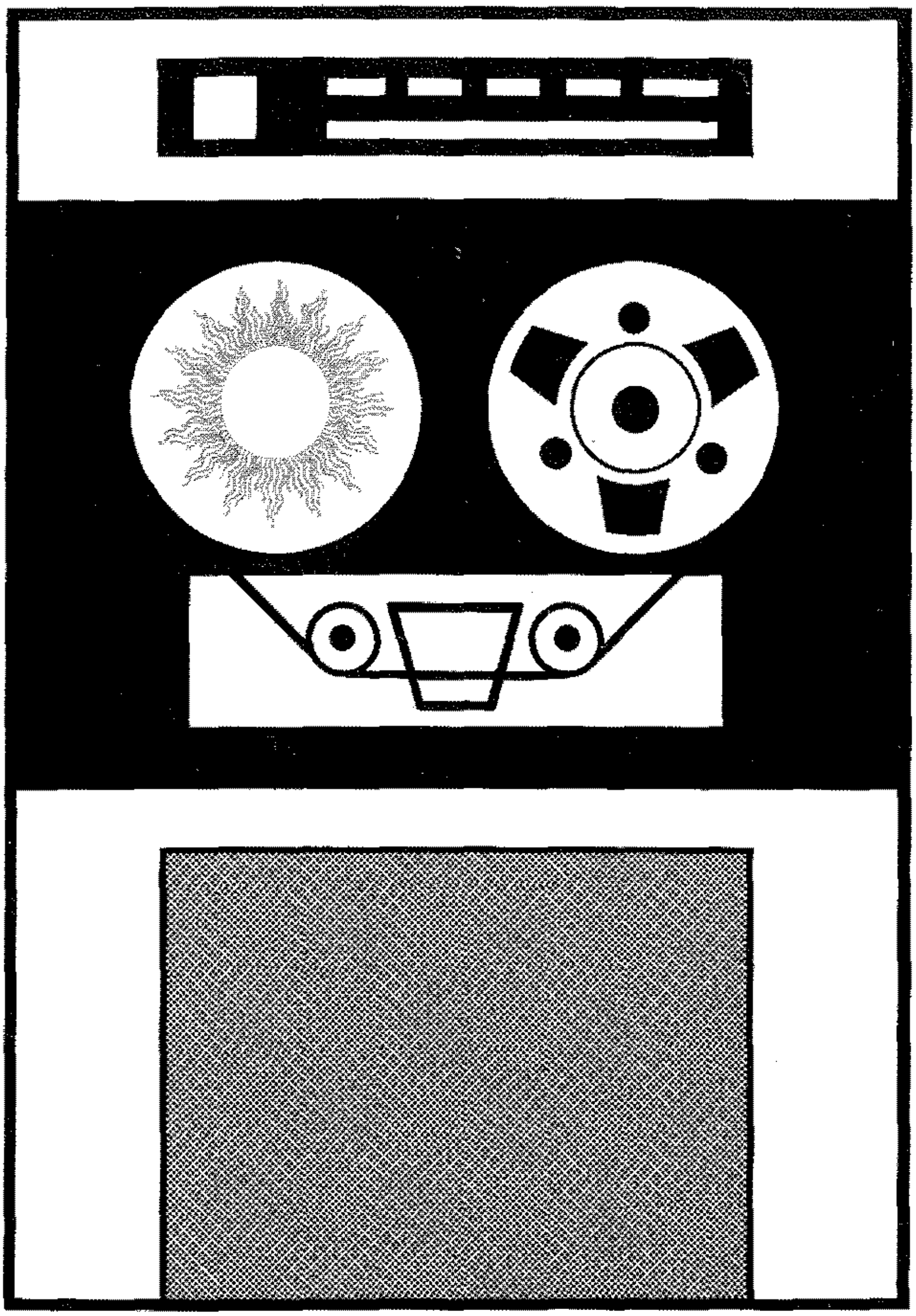

SERI Standard Broadband

iat

...orological Data
Archival Format

SERI Standard Broadband Format

A Solar and Meteorological Data Archival Format

April 1988

A Product of the

Solar Technical Information Program

Solar Energy Research Institute

1617 Cole Boulevard, Golden, Colorado 80401

Operated by Midwest Research Institute for the

U.S. Department of Energy

SERI/SP-320-3305

DE88001145

Preface

The primary responsibility of the Solar Energy Research Institute (SERI) Resource Assessment and Instrumentation Branch is to characterize the solar energy resource in terms of its spatial, temporal, and spectral variations. As a part of this goal, the branch maintains a solar radiation–meteorological data base, the Solar Data Archive, that provides information on the U.S. solar resource in support of research in all the solar energy conversion technologies. The SERI Solar Data Archive holds over 800 magnetic computer tapes that contain solar radiation measurements and model estimates assembled from a variety of sources, including federal agencies, academia, public utilities, and individuals in volunteer observation networks. Information is available for a variety of regions and types of data parameters. The measurement sampling and recording rates range from 1-min to 24-h intervals. Measurements are available "as observed"; in most cases, these measurements were also edited using limited quality control methods.

Acknowledgments

SERI Standard Broadband Format was developed through the cooperative efforts of the Solar Technical Information Program and the Resource Assessment and Instrumentation Branch of the Solar Energy Research Institute, under contract to the U.S. Department of Energy. The tape format was created by Martin Rymes of the Resource Assessment and Instrumentation Branch.

Contents

Figures

Tables

Chapter 1

Introduction

This manual describes a tape archival format appropriate for use with research-level solar radiation data. It serves both as a reference for users reading data recorded in the SERI Broadband Format (SBF) and as a guide to archiving solar, meteorological, and weather data in SBF. The manual's intended audience includes solar researchers, engineers, and climatologists as well as data processing professionals.

The SERI Standard Broadband Format (SBF) was specifically designed to handle the research-level data found on many of the tapes in the archive. A large variety of data parameters can be stored in SBF without unduly sacrificing tape efficiency or ease of use. A comprehensive list of solar, meteorological, and weather parameters is encoded in the format. In addition, the format's flexibility allows the user to add parameters and otherwise tailor the format to meet individual needs. SBF is particularly well suited to handling broadband solar radiation data. Also, instrument orientations (viewing angles), of special interest in solar applications, are given complete, unambiguous coverage in the header for each parameter.

Standardized block lengths and detailed header information make it easy to read the data. A researcher recording in this format should be able to include all the basic information a user would require to interpret the data. Blanks and nulls are interspersed in the header and between data elements to make tape dumps readable.

Additional information on SBF can be obtained from SERI. Contact:

Solar Energy Research Institute
Resource Assessment and Instrumentation Branch
1617 Cole Boulevard
Golden, CO 80401
(303) 231-7238

Format Background

SBF was developed to overcome some of the typical problems and limitations encountered in existing solar-meteorological tape archive formats. Broadband solar formats fall into two types: fixed element and flexible element.

Often designed for a particular application, the fixed-element format limits choices in the measurement time interval, the number of parameters, and the type of parameters allowed. For example, you can use the Solar Meteorological Format (SOLMET) only with hourly data and 10 solar parameters (including 2 user-defined parameters). Because SERI's Solar Data Archive contains a wide variety of data sets, no one fixed-element format can work for all cases.

The flexible format tends to be general purpose. It allows the user to define the time interval and measurement parameters, making the format ideal for research applications. Such a format could be tailored to fit any of the data sets in SERI's collection. We looked at one such format in particular for our applications—the Research Cooperator Format (RCF) developed by the National Climatic Data Center.

RCF is excellent for sites having a wide variety of instruments and time resolutions. It is also compact; i.e., it uses storage space efficiently. However, RCF also has a number of drawbacks: (1) Its large record length and the fact that it produces logical records and odd-length blocks make it hard for some computers (and most people) to read and process. (2) The lack of a decimal point in the Data-Element field increases the processing overhead. The different exponents also make it difficult to compare data if the exponents are different. (3) The seven-character integer in the Data-Element field is too large for some computers. (4) Tape blocks have no intrinsic meaning. (5) Data from the same time period are often in two separate blocks. (6) As with many other formats, RCF uses site codes, which are arbitrary identifiers that require the user to look up the site's name and information on its characteristics.

Although we could have fixed these perceived problems by making such changes as substituting a Floating-Point–Element field, it was decided instead to start from scratch. This decision was made partially out of the belief that formats should be consistent. The user should be able to use the basic RCF manual and not worry about alternate versions or special modifications. More importantly, simply fixing RCF would not address all our format concerns.

We had three goals for our new format: (1) It should be easily readable to computers. (2) It should be easily readable to users. (3) It should include all the basic information necessary for processing. The format needed to be easily readable to computers so that it could be used on a wide variety of equipment and so that data processing was efficient. In response to the RCF drawbacks, SBF is able to take care of many of the accessibility problems. The 80-character line length is convenient for terminals and printers. Data are in fixed-point form, eliminating integer overflow and allowing the data to be read without conversion into the program. Data are grouped into sets of obvious time intervals, making the block the logical unit of information. This grouping permits programs to process data types as blocks and eliminates the need to untangle blocks in search of data. To increase data processing efficiency, SBF provides pertinent information for the program in the second header line. Complete site information is given, eliminating the need for the lookup tables that RCF site codes require. Date and time, measurement type, and instrument angles are all included. Finally, SBF provides blocking information so that the program can automatically deblock.

The format was designed to be easily readable to the user so that the user could examine the data, quickly obtain basic information about it, and determine its quality. The data should not be so compressed that it is difficult to locate the desired information. SBF uses two header lines, the first line in text especially for the user. The second header line is spaced to make it readable. The data lines are grouped so that the data are presented in columns. Leading zeros are suppressed to create blanks between fields, making the data easier to examine. Finally, solar data are presented in watts per square meter to simplify the comparison of data in different time intervals.

The final goal was to provide all the basic information the user needed in the header so that no other reference tools would be required (except, possibly, for the format manual). In particular, we wanted to eliminate the need for translating a site code into a site name and its characteristics. The benefit of having all the information readily at hand was weighed against the drawback of introducing a header 160 characters in length. Clearly, if such a header were attached to each logical record, even one as long as in RCF, the penalty would be too great. The drawback could be reduced by using the header to represent a block of data, thus averaging the header overhead over all the sets in the block. Such an approach is a departure from previous formats. Thus, we discarded the logical record as a header and a set of data elements and replaced it in SBF with a block consisting of a header and many sets of elements.

SBF is, of course, not without its own drawbacks. Although it is still more efficient than fixed-element formats, it needs more storage than other flexible-field formats. For example, 1-min data stored on disk in SBF uses 16% more space than the same data in RCF, 13% more on 1600-bpi tape. We believe this sacrifice is worth the improved processing efficiency. Although SBF is relatively simple to use, the idea that the basic unit of information is the block, rather than the logical record, might require users familiar with other formats to make some adjustments.

The following chapters of this manual give the user a basic understanding of SBF. The tape, file, and block structures of the format are explained, and sample data blocks and field descriptions are given. The appendixes include a unit conversion table and sample programs.

Chapter 2

Format Structure

Overview

The two smallest structural units in SBF are the element and header fields. An *element* is a 10-byte, floating-point datum field. It can contain a datum and its associated flag, a missing datum indicator, or a null. Missing data and null elements help to ensure predictable set, block, and file sizes and, therefore, reliable data retrieval and sizing. Elements are described in detail in Chapter 5, "Element Field and Element-Code Descriptions." The 160-byte block header comprises numerous fields containing integer or character data of various lengths. Header fields are described in Chapter 4, "Header Field Descriptions."

Lines, logical records, are 80 bytes long. They contain either one line of header information or eight data elements (which can include nulls used to fill the set). Contrary to typical use, the smallest independent entity in SBF is the block, not the logical record. In this regard, it is helpful to think of the block as consisting of one logical record. However, the division of the block into 80-character lines eases inspection of the block and, in many cases, simplifies data processing.

Data elements are grouped chronologically into *sets.* Several lines reside in each set. A collection of sets, together with their block header, makes up the block. The number of lines in a set and of sets in a block is dependent on the time resolution of the data (see Table 2-1). The number of elements in a set is exactly divisible by 8. When the number of data elements in the set does not fulfill this criterion, nulls are added to complete the set.

A *block* is the logical unit of data; it consists of two header lines and a number of subsets specified by the blocking factor. All blocking factors are even numbered and ten based (see Table 2-1). The blocks are collated by time period and within the same time period by increasing element number, i.e., measurement parameter. For additional information on blocks, see Chapter 3, "Block Structure."

Files group measurements of a specific time resolution from one station into significant time intervals, e.g., a month of Georgia Tech 1-min data. The file's time span is determined by the time resolution of the data (see Table 2-1). Files end with one end-of-file (EOF) mark. The last file on the tape terminates with two EOF marks.

Blocking Table

The *blocking table* presents the format specifications for recording a specific data set. The time resolution of the data determines how the format structures the sets, blocks, and files. The following example illustrates how a data set of hourly data is blocked.

Example Blocking for Hourly Data

To determine the blocking for hourly data, the user finds "hour" under Element Time Resolution in Table 2-1. The information in the row tells the user that 24 data elements and no nulls are used to compose a set. Therefore, each set has a day of data. Each block contains 16 sets of data for a total length of 4000 characters (including the two header lines). Each block represents 16 d of data. The blocks are broken on natural time boundaries so that one block contains data for the first half of the month, and the second block contains data for the remainder of the month. Because the second block has more sets than there are days in the month, the remaining sets are filled with missing data indicators. Thus, for the month of January, the second block would have 15 sets of data elements (representing days 17–31) and 1 set of missing data elements. Finally, a file holds 1 yr of hourly data.

Table 2-1. Blocking Table

Element Time Resolution	Number of Data Elements per Set	Number of Null Elements per Set	Number of Lines per Set	Set Time Resolution	Number of Sets per Block	Total Block Length (sets + header)	Blocking Factor (lines per block)	Block Time Resolution	File Time Resolution
Year	10	6	2	Decade	30	4960	62	300 yr	30,000 yr
Month	12	4	2	Year	30	4960	62	30 yr	3,000 yr
Day	28–31	4-1	4	Month	12	4000	50	1 yr	100 yr
Hour	24	0	3	Day	16	4000	50	16 d[1]	1 yr
30 min	48	0	6	Day	8	4000	50	8 d[1]	1 yr
20 min	72	0	9	Day	5	3760	47	5 d[1]	1 yr
15 min	96	0	12	Day	5	4960	62	5 d[1]	1 yr
12 min	5	3	1	Hour	48	4000	50	2 d[1]	1 mo
10 min	6	2	1	Hour	48	4000	50	2 d[1]	1 mo
6 min	10	6	2	Hour	24	4000	50	1 d	1 mo
5 min	12	4	2	Hour	24	4000	50	1 d	1 mo
4 min	15	1	2	Hour	24	4000	50	1 d	1 mo
3 min	20	4	3	Hour	12	3040	38	1/2 d	1 mo
2 min	30	2	4	Hour	12	4000	50	1/2 d	1 mo
1 min	60	4	8	Hour	8	5280	66	1/3 d	1 mo
30 s	2	6	1	Minute	60	4960	62	1 h	1 mo
20 s	3	5	1	Minute	60	4960	62	1 h	1 mo
15 s	4	4	1	Minute	60	4960	62	1 h	1 mo
12 s	5	3	1	Minute	60	4960	62	1 h	1 mo
10 s	6	2	1	Minute	60	4960	62	1 h	1 mo
6 s	10	6	2	Minute	30	4960	62	1/2 h	1 d
5 s	12	4	2	Minute	30	4960	62	1/2 h	1 d
4 s	15	1	2	Minute	30	4960	62	1/2 h	1 d
3 s	20	4	3	Minute	20	4960	62	1/3 h	1 d
2 s	30	2	4	Minute	15	4960	62	1/4 h	1 d
1 s	60	4	8	Minute	6	4000	50	1/10 h	1 d

Constant Values

Element	=	10 characters (bytes).
Line	=	80 characters (a logical record) or eight elements if part of a data set.
Header	=	160 characters or two lines.

[1]Sets cannot cross month boundaries within a block. Months begin with the first set of a block. If a block is not filled when a month is completed, the remainder of the block is filled with nulls.

Collation Sequence

The collation sequence organizes the data for efficient retrieval. The most common types of data requests can be simplified to one of the following two basic forms:

1. For one instrument over an entire record period
2. For all instruments over one time interval.

Unfortunately, the ideal collation sequences for the two types of requests are mutually incompatible. An organization that efficiently retrieves data for one type of request would be the worst possible organization for the other. Type 1 requests retrieve data more efficiently if all the data for one instrument are contiguous to the end of the recording period. Type 2 data retrieval requires that all the instruments be represented at each time increment.

The SBF collation sequence compromises between these two forms (see Table 2-2). Data are organized so that the same instrument is represented through a significant block of time before the next instrument is listed. Case 1 requests using SBF need to examine each block's header to find the desired instrument. However, an instrument search can proceed rapidly because several sets of data are associated with each header, enabling the user to move past unwanted data. Case 2 requests are facilitated by the fact that instruments are grouped together in time. Therefore, the user doesn't have to search far through a serial record to retrieve data for all instruments in a specific time period (see Figure 2-1).

The SBF collation sequence organizes sets of data chronologically. Data blocks are organized by time period and, within the same time period, by increasing element number or instrument type. Each file contains data covering a significant period of time (e.g., year, month, day). Files are ordered

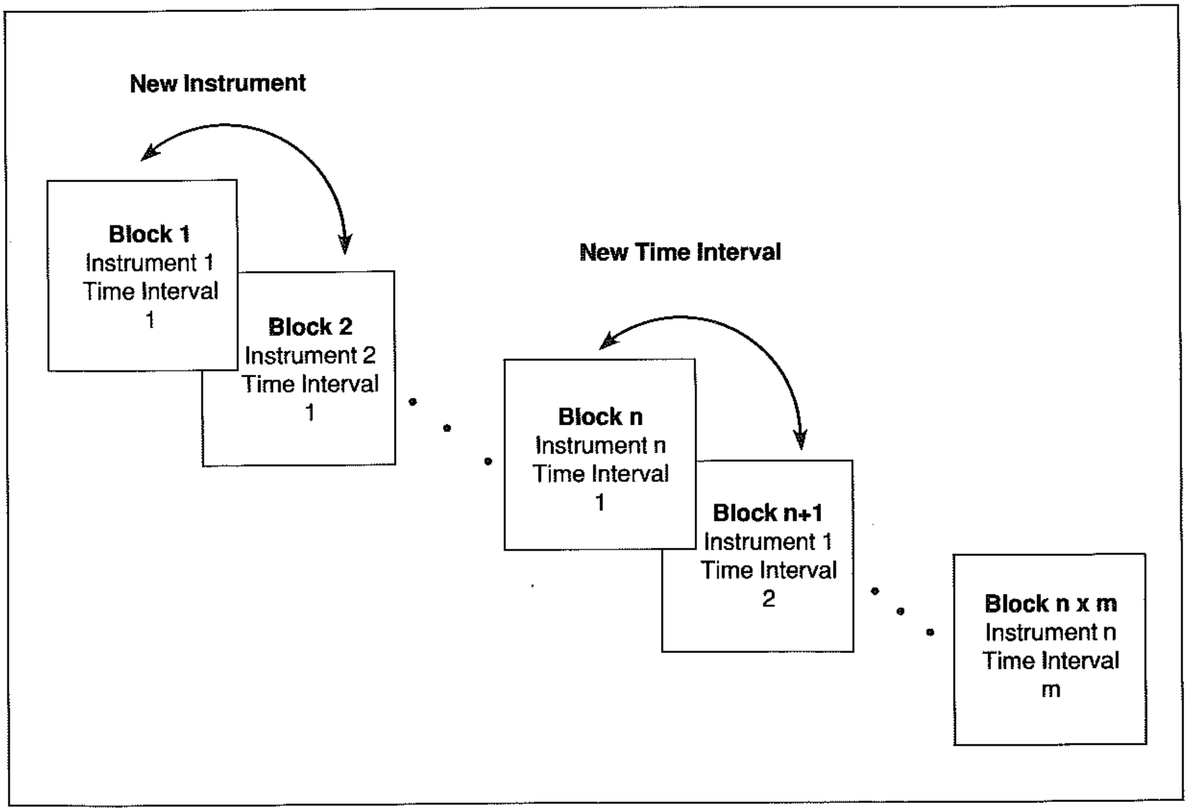

Figure 2-1. Collation Sequence

Table 2-2. Typical Collation Sequences

Format Level	Ordered By	Format Level	Ordered By
One-Minute Data		**Five-Minute Data**	
File	Month	File	Month
Blocks	1. 1/3 d	Blocks	1. 1 d
	2. Instrument		2. Instrument
Sets	Hours of 1-Min Data	Sets	Hours of 5-Min Data
Fifteen-Minute Data		**Hourly Data**	
File	Year	File	Year
Blocks	1. 5 d[1]	Blocks	1. 16 d[1]
	2. Instrument		2. Instrument
Sets	Days of 15-Min Data	Sets	Days of Hourly Data

[1]Blocks are filled with nulls after the end of the month.

consecutively by date. Nulls are used throughout to ensure predictable set, block, and file sizes and, therefore, reliable data retrieval and skipping. If an instrument begins processing in midblock or if this instrument goes offline before the end of the block, the block is filled with missing data indicators and is not truncated. Nulls are used to ensure that blocks end on natural time boundaries (see Table 2-1).

Example Collation for One-Minute Data

Monthly file of "m" days per month. Number of instruments (n_i) varying with time period. If a constant "n" instrument is assumed, then there are 3mn blocks in the file.

Block 1: Instrument 1, Time 0:00 → 8:00, Day 1
Set 1: Time 0:00 → 1:00
⋮
Set 8: Time 7:00 → 8:00

Block 2: Instrument 2, Time 0:00 → 8:00, Day 1
Set 1: Time 0:00 → 1:00
⋮
Set 8: Time 7:00 → 8:00

Block 3: Instrument 3, Time 0:00 → 8:00, Day 1
⋮

Block n_1: Instrument n_i, Time 0:00 → 8:00, Day 1
Set 1: Time 0:00 → 1:00
⋮
Set 8: Time 7:00 → 8:00

Block $n_1 + 1$: Instrument 1, Time 8:00 → 16:00, Day 1
Set 1: Time 8:00 → 9:00
⋮
Set 8: Time 15:00 → 16:00

Block $n_1 + 2$: Instrument 2, Time 8:00 → 16:00, Day 1

⋮

Block $n_1 + n_2$: Instrument n_2, Time 8:00 → 16:00, Day 1

⋮

Block $n_1 + n_2 + 1$: Instrument 1, Time 16:00 → 24:00, Day 1

⋮

Block $n_1 + n_2 + n_3$: Instrument n_3, Time 16:00 → 24:00, Day 1
Set 1: Time 16:00 → 17:00

⋮

Set 8: Time 23:00 → 24:00

Block $\sum_{i=1}^{3} n_i + 1$: Instrument 1, Time 0:00 → 8:00, Day 2

⋮

Block $\sum_{i=1}^{3j} n_i + 1$: Instrument 1, Time 0:00 → 8:00, Day j + 1

⋮ Last Block

Block $\sum_{i=1}^{3m} n_i$: Instrument n_{3_m} last, Time 16:00 → 24:00, Day m

Magnetic Tape Specifications

The following elements describe the basic SBF tape structure:

Media: 9-track tape

Density: 1600 bpi

Parity: Odd

Label: Unlabeled

Coding: ASCII

Block Size: Dependent on data time resolution (see Table 2-1)

Fixed-length records and blocks

1 tape mark (EOF) per file

2 tape marks (EOFs) indicate the end of the information on the tape.

Chapter 3

Block Structure

Overview

Blocks consist of two parts: (1) an identification part or header and (2) the data-element sets (see Figure 3-1).

The first two 80-character lines (the block headers) describe the characteristics of the entire block. These headers contain all the information relevant to the data-element set for a specified parameter. The header information uses text descriptions and standard units to make it easily readable. Generally, leading zeros are suppressed to provide spacing between fields.

The data portion of the block (the Element field) contains information about each element value reported. It is composed of the measured values and associated quality control flags that together make up the Element field. The sets are repeated a certain number of times depending on the data-element time resolution (see Table 2-1).

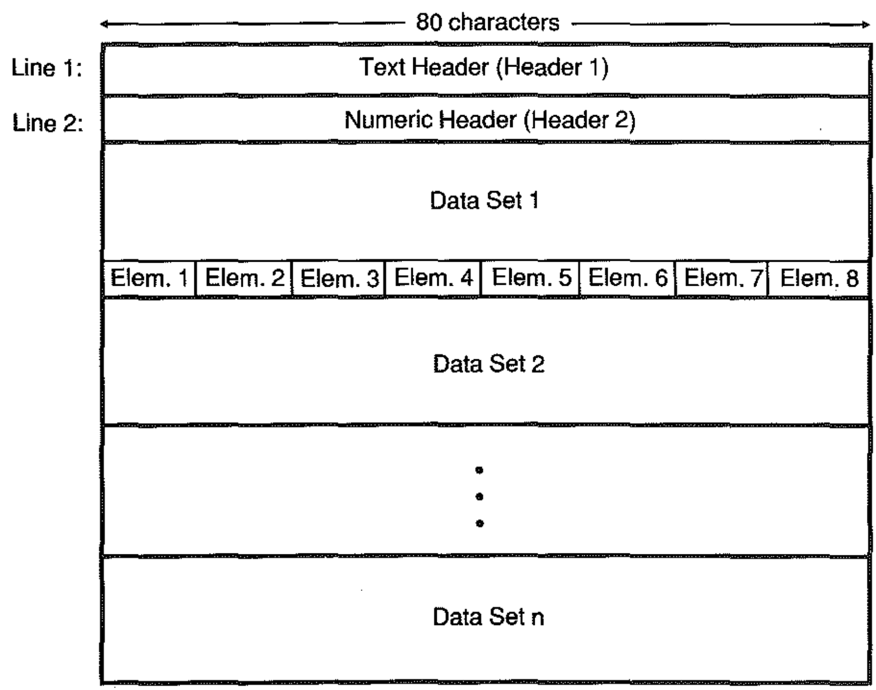

Figure 3-1. Block Structure

Assigning only one header per block saves space and enables a searcher to skip over the data-set portion of undesired blocks. Only one type of data parameter is recorded for the block interval. For example, if the element number in the header is 1000, the data sets contain only direct normal radiation data (see Table 2-1). Blocks begin on natural time boundaries. For example, blocks of hourly records begin at 00:00, blocks of daily records begin on January 1, etc.

If an instrument begins processing in midblock or if the instrument goes offline before the end of the block, the block is filled with missing data indicators and is not truncated. Nulls fill the end of the sets for some time resolutions to ensure that the blocks end on natural time boundaries. Block structure is determined by the data-acquisition time period using Table 2-1.

Block Layout

The fields within a block are laid out in a sequential manner, as illustrated in Figure 3-2. The Xs indicate the length of each field. The strips are labeled with the field code, indicating the name of the field, and the tape field number. Table 3-1 summarizes the field information and explains the field codes. For additional information on the header and element fields, see Chapters 4 and 5, respectively.

Header Line 1

SN	OB
XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
001	002

UM	FN
XXXXXXXXXX	X
003	004

Header Line 2

SR	LT	LG	EL	TZ		EC		ZN	OR	AZ		ST	
XX	XXXXX	XXXXXX	XXXXX	XXXX	b	XXXX	b	XX	XX	XXX	b	XXXXXXXXXXXX	b
005	006	007	008	009		010		011	012	013		014	

ET		AM		TI	BI		NE	NN	BF
XXXXXXXXXXXX	b	X	b	XXXX	XXXX	b	XX	XX	XXX
015		016		017	018		019	020	021

Element Field

DE	FF	DE	FF	DE	FF	DE	FF	DE	FF
XXXX.XXX	XX	XXXX.XXX	XX	XXXX.XXX	XX	XXXX.XXX	XX	XXXX.XXX	XX

DE	FF	DE	FF	DE	FF	
XXXX.XXX	XX	XXXX.XXX	XX	XXXX.XXX	XX	

Figure 3-2. Block Layout on Tape

Sample Block of One-Minute Data

The printout of a 1-min data block appears in Figure 3-3. For an explanation of what appears in this tape dump, see Table 3-2.

Sample Block of Five-Minute Data

The printout of a 5-min data block appears in Figure 3-4. For an explanation of what appears in this tape dump, see Table 3-3.

Table 3-1. Block Layout

Field Code	Tape Field	Position	No. Bytes	Data Type	Field Type
Header Line 1					
SN	001	1–20	20	chr	Site Name
OB	002	21–69	49	chr	Instrument/Observation
UM	003	70–79	10	chr	Units of Measure
FN	004	80	1	int	Footnote
Header Line 2					
SR	005	1–2	2	int	Site Rank
LT	006	3–7	5	int	Latitude
LG	007	8–13	6	int	Longitude
EL	008	14–18	5	int	Elevation
TZ	009	19–22	4	int	Time Zone Number
	23		blank		
EC	010	24–27	4	int	Element Code
	28		blank		
ZN	011	29–30	2	int	Zenith
OR	012	31–32	2	chr	Instrument Orientation
AZ	013	33–35	3	int	Azimuth
	36		blank		
ST	014	37–48	12	int	Start Time
	49		blank		
ET	015	50–61	12	int	End Time
	62		blank		
AM	016	63	1	int	Archive Mode
	64		blank		
TI	017	65–68	2,2	int,chr	Element Time Interval
BI	018	69–72	2,2	int,chr	Block Interval
	73		blank		
NE	019	74–75	2	int	No. Elements/Set
NN	020	76–77	2	int	No. Nulls/Set
BF	021	78–80	3	int	Blocking Factor
Element Fields					
DE	—	—	8	float	Data Element
FF	—	—	2	int	Flag

```
GEORGIA TECH SEMRTS:Direct Normal, Eppley NIP                          Watts/m*m 0
 1 3377 -8438  292 -50 1000 992X999 800701080100 800701160000 0  1MI 8HR 60 4 66
  728.33302 728.33302 731.66702 733.33302 736.66702 735.00002 733.33302 735.00002
  735.00002 736.66702 738.33302 740.00002 738.33302 740.00002 741.66702 743.33402
  748.33402 753.33302 755.00002 756.66702 763.33302 761.66702 763.33302 761.66702
  765.00002 765.00002 763.33302 766.66702 768.33402 768.33402 773.33402 775.00002
  776.66702 778.33402 706.667029900.00099 785.00002 783.33302 783.33302 783.33302
  783.33302 785.00002 788.33302 791.66702 793.33402 798.33402 798.33402 796.66702
  798.33402 800.00002 803.33402 805.00002 800.00002 801.66702 800.00002 803.33402
  805.00002 806.66702 806.66702 806.66702-999.99999-999.99999-999.99999-999.99999
  810.00002 810.00002 810.00002 810.00002 808.33302 808.33302 810.00002 816.66702
  820.00002 820.00002 820.00002 825.00002 820.00002 821.66702 825.00002 823.33402
  821.66702 821.66702 823.33402 821.66702 825.00002 828.33402 831.66702 831.66702
  831.66702 828.33402 830.00002 836.66702 836.66702 833.33402 830.00002 830.00002
  828.33402 831.66702 836.66702 841.66702 841.66702 841.66702 845.00002 760.00003
  845.00002 846.66702 851.66702 851.66702 855.00002 858.33402 858.33402 858.33402
  856.66702 858.33402 860.00002 858.33402 856.66702 860.00002 863.33302 861.66702
  865.00002 858.33402 860.00002 871.66702-999.99999-999.99999-999.99999-999.99999
  870.00002 868.33402 868.33402 871.66702 871.66702 868.33402 871.66702 873.33402
  875.00002 871.66702 870.00002 875.00002 876.66702 873.33402 873.33402 876.66702
  875.00002 871.66702 871.66702 875.00002 876.66702 880.00002 880.00002 880.00002
  883.33402 880.00002 880.00002 885.00002 885.00002 886.66702 888.33302 886.66702
  885.00002 881.66702 886.66702 885.00002 883.33402 883.33402 888.33302 886.66702
  886.66702 888.33302 888.33302 885.00002 888.33302 890.00002 890.00002 890.00002
  893.33402 893.33402 890.00002 888.33302 890.00002 890.00002 881.66702 863.33302
  856.66702 850.00002 846.66702 843.33402-999.99999-999.99999-999.99999-999.99999
  820.00002 795.00002 745.00002 620.00002 626.66702 560.00002 696.66702 663.33302
  593.33302 668.33402 710.00002 706.66702 645.00002 590.00002 566.66702 528.33302
  543.33302 646.66702 778.33402 831.66702 868.33402 896.66702 898.33402 888.33302
  871.66702 850.00002 853.33402 801.66702 813.33302 855.00002 891.66702 886.66702
  846.66702 801.66702 735.00002 840.00002 841.66702 825.00002 850.00002 880.00002
  885.00002 888.33302 891.66702 893.33402 891.66702 886.66702 885.00002 885.00002
  885.00002 885.00002 891.66702 893.33402 880.00002 863.33302 863.33302 866.66702
  858.33402 871.66702 871.66702 880.00002-999.99999-999.99999-999.99999-999.99999
  885.00002 891.66702 890.00002 893.33402 896.66702 901.66702 898.33402 891.66702
  893.33402 891.66702 896.66702 898.33402 896.66702 891.66702 898.33402 898.33402
  901.66702 901.66702 891.66702 883.33402 873.33402 871.66702 873.33402 871.66702
  866.66702 880.00002 885.00002 886.66702 883.33402 881.66702 865.00002 860.00002
  855.00003 863.33302 871.66702 863.33302 860.00002 863.33302 863.33302 863.33302
  856.66702 855.00002 855.00002 845.00002 850.00002 855.00002 851.66702 843.33402
  838.33302 835.00002 821.66702 831.66702 841.66702 840.00002 848.33402 845.00002
  848.33402 840.00002 841.66702 841.66702-999.99999-999.99999-999.99999-999.99999
  833.33402 821.66702 828.33402 828.33402 820.00002 816.66702 815.00002 820.00002
  811.66702 808.33302 810.00002 805.00002 806.66702 805.00002 815.00002 811.66702
  788.33302 806.66702 818.33402 818.33402 808.33302 828.33402 843.33402 841.66702
  841.66702 850.00002 851.66702 848.33402 846.66702 846.66702 850.00002 846.66702
  845.00002 841.66702 845.00002 850.00002 855.00002 851.66702 851.66702 860.00002
  858.33402 861.66702 866.66702 870.00002 871.66702 873.33402 870.00002 865.00002
  863.33302 866.66702 860.00002 855.00002 856.66702 855.00002 855.00002 845.00002
  845.00002 850.00002 843.33402 835.00002-999.99999-999.99999-999.99999-999.99999
  830.00002 830.00002 826.66702 828.33402 835.00002 838.33302 838.33302 838.33302
  838.33302 841.66702 835.00002 833.33402 825.00002 815.00002 810.00002 811.66702
  811.66702 788.33302 790.00002 793.33402 766.66702 760.00002 760.00002 736.66702
  721.66702 696.66702 713.33302 720.00002 720.00002 735.00002 748.33402 760.00002
  766.66702 746.66702 731.66702 735.00002 761.66702 771.66702 776.66702 785.00002
  781.66702 758.33302 766.66702 791.66702 811.66702 820.00002 815.00002 811.66702
  815.00002 815.00002 820.00002 825.00002 823.33402 823.33402 823.33402 818.33402
  810.00002 801.66702 793.33402 776.66702-999.99999-999.99999-999.99999-999.99999
  775.00002 783.33302 783.33302 791.66702 781.66702 786.66702 786.66702 780.00002
  783.33302 785.00002 781.66702 785.00002 785.00002 785.00002 786.66702 781.66702
  776.66702 781.66702 778.33402 776.66702 775.00002 778.33402 771.66702 763.33302
  750.00002 736.66702 731.66702 720.00002 698.33302 675.00002 638.333039900.00099
 9900.000999900.000999900.000999900.000999900.000999900.000999900.000999900.00099
 9900.000999900.000999900.000999900.000999900.000999900.000999900.000999900.00099
 9900.000999900.000999900.000999900.000999900.000999900.000999900.000999900.00099
 9900.000999900.000999900.000999900.00099-999.99999-999.99999-999.99999-999.99999
```

Figure 3-3. Printout of One-Minute Data Block

Table 3-2. Explanation of One-Minute Sample Block

Position	Field Title	Value	Explanation
Header Line 1			
1–20	Site Name	GEORGIA TECH SEMRTS:	The location and program name make up the site's name. This code indicates the Georgia Tech site of the Solar Energy and Meteorological Research and Training Sites.
21–69	Instrument/ Observation	DIRECT NORMAL, EPPLEY NIP	Direct normal radiation was measured with an Eppley normal incidence pyrheliometer (NIP).
70–79	Units of Measure	WATTS/M*M	Data values are reported in watts per square meter.
80	Footnote	0	Code indicates raw data, i.e., data that were not modified or corrected.
Header Line 2			
1–2	Site Rank	1	Site is the first in the "box" bounded by 33.765° to 33.775° latitude and -84.375° to -84.385° longitude.
3–7	Latitude	3377	Value translates into 33.77° or 33°46' north.
8–13	Longitude	-8438	Value translates into -84.38° or -84°23' west.
14–18	Elevation	292	Value translates into 292 m above sea level.
19–22	Time Zone Number	-50	Value translates into time zone -5 (eastern standard time).
24–27	Element Code	1000	Code indicates the data are direct normal radiation (a subcategory of broadband irradiance in the element code index).
29–30	Zenith	99	Code indicates zenith angle doesn't apply (it's a two-axis instrument).
31–32	Instrument Orientation	2X	Code indicates instrument is a double-axis tracker.
33–35	Azimuth	999	Code indicates azimuth angle doesn't apply (it's a two-axis instrument).
37–48	Start Time	800701080100	Value translates into July 1, 1980, 8:01 a.m.
52–63	End Time	800701160000	Value translates into July 1, 1980, 4:00 p.m.
64	Archive Mode	0	Code indicates the data values are averaged.
65–68	Element Time Interval	1MI	Data were recorded at 1-min intervals.
69–72	Block Interval	8HR	Data are organized by 8-h blocks; i.e., there are eight, hour-long sets of data in each block.
74–75	No. Elements/ Set	60	Sixty data elements exist in each subset of the block, i.e., 1 h of data per set.
76–77	No. Nulls/Set	4	Four nulls are appended to each set to create eight complete 80-character lines.
78–80	Blocking Factor	66	Each block contains sixty-six 80-character lines: 2 header lines and 64 data lines.

Continued on next page

Table 3-2. Explanation of One-Minute Sample Block (Concluded)

Data Lines 3–66

Each hour of 1-min data is organized into 64 element sets containing 60 data elements and four nulls. A block consists of eight of these sets, for a total of 5280 characters. The block following this sample contains 8 h of data from the next parameter, in this case the direct normal secondary instrument. After all the parameters for this time period are listed, the next 8 h of the first instrument—in this case, direct normal radiation data—are presented. The value for the first minute of direct normal radiation data in the first hour-set is 728.333 W/m^2. The flag 02 indicates the datum passed inspection. A missing or unreadable datum is represented by a 9900.00099 element. Nulls use the form -999.99999. Four nulls appear at the end of each set. Note the last hour of data: Missing data indicators are used to complete the data set.

```
BC-HBCU             DIFFUSE SB          PSP 25782F3 10.179uV/Wm-2 0585 W/sq m   1
 1 2918 -8101    20 -50 1300  0UP  0 860102000500 860103000000 0  5MI 1DY 12 4 50
   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000
   0.00000   0.00000   0.00000   0.00000-999.99999-999.99999-999.99999-999.99999
   0.00000  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707   0.00000  -1.10707
  -1.10707  -1.10707  -1.10707  -1.10707-999.99999-999.99999-999.99999-999.99999
  -1.10707  -1.10707   0.00000   0.00000  -1.10707  -1.10707   0.00000   0.00000
   0.00000   0.00000   0.00000   0.00000-999.99999-999.99999-999.99999-999.99999
   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000  -1.10707
  -1.10707  -1.10707  -1.10707  -1.10707-999.99999-999.99999-999.99999-999.99999
  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707   0.00000   0.00000   0.00000
   0.00000   0.00000   0.00000   0.00000-999.99999-999.99999-999.99999-999.99999
   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000   0.00000  -1.10707
  -2.21407  -2.21407  -2.21407  -2.21407-999.99999-999.99999-999.99999-999.99999
  -2.21407  -2.21407  -2.21407  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707
  -1.10707  -1.10707  -1.10707  -1.10707-999.99999-999.99999-999.99999-999.99999
  -1.10707   0.00000   1.10700   3.32100   6.64200  12.17700  15.49800  23.24700
  35.42500  34.31800  34.31800  47.60200-999.99999-999.99999-999.99999-999.99999
  63.10000  77.49100  84.13300  98.52500  99.63200 117.34400 129.52100 127.30700
 100.73900  77.49101  78.59801 109.59501-999.99999-999.99999-999.99999-999.99999
 112.91601 119.55801  95.20401 135.05601 156.09001 149.44801 149.44801 138.37701
 135.05601 135.05601 130.62801 153.87601-999.99999-999.99999-999.99999-999.99999
 174.90901 210.33401 207.01301 256.82801 275.64801 272.32701 263.47101 213.65501
 147.23401 128.41401 130.62801 145.01901-999.99999-999.99999-999.99999-999.99999
 159.41101 176.01601 182.65801 185.97901 204.79901 253.50701 333.21311 328.78501
 376.38693 338.74801 342.06961 314.39329-999.99999-999.99999-999.99999-999.99999
 282.29001 275.64801 271.22001 220.29701 269.00601 274.54101 277.86201 271.22001
 290.03901 307.75101 275.64801 275.64811-999.99999-999.99999-999.99999-999.99999
 283.39715 252.40015 228.04619 224.72501 253.50701 360.88801 349.81801 294.46701
 275.64801 269.00601 247.97201 222.51101-999.99999-999.99999-999.99999-999.99999
 216.97611 212.54811 200.37011 199.26311 200.37011 204.79901 214.76201 201.47701
 202.58401 199.26311 192.62111 179.33711-999.99999-999.99999-999.99999-999.99999
 183.76501 198.15601 225.83201 218.08301 208.12001 187.08601 172.69501 167.16001
 148.34101 128.41401 116.23701 105.16701-999.99999-999.99999-999.99999-999.99999
  88.56201  78.59801  68.63500  58.67200  49.81600  43.17400  40.96000  37.63900
  30.99700  26.56800  24.35400  19.92600-999.99999-999.99999-999.99999-999.99999
  15.49800  14.39100  13.28400  12.17700   7.74900   3.32100   0.00000   0.00000
  -1.10707  -1.10707  -2.21407  -2.21407-999.99999-999.99999-999.99999-999.99999
  -2.21407  -2.21407  -1.10707  -1.10707  -1.10707  -2.21407  -1.10707  -1.10707
  -2.21407  -2.21407  -2.21407  -2.21407-999.99999-999.99999-999.99999-999.99999
  -2.21407  -2.21407  -1.10707  -1.10707  -1.10707  -2.21407  -1.10707  -2.21407
  -2.21407  -2.21407  -2.21407  -2.21407-999.99999-999.99999-999.99999-999.99999
  -2.21407  -2.21407  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707
  -1.10707  -1.10707  -1.10707  -1.10707-999.99999-999.99999-999.99999-999.99999
  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707
  -1.10707   0.00000  -1.10707  -1.10707-999.99999-999.99999-999.99999-999.99999
  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707  -1.10707
  -1.10707  -1.10707  -1.10707  -2.21407-999.99999-999.99999-999.99999-999.99999
  -2.21407  -1.10707  -2.21407  -2.21407  -1.10707  -2.21407  -2.21407  -2.21407
  -2.21407  -1.10707  -1.10707  -1.10707-999.99999-999.99999-999.99999-999.99999
```

Figure 3-4. Printout of Five-Minute Data Block

Table 3-3. Explanation of Five-Minute Sample Block

Position	Field Title	Value	Explanation
Header Line 1			
1–20	Site Name	BC-HBCU	Code indicates the Bethune-Cookman College site from the Historically Black Colleges and Universities data set.
21–39	Instrument/ Observation	DIFFUSE SB PSP 25782F3 10.179uV/Wm-2 0585	Diffuse radiation with a shadow band was measured with an Eppley precision spectral pyranometer (PSP), model no. 25782F3; the calibration factor of 10.179uV/Wm^2 was determined in May 1982.
70–79	Units of Measure	W/sq m	Data values are reported in watts per square meter.
80	Footnote	1	Code indicates the data were modified for shadow-band correction factor.
Header Line 2			
1–2	Site Rank	1	Site is the first in the "box" bounded by 29.175° to 29.185° latitude and -81.005° to -81/015° longitude.
3–7	Latitude	2918	Value translates into 29.18° north.
8–13	Longitude	-8101	Value translates into -81.01° west.
14–18	Elevation	20	Value translates into 20 m above sea level.
19–22	Time Zone Number	-50	Value translates into time zone -5 (eastern standard time).
24–27	Element Code	1300	Code indicates the data are diffuse radiation taken with a shadow band.
29–30	Zenith	0	Code indicates the instrument is tilted at a 0° zenith angle.
31–32	Instrument Orientation	UP	Code indicates the instrument is facing up.
33–35	Azimuth	0	Code indicates the instrument is tilted at a 0° azimuth angle.
37–48	Start Time	860102000500	Code indicates the first data element was averaged over the time period ending January 2, 1986, 12:05 a.m.
50–61	End Time	860103000000	Last data element was averaged over the time period ending January 3, 1986, 12:00 p.m. (between January 2 and January 3).
63	Archive Mode	0	Code indicates the data values are averaged over the element time interval.
65–68	Element Time Interval	5MI	Data were recorded at 5-min intervals.
69–72	Block Interval	1DY	Data are organized by daily block; i.e., there are 24, hour-long sets of data in each block.

Continued on next page

Table 3-3. Explanation of Five-Minute Sample Block (Concluded)

74–75	No. Elements/Set	12	Twelve data elements exist in each set of the block, i.e., 1 h of data per set.
76–77	No. Nulls/Set	4	Four nulls are appended to each set to create two complete 80-character lines.
78–80	Blocking Factor	50	Each block contains fifty 80-character lines: 2 header lines and 48 data lines.

Data Lines 3–50

Each hour of 5-min data is organized into 16 element sets containing 12 data elements and four nulls. A block consists of 24 of these sets and two header lines for a total of 4000 characters. The block following this sample contains 8 h of data from the next parameter, in this case, global-horizontal radiation. After all the parameters for this time period are listed, the next day of data for the first instrument is presented. The value for the first 5-min period of diffuse radiation in the sample block's tenth hour (set) is 112.916 W/m^2. The flag 01 indicates the datum passed tests on physical limits, model limits (for tolerances less than 3%), and reasonable coupling with other elements (for tolerances less than 3%).

Chapter 4

Header Field Descriptions

The *block header* consists of two 80-character lines describing the data, the site, and the block itself. The first line allows the user to enter text descriptions of the site and the measurement parameter. The second header line uses numeric values and codes to describe the block contents. All the information needed by the computer to process the data is contained in this line. See Table 4-1 for descriptions of the header fields.

Table 4-1. Header Field Descriptions

Tape Field	Position	Field Length (#Chr)	Data Type	Field Title	Description
Header Line 1					
Block Identification					
001	1–20	20	chr	Site Name	The field contains a text description.
002	21–69	49	chr	Instrument/ Observation	The field contains a text description.
003	70–79	10	chr	Units of Measure	The field contains a text description.
004	80	1	int	Footnote	The code indicates if data were modified (0 = no modification; 1–9 = altered so that it no longer corresponds to the raw data; note that unit conversion is not considered a modification). The following codes are valid: 0 Mean or total 1 Altered 2 Standard deviation 3 Minimum 4 Maximum 5 Mode 6 Median 7–9 Other. When using footnotes 1–9, the user should provide additional documentation. The collation sequence is affected if several footnotes are used for the same parameter (i.e., the same instrument was modified several ways, each recorded separately). In this case, data blocks within the same time period recording the same instrument are grouped together in order of increasing footnote code.

Continued on next page

Table 4-1. Header Field Descriptions (Continued)

Tape Field	Position	Field Length (#Chr)	Data Type	Field Title	Description
Header Line 2					
Site Information					
005	1–2	2	int	Site Rank	The field indicates the rank of the site, usually 1.
006	3–7	5	int	Latitude	The field indicates site latitude in degrees N * 100. Position for a negative sign is included (positive = north, negative = south), e.g., 39.273° north = 3927.
007	8–13	6	int	Longitude	The field indicates site longitude in degrees E * 100. Position for a negative sign is included (positive = east, negative = west), e.g., 90.33° west = -9033.
008	14–18	5	int	Elevation	The field indicates site elevation (instrument elevation can be noted in header line 1) in meters (round off fractions); sign floats.
009	19–22	4	int	Time Zone Number	The field indicates time zone number * 10. Position for negative sign is included (positive = east longitude, negative = west), e.g., time zone 5 (eastern standard time) = -50.
Data and Instrument Information					
010	24–27	4	int	Element Code	The field indicates the type of measurement or observation recorded in the element fields (complete information is in Chapter 5, "Element Field and Element-Code Descriptions"). The user should provide supplemental documentation if one of the "other" categories is used.
011	29–30	2	int	Zenith	The field normally indicates the zenith or nadir angle from 0 to 90° (tilt from horizontal). Single-axis trackers use axis angle of the tracker compared to the zenith. Downward-facing instruments use nadir angle (180° - zenith angle). Two-axis instruments that are not applicable use 99.
012	31–32	2	chr	Instrument Orientation	The following codes are valid: UP = Normal, upward-facing instrument DN = Downward-facing instrument (zenith = 180° - zenith angle) 1X = Orientation applied to single-axis tracker 2X = Double-axis tracker NA = Not applicable.
013	33–35	3	int	Azimuth	The field indicates the azimuth angle of instrument from 0 to 360°. Expected values are 0 and 360 = north, 90 = east, 180 = south, and 270 = west. Azimuth angle of the tracker axis = single axis. Two axis or instruments that are not applicable = 999.

Continued on next page

Table 4-1. Header Field Descriptions (Continued)

Tape Field	Position	Field Length (#Chr)	Data Type	Field Title	Description
Data-Acquisition Time Period					
014	37–48	12		Start Time	The field indicates the beginning of data acquisition for the block written in local standard time using a 24-h clock (not Greenwich, solar, or daylight savings time). Leading zeros are retained. For example, 8:02 p.m., January 1, 1987, is written as 870101200200. If the data values are averaged or integrated (Archive Mode = 0 or 1), the time represents the end of the first element's measurement interval. If the data values are instantaneous (Archive Mode = 2), this time is the exact point at which the first element in the block was measured (see Archive Mode for some examples). The following subfields exist:
	37–38	2	int		YR = Year (last two digits)
	39–40	2	int		MO = Month (01–12)
	41–42	2	int		DY = Day of month (01–31)
	43–44	2	int		HR = Hour (00–23)
	45–46	2	int		MI = Minute (00–59)
	47–48	2	int		SC = Second (00–59).
015	50–61	12	int	End Time	The field indicates the end of data acquisition for the block written in local standard time. Leading zeros are retained. If the data values are averaged or integrated, the time represents the end of the last element's measurement interval. Otherwise, if the data values are instantaneous, this time is the exact point at which the last element in the block was measured. The following subfields exist:
	50–51	2	int		YR = Year (last two digits)
	52–53	2	int		MO = Month (01–12)
	54–55	2	int		DY = Day of month (01–31)
	56–57	2	int		HR = Hour (00–23)
	58–59	2	int		MI = Minute (00–59)
	60-61	2	int		SC = Second (00-59).
Data Resolution and Recording Information					
016	63	1	int	Archive Mode	The code indicates how the data element was recorded over time (0 = averaged, 1 = integrated, 2 = instantaneous). Averaged and integrated values (codes 0 and 1) span the entire Element Time Interval. For instance, based on the assumption of 5-min data (5MI in Element Time Interval) and Start Time = 860101000500, the first Data-Element field contains a value averaged or integrated over the

Continued on next page

Table 4-1. Header Field Descriptions (Concluded)

Tape Field	Position	Field Length (#Chr)	Data Type	Field Title	Description
					D5-min period ending at 12:05 a.m., the second element ends at 12:10 a.m., the third ends at 12:15 a.m., etc.; the last element ends at 12:00 a.m. on day 2. Instantaneous data, however, are measured once during the time period. Therefore, for 1-min data with a start time of 8007080100, the first data field contains the measurement taken at 8:01 a.m., the second field at 8:02 a.m., etc.
017	65–68	2,2		Element Time Interval	The field indicates the time period spanned by the measurement of each element. Examples include 1-min data written as 1MI, 15-min data as 15MI, and hourly data as 1HR. The field consists of the following two parts:
	65–66	2	int		1 = Number of time units per element.
	67–68	2	chr		2 = Code representing time units. The following codes are valid: SC = Second MI = Minute HR = Hour DY = Day WK = Week MO = Month YR = Year.
Blocking Information (also see Table 2-1)					
018	69–72	2,2		Block Interval	The field indicates the time period spanned by the sets in each block. As with all the blocking information, Block Interval is dependent on the Element Time Interval. For instance, sets of 1-min data are grouped into 8-h blocks (written 8HR); 24 sets of 5-min data are grouped into a 1-d block (written 1DY). The field consists of two parts:
	69–70	2	int		1 = Number of time units per block.
	71–72	2	chr		2 = Code representing time units. The following codes are valid: SC = Second MI = Minute HR = Hour DY = Day WK = Week MO = Month YR = Year.
019	74–75	2	int	No. Elements/ Set	The field indicates the number of elements in a set.
020	76–77	2	int	No. Nulls/Set	The field indicates the number of nulls in a set.
021	78–80	2	int	Blocking Factor	The field indicates the number of 80-character lines (both header and data) in a block. Multiplying the blocking factor by 80 gives the total number of characters in the block.

Chapter 5

Element Field and Element-Code Descriptions

The term *element* refers to a measurement parameter such as global-horizontal radiation or dry-bulb temperature. In the header, the Element-Code field specifies which parameter is recorded in the block. In the data sets that follow, the element fields contain the actual data and flags for the specified parameter.

Element Field Descriptions

The Element field is 10 characters in length, represented in the following format:

x x x x . x x x | x x

(see Figure 5-1). The element is right justified with no leading zeros. A sign can float within the first four positions. The decimal is fixed in the fifth position. Null elements appear as -999.99999 and missing or unreadable data elements as 9900.00099.

In general, the data portion of the field contains the element's actual measured, estimated, or modeled value. Values down to the thousandths can be recorded. For example, a dry-bulb temperature of 25°C would be recorded as 25.000. However, the Element field is used differently for weather observations, where in most cases the data consist of subfield codes. For these elements, more than one observation can be recorded in the field, and placement of the codes within the field can affect their meaning. For example, the occurrence of both freezing rain (subfield code 300) and light snow (subfield code 10) would be recorded in the Element field as 310.000. Subfield codes (not to be confused with the element code) and the element field position are described in greater detail under Weather Observations in Element-Code Descriptions and in Appendix C, "Cloud Layer Observations." A *flag* occupies the last two positions and can contain a leading zero. Flags are independent of the footnote in header line 1. Flags indicate the type of quality control the data have undergone and provide the results. Note that in the case of both null and missing data elements, the flag is 99.

$$\overbrace{\mathrm{X\,X\,X\,X\,.\,X\,X\,X}}^{\text{Data}} \mid \overbrace{\mathrm{X\,X}}^{\text{Flag}}$$

Figure 5-1. Element Field Description

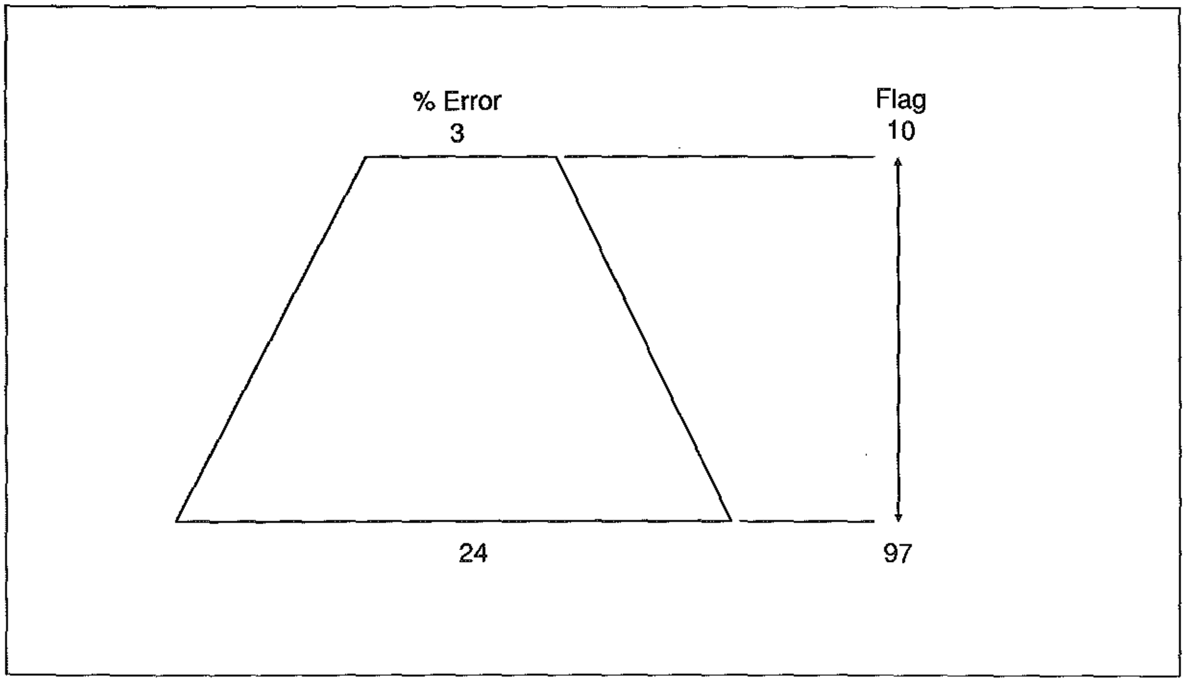

Figure 5-2. Quality Control Flagging, Flags vs. Errors

Quality Control Flagging

The two-digit code at the end of the Element field describes the data's quality. These flagging codes fall into three groups: Codes 00–08 provide a general explanation of data quality in a hierarchical manner, i.e., the lower the flag code, the better the data. Codes 10–97 describe quality control tests in further detail when the results indicate an error. The error's type, direction, and degree of severity (as an integer percent ranging from 3 to 24 or greater) are encoded in the flag (see Figure 5-2). Code 99 indicates missing data. The quality control flags are explained in Table 5-1.

Element-Code Descriptions

The *element code* identifies the type of data contained in the data-element fields. Other header fields expand on this information. The Instrument/Observation field in header line 1 allows the user to provide a written description. The Zenith, Instrument Orientation, and Azimuth fields in header line 2 describe the instrument's viewing angle. For instance, the angle for a horizontal, upward-facing instrument is coded as 0, UP, and 0, respectively; a two-axis tracking instrument as 99, 2X, and 999; and a latitude-tilted instrument as 34, UP, and 180.

The Element-Code field is four characters long, represented in the following format:

$$\frac{\text{x x x x}}{\text{A B C D}}\,.$$

Each character represents a different level or relationship. The A level identifies the basic measurement categories. The B level describes the parameter being measured and expands on the restrictions placed on this measurement. The C and D levels usually enumerate the instruments used (see Figure 5-3). In most of the element-code categories, extra space is allotted for the user to incorporate parameters. These additions should be documented by the user. Also, 0xxx is unused, allowing the user to define an additional basic measurement category. For a list of codes, see Appendix A; for descriptions of these codes, see Table 5-2.

Table 5-1. Quality Control Flags

<table>
<tr><th>Flag</th><th>Explanation</th></tr>
<tr><td>00</td><td>Element was untested (original data).</td></tr>
<tr><td>01</td><td>Element passed tests on physical limits, model limits (for tolerances less than 3%), and reasonable coupling with other parameters (for tolerances less than 3%).</td></tr>
<tr><td>02</td><td>Element passed inspection (note that 01 supersedes this flag).</td></tr>
<tr><td>03</td><td>Element failed inspection (note this flag supersedes 01).</td></tr>
<tr><td>04</td><td>Element was originally missing; current value was interpolated from neighboring values.</td></tr>
<tr><td>05</td><td>Element was originally missing; current value was modeled from other elements. Modeled element passed all tests for tolerances less than 3%.</td></tr>
<tr><td>06</td><td>Element was originally missing; current value was derived by a method other than modeling or interpolation.</td></tr>
<tr><td>07</td><td>Element was lower than physical minimum.</td></tr>
<tr><td>08</td><td>Element was higher than physical maximum.</td></tr>
<tr><td>10–97</td><td>Element exceeded the 3% tolerance in one of four ways. The following error types are valid:
0 = Too low when coupled with other parameters
1 = Too high when coupled with other parameters
2 = Too low when compared to a model
3 = Too high when compared to a model.

The flags in this range are constructed in such a way that you can encode both the percentage of disagreement and the type of error.

To create the flag, you multiply the percentage of disagreement by 4, subtract 2, and add the error type. Note that the percentage of disagreement should be truncated; only the integer part is used; e.g., 15.4 becomes 15, and 15.6 becomes 15.

Example

Assuming an element value tested 10% too high when coupled with the other parameters (error type 1), you construct the flag as follows:

$$\begin{array}{rl} 10\% & \text{(percent disagreement)} \\ \underline{\times 4} & \text{(constant)} \\ 40 & \\ \underline{-2} & \text{(constant)} \\ 38 & \\ \underline{+1} & \text{(error type 1)} \\ 39 & \text{(the final flag recorded)} \end{array}$$
To decipher the flag, reverse the process:

$$\begin{array}{rrl} & 39 & \text{(flag)} \\ & \underline{+2} & \text{(constant)} \\ & 41 & \\ & 10 & \text{(percent disagreement—quotient)} \\ 4 & \overline{)41} & \\ & \underline{-40} & \\ & 1 & \text{(error type—remainder)} \end{array}$$
</td></tr>
<tr><td>99</td><td>Element is missing or null.</td></tr>
</table>

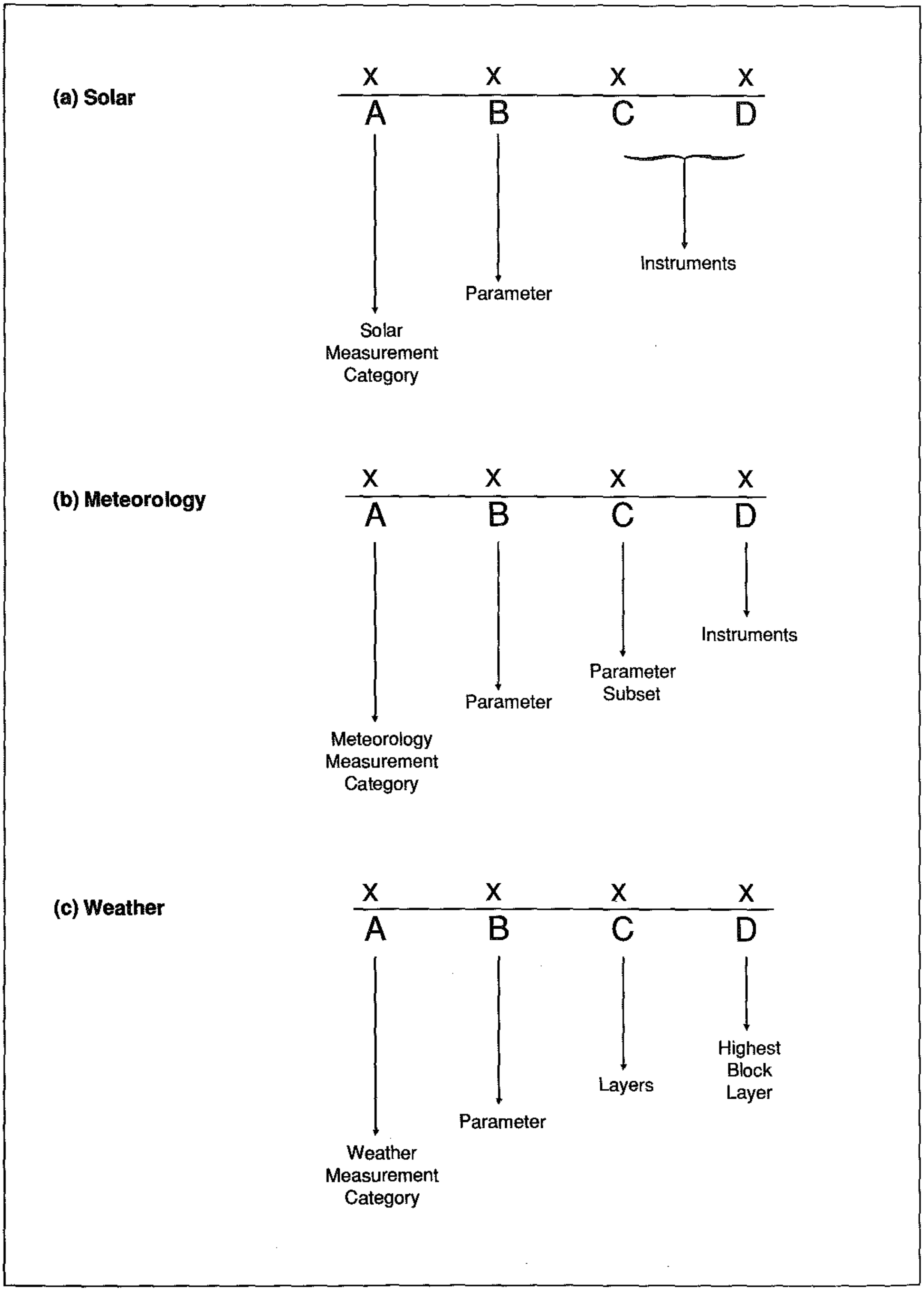

Figure 5-3. Element-Code Descriptions

Table 5-2. Element-Code Descriptions

A	B	C	D	Explanation
1–7				Broad-Spectrum Solar Radiation Measurements Elements under this category describe data collected with solar radiation instruments. Instrument orientation is indicated in the three instrument-angle fields in header line 2. All units are in watts per square meter (see Appendix B).
1				Broadband Solar Spectrum It measures radiation over the entire bandwidth, i.e., the integrated values over the complete solar spectrum (typically, 0.29–4.0 um).
2–6				Subsets of the Broadband Solar Spectrum It measures the amount of radiation over other spectral bandwidths.
2				Illuminance (Visible) It measures sunlight-matching human spectral response (typically, 0.39–0.77 um).
3				Ultraviolet radiation (UV) (typically, 0.2–0.4 μm)
4				Infrared Radiation (IR) (typically, 0.77–1000 um)
5				Photosynthetically Active Radiation (PAR) It measures sunlight-matching plant spectral responses (typically, 0.4–0.7 um).
6				Other Spectral Bandwidths
	0–9			These codes describe the instrument's field of view.
	0			Direct Normal Radiation This measurement indicates the solar radiation incident on a surface perpendicular to the sun's rays (i.e., facing the sun). Instrument typically used is a pyrheliometer, which tracks the sun.
	1			Global Unobstructed View This measurement indicates the total direct and diffuse radiant energy received on a horizontal or tilted surface. Suggested coding reserves 1100–1109 for global-horizontal measurements and 1110 and on for global-tilt measurements (unless an artificial horizon is used, in which case category 12xx is used). Instrument typically used is a pyranometer.
	2			Artificial Horizon This measurement is the same as in Global Unobstructed View (x|xx), but the instrument's field of view below the horizon is blocked.
	3,4			Diffuse Radiation Measurements *Diffuse radiation* is the amount of radiant energy received at the instrument indirectly from the entire celestial dome, blue sky, and clouds (sky radiation), excluding the sun's disk, and the ground after reflection or scattering by neighboring surfaces (albedo). Measurement techniques involve shading the receiver from the direct rays of the sun. Diffuse radiation can also be calculated from the direct normal and global radiation values.
	3			Diffuse with Shadow Band It measures diffuse radiation with a pyranometer using a shadow band. If the value is corrected for the presence of the shadow band, the footnote in header line 1 should be set to 1.

Continued on next page

Table 5-2. Element-Code Descriptions (Continued)

A	B	C	D	Explanation
				Broad-Spectrum Solar Radiation Measurements (Continued)
	4			Diffuse with Shading Disk It measures diffuse radiation with a pyranometer using a tracking disk. This code is also used if the method measuring diffuse radiation is unknown or is calculated (e.g., global - direct * cos(solar zenith angle)). If the value is calculated, the footnote in header line 1 should be set to 1. The Instrument/Observation field in header line 1 is used to indicate how the measurement was taken.
	5			Artificial Horizon and Shadow Band
	6			Artificial Horizon and Shading Disk
	7			Sky Shield The instrument's field of view above the horizontal is blocked in order to measure surface-reflected radiation.
	8			Other Visibility Restriction 1
	9			Other Visibility Restriction 2
7				Other Solar Measurements
	0			Net Global Radiation It measures the difference between the incoming and outgoing radiant energy during the data-acquisition time period. Units are in watts per square meter.
	1–3			Solar Position Sensor The following categories describe which way the tracker is facing relative to the sun:
	1			Position sensor, hour angle (angular degrees)
	2			Position sensor, declination (angular degrees)
	3			Position sensor, total voltage (millivolts)
	4–9			Other
			00–99	Instrument Rank (00 = primary) Instrument Rank applies to all broad-spectrum solar radiation measurements.
8				Meteorological Instrumentation The units appear with each instrument.
	0			Sunshine It is the duration of sunshine measured by a sunshine recorder.
		0		Percent Possible
		1		Percent Actual
		2		Hours Possible
		3		Hours Actual
		4		Minutes of Sunshine
		5–9		Other
	1			Temperature/Humidity
		0		Dry Bulb (degrees centigrade)
		1		Wet Bulb (degrees centigrade)

Continued on next page

Table 5-2. Element-Code Descriptions (Continued)

A	B	C	D	Explanation
				Meteorological Instrumentation (Continued)
		2		Dew Point (degrees centigrade)
		3		Relative Humidity (percent)
		4		Mixing Ratio (dimensionless)
		5–9		Other
	2			Wind
		0		Direction (degrees from north, east = 90°)
		1		Speed (meters per second)
		2–9		Other
	3			Pressure
		0		Station (kilopascals)
		1		Sea Level (reduced to sea level, in kilopascals)
		2		10–20 m (kilopascals)
		3		20–30 m (kilopascals)
		4		30–40 m (kilopascals)
		5		40–50 m (kilopascals)
		6		50–100 m (kilopascals)
		7–9		Other Levels (kilopascals)
	4			Precipitation
		0		Precipitation (millimeters)
		1–9		Other
	5			Soil Temperature
		0		First Level (degrees centigrade)
		1–9		Other
	6			Ozone
		0		Absolute (atmospheric centimeters)
		1		Relative (percent)
		2		Precipitable (atmospheric centimeters)
		3		Mixing Ratio (absolute, 0 to 1.0)
		4–9		Other
	7			Particulates
		0		Total Suspended Particulates (TSPs) (micrograms per cubic meter)
		1–9		Other
	8			Met Other1

Continued on next page

Table 5-2. Element-Code Descriptions (Continued)

A	B	C	D	Explanation
				Meteorological Instrumentation (Continued)
	9			Met Other2
			0–9	Instrument Rank (0 = primary) Instrument Rank applies to all meteorological instrumentation.
9				Weather Observations Many of the observations use element subfields that are recorded in the Data-Element field. The position of the subfield within the Data-Element field affects its meaning for several types of weather observations.
	0–3			Cloud Layer Observations (See Appendix C for an explanation of how to construct levels C and D of the element code and position the subfield codes within the data-element fields.)
	0			Total Cloud Cover Element subfield contains tenths of sky for each layer: 00–10.
	1			Opaque Cloud Cover Element subfield contains tenths of sky for each layer: 00–10.
	2			Cloud Type The element subfield contains the generic cloud-type code of obscuring phenomena for each layer. The following codes are valid: 00 = None 01 = Fog 02 = Stratus 03 = Stratocumulus 04 = Cumulus 05 = Cumulonimbus 06 = Altostratus 07 = Altocumulus 08 = Cirrus 09 = Cirrostratus 10 = Stratus fractus 11 = Cumulus fractus 12 = Cumulonimbus mamma 13 = Nimbostratus 14 = Altocumulus castellanus 15 = Cirrocumulus 16 = Obscuring phenomena other than fog.
	3			Sky Condition The element subfield contains the code for each layer. The following codes are valid: 00 = Clear or less than .1 cover 01 = Thin scattered (.1–.5 cover) 02 = Opaque scattered (.1–.5 cover) 03 = Thin broken (.6–.9 cover) 04 = Opaque broken (.6–.9 cover) 05 = Thin overcast (1.0 cover) 06 = Opaque overcast (1.0 cover) 07 = Obscuration 08 = Partial obscuration.

Continued on next page

Table 5-2. Element-Code Descriptions (Continued)

A	B	C	D	Explanation
				Weather Observations (Continued)
	4			Ceiling Height The Data-Element field contains either kilometers or one of the following valid codes: 7777 = Unlimited, clear 8888 = Cirroform layer 9900 = Unknown height or missing (the flag is 99).
	5			Precipitation Type The data in the element fields under precipitation type consist of subfield code numbers. As shown in Figure 5-4, the position of the code number within the element field determines the general type of precipitation. Within a general precipitation type, each number represents a unique condition. For example, light snow is coded as 10.000; a thunderstorm with heavy rain showers is coded as 1008.000. Trailing spaces in the element field are filled with zeros. a: Occurrence of thunderstorm, tornado, or squall: 0000.000 = None 1000.000 = Thunderstorm—lightning and thunder; wind gusts less than 50 knots and hail less than 3/4-in. diameter, if any 2000.000 = Heavy or severe thunderstorm—frequent intense lightning and thunder. Wind gusts of 50 knots or greater and hail 3/4-in. or greater diameter, if any 3000.000 = Report of tornado or waterspout 4000.000 = Squall (sudden increase of wind speed by at least 16 knots, reaching 22 knots or more and lasting at least 1 min) b: Occurrence of ice pellets, hail, and freezing drizzle or rain: 000.000 = None 100.000 = Freezing drizzle 200.000 = Heavy freezing drizzle 300.000 = Freezing rain 400.000 = Heavy freezing rain 500.000 = Ice crystals 600.000 = Ice pellets (sleet) 700.000 = Heavy ice pellets (sleet) 800.000 = Hail 900.000 = Heavy hail c: Occurrence of snow, snow showers, and snow grains: 00.00 = None 10.00 = Light snow 20.00 = Moderate snow 30.00 = Heavy snow 40.00 = Snow showers 50.00 = Heavy snow showers 60.00 = Snow grains 70.00 = Snow pellets 80.00 = Heavy snow pellets 90.00 = Blowing snow[1]

Continued on next page

[1]These values are recorded only when visibility is less than 7 mi.

Table 5-2. Element-Code Descriptions (Concluded)

A	B	C	D	Explanation
				Weather Observations (Continued) d: Occurrence of drizzle, rain, or rain showers: 0 = None 1 = Light drizzle 2 = Moderate drizzle 3 = Heavy drizzle 4 = Light rain 5 = Moderate rain 6 = Heavy rain 7 = Rain showers 8 = Heavy rain showers 9 = Blowing spray[1] e: Occurrence of fog or blowing fog: .0 = None .1 = Fog .2 = Ice fog .3 = Ground fog .4 = Blowing fog[1] .5 = Blowing ice fog[1] .6 = Blowing ground fog[1] f: Occurrence of haze, smoke, or dust particulates: .00 = None .01 = Haze .02 = Smoke .03 = Smoke and haze .04 = Dust .05 = Blowing dust[1] .06 = Blowing sand[1]
	6			Visibility The Data-Element field contains either kilometers or one of the following valid codes: 7777 = Unlimited, clear 9900 = Unknown or missing (the flag is 99).
	7			Snow Cover (tenths of total possible)
	8			Weather Other1
	9			Weather Other2
			00	Only for weather observations 4–9. (Instrument rank does not apply for weather observations.)
			1–9	Not used.

[1]These values are recorded only when visibility is less than 7 mi.

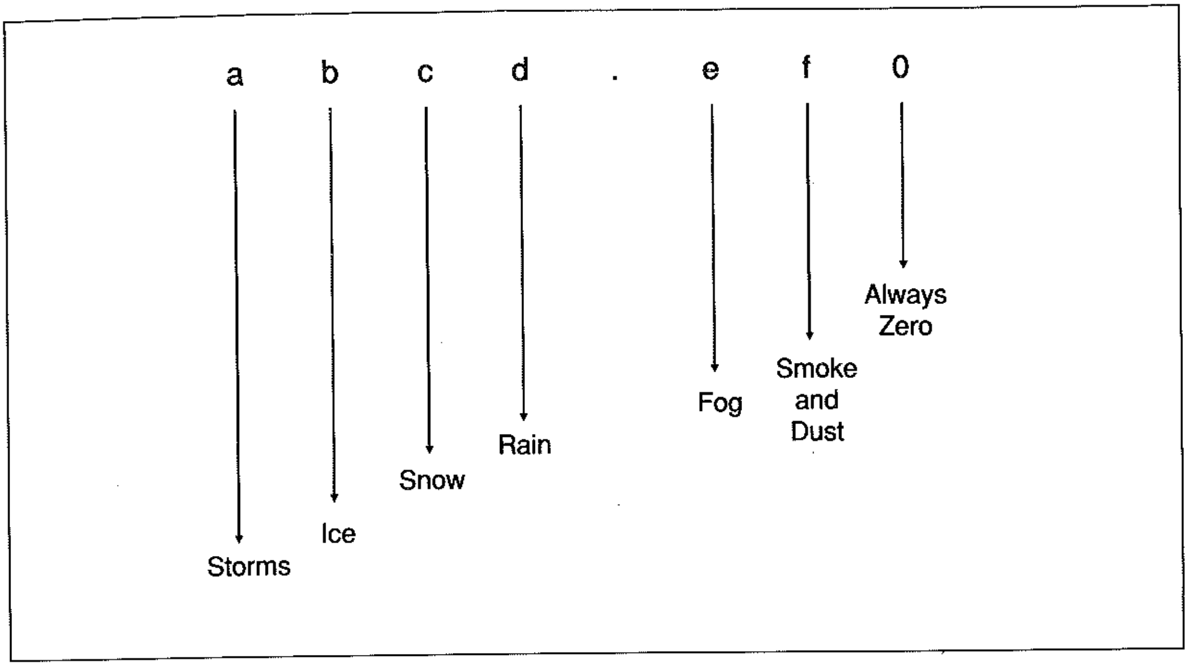

Figure 5-4. Element Field for Weather Observation

Appendix A

Index of Element Codes

This index (Table A-1) provides an overview of the element-code numbers and their general meaning. A detailed explanation of the codes appears in Element-Code Descriptions in Chapter 5, "Element Field and Element-Code Descriptions." Columns A, B, C, and D represent different levels of information. Solar radiation measurement codes are indexed at levels (columns) A and B; the NN in levels C and D represents the instrument rank. Meteorological instrumentation codes are indexed at levels A, B, and C; the N in level D represents the instrument rank. Weather Observation codes are indexed at levels A and B; the first four types use X and Y in levels C and D to describe the cloud layers.

Table A-1. Element Codes (n = instrument rank)

Element Code	Explanation
Broad-Spectrum Solar Radiation Measurements	
10NN	Direct normal broadband radiation measurement, NNth instrument
11NN	Global broadband radiation measurement
12NN	Artificial horizon broadband radiation measurement
13NN	Diffuse with shadow-band broadband radiation measurement
14NN	Diffuse with shading disk broadband radiation measurement
15NN	Artificial horizon and shadow-band broadband radiation measurement
16NN	Artificial horizon and shading disk broadband radiation measurement
17NN	Sky-shield broadband radiation measurement
18NN–19NN	Other visibility restrictions broadband radiation measurements
20NN	Illuminance direct normal spectral radiation measurement
21NN	Illuminance global spectral radiation measurement
22NN	Illuminance artificial horizon spectral radiation measurement
23NN	Illuminance diffuse with shadow-band spectral radiation measurement
24NN	Illuminance diffuse with shading disk spectral radiation measurement
25NN	Illuminance artificial horizon and shadow-band spectral radiation measurement
26NN	Illuminance artificial horizon and shading disk spectral radiation measurement
27NN	Illuminance sky-shield spectral radiation measurement
28NN–29NN	Other illuminance visibility restriction spectral radiation measurements
30NN	UV direct normal spectral radiation measurement
31NN	UV global-spectral radiation measurement
32NN	UV artificial horizon spectral radiation measurement
33NN	UV diffuse with shadow-band spectral radiation measurement
34NN	UV diffuse with shading disk spectral radiation measurement
35NN	UV artificial horizon and shadow-band spectral radiation measurement
36NN	UV artificial horizon and shading disk spectral radiation measurement
37NN	UV sky-shield spectral radiation measurement
38NN–39NN	Other UV visibility restriction spectral radiation measurements

Continued on next page

Table A-1. Element Codes (Continued)

Element Code	Explanation
40NN	IR direct normal spectral radiation measurement
41NN	IR global-spectral radiation measurement
42NN	IR artificial horizon spectral radiation measurement
43NN	IR diffuse with shadow-band spectral radiation measurement
44NN	IR diffuse with shading disk spectral radiation measurement
45NN	IR artificial horizon and shadow-band spectral radiation measurement
46NN	IR artificial horizon and shading disk spectral radiation measurement
47NN	IR sky-shield spectral radiation measurement
48NN–49NN	Other UV visibility restriction spectral radiation measurements
50NN	PAR direct normal spectral radiation measurement
51NN	PAR global-spectral radiation measurement
52NN	PAR artificial horizon spectral radiation measurement
53NN	PAR diffuse with shadow-band spectral radiation measurement
54NN	PAR diffuse with shading disk spectral radiation measurement
55NN	PAR artificial horizon and shadow-band spectral radiation measurement
56NN	PAR artificial horizon and shading disk spectral radiation measurement
57NN	PAR sky-shield spectral radiation measurement
58NN–59NN	Other PAR visibility restriction spectral radiation measurements
6000–6999	Other spectral measurements
70NN	Net global broadband radiation measurements
71NN	Position sensor measurement using hour angles
72NN	Position sensor measurement using declination
73NN	Position sensor measurement using total voltage
74NN–79NN	Other solar measurements
Meteorological Instrumentation	
800N	Percent possible sunshine measurement
801N	Percent actual sunshine measurement
802N	Hours possible sunshine measurement
803N	Hours actual sunshine measurement
804N	Minutes of sunshine measurement
805N–809N	Other sunshine measurements
810N	Dry-bulb temperature measurement
811N	Wet-bulb temperature measurement
812N	Dew-point temperature measurement
813N	Relative humidity measurement
814N	Mixing ratio
815–819N	Other temperature and humidity measurements
820N	Wind-direction measurement
821N	Wind-speed measurement
822N–829N	Other wind measurements
830N	Station barometric pressure measurement
831N	Sea-level barometric pressure measurement
832N	10–20 m barometric pressure measurement
833N	20–30 m barometric pressure measurement
834N	30–40 m barometric pressure measurement
835N	40–50 m barometric pressure measurement
836N	50–100 m barometric pressure measurement
837N–839N	Barometric pressure at other levels

Continued on next page

Table A-1. Element Codes (Concluded)

Element Code	Explanation
840N	Precipitation measurement
841N–849N	Other precipitation measurements
85KN	Soil temperature at level K, instrument N
860N	Absolute ozone measurement
861N	Relative ozone measurement
862N	Precipitable ozone measurement
863N	Ozone mixing ratio measurement
864N–869N	Other ozone measurements
8700	Total suspended particulates measurement
871N–879N	Other particulate measurements
88KN–89KN	Other meteorological measurements, type K, instrument N
Weather Observations	
9000	Total cloud cover, all layers
90XY	Total cloud cover, number of layers X, highest layer reported in block Y.
9100	Opaque cloud cover, all layers
91XY	Opaque cloud cover, number of layers X, highest layer reported in block Y.
9200	Cloud-type measurement
92XY	Cloud-type, number of layers X, highest layer reported in block Y.
9300	Sky condition measurement
93XY	Sky condition, number of layers X, highest layer reported in block Y.
9400	Ceiling height
9500	Precipitation type
9600	Visibility
9700	Snow cover
9800–99NN	Other weather observations
0000–0999	Unused or other

Appendix B

Unit Conversions

The following table converts other common units to the measurement units specified by the SERI Standard Broadband Format. Both energy-flux units and power-flux units are given for solar radiation measurements, thereby allowing conversion between types of units. For example, an average power density of 1.0 W/m^2 over 1 min is equal to 0.06 kJ/m^2 of energy density.

Common solar radiation measurement units are langleys, Btus per square foot, kilojoules per square meter, and watts per square meter. In order to adhere to standard international (SI) units, only kilojoules per square meter and watts per square meter were considered for SBF. The energy-flux unit, kilojoules per square meter, causes scaling problems that are typically resolved by altering the magnitude of the unit. Thus, 1-min and hourly data can be recorded compactly as kilojoules per square meter, but daily data would be recorded in megajoules per square meter and yearly data in gigajoules per square meter. This situation creates an unwanted ambiguity. In addition, recording in kilojoules per square meter causes an additional problem. The units of energy, as integrals, do not lend themselves to comparisons between measurement time intervals. For example, it is not immediately obvious that a 1-min radiation measurement of 48 kJ/m^2 is equivalent to a 15-min radiation measurement of 720 kJ/m^2.

Recording with the power-flux unit, watts per square meter, removes both the ambiguity and comparison problems. It is no longer necessary for the user to maintain multiple units for various measurement time intervals. All radiation values can be expressed in the same range (0–2000 W/m^2). Also, comparison is simplified because the user is not comparing apples and oranges. With the example given for kilojoules, it is readily apparent to the user that a 1-min radiation measurement is equivalent to a 15-min measurement when the values are given in watts per square meter (in this case, both equal 800 W/m^2). A daily value in SBF can be converted from an average daily value (watts per square meter) to an integrated daily value (watts per square meter) by multiplying by 24 (hours).

One-Minute* Solar Radiation Conversions

To Convert From	To	Multiply By
W/m^2	kJ/m^2	0.06
W/m^2	langley/min	0.001433
W/m^2	cal/cm^2 min	0.001433
W/m^2	Btu/ft^2 min	0.005285
kJ/m^2	W/m^2	16.66667
langley/min	W/m^2	697.3
cal/cm^2 min	W/m^2	697.3
Btu/ft^2 min	W/m^2	189.1

*To obtain the conversion factor for time intervals greater than 1 min, multiply by the number of minutes for conversions from watts per square meter, and divide by the number of minutes for conversions to watts per square meter.

One-Hour* Solar Radiation Conversions

To Convert From	To	Multiply By
W/m^2	kJ/m^2	3.6
W/m^2	langley/hour	0.0858
W/m^2	cal/cm^2 hour	0.0858
W/m^2	Btu/ft^2 hour	0.317
W/m^2	kWh/m^2	0.024
kJ/m^2	W/m^2	0.27
langley/hour	W/m^2	11.22
cal/cm^2 hour	W/m^2	11.622
Btu/ft^2 hour	W/m^2	3.152
kWh/m^2	W/m^2	41.66

Pressure Conversions

To Convert From	To	Multiply By
kPa	millibars	10.
millibar	kPa	0.1

Velocity Conversions

To Convert From	To	Multiply By
m/s	mph	2.2369
mph	m/s	0.44704
knot	m/s	51.44

Length Conversions

To Convert From	To	Multiply By
mm	in.	0.03937
in.	mm	25.4

Temperature Conversions

To Convert From	To	
Celsius	Fahrenheit	multiply by 1.8 and add 32
Fahrenheit	Celsius	subtract 32 and multiply by 0.555

*To obtain the conversion factor for time intervals greater than 1 h, multiply by the number of hours for conversions from watts per square meter, and divide by the number of hours for conversions to watts per square meter.

Appendix C

Cloud Layer Observations

The following information explains how to construct the cloud layer element code and position the cloud layer subfield codes within the data-element fields. The element subfield values for total cloud cover (element code 90CD), opaque cloud cover (91CD), cloud type (92CD), and sky condition (93CD) are reported for one or more cloud layers. The number of layers is indicated by the last two positions (i.e., C and D) of the header's Element-Code field.

Position "C" of the Element-Code field specifies the total number of layers observed and reported in the data-element fields.

C = 0, only total (no layers) recorded in the block
C = 1–9, the number of layers recorded in the file.

Position D of the Element-Code field specifies which layers are reported in this particular block (D cannot exceed C). The element subfields can report either one or two cloud layers at a time.

D = 0, only total (no layers) reported in this block
D = 1, layer 1 reported in this block
D = 2, layer 1 and layer 2 reported in this block
D = 3, layer 3 reported in this block
D = 4, layer 3 and layer 4 reported in this block
D = 5, layer 5 reported in this block
D = 6, layer 5 and layer 6 reported in this block
D = 7, layer 7 reported in this block
D = 8, layer 7 and layer 8 reported in this block
D = 9, layer 9 reported in this block.

To summarize, a Data-Element field contains one element subfield if D is 0 or odd and two element subfields if D is even and not 0.

The Data-Element fields within the block use subfield codes to describe cloud layer observations. The position of the subfield codes within the field relate to element-code level D as follows:

Element Code D	Data-Element Field
0	aa.000
1	aa.000
2	aa.bb0
3	cc.000
4	cc.dd0
5	ee.000
6	ee.ff0
7	gg.000
8	gg.hh0
9	ii.000

The layers of the subfield's contents are represented by the following letters. See Table C-1.

aa = contents of the subfield for layer 1 or total of all layers
bb = contents of the subfield for layer 2
cc = contents of the subfield for layer 3
dd = contents of the subfield for layer 4
ee = contents of the subfield for layer 5
ff = contents of the subfield for layer 6
gg = contents of the subfield for layer 7
hh = contents of the subfield for layer 8
ii = contents of the subfield for layer 9.

Table C-1. Element-Code Examples for Multiple Layers

Element Code	Possible Element Subfield Data	Description
9000	08.000	There was 8/10 total cloud cover, all sky (no layers).
9122	04.060	Two layers were observed. Layer 1 has 4/10 opaque cloud cover, and layer 2 has 6/10 opaque cloud cover.
9242	00.110	Four layers were observed. Layer 1 is clear, and layer 2 has cumulus fractus clouds.
Followed by 9244	07.080	Four layers were observed. Layer 3 has altocumulus clouds, and layer 4 has cirrus clouds.
9332	01.020	Three layers were observed. Layer 1 has thin scattered clouds, and layer 2 has opaque scattered clouds.
Followed by 9333	05.000	Three layers were observed. Layer 3 has thin overcast clouds.

Appendix D

Sample Programs

The following two programs are examples of retrieving and storing data in the SERI Standard Broadband Format (SBF). The first example is a program fragment used to read data stored in SBF. The second example, Program GeoTec, converts an existing Research Cooperator Format file of Georgia Institute of Technology data to SBF. Both programs were written in FORTRAN-77 on a VAX 1173 with a VMS operating system. System assumptions include opening the input file with unit number 11, the output file with 41, and the data file with 42.

Sample Data Retrieval Program

```
! Program excerpt reading one block of one-minute data stored in SBF.
! Variables for Header Lines 1 and 2 correspond to the fields listed in
! Chapter 4, "Header Field Descriptions." The arrays, Dat and Iflag, hold
! an entire block of data/null elements and flags respectively. The control
! variables are:

!     Jfirst - beginning of data line.
!     Jlast  - end of data line.
!     LinDat - total number of data lines (eliminates the two header lines).

      CHARACTER*2   Orient, Elemnt, BlkInt
      CHARACTER*10, Units
      CHARACTER*20, Sitnam
      CHARACTER*49  Instnm
      DIMENSION     Dat(512), Iflag(512)

!     Header line 1:

  100 FORMAT (A20, I49, A10, I1)

!     Header line 2:

  200 FORMAT (I2, I5, I6, I5, I4, I5, I3, A2, I3, 2(I3.2, 5I2.2),
     2        I2, I3, A2, I2, A2, I3, I2, I3)

!     Data element lines:

  300 FORMAT (8 (F8.3, I2))

!     Note: "In.m" means field-width "n" with a minimum of "m" places
!           filled. Leading zeroes will be used to fill if the number
!           comprises less than "m" places. Used for the Start Time,
!           End Time, and element fields.

            READ (11, 100) Sitnam, Instnm, Units, Ifoot
            READ (11, 200) Irank, Ilat, Ilong, Ielev, Izone, Ielem, Izen,
    2                   Orient, Iazim, Iyr, Imo, Idy, Ihr, Imi, Isc, Jyr,
    3                   Jmo, Jdy, Jhr, Jmi, Jsc, Mode, IntElm, ElmInt,
    4                   Intblk, BlkInt, NumElm, NumNul, IBlkFc

            Jfirst = 1
            Jlast = 8
```

```
              LinDat = IBlkFc - 2

! The following loops through a block, reading the eight element fields in
! each line.

         DO 2000 I = 1, LinDat
              READ (11, 300) ( Dat(J), Iflag(J), J = Jfirst, Jlast)
              Jfirst = Jfirst + 8
              Jlast  = Jlast + 8
    2000 CONTINUE
```

Sample Data Conversion Program

```
       Program Geotec

!      Converts one Georgia Tech archival tape file from
!      NCDC's Research Cooperator Format (RCF) to SERI's
!      Standard Broadband Format. The program assumes the
!      incoming RCF file is sorted (collated) by date and
!      then element code. Another common RCF collation
!      sequence organizes the file by element code first and
!      date second. The VAX Sort/Merge utility was used to
!      reorganize files with the latter collation.
!
!                 Variable Descriptions
!
!      Input variables to read RCF values:
!        Iarcd      - First part of RCF's R&T code indicating
!                       averaged, integrated, or instantaneous data.
!        Iartm      - Second part of R&T code indicating measurement
!                       time period (one-minute in this case).
!        Inelm      - Element code indicating the measurement type.
!        Newhr      - Hour during which measurement was taken.
!        Newdy      - Day during which measurement was taken.
!        Newmo      - Month during which measurement was taken.
!        Newyr      - Year during which measurement was taken.
!        Nexp       - Exponent for converting the RCF data fields.
!        Idata(60)  - Array storing one hour (one RCF record)
!                       of one-minute data.
!        Iflag(60)  - Array storing the data's accompanying flags.
!
!      Output variables to write SBF values:
!        Head1(25)  - Array containing the First Header line for each
!                       of Georgia Tech's 25 elements or measurements.
!                       The data are taken from a text file ('Geo.fil').
!        Head2(25)  - Array containing the Second Header line, also
!                       taken from a file except for time information.
!        Istart     - Start Time hour; controls hour loop in blocking.
!        Olddy      - Start Time day.
!        Oldmo      - Start Time month; index in Monend array.
!        Oldyr      - Start Time year.
!        Khr        - End Time hour.
!        Kdy        - End Time day.
!        Kmo        - End Time month.
!        Kyr        - End Time year.
!        Datnew(25,0:23,60) - Array storing one day's worth of minute
!                               data for each of the element types.
!        Newflg(25,0:23,60) - Array storing the data flags.
!
!      Control variables:
!       Monend(12) - Array containing the last day of each month.
!       Ndays      - Last day of Oldmo.
!       Istart     - First hour of the current 8-hour block.
!       Iend       - Last hour of the current 8-hour block.
!       Master     - Loop control to create three blocks per day.
!       Kntdat(25,3)  - Flag indicating if data are present in the
!                         element's current block; if data missing
!                         the block is not written (thus saving space).
!       Nelm, Nmin, Nhr, Nblk - Counters for loops and array indexes;
!                                 values are 25, 60, 8, and 3 respectively.
```

```
!
!    Conversion variables:
!     Oldelm(25)    - Array of RCF element codes used to check
!                       for valid element codes and to reorder the
!                       records into SBF element code order.
!     Factor(25)    - Converts element from RCF units to SBF
!                       preferred units. The solar parameters
!                       are converted from kilojoules to Watts per
!                       square meter. Station pressure is converted
!                       from millibars to kiloPascals.
!     Myflag(0:99) - Converts RCF flags to equivalent SBF flags.
!

       INTEGER*2     Oldelm(25), Myflag(0:99),
     2                 Newflg(25,0:23,60), Iflag(60), Oldhr,
     3                 Olddy, Oldmo, Oldyr, Monend(12)
       INTEGER*4     Idata(60), Kntdat(25,3) / 75*0 /
       REAL*8        Datnew(25,0:23,60), Factor(25)
       CHARACTER*80 Head1(25), Head2(25)

       DATA  Oldelm /2010, 2011, 2012, 1000, 1001, 1002,
     2                 1003, 1460, 1461, 3000, 5000, 6000,
     3                 6001, 7010, 7000, 9300, 9301, 9320,
     4                 9321, 9200, 9201, 9210, 9211, 9400,
     5                 9150 /
       DATA Factor /15*16.66667, 8*1., 1*10., 1*1. /
       DATA Myflag /11*99, 0, 2, 3, 2, 3, 2, 3, 3*99, 0, 2, 3, 2,
     2                  3, 2, 3, 2*99, 30*5, 10*4, 20*6, 10*99 /
       DATA Monend /31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31/

 300 FORMAT ( a80 )
! 400 FORMAT reads the RCF format.
  400 FORMAT ( 7x, i1, i2, i4, 4i2, 2x, i3, 60(i7, i2) )
! 500 FORMAT writes starting and ending times for Header Line 2.
  500 FORMAT ( 4i2.2, '0100 ', 4i2.2 )
! 600 FORMAT writes one hour of data and flags plus four nulls.

  600 FORMAT ( 7( 8( f8.3, i2.2 ),/ ), 4( f8.3, i2.2 ),
    +          4( '-999.99999'))

! Initialize files. (Brief examples of each type of file follow the program.)

       OPEN ( 11, File = 'RCFGeo',  Status = 'Old', Recordsize = 567 )
       OPEN ( 41, File = 'SBFGeo',  Status = 'New' )
       OPEN ( 42, File = 'Geo.fil', Status = 'Old' )

       Olddy = 1

! Get Header Line text descriptions for each of the elements or parameters.

      DO Nelm = 1, 25
        READ ( 42, 300 ) Head1(Nelm)
        READ ( 42, 300 ) Head2(Nelm)
      END DO! (I)

! 1000: Read 1 logical record from RCF.

 1000 CONTINUE
       READ ( 11, 400, ERR=1000, END=2000 ) Iarcd, Iartm,
     2         Inelm, Newyr, Newmo, Newdy, Newhr, Nexp,
     3       ( Idata(J), Iflag(J), J=1,60 )
       IF ( Newmo .lt. 1 .or. Newmo .gt. 12 )        GO TO 1000
       GO TO 3000

! 2000: End of file. Set Newdy as end-of-file flag and
!        Ndays to last day of the month.

 2000 CONTINUE
       Newdy = -1

! How many days in a month?
```

```
        IF ( Oldmo.EQ.2 .AND. MOD(Oldyr,4).EQ.0 ) THEN
            Ndays = 29
        ELSE
            Ndays = Monend(Oldmo)
        END IF!

! 3000: If it is a new day, write the preceding records
!         in three 8-hour blocks of data for each of the
!         25 parameters. Otherwise, convert the record
!         to the SBF format.

 3000 CONTINUE
        IF ( Newdy .NE. Olddy ) THEN
              Iend     = -1
          DO Master = 1, 3
              Iend     = Iend + 8
              Istart   = Iend - 7

! If last block of day; establish ending date.

             IF ( Iend .EQ. 23 ) THEN
                 Khr    = 0
                 Kyr    = Oldyr

! If last day of file; what is tomorrow?

               IF ( Newdy .EQ. -1 ) THEN

! Just another day.

                 IF ( Olddy .NE. Ndays ) THEN
                     Kmo = Oldmo
                     Kdy = Olddy + 1

! Tomorrow is a new month.

                 ELSE
                     Kdy = 1
                     Kmo = Oldmo + 1

! Tomorrow is a new year.

                   IF ( Kmo .EQ. 13 ) THEN
                       Kmo = 1
                       Kyr = Oldyr + 1
                   END IF!

                 END IF!

! Else, if NOT last day of file.

               ELSE
                 Kmo = Newmo
                 Kdy = Newdy
               END IF!

! Else, if NOT the last block of the day.

             ELSE
               Kyr    = Oldyr
               Kmo    = Oldmo
               Kdy    = Olddy
               Khr    = Iend + 1
             END IF!

! Write the Header Lines (if Kntdat indicates data are present):

          DO Nelm = 1, 25
            IF ( Kntdat(Nelm,Master) .GT. 0 ) THEN
              WRITE ( 41, 300 ) Head1(Nelm)
              WRITE ( Head2(Nelm)(37:57), 500 ) Oldyr, Oldmo, Olddy,
     +                  Istart, Kyr, Kmo, Kdy, Khr
              WRITE ( 41, 300 ) Head2(Nelm)
```

```
! Write the Data Sets for one 8-hour block:

               DO Nhr = Istart, Iend
                 WRITE ( 41, 600 ) ( Datnew(Nelm, Nhr, Nmin),
     +                    Newflg(Nelm, Nhr, Nmin), Nmin = 1,60 )
               END DO! (Nhr)
               Kntdat(Nelm,Master) = 0
             END IF!
           END DO! (Nelm)
           END DO! (Master)

             IF ( Newdy .EQ. -1 )                       GO TO 9000
         END IF!

! Not a new day, so process the new record just read.

         IF ( Newdy .EQ. 0 )                            GO TO 9000
           Oldyr = Newyr
           Oldmo = Newmo
           Olddy = Newdy
           Oldhr = Newhr

! Check if RCF R&T code and element number legitimate:
! On error - skip the record, go back to beginning, and
!              read a new record.

         IF ( Iarcd .LT. 1 .OR. Iarcd .GT. 3 )          GO TO 1000

       DO Nelm = 1, 25
         IF ( Inelm .EQ. Oldelm(Nelm) )                 GO TO 7000
       END DO! (Nelm)
         GO TO 1000

! Convert data and flags to new format.

 7000 CONTINUE
         Nblk  = 1 + Newhr / 8
       DO Nmin = 1, 60
         IF ( Iflag(Nmin) .EQ. 99 ) THEN
              Datnew (Nelm, Newhr, Nmin) = 9900.
              Newflg (Nelm, Newhr, Nmin) = 99
         ELSE
             Kntdat (Nelm, Nblk)   = 1
             Datnew (Nelm, Newhr, Nmin) = Float ( Idata(Nmin) ) *
     +                           ( 10. ** Nexp ) * Factor (Nelm)
             IF ( Abs (Datnew(Nelm, Newhr, Nmin)) .GT. 5000 ) THEN
                  Datnew (Nelm, Newhr, Nmin) = 9900.
                  Newflg (Nelm, Newhr, Nmin) = 99
             ELSE
                  Newflg (Nelm, Newhr, Nmin) = Myflag ( Iflag(Nmin) )
             END IF
         END IF
       END DO! (Nmin)

! Read the next record.

         GO TO 1000

! Finished, so close files.
 9000 CONTINUE

         END
```

Example RCF Input File

File excerpt showing collation sequence:

```
00038841011000800701080l-0100002421200002441200002451200002481200002491200002521..
000388410110018007010801-0100002431200002451200002471200002491200002521200002551..
000388410110028007010801-0100002561300002571300002591300002621300002641300002651..
000388410110038007010801-0109999999909999999909999999909999999909999999909999999..
000388410114608007010801-0100001611200001631200001661200001681200001701200001721..
000388410114618007010801-0100001851300001871300001901300001921300001951300001961..
000388410120108007010801-0100004371200004371200004391200004401200004421200004411..
000388410120118007010801-0100000019900000019900000019900000029900000029900000019..
000388410120128007010801-0100000019900000019900000019900000019900000019900000019..
000388410130008007010801-0100000411200000411200000421200000421200000421200000431..
000388410150008007010801-0100000111200000111200000111200000111200000111200000111..
000388410160008007010801-0100002412200002412200002422200002432200002402200002382..
000388410170008007010801-0100001491200001511200001521200001541200001541200001551..
000388410170108007010801-0100002981200002991200003001200003001200003011200003011..
000388410191508007010801-0100000001200000011200000001200000001200000011200000001..
000388430192008007010801000000000561200000551200000181200000401200000391200000481..
000388430192018007010801000000000631200000721200000551200000501200000611200000301..
000388420192108007010801-0100000141200000131200000161200000151200000321200000251..
000388420192118007010801-0100000151200000171200000191200000181200000341200000341..
000388420193008007010801-0100002211200002221200002231200002231200002231200002221..
000388420193018007010801-0100002211200002221200002241200002241200002241200002221..
000388420193208007010801-0100001451200001521300001551200001551200001521200001491..
```

Complete record (one hour) of direct normal data:

```
000388410120108007010801-0100004371200004371200004391200004401200004421200004411
200000440120000441120000441120000442120000443120000444120000443120000444120000445
12000044612000044912000045212000045312000045412000045812000045712000045812000045
712000045912000045912000045812000046012000046112000046112000046412000046512000004
661200000467120000424120999999990000471120000470120000470120000470120000470120000
471120000473120000475120000476120000479120000479120000478120000479120000480120000
048212000048312000048012000048112000048012000048212000048312000048412000048412000
0048412
```

Example SBF Output File

Block header plus one set (one hour) of direct normal data:

```
GEORGIA TECH SEMRTS:Direct Normal, Eppley NIP                          Watts/m*m 0
 1 3377 -8438 327 -50 1000 992X999 800701080100 800701160000 0 1MI 8HR 60 4 66
 728.33302 728.33302 731.66702 733.33302 736.66702 735.00002 733.33302 735.00002
 735.00002 736.66702 738.33302 740.00002 738.33302 740.00002 741.66702 743.33402
 748.33402 753.33302 755.00002 756.66702 763.33302 761.66702 763.33302 761.66702
 765.00002 765.00002 763.33302 766.66702 768.33402 768.33402 773.33402 775.00002
 776.66702 778.33402 706.667029900.00099 785.00002 783.33302 783.33302 783.33302
 783.33302 785.00002 788.33302 791.66702 793.33402 798.33402 798.33402 796.66702
 798.33402 800.00002 803.33402 805.00002 800.00002 801.66702 800.00002 803.33402
 805.00002 806.66702 806.66702 806.66702-999.99999-999.99999-999.99999-999.99999
```

Example Header Line Text File

```
GEORGIA TECH SEMRTS:Direct Normal, Eppley NIP                          Watts/m*m 0
 1 3377 -8438 292 -50 1000 992X999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Direct Normal, Eppley NIP                          Watts/m*m 0
 1 3377 -8438  292 -50 1001 992X999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Direct Normal, Lambda LI-200S                      Watts/m*m 0
 1 3377 -8438  292 -50 1002 992X999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Global Horizontal, Eppley PSP                      Watts/m*m 0
 1 3377 -8438  292 -50 1100  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Global Horizontal, Spectrolab SR75                 Watts/m*m 0
 1 3377 -8438  292 -50 1101  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Global Horizontal, Lambda LI-200S                  Watts/m*m 0
 1 3377 -8438  292 -50 1101  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
```

```
GEORGIA TECH SEMRTS:Global Horizontal, Dodge SS-100               Watts/m*m 0
 1 3377 -8438  292 -50 1101  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Global Latitude Tilt, Eppley PSP              Watts/m*m 0
 1 3377 -8438  292 -50 1200 34UP180 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Global Latitude Tilt, Lambda LI-200S          Watts/m*m 0
 1 3377 -8438  292 -50 1201 34UP180 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Diffuse, Eppley PSP with shading disk         Watts/m*m 0
 1 3377 -8438  292 -50 1400  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Ultraviolet, Eppley TUVR                      Watts/m*m 0
 1 3377 -8438  292 -50 3100  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Infrared (Total Global), Swissteco FUNK       Watts/m*m 0
 1 3377 -8438  292 -50 4100  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Infrared, Eppley PIR                          Watts/m*m 0
 1 3377 -8438  292 -50 4101  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Direct Normal Spectral, Eppley NIP with RG630 Watts/m*m 0
 1 3377 -8438  292 -50 6000 992X999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Global Spectral, Eppley PSP with RG630        Watts/m*m 0
 1 3377 -8438  292 -50 6100  0UP  0 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Dry Bulb Temp. - lower level, R.M. Young 43406B  Degrees C 0
 1 3377 -8438  292 -50 8100 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Dry Bulb Temp. - upper level, R.M. Young 43406B  Degrees C 0
 1 3377 -8438  292 -50 8101 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Dewpoint Temp. - lower level, R.M. Young 43406B  Degrees C 0
 1 3377 -8438  292 -50 8120 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Dewpoint Temp. - upper level, R.M. Young 43406B  Degrees C 0
 1 3377 -8438  292 -50 8121 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Wind Direction - lower level, R.M. Young 8002    Degrees N 0
 1 3377 -8438  292 -50 8200 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Wind Direction - upper level, R.M. Young 8002    Degrees C 0
 1 3377 -8438  292 -50 8201 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Wind Speed     - lower level, R.M. Young 8002    m/s       0
 1 3377 -8438  292 -50 8210 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Wind Speed     - upper level, R.M. Young 8002    m/s       0
 1 3377 -8438  292 -50 8211 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Station Pressure, YSI 14446                      kiloPascal0
 1 3377 -8438  292 -50 8300 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
GEORGIA TECH SEMRTS:Hour Cum. Rain, Belfor 5915RXE12 Weighing Gage   mm        0
 1 3377 -8438  292 -50 8400 99NA999 ????????0100 ????????0000 0  1MI 8HR 60 4 66
```

A Product of the
Solar Technical Information Program

Solar Energy Research Institute
A Division of Midwest Research Institute

1617 Cole Boulevard
Golden, Colorado 80401

Operated for the
U.S. Department of Energy

SERI/SP-320-3305
DE88001145
April 1988