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Circumsolar Radiation Data: The Lawrence Berkeley Laboratory Reduced Data Base

Final Subcontract Report

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FOREWORD

This report describes the content and format of a large data base that contains detailed intensity profiles of the solar and circumsolar region (out to 3° from the sun's center), the total and spectrally divided direct normal radiation data, as well as the total hemispherical solar radiation in the horizontal plane and the plane facing the sun. Data are available for 11 locations in the United States in the period 1976 to 1981. The measurements were made by four automatic scanning instruments called circumsolar telescopes that operated about 16 hours per day. The data base contains about 200 megabytes of information.

This Reduced Data Base represents about one-tenth of the total data taken by the circumsolar telescopes. The original data include, in addition to the above mentioned information, solar and circumsolar scans divided into eight (approximately equal in energy) spectral bands and weather information (wind speed and direction, temperature and relative humidity). The Reduced Data Base was generated from the larger data set to provide the data in a more manageable form. This report describes a reformatted Reduced Data Base (in the form of a sequential ASCII file) to make it more generally available to potential users. A "best effort" attempt was made to eliminate bad or inaccurate data, but Lawrence Berkeley Laboratory and the Solar Energy Research Institute do not take any responsibility for the accuracy of information contained in this Reduced Data Base.

1. INTRODUCTION

Circumsolar radiation refers to light that, to an observer on the ground, appears to originate from the region around the sun. The term solar aureole is often used to describe easily observable or characteristic occurrences of circumsolar radiation. The phenomenon can easily be observed by using a finger or nearby object to block the direct sunlight from entering the eye and examining the light that streams around the occulting object.

Circumsolar radiation is caused by forward scattering of light through small angles by particles (aerosols) in the earth's atmosphere with dimensions on the order of or greater than the wavelength of light. The aerosol particles may be composed of ice crystals or water droplets in thin clouds. They may be dust or sea salt particles, smoke or fumes, photochemical pollutants, sulfuric acid droplets, solid particles with a water mantle, flocks formed of a loose aggregate of smaller particles, or any of a large variety of solid, liquid or heterogeneous materials that are small enough to be airborne. The amount and character of circumsolar radiation vary widely with geographic location, climate, season, time of day, and observing wavelength. Some of the more striking cases can be observed in the presence of high, thin cirrus clouds.

Under some circumstances these aerosols can cause a significant fraction of the solar flux to be deviated to angles of several degrees or more. Solar energy conversion techniques using high concentration ratios, such as solar central receivers and parabolic dishes, only collect light from the solar disk and a small portion of the circumsolar region. Pyrheliometers, the instruments normally used to measure the direct solar radiation, typically have a field of view of 5° to 6°. The pyrheliometer measurement includes a large portion of the circumsolar radiation and thus overestimates the amount of direct sunlight that would be collected by a concentrating system. The detailed angular distribution of the circumsolar radiation is important, as it affects the radiant energy distribution on the surface of the receiver in concentrating solar energy conversion systems.

2. CIRCUMSOLAR TELESCOPE

In the mid-1970s, Lawrence Berkeley Laboratory (LBL) designed and built four identical instruments to measure circumsolar radiation. Each circumsolar telescope, as they were called, consisted of a "scanning telescope" mounted on a precision solar tracker. A digital electronics system provided control for the tracking and scanning mechanisms. The design has been described in more detail elsewhere.*

The telescope used as its basic optical element an off-axis mirror of 7.5 cm diameter and 1 m focal length. A fused silica window protected the mirror from the environment. The mirror formed an image of the sun and sky around it on a plate to the side of the telescope axis. A small hole in this plate, the detector aperture, defined the angular resolution (1/20 of the solar diameter), and the amount of light passing through the aperture into the detector assembly constituted the fundamental measurement. In the detector assembly the light was mechanically chopped, optically filtered, and focused onto a pyroelectric (thermal) detector. This type of detector was chosen for its uniform wavelength response in the 0.3 to 2.5 μm region and its wide dynamic range.

The telescope scanned through a 6° arc with the sun at the center and measured the intensity of the solar and circumsolar radiation as a function of angle. The instrument scanned in declination so that at sunrise and sunset it traveled nearly parallel to the horizon and at noon it moved in a vertical plane.

Each 6° scan required 1 minute of time. The intensity was digitized every 1.5' of arc. Within 0.5° on either side of the sun an aperture of size 1.5' of arc was used, and outside this region the aperture was increased to 4.5' of arc. A set of measurements consisted of one scan at each of 10 filter positions: eight optical filters, one open (or clear) position, and one opaque position. The opaque position was used to measure the detector noise. The absolute determination of the normal incident flux (within 2.5° of the sun center) was provided by an active cavity radiometer.** This device was self-calibrating and had an accuracy of 0.5%. This pyrheliometer was provided with a matched set of filters that rotated synchronously with those on the scanning telescope. Thus the telescopes produced an absolute measurement of the normally incident flux along with the detailed solar profile in eight wavelength bands. Two pyranometers were used, one mounted in the conventional horizontal position, and one tracking the sun.

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*Donald Grether, Jerry Nelson, and Michael Wahlig, "Measurement of Circumsolar Radiation," Proceedings of the Society of Photo-optical Instrumentation Engineers, Volume 68, page 41, 1975.

**R.C. Willson, "Active Cavity Radiometer," Applied Optics, vol. 12, page 810, 1973.

The telescopes were capable of unattended operation for up to a week, although they typically received a daily inspection during the work week. During the night the solar trackers ran backwards and automatically initiated operation at the beginning of each day. The data were recorded on magnetic tape and processed at LBL's computer center.

During the late 1970s and early 1980s, the circumsolar telescopes were installed at various locations in the United States and collected a large amount of data, which LBL has archived.

3. DESCRIPTION AND FORMAT OF THE REDUCED DATA BASE

Data taken at 11 different sites by the four circumsolar telescopes were assembled into a single data base called the Reduced Data Base (RDB). This section gives the details necessary to read and interpret the RDB, as provided to the Solar Energy Research Institute (SERI). Table 1 presents pertinent information about the 11 sites represented in the RDB.

Following are the requirements used to design the format of the final RDB provided to SERI:

1. It should be easy to read and interpret as it stands without further processing.

2. It should be constructed so it could be correctly ordered by simple sorting utilities. This would allow rapid and easy reconstruction in the event the data lines get out of sequence.

3. It should be relatively simple to generate desired subsets without excessive processing. A related requirement is that it would be a simple matter to compress the data base (for reducing storage requirements), or to adapt it to one of the many advanced data base utilities available today.

Based on these requirements, we designed the RDB to be a sequential ASCII file. Each data set in the RDB is composed of 20 lines, each line consisting of 77 characters.* An example of two sequential data sets in the final RDB, taken from the Barstow data, are shown in the Appendix. Each line in the RDB is structured according to the following format:

Data Set Identifier (DSI) (22 characters)	Data Line Identifier (DLI) (3 characters)	Data (52 characters)

---

*A data set represents the data taken over a 10 minute (approximate) interval. As previously stated in Section 2, 10 different scans were made in this 10 minute interval, one for each of the 10 filter positions. In the RDB, we include only the unfiltered scan. However, we do include *filtered* as well as *unfiltered* pyrheliometer data.

Table 1. RDB Site Summary

Site Number	Location	Latitude (degrees)	Longitude (degrees)	Elevation (feet)	Scope Number	Dates Incl. (mo/yr)	Number of Data Sets
1	Albuquerque, NM STTF	34°57'44"	106°30'32"	5589	2	4/77 to 10/79	28971
2	Albuquerque, NM TETF	35°03'	106°40'	5600	2	5/76 to 3/77	13851
3	Argonne, IL	41°43'	87°58'	725	3	8/77 to 8/78	9702
4	Atlanta, GA	33°46'	84°24'	990	1	6/77 to 6/80	38405
5	Barstow, CA	34°53'	117°00'	2180	4	7/77 to 10/79	36632
6	Boardman, OR	45°42'32"	119°52'54"	620	1	2/77 to 5/77	4782
7	China Lake, CA	35°39'	117°40'	2700	4	7/76 to 3/77	10683
8	Colstrip, MT	45°48'28"	106°31'09"	3060	1	5/77 to 6/77	616
9	Edwards AFB, CA	34°59.5'	117°52'	2300	3	10/79 to 6/81	27344
10	Fort Hood, TX Bunker	31°04'	97°24'	800	3	7/76 to 11/76	5150
11	Fort Hood, TX TES	31°03'	97°31'	1030	3	11/76 to 8/77	8250

DATA SET IDENTIFIER

The Data Set Identifier (DSI), contains basic important information about the data set. The DSI is identical for all 20 lines in the data set. The information included in the DSI is the site and scope number, the date, the time of day (solar time), the overall flag status, and the status of the rain flap (the error and status flags will be discussed in detail later). The overall flag status indicates whether or not any of the error and status conditions apply to this data set (a "1" means there are conditions). The rain flap flag indicates whether or not the rain flap (which covered the telescope aperture in the event of rain) was open ("0") or closed ("1"). Obviously, a closed rain flap means that the scan data, though present in the data set, have no significance. The format of the DSI is:

Format of the Data Set Identifier (DSI). Position 1:22

Data Item	Position	Size	Format
Site Number	1:2	2	I2
Scope Number	3:4	2	I2
	5	1	(blank)
Date (YY/MM/DD)	6:13	8	I2,1H/,I2.2,1H/,I2.2
	14	1	(blank)
Solar Time (HH:MM)	15:19	5	I2,1H:,I2.2
	20	1	(blank)
Overall Flag Status	21	1	I1
Rain Flap Flag	22	1	I1

DATA LINE IDENTIFIER

The Data Line Identifier (DLI) uniquely identifies the type of data contained in each line of the data set. The format of the DLI is:

Format of the Data Line Identifier (DLI). Position 23:25

Data Item	Position	Size	Format
	23	1	(blank)
Data Line Identifier	24:25	2	I2.2

The summary description of the various data line identifiers is given in the following table:

Summary Description of Data Line Identifiers

Data Line Identifier	Description
01	Local Time, Solar Altitude and Azimuth, Normalized Earth-Sun Distance
02	Flag Field
03	Pyranometer Data
04	Pyrheliometer Data (unfiltered)
05	Pyrheliometer Data (filtered)
06	Solar, Circumsolar Radiation and Ratio
07	Miscellaneous
21-24	Unfiltered Scan Data: Brightness Every 1.5' of Arc
41-48	Unfiltered Scan Data: Brightness Every 4.5' of Arc
99	Data Set Separator

Following are the more complete format descriptions for each DLI. Note that all radiation intensities are given in Watts/m^2, and the scan intensity values are in Watts/m^2 steradian.

Format of Data in DLI01. Position 26:77

Data Item	Position	Size	Format
	26:33	8	(text)
Local Time (HH:MM)	34:38	5	I2,1H:,I2.2
	39:45	7	(text)
Solar Altitude (degrees)	46:50	5	F5.2
	51:57	7	(text)
Solar Azimuth (degrees)	58:64	7	F7.2
	65:71	7	(text)
Normalized Earth to Sun Distance (dimensionless)	72:77	6	F6.4

(Note: The normalized earth-sun distance is the ratio of the actual distance to the mean distance.)

Format of Data in DLI02. Position 26:77

Data Item	Position	Size	Format
	26:43	18	(text)
Flags 1 to 5	44:48	5	5(I1)
	49	1	(blank)
Flags 6 to 10	50:54	5	5(I1)
	55	1	(blank)
Flags 11 to 15	56:60	5	5(I1)
	61	1	(blank)
Flags 16 to 20	62:66	5	5(I1)
	67	1	(blank)
Flags 21 to 25	68:72	5	5(I1)
	73	1	(blank)
Flags 26 to 29	74:77	4	4I1

(Note: A complete description of the flags will be given later.)

Format of Data in DLI03. Position 26:77

Data Item	Position	Size	Format
	26:45	20	(text)
Tracking Pyranometer (clear scan)	46:51	6	F6.1
	52	1	(blank)
Tracking Pyranometer (10 minute average)	53:58	6	F6.1
	59:64	6	(text)
Horizontal Pyranometer (clear scan)	65:70	6	F6.1
	71	1	(blank)
Horizontal Pyranometer (10 minute average)	72:77	6	F6.1

Format of Data for DLI04. Position 26:77

Data Item	Position	Size	Format
	26:42	17	(text)
Pyrheliometer (clear)	43:49	7	F7.1
	50:77	28	(text)

Format of Data in DLI05. Position 26:77

Data Item	Position	Size	Format
	26:29	4	(blanks)
Filtered Pyranometer			
0.38-0.46 µm	30:35	6	F6.1
0.46-0.54 µm	36:41	6	F6.1
0.54-0.62 µm	42:47	6	F6.1
0.62-0.72 µm	48:53	6	F6.1
0.72-0.85 µm	54:59	6	F6.1
0.85-1.05 µm	60:65	6	F6.1
1.05-1.25 µm	66:71	6	F6.1
> 1.25 µm	72:77	6	F6.1

(Note: For DLI 04 and DLI 05, the nine indicated pyrheliometer readings were taken in the following order: 0.62-0.72 µm, 1.05-1.25 µm, 0.46-0.54 µm, 0.72-0.85 µm, clear, 0.54-0.62 µm, >1.25 µm, 0.38-0.46 µm, and 0.85-1.05 µm.)

Format of Data in DLI06. Position 26:77

Data Item	Position	Size	Format
	26:34	9	(text)
Solar Radiation (within solar radius)	35:41	7	F7.1
	42:50	9	(text)
Circumsolar Radiation (solar radius to 3°)	51:56	6	F6.1
	57:67	11	(text)
Ratio: Circumsolar to Solar + Circumsolar (dimensionless)	68:77	10	F10.7

Format of Data in DLI07. Position 26:77

Data Item	Position	Size	Format
	26:40	15	(text)
Active Cavity Radiometer Fractional Error	41:48	8	F8.5
	49:54	6	(text)
Normal Incidence Pyrheliometer Fractional Error	55:62	8	F8.5
	63:67	5	(text)
Conversion Constant	68:77	10	1PE10.3

(Note: The conversion constant is the conversion from pyroelectric to Watts/m^2 steradian.)

The intensity data for the unfiltered scan are given in DLIs 21-24, 41-48. DLIs 21-24 contain the intensity data for what is normally considered to be the solar disk, that is, from the center of the sun to 30' from the sun center. DLI 41-48 contain the intensity data for what we term the circumsolar region, that is, 30' from the sun center to 3.2° from the sun center.

For purposes of presenting the data, the solar disk region is divided into 20 angular intervals of 1.5' of arc, and the circumsolar region is divided into 36 angular intervals of 4.5' of arc. The intensity values given in the RDB reflect the average values at the center of each interval. For example, at the first interval, which ranges from 0' to 1.5' from the sun center, the intensity corresponds to the center of this interval, or 0.75' from the sun center. Of course, the intensity data are presented in sequential order from the center of the sun outward.

Format of Data in DLI21-24, 41-47. Position 26:77

Data Item	Position	Size	Format
	26:77	2	(blanks)
Intensity Data	28:77	50	5(1PE10.3)

Format of Data in DLI48. Position 26:77

Data Item	Position	Size	Format
	26:77	2	(blanks)
Intensity Data	28:77	10	1PE10.3
	38:77	40	(text)

Format of Data Set Separator, DLI99. Position 26:77

Data Item	Position	Size	Format
	26:77	52	52(1H*)

FLAG DESCRIPTION

Each of the 29 flags, when on (i.e., "1"), indicates various error and status conditions for the given data set. The significance (or pathology) of many of these flags is no longer remembered, although the authors will attempt to answer any inquiries concerning these flags. We believe that most of the data sets are reliable since great effort was expended about 10 years ago to fix and include only *good* data into the RDB, but caution should be used when certain of the flags are set. (Note: Colstrip, Mont., and Edwards AFB do not contain any data sets where all the flags are off, due to flag number 10 being turned on for all data sets.) There are no data sets in the entire RDB that turned on flag numbers 5 and 26, because those records were removed at the time the data were transferred to regular magnetic tape. The following table summarizes the meaning of the various flags, along with an overall statistical count of the on flags for each flag category.

Summary Description of Error and Status Flags

Flag Number	Meaning if on or "1"	Number of Data Sets with Flag On
1	Steps out of tolerance	23118
2	Filter wheel problem	4836
3	Aperture in wrong position	12561
4	Rain flap closed	6882
5	Half speed scan	0
6	Quarter speed scan	22
7	Scan points outside tolerance	3018
8	Solar guider off	25905
9	Voltage reference comparison out of tolerance	68845
10	Voltage reference comparison out of tolerance	55939
11	Average noise outside tolerance	60649
12	RMS noise outside tolerance	30324
13	Pyrheliometer diff. out of tolerance	38717
14	Bad match, 1st aperture switch	115251
15	Bad match, 2nd aperture switch	99409
16	Scan failed 1st quality criterion	50272
17	Scan failed 2nd quality criterion	37528
18	Saturated scan (pathological)	18
19	Sun not centered in scan	3034
20	Recouped scan	35091
21	Solar radius fixed	7012
22	Aperture drop fixed	5891
23	Pyrheliometer reading fixed	9475
24	Scan smoothed	2724
25	Scan would not smooth on failed test	300
26	Record had parity error on Kennedy tape	0
27	Failed QTEST reality criterion	408
28	Failed QTEST effective radius criterion	5221
29	By QTEST, radius can be fixed	4541

Expanded Descriptions for flags 24-26:

24 Scan mathematically smoothed. The smoothing may or may not have been successful (see flag 25). The smoothing is done for periods of time during which the detector was noisy.

25 The scan either could not be smoothed (too much scatter in the data points) or the smoothed scan failed a continuity test at the aperture switch point.

26 The data set on the original Kennedy tape had a parity error. Such records are normally rejected. The presence of a record with this bit "on" indicates that there was evidence that the trouble was with the parity error generator and that the basic record was okay.

STORAGE REQUIREMENTS OF THE REDUCED DATA BASE

The RDB provided to SERI is composed of 11 ASCII files, 1 for each site. The total number of data sets is 184,332, thus the size of the total RDB is 288 Mbytes. To determine the size of the file in bytes for each site, multiply the number of data sets (given in Table 1) by 1560.

RELATED REPORTS AND PUBLICATIONS

A. J. Hunt, D. F. Grether, and M. Wahlig, "The Measurement of Circumsolar Radiation," Chapter 7 "An Introduction to Meteorological Measurements and Data Handling for Solar Energy Applications," by the International Energy Association, 1980, LBL 8345.

D. Grether, D. Evans, A. Hunt, and M. Wahlig, "The Effects of Circumsolar Radiation on the Accuracy of Pyrheliometer Measurements of the Direct Solar Radiation," Presented at the Solar Radiation Workshop of the 1981 Annual Meeting of the American Sect. of ISES, May 26-30, 1981, Philadelphia, PA. LBL-12707.

D. B. Evans, D. F. Grether, A. J. Hunt, and M. Wahlig, "The Spectral Character of Solar and Circumsolar Radiation," Presented at the American Sect. of the International Solar Energy Society Meeting, Phoenix, Arizona, June 2-6, 1980, LBL-10802.

D. F. Grether, D. Evans, A. Hunt, and M. Wahlig, "Application of Circumsolar Measurements to Concentrating Collectors," Proceedings of the International Solar Energy Society Conference, May 28-June 1, 1979, Atlanta, GA, LBL 9412.

D. F. Grether, A. Hunt, M. Wahlig, "Intensity of Sky Radiation in the Region of the Solar Aureole," presented at the International Solar Energy Society Congress, May 28-June 1, 1979, Atlanta, GA.

A. J. Hunt, D. F. Grether and M. Wahlig, "The Circumsolar Measurement Program: Assessment of the Effects of Atmospheric Scattering on Solar Energy Conversion," Proceedings of the Fourth Joint Conference on Sensing of Environmental Pollutants, New Orleans, La., November 6-11 1977.

A. J. Hunt, D. F. Grether and M. Wahlig, "Circumsolar Radiation Data for Central Receiver Simulation," Proceedings of the Solar Workshop on Methods for Optical Analysis of Central Receiver Systems, Houston, TX, August 10-11, 1977, LBL 8371.

D. F. Grether, A. J. Hunt and M. Wahlig, "Results from Circumsolar Radiation Measurements," Proceedings of the International Solar Radiation Conference, Winnipeg, Canada, August 16-20, 1976, LBL 5292.

D. F. Grether, A. J. Hunt and M. Wahlig, "Atmospheric Aerosol Data from the Circumsolar Telescope Measurements," Proceedings of the OSA/NASA Topical Meeting on Atmospheric Aerosols, Their Optical Properties and Effects, Williamsburg, VA, December 13-15, 1976, LBL 5297.

D. F. Grether, D. Evans, A. Hunt and M. Wahlig, "Measurement and Analysis of Circumsolar Radiation," 1980, LBL-10802.

D. F. Grether, D. Evans, A. Hunt and M. Wahlig, "Measurement and Analysis of Circumsolar Radiation," 1979, LBL 10243.

D. F. Grether, A. Hunt, D. Evans, M. Wahlig, "Measurement of Circumsolar Radiation - Status Report," 1978, LBL 8391.

D. F. Grether, A. Hunt and M. Wahlig, "Circumsolar Radiation: Monthly Summaries of Effect on Focusing Solar Energy Collection Systems," 1977, UCID 8074.

D. F. Grether, A. Hunt and M. Wahlig, "Circumsolar Radiation: Sensitivity Analysis for Central Receiver Designs," 1977, UCID 8073.

D. F. Grether, A. Hunt and M. Wahlig, "Circumsolar Radiation: Correlations with Solar Radiation," October 1977, UCID 8072.

APPENDIX

Following are two sequential data sets from the Barstow RDB data, included here to show how the RDB looks:

```
5 4 77/07/29 14:12 00 01  Time: 14:08  Alt: 56.57  Azi:  249.52  ESD: 1.0151
5 4 77/07/29 14:12 00 02  Flag Field:     00000 00000 00000 00000 00000 0000
5 4 77/07/29 14:12 00 03  Pyranometers. Trk:  963.5  977.5  Hor: 799.0  811.3
5 4 77/07/29 14:12 00 04  Pyrheliometer:   855.5 (clear),  filtered next line
5 4 77/07/29 14:12 00 05      46.9  84.5 101.9  73.0  84.5  90.3   38.1  64.3
5 4 77/07/29 14:12 00 06  SolRad:  813.1  Circum:  47.8  C/(C+S):   0.0555048
5 4 77/07/29 14:12 00 07  Misc.   ACR: 0.04956  NIP: 0.05268  CC:  2.653E+07
5 4 77/07/29 14:12 00 21   1.575E+07 1.574E+07 1.563E+07 1.545E+07  1.517E+07
5 4 77/07/29 14:12 00 22   1.476E+07 1.428E+07 1.360E+07 1.238E+07  8.902E+06
5 4 77/07/29 14:12 00 23   1.983E+06 2.378E+05 1.976E+05 1.700E+05  1.460E+05
5 4 77/07/29 14:12 00 24   1.234E+05 1.036E+05 8.689E+04 7.353E+04  6.168E+04
5 4 77/07/29 14:12 00 41   4.458E+04 3.036E+04 2.164E+04 1.602E+04  1.224E+04
5 4 77/07/29 14:12 00 42   9.591E+03 7.693E+03 6.507E+03 5.489E+03  4.648E+03
5 4 77/07/29 14:12 00 43   4.037E+03 3.555E+03 3.088E+03 2.692E+03  2.406E+03
5 4 77/07/29 14:12 00 44   2.194E+03 2.009E+03 1.827E+03 1.640E+03  1.480E+03
5 4 77/07/29 14:12 00 45   1.369E+03 1.283E+03 1.217E+03 1.146E+03  1.062E+03
5 4 77/07/29 14:12 00 46   1.012E+03 9.706E+02 9.090E+02 8.443E+02  7.830E+02
5 4 77/07/29 14:12 00 47   7.423E+02 7.135E+02 6.717E+02 6.247E+02  6.068E+02
5 4 77/07/29 14:12 00 48   6.011E+02 ======= End of Brightness Data ========
5 4 77/07/29 14:12 00 99**************************************************
5 4 77/07/29 14:23 00 01  Time: 14:19  Alt: 54.46  Azi:  252.14  ESD: 1.0151
5 4 77/07/29 14:23 00 02  Flag Field:     00000 00000 00000 00000 00000 0000
5 4 77/07/29 14:23 00 03  Pyranometers. Trk:1022.5 1008.1  Hor: 825.5  814.3
5 4 77/07/29 14:23 00 04  Pyrheliometer:   913.2 (clear),  filtered next line
5 4 77/07/29 14:23 00 05      49.8  89.0 104.9  74.5  84.6  93.4   42.6  61.5
5 4 77/07/29 14:23 00 06  SolRad:  902.4  Circum:  13.2  C/(C+S):   0.0144488
5 4 77/07/29 14:23 00 07  Misc.   ACR: 0.01183  NIP: 0.01319  CC:  2.672E+07
5 4 77/07/29 14:23 00 21   1.763E+07 1.756E+07 1.738E+07 1.720E+07  1.690E+07
5 4 77/07/29 14:23 00 22   1.644E+07 1.587E+07 1.495E+07 1.370E+07  1.043E+07
5 4 77/07/29 14:23 00 23   1.735E+06 5.658E+04 4.156E+04 3.421E+04  2.848E+04
5 4 77/07/29 14:23 00 24   2.321E+04 1.956E+04 1.680E+04 1.445E+04  1.270E+04
5 4 77/07/29 14:23 00 41   9.624E+03 6.937E+03 5.237E+03 4.190E+03  3.455E+03
5 4 77/07/29 14:23 00 42   2.904E+03 2.498E+03 2.182E+03 1.912E+03  1.687E+03
5 4 77/07/29 14:23 00 43   1.507E+03 1.357E+03 1.223E+03 1.100E+03  9.941E+02
5 4 77/07/29 14:23 00 44   9.137E+02 8.464E+02 7.781E+02 7.151E+02  6.679E+02
5 4 77/07/29 14:23 00 45   6.206E+02 5.730E+02 5.364E+02 5.037E+02  4.743E+02
5 4 77/07/29 14:23 00 46   4.458E+02 4.260E+02 4.068E+02 3.880E+02  3.677E+02
5 4 77/07/29 14:23 00 47   3.486E+02 3.321E+02 3.165E+02 3.028E+02  2.987E+02
5 4 77/07/29 14:23 00 48   3.016E+02 ======= End of Brightness Data ========
5 4 77/07/29 14:23 00 99**************************************************
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16. Abstract (Limit: 200 words)

This report describes the content and format of a circumsolar radiation data base assembled by Lawrence Berkeley Laboratory. This 200-megabyte data base contains detailed intensity profiles of the solar and circumsolar region (out to 3° from the sun's center), the total and spectrally divided direct normal radiation data, and the total hemispherical solar radiation in the horizontal plane and the plane facing the sun. Data are available for 11 locations in the United States covering 1976 to 1981. Measurements were made by four automatic scanning instruments called circumsolar telescopes that operated about 16 hours per day. This data base, the Reduced Data Base, was generated from a larger data set to provide data in a more manageable form.

17. Document Analysis

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