	33.1								
HEATING DEGREE DAYS(65 BASE)	1227	1111	949	705	538								

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1968	CENTER											1968	
HEMISPHERIC (MJ/SQM DAY)	10.85	14.30	19.06	20.67	24.17	27.47	22.49	22.19	19.50	15.31	9.52	9.32	17.90
NUMBER OF DAYS WITH DATA	31	27	27	30	31	28	29	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	25.0	35.7	48.6	55.2	66.5	78.0	78.4	75.3	72.0	65.7	47.0	38.3	57.1
AVERAGE MINIMUM TEMP. (DEG F)	-10.3	5.2	16.6	22.6	33.4	42.4	47.2	44.5	34.0	27.4	15.0	2.5	23.4
HEATING DEGREE DAYS(65 BASE)	1780	1284	996	775	458	142	69	154	353	566	1012	1377	8966
1969	CENTER											1969	
HEMISPHERIC (MJ/SQM DAY)	9.45	12.83	17.09	21.88	23.76	25.57	23.13	22.05	17.12	13.23	10.86	8.58	17.13
NUMBER OF DAYS WITH DATA	31	28	31	30	30	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	42.4	43.5	47.6	62.4	71.5	72.1	81.0	82.1	73.1	54.1	50.3	37.0	59.8
AVERAGE MINIMUM TEMP. (DEG F)	8.9	7.9	14.7	27.5	36.2	40.1	49.3	47.9	39.0	25.7	14.7	5.2	26.4
HEATING DEGREE DAYS(65 BASE)	1211	1092	1042	594	340	258	27	30	261	772	969	1353	7949
1970	CENTER											1970	
HEMISPHERIC (MJ/SQM DAY)	9.98	12.53				26.11	24.57	21.55	18.87	15.69			
NUMBER OF DAYS WITH DATA	31	25	0	0	0	25	31	31	30	11	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	37.5	49.3	48.1	54.7	70.6	75.4	80.3	80.5		53.9	48.9	40.1	
AVERAGE MINIMUM TEMP. (DEG F)	2.7	13.4	16.5	20.8	34.4	39.5	47.6	46.7		22.0	15.0	4.1	
HEATING DEGREE DAYS(65 BASE)	1388	936	1006	810	380	231	44	53		830	983	1321	
1971	CENTER											1971	
HEMISPHERIC (MJ/SQM DAY)	9.25	13.01	18.28	20.45	24.67	26.02	23.58	24.43	20.87	15.78	11.49	9.07	18.07
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	30	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	37.8	39.7	50.5	58.5	63.8	75.6	77.4	76.5	69.5	58.8	43.8	32.0	57.0
AVERAGE MINIMUM TEMP. (DEG F)	1.9	6.1	13.7	21.5	29.8	38.5	43.5	44.0	34.1	25.7	12.4	4.1	22.9
HEATING DEGREE DAYS(65 BASE)	1394	1171	1013	742	555	232	141	137	390	699	1097	1448	9019
1972	CENTER											1972	
HEMISPHERIC (MJ/SQM DAY)	10.43	14.34	18.29	21.20	23.69	25.60	22.63	22.95	19.33	11.54	10.98	9.59	17.55
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	33.9	45.1	56.5	60.3	66.4	75.3	77.9	74.9	69.8	59.7	32.9	26.2	56.6
AVERAGE MINIMUM TEMP. (DEG F)	.1	9.9	19.6	23.9	31.6	41.2	42.9	42.3	34.9	29.6	2.0	-9.9	22.3
HEATING DEGREE DAYS(65 BASE)	1402	1081	824	680	490	195	136	190	373	622	1420	1758	9251

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1973	CENTER												1973
HEMISPHERIC (MJ/SQM DAY)	10.76	14.96	17.64	21.13	23.13	26.98	24.28	21.43	19.16	15.34	10.61	7.98	17.78
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	23.4	31.2	42.4	52.7	66.5	75.7	77.3	76.3	70.4	62.9	50.4	39.3	55.7
AVERAGE MINIMUM TEMP. (DEG F)	-14.7	-5.4	16.7	22.4	33.9	41.5	44.6	42.2	34.1	24.1	15.8	6.0	21.8
HEATING DEGREE DAYS(65 BASE)	1872	1452	1093	814	451	199	133	168	379	661	948	1303	9473
1974	CENTER												1974
HEMISPHERIC (MJ/SQM DAY)	10.30	14.46	18.22	20.45	24.92	23.06	24.24	20.09	18.09	13.20	10.15	8.40	17.13
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	26.1	33.1	53.6	56.8	72.3	78.3	77.9	74.4	71.0	60.8	45.4	30.7	56.7
AVERAGE MINIMUM TEMP. (DEG F)	-8.1	-5.7	19.9	20.6	34.8	41.1	45.8	40.7	36.3	30.2	14.8	-6	22.5
HEATING DEGREE DAYS(65 BASE)	1729	1433	867	782	347	166	94	223	331	598	1040	1544	9154
1975	CENTER												1975
HEMISPHERIC (MJ/SQM DAY)	9.71	13.16	17.17	22.04	24.22	25.07	24.75	19.57					
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	24	0	0	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	25.3	33.3	43.6	52.8	64.2	73.0	77.4	76.6	70.1	62.3	43.4	29.5	54.3
AVERAGE MINIMUM TEMP. (DEG F)	-10.6	.1	19.4	22.2	32.1	37.4	45.8	41.7	35.6	21.5	8.2	-5.3	20.7
HEATING DEGREE DAYS(65 BASE)	1782	1347	1030	818	516	284	101	173	357	709	1171	1633	9921
1976	CENTER												1976
HEMISPHERIC (MJ/SQM DAY)			18.49	20.24	22.69	25.18	23.07	20.69	16.95	13.85	9.91	9.39	
NUMBER OF DAYS WITH DATA	0	0	26	30	31	30	31	31	30	31	29	31	
AVERAGE MAXIMUM TEMP. (DEG F)	27.0	42.6	48.2	57.5	65.7	73.3	79.3	75.2	70.7	58.0	47.0	28.5	56.1
AVERAGE MINIMUM TEMP. (DEG F)	-10.8	10.7	15.1	23.6	32.4	34.9	42.4	38.4	34.4	20.0	9.3	-11.7	19.9
HEATING DEGREE DAYS(65 BASE)	1760	1105	1027	727	487	319	121	248	364	798	1100	1747	9803
1977	CENTER												1977
HEMISPHERIC (MJ/SQM DAY)	9.94	13.04	17.40	18.89	24.88	24.87	23.01	20.48	18.46	14.90	9.99	8.20	17.00
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	28	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	28.2	39.4	45.0	59.0	68.2	80.2	79.0	79.1	73.7	64.5	47.3	41.9	58.8
AVERAGE MINIMUM TEMP. (DEG F)	-11.8	3.3	10.2	24.8	29.5	39.2	43.6	42.2	33.7	21.9	14.1	6.0	21.4
HEATING DEGREE DAYS(65 BASE)	1755	1217	1153	685	494	150	110	131	330	668	1023	1265	8981

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
	1978												
	CENTER												
	1978												
HEMISPHERIC (MJ/SQM DAY)	8.77	12.73	17.10	21.72	23.89	27.43	24.90	23.12	19.46	13.75	9.73	9.14	17.64
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	38.9	43.3	54.3	60.3	62.3	75.2	78.5	79.0	72.5	63.0	45.0	21.5	57.8
AVERAGE MINIMUM TEMP. (DEG F)	5.6	9.1	18.1	22.7	29.4	36.6	41.3	38.7	33.7	24.8	16.1	-14.6	21.8
HEATING DEGREE DAYS(65 BASE)	1316	1079	886	696	586	265	151	185	351	646	1025	1908	9094
	1979												
	CENTER												
	1979												
HEMISPHERIC (MJ/SQM DAY)	9.92	14.34	18.30	20.64	21.43	25.23	24.75	21.03	19.65	14.33	10.00	8.12	17.31
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	30	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	20.1	28.6	41.1	58.1	65.5	73.0	78.8	74.3	74.7	64.4	39.3	37.5	54.6
AVERAGE MINIMUM TEMP. (DEG F)	-15.2	-12.7	10.5	23.0	32.6	37.0	42.0	40.1	35.0	26.2	3.7	1.9	18.7
HEATING DEGREE DAYS(65 BASE)	1935	1595	1206	724	487	291	137	234	295	602	1295	1398	10199
	1980												
	CENTER												
	1980												
HEMISPHERIC (MJ/SQM DAY)	9.37	13.21	16.23	20.27	22.95	28.77	26.21	22.01	19.52	15.27			
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	30	30	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	33.0	42.6	45.3	54.0	61.8	76.9	81.2	76.9	72.8	59.3	50.4	47.9	58.5
AVERAGE MINIMUM TEMP. (DEG F)	.5	13.6	15.4	24.3	32.1	38.0	43.4	39.1	34.0	19.7	10.0	8.1	23.2
HEATING DEGREE DAYS(65 BASE)	1490	1063	1067	767	553	220	79	209	342	781	1036	1139	8746

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1977	CHEYENNE												1977
HEMISPHERIC (MJ/SQM DAY)			17.47	18.39	23.18	23.23	22.27	19.19	18.74	14.92	9.27	7.80	
NUMBER OF DAYS WITH DATA	0	0	22	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	35.8	45.8	44.0	56.6	66.3	78.4	81.5	75.5	75.9	62.0	45.5	40.1	59.0
AVERAGE MINIMUM TEMP. (DEG F)	9.0	19.9	20.1	32.7	40.5	52.0	54.8	51.5	45.4	34.5	23.3	17.9	33.5
HEATING DEGREE DAYS(65 BASE)	1314	894	1014	602	352	44	21	74	150	511	910	1108	6994
MEAN CLOUD COVER (PERCENT)	63	64	55	57	64	59	55	59	43	41	61	65	57
POSSIBLE SUNSHINE (PERCENT)	61	74	77	48	60	57	58	54	64	68	53	51	60
1978	CHEYENNE												1978
HEMISPHERIC (MJ/SQM DAY)	7.68	10.25	17.20	19.13	21.58	25.11	25.29	21.22	19.59	14.20	7.80	7.91	16.41
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	32.6	34.9	49.8	55.8	60.4	75.3	83.5	78.5	74.3	61.5	44.3	32.1	56.9
AVERAGE MINIMUM TEMP. (DEG F)	11.5	15.1	25.5	32.8	37.5	46.7	53.9	50.1	44.8	34.2	22.7	10.0	32.1
HEATING DEGREE DAYS(65 BASE)	1324	1115	1840	627	491	157	28	73	200	523	937	1358	7673
MEAN CLOUD COVER (PERCENT)	59	62	62	65	66	55	50	51	46	47	55	57	56
POSSIBLE SUNSHINE (PERCENT)	61	65	65	60	59	64	68	67	69	69	60	59	63
1979	CHEYENNE												1979
HEMISPHERIC (MJ/SQM DAY)	9.06	13.33	16.00	21.77			23.67	20.29	19.28	13.24	9.30	7.35	
NUMBER OF DAYS WITH DATA	31	28	31	30	0	0	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	28.5	42.3	46.6	57.9	60.7	74.5	84.4	78.6	78.1	63.0	39.7	44.3	58.2
AVERAGE MINIMUM TEMP. (DEG F)	6.1	20.8	25.3	31.8	39.0	48.5	55.4	53.2	47.6	36.5	19.2	21.4	33.7
HEATING DEGREE DAYS(65 BASE)	1471	933	893	597	459	139	2	62	105	468	1058	990	7177
MEAN CLOUD COVER (PERCENT)	51	47	55	58	68	66	65	67	52	48	58	52	57
POSSIBLE SUNSHINE (PERCENT)	50	37	44	31	51	37	35	40	28	33	54	47	40
1980	CHEYENNE												1980
HEMISPHERIC (MJ/SQM DAY)	8.19	11.42	14.84	22.59	20.95	26.59	24.09	20.63	18.79	13.58	8.33	6.77	16.40
NUMBER OF DAYS WITH DATA	31	27	31	30	28	28	31	31	30	31	30	30	
AVERAGE MAXIMUM TEMP. (DEG F)	32.8	39.2	42.9	54.0	62.1	81.4	85.8	80.6	75.8	59.8	48.7	50.4	59.5
AVERAGE MINIMUM TEMP. (DEG F)	11.6	19.5	23.1	30.5	40.2	49.5	56.8	52.1	44.9	33.6	24.9	26.6	34.5
HEATING DEGREE DAYS(65 BASE)	1321	1027	984	673	424	65	0	41	151	558	840	812	6896
MEAN CLOUD COVER (PERCENT)	60	60	62	69	80	60	64	66	59	57	58	58	62
POSSIBLE SUNSHINE (PERCENT)	57	55	49	47	51	25	36	35	32	37	51	53	44

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1977													
DENVER (SOUTHEAST)													
HEMISPHERIC (MJ/SQM DAY)			17.39	17.80	22.93	24.02	22.56	19.73	18.58	13.93	9.55	7.42	
NUMBER OF DAYS WITH DATA	0	0	24	30	31	30	31	31	30	29	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	43.9	51.8	53.8	63.3	74.9	86.3	87.8	82.9	82.3	69.4	53.7	49.1	66.6
AVERAGE MINIMUM TEMP. (DEG F)	14.4	24.1	25.9	38.8	46.4	57.5	60.7	57.5	50.8	37.1	26.8	21.0	38.4
HEATING DEGREE DAYS(65 BASE)	1105	749	771	414	137	0	2	14	38	358	737	920	5245
MEAN CLOUD COVER (PERCENT)	51	60	51	56	58	56	54	60	45	40	55	61	53
POSSIBLE SUNSHINE (PERCENT)	86	79	76	65	81	79	75	73	81	78	70	59	75
1978													
DENVER (SOUTHEAST)													
HEMISPHERIC (MJ/SQM DAY)	7.75	11.30	16.57	20.40	22.01	24.58	25.35	22.11	20.80	14.55	9.04	8.17	16.89
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	29	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	37.5	42.2	57.0	63.6	67.1	80.6	90.4	85.5	81.2	68.2	49.8	36.9	63.3
AVERAGE MINIMUM TEMP. (DEG F)	14.1	20.5	29.6	36.9	41.7	53.1	59.0	53.7	48.7	37.9	25.7	12.3	36.1
HEATING DEGREE DAYS(65 BASE)	1206	936	665	435	335	87	0	20	96	366	811	1245	6202
MEAN CLOUD COVER (PERCENT)	69	66	64	64	61	57	43	47	25	40	60	53	54
POSSIBLE SUNSHINE (PERCENT)	69	73	84	78	65	67	73	73	85	74	56	72	72
1979													
DENVER (SOUTHEAST)													
HEMISPHERIC (MJ/SQM DAY)	9.06	12.44	15.86	21.85	20.85	26.12	25.06	21.20	20.03	13.48	9.90	7.57	16.95
NUMBER OF DAYS WITH DATA	31	28	31	30	30	30	31	30	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	30.6	47.3	52.0	62.1	66.5	79.9	89.5	82.5	80.7	67.7	44.5	47.6	62.6
AVERAGE MINIMUM TEMP. (DEG F)	5.4	21.1	29.0	36.1	43.1	51.7	57.8	56.4	51.8	39.9	22.1	21.4	36.3
HEATING DEGREE DAYS(65 BASE)	1450	854	751	473	313	81	0	20	58	347	941	939	6227
MEAN CLOUD COVER (PERCENT)	56	59	61	61	62	50	49	49	43	44	53	53	53
POSSIBLE SUNSHINE (PERCENT)	72	72	71	67	65	71	71	73	75	73	65	69	70
1980													
DENVER (SOUTHEAST)													
HEMISPHERIC (MJ/SQM DAY)	9.09	11.99	14.81	18.93	21.98	29.53		22.38				9.50	
NUMBER OF DAYS WITH DATA	31	27	31	24	31	17	0	22	0	0	0	1	
AVERAGE MAXIMUM TEMP. (DEG F)	37.5	46.1	49.9	59.4	68.4	87.0	89.8	87.1	80.7	67.0	55.3	55.0	65.3
AVERAGE MINIMUM TEMP. (DEG F)	14.4	22.9	26.1	35.9	45.8	56.8	62.9	59.2	50.8	37.8	28.5	27.4	39.0
HEATING DEGREE DAYS(65 BASE)	1204	876	828	514	247	9	0	4	56	386	683	731	5538
MEAN CLOUD COVER (PERCENT)	71	63	68	59	65	37	37	47	32	38	60	70	53
POSSIBLE SUNSHINE (PERCENT)	64	69	67	75	70	87	81	79	85	78	57	54	72

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1977	DENVER (HOLLY)											1977	
HEMISPHERIC (MJ/SQM DAY)			17.81	17.87	23.47	23.79	23.30	19.91	18.75	13.87	9.66	7.24	
NUMBER OF DAYS WITH DATA	0	0	24	28	24	30	27	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	43.9	51.8	53.8	63.3	74.9	86.3	87.8	82.9	82.3	69.4	53.7	49.1	66.6
AVERAGE MINIMUM TEMP. (DEG F)	14.4	24.1	25.9	38.8	46.4	57.5	60.7	57.5	50.8	37.1	26.8	21.0	38.4
HEATING DEGREE DAYS(65 BASE)	1105	749	771	414	137	0	2	14	38	358	737	920	5245
MEAN CLOUD COVER (PERCENT)	51	60	51	56	58	56	54	60	45	40	55	61	53
POSSIBLE SUNSHINE (PERCENT)	86	79	76	65	81	79	75	73	81	78	70	59	75
1978	DENVER (HOLLY)											1978	
HEMISPHERIC (MJ/SQM DAY)	8.22	11.75	16.42	19.52	22.72	23.24	23.63	21.28	19.23	13.53	8.08	7.70	16.28
NUMBER OF DAYS WITH DATA	31	27	28	25	26	30	25	30	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	37.5	42.2	57.0	63.6	67.1	80.6	90.4	85.5	81.2	68.2	49.8	36.9	63.3
AVERAGE MINIMUM TEMP. (DEG F)	14.1	20.5	29.6	36.9	41.7	53.1	59.0	53.7	48.7	37.9	25.7	12.3	36.1
HEATING DEGREE DAYS(65 BASE)	1206	936	665	435	335	87	0	20	96	366	811	1245	6202
MEAN CLOUD COVER (PERCENT)	69	66	64	64	61	57	43	47	25	40	60	53	54
POSSIBLE SUNSHINE (PERCENT)	69	73	84	78	65	67	73	73	85	74	56	72	72
1979	DENVER (HOLLY)											1979	
HEMISPHERIC (MJ/SQM DAY)	8.13	10.96	13.95	20.61	18.72	23.30	24.68	21.61	18.88	12.84	9.28	7.07	15.84
NUMBER OF DAYS WITH DATA	31	28	31	30	30	30	29	26	24	31	28	31	
AVERAGE MAXIMUM TEMP. (DEG F)	30.6	47.3	52.0	62.1	66.5	79.9	89.5	82.5	80.7	67.7	44.5	47.6	62.6
AVERAGE MINIMUM TEMP. (DEG F)	5.4	21.1	29.0	36.1	43.1	51.7	57.8	56.4	51.8	39.9	22.1	21.4	36.3
HEATING DEGREE DAYS(65 BASE)	1450	854	751	473	313	81	0	20	58	347	941	939	6227
MEAN CLOUD COVER (PERCENT)	56	59	61	61	62	50	49	49	43	44	53	53	53
POSSIBLE SUNSHINE (PERCENT)	72	72	71	67	65	71	71	73	75	73	65	69	70
1980	DENVER (HOLLY)											1980	
HEMISPHERIC (MJ/SQM DAY)	8.23	11.04	13.61	18.37	20.73	26.66	24.51	21.25	23.01				
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	2	0	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	37.5	46.1	49.9	59.4	68.4	87.0	89.8	87.1	80.7	67.0	55.3	55.0	65.3
AVERAGE MINIMUM TEMP. (DEG F)	14.4	22.9	26.1	35.9	45.8	56.8	62.9	59.2	50.8	37.8	28.5	27.4	39.0
HEATING DEGREE DAYS(65 BASE)	1204	876	828	514	247	9	0	4	56	386	683	731	5538
MEAN CLOUD COVER (PERCENT)	71	63	68	59	65	37	37	47	32	38	60	70	53
POSSIBLE SUNSHINE (PERCENT)	64	69	67	75	70	87	81	79	85	78	57	54	72

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1977	DODGE CITY												1977
HEMISPHERIC (MJ/SQM DAY)	9.98	13.45	17.83	18.97	21.64	26.23	25.97	21.00	18.71	14.71	9.95	8.80	17.28
NUMBER OF DAYS WITH DATA	24	25	31	28	30	29	30	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	34.6	56.4	63.1	70.7	79.1	93.1	97.5	89.0	84.4	72.5	57.6	49.0	70.6
AVERAGE MINIMUM TEMP. (DEG F)	12.7	27.3	32.5	47.1	58.5	65.9	71.0	66.1	60.4	44.6	31.4	22.2	45.0
HEATING DEGREE DAYS(65 BASE)	1274	645	529	198	8	0	0	0	3	219	609	903	4388
MEAN CLOUD COVER (PERCENT)	49	50	44	64	69	53	45	55	53	43	59	51	52
POSSIBLE SUNSHINE (PERCENT)	75	79	75	64	64	79	82	66	72	84	66	72	73
1978	DODGE CITY												1978
HEMISPHERIC (MJ/SQM DAY)	8.37	12.46	17.12	20.52	19.83	24.69	26.59	23.37	19.50	16.01	7.08	8.13	16.97
NUMBER OF DAYS WITH DATA	31	26	31	30	31	30	27	30	29	30	29	30	
AVERAGE MAXIMUM TEMP. (DEG F)	32.1	29.6	58.3	71.1	72.0	87.2	98.2	91.7	85.9	73.0	52.3	43.4	66.2
AVERAGE MINIMUM TEMP. (DEG F)	11.6	12.9	31.1	43.5	51.8	63.2	68.5	64.5	59.6	43.8	33.2	18.1	41.8
HEATING DEGREE DAYS(65 BASE)	1330	1216	630	252	169	12	0	2	41	228	667	1054	5601
MEAN CLOUD COVER (PERCENT)	74	64	61	60	65	48	35	45	40	30	70	47	53
POSSIBLE SUNSHINE (PERCENT)	54	53	64	65	52	63	82	78	82	88	46	67	66
1979	DODGE CITY												1979
HEMISPHERIC (MJ/SQM DAY)	9.13	12.94	15.19	20.91	22.36	26.48	23.00	22.79	20.44	16.33	11.02	8.19	17.40
NUMBER OF DAYS WITH DATA	29	26	30	30	30	30	29	28	27	27	23	28	
AVERAGE MAXIMUM TEMP. (DEG F)	23.0	40.3	56.9	66.8	72.4	87.0	90.4	87.7	84.2	73.3	48.2	47.3	64.8
AVERAGE MINIMUM TEMP. (DEG F)	6.6	16.9	33.0	41.4	48.6	60.3	65.5	60.5	57.2	43.5	26.7	21.5	40.1
HEATING DEGREE DAYS(65 BASE)	1549	1013	615	343	175	25	0	7	27	237	816	940	5747
MEAN CLOUD COVER (PERCENT)	60	57	65	54	66	41	55	41	23	44	40	45	49
POSSIBLE SUNSHINE (PERCENT)	60	75	61	57	56	70	64	74	89	78	68	71	68
1980	DODGE CITY												1980
HEMISPHERIC (MJ/SQM DAY)	7.78	11.71	15.27	18.14	21.31	24.96	27.70	22.80	19.24		9.21	7.49	
NUMBER OF DAYS WITH DATA	28	27	27	22	30	22	31	31	24	0	16	24	
AVERAGE MAXIMUM TEMP. (DEG F)	35.7	40.3	50.9	65.9	73.6	90.3	101.9	94.8	86.9	74.5	61.1	51.1	68.9
AVERAGE MINIMUM TEMP. (DEG F)	18.1	20.4	28.3	40.5	51.5	66.4	72.4	69.4	60.1	42.0	32.3	25.4	43.9
HEATING DEGREE DAYS(65 BASE)	1171	996	780	364	130	3	0	0	26	257	548	822	5097
MEAN CLOUD COVER (PERCENT)	76	61	61	59	64	44	24	38	46	22	45	69	50
POSSIBLE SUNSHINE (PERCENT)	46	56	53	63	62	75	85	77	73	88	76	65	68

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
	1975												
	FORT COLLINS												
HEMISPHERIC (MJ/SQM DAY)					18.77	24.99	25.04	21.90	18.50	19.76			
NUMBER OF DAYS WITH DATA	0	0	0	0	8	24	13	15	23	1	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	43.4	43.9	49.5	56.4	67.1	77.6	85.5	84.1	74.6	67.7	50.9	45.9	62.2
AVERAGE MINIMUM TEMP. (DEG F)	16.6	16.0	24.2	30.1	39.5	49.4	57.8	54.2	44.0	34.8	22.0	19.6	34.0
HEATING DEGREE DAYS(65 BASE)	1078	975	865	644	357	92	1	14	186	418	848	992	6470
	1976												
	FORT COLLINS												
HEMISPHERIC (MJ/SQM DAY)	10.10	11.43	18.58	19.08	19.32	24.99	21.63		14.09	13.87	8.13	8.15	
NUMBER OF DAYS WITH DATA	8	16	26	28	23	22	30	0	21	4	13	11	
AVERAGE MAXIMUM TEMP. (DEG F)	42.4	50.8	51.8	61.8	69.5	80.5	86.7	82.7	73.2	61.6	51.1	48.9	63.4
AVERAGE MINIMUM TEMP. (DEG F)	14.2	23.2	22.1	35.3	42.8	49.3	58.3	54.0	47.7	32.0	23.0	17.5	35.0
HEATING DEGREE DAYS(65 BASE)	1132	805	860	486	265	58	0	6	148	554	834	979	6127
	1977												
	FORT COLLINS												
HEMISPHERIC (MJ/SQM DAY)	9.20	11.85	18.65	17.17	24.48	24.46	22.42	18.59	18.61	14.21	9.54	7.57	16.40
NUMBER OF DAYS WITH DATA	19	13	27	10	27	20	26	28	17	28	14	22	
AVERAGE MAXIMUM TEMP. (DEG F)	40.4	50.6	53.2	63.5	72.9	85.8	86.2	80.0	79.8	66.9	52.1	46.8	64.9
AVERAGE MINIMUM TEMP. (DEG F)	10.3	22.1	24.2	36.5	46.4	56.7	59.5	56.3	49.3	36.6	24.9	21.0	37.0
HEATING DEGREE DAYS(65 BASE)	1224	794	808	442	165	0	3	15	59	405	787	955	5657
	1978												
	FORT COLLINS												
HEMISPHERIC (MJ/SQM DAY)	8.93	10.18	16.94	19.53	24.04	24.25	23.66	20.90	19.64	13.92	8.66	7.56	16.52
NUMBER OF DAYS WITH DATA	19	25	24	22	20	29	24	29	24	29	23	25	
AVERAGE MAXIMUM TEMP. (DEG F)	35.0	37.1	56.8	62.9	67.0	80.7	87.3	82.6	78.8	66.1	48.3	35.7	61.5
AVERAGE MINIMUM TEMP. (DEG F)	12.3	18.7	28.2	36.3	41.0	52.0	57.5	53.5	47.5	34.8	23.5	9.5	34.6
HEATING DEGREE DAYS(65 BASE)	1273	1032	689	454	341	76	2	20	114	445	863	1309	6618
	1979												
	FORT COLLINS												
HEMISPHERIC (MJ/SQM DAY)	8.85	12.19	15.04	20.34	18.99	24.85	24.71	23.49	20.68	12.80	9.34	7.48	16.56
NUMBER OF DAYS WITH DATA	21	22	25	18	23	23	21	12	6	21	20	29	
AVERAGE MAXIMUM TEMP. (DEG F)	28.8	42.5	52.8	62.2	66.4	79.4	86.4	80.9	79.4	67.3	43.8	45.3	61.3
AVERAGE MINIMUM TEMP. (DEG F)	4.9	13.2	27.9	34.8	41.2	50.3	57.4	53.3	48.1	38.1	18.1	17.9	33.8
HEATING DEGREE DAYS(65 BASE)	1464	1036	754	489	343	82	1	33	86	375	1013	1030	6726

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
	1980			FORT COLLINS						1980			
HEMISPHERIC (MJ/SQM DAY)	7.70	11.82	14.00	20.53	17.98	26.98	24.15	16.43	20.22	13.73	10.45	7.89	15.99
NUMBER OF DAYS WITH DATA	29	14	27	25	18	19	14	2	4	17	10	14	
AVERAGE MAXIMUM TEMP. (DEG F)	35.8	42.7	46.9	60.0	66.6	86.0	88.2	83.4	78.3	64.0	52.6	53.1	63.1
AVERAGE MINIMUM TEMP. (DEG F)	11.5	17.1	23.8	32.4	42.1	52.3	53.9	55.1	46.8	33.8	25.8	24.5	35.3
HEATING DEGREE DAYS(65 BASE)	1273	1011	911	555	324	22	0	14	96	490	764	804	6264

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
	1980					GOLDEN					1980		
HEMISPHERIC (MJ/SQM DAY)	7.80	10.93	13.51	17.99	19.46	26.13	23.59	20.21	18.21	13.28	8.13	5.92	15.43
NUMBER OF DAYS WITH DATA	31	27	31	30	31	30	31	31	30	31	30	31	
AVERAGE MAXIMUM TEMP. (DEG F)	37.6	46.6	48.0	55.8	64.1	85.1	89.0	86.7	77.7	66.0	53.3	54.4	63.7
AVERAGE MINIMUM TEMP. (DEG F)	15.3	23.4	25.9	34.4	43.3	50.0	62.1	59.6	50.3	38.1	30.1	28.3	38.9
HEATING DEGREE DAYS(65 BASE)	1189	864	856	536	349	24	0	0	04	390	692	755	5795
	1981					GOLDEN					1981		
HEMISPHERIC (MJ/SQM DAY)	8.20	10.96	14.85	19.40	16.96	23.85	21.57	18.14	15.70		9.80		
NUMBER OF DAYS WITH DATA	31	28	31	30	31	30	31	31	30	0	30	0	
AVERAGE MAXIMUM TEMP. (DEG F)	51.0	50.1	51.5	67.9	65.4	62.5	60.9	62.8	70.5	63.5	58.5	47.5	65.5
AVERAGE MINIMUM TEMP. (DEG F)	24.2	21.9	28.0	41.9	42.8	55.0	61.5	57.8	50.2	36.2	29.8	21.1	35.0
HEATING DEGREE DAYS(65 BASE)	846	805	773	507	353	27	1	25	58	463	619	944	5203

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1977	GRAND JUNCTION												1977
HEMISPHERIC (MJ/SQM DAY)				24.02	25.28	30.62	25.75	24.62	21.81				7.33
NUMBER OF DAYS WITH DATA	0	0	0	23	31	13	31	31	19	0	0		23
AVERAGE MAXIMUM TEMP. (DEG F)	36.0	52.4	55.2	71.8	77.9	95.5	94.5	92.9	84.9	72.4	52.0	43.3	69.1
AVERAGE MINIMUM TEMP. (DEG F)	11.8	21.7	26.4	42.0	49.4	62.6	65.9	63.7	55.5	43.9	28.5	23.3	41.2
HEATING DEGREE DAYS(65 BASE)	1267	775	743	250	94	0	0	1	17	214	736	975	5072
MEAN CLOUD COVER (PERCENT)	55	50	55	51	52	40	47	48	37	33	58	69	49
POSSIBLE SUNSHINE (PERCENT)	78	91	78	77	70	87	75	79	80	81	57	57	75
1978	GRAND JUNCTION												1978
HEMISPHERIC (MJ/SQM DAY)	7.08	11.19	15.41	18.29	23.80	26.70	27.02	25.25	20.69	17.08			7.51
NUMBER OF DAYS WITH DATA	30	28	31	30	31	19	27	14	14	19	0		17
AVERAGE MAXIMUM TEMP. (DEG F)	35.4	42.5	57.1	64.5	72.5	89.2	93.9	89.7	80.7	69.4	50.9	25.3	64.3
AVERAGE MINIMUM TEMP. (DEG F)	23.4	26.2	36.2	40.1	45.0	56.8	62.8	59.3	50.7	40.0	29.4	6.7	39.7
HEATING DEGREE DAYS(65 BASE)	1098	852	561	373	210	9	0	6	95	313	737	1510	5764
MEAN CLOUD COVER (PERCENT)	82	69	66	72	57	38	28	38	36	34	53	58	52
POSSIBLE SUNSHINE (PERCENT)	44	55	56	71	83	91	88	83	87	76	58	51	70
1979	GRAND JUNCTION												1979
HEMISPHERIC (MJ/SQM DAY)	7.25	12.25	16.44	24.24	25.38	29.81	21.49	20.17	21.68	15.70	9.78	7.80	17.67
NUMBER OF DAYS WITH DATA	21	14	26	16	27	12	4	21	30	29	28	29	
AVERAGE MAXIMUM TEMP. (DEG F)	25.2	33.1	50.5	64.7	72.3	86.1	94.2	88.3	86.7	72.3	43.4	36.5	62.8
AVERAGE MINIMUM TEMP. (DEG F)	7.9	13.8	31.7	40.2	48.2	55.9	63.1	60.8	57.3	45.5	23.0	17.2	38.7
HEATING DEGREE DAYS(65 BASE)	1493	1154	732	377	192	37	0	3	0	209	945	1175	6317
MEAN CLOUD COVER (PERCENT)	78	70	62	56	57	34	43	47	24	44	50	60	52
POSSIBLE SUNSHINE (PERCENT)	35	36	47	64	61	78	76	66	88	74	54	59	61
1980	GRAND JUNCTION												1980
HEMISPHERIC (MJ/SQM DAY)	7.00	11.84	15.42	22.14	23.16	31.04	25.93						
NUMBER OF DAYS WITH DATA	28	27	30	24	28	27	6	0	0	0	0	0	
AVERAGE MAXIMUM TEMP. (DEG F)	39.8	49.3	51.5	65.8	72.0	90.9	94.1	90.0	83.2	67.4	54.2	51.7	67.5
AVERAGE MINIMUM TEMP. (DEG F)	25.4	29.1	30.3	36.9	46.1	57.1	63.0	60.5	52.6	40.1	30.4	28.5	41.7
HEATING DEGREE DAYS(65 BASE)	999	741	740	405	195	4	0	2	21	359	674	765	4905
MEAN CLOUD COVER (PERCENT)	75	63	66	49	63	24	40	36	30	35	48	58	48
POSSIBLE SUNSHINE (PERCENT)	36	57	53	79	70	96	86	88	78	75	69	70	71

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN			
1977													PUEBLO		1977	
HEMISPHERIC (MJ/SQM DAY)			20.38	20.06	25.76		24.42	21.88	19.12	15.22	10.50	9.18				
NUMBER OF DAYS WITH DATA	0	0	21	29	30	0	30	31	29	31	30	31				
AVERAGE MAXIMUM TEMP. (DEG F)	45.2	56.8	60.2	69.8	81.3	91.0	93.8	88.0	85.8	72.1	58.6	52.5	71.3			
AVERAGE MINIMUM TEMP. (DEG F)	10.0	19.5	23.7	38.6	49.3	57.4	61.2	60.2	49.1	35.4	22.6	19.4	37.2			
HEATING DEGREE DAYS(65 BASE)	1151	747	708	318	44	1	0	4	34	343	723	894	4967			
MEAN CLOUD COVER (PERCENT)	45	53	45	55	46	55	49	53	40	33	49	59	48			
POSSIBLE SUNSHINE (PERCENT)	85	86	90	83	89	89	87	84	89	89	79	75	85			
1978													PUEBLO		1978	
HEMISPHERIC (MJ/SQM DAY)	9.59	11.79	17.74	22.76	23.43	23.22	24.50	22.35	20.73	15.06	8.32	8.97	17.37			
NUMBER OF DAYS WITH DATA	30	27	31	30	30	29	31	31	30	31	30	31				
AVERAGE MAXIMUM TEMP. (DEG F)	38.1	41.8	60.7	69.0	71.6	85.0	94.8	88.7	83.7	71.2	52.4	37.5	66.2			
AVERAGE MINIMUM TEMP. (DEG F)	12.3	16.3	26.7	37.4	44.3	55.4	60.9	56.9	49.6	36.0	25.4	10.4	36.0			
HEATING DEGREE DAYS(65 BASE)	1228	1001	653	347	238	54	0	6	59	347	778	1264	5975			
MEAN CLOUD COVER (PERCENT)	65	67	53	56	56	51	38	44	24	38	62	48	50			
POSSIBLE SUNSHINE (PERCENT)	73	73	86	87	86	87	90	87	94	86	70	86	83			
1979													PUEBLO		1979	
HEMISPHERIC (MJ/SQM DAY)	10.10	13.11	15.72	21.07	20.93	27.05	25.36	22.16	20.18	14.42	11.18	8.69	17.50			
NUMBER OF DAYS WITH DATA	31	28	31	30	29	29	31	30	30	31	29	31				
AVERAGE MAXIMUM TEMP. (DEG F)	28.9	49.9	56.5	67.4	70.5	85.3	92.8	88.5	85.3	73.2	51.3	51.4	66.8			
AVERAGE MINIMUM TEMP. (DEG F)	3.3	18.9	29.7	36.2	44.7	52.4	60.1	54.8	49.5	37.1	20.2	16.4	35.3			
HEATING DEGREE DAYS(65 BASE)	1509	849	674	391	247	48	0	8	45	299	870	959	5899			
MEAN CLOUD COVER (PERCENT)	59	48	56	57	70	39	49	44	30	49	38	51	49			
POSSIBLE SUNSHINE (PERCENT)	84	85	85	90	77	89	87	87	92	86	84	77	85			
1980													PUEBLO		1980	
HEMISPHERIC (MJ/SQM DAY)	9.30	12.17	15.32	20.71	23.09	28.00	27.71	25.59	21.29	20.90		8.25				
NUMBER OF DAYS WITH DATA	30	27	31	30	31	27	30	29	29	7	0	30				
AVERAGE MAXIMUM TEMP. (DEG F)	39.9	52.8	55.9	64.2	71.5	91.6	96.6	91.7	83.5	70.9	57.4	57.8	69.5			
AVERAGE MINIMUM TEMP. (DEG F)	16.5	21.6	25.2	32.4	45.1	54.0	63.8	60.3	50.4	33.9	24.1	24.6	37.7			
HEATING DEGREE DAYS(65 BASE)	1135	797	751	492	214	6	0	0	46	383	717	731	5272			
MEAN CLOUD COVER (PERCENT)	69	64	64	49	59	32	33	40	29	32	58	74	50			
POSSIBLE SUNSHINE (PERCENT)	77	75	81	86	76	87	86	85	86	85	63	51	78			

Appendix C.

METHOD FOR ESTIMATING TILTED SURFACE RADIATION

Correlation techniques were formulated by Liu and Jordan (1960) to derive estimates of solar radiation on tilted surfaces from horizontal data. By separating hemispheric radiation into its two components, direct (beam) and diffuse, the radiation arriving on any tilted surface can be obtained approximately. The discussion of these formulations by Kreith and Kreider (1978) suggested the procedure which was used here.

The clearness index, C , is defined by

$$C = \frac{\bar{H}}{\overline{ETR}} ,$$

where \bar{H} is the monthly average hemispheric radiation and \overline{ETR} is the monthly average extraterrestrial radiation. (\overline{ETR} was calculated assuming a solar constant of 1394 joules per meter² second. That was the accepted value of the solar constant at that time and is associated with the resulting correlation coefficient.) The monthly diffuse component, \bar{D} , is then obtained by the correlation equation:

$$\bar{D} = \bar{H} (1.390 - 4.027 C + 5.531 C^2 - 3.108 C^3) .$$

The monthly average direct component, \bar{B} , is the difference between the horizontal and diffuse, or

$$\bar{B} = \bar{H} - \bar{D} .$$

For south-facing surfaces, the monthly mean tilt factor of the sun, \bar{R} , can be computed from the relationship:

$$\bar{R} = \frac{\cos(L - \beta) \cos \delta \sin h''_{SR} + h''_{SR} \sin(L - \beta) \sin \delta}{\cos L \cos \delta \sin h'_{SR} + h'_{SR} \sin L \sin \delta}$$

where,

$L \equiv$ latitude of station

$\beta \equiv$ angle of tilted surface measured
from the horizontal

$\delta \equiv$ solar declination angle

and,

$$h'_{SR} \equiv \cos^{-1}(-\tan L \tan \delta) \equiv \text{sunrise hour angle on horizontal surface}$$

and h''_{SR} is the smaller of h'_{SR} or

$$h''_{SR} = \cos^{-1}(-\tan(L - \beta) \tan \delta) .$$

The monthly average radiation on a tilted surface at angle β , \bar{H}_β , is then obtained from:

$$\bar{H}_\beta = \bar{R} \bar{B} + \bar{D} \cos^2 \frac{\beta}{2} + (\bar{D} + \bar{B}) \rho \sin^2 \frac{\beta}{2}$$

where ρ is the diffuse reflectance of the surface area to the south of the collector (ground, hills, trees, snow, buildings, etc). The values of ρ can range from 0 (no reflection) to 1 (perfect reflection).

Reflectivity properties are wavelength dependent. Sellers (1965) determined typical reflectivities for various types of surfaces from the visible portion of the solar spectrum.

Table C-1. Typical Reflectivities for Common Surfaces

<u>Surfaces</u>	<u>Reflectivity</u>
A. Bare Areas and Soils	
Snow, fresh	.75 - .95
Snow, old	.40 - .70
Ice, sea	.30 - .40
Sand dune, dry	.35 - .45
Sand dune, wet	.20 - .30
Soil, dark	.05 - .15
Soil, moist gray	.10 - .20
Soil, dry clay or gray	.20 - .35
Soil, dry light sand	.25 - .45
Concrete, dry	.17 - .27
Road, black top	.05 - .10

Table C-1. continued

<u>Surfaces</u>	<u>Reflectivity</u>
B. Natural Surfaces	
Desert	.25 - .30
Savanna, dry season	.25 - .30
Savanna, wet season	.15 - .20
Chaparral	.15 - .20
Meadows, green	.10 - .20
Forest, deciduous	.10 - .20
Forest, coniferous	.05 - .15
Tundra	.15 - .20
Crops	.15 - .25

Calculations of tilted surface radiation which appear on the Climatic Summary Tables in Section III all assumed south-facing surfaces and diffuse reflectance values of 0.2. South-facing surfaces were chosen since that is the customary orientation of solar collectors designed for maximum full-day collection. A reflectance of 0.2 was used because that is a typical value for common surfaces such as grass or concrete. However, reflectivity values can vary considerably as shown in the above tables.

The effects of increasing surface reflectivity are most pronounced on surfaces with large tilt angles, especially vertical surfaces. This is to be expected since these surfaces receive less radiation from the sky and more from the ground than surfaces which are more nearly horizontal. The greatest effects occur on vertical surfaces during the summer months when the sun is high in the sky and little direct radiation strikes the tilted surface.

Users of calculated tilted surface radiation should be aware that the correlations obtained by Liu and Jordan were based on measurements taken at locations far away from Colorado. It is possible that due to

the clearer skies and drier atmosphere here in Colorado, the correlations obtained between hemispheric radiation and its direct and diffuse components may not apply as accurately as they did to the non-Colorado data.

Appendix D. SUN-PATH DIAGRAM

Polar sky charts are provided in 2° increments from 35° to 41° north latitudes (Berdahl et al, 1978). These are useful geometric aids to determine the extent of shading from obstructions or, conversely, the direct-beam exposure on solar designs. Sky charts or sun-path diagrams are the projection of the sun path on a horizontal plane. For a given latitude, the instantaneous sun position is easily determined by the intersection of the time of day (solar time) and day of the year on the chart.

Important polar chart parameters are:

Azimuth angle - measured clockwise from true north and represented by radial lines.

Altitude angle - measured from the horizon. Equal altitude angles are concentric circles where the horizon (0°) is the polar-chart circumference and the zenith (90°) is at the center.

Sun transit paths - quasi-horizontal bowed curves. Paths are plotted for specific days. Paths for intermediate days are obtained by interpolation.

Local solar time - quasi-vertical bowed curves. Plotted hourly; other times require interpolation.

Local solar time is provided by the following equation:

$$\text{LST} = \text{MST} + E - 4 (L_{\text{Local}} - 105^\circ)$$

where

LST: Local solar time defined so that local solar noon coincides with maximum sun altitude.

MST: Mountain Standard Time or Mountain Daylight Time minus 1 hour.

E: Equation of Time; determined from Figure D-1.

L_{Local} : Local longitude at specific site.

105° : Center longitude for Mountain Time Zone.

Obstruction outlines defined by altitude and azimuth angles relative to the observer can be plotted on the correct latitude sky-chart to determine the extent of shading. Outlines that project into the sun-transit paths will shade the site from direct sunlight. The duration of shading relative to both the time during the day and days during the year can be read directly from the chart.

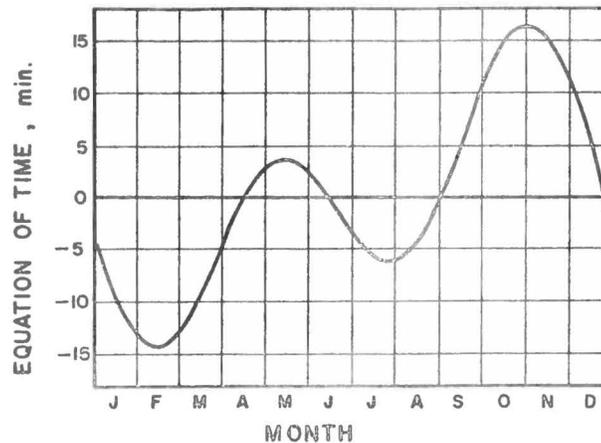


Figure D-1. Equation of time (E).

Figure D-2. 35° Latitude

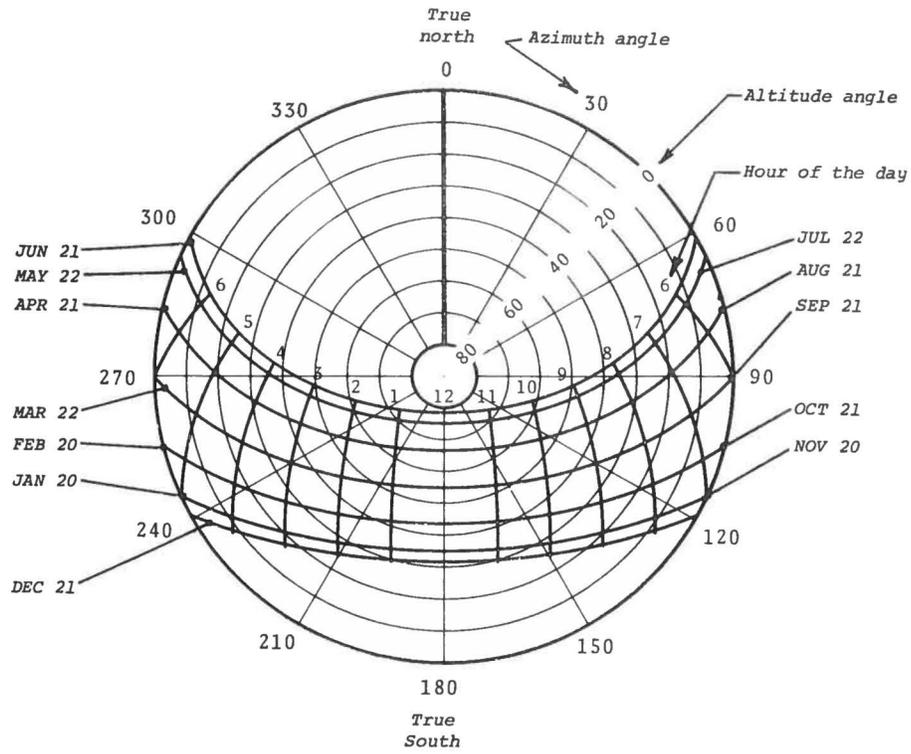


Figure D-3. 37° Latitude

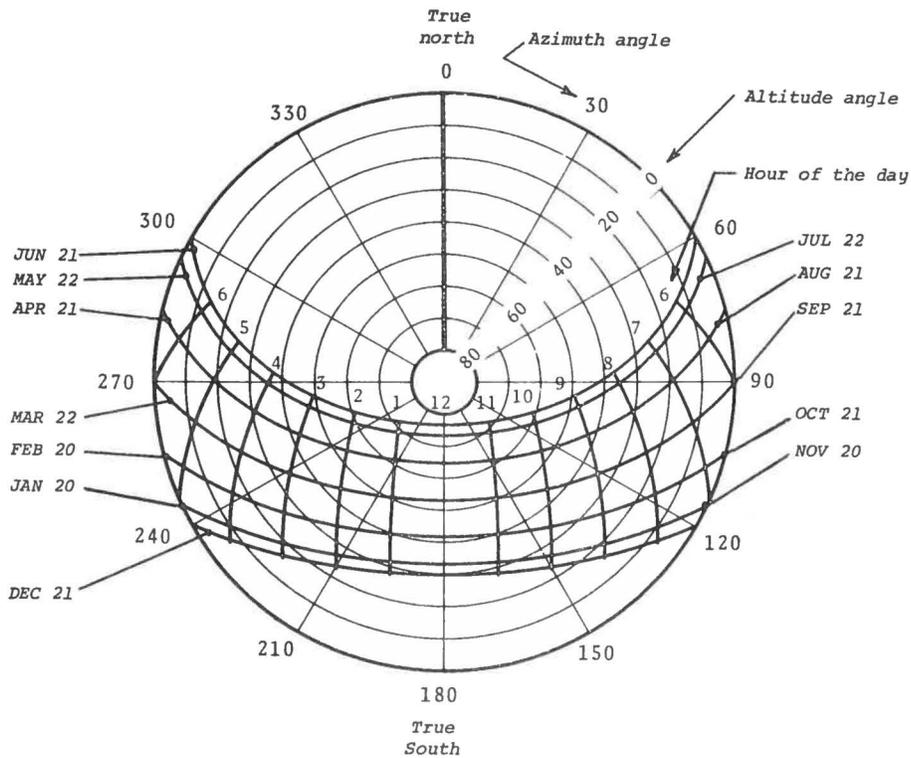


Figure D-4. 39° Latitude

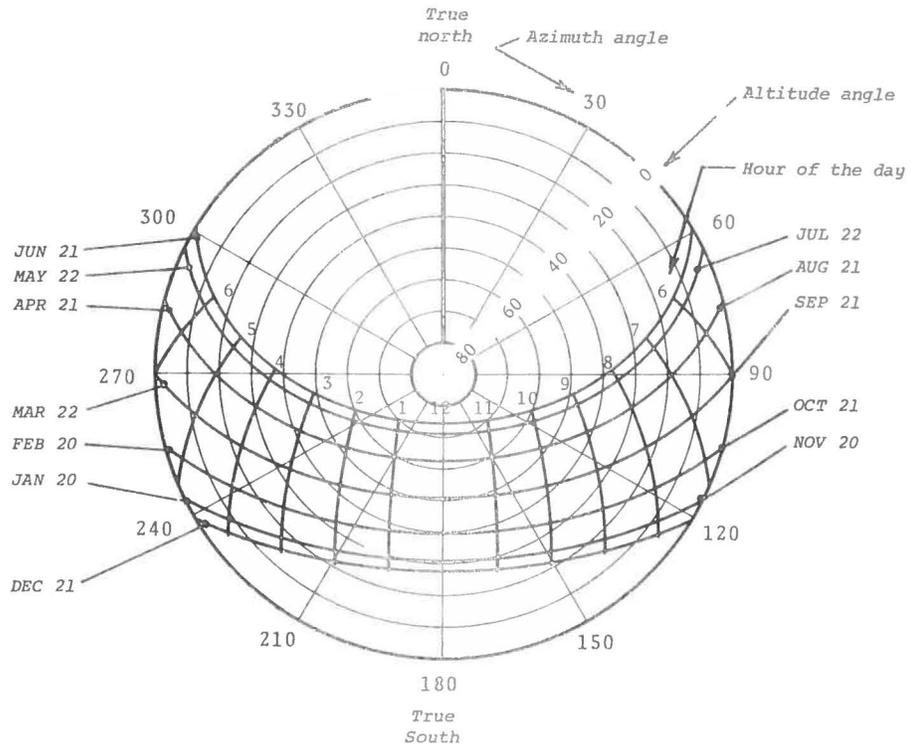
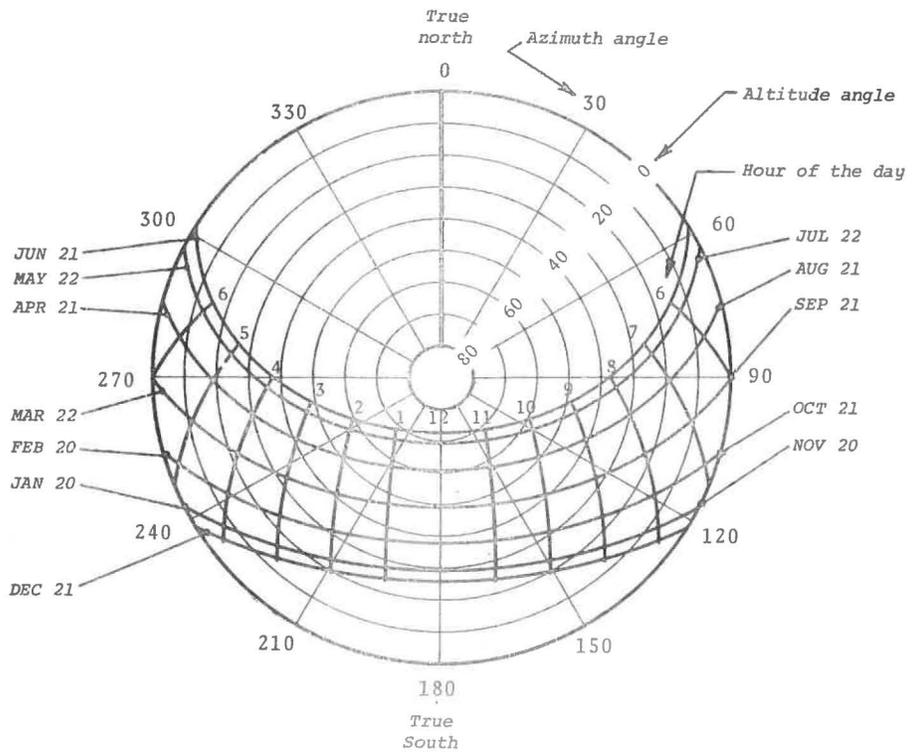


Figure D-5. 41° Latitude



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