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COOPERATIVE SOLAR RADIATION
DATA COLLECTION PROGRAM

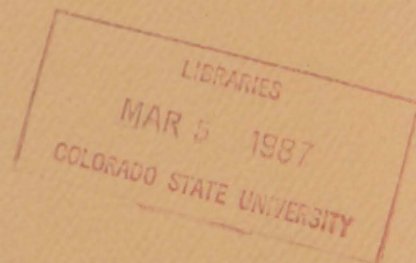
FORT COLLINS, COLORADO

June 1985–May 1986

Nolan J. Doesken

John D. Kleist

Douglas K. Swartz



CLIMATOLOGY REPORT NO. 86-5

DEPARTMENT OF ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO

COOPERATIVE SOLAR RADIATION DATA COLLECTION PROGRAM

FORT COLLINS, COLORADO

JUNE 1985 - MAY 1986

by

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September 1986

Climatology Report No. 86-5

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1. INTRODUCTION

Energy from the sun, solar radiation, is the basic source of energy on our globe. An understanding of the magnitude and variation of this energy source is very important from many perspectives. It is the fundamental driving force for global weather and climate patterns. It influences how and where we live. And it has many economic ramifications, influencing water supply and agriculture as well as the costs of heating homes and businesses. In recent years much attention has been focused on the substitution of solar energy for conventional, nonrenewable energy sources.

Despite its importance, monitoring the solar energy resource has rarely been a part of traditional weather observations. Accurate solar radiation measurement required moderately expensive equipment, routine instrument inspection, careful operation and regular calibration. Within the past decade, consistent solar energy measurements have been made in selected locations across the U.S. Two sites in Colorado were included as part of a national network: Boulder and Grand Junction. In addition, solar data have been collected in Fort Collins in support of research at Colorado State University related to agriculture, atmospheric science and solar energy applications. Though solar radiation has been monitored in Fort Collins for approximately 10 years, data have often been incomplete and not available for public use for months or years after being collected. Additionally, these monitoring programs rely on year to year funding with no guarantee that they will continue in the future.

The data reported here were collected in the first year of a solar radiation monitoring program undertaken by the City of Fort Collins Light and Power Utility and the Colorado Climate Center at CSU. A unique cooperative agreement was signed in November 1984, in which the Utility agreed to purchase the instrumentation necessary to measure incoming solar radiation on a horizontal surface. The instrumentation is located at the CSU main campus weather station, at which many elements of the Fort Collins climate have been continuously monitored since 1887. The Colorado Climate Center is responsible for the routine maintenance and operation of the equipment, and archival and dissemination of the data. These activities were added to existing data collection procedures at the weather station. Solar data collection began during May 1985 and is planned to continue indefinitely.

This cooperative data collection program provides several advantages. Solar data are now publicly available on a nearly real time basis. The continuous presence of weather station personnel results in high quality data with very few interruptions. The ready availability of the data encourages more use of the data and motivates research ideas from both the renewable energy and the atmospheric science perspective. The program is a logical complement to Utility programs which promote the use of solar energy, and the Utility also hopes to use the information to help to forecast system electrical loads.

2. DATA COLLECTION

The instrumentation used in this program includes:

- a Kipp and Zonen Model CM11 thermopile pyranometer,
- a Li-Cor Model 1776 single channel datalogger (with Model 1776-01 Millivolt Input Module),
- a Radio Shack Model 100 portable computer.

Specifications for the response characteristics of this type of pyranometer appear in Figure 1. A field calibration check showed excellent agreement with the conversion constant supplied by the manufacturer.

The equipment is installed at the CSU campus weather station (just NW of the Lory Student Center). The sensor is mounted approximately 2 meters off the ground with no obstructions within its field of view. The datalogger and computer are located inside the conditioned weather observation office, approximately 20 meters from the sensor.

Instantaneous radiation measurements (total hemispheric) are integrated by the datalogger over an hour long period which ends at the top of each hour. The computer interrogates the datalogger hourly, recovers the most recent hourly value, converts units, stores the data, and updates the daily total. Up to one month of hourly solar data can be stored in the computer, and the datalogger holds the 128 most recent readings in memory as backup protection.

Experience has shown that without regular manual attention, automated data collection systems often fail. Therefore, special effort is made to assure frequent manual evaluation of the system. Every two hours, at times corresponding to the bihourly scheduled weather



KIPP & ZONEN

CALIBRATION CERTIFICATE

PYRANOMETER:	KIPP & ZONEN "SOLARIMETER"		
TYPE:	CM 10	No.	840535
SENSITIVITY AT 20°:	<u>4.52 x 10⁻⁶ V per W/m² (with no load).</u>		
RADIOMETRIC REFERENCE:	World Radiometric Reference (WRR).		
CALIBRATION PROCEDURE:	Source: 1000 W tungsten-halogen lamp. Colour temperature: 3300° K. Angle of incidence: normal incidence. Standard pyranometer: CM 10 900074 Orientation of the pyranometers: horizontal. Irradiance: 450 - 550 W/m ²		
IMPEDANCE:	1411	Ohms at approx 20° C.	
COSINE RESPONSE:			
at zenith angle:	40°	-0.3	%
	60°	-0.8	%
	70°	-1.1	%
	80°	1	%

(expressed as percentage deviation from the ideal proportionality to the cosine) for a radiometrically levelled instrument irradiated by a parallel beam of light (full collimation angle 0.5°)

N.B.

This calibration is referred to WRR.

The WRR is brought into effect from January 1st, 1981.

To express radiation measurements in the old IPS 1956 scale, WRR irradiances have to be decreased by 2.2 %.

To express sensitivity in mV per cal/cm² min multiply by 0.6978 x 10⁶.

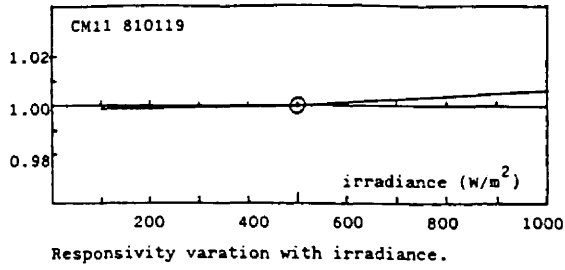
To express sensitivity in mV per W/cm² multiply by 10⁷.

CALIBRATION DATE: September 1984.

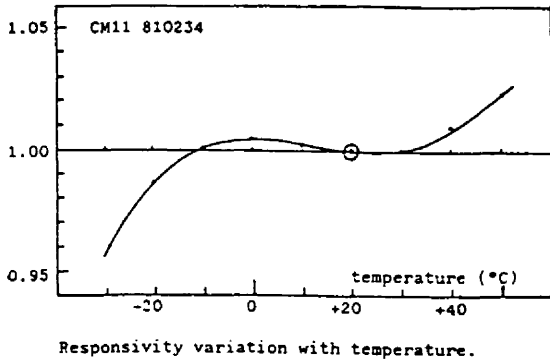
KIPP & ZONEN

DELFT/HOLLAND.

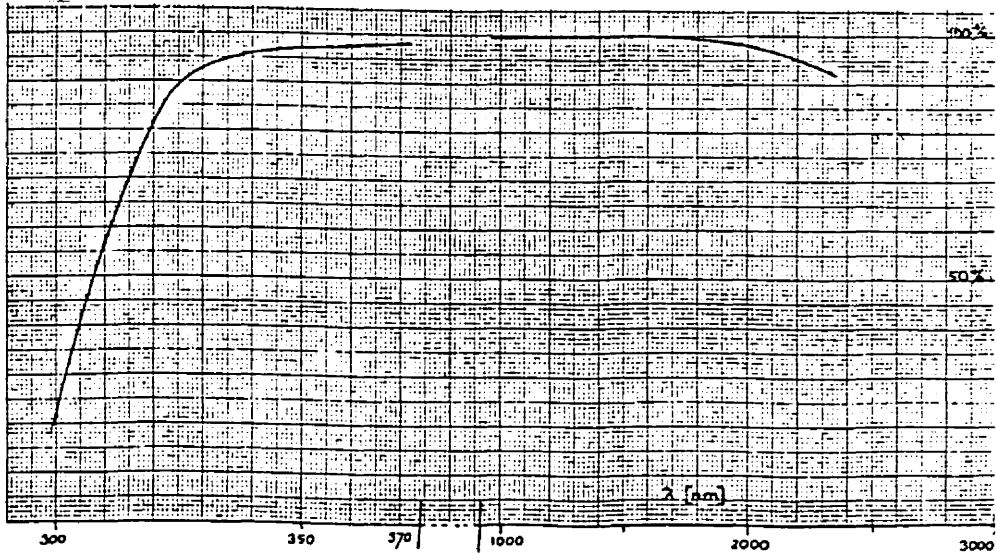
Figure 1. Calibration characteristics of Kipp and Zonen Model CM11 thermopile pyranometer.



KIPP & ZONEN PYRANOMETER CM11
 Typical Performance Curves
 ○ Calibration conditions.
 Delft, 1981.



TILT EFFECT
 Not any tilt effect is observed
 at irradiance levels up to
 1000 W/m².



Relative transmission vs. wavelength of Solarimeter domes
 for 2 x 2 mm material thickness - 4 surface reflections
 included (normal incidence) - taking into account the
 index change with wavelength - calculated from Schott
 data sheet K5 - 522595.

Figure 1 continued. Response characteristics of Kipp and Zonen Model CM11 thermopile pyranometer.

observations (24 hours a day, 7 days a week), a trained weather observer reads the hourly solar data file on the portable computer and manually records the most recent hourly values on an observation form. Remarks are recorded and the station director contacted if any problem with the data collection system is noted. Each two hours the two most recent hourly solar values are also manually entered into a public access data file on the CSU computer system. In addition, the observer cleans the dome of the pyranometer each morning at sunrise. If precipitation is falling during the day, the observer also wipes the dome clean every two hours throughout the day. This is especially important during periods of snow accumulation.

The weather station director weekly verifies each hourly solar reading for that week and flags problems. Data obviously in error are carefully checked. If cloud cover appeared to be relatively stable through the period in question, values may be estimated. When no estimates are possible, values are eventually replaced by hourly readings from the pyranometer operated by the Atmospheric Science Department at the CSU foothills campus. If no data are available to produce an estimate, a zero value is entered along with an appropriate flag for missing data. Data in question for other reasons are marked as "suspect."

This verified data set is uploaded from the weather station portable computer to a public access file on the CSU Cyber mainframe computer system. The final archive file is maintained under Colorado Climate Center control on a VAX computer system in the Department of Atmospheric Science and is updated monthly. Summary tables are printed each month giving hourly and daily totals and hourly averages. These

tables, in a format similar to the data tables in this report, are available from the Center a few days after the end of each calendar month.

Hourly and daily global solar radiation data from this cooperative program are disseminated to users in a variety of ways. Data from recent months can be obtained in hard copy form from the Colorado Climate Center, or accessed on either the CSU GREEN computer system or the Atmospheric Science Department's VAX system (in both cases, prior arrangements must be made with the Center to insure user access). For more recent data and for near real-time access, there are also several options. Small amounts of data may be obtained via a phone request to the weather station, the Colorado Climate Center or the Utility. Access to the appropriate data file on the CSU GREEN system can also be granted on request. For broader dissemination, daily solar radiation values are published each month as part of the "Sunshine and Solar Radiation" section of Colorado Climate, a monthly statewide climate information publication of the Colorado Climate Center.

3. OPERATIONS SUMMARY

The Fort Collins cooperative solar data collection program has been in operation for more than one year. There have been several minor problems during this first year, but they have had little impact on the overall data quality and most have been solved.

The majority of the suspect values and some of the estimated values are due to moisture in the pyranometer electrical connector. Following periods of rain, nighttime values significantly above zero were

sometimes recorded. The nighttime effect is obvious, but it is impossible to accurately estimate the error in the daytime measurements. Any hourly value which may have been affected by this problem has been labelled "suspect" even though the effect may have been very small.

The automated data transfer from datalogger to computer occasionally failed for unknown reasons. In most of these cases missing data could be manually recovered from the datalogger's internal memory. In a few isolated instances, the datalogger skipped an integration period or produced spurious hourly values. No pattern to this behavior has been discernible.

A final problem, due to an interaction between the datalogger and portable computer, was a timing error which accumulated at a few seconds per day. When first recognized, the integration period had been shifted forward by approximately 15 minutes and was resetting at 15 minutes after the hour rather than at the top of each hour. Hourly total values, therefore, do not correspond exactly with the time period listed, but this caused no error in the daily totals. After September 1985 time errors were held to five minutes or less by making small modifications in the operating procedures and by manually resetting the clock twice a month. In early 1986 the problem was solved. Time errors were logged by weather observers so that corrections to hourly values can be made if necessary.

Despite these problems, overall data quality is excellent. During the period 1 June 1985 through 31 May 1986 there were 4870 hours with potential sunlight. Only 61 hourly values (1.3%) were missing or in error, and for all of these, estimates were possible using procedures outlined above. Additionally, 134 hourly values (2.8%) were flagged as

"suspect." For these, although individual hours may have large relative errors (i.e. twilight hours at dawn and dusk), impacts of these suspect readings on daily totals is believed to be very small (on the order of 1 to 5%). The remaining hourly values all appear to be correct within the accuracy of the instrumentation. The first year data recovery rate is, therefore, 96% or better. This data quality and recovery rate is much higher than reported by either the National Solar Radiation Network or previous CSU data collection programs. Much of this success is due to the routine manual intervention which is part of the weather station standard operating procedure.

4. DATA SUMMARY

The graphs and tables which follow depict the solar energy climate of Fort Collins, Colorado, during the 1 June 1985 through 31 May 1986 period. All hourly values and daily totals are presented in Table 1-12. Figures 2-13 plot the daily radiation totals and, for comparison, the extraterrestrial radiation (the amount of energy received on a horizontal surface in the absence of the atmosphere). Days including one or more estimated or suspect hourly values are flagged accordingly. Figure 14 presents the distribution of daily total solar radiation for the entire year. Hourly solar values for select clear days in December and June (near the winter and summer solstices, respectively) are displayed on Figure 15. A comparison shows almost exactly three times more solar radiation falling on a horizontal surface for a clear day in June than December. Finally, monthly values of average daily solar radiation are compared to the Fort Collins averages for the 1975-1985

period developed from the data collected at the CSU Atmospheric Science Department on the foothills campus (Table 13 and Figure 16). Monthly values for 1985-1986 are higher than average for five months and lower than average for seven months. For the year as a whole, total solar energy received on a horizontal surface nearly equalled the 1975-1985 average.

Conversion factors are given in Table 14 to convert the units used in this report (Megajoules per square meter) to other commonly used solar energy units.

Table 1.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION
 Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: June 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.032	0.256	0.700	1.472	2.261	1.807	3.370	1.771E	1.602	1.537	1.512	1.044	1.020	0.590	0.191	0.014	19.195*
2	0.007	0.119	0.702	1.825	2.390	2.351	2.588E	3.082	3.784	2.200	2.930	2.056	0.652	0.421	0.120	0.022E	25.254*
3	0.000E	0.454E	0.288	1.235	2.725	2.844	2.660	3.305	1.386	0.875	1.016	0.240	0.223	0.137	0.166	0.014	18.176*
4	0.000E	0.086*	0.186	0.263	0.349	0.500	0.623	0.835	1.674	0.652	0.900	0.500	0.263	0.238	0.176*	0.065*	7.290*
5	0.000E	0.166*	0.893*	1.674*	2.365*	2.916*	3.233*	3.535*	3.442*	3.226	1.825	1.058	1.624	0.428	0.097	0.007	26.489*
6	0.000E	0.414	1.012	1.681	2.423	3.010	2.884	2.660	1.904	1.610	2.628	2.563	1.156	0.335	0.119	0.007	24.412*
7	0.072	0.583	1.217	1.937	2.549	3.042	3.384	3.560	3.560	3.265	2.837	2.261	1.609	0.985	0.184	0.007	31.032
8	0.047	0.551	1.217	1.897	2.516	3.010	3.384	3.568	2.603	1.505	0.821	0.401	0.439	0.500	0.238	0.025	22.781
9	0.047	0.533	1.195	1.872	2.491	2.948	3.330	2.909	1.386	1.314	1.220	0.781	0.439	0.256	0.047	0.000	20.776
10	0.007	0.151	0.328	0.486	0.454	0.612	1.044	1.084	1.123	1.044	1.361	2.048	0.781	0.216	0.097	0.007	10.843
11	0.025	0.335	1.195	1.888	2.509	2.754	2.586E	2.423	2.405	1.849	1.570	0.551	0.454	0.302	0.119	0.000	20.761*
12	0.054	0.054*	0.583	1.260	1.966	3.107	3.442	3.442	3.593	3.528	3.265	2.828	1.602	1.602*	0.763	0.191	31.277*
13	0.000	0.047	0.763E	0.940	1.919	2.556	2.556	2.948	3.017	2.732	1.847	1.498	1.688	1.418	0.677	0.158	24.764*
14	0.000	0.054	0.583	1.242	1.926	1.926*	2.866	3.179	2.765	2.372	2.452	2.452*	1.019	0.598	0.605	0.137	24.174*
15	0.000	0.072	0.598	1.267	1.966	2.581	3.067	3.416	3.548	3.488	3.226	2.797	2.221	1.552	0.788	0.158	30.744
16	0.000	0.079	0.630	1.274	1.814	2.516	3.074	3.442	3.402	2.444	1.148	0.280	1.051	0.605	0.007	0.032	21.809
17	0.000	0.032	0.191	0.400	0.691	1.307	3.067	3.402	3.548	3.456	3.186	2.182	0.907	1.428	0.803	0.176	24.772
18	0.000	0.040	0.598	1.274	1.976	2.603	3.114	3.442	3.588	3.503	3.233	2.786	2.182	1.523	0.788	0.166	30.794
19	0.000	0.072	0.630	1.307	1.998	2.614	3.107	3.442	3.560	3.481	3.211	2.765	2.182	1.490	0.662	0.144	30.665
20	0.007	0.054	0.335	1.314	2.009	2.635	2.351	2.837	3.488	1.775	2.326	2.725	0.932	0.248	0.104	0.097	23.238
21	0.007	0.032	0.209	1.210	1.966	2.603	3.100	3.416	3.107	2.891	1.879	2.819	2.207	1.228	0.796	0.166	27.634
22	0.007	0.079	0.644	1.321	2.030	2.653	3.161	3.488	3.607	3.546	3.290	2.819	2.239	1.577	0.835	0.144	31.442
23	0.007	0.086	0.644	1.381	2.030	2.628	3.139	3.600	3.100	2.826	1.177	1.433	2.207	1.577	0.788	0.137	26.741
24	0.007	0.126	0.583	1.195	1.944	2.772	3.211	3.352	3.179	2.279	2.272	1.609	0.860	0.317	0.367	0.144	24.217
25	0.000	0.014	0.238	0.925	1.584	1.793	1.400	1.418	0.821	0.126	1.364	1.919	1.084	0.446	0.047	0.000	13.169
26	0.007	0.014	0.176	0.479	0.835	0.079	1.433	2.102	2.167	1.872	1.051	1.433	1.156	0.796	0.763	0.166	14.530
27	0.007	0.126	0.716	1.388	2.102	2.725	3.233	3.535	3.647	3.568	3.283	2.819	2.214	1.530	0.788	0.126	31.806
28	0.007	0.119	0.691	1.381	2.056	2.668	3.154	3.474	3.586	3.496	3.211	2.732	2.063	0.439	0.032	0.025	29.113
29	0.000	0.112	0.670	1.339	1.991	2.452	2.797	2.318	2.635	1.361	1.372	1.807	1.728	0.684	0.637	0.151	22.054
30	0.000	0.104	0.583	1.116	2.038	2.635	3.089	2.675	2.707	2.970	2.747	2.365	0.198	0.407	0.652	0.137	24.422
Tot.	0.35	4.96	18.99	38.20	57.07	70.65	83.44	87.66	83.91	76.00	64.76	55.65	38.40	23.85	12.46	2.62	714.37*
Ave.	0.012	0.165	0.633	1.273	1.929	2.355	2.781	2.922	2.797	2.353	2.159	1.855	1.280	0.795	0.415	0.087	23.812

M = Missing
 E = Estimated
 * = Suspect

Table 2.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION

Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: July 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.086	0.677	1.339	2.009	2.596	3.114	3.665	2.812	1.300	0.216	0.209	0.565	0.590	0.691	0.248	20.117
2	0.166	0.288	0.814	1.440	2.135	2.707	3.146	3.409	3.488	3.391	2.603	2.365	1.740	1.235	0.540	0.144	29.617
3	0.007	0.119	0.691	1.379	2.056	2.675	3.114	3.240	3.665	3.449	3.251	2.070	0.860	0.583	0.320	0.025	27.511
4	0.007	0.065	0.652	1.314	1.958	2.581	3.107	3.391	3.474	3.456	3.017	1.998	0.652	0.630	0.709	0.072	27.083
5	0.007	0.112	0.623	1.289	1.919	2.534	3.067	3.344	3.488	3.344	2.866	2.318	2.023	1.339	0.612	0.079	28.966
6	0.007	0.097	0.623	1.307	2.009	2.653	3.139	3.463	3.226	3.521	0.860	1.210	0.788	0.518	0.310	0.079	23.810
7	0.000	0.119	0.598	1.372	1.991	2.326	3.200	3.370	0.997	0.414	0.778	1.634	0.637	0.439	0.144	0.040	18.058
8	0.000	0.104	0.677	0.518	1.321	2.916	2.930	3.139	3.362	3.100	1.037	0.349	0.263	0.749	0.342	0.079	20.887
9	0.000	0.097	0.439	0.479	0.800	1.847	2.135	3.121	3.402	2.819	2.398	1.696	2.016	1.138	0.479	0.054	22.979
10	0.000	0.112	0.612	1.206	1.372	2.088	2.916	3.424	2.491	3.179	1.076	1.282	1.109	0.662	0.382	0.025	21.989
11	0.000	0.097	0.598	1.249	1.886	2.484	2.923	1.170	1.976	0.875	0.428	0.079	0.518	0.360	0.097	0.007	14.749
12	0.000	0.119	0.421	1.012	0.803	2.509	2.542	2.048	2.261	1.249	2.516	2.228	0.389	0.166	0.277	0.079	18.619
13	0.000	0.072	0.684	1.393	1.854	2.174	2.851	2.135	1.242	1.681	1.584	1.418	0.335	1.282	0.342	0.040	19.087
14	0.000	0.119	0.652	1.328	2.016	2.621	3.089	3.449	1.109	1.051	1.681	1.037	1.874	1.217	0.439	0.032	21.514
15	0.000	0.144	0.716	1.314	1.793	1.346	1.689	3.553	1.544	0.644	2.272	1.195	0.763	1.348	0.486	0.040	18.846
16	0.000	0.151	0.533	1.300	1.976	2.581	3.146	2.638	2.916	3.283	2.938	1.591	0.461	1.195	0.360	0.040	24.509
17	0.000	0.097	0.256	1.269	1.976	2.534	3.121	3.263	3.017	1.919	0.342	0.248	1.084	0.846	0.248	0.065	20.326
18	0.000	0.007	0.097	0.310	0.893	1.609	2.596	3.139	1.832	0.328	0.446	0.691	0.079	0.176	0.104	0.007	12.316
19	0.032	0.047	0.104	0.126	0.223	0.382	0.572	0.540	0.702	0.295	0.248	0.277	0.295	0.158	0.079	0.032	4.115
20	0.040	0.151	0.583	0.803	1.465	1.991	2.844	1.696	2.056	2.221	1.944	0.835	0.479	0.479	0.054	0.007	17.647
21	0.025	0.040	0.288	0.644	0.702	0.781	1.968	2.603	2.070	2.819	3.074	1.523	1.451	0.749	0.302	0.025	19.062
22	0.000	0.054	0.421	0.680	1.339	1.897	1.912	1.786	2.110	3.258	2.365	1.386	1.386	0.551	0.360	0.230	19.634
23	0.209	0.310	0.677	0.972	1.735	1.872	2.214	3.496	2.405	0.526	2.646	2.239	1.498	1.026	0.360	0.158	22.342
24	0.086	0.288	0.709	1.372	1.814	3.017	1.753	2.509	2.484	0.821	1.098	1.663	1.289	1.037	0.702	0.428	21.071
25	0.389	0.637	1.202	1.735	2.326	3.035	3.074E	3.377	2.930	2.398	2.398	2.286	1.609	0.893	0.198	0.000	29.466
26	0.000	0.137	0.526	0.814	1.490	2.326	3.089	3.384	3.434	3.017	1.328	1.960	1.624	0.893	0.198	0.007	24.232
27	0.000	0.230	0.788	1.483	2.189	2.747	3.186	2.358	1.735	3.233	1.465	0.335	1.490	0.914	0.191	0.007	22.352
28	0.007	0.238	0.796	1.544	2.160	2.765	3.200	1.642	0.781	0.763	1.267	1.012	0.716	0.079	0.007	0.000	16.978
29	0.000	0.040	0.144	0.486	0.623	1.076	0.407	1.177	1.361	1.505	1.865	1.644	1.076	0.479	0.144	0.000	11.426
30	0.000	0.198	0.389	0.709	1.249	2.628	3.107	2.740	1.300	1.361	1.753	0.677	1.012	0.389	0.047	0.000	17.557
31	0.047	0.176	0.533	1.249	2.318	2.797	3.161	3.434	3.449	3.100	2.714	0.788	0.716	0.389	0.158	0.007	25.038
Tot.	1.03	4.55	17.52	33.41	50.46	70.10	82.31	85.12	73.57	64.85	54.48	39.65	30.60	22.51	9.69	2.06	641.90
Ave.	0.033	0.147	0.565	1.078	1.628	2.261	2.655	2.746	2.373	2.092	1.757	1.279	0.987	0.726	0.313	0.066	20.707

M = Missing
 E = Estimated
 * = Suspect

Table 3.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION
 Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: August 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.120	0.151	0.518	1.019	1.944	2.563	2.484	2.747	2.909	2.509	2.174	1.004	0.088	0.032	0.000	20.268
2	0.000	0.184	0.774	1.372	2.207	2.686	2.383	2.300	2.318	2.444	0.518	0.166	0.907	0.670	0.054	0.000	18.983
3	0.000	0.248	0.840	1.602	2.207	2.725	3.172	3.290	3.391	3.180	2.740	2.167	1.512	0.798	0.104	0.000	27.988
4	0.000	0.248	0.893	1.591	2.254	2.797	3.179	3.384	3.362	3.128	2.714	2.160	1.490	0.783	0.097	0.000	28.062
5	0.000	0.250	0.880	1.602	2.246	2.866	3.305	3.035	2.826	1.584	1.735	1.591	1.591	0.814	0.104	0.000	24.440*
6	0.000	0.238	0.875	1.584	2.246	2.779	3.188	3.233	3.067	2.582	2.189	1.091	1.249	0.481	0.104	0.000	24.804
7	0.000	0.238	0.932	1.328	1.530	2.340	2.038	1.570	3.074	2.221	1.202	1.768	0.814	0.583	0.112	0.000	19.750
8	0.000	0.240	0.900	1.577	2.207	2.786	3.193	3.370	3.377	3.067	2.740	1.814	1.051	0.652	0.097	0.000	27.079
9	0.000	0.209	0.320	0.860	0.644	0.780	0.868	0.662	0.277	0.724	2.452	2.038	1.393	0.684	0.079	0.000	12.000
10	0.000	0.238	0.886	1.024	2.279	2.826	3.200	3.370	3.312	3.042	2.596	1.937	1.051	0.439	0.032	0.000	26.831
11	0.000	0.335	1.163	0.749	0.828	1.991	2.214	3.211	2.117	2.837	1.872	1.321	1.267	0.407	0.032	0.000	20.344
12	0.000	0.250	0.932	1.874	2.340	2.610E	2.866	3.330E	3.391	3.179	2.797	2.221	1.552	0.821	0.144	0.000	28.112*
13	0.000	0.144	0.749	1.458	2.149	2.714	3.074	3.330	3.344	3.128	2.837	1.123	0.670	0.590	0.054	0.000	25.366
14	0.000	0.032	0.263	0.454	0.191	0.821	1.584	1.091	3.049	2.272	2.583	2.149	1.426	0.710	0.126	0.000	16.736
15	0.000	0.126	0.652	1.274	2.102	2.693	3.089	3.323	3.344	3.128	2.725	1.721	0.900	0.328	0.137	0.000	25.542
16	0.000	0.137	0.734	1.433	2.128	2.725	3.146	1.544	1.084	1.487	1.775	0.702	0.677	0.986	0.126	0.000	18.884
17	0.000	0.119	0.652	1.372	1.919	2.581	3.107	2.038	3.010	2.574	1.775	1.440	1.400	0.481	0.047	0.000	22.493
18	0.000	0.184	0.414	0.652	0.749	0.677	0.389	1.148	1.051	0.166	1.328	1.282	0.400	0.270	0.040	0.000	8.748
19	0.000	0.151	0.590	0.886	1.037	1.004	2.063	0.288	1.130	1.674	1.361	1.019	1.170	0.461	0.032	0.000	12.866
20	0.000	0.144	0.691	1.440	2.142	2.786	3.154	3.305	3.179	2.850	2.102	0.374	0.526	0.137	0.025	0.000	22.864
21	0.000	0.072	0.493	1.393	2.063	2.628	3.128	1.886	0.511	2.423	0.965	0.486	0.893	0.198	0.065	0.000	17.204
22	0.000	0.097	0.572	1.400	2.063	2.675	3.042	2.891	1.116	0.710	0.972	0.572	0.925	0.374	0.047	0.000	17.464
23	0.000	0.112	0.677	1.393	2.077	2.653	3.035	3.218	3.193	2.938	2.502	1.912	1.228	0.526	0.032	0.000	25.495
24	0.000	0.119	0.716	1.426	2.110	2.675	3.074	3.265	3.220	2.963	2.516	1.937	1.228	0.500	0.014E	0.000	25.769*
25	0.000	0.079	0.637	1.346	2.048	2.628	3.035	3.240	3.240	3.010	2.500	1.984	1.170	0.511	0.065	0.000	25.502
26	0.000	0.086	0.644	1.346	1.998	2.581	2.786	1.904	2.779	2.430	1.012	1.663	0.572	0.144	0.007	0.000	19.955
27	0.000	0.086	0.612	1.321	1.976	1.616	1.463	2.009	1.944	2.534	0.965	0.256	0.263	0.248	0.047	0.000	15.361
28	0.000	0.079	0.461	0.572	1.951	2.174	2.732	2.117	1.274	0.940	1.634	1.465	0.472	0.374	0.007	0.000	16.254
29	0.000	0.072	0.605	1.300	1.976	2.239	1.746	2.383	1.458	2.688	1.681	0.749	1.116	0.176	0.007	0.000	18.176
30	0.000	0.065	0.598	1.242	2.009	2.556	2.948	3.139	3.114	2.516	2.437	1.314	0.374	0.367	0.032	0.000	22.712
31	0.000	0.072	0.612	1.289	1.966	2.542	2.804	1.267	0.558	0.407	1.004	0.691	0.382	0.238	0.040	0.000	13.871
Tot.	0.00	4.80	20.94	39.08	56.66	72.11	81.59	76.63	74.87	71.65	60.81	43.29	30.67	14.78	1.94	0.00	649.81*
Ave.	0.000	0.155	0.675	1.261	1.828	2.326	2.632	2.472	2.415	2.311	1.962	1.396	0.989	0.477	0.063	0.000	20.962

M = Missing
 E = Estimated
 * = Suspect

Table 4.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION

Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: September 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.025	0.158	0.367	0.558	1.348	1.768	1.577	0.500	1.847	1.458	0.644	0.151	0.014	0.000	0.000	10.415
2	0.000	0.120	0.590	0.932	0.907	1.760	2.311	2.786	1.577	2.016	0.421	1.116	1.400	0.216	0.007	0.000	16.175
3	0.000	0.025	0.500	1.274	1.865	1.314	1.451	2.970	3.312	1.793	0.796	0.236	0.144	0.126	0.000	0.000	15.000
4	0.000	0.032	0.209	0.331	1.044	2.398	2.286	1.847	1.300	1.426	2.228	0.724	0.342	0.007	0.007	0.000	14.180
5	0.000	0.072	0.648	1.321	1.998	2.542	2.923	3.107	3.082	2.837	2.398	1.760	1.037	0.191	0.007	0.000	23.922
6	0.000	0.065	0.612	1.321	1.991	2.556	2.916	3.100	3.038	2.765	2.293	1.696	0.774	0.144	0.007	0.000	23.278
7	0.000	0.065	0.742	1.026	1.854	1.944	1.998	1.951	2.412	2.844	1.775	0.907	0.112	0.047	0.007	0.000	17.683
8	0.000	0.065	0.005	1.314	2.009	2.556	2.923	3.074	3.017	2.732	2.279	1.663	0.947	0.151	0.007	0.000	23.342
9	0.000	0.072	0.310	1.026	2.009	2.491	2.858	3.010	2.948	1.951	1.228	0.540	0.407	0.126	0.007	0.000	18.983
10	0.000	0.025	0.216	0.310	1.076	1.242	1.577	2.491	1.976	2.182	1.753	1.400	0.328	0.047	0.007	0.000	14.630
11	0.000	0.000	0.032	0.191	0.907	1.123	1.138	1.019	0.932	0.914	0.389	0.310	0.097	0.184	0.032	0.000	7.268
12	0.000	0.032	0.518	1.242	1.951	2.534	2.916	3.107	3.089	2.844	2.365	1.728	1.019	0.223	0.007	0.000	23.576
13	0.000	0.032	0.486	1.188	1.919	2.502	2.876	3.049	3.017	2.747	2.279	1.656	0.846	0.144	0.007	0.000	22.748
14	0.000	0.025	0.198	0.925	1.919	2.328	2.819	2.916	2.844	2.542	2.160	1.440	0.025	0.097	0.007	0.000	20.243
15	0.000	0.007	0.137	0.238	0.781	2.128	2.542	2.254	1.991	1.091	0.486	0.583	0.270	0.072	0.000	0.000	12.578
16	0.000	0.014	0.486E	1.138	1.807	2.372	2.804	2.963	2.837	2.923	1.602	0.749	0.446	0.097	0.007	0.000	20.246
17	0.000	0.025	0.454	1.148	1.825	2.398	2.700E	3.035	3.082	2.477	1.944	1.537	0.860	0.072	0.014	0.000	21.571
18	0.000	0.025	0.191	0.814	1.465	1.897	1.753	1.451	1.458	1.440	0.342	0.493	0.079	0.014	0.007	0.000	11.430
19	0.000	0.014	0.400	1.076	1.753	2.365	2.804	2.948	2.866	2.614	2.160	1.530	0.756	0.097	0.007	0.000	21.391
20	0.000	0.000	0.184	0.263	0.702	0.907	0.812	0.716	1.138	1.051	1.418	0.821	0.288	0.065	0.000	0.000	8.185
21	0.000	0.007	0.263	1.163	1.721	2.398	2.747	2.898	2.804	2.509	1.393	0.407	0.119	0.014	0.000	0.000	18.436
22	0.000	0.000	0.158	0.526	0.407	0.565	0.691	0.979	2.646	1.269	1.098	0.518	0.144	0.000	0.025	0.000	9.047
23	0.000	0.007	0.335	0.716	1.282	2.030	2.462	2.272	1.570	0.846	0.526	0.526	0.248	0.025	0.000	0.000	12.845
24	0.000	0.000	0.144	0.360	0.691	0.637	0.461	0.558	0.893	1.814	1.609	0.277	0.079	0.025	0.000	0.000	7.549
25	0.000	0.007	0.342	0.868	1.768	2.261	2.423	3.028	2.898	1.728	1.498	1.300	0.814	0.040	0.007	0.000	18.979
26	0.000	0.007	0.374	1.051	1.753	2.300	2.686	2.819	2.772	2.509	1.926	1.260	0.310	0.047	0.014	0.000	19.829
27	0.000	0.000	0.151	0.572	0.742	1.084	1.249	1.044	1.386	1.249	0.670	0.367	0.198	0.007	0.000	0.000	8.719
28	0.000	0.032	0.032	0.072	0.086	0.184	0.295	0.774	0.853	0.853	0.742	0.342	0.176	0.007	0.000	0.000	4.450
29	0.000	0.000	0.014	0.072	0.166	0.428	0.612	0.479	0.367	0.472	0.493	0.270	0.144	0.007	0.000	0.000	3.524
30	0.000	0.007	0.400	1.123	1.753	2.254	2.732	2.866	2.714	2.303	1.912	1.267	0.533	0.025	0.007	0.000	19.976
Tot.	0.00	0.82	9.89	23.97	40.71	54.84	62.33	67.89	65.32	58.69	43.64	28.86	13.89	2.33	0.26	0.00	470.98
Ave.	0.000	0.027	0.330	0.799	1.357	1.828	2.078	2.236	2.177	1.956	1.455	0.935	0.436	0.078	0.007	0.000	15.699

M = Missing
 E = Estimated
 * = Suspect

Table 5.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION

Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: October 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.000	0.734*	1.483*	1.865*	2.272	2.621	2.754	2.688	2.351	1.825	1.188	0.454	0.014	0.000	0.000	20.228*
2	0.000	0.000	0.054	0.367	1.426	2.142	2.491	2.556	2.444	2.246	1.775	1.156	0.374	0.014	0.000	0.000	17.046
3	0.000	0.000	0.335	1.012	1.656	2.208	2.542	2.688	2.603	2.167	0.846	0.493	0.166	0.007	0.000	0.000	16.711
4	0.000	0.000	0.368	1.076	1.746	2.279	2.628	2.772	2.668	2.351	1.840	1.177	0.414	0.007	0.000	0.000	19.310
5	0.000	0.000	0.342	1.044	1.688	2.287	2.549	2.693	2.603	2.286	1.768	1.123	0.324E	0.007	0.000	0.000	18.634*
6	0.000	0.000	0.209	0.868	1.537	2.063	1.991	1.897	1.696	0.914	1.268	0.702	0.302	0.014	0.000	0.000	13.453
7	0.000	0.000	0.032	0.097	0.630	1.793	2.063	2.365	2.365	1.609	0.598	0.868	0.288	0.025	0.000	0.000	12.733
8	0.000	0.000	0.007	0.144	0.349	0.598	0.414	0.400	0.270	0.288	0.198	0.137	0.054	0.000	0.000	0.000	2.858
9	0.000	0.000	0.032	0.144	0.335	0.428	0.454	0.511	0.605	0.500	0.565	0.439	0.137	0.007	0.000	0.000	4.158
10	0.000	0.000	0.079	0.662	1.498	1.991	2.333	2.518	2.430	2.135	1.663	1.037	0.349	0.007	0.000	0.000	16.700
11	0.000	0.000	0.014	0.097	0.065	0.054	0.137	0.605	1.249	1.483	0.788	0.486	0.184	0.025	0.000	0.000	5.188
12	0.000	0.000	0.191	0.814	1.451	2.088	1.728	1.793	2.858	2.351	1.825	0.868	0.283	0.007	0.000	0.000	16.236
13	0.000	0.000	0.007	0.112	0.230	0.368	0.277	0.439	0.302	0.742	0.486	0.317	0.176	0.000	0.000	0.000	3.528
14	0.000	0.000	0.072	0.590	1.490	1.991	2.358	2.524	2.444	2.149	1.674	1.058	0.328	0.007	0.000	0.000	16.686
15	0.000	0.000	0.137	0.756	1.411	1.951	2.318	2.470	2.390	2.083	1.584	0.979	0.277	0.007	0.000	0.000	16.344
16	0.000	0.000	0.126	0.749	1.386	1.904	2.279	2.437	2.398	2.077	1.602	0.965	0.263	0.014	0.000	0.000	16.200
17	0.000	0.000	0.072	0.742	1.372	1.904	2.272	2.412	2.333	2.048	1.562	0.972	0.310	0.000	0.000	0.000	15.998
18	0.000	0.000	0.047	0.407	0.533	1.195	1.307	1.148	1.098	1.976	1.123	0.925	0.238	0.007	0.000	0.000	10.004
19	0.000	0.000	0.158	0.756	1.346	1.879	2.228	2.372	2.272	1.951	1.465	0.886	0.209	0.025	0.000	0.000	15.548
20	0.000	0.000	0.104	0.691	1.307	1.840	2.200	2.358	2.293	2.016	1.552	0.914	0.230	0.014	0.000	0.000	15.520
21	0.000	0.000	0.097	0.652	1.274	1.786	2.160	2.189	2.207	1.537	0.652	0.605	0.288	0.007	0.000	0.000	13.453
22	0.000	0.000	0.054	0.644	1.267	1.768	2.254	2.390	2.333	1.346	1.832	1.044	0.288	0.007	0.000	0.000	15.228
23	0.000	0.000	0.097	0.749	1.321	1.634	2.196	2.484	2.502	1.602	0.925	0.886	0.209	0.007	0.000	0.000	14.612
24	0.000	0.000	0.086	0.637	1.249	1.753	2.110	2.261	2.182	1.886	1.433	0.691	0.191	0.014	0.000	0.000	14.494
25	0.000	0.000	0.097	0.644	1.268	1.825	2.048	1.919	1.098	1.098	1.051	0.749	0.151	0.007	0.000	0.000	11.948
26	0.000	0.000	0.014	0.328	1.249	1.411	2.048*	1.714	2.246	1.714	1.354	0.774	0.144	0.007	0.000	0.000	13.003*
27	0.000	0.000	0.054	0.572	1.188	1.703	2.063	2.228	2.117	1.879	1.400	0.814	0.166	0.014	0.000	0.000	14.198
28	0.000	0.000	0.054	0.551	1.156	1.498	1.433	1.577	1.832	1.904	0.853	0.374	0.184	0.007	0.000	0.000	11.423
29	0.000	0.000	0.054	0.528	1.148	1.696	1.904	2.149	2.088	1.800	1.314	0.734	0.137	0.007	0.000	0.000	13.558
30	0.000	0.000	0.054	0.558	1.123	1.649	1.991	2.135	2.048	1.753	0.907	0.774	0.072	0.007	0.000	0.000	13.072
31	0.000	0.000	0.000	0.065	0.144	0.493	0.630	0.288	0.223	0.126	0.126	0.144	0.032	0.000	0.000	0.000	2.272
Tot.	0.00	0.00	3.78	18.54	35.70	50.35	58.02	61.04	60.94	52.35	37.86	24.28	7.20	0.30	0.00	0.00	410.35*
Ave.	0.000	0.000	0.122	0.598	1.152	1.624	1.872	1.969	1.966	1.689	1.221	0.783	0.232	0.010	0.000	0.000	13.237

M = Missing
 E = Estimated
 * = Suspect

Table 6.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION
 Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: November 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.000	0.072	0.454	1.170	1.465	1.991	2.142	2.050	1.700	1.274	0.652	0.088	0.000	0.000	0.000	13.129
2	0.000	0.000	0.040	0.238	1.100	1.300	1.584	2.340	1.703	1.282	0.630	0.439	0.088	0.000	0.000	0.000	10.750
3	0.000	0.000	0.014	0.479	1.076	1.602	1.944	2.088	2.016	1.735	1.282	0.702	0.104	0.000	0.000	0.000	13.043
4	0.000	0.000	0.025	0.367	0.932	1.512	1.591	1.984	2.030	1.735	1.280	0.670	0.088	0.000	0.000	0.000	12.193
5	0.000	0.000	0.007	0.223	0.526	1.537	1.800	1.897	0.888	0.216	0.407	0.533	0.088	0.000	0.000	0.000	8.118
6	0.000	0.000	0.040	0.612	1.138	1.584	1.958	1.688	1.242	1.602	1.267	0.590	0.079	0.000	0.000	0.000	11.801
7	0.000	0.000	0.025	0.461	1.058	1.562	1.910	2.016	1.910	1.634	1.249	0.623	0.047	0.000	0.000	0.000	12.514
8	0.000	0.000	0.025	0.454	1.026	1.584	1.904	1.066	0.684	0.407	0.486	0.238	0.014	0.000	0.000	0.000	7.888
9	0.000	0.000	0.000	0.054	0.119	0.238	0.400	0.565	0.734	0.734	0.511	0.288	0.032	0.000	0.000	0.000	3.676
10	0.000	0.000	0.007	0.166	0.230	0.310	0.479	0.479	0.421	0.270	0.209	0.097	0.007	0.000	0.000	0.000	2.675
11	0.000	0.000	0.007	0.191	0.454	0.724	1.076	1.591	1.393	1.379	0.828	0.461	0.007	0.000	0.000	0.000	8.111
12	0.000	0.000	0.000	0.104	0.223	0.420	0.493	0.623	0.558	0.400	0.238	0.079	0.007	0.000	0.000	0.000	3.154
13	0.000	0.000	0.007	0.151	0.328	0.644	1.289	1.966	1.926	1.840	1.109	0.493	0.040	0.000	0.000	0.000	9.792
14	0.000	0.000	0.007	0.112	0.302	0.540	0.407	0.407	0.493	0.342	0.176	0.047	0.000	0.000	0.000	0.000	2.833
15	0.000	0.000	0.000	0.047	0.270	1.483	1.418	1.886	1.267	1.156	1.051	0.947	0.079E	0.000	0.000	0.000	9.605*
16	0.000	0.000	0.025	0.565	0.691	1.282	1.044	0.947	0.868	0.637	0.360	0.295	0.119	0.000	0.000	0.000	6.833
17	0.000	0.000	0.000	0.144	0.565	1.512	1.768	1.991	2.023	1.393	0.821	0.238	0.025	0.000	0.000	0.000	10.480
18	0.000	0.000	0.000	0.088	0.637	1.004	0.940	1.854	1.411	1.498	0.965	0.511	0.025	0.000	0.000	0.000	8.932
19	0.000	0.000	0.000	0.310	0.907	1.512	2.016	1.897	1.919	1.624	1.138	0.511	0.014	0.000	0.000	0.000	11.840
20	0.000	0.000	0.007	0.184	0.907	1.440	1.854	1.944	1.847	1.663	1.098	0.428	0.014	0.000	0.000	0.000	11.387
21	0.000	0.000	0.000	0.126	0.533	0.846	1.321	1.944	1.775	1.584	1.109	0.454	0.014	0.000	0.000	0.000	9.706
22	0.000	0.000	0.000	0.367	1.044	1.696	1.696	1.746	1.865	1.328	0.788	0.191	0.007	0.000	0.000	0.000	10.728
23	0.000	0.000	0.007	0.295	1.260	1.650	1.685	1.872	1.896	0.774	0.886	0.461	0.007	0.000	0.000	0.000	10.598
24	0.000	0.000	0.000	0.342	1.026	1.393	1.674	1.775	1.674	1.379	1.116	0.479	0.025	0.000	0.000	0.000	10.883
25	0.000	0.000	0.000	0.088	0.590	1.282	1.649	1.919	1.840	1.530	1.058	0.328	0.014	0.000	0.000	0.000	10.296
26	0.000	0.000	0.000	0.032	0.198	0.446	0.724	0.644	0.605	0.454	0.374	0.151	0.007	0.000	0.000	0.000	3.636
27	0.000	0.000	0.000	0.054	0.565	1.004	1.098E	1.249	0.844	1.537	0.893	0.277	0.025	0.000	0.000	0.000	7.348*
28	0.000	0.000	0.000	0.151	0.400	0.965	1.267	1.300	1.274	0.997	0.907	0.328	0.032	0.000	0.000	0.000	7.621
29	0.000	0.000	0.000	0.032	0.166	0.389	0.518	0.558	0.630	0.367	0.288	0.198	0.007	0.000	0.000	0.000	3.154
30	0.000	0.000	0.000	0.054	0.317	0.652	0.709	0.940	1.354	1.051	0.954	0.288	0.032	0.000	0.000	0.000	6.350
Tot.	0.00	0.00	0.32	6.94	19.77	33.59	40.22	45.32	40.75	34.32	24.73	12.00	1.13	0.00	0.00	0.00	259.08*
Ave.	0.000	0.000	0.011	0.231	0.659	1.120	1.341	1.511	1.358	1.144	0.824	0.400	0.038	0.000	0.000	0.000	8.636

M = Missing
 E = Estimated
 * = Suspect

Table 7.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION

Hourly Values (Megajoules/Square Meter)
 Klipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: December 1985

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.000	0.000	0.104	0.400	1.044	1.490	1.280	1.775	1.465	0.558	0.184	0.025	0.000	0.000	0.000	8.334
2	0.000	0.000	0.000	0.079	0.428	0.788	1.642	1.321	0.788	0.691	0.486	0.414	0.032	0.000	0.000	0.000	6.671
3	0.000	0.000	0.000	0.151	0.677	1.217	1.584	1.788	1.793	1.451	1.058	0.446	0.025	0.000	0.000	0.000	10.170
4	0.000	0.000	0.000	0.126	0.652	1.202	1.591	1.768	1.728	1.465	1.026	0.439	0.014	0.000	0.000	0.000	10.012
5	0.000	0.000	0.000	0.238	0.972	1.426	1.591	1.552	1.339	1.098	0.623	0.248	0.014	0.000	0.000	0.000	9.101
6	0.000	0.000	0.000	0.047	0.295	0.558	0.709	0.880	0.853	0.900	1.156	0.407	0.007	0.000	0.000	0.000	5.792
7	0.000	0.000	0.000	0.184	0.940	1.300	1.530	1.703	1.656	1.411	0.979	0.407	0.007	0.000	0.000	0.000	10.110
8	0.000	0.000	0.000	0.047	0.389	1.044	1.393	0.486	0.209	0.151	0.166	0.054	0.000	0.000	0.000	0.000	3.938
9	0.000	0.000	0.000	0.086	0.335	0.774	0.724	0.828	0.886	0.670	0.551	0.288	0.007	0.000	0.000	0.000	5.148
10	0.000	0.000	0.000	0.025	0.144	0.454	0.691	0.798	0.803	1.012	0.389	0.209	0.007	0.000	0.000	0.000	4.529
11	0.000	0.000	0.000	0.085	0.526	1.458	2.128	1.786	1.714	1.418	0.914	0.360	0.007	0.000	0.000	0.000	10.375
12	0.000	0.000	0.000	0.086	0.551	1.217	1.624	1.753	1.379	1.177	0.605	0.238	0.007	0.000	0.000	0.000	8.636
13	0.000	0.000	0.000	0.112	0.821	1.703	2.070	2.437	2.304	1.897	1.300	0.558	0.007	0.000	0.000	0.000	13.208*
14	0.000	0.000	0.000	0.079	0.428	1.210	2.023	1.091	1.372	0.925	0.662	0.349	0.025	0.000	0.000	0.000	8.165
15	0.000	0.000	0.000	0.112	0.742	1.170	1.644	1.714	1.663	1.418	0.972	0.389	0.007	0.000	0.000	0.000	9.731
16	0.000	0.000	0.000	0.097	0.662	1.148	1.537	1.753	1.696	1.386	0.670	0.428	0.040	0.000	0.000	0.000	9.418
17	0.000	0.000	0.000	0.150	0.479	0.875	1.130	1.177	1.512	1.602	0.886	0.238	0.014	0.000	0.000	0.000	8.071
18	0.000	0.000	0.000	0.032	0.223	0.421	0.796	1.098	1.026	0.691	0.428	0.191	0.014	0.000	0.000	0.000	4.921
19	0.000	0.000	0.000	0.047	0.360	0.670	0.940	1.300	1.026	0.965	0.716	0.374	0.014	0.000	0.000	0.000	6.412
20	0.000	0.000	0.000	0.079	0.558	1.044	1.433	1.634	1.591	1.418	0.914	0.317	0.032	0.000	0.000	0.000	9.022
21	0.000	0.000	0.000	0.104	0.605	1.098	1.451	1.642	1.642	1.339	0.954	0.414	0.025	0.000	0.000	0.000	9.274
22	0.000	0.000	0.000	0.032	0.461	1.044	1.440	1.642	1.634	1.418	1.019	0.500	0.025	0.000	0.000	0.000	9.216
23	0.000	0.000	0.000	0.085	0.277	0.623	1.004	1.681	1.386	0.533	0.256	0.209	0.054	0.000	0.000	0.000	6.088
24	0.000	0.000	0.000	0.007	0.144	0.349	0.360	0.374	0.461	0.670	0.900	0.382	0.025	0.000	0.000	0.000	3.672
25	0.000	0.000	0.000	0.032	0.439	1.058	1.440	1.642	1.634	1.418	1.051	0.533	0.025	0.000	0.000	0.000	9.274
26	0.000	0.000	0.000	0.040	0.486	1.066	1.428	1.642	1.656	1.458	1.058	0.533	0.025	0.000	0.000	0.000	9.389
27	0.000	0.000	0.000	0.054	0.702	1.328	1.624	1.760	1.696	1.472	1.084	0.551	0.032	0.000	0.000	0.000	10.303
28	0.000	0.000	0.000	0.065	0.781	1.307	1.307	1.681	1.688	1.490	1.130	0.590	0.032	0.000	0.000	0.000	9.983
29	0.000	0.000	0.000	0.079	0.558	1.091	1.490	1.847	1.775	1.523	0.565	0.392	0.032	0.000	0.000	0.000	9.342
30	0.000	0.000	0.000	0.032	0.407	0.860	1.130	1.740	1.688	1.584	1.210	0.590	0.040	0.000	0.000	0.000	9.288
31	0.000	0.000	0.000	0.032	0.598	1.418	0.947	0.940	0.821	0.742	1.019	0.630	0.032	0.000	0.000	0.000	7.178
Tot.	0.00	0.00	0.00	2.50	16.04	31.90	41.79	44.71	43.19	36.86	25.30	11.76	0.66	0.00	0.00	0.00	254.76*
Ave.	0.000	0.000	0.000	0.081	0.517	1.031	1.348	1.442	1.393	1.189	0.816	0.379	0.021	0.000	0.000	0.000	8.219

M = Missing
 E = Estimated
 * = Suspect

Table 8.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION

Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: January 1986

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.007	0.000	0.014	0.295	1.066	1.537	1.123	0.940	1.379	1.051	0.472	0.072	0.007	0.000	0.000	7.963
2	0.000	0.007	0.007	0.047	0.486	1.091	1.483	1.703	1.703	1.523	1.138	0.583	0.032	0.007	0.000	0.000	9.810
3	0.000	0.000	0.000	0.032	0.486	1.076	1.490	1.721	1.380	1.195	0.565	0.223	0.025	0.007	0.000	0.000	8.208
4	0.000	0.007	0.007	0.007	0.486	1.098	1.523	1.740	1.753	1.490	1.138	0.605	0.040	0.007	0.000	0.000	9.907
5	0.000	0.007	0.000	0.065	0.533	1.123	1.051	1.123	0.932	0.965	0.880	0.598	0.054	0.000	0.000	0.000	7.312
6	0.000	0.007	0.000	0.007	0.112	0.288	0.590	0.774	0.875	0.954	0.486	0.223	0.014	0.000	0.000	0.000	4.331
7	0.000	0.000	0.000	0.040	0.052	1.123	1.472	1.721	1.760	1.562	1.123	0.590	0.047	0.007	0.000	0.000	10.098
8	0.000	0.000	0.000	0.126	0.716	1.123	1.458	1.148	1.163	1.012	0.742	0.382	0.032	0.007	0.000	0.000	7.909
9	0.000	0.000	0.000	0.079	0.572	1.130	1.505	1.649	1.760	1.530	1.123	0.414	0.054	0.007	0.000	0.000	9.824
10	0.000	0.000	0.000	0.112	0.677	0.925	1.386	1.609	1.530	1.163	0.986	0.583	0.065	0.007	0.000	0.000	9.043
11	0.000	0.000	0.000	0.104	0.520	1.109	1.109	1.746	1.768	1.483	1.249	0.788	0.112	0.007	0.000	0.000	10.001*
12	0.000	0.007	0.000	0.079	0.563	1.116	1.537	1.768	1.775	1.570	1.170	0.630	0.072	0.007	0.000	0.000	10.314
13	0.000	0.007	0.007	0.126	0.724	0.954	0.551	0.605	1.123	0.997	1.076	0.583	0.112	0.014	0.000	0.000	6.880
14	0.000	0.000	0.000	0.112	0.652	1.148	1.570	1.775	1.793	1.609	1.217	0.652	0.072	0.014	0.000	0.000	10.613
15	0.000	0.000	0.000	0.054	0.263	1.058	1.523	1.681	1.760	1.339	0.932	0.558	0.047	0.007	0.000	0.000	9.223
16	0.000	0.007	0.007	0.119	0.756	1.012	1.051	1.505	1.872	1.602	1.235	0.295	0.137	0.007	0.000	0.000	9.605
17	0.000	0.000	0.000	0.065	0.572	0.684	1.044	1.130	1.004	0.888	0.888	0.637	0.151	0.007	0.000	0.000	7.038
18	0.000	0.007	0.000	0.088	0.805	1.156	1.591	1.814	1.898	1.562	1.026	0.486	0.088	0.000	0.000	0.000	9.518
19	0.000	0.000	0.000	0.025	0.230	0.428	0.518	0.533	0.533	0.716	1.066	0.421	0.176	0.000	0.000	0.000	4.648
20	0.000	0.000	0.000	0.025	0.166	0.461	0.821	1.577	1.793	1.634	1.267	0.637	0.040	0.007	0.000	0.000	8.428
21	0.000	0.007	0.007	0.104	0.652	1.210	1.656	1.897	1.912	1.688	1.314	0.763	0.126	0.007	0.000	0.000	11.344
22	0.000	0.000	0.000	0.184	0.828	1.346	0.954	1.418	1.116	0.860	0.846	0.288	0.164	0.000	0.000	0.000	7.945
23	0.000	0.000	0.000	0.072	0.439	1.170	1.591	1.768	1.483	1.321	0.821	0.288	0.065	0.000	0.000	0.000	9.018
24	0.000	0.007	0.007	0.126	0.684	1.260	1.681	1.897	1.904	1.840	0.821	0.454	0.176	0.000	0.000	0.000	10.858
25	0.000	0.007	0.007	0.126	0.684	1.235	1.688	1.944	1.951	1.753	1.354	0.803	0.144	0.007	0.000	0.000	11.704
26	0.000	0.000	0.000	0.230*	0.804E	1.483*	1.728	1.897	1.919	1.703	1.328	0.788	0.144	0.000	0.000	0.000	11.905*
27	0.000	0.000	0.000	0.137	0.677	1.267	1.688	1.897	1.960	1.663	1.393	0.886	0.151	0.007	0.000	0.000	11.732
28	0.000	0.007	0.007	0.065	0.248	1.076	1.512	1.721	1.188	1.624	1.314	0.702	0.176	0.007	0.000	0.000	9.648
29	0.000	0.007	0.000	0.151	0.637	1.217	1.714	1.562	1.991	1.649	0.734	0.374	0.223	0.007	0.000	0.000	10.267
30	0.000	0.000	0.000	0.054	0.295	0.598	0.796	0.893	1.235	0.788	0.191	0.119	0.047	0.000	0.000	0.000	5.015
31	0.000	0.000	0.000	0.065	0.724	1.267	1.696	1.951	2.016	1.483	1.372	0.518	0.166	0.000	0.000	0.000	11.257
Tot.	0.00	0.10	0.06	2.64	16.64	32.30	41.52	47.30	47.00	42.53	31.81	16.34	2.96	0.17	0.00	0.00	281.37*
Ave.	0.000	0.003	0.002	0.085	0.537	1.042	1.339	1.526	1.516	1.372	1.026	0.527	0.090	0.005	0.000	0.000	9.076

M = Missing
 E = Estimated
 * = Suspect

Table 9.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION
 Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: February 1986

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.000	0.000	0.191	0.796	1.321	1.746	1.602	1.458	1.624	0.965	0.734	0.191	0.007	0.000	0.000	10.634
2	0.000	0.000	0.000	0.080	0.288	0.796	1.249	1.958	2.023	1.800	1.428	0.886	0.223	0.007	0.000	0.000	10.742
3	0.000	0.000	0.000	0.144	0.598	1.260	1.775	1.307	1.411	0.493	0.151	0.025	0.025	0.000	0.000	0.000	7.189
4	0.000	0.000	0.000	0.104	0.533	1.418	1.854	1.584	1.642	1.937	0.986	0.814	0.230	0.000	0.000	0.000	11.102
5	0.000	0.000	0.000	0.040	0.288	0.511	0.742	0.788	0.986	0.742	0.846	0.367	0.032	0.000	0.000	0.000	5.342
6	0.000	0.000	0.000	0.151	0.518	1.217	1.919	1.958	1.202	0.868	0.907	0.644	0.230	0.007	0.000	0.000	9.623
7	0.000	0.000	0.000	0.126	0.630	0.940	0.814	0.965	0.886	0.652	0.428	0.328	0.151	0.000	0.000	0.000	5.918
8	0.000	0.000	0.000	0.079	0.439	1.228	1.217	1.577	1.746	0.868	0.684	0.558	0.144	0.000	0.000	0.000	8.539
9	0.000	0.000	0.000	0.144	0.803	1.458	1.393	1.703	1.577	1.634	1.026	0.248	0.119	0.007	0.000	0.000	10.112
10	0.000	0.000	0.007	0.209	0.954	1.217	1.372	1.552	1.386	1.451	1.004	0.724	0.151	0.007	0.000	0.000	10.033
11	0.000	0.000	0.000	0.119	0.511	0.900	0.900	2.063	2.621	2.509	2.128	1.274	0.256	0.014	0.000	0.000	13.295
12	0.000	0.000	0.000	0.166	0.886	1.458	1.760	2.221	1.840	1.642	1.602	1.148	0.277	0.014	0.000	0.000	13.014
13	0.000	0.000	0.000	0.097	0.684	1.361	1.267	0.986	0.893	0.893	0.590	0.446	0.198	0.032	0.000	0.000	7.448
14	0.000	0.000	0.000	0.166	0.803	1.537	1.991	2.149	1.634	1.393	1.800	1.472	0.836	0.047	0.000	0.000	13.828
15	0.000	0.000	0.000	0.126	0.461	1.300	2.038	2.300	2.326	2.214	1.872	1.118	0.166	0.032	0.000	0.000	13.950
16	0.000	0.000	0.000	0.268	0.716	1.195	1.680	1.879	2.128	2.293	0.914	0.742	0.640	0.007	0.000	0.000	11.891
17	0.000	0.000	0.000	0.097	0.400	0.446	0.900	1.847	1.849	1.451	1.109	0.893	0.565	0.047	0.000	0.000	9.403
18	0.000	0.000	0.000	0.198	0.454	0.684	1.282	1.991	1.888	1.498	1.289	0.500	0.191	0.025	0.000	0.000	9.997
19	0.000	0.000	0.000	0.166	0.623	1.037	1.451	1.814	2.300	2.200	1.658	0.763	0.047	0.007	0.000	0.000	12.064
20	0.000	0.000	0.000	0.086	0.230	0.439	0.428	1.076	0.965	0.558	0.605	0.317	0.144	0.014	0.000	0.000	4.864
21	0.000	0.000	0.007	0.684	1.440	1.681	2.128	2.372	2.484	1.346	1.624	1.433	0.652	0.032	0.000	0.000	15.883
22	0.000	0.000	0.007	0.302	1.058	1.681	2.187	2.423	2.470	2.272	1.872	1.361	0.702	0.032	0.000	0.000	16.427
23	0.000	0.000	0.007	0.144	0.439	0.749	0.979	1.210	1.282	0.835	0.749	0.572	0.868	0.086	0.000	0.000	7.920
24	0.000	0.000	0.007	0.414	0.914	1.544	1.937	2.303	2.246	1.584	1.177	0.940	0.652	0.072	0.000	0.000	13.871
25	0.000	0.000	0.025	0.526	1.098	1.768	2.149	2.405	2.963	2.581	1.217	0.868	0.763	0.054	0.000	0.000	16.409
26	0.000	0.000	0.014	0.295	0.907	1.584	1.728	1.058	2.542	2.300	2.030	1.458	0.749	0.079	0.000	0.000	14.746
27	0.000	0.000	0.025	0.479	1.177	1.807	2.286	2.462	2.272	2.149	2.016	1.658	0.511	0.040	0.000	0.000	16.880
28	0.000	0.000	0.025	0.526	1.217	1.865	2.340	2.614	2.628	2.398	1.991	1.411	0.742	0.032	0.000	0.000	17.788
Tot.	0.00	0.00	0.13	6.23	19.86	34.40	43.50	50.25	51.44	44.18	34.66	23.69	9.85	0.71	0.00	0.00	318.91
Ave.	0.000	0.000	0.004	0.223	0.709	1.229	1.554	1.795	1.837	1.578	1.238	0.846	0.352	0.025	0.000	0.000	11.390

M = Missing
 E = Estimated
 * = Suspect

Table 10.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION
 Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: March 1988

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.007	0.032	0.533	1.228	1.840	2.254	2.596	2.628	2.423	1.976	1.448	0.774	0.079	0.014	0.000	17.824
2	0.000	0.007	0.032	0.526	1.202	1.814	2.246	2.160	1.728	1.663	1.609	1.202	0.566	0.097	0.000	0.000	14.854
3	0.000	0.000	0.032	0.565	1.217	1.840	2.333	2.563	2.021	2.423	1.991	1.307	0.724	0.065	0.007	0.000	17.687
4	0.000	0.000	0.040	0.540	1.328	1.814	2.398	2.491	2.779	2.524	2.117	1.537	0.914	0.126	0.014	0.000	18.623
5	0.000	0.007	0.047	0.572	1.287	1.897	2.340E	2.430	2.646	2.444	2.030	1.490	0.798	0.088	0.014	0.000	18.088*
6	0.000	0.007	0.088	0.677	1.328	1.951	2.430	2.686	2.603	2.366	2.182	1.552	0.875	0.072	0.007	0.000	18.742
7	0.000	0.000	0.040	0.342	0.803	1.897	2.383	2.660	2.675	2.444	2.056	1.346	0.439	0.065	0.007	0.000	17.150
8	0.000	0.000	0.007	0.256	0.630	1.530	2.470	2.318	1.386	1.768	1.372	1.361	0.540	0.079	0.007	0.000	13.723
9	0.000	0.007	0.072	0.724	1.228	1.753	2.077	0.184	0.230	1.472	1.217	0.886	0.526	0.151	0.007	0.000	10.534
10	0.000	0.000	0.047	0.540	1.004	1.289	1.084	1.138	0.932	0.446	0.414	0.526	0.270	0.054	0.000	0.000	7.744
11	0.000	0.000	0.054	0.216	0.540	1.418	2.200	2.423	1.775	1.109	0.551	0.446	0.126	0.040	0.000	0.000	10.897
12	0.000	0.000	0.079	0.572	1.321	2.102	2.603	2.837	2.340	0.860	0.612	0.184	0.054	0.040	0.000	0.000	13.604
13	0.000	0.000	0.097	0.576E	0.868	1.379	2.279	2.272	2.398	2.326	2.149	1.703	0.734	0.166	0.007	0.000	16.952*
14	0.000	0.000	0.054	0.576E	1.289E	2.095	2.574	2.786	2.603	1.991	1.562	0.598	0.191	0.032	0.000	0.000	16.351*
15	0.000	0.007	0.054	0.151	0.288	0.428	0.652	0.932	2.383	2.365	2.246	0.979	0.803	0.151	0.025*	0.000	11.466*
16	0.000	0.007	0.119	0.590	0.756	0.702	1.051	1.793	2.300	1.562	1.512	1.188	0.472	0.065	0.000	0.000	12.110
17	0.000	0.007	0.047	0.421	0.691	0.997	1.328	1.634	1.570	1.170	0.846	0.763	0.263	0.007	0.007	0.000	9.752
18	0.000	0.007	0.119	0.880	0.598*	0.598*	0.598*	0.644	0.742	0.605	1.703	1.372	0.932	0.277	0.007	0.000	9.081*
19	0.000	0.000	0.047	0.288	0.526	0.763	0.796	1.562	1.814	0.979	0.940	0.421	0.119	0.040	0.000	0.000	8.294
20	0.000	0.000	0.144	0.846	1.816	2.254	2.437	2.246	2.149	2.187	2.088E	1.372	0.864E	0.256	0.007	0.000	18.446*
21	0.000	0.000	0.238	0.914	1.562	2.246	2.707	2.963	2.977	2.772	2.300	1.721	1.019	0.256	0.014	0.000	21.690
22	0.000	0.000	0.072	0.407	0.888	1.400	1.912	2.142	2.686	2.797	2.340	1.612	0.763	0.295	0.007	0.000	16.700
23	0.000	0.000	0.151	0.652	1.562	2.239	2.668	2.876	2.977	2.516	1.123	1.228	0.670	0.256	0.007	0.000	18.925
24	0.000	0.000	0.047	0.144	0.248	0.349	0.439	0.590	1.098	1.465	1.202	1.019	0.623	0.380	0.007	0.000	7.592
25	0.000	0.007	0.137	0.479	1.321	1.840	1.030E	1.267	1.483	1.865	0.821	1.642	1.091	0.288	0.007	0.000	13.277*
26	0.000	0.007	0.263	0.925	1.663	2.254	2.725	3.010	3.002	2.747	2.326	1.696	1.004	0.256	0.007	0.000	21.884
27	0.000	0.007	0.295	1.019	1.688	2.333	2.826	2.948	3.010	2.714	2.372	1.721	1.012	0.238	0.014	0.000	22.198
28	0.000	0.007	0.310	1.026	1.753	2.365	2.804	3.002	2.977	2.754	2.300	1.696	0.598	0.302	0.014	0.000	21.910
29	0.000	0.007	0.310	0.954	1.768	2.516	2.077	2.016	2.876	2.470	2.117	1.775	1.026	0.277	0.014	0.000	20.203
30	0.000	0.007	0.360	1.058	1.768	2.372	2.804	3.028	3.035	2.819	2.326	1.807	1.058	0.238	0.014	0.000	22.694
31	0.000	0.000	0.032	0.191	0.439	0.623	2.412	0.947	1.386	1.217	0.954	0.270	0.382	0.065	0.000	0.000	8.917
Tot.	0.00	0.11	3.46	18.14	34.37	50.90	62.94	65.15	67.81	61.24	51.27	37.26	20.22	4.78	0.24	0.00	477.89*
Ave.	0.000	0.003	0.112	0.585	1.109	1.642	2.030	2.101	2.187	1.976	1.654	1.202	0.652	0.154	0.008	0.000	15.416

M = Missing
 E = Estimated
 * = Suspect

Table 11.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION
 Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: April 1986

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.000	0.104	0.414	0.749	1.156	1.411	3.010	2.740	2.221	1.544	0.814	0.684	0.223	0.007	0.000	15.077
2	0.000	0.000	0.126	0.540	0.900	1.019	2.563	3.128	2.574	1.130	1.070	0.821	0.047	0.040	0.000	0.000	13.964
3	0.000	0.000	0.007	0.032	0.072	0.119	1.242	0.820E	0.972E	0.468E	0.389	0.637	0.360E	0.119	0.007	0.000	5.252*
4	0.000	0.007	0.158	0.612	1.847*	2.653*	3.067*	3.283*	2.930*	1.886	1.386	1.156	0.868	0.317	0.007	0.000	26.178*
5	0.000	0.040*	0.598*	1.260*	1.958	1.847	3.002	3.161	2.603	2.851	2.423	1.912	0.691	0.209	0.007	0.000	22.561*
6	0.000	0.032*	0.518*	1.242*	1.242	2.556	2.977	3.186	3.186	2.938	2.502	1.904	1.177	0.310	0.014	0.000	23.786*
7	0.000	0.007	0.151	0.382	0.853	1.361	2.038	2.372	2.102	1.832	1.990	1.042	0.295	0.216	0.014	0.000	15.264
8	0.000	0.000	0.086	0.342	0.637	0.349	0.191	0.328	0.209	1.235	1.177	0.374	0.151	0.047	0.000	0.000	5.126
9	0.000	0.000	0.014	0.367	1.260	1.195	1.919	1.228	1.148	0.677	2.102	1.483	0.511	0.007	0.047*	0.000*	11.959*
10	0.000	0.032*	0.540*	1.098*	1.440	2.239	1.800	2.452	1.386	2.491	2.023	1.806	1.260	0.421	0.025	0.000	19.094*
11	0.000	0.025	0.198	0.932	1.505	2.542	2.675	2.221	2.050	1.512	1.602	0.828	0.184	0.079	0.014	0.000	16.373
12	0.000	0.007	0.097	0.342	0.702	1.012	0.846	1.609	2.898	2.502	2.509	1.897	1.217	0.382	0.007	0.000	16.027
13	0.000	0.025	0.421	1.249	1.577	2.390	2.228	2.754	3.456	3.146	2.686	2.102	1.188	0.263	0.025	0.000	23.512
14	0.000	0.097	0.724	1.505	2.246	2.851	3.233	3.434	3.402	3.204E	2.700E	2.160E	1.260E	0.403	0.032	0.000	27.252*
15	0.000	0.119	0.710	1.465	2.182	2.772	3.179	3.370	3.344	3.168E	2.700E	2.160E	1.224E	0.432E	0.036E	0.000	28.867*
16	0.000	0.032	0.248	0.774	1.753	2.747	2.916	2.326	1.807	0.670	1.498	0.835	1.289	0.295	0.014	0.000	17.204
17	0.000	0.065	0.454	0.166	0.428	0.335	0.389	0.184	0.176	0.590	0.684	0.724	0.590	0.270	0.025	0.000	5.080
18	0.000	0.079	0.558	0.814	1.433	2.581	2.826	3.035	2.995	2.765	0.997	0.925	0.605	0.382	0.007	0.000	20.002
19	0.000	0.072	0.691	1.451	2.142	2.646	2.995	3.128	3.154	2.754	2.462	1.361	0.605	0.216	0.007	0.000	23.684
20	0.000	0.025	0.166	0.374	1.026	0.997	3.028	3.424	1.609	0.821	1.004	0.788	0.360	0.184	0.007	0.000	13.613
21	0.000	0.065	0.288	0.565	1.411	2.549	2.765	2.542	2.437	1.386	1.084	0.866	0.835	0.558	0.040	0.000	17.384
22	0.000	0.126	0.756	1.451	2.149	2.754	3.211	3.344	3.323	3.172	2.732	1.372	0.630	0.151	0.000	0.000	25.171
23	0.000	0.072	0.670	1.465	2.160E	2.574E	2.088E	2.034E	2.448E	2.288E	2.484E	1.440E	0.630E	0.324E	0.025E	0.000E	20.682*
24	0.000E	0.025E	0.216E	0.360E	0.612E	1.440E	1.170	1.721	2.358	2.747	1.051	1.721	1.044	0.612	0.061	0.000	15.138*
25	0.000	0.086	0.774	1.570	2.174	2.837	3.251	3.668	3.211	1.753	1.775	1.037	0.295	0.086	0.014	0.000	22.432
26	0.000	0.032	0.097	0.191	0.500	1.562	1.440	1.339	1.300	0.166	0.637	0.191	0.248	0.835	0.104	0.000	8.644
27	0.000	0.097	0.533	1.440	2.135	2.876	3.298	3.503	3.488	3.265	2.844	1.825	1.530	0.677	0.104	0.000	27.616
28	0.000	0.184	0.742	1.800	1.393	2.182	1.703	1.825	2.884	1.058	0.644	0.644	0.367	0.166	0.047	0.000	15.638
29	0.000	0.191	0.846	1.584	2.279	2.844	3.251	3.377	3.402	3.154	2.412	1.760	0.572	0.511	0.097	0.000	26.280
30	0.000	0.176	0.821	1.570	2.272	2.837	3.226	3.434	3.409	3.161	2.732	2.135	1.418	0.691	0.097	0.000	27.979
Tot.	0.00	1.72	12.32	27.36	43.04	59.82	69.93	75.15	73.01	66.99	53.86	39.39	22.14	9.42	0.98	0.00	549.64*
Ave.	0.000	0.057	0.411	0.912	1.435	1.994	2.331	2.505	2.434	2.633	1.795	1.313	0.738	0.314	0.030	0.000	18.361

M = Missing
 E = Estimated
 * = Suspect

Table 12.

Atmospheric Science Department
 CSU Main Campus
 Weather Station
 Fort Collins, Colorado

HEMISPHERIC SOLAR RADIATION

Hourly Values (Megajoules/Square Meter)
 Kipp and Zonen Pyranometer
 Mountain Standard Time
 HOURS

Date: May 1988

Date	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Total
1	0.000	0.176	0.828E	1.544	2.239	2.797	3.200	3.449	3.352	3.344	2.772	1.235	1.249	0.630	0.040	0.007	26.863*
2	0.000	0.040	0.216	0.533	1.458	1.562	2.088	1.937	2.891	2.646	1.361	0.954	0.590	0.335	0.025	0.007	16.643
3	0.000	0.223	0.868	1.379	1.300	1.602	3.114	1.944	2.786	3.344	1.260	1.451	1.091	0.702	0.112	0.007	21.182
4	0.000	0.238	0.907	1.634	2.318	2.876	3.272	3.503	3.434	2.891	2.261	1.714	1.076	0.238	0.072	0.014	26.449
5	0.007	0.238	0.954	1.703	2.246	2.963	3.402	3.654	3.672	3.344	2.984E	2.300	1.577	0.868	0.176	0.014	30.103*
6	0.007	0.191	0.988	1.760	2.110	2.988	2.826	2.063	2.653	1.465	0.875	0.677	0.572	0.277	0.032	0.007	19.490
7	0.000	0.014	0.104	0.184	0.263	0.389	0.528	1.418	2.779	1.562	0.439	0.238	0.184	0.238	0.000	0.000	8.338
8	0.198*	0.047	0.158	0.788	1.037	1.912	0.821	2.030	1.019	0.342	0.630	1.004	0.540	0.158	0.097	0.014	10.796*
9	0.007	0.097	0.691	0.749	0.925	2.797	3.200	3.179	1.361	1.897	2.588	2.228	1.451	0.493	0.184	0.000	21.848
10	0.000	0.263	1.019	1.746	2.430	2.988	3.377	3.568	3.463	3.139	2.898	2.293	1.570	0.788	0.126	0.014	29.682
11	0.007	0.270	1.012	1.746	2.423	2.995	3.384	3.568	3.546	3.272	2.891	2.300	1.591	0.781	0.119	0.014	29.920
12	0.007	0.317	0.803	1.076	1.116	2.239	3.107	2.030	0.310	2.916	0.853	0.302	1.552	0.691	0.119	0.000	17.438
13	0.007	0.367	0.965	1.735	2.437	2.995	3.382	3.528	3.498	2.916	2.228	1.703	1.267	0.407	0.054	0.007	27.475
14	0.000	0.086	0.360	0.724	0.716	1.242	2.221	3.298	1.386	1.346	0.670	0.342	0.868	0.821	0.065	0.000	14.144
15	0.000	0.256	0.565	1.314	2.149	2.898	1.926	2.128	2.254	0.572	0.407	0.191	0.238	0.112	0.014	0.000	15.023
16	0.007	0.025	0.054	0.176	0.446	0.238	0.652	0.884	0.914	0.367	0.342	0.216	0.112	0.065	0.025	0.025*	4.349*
17	0.047*	0.191*	0.023*	1.393*	2.070	2.221	2.707	3.575	3.463	3.330	2.891	2.254	1.562	0.788	0.144	0.000	27.259*
18	0.007	0.317	1.148	1.735	2.549	3.035	3.409	3.679	2.930	2.740	2.700	1.649	1.163	0.583	0.137	0.000	27.781
19	0.014	0.389	1.066	1.753	2.437	2.916	3.323	3.535	3.480	3.172	2.135	2.261	1.465	0.295	0.176	0.000	28.426
20	0.007	0.382	1.084	1.793	2.437	2.938	1.562	1.904	2.142	2.326	1.944	1.202	1.321	0.335	0.126	0.000	21.503
21	0.047	0.540	0.893	1.800	2.484	2.938	3.312	3.560	3.514	3.233	2.660	1.267	0.749	0.349	0.104	0.000	27.450
22	0.014	0.184	1.130	1.814	2.444	2.988	3.384	3.449	3.614	2.286	0.691	1.098	1.530	0.853	0.137	0.007	25.625
23	0.025	0.414	1.123	1.854	2.524	3.060	3.424	3.593	3.535	3.312	2.909	1.728	0.590	0.238	0.054	0.000	28.382
24	0.025	0.387	1.037	1.788	2.470	3.010	3.402	3.600	3.449	2.938	2.482	1.346	1.195	0.533	0.166	0.007	27.774
25	0.007	0.295	1.026	1.788	2.444	2.988	3.362	3.553	3.535	3.323	2.812	2.279	1.530	0.875	0.126	0.007	29.948
26	0.014	0.317	1.066	1.282	2.437	3.002	3.456	3.607	3.640	3.344	2.884	2.279	1.591	0.558	0.126	0.007	29.610
27	0.014	0.263	0.691	0.684	1.886	1.058	1.418	1.649	2.340	0.342	1.552	1.825	1.624	0.965	0.270	0.000	16.582
28	0.000	0.248	0.421	0.677	2.365	2.286	1.937	2.423	1.418	0.662	0.821	0.439	0.407	0.072	0.086	0.025	14.288
29	0.040	0.191	0.756	1.634	1.775	1.897	1.400	1.458	1.649	1.912	1.814	2.340	0.400	0.360	0.072	0.007	17.705
30	0.025	0.277	1.051	1.768	2.423	2.970	3.362	3.474	3.384	3.028	2.714	2.437	1.688	0.900	0.216	0.007	29.725
31	0.007	0.288	0.947	1.537	2.023	2.588	3.226	3.481	3.416	3.218	2.740	2.318	1.793	0.270	0.104	0.007	27.965
Tot.	0.54	7.51	24.55	42.07	60.38	75.30	83.16	88.52	84.83	74.53	59.19	45.87	34.14	15.58	3.30	0.21	699.77*
Ave.	0.018	0.242	0.792	1.357	1.948	2.432	2.683	2.855	2.737	2.404	1.909	1.480	1.101	0.502	0.107	0.007	22.573

M = Missing
 E = Estimated
 * = Suspect

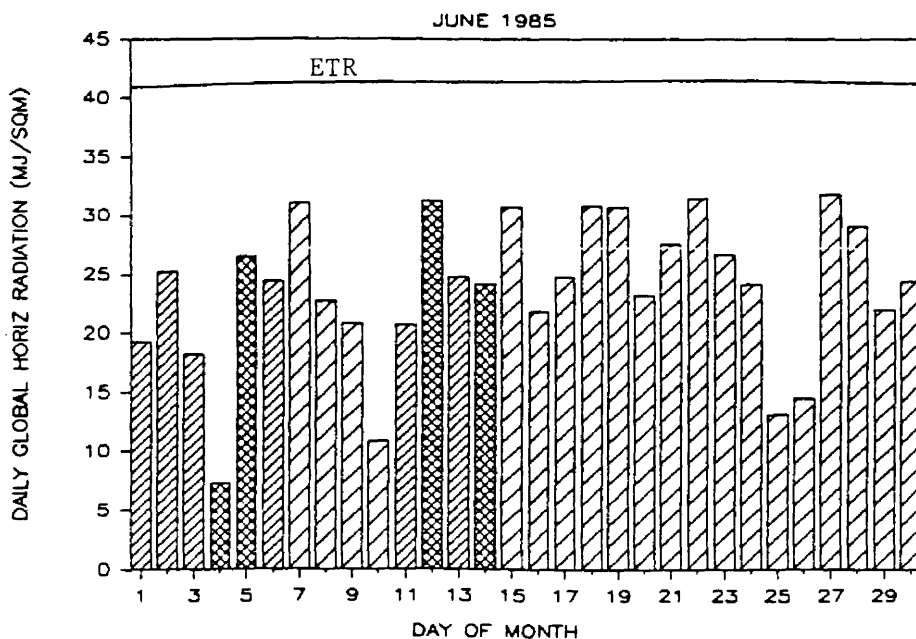


Figure 2. Daily global radiation on a horizontal surface (Megajoules per meter²) on the campus of Colorado State University for June 1985. Top smooth curve is daily extra-terrestrial radiation (ETR).

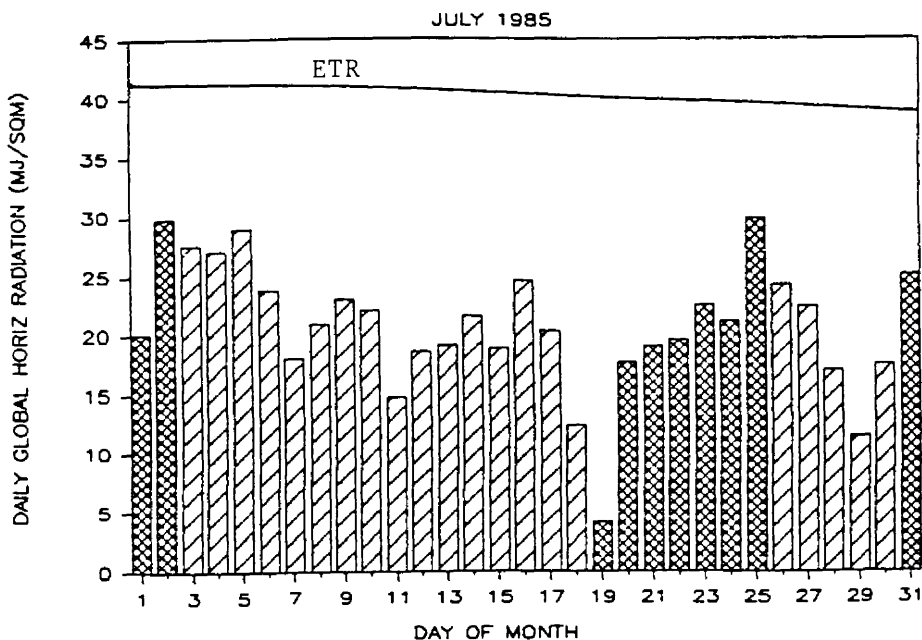
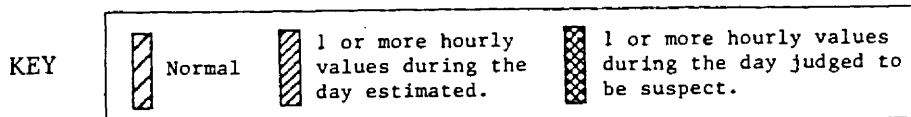


Figure 3. Daily global radiation on a horizontal surface on the campus of Colorado State University for July 1985.



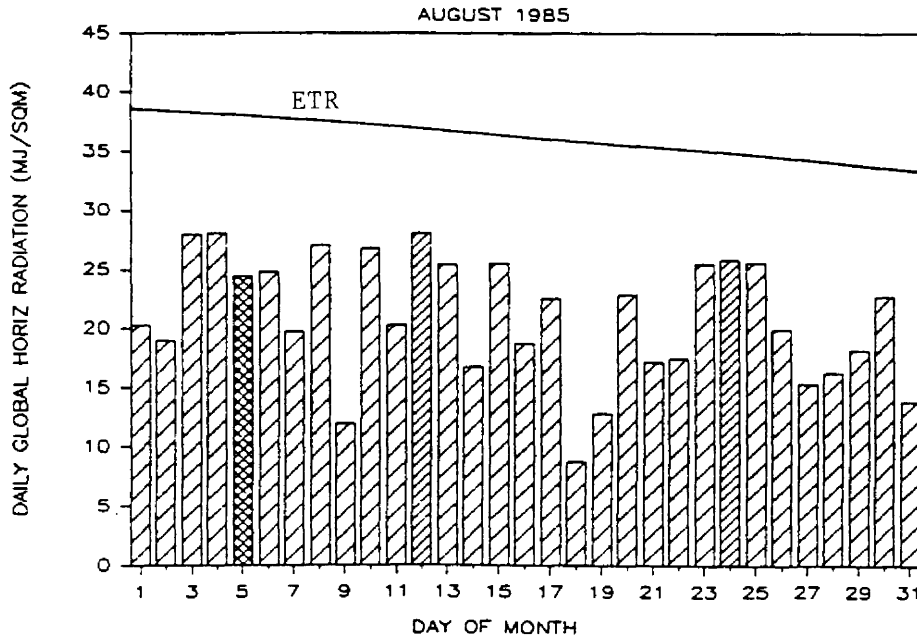


Figure 4. Daily global radiation on a horizontal surface (MJ/m^2) on the campus of Colorado State University for August 1985.

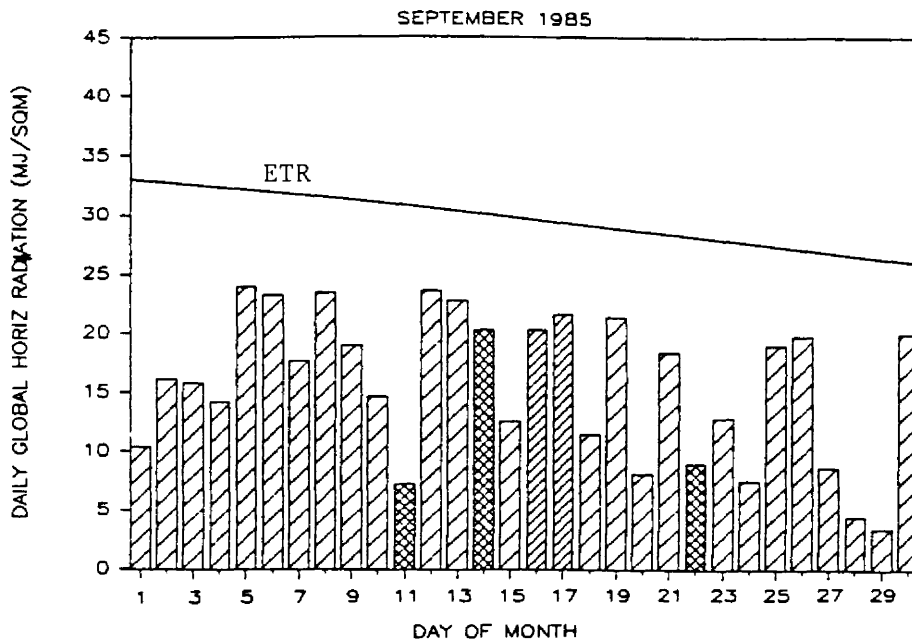
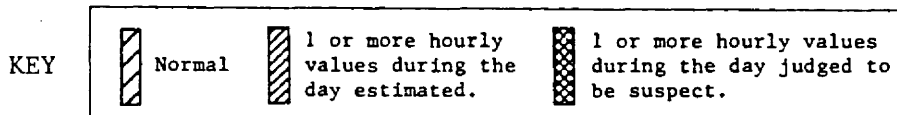


Figure 5. Daily global radiation on a horizontal surface on the campus of Colorado State University for September 1985.



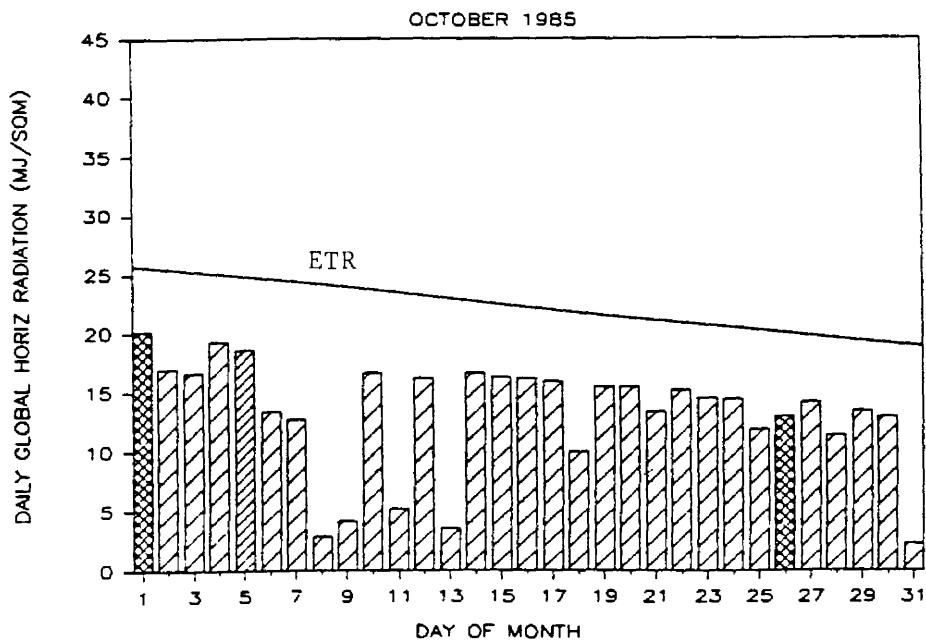


Figure 6. Daily global radiation on a horizontal surface (MJ/m^2) on the campus of Colorado State University for October 1985.

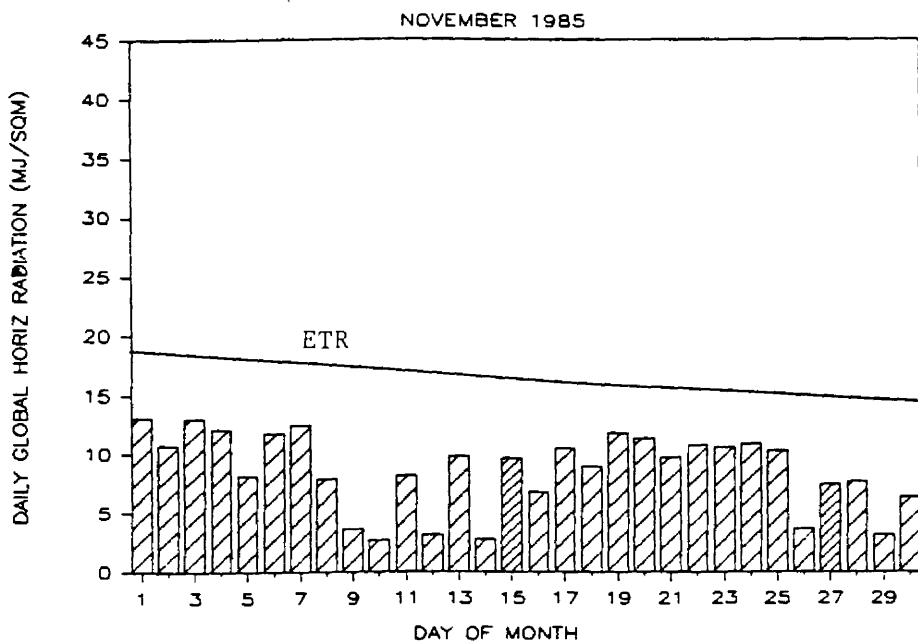
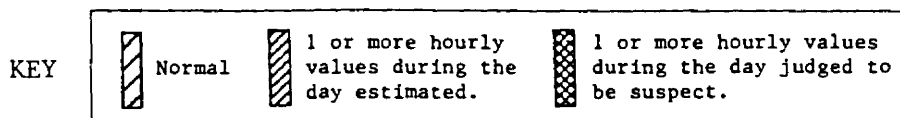


Figure 7. Daily global radiation on a horizontal surface on the campus of Colorado State University for November 1985.



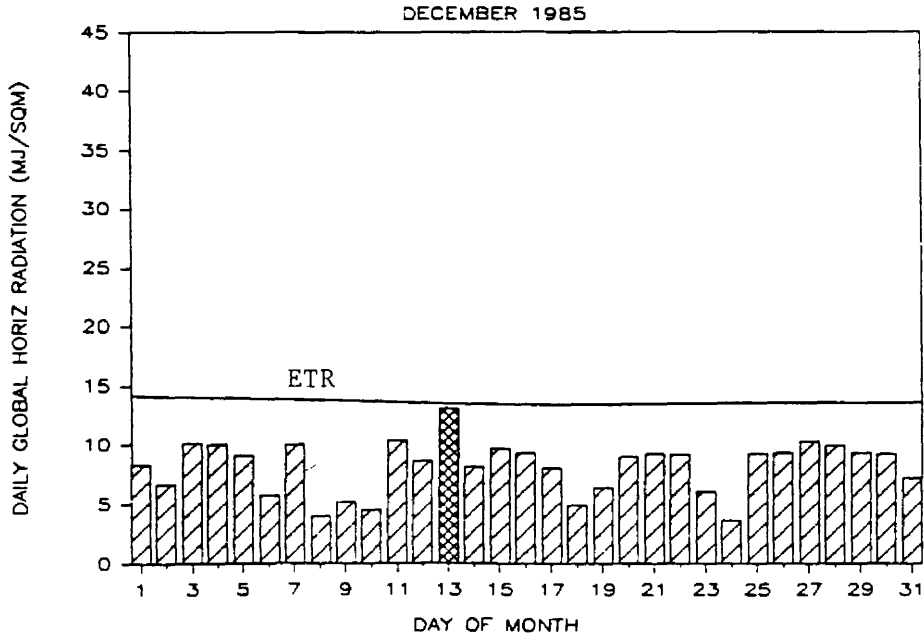


Figure 8. Daily global radiation on a horizontal surface (MJ/m^2) on the campus of Colorado State University for December 1985.

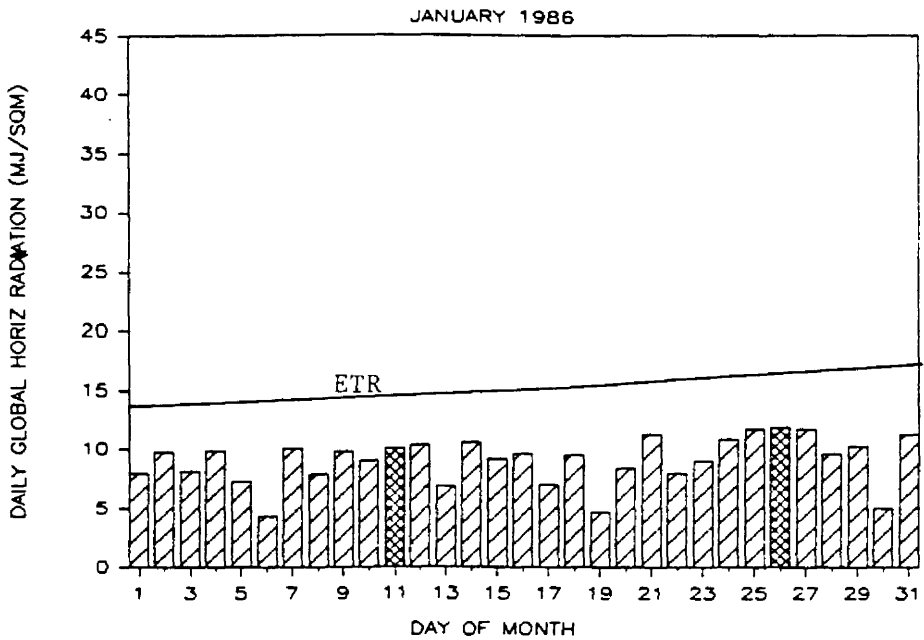
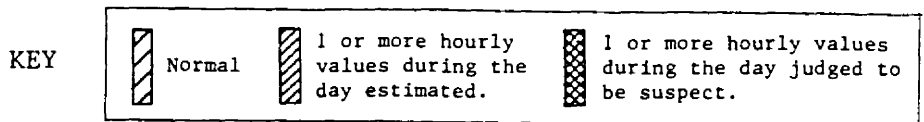


Figure 9. Daily global radiation on a horizontal surface on the campus of Colorado State University for January 1986.



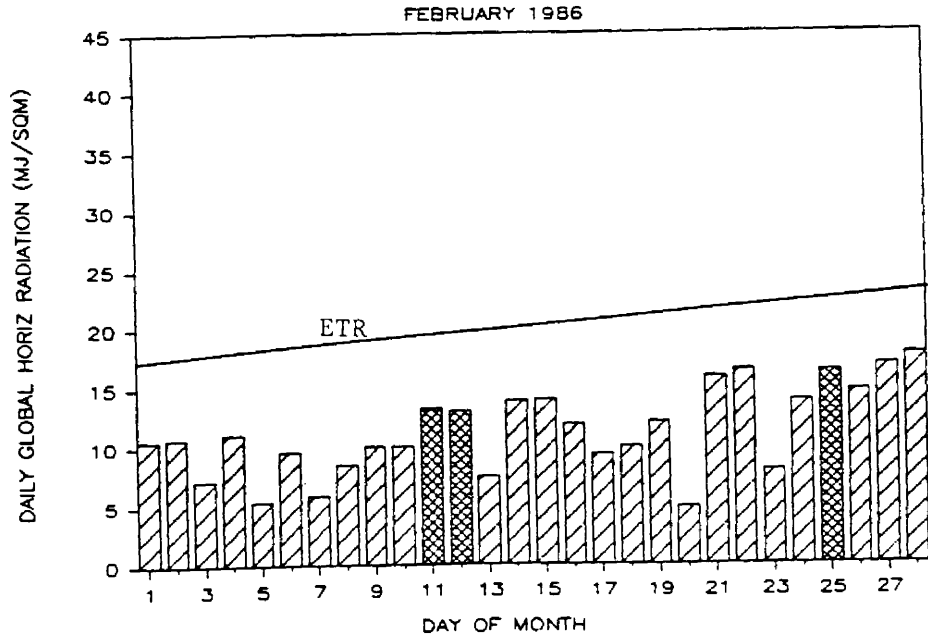


Figure 10. Daily global radiation on a horizontal surface (MJ/m^2) on the campus of Colorado State University for February 1986.

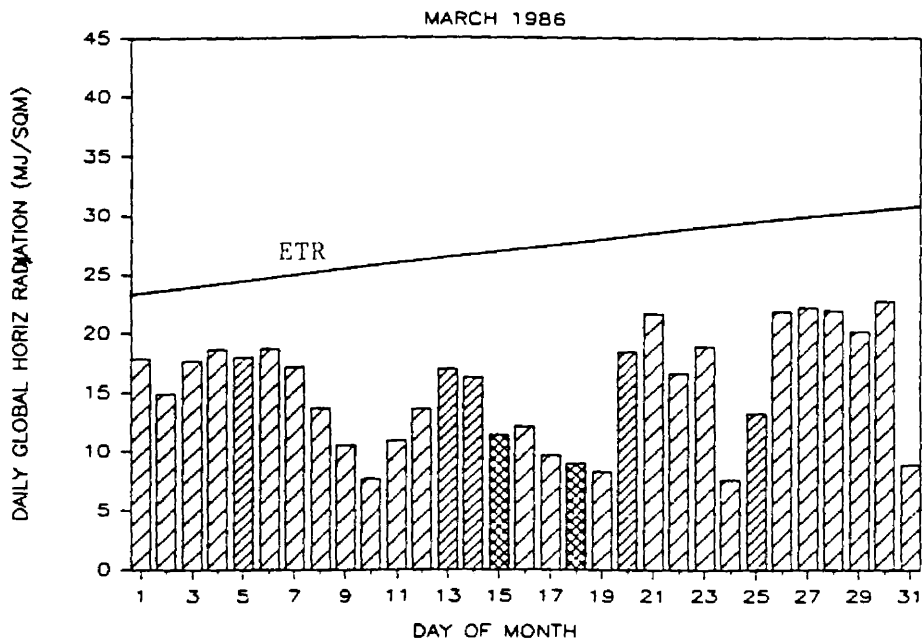
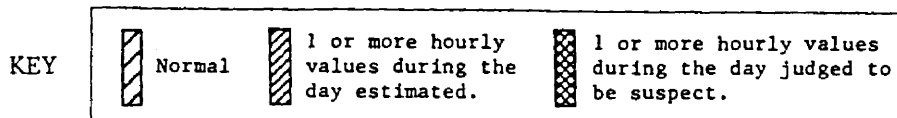


Figure 11. Daily global radiation on a horizontal surface on the campus of Colorado State University for March 1986.



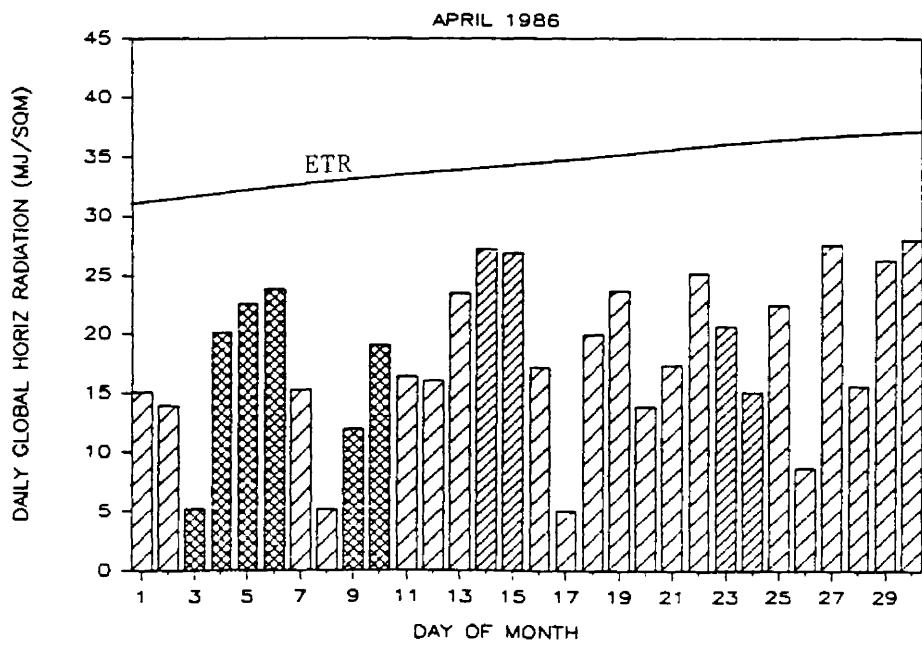


Figure 12. Daily global radiation on a horizontal surface (MJ/m^2) on the campus of Colorado State University for April 1986.

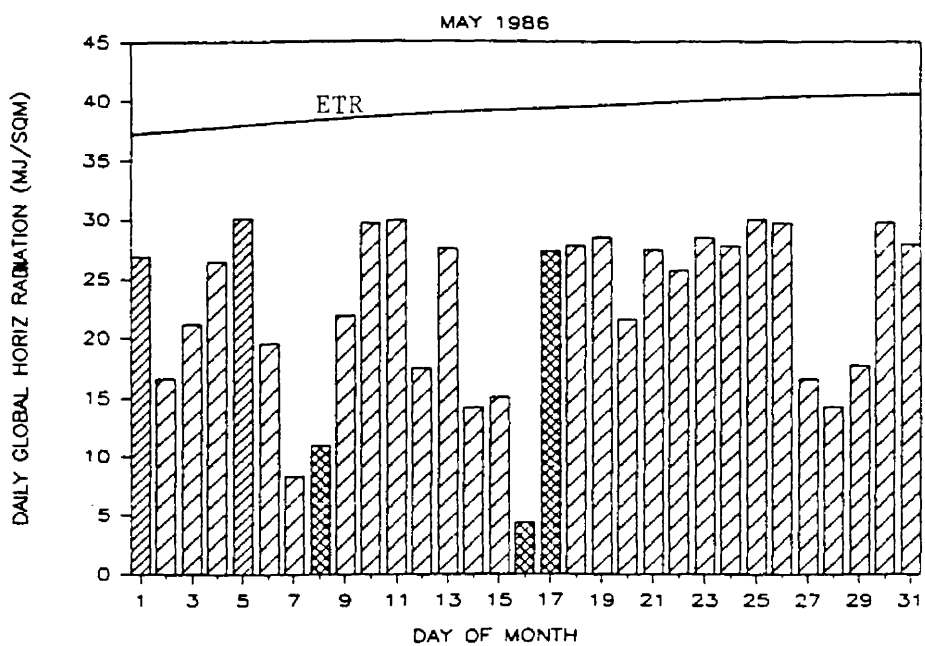
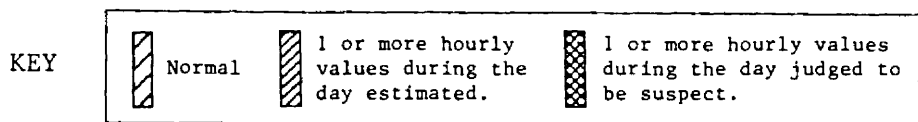


Figure 13. Daily global radiation on a horizontal surface on the campus of Colorado State University for May 1986.



JUNE 1985 - MAY 1986

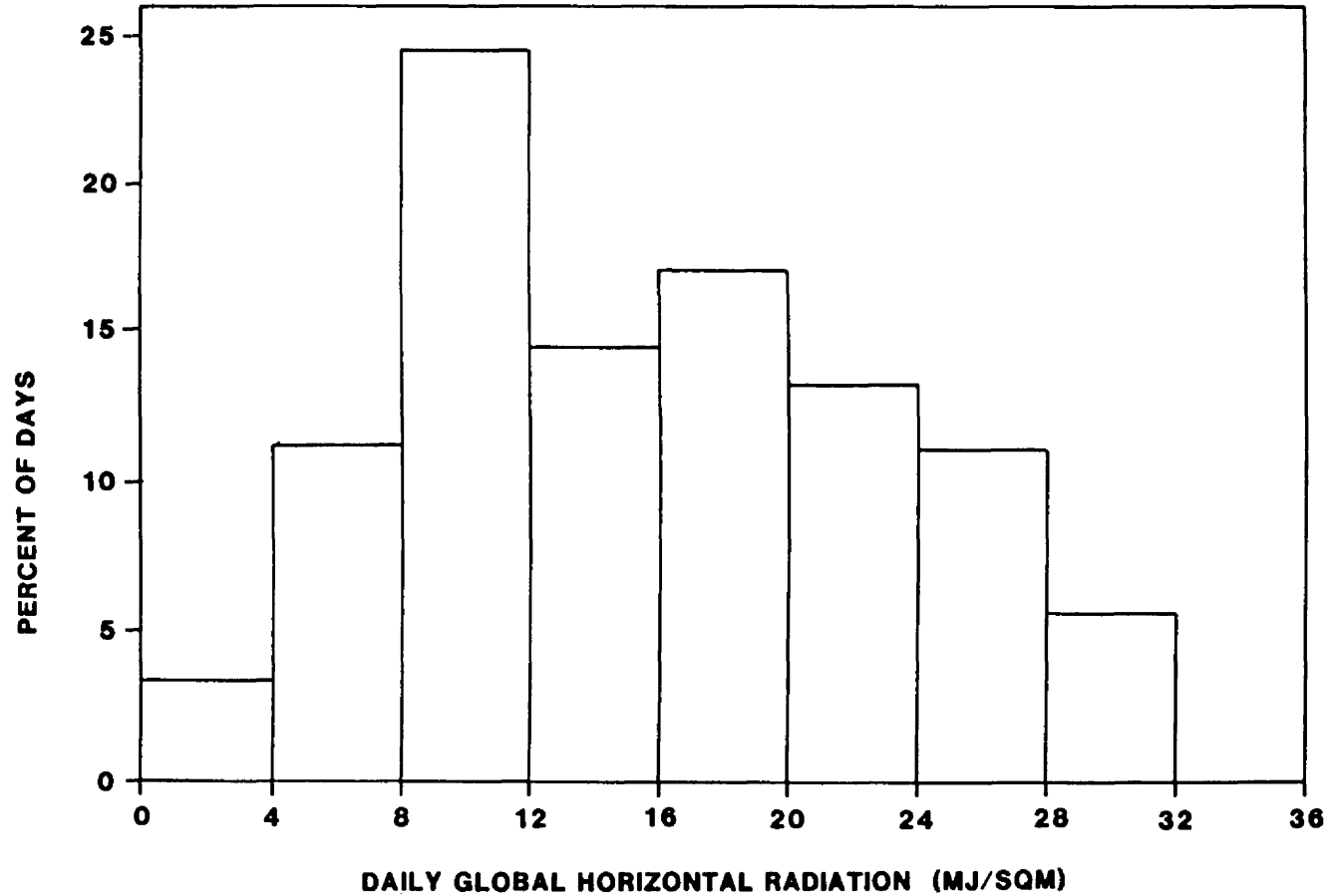


Figure 14. Annual frequency distribution of daily global horizontal (hemispheric) radiation for the 12-month period June 1985-May 1986 at Fort Collins, Colorado.

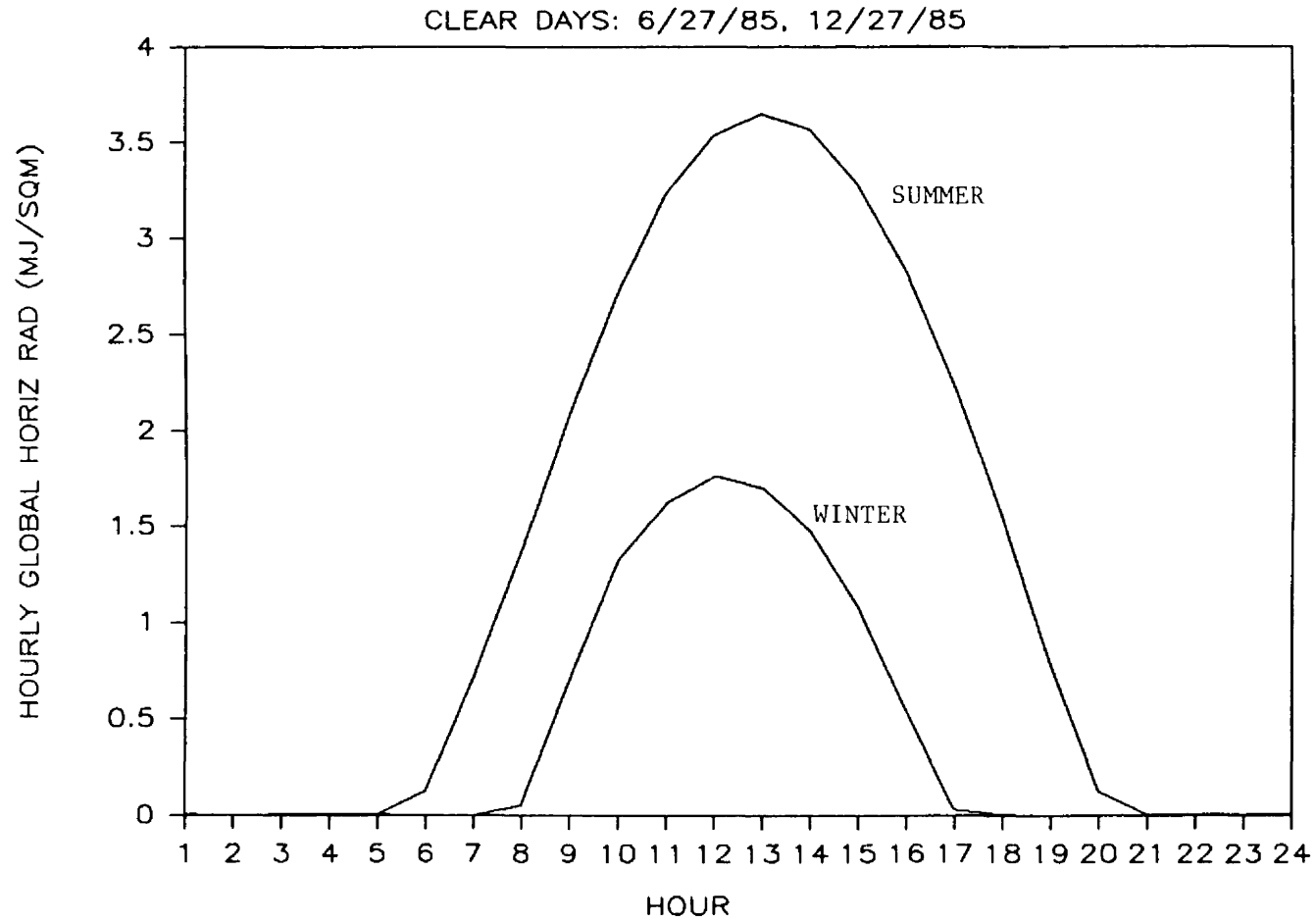


Figure 15. Comparison of hourly distribution of solar energy on a clear day in winter and summer.

Table 13.

Fort Collins, Colorado, Solar Radiation Summary,
June 1985-May 1986.

Month	Total Hemispheric Mean Daily Solar Radiation (MJ/M ²)	Average*	Percent Departure
=====	=====	=====	=====
June 1985	23.81	23.76	+0.2%
July	20.71	22.67	-8.6%
August	20.96	20.01	+4.7%
September	15.70	16.75	-6.3%
October	13.24	13.74	-3.9%
November	8.64	8.92	-3.1%
December	8.22	7.26	+13.2%
January 1986	9.08	8.58	+5.8%
February	11.39	11.93	-4.5%
March	15.42	16.18	-4.7%
April	18.30	19.09	-4.1%
May	22.57	21.20	+6.5%
=====	=====	=====	=====
Annual	15.67	15.76	-0.6%

*Average based on 1975-1985 data collected at Colorado State University foothills campus, Department of Atmospheric Science.

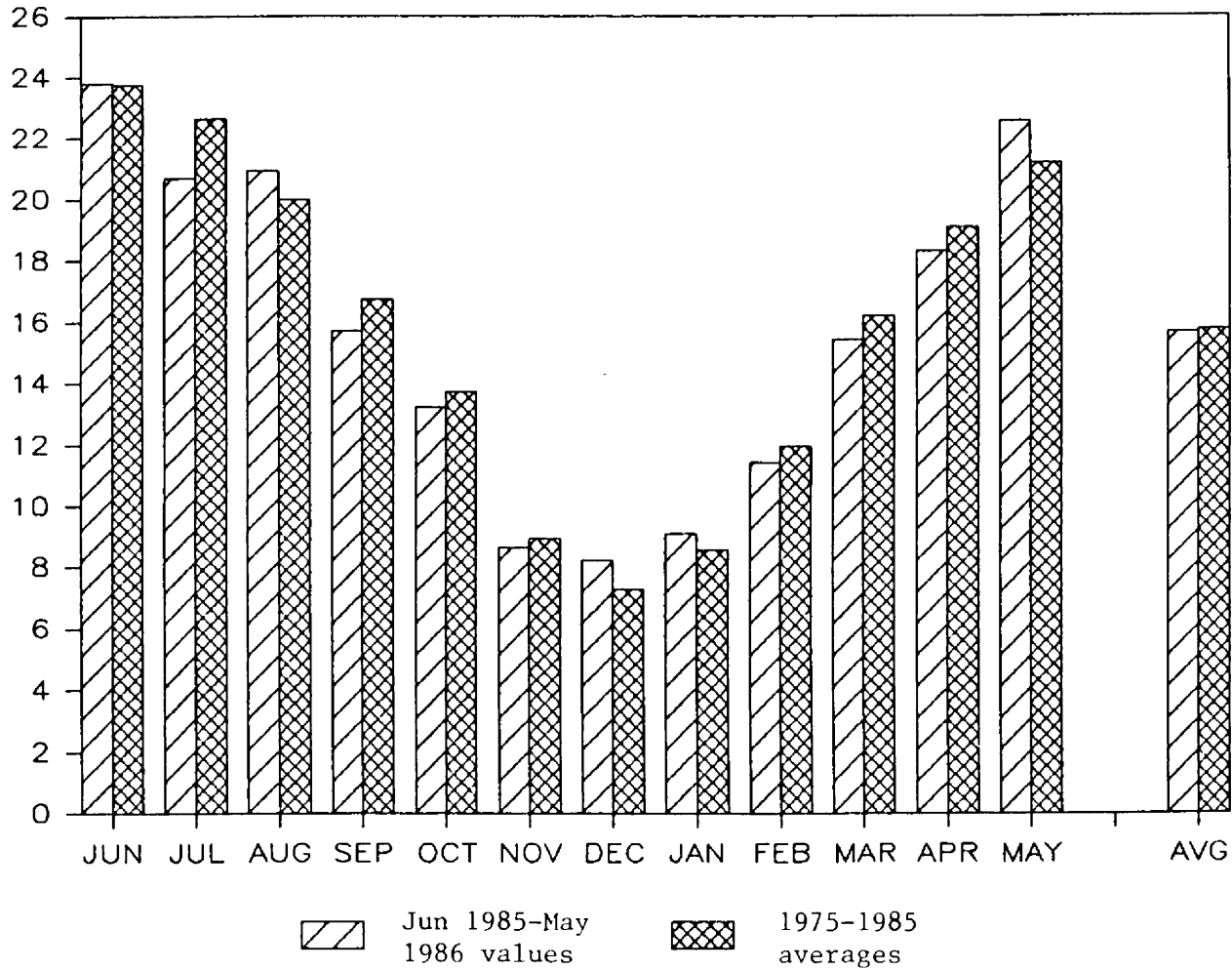


Figure 16. Comparison of Fort Collins monthly averaged daily solar radiation (MJ/m^2) for June 1985 through May 1986 with 1975-1985 monthly averages (from Table 13). The 11-year average is based on data collected by the Colorado State University Department of Atmospheric Science on the Foothills Campus.

Table 14.

Solar Radiation Conversion Factors.

To Convert from =====	To =====	Multiply by =====
1 MJ/m ²	J/m ²	10 ⁶
	KJ/m ²	10 ³
	W-hr/m ²	277.78
	Langleys	23.9
	Btu/ft ²	88.11