World Climate Research Program WCRP (WMO/ICSU/IOC) Baseline Surface Radiation Network (BSRN) Update of the Technical Plan for BSRN Data Management World Radiation Monitoring Center (WRMC) Technical Report 2 Version 1.0

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Contents

List of Tables

List of Figures

1 Introduction

Previous descriptions of the BSRN project are available in (WMO, 1991a), (WMO, 1991b), (Gilgen et al., 1995), (Heimo et al., 1993) and in the Operations Manual (McArthur, 1998). Information on the project can also be found at the BSRN/WRMC homepage on the World Wide Web (URL: http://bsrn.ethz.ch/).

Currently, 15 "operational" stations carry out observations, some since 1992, and forward the measured data to the World Radiation Monitoring Center (WRMC), where they are archived. Another seven "pending" stations will soon begin submitting data to the archive. In total, the national organizations participating in the BSRN intend to establish some 20 - 30 stations world-wide.

Not all active BSRN stations measure the same set of quantities. Some stations perform only the "basic" measurements, with or whithout synoptic and upperair observations, while others carry out also the "expanded" and the "other " measurements (cf. (Gilgen et al., 1995), page 5). The time intervals for the irradiance measurements also vary between 1, 2, 3 and 5 minutes for the radiation measurements.

Since the start of the BSRN measurements in 1992 more than 600 monthly files have been sent to the WRMC. Until the publication of this report 642 files have passed the consistency checks and have been inserted into the BSRN database.

Since the publication of Version 2.1 of the Technical Plan in February 1995, institutions operating more than one BSRN station systematically rotated their instruments from one station to another. As a result, the BSRN database has been redesigned and the data entry application updated. At the time of this redesign, some inconsistencies and errors were also removed from the station-to-archive file format and the basic quality check procedures were implemented.

The objective of this report is to present the latest means of data in- and output developed at the WRMC. It should therefore ideally be read in conjunction with the Technical Report 1 (Technical Plan for BSRN Data Management, Version 2.1) (Gilgen et al., 1995). In Chapter 2 the updated station-to-archive file format and the programs for format and consistency checks are presented and explained. In Chapter 3 the transfer of the data from the BSRN station to the WRMC and the data processing and redistribution are described. Chapter 4 presents the updated quality check procedures. Chapter 5 gives an overview of the state of the project and Chapter 6 an overview of the applications, users and publications utilizing BSRN data. Chapter 7 contains the bibliography.

2 Station-to-Archive File

Several programs to check the format of the data and the consistency of the atmospheric data and meta data in a station-to-archive file have been developed. As a result of this work the station-to-archive file format has been improved and inconsistencies and errors have been removed. The updated station-to-archive file format is described and explained in the following section.

The format and consistency check programs are described in the next two sections.

2.1 Update of the Station-to-Archive File Format

During the BSRN database redesign and development of the data insertion programs some inconsistencies and errors in the station-to-archive file format were found. These were removed and the file format improved in cooperation with the affected station scientists. Additionally a new logrec, 0500 for ultra-violet mesaurements, was added. In Table 2.1 the updated station-to-archive file format is shown. Changes as compared with the format given in (Gilgen et al., 1995) are marked with "**I**" on the left side. Numbers, for example [1], at the same position also indicate changes and refer to the explanations following later in this section. At the end of this section an example of the correct format of the station metadata portion of a station-to-archive file is listed in Table 2.2. This example is also available in digital form from the WRMC.

A format check program "f_check.c" written in C is also available from the WRMC. The WRMC recommends that BSRN station scientists apply "f_check" to their station-to-archive before forwarding them to the WRMC.

General remarks.

The first line of most station metadata logical records and instrument subrecords contains the *date when any change as compared to the previous accumulation period occurred.* This date is the start of the period for which the values given in the following fields of the record apply. The format of this date is day (1...31), hour (0...23) and minute (0...59) . The missing value code (-1), indicating that no change occurred, is mandatory if the logical record is flagged as unchanged in the record header line. In the very first file sent to the WRMC all of these dates must be set to the start date of the BSRN measurements at that station. A missing value code may then be used in the following files if no change occurred in the logical records concerned. If there was a change, and new information is contained in the logical record or subrecord, the date must be entered to give the time when this change was made.

For some fields a *missing value code* is given. For example, the missing value code of the TCP/IP number in logical record 0002 is "XXX". The missing value code must be set only when it is intended in the station-to-archive file format. Otherwise the field remains empty.

Logical records 0005 and/or 0006 may be omitted if no upperair and/or ozone measurements are performed. All other logical records are mandatory, especially logical record 0007 (see below).

In addition the format check requires that *line length and position of each character* are fixed.

Special remarks. The numbers [1] are used as labels of lines changed in the station-to-archive file format definition in Table 2.1 as compared to the previous definition in Table 4.1 in (Gilgen et al., 1995).

[1] In logical record 0004 a missing value code ("XXX") is now allowed for the telephone and fax number of a station.

[2] In logical record 0004 *latitude and longitude* have to be converted into the BSRN format. Latitude ranges from 0 to 180°, 0°is South Pole. Longitude ranges from 0 to 360°, 0°is 180°W.

[3] Logical record 0007 is mandatory because the information from these seven lines is used in the table *stathist* that makes the connection between the radiation data and the station history in the database. Logical record 0007 reads as follows, e.g. with synoptic observations and instrumentally measured cloud base height as a new entry beginning at the first day of the month:

```
-------------------------------------------
*C0007
  1  0  0
XXX
Cloud base height is measured using ...
XXX
XXX
XXX
Y N Y N N N
-------------------------------------------
```

Each flag in line number 7 represents a quantity of the expanded type (cf. (Gilgen et al., 1995),Table 2.1). The first sign indicates if SYNOP measurements were carried out ("Y") or not ("N"). If it reads "Y", logical record 1000 has to be in the file. The second sign stands for the cloud amount measurement method. If it reads "Y", (i) measured quantity 301 has to be in logical record 0001, (ii) the field "total cloud amount with instrument" in logical record 1300 must contain at least one non-missing value and (iii) the second line of logical record 0007 does not contain the missing code. The third sign stands for the cloud base height measurement method. If it reads "Y", measured quantity 302 has to be in logical record 0001, the field "cloud base height with instrument" in logical record 1300 must contain at least one non-missing value and the third line of logical record 0007 does not contain the missing code. The fourth sign stands for the cloud liquid water content measurement method. If it reads "Y", measured quantity 303 has to be in logical record 0001, the field "cloud liquid water" in logical record 1300 must contain at least one non-missing value and the fourth line of logical record 0007 does not contain the missing code. The fifth sign stands for the cloud aerosol vertical distribution measurement method. The sixth sign stands for the water vapor vertical distribution measurement by lidar.

The WRMC recommends that BSRN station scientists use the example of logical record 0007given above which is also available at the WRMCs web site.

[4] In logical record 0008 the *date when change ocurred* of each instrument has to be set when it has been replaced by another one. Both instruments have to be listed. If the replacement took place at the beginning of the month the first line of the subrecord of the old instrument reads " 1 0 0 N" and of the new " 1 0 0 Y". If the replacement took place during the month the old instrument has to be listed twice. Table 2.3 shows an example of the logical record 0008 with the replacement of an instrument as described below. The Eppley PIR with the serial number 28897 F3 and the WRMC identification number 11001 is recorded in a first subrecord as unchanged " -1 -1 -1 Y", and in a second subrecord with the date of change " 17 14 00 N" (on the 17. day of the month at 14:00 measurements with the instrument 11001 were stopped). The new instrument (Eppley PIR with the serial number 28895 F3 and the WRMC identification number 11004) appears as " 17 14 05 Y" (instrument 11004 started its work at 17. day of the month at 14:05).

The replacement of instruments must also be recorded in logical record 0009. In the case of replacement at the beginning of the month, only the new instrument is associated with the quantity measured at date " 1 0 0". In the case of replacement during the month, both instruments are associated with the same radiation quantity. The instrument unchanged with date " -1 -1 -1" and the new with the date of change, e.g. " 17 14 05".

[5] The *date of purchase* of the instruments should be in the file. Because it seems that this information is not always available, a missing value code ("XXX") is now allowed.

[6] For *remarks about the radiation instruments* only one line is allowed.

[7] The first line of the *calibration part* of each instrument is required and must contain data (line no. 6 of each subrecord). Only for the "number of comparisons (band 1 of spectr. instr.)" and the "standard error of of cal. coeff. (band 1 of spectr. instr.)" are missing value codes, "-1", "-1.0000" respectively, allowed.

[8] For *remarks on calibration* two lines are allowed.

[9] A new logical record , 0500 for ultra-violet mesaurements, was added.

[10] The format of logical record 1000 (*surface SYNOP observations*) has been tightened. It still follows still the WMO format of the standard message, but requires a fixed form. The message must contain the following parts.

"YYGG4 44hVV Nddff 1SnTTT 2SnTdTdTd 3P0P0P0 4PPPP 7wwW1W1 8NhClCmCh 333 8NsChshsh 8NsChshsh 8NsChshsh"

One observation/line. Missing parts have to be replaced by the missing value code "/".

[11] The format of logical record 1100 (*radiosonde observations*) has been newly designed. It no longer follows the TEMP code but is specified similar to other atmospheric data logical records (Table 2.1).

[12] The logical record number of measurements at non-standard-heights has been changed. Now, the height of measurements up to 900 m can be encoded in the logical record as follows. The number of a logical record containing measurements at non-standard-height is calculated from the height of the measurement in meters plus 3000. That is, measurements at 10, 30, 100 and 300 m are stored in logical record 3010, 3030, 3100 and 3300 respectively.

2.2 Format Check Program

Two format check programs, *format_check.c* and *f_check.c*, are used as a first check of the format of a monthly station-to-archive file. The program *format_check.c* is used by the WRMC and requires information from the database. The program *f_check.c*, on the other hand, is database independent. It is available to the BSRN station scientists. Both programs check the same information, that is station name, line length, illegal characters and several logical record specific line formats.

Format check produces the following lines, provided a positive result is obtained.

```
-------------------------------------------
ezges90[ber]% format_check ber0193.dat

**********
File name: ber0193.dat
**********
*Check for line length.......... OK
*Check for illegal characters... OK
*Check for line format.......... OK
-------------------------------------------
```

Table 2.1: BSRN station-to-archive file format

All logical records are compulsory definitions. The file is identified by the station id. no., the year and the month in logical record 0001. The dates of change in logical records 0002, 0004, 0005, 0006, 0007, 0008 and 0009 are given by day, hour and minute with ranges 1 . . . 31, 0 . . . 23 and 0 . . . 59. The dates of measurement in logical records 0100, 0200, . . . are given by day and minute with ranges 1 . . . 31 and 0 . . . 1439 also for quantities measured in hour intervals.

logical record	line no.	description of field / format of line	Range of values	Missing code	Format of v./l.
I 0001	1	station identification number	Table 5.1		I3
id. of	1	month of measurement	1 - 12		I2
file	1	year of measurement	$\geq$ 1992		I4
	1	version of data	1 - 99		I2
	1	(X,I2,X,I2,X,I4,X,I2)			
I	2	id. no. of 1st, 2nd, . . . quantity measured			I9
I	et seq.	(8(X,I9)); missing values -1 to fill up line, as many lines as needed			I9
0002	1	date when scientist changed (day, hour, min.)	0 - 59	-1	(3(X,I2))
scientist	2	name of station scientist			A38
	2	telephone no. of station scientist			A20
	2	FAX no. of station scientist			A20
	2	(A38,X,A20,X,A20)			
	3	TCP/IP no.		XXX	A15
	3	e-mail address		XXX	A50
	3	(A15,X,A50)			
	4	address of station scientist			(A80)
	5	date when deputy changed (day, hour, min.)	0 - 59	-1	(3(X,I2))
	6	name of station deputy			A38
	6	telephone no. of station deputy			A20
	6	FAX no. of station deputy			A20
	6	(A38,X,A20,X,A20)			
	7	TCP/IP no. of deputy		XXX	A15
	7	e-mail address of deputy		XXX	A50
	7	(A15,X,A50)			
	8	address of deputy			(A80)
0003	1	messages not to be inserted in		XXX	(A80)
	et seq.	the BSRN database		XXX	(A80)
0004	1	date when stat. descr. ch. (day, hour, min.)	0 - 59	-1	(3(X,I2))
station	2	surface type			I2
description,	2	topography type			I2
horizon	2	(X,I2,X,I2)			
	3	address (A80)			
[**1**]	4	telephone no. of station		XXX	A20
[**1**]	4	FAX no. of station		XXX	A20
	4	(A20,X,A20)			
	5	TCP/IP no. of station		XXX	A15
	5	e-mail address of station		XXX	A50
	5	(A15,X,A50)			
[**2**]	6	latitude [degrees, 0 is South pole, positive is northw.]	0 - 179		F7.3
[**2**]	6	longitude [degrees, 0 is 180 W, positive is eastwards]	0 - 359		F7.3
	6	altitude [m above sea level]			I4
I	6	identification of "SYNOP" station		XXXXX	A5
	6	(2(X,F7.3),X,I4,X,A5)			
	7	date when horizon changed (day, hour, min.)	0 - 59	-1	(3(X,I2))
	8	azimuth [degrees from north clockwise]	0 - 359	-1	I3
	et seq.	elevation [degrees] (11(X,I3,X,I2)); as many lines with 11 pairs to give horizon, last line filled up with -1	0 - 89	-1	I2

Table 2.1: BSRN station-to-archive file format continued

logical record	line no.	description of field / format of line	Range of values	Missing code	Format of v./l.
0005	1	date when change occurred (day, hour, min.)	0 - 59	-1	3(X,I2)
radiosonde	1	is radiosonde operating?	Y, N		A1
equipment	1	(3(X,I2),X,A1)			
	2	manufacturer			A30
	2	location			A25
	2	distance from radiation site [km]			I3
I	2	time of 1st launch [h UTC]		0 - 23	I2
	2	time of 2nd launch [h UTC]			I2
	2	time of 3rd launch [h UTC]		-1	I2
	2	time of 4th lanch [h UTC]		-1	I2
	2	identification of radiosonde			A5
	2	(A30,X,A25,X,I3,4(X,I2),X,A5)			
	3	remarks about radiosonde		XXX	(A80)
0006	1	date when change occurred (day, hour, min.)	0 - 59	-1	3(X,I2)
ozone m.	1	are ozone measurements operated?	Y, N		A1
equipment	1	(3(X,I2),X,A1)			
	2	manufacturer			A30
	2	location			A25
	2	distance from radiation site [km]			I3
	2	identification number of ozone instrument			A5
	2	(A30,X,A25,X,I3,X,I5)			
	3	remarks about ozone measurement		XXX	(A80)
0007	1	date when change occurred (day, hour, min.)	0 - 59	-1	(3(X,I2))
station	2	method est. cloud amount (digital proc.)		XXX	(A80)
history	3	method est. cloud base h. (with instr.)		XXX	(A80)
	4	method est. cloud liquid water cont.		XXX	(A80)
	5	method est. cloud aerosol vertical distr.		XXX	(A80)
	6	method est. water vapor press. v.d. (A80)		XXX	(A80)
[**3**]	7	6 flags indicating if the SYNOP and/or the corresponding quantities of the expanded programme, are measured	Y,N		A1
	7	(A1,X,A1,X,A1,X,A1,X,A1,X,A1)			
[**4**] 0008	1	date when change occurred (day, hour, min.)	0 - 59	-1	3(X,I2)
radiation	1	is instrument measuring	Y,N		A1
instruments	1	(3(X,I2),X,A1)			
	2	manufacturer			A30
	2	model			A15
	2	serial number			A18
[**5**]	2	date of purchase [MM/DD/YY]		XXX	A8
	2	identification number assigned by the WRMC			I5
	2	(A30,X,A15,X,A18,X,A8,X,I5)			
[**6**]	3	remarks about the radiation instrument		XXX	(A80)
	4	pyrgeometer body compensation code		-1	I2
	4	pyrgeometer dome compensation code		-1	I2
I	4	wavelength of band 1 of spectral i. [micron]		-1.000	F7.3
I	4	bandwidth of band 1 of spectral i. [micron]		-1.000	F7.3
I	4	wavelength of band 2		-1.000	F7.3
I	4	bandwidth of band 2		-1.000	F7.3
I	4	wavelength of band 3		-1.000	F7.3
I	4	bandwidth of band 3		-1.000	F7.3
	4	max.] zenith angle [degree] of direct	0 - 90	-1	I2
	4	min.] (spectral) instrument	0 - 90	-1	I2
	4	(2(X,I2),6(X,F7.3),2(X,I2))			
	5	location of calibration			A30
	5	person doing calibration			A40
	5	(A30,X,A40)			

Table 2.1: BSRN station-to-archive file format continued

logical record	line no.	description of field / format of line	Range of values	Missing code	Format of v./l.
[**7**]	6	start of calibration period (band 1 of spectr. instr.)			A8
	6	end of ... (both [MM/DD/YY])			A8
I	6	number of comparisons (band 1 of spectr. instr.)		-1	I2
	6	mean calibration coefficient (band 1 of spectr. instr.)			F12.4
I	6	standard error of cal. coeff. (band 1 of spectr. instr.)		-1.0000	F12.4
	6	(A8,X,A8,X,I2,2(X,F12.4))			
	7	start of calibration period band 2 of spectr. instr.		XXX	A8
	7	end of ... (both [MM/DD/YY])		XXX	A8
	7	number of comparisons band 2 of spectr. instr.		-1	I2
I	7	mean calibration coefficient band 2 of spectr. instr.		-1.0000	F12.4
I	7	standard error of cal. coeff. band 2 of spectr. instr.		-1.0000	F12.4
	7	(A8,X,A8,X,I2,2(X,F12.4))			
	8	start of calibration period band 3 of spectr. instr.		XXX	A8
	8	end of ... (both [MM/DD/YY])		XXX	A8
	8	number of comparisons band 3 of spectr. instr.		-1	I2
I	8	mean calibration coefficient band 3 of spectr. instr.		-1.0000	F12.4
I	8	standard error of cal. coeff. band 3 of spectr. instr		-1.0000	F12.4
	8	(A8,X,A8,X,I2,2(X,F12.4))			
[**8**]	9	remarks on calibration, e.g. units of cal. coeff.		XXX	(A80)
	10	remarks on calibration (continued)		XXX	(A80)
	11	date when change occurred	0 - 59	-1	3(X,I2)
	11	...			
		Every radiation instr. at the station is described by 10 lines in the format given above (radiation subrecord)			
0009	1	date when change occurred (day, hour, min.)	0 - 59	-1	3(X,I2)
assignment	1	id. no. of radiation quantity measured			I9
of radiation	1	id. no. of instrument which measured quantity			I5
quantities	1	no. of band (for spectral instruments)		-1	I2
to	1	(3(X,I2),X,I9,X,I5,X,I2)			
instruments	2	date when change occurred (day, hour, min.)	0 - 59	-1	I2
	2	...			
		as many lines to list all quantities together with the instruments; e.g.,			
		...			
		`1 0 0 101 21013 1`			
		`1 0 0 102 21013 2`			
		`1 0 0 103 21013 3`			
		`1 0 0 3 21005 -1`			
		`1 0 0 4 21006 -1`			
		`15 0 0 3 21007 -1`			
		...			
		The above lines mean that (i) the shortwave spectral fluxes at bands 1, 2 and 3 are measured with instrument 21013, bands 1, 2, 3, (ii) the direct radiation is measured with instrument 21005 from the 1st day of the month until the 14th day of the month, with instrument 21007 since the 15th day of the month, and (iii) the diffuse radiation is measured with instrument 21006. Legal quantity id. nos. are listed in relation *measvar*, legal instrument id. nos. are assigned to the instruments at the BSRN stations by the WRMC. If an instrument measures more than one quantity, lines with the same instrument id. no. and the same date, but with different quantity id. nos. are repeated. However, repeating lines with the same date and the same quantity id. no. is not allowed. As as consequence, the following two lines are illegal, (i) quantity id. no. 1 is not in relation *measvar*, but in relation *calcvar*, and (ii) there is more than 1 line with the same time and quantity id. no.			
		`< 1 0 0 1 21005 -1 not allowed >`			
		`< 1 0 0 1 21006 -1 not allowed >`			
		Thus calculated quantities are calculated at the WRMC.			

Table 2.1: BSRN station-to-archive file format continued

logical record	line no.	description of field / format of line	Range of values	Missing code	Format of v./l.
0100	1	date [day]	1 - 31		I2
basic	1	time [minute]	0 - 1439		I4
meas.	1	global 2 (mean, std. dev., min., max.: columns 12 - 31)		-999 or	I4 or
	1	direct (mean, std. dev., min., max.: columns 35 - 54)		-99.9	F5.1
	2	diffuse (mean, std. dev., min., max.: columns 12-31)			
	2	downward longwave radiation			
		(mean, std. dev., min., max.: columns 35 - 54)			
	2	air temperature at downw. longw. instr. height		-99.9	F5.1
	2	relative humidity at ...		-99.9	F5.1
	2	pressure at ...		-999	I4
		(X,I2,X,I4,2(3X,I4,X,F5.1,X,I4,X,I4),/			
		8X,2(3X,I4,X,F5.1,X,I4,X,I4),4X,F5.1,X,F5.1,X,I4)			
	3	date [day]	1 - 31		I2
	3	...			
		2 lines for each time measured			
0200	1	date [day]	1 - 31		I2
expanded	1	time [minute]	0 - 1439		I4
measurem.	1	downw. shortw. spectr. at wavel. 1		-999 or	I4 or
	1	(mean, std. dev., min., max.: columns 12-31)		-99.9	F5.1
	1	...at wavel. 2 (mean, std. dev., min., max.: col. 35 - 54)			
	1	...at wavel. 3 (mean, std. dev., min., max.: col. 58-77)			
		(X,I2,X,I4,3(3X,I4,X,F5.1,X,I4,X,I4))			
	2	...			
		1 line for each time measured			
0300	1	date [day]	1 - 31		I2
other	1	time [minute]	0 - 1439		I4
measurem.	1	upward shortwave reflected		-999 or	I4 or
in		(mean, std. dev., min., max.: columns 12-31)		-99.9	F5.1
minutes	1	upward longwave			
intervals		(mean, std. dev., min., max.: columns 35-54)			
	1	net radiation (net radiometer)			
		(mean, std. dev., min., max.: columns 58-77)			
	1	(X,I2,X,I4,3(3X,I4,X,F5.1,X,I4,X,I4)			
	2	...			
		1 line for each time measured			
0400	1	date [day]	1 - 31		I2
special	1	time [minute]	0 - 1439		I4
spectral	1	downw. shortw. spectr. at wavel. 4		-999 or	I4 or
measurem.	1	(mean, std. dev., min., max.: columns 12-31)		-99.9	F5.1
	1	...at wavel. 5 (mean, std. dev., min., max.: col. 35 - 54)			
	1	...at wavel. 6 (mean, std. dev., min., max.: col. 58-77)			
	2	...at wavel. 7 (mean, std. dev., min., max.: col. 12 - 31)			
	2	...at wavel. 8 (mean, std. dev., min., max.: col. 35 - 54)			
	2	...at wavel. 9 (mean, std. dev., min., max.: col. 58-77)			
	3	...at wavel. 10 (mean, std. dev., min., max.: col. 12 - 31)			
	3	...at wavel. 11 (mean, std. dev., min., max.: col. 35 - 54)			
	3	...at wavel. 12 (mean, std. dev., min., max.: col. 58-77)			
		(X,I2,X,I4,3(3X,I4,X,F5.1,X,I4,X,I4)/			
		2(8X,3(3X,I4,X,F5.1,X,I4,X,I4)/))			
	4	...			
		3 lines for each time measured			

Table 2.1: BSRN station-to-archive file format continued

logical record	line no.	description of field / format of line	Range of values	Missing code	Format of v./l.
[9] 0500	1	date [day]	1 - 31		I2
ultra-violet	1	time [minute]	0 - 1439		I4
meas.	1	uv-a global (mean, std. dev., min., max.: columns 10 - 32)		-99.9	F5.1
	1	uv-b direct (mean, std. dev., min., max.: columns 34 - 56)			
	1	uv-b global (mean, std. dev., min., max.: columns 10 - 32)			
	2	uv-b diffuse (mean, std. dev., min., max.: columns 34 - 56)			
	2	upward reflected			
		(mean, std. dev., min., max.: columns 58 - 80)			
		(X,I2,X,I4,4(X,F5.1),4(X,F5.1),/			
		8X,4(X,F5.1),4(X,F5.1),4(X,F5.1)			
	3	date [day]	1 - 31		I2
	3	...			
		2 lines for each time measured			
[10] 1000	1	*YYGG*9 *IIiii Nddff* 1*SnTTT* 2*SnTdTdTd* 3*P*0*P*0*P*0			(A80)
surface		4*PPPP* 7*wwW*1*W*1 8*NhClCmCh*			
SYNOP		333 8NsChshsh 8NsChshsh 8NsChshsh			
		as many lines as needed in format (A80)			
[11] 1100	1	date [day]	1 - 31		I2
radiosonde	1	time [minute]	0 - 1439		I4
measurem.	1	observation number			I4
in launch	1	pressure at level		-999	I4
intervals	1	height at level			I5
	1	temperature		-99.9	F5.1
	1	dew point		-999.9	F6.1
	1	wind direction, azimuth	0 - 359	-99	I3
	1	wind speed		-99	I3
	1	ozone concentration		-9.9	F4.1
	1	(X,I2,X,I4,3X,I4,X,I4,X,I5,X,F5.1,X,F6.1,X,I3,X,I3,X,F4.1)			
	2	date [day]	1 - 31		I2
	2	...			
		1 line for each level measured			
1200	1	date [day]	1 - 31		I2
ozone	1	time [minute]	0 - 1439		I4
I measurem.	1	total ozone amount		-999	I4
in hours	1	(X,I2,X,I4,3X,I4)			
intervals	2	date [day]	1 - 31		I2
	2	...			
		1 line for each time measured			
1300	1	date [day]	1 - 31		I2
expanded	1	time [minute]	0 - 1439		I4
measurem.	1	total cloud amount with instrument		-9	I2
in hours	1	cloud base height with instrument in m			
I		(no clouds 99999)		-9999	I5
I intervals	1	cloud liquid water in mm		-99.9	F5.1
1st part	1	spectral aerosol optical depth at wavelength 1		-9.999	F6.3
	1	spectral aerosol optical depth at wavelength 2		-9.999	F6.3
	1	spectral aerosol optical depth at wavelength 3		-9.999	F6.3
	1	(X,I2,X,I4,3X,I2,X,I5,X,F5.1,2X,3(X,F6.3))			
	2	date [day]	1 - 31		I2
	2	...			
		1 line for each time measured			
1400		expanded measurements second part in hours intervals			
		(water vapour vertical profile by lidar):			
		to be defined later			

Table 2.1: BSRN station-to-archive file format continued

logical record	line no.	description of field / format of line	Range of values	Missing code	Format of v./l.
1500	1	date [day]	1 - 31		I2
other	1	time [minute]	0 - 1439		I4
measurem.	1	thermal spectral at wavelength 1		-9	I4
in hours	1	thermal spectral at wavelength 2		-9	I4
intervals	1	thermal spectral at wavelength 3		-9	I4
	1	hemispheric solar spectral at wavelength 1		-9	I4
	1	hemispheric solar spectral at wavelength 2		-9	I4
	1	hemispheric solar spectral at wavelength 3		-9	I4
	1	(X,I2,X,I4,2(3X,I4,X,I4,X,I4))			
	2	. . .			
		1 line for each time measured			

The following are two examples of logical records defined for the measurements at heights of 10 and 30m on the Payerne station tower. Such logical records , and the corresponding relations in the BSRN database, are defined according to the configuration of the instruments at the BSRN stations that perform measurements at heights other than the standard height, i.e., for BSRN stations with a tower. The formats of both records are approximately the same as the format for logical record 100, thus the software for writing the records to the station-to-archive file at Payerne and for reading and inserting the data in the BSRN database at the WRMC is more standardized.

[**12**] 3010	1	date [day]	1 - 31		I2
other	1	time [minute]	0 - 1439		I4
meas.	1	global 2 (mean, std. dev., min., max.: columns 12 - 31)		-999 or	I4 or
at	1	shortwave upward			
10m		(mean, std. dev., min., max.: columns 35 - 54)		-99.9	F5.1
	2	downward longwave radiation			
		(mean, std. dev., min., max.: columns 12 - 31)			
	2	upward longwave radiation			
		(mean, std. dev., min., max.: columns 35 - 54)			
	2	air temperature		-99.9	F5.1
	2	relative humidity		-99.9	F5.1
		(X,I2,X,I4,2(3X,I4,X,F5.1,X,I4,X,I4),/			
		8X,2(3X,I4,X,F5.1,X,I4,X,I4),4X,F5.1,X,F5.1)			
	3	date [day]	1 - 31		I2
	3	. . .			
		2 lines for each time measured			
[**12**] 3030	1	date [day]	1 - 31		I2
other	1	time [minute]	0 - 1439		I4
meas.	1	global 2 (mean, std. dev., min., max.: columns 12 - 31)		-999 or	I4 or
at	1	shortwave upward			
30m		(mean, std. dev., min., max.: columns 35 - 54)		-99.9	F5.1
	2	downward longwave radiation			
		(mean, std. dev., min., max.: columns 12 - 31)			
	2	upward longwave radiation			
		(mean, std. dev., min., max.: columns 35 - 54)			
	2	air temperature		-99.9	F5.1
	2	relative humidity		-99.9	F5.1
		(X,I2,X,I4,2(3X,I4,X,F5.1,X,I4,X,I4),/			
		8X,2(3X,I4,X,F5.1,X,I4,X,I4),4X,F5.1,X,F5.1)			
	3	date [day]	1 - 31		I2
	3	. . .			
		2 lines for each time measured			

Table 2.2: Metadata portion of a BSRN station-to-archive file
(#:= comment, not part of the file)

```
--------------------------------------------------------------------------------
*C0001
 21  1 1996  1
         2         4         5        21        22        23       131       132
# (as many lines as needed, fill last line with ‘‘-1’’)
*U0002
 -1 -1 -1
Dr. A. Heimo                          037-626111          037-611194
141.249.20.60   ahe@sap.sma.ch
Aerological Station, CH-1530 Payerne, Switzerland
 -1 -1 -1
P. Wasserfallen                       037-626111          037-611194
141.249.20.60   pwa@sap.sma.ch
Aerological Station, CH-1530 Payerne, Switzerland
*C0003
BSRN-Payerne file for January 1996 (new format V2.0).
*U0004
 -1 -1 -1
 13  4
Aerological Station, CH-1530 Payerne, Switzerland
037-626111          037-611194
141.249.20.60   ahe@sap.sma.ch
 136.815 186.944  491 06610
 -1 -1 -1
  53  2  54  2  55  2  56  2  57  2  58  1  59  1  60  1  61  1  62  1  63  1
# (as many lines as needed, fill last line up with ‘‘-1’’)
*U0005
 -1 -1 -1 Y
METEOLABOR AG                  Payerne                    0  0 12 -1 -1 SRSCH
XXX
*U0006
 -1 -1 -1 Y
Dobson                         CH-7050 Arosa            200 101
XXX
*U0007
 -1 -1 -1
XXX
XXX
XXX
XXX
XXX
Y N N N N N
*C0008
 -1 -1 -1 Y
Kipp & Zonen                   CM21           920039              1/28/92 21005
XXX
 -1 -1    -1.0    -1.0    -1.0    -1.0    -1.0    -1.0 70 64
Delft Holland                  F. de Wit
 4/23/92  4/23/92 -1        12.66         -1.0
XXX      XXX      -1         -1.0         -1.0
XXX      XXX      -1         -1.0         -1.0
Calibration units : 10E-6 V/W/m2
XXX
# (as many subrecords as instruments)
*U0009
 -1 -1 -1         2 21005 -1
# (as many lines as needed)
--------------------------------------------------------------------------------
```

Table 2.3: Replacement of an instrument midmonth.

```
--------------------------------------------------------------------------------
*C0008

 ...
 -1 -1 -1 Y
Eppley                        PIR             28897 F3          01/01/92 11001
Instrument gets ventilated artificially.
  3  2  -1.000  -1.000  -1.000  -1.000  -1.000  -1.000 -1 -1
DWD Met. Observatory Hamburg   Dr. K. Dehne
02/08/93 02/08/93  3       0.0435       0.0002
XXX      XXX      -1      -1.0000      -1.0000
XXX      XXX      -1      -1.0000      -1.0000
Instrument was factory calibrated.
the unit is milliVolt/milliWattcentimeter**-2 (mV/mWcm**-2).
 17 14 00 N
Eppley                        PIR             28897 F3          01/01/92 11001
Instrument gets ventilated artificially.
  3  2  -1.000  -1.000  -1.000  -1.000  -1.000  -1.000 -1 -1
DWD Met. Observatory Hamburg   Dr. K. Dehne
02/08/93 02/08/93  3       0.0435       0.0002
XXX      XXX      -1      -1.0000      -1.0000
XXX      XXX      -1      -1.0000      -1.0000
Instrument was factory calibrated.
the unit is milliVolt/milliWattcentimeter**-2 (mV/mWcm**-2).

...

 17 14 05 Y
Eppley                        PIR             28895 F3          01/01/92 11004
Instrument gets ventilated artificially.
  3  2  -1.000  -1.000  -1.000  -1.000  -1.000  -1.000 -1 -1
DWD Met. Observatory Hamburg   Dr. K. Dehne
02/23/94 02/23/94  3       0.0416       0.0001
XXX      XXX      -1      -1.0000      -1.0000
XXX      XXX      -1      -1.0000      -1.0000
Instrument was recalibrated.
the unit is milliVolt/milliWattcentimeter**-2 (mV/mWcm**-2).

 ...
--------------------------------------------------------------------------------
*C0009
 ...

 -1 -1 -1         5 11001 -1
 17 14 05         5 11004 -1

...
--------------------------------------------------------------------------------
```

In the first step, the *file name* of the station-to-archive file is checked. The filename reads “stammyy.dat” with “sta” = station short name, “mm” = month and “yy” = year. For example, the name of the January 1993 station-to-archive file with the data measured at Bermuda is “ber0193.dat”. The short name has to be the same as in Table 5.1, but in **lowercase letters**.

Example: Output in the case of incorrect station short name (the station short name is not in the above mentioned list).

```
-------------------------------------------
ezges90[ber]% format_check bir0193.dat

*ERROR: Unknown station abbreviation ''bir''
        - first 3 characters
        in input file name ''bir0193.dat''.
-------------------------------------------
```

Example: Output in case of wrong station (the station short name is in uppercase letters).

```
-------------------------------------------
ezges90[ber]% format_check BER0193.dat

*ERROR: Unknown station abbreviation ''BER''
        - first 3 characters
        in input file name ''BER0193.dat''.
-------------------------------------------
```

Month, year and extension of the name of the station-to-archive are checked next.

Example: Output in case of wrong month.

```
-------------------------------------------
ezges90[ber]% format_check ber1393.dat

*ERROR: Illegal month ''13'' - 4th and 5th
        characters in input file name
        ''ber1393.dat''.
-------------------------------------------
```

The output in the other two cases looks similar.

As specified at the beginning of section 6.2 of Technical Plan for BSRN Data Management, Version 2.1 *no line must be longer than 80 characters.* Each line of the file is checked for length. Example: Output in case of a line longer than 80 characters.

```
-------------------------------------------
ezges90[ber]% format_check ber0193.dat

**********
File name: ber0193.dat
**********
*ERROR: A line longer than 80 characters or
        missing line separator.

For help the number and the first 20
characters of the line causing the
problem are printed below.
-------------------------------------------
| line number:  |  first 20 characters:   |
-------------------------------------------
|       34      |  Eppley                 |
-------------------------------------------

-------------------------------------------
```

Then the file is checked for *illegal characters.* In logical records 100 to 1500, exclusive of logical record 1000, only “space”, “+”, “-”, “.” and digits from “0” to “9” are allowed. In the other logical records all printable characters from “space” to “~” and in addition, for logical record 3 also “tabulator” (09 hex) are allowed.

Table 2.4 shows an example of the output in case an illegal character was found.

At the end there are several *logical record dependent checks.* The format of each line is checked. They have to be exactly as explained in Table 2.1.

Table 2.5 shows an example of the output in case of wrong line format.

2.3 Consistency Check Program

The consistency check is part of the data insertion program *instat*, which inserts data into the BSRN database. Because instat needs information from the database, it can be used only at the WRMC.

If a file does not pass the consistency check it is sent back to the station together with a consistency report containing the complaints. An example of such a consistency report is presented in Table 2.6.

As a first step, the values given for month and year in logical record 0001 of the file are validated against month and year in the filename of the station-to-archive file.

In a second step, the program then deals withlogical records 0002, 0004, 0005, 0006, 0007, 0008 and 0009 independently. On each record, the following checks are performed.

1. The information in a logical record is compared with the corresponding information in the database: is there a change? If there is a change, the date of change must be given in the first line of the logical record or subrecord and the record must be flagged as having been changed in the record header line.

2. The records must be complete, i.e. missing codes are allowed only where legal.

3. The logical records are checked for legal values as shown in Table 2.4.

4. All subrecords in logical record 0008 which describe the radiation instruments are checked for

Table 2.4: Illegal characters in BSRN station-to-archive file

```
--------------------------------------------------------------------------------
ezges90[ber]% format_check ber0193.dat

**********
File name: ber0193.dat
**********
*Check for line length.......... OK
*ERROR: An illegal character occured.

        Allowed ASCII characters:
           - in logical records  1000, 1100 and less than 100:
                         all printable characters from ``space'' to ``~'',
                         and in addition, for logical record 3 also
                         ``tabulator'' (09 hex) is allowed.
           - in all other logical records:
                         ``space'',``+'',``-'',``.'' and digits from ``0'' to ``9''.

        For help the logical record number, the number of the line from
        beginning of the file, position of the illegal character in the
        line, character itself (if printable) and its hexadecimal value
        are printed below.
        --------------------------------------------------------------------
        |  log. record:  | line number:  |  position:  |  wrong character  |
        --------------------------------------------------------------------
        |        8       |       44      |      53     |       |  09 (hex) |
        --------------------------------------------------------------------

--------------------------------------------------------------------------------
```

Table 2.5: Wrong line format in BSRN station-to-archive file

```
--------------------------------------------------------------------------------
ezges90[ber]% format_check ber0193.dat

**********
File name: ber0193.dat
**********
*Check for line length.......... OK
*Check for illegal characters... OK
*ERROR: Incorrect format.

        For each logical record the line number from the beginning of
        the file and the message only for the first line with wrong
        format is printed below.

     Log. record:      4
     Line number:     21
        +Wrong format of the line...
         In the following lines the expected format and the current
         format of the line are printed.

         ``#'' stands for a digit (leading zeros are not allowed)
         ``X'' stands for a character
         ``|'' stands for the line end if it is present within first 80 characters
             (additional characters or spaces are not allowed)
--------------------------------------------------------------------------------
 ###.### ###.### #### XXXXX|
 122.267 115.333    8 -1|

--------------------------------------------------------------------------------
```

Table 2.6: Output of consistency check program with complaints

```
--------------------------------------------------------------------------------
*****************************************************
******** Station: ber   Month:  1   Year: 1993  ********
*****************************************************


CHECKING CONSISTENCY...
=======================

*ERROR G06: Missing calibration date for band 1 of radiation
            instrument ID 24003 in the logical record 0008!

*ERROR G06: Missing calibration date for band 1 of radiation
            instrument ID 24001 in the logical record 0008!

--------------------------------------------------------------------------------
```

uniqueness in the database (using the fields manufacturer, model and serial number) and their WRMC identification number.

In a third step several checks across the logical records within the station-to-archive file are performed.

1. - The existence of the logical records and their correct assignment to the measured quantity keys are checked. Only logical records 0003, 0005 and 0006 can be missing in the meta data part (logical records 0001 to 0009) of a station-to-archive . If a measured quantity key is listed in logical record 0001 the corresponding atmospheric data must appear in the file with not all data missing.

2. - In logical record 0009, the assignments of the measured quantities (in logical record 0001) to the radiation instruments (in logical record 0008) are checked.

3. - In logical record 0007, information on the station history such as availability of surface synoptic observations, estimation method of cloud amount and so on are checked.

In a fourth step further cross checks between the station-to-archive file and the BSRN database are performed.

The two different formats of the date ("day,hour,min" or "MM/DD/YY") are checked.

A check for "Y"/"N" tests if the "is instrument operating/measuring" question in logical records 0005 to 0008 is correctly answered.

3 Data processing at the WRMC

The processing of data files sent to the WRMC is done automatically. Files are checked and inserted into the database with as little manual work as possible.

The BSRN stations transfer their monthly batches of data to the WRMC by using the file transfer protocol (ftp).

Users receive quality checked BSRN data in fixed file formats after having placed an order using the WRMC Web page.

Please contact the BSRN data manager, H. Hegner (bsrnadm@geo.umnw.ethz.ch) in case of questions concerning data delivery to and from the WRMC.

Questions on the data quality checks performed by the WRMC should be addressed to the BSRN quality manager, G. Müller (muller@geo.umnw.ethz.ch).

3.1 Changes in the BSRN database

There were a few changes in the structure and the table definitions of the database. The new schema of the BSRN database is shown in Fig. 3.1.

The implementation of the BSRN data retrieval facility on the Internet required two changes. First, tables *measvar* and *calcvar* in the BSRN database version 1995 have been replaced by the table *variables* in the new version. Second, a new table *quality_check* has been introduced. This table contains a summary of the quality of the BSRN data.

Instruments used at more than one station run by the same institution led to the introduction of the relation *agency*.This relation describes the institutions running one or more BSRN stations and owning the radiation instruments used at these stations. These relationships are modelled by introducing additional foreign keys *agkey* in the already existing relations *station* and *radinstr*.

In the table *radinstr*, the primary key has been shifted from "raidnum" to the newly introduced attribute "rakey".

Also in the table *rihist* the attribute "stkey" has been added as foreign key to "station".

In the table *sta_synopbas_yyyy*, the reduced sea level pressure has been added. The attribute *sslpres* is similar to *spres*.

In the table *sta_upperair_yyyy*, the type of the attribute *uaobs* has been changed from I3 to I4 due to the appearance of radiosonde profiles with more than 999 levels. The attribute *uadewp* has been changed from F5.1 to F6.1 due to the appearance of dewpoint temperatures lower than -99.9°C in the Antarctic winter. Finally a new attribute for ozone measurements has been added. *uaozone* is of type F4.1. The ozone concentration is given in mPa, with the missing value -9.9.

3.2 Transfer of BSRN datafiles to the WRMC

Station scientists can transfer data to the WRMC easily by ftp in BSRN station-to-archive files formatted as prescribed in Chapter 2. All station-to-archive files can be accessed (read and write) only by the owner stations and by the WRMC. This is guaranteed by a dedicated WRMC server.

A separate account for each station has been established. After a login to a station account, the station scientist is already in the correct directory in which to put the files. The accountname is the station short name (e.g. bar, ber, bou, ...). The password, which is the same for all accounts belonging to one station scientist, will be transmitted by mail or fax. Access is restricted in addition to one or two Internet addresses (IP-Number) given by the station scientist.

Information about the database, the number of files sent to the WRMC, some descriptions of the stations and the amount of data in the database of each station are presented on the BSRN/WRMC homepage on the WWW.

3.3 Data Processing

The flow of a data file sent to the WRMC is shown in Fig. 3.2.

A datafile sent to the WRMC first undergoes format checks. If the format check fails the datafile will be sent back to the station scientist together with a list of the complaints. If it passes the check the datafile will be moved to another directory where it is tested for consistency as described above.

If a file does not pass the consisteny check it will also be sent back to the station scientist. A consistency report containing a list of violations of the consistency rules is sent to the station scientist. An example is shown in Table 2.6.

If a file passes the consisteny check it is inserted into the BSRN database. Quality checks are performed only on data in the BSRN database.

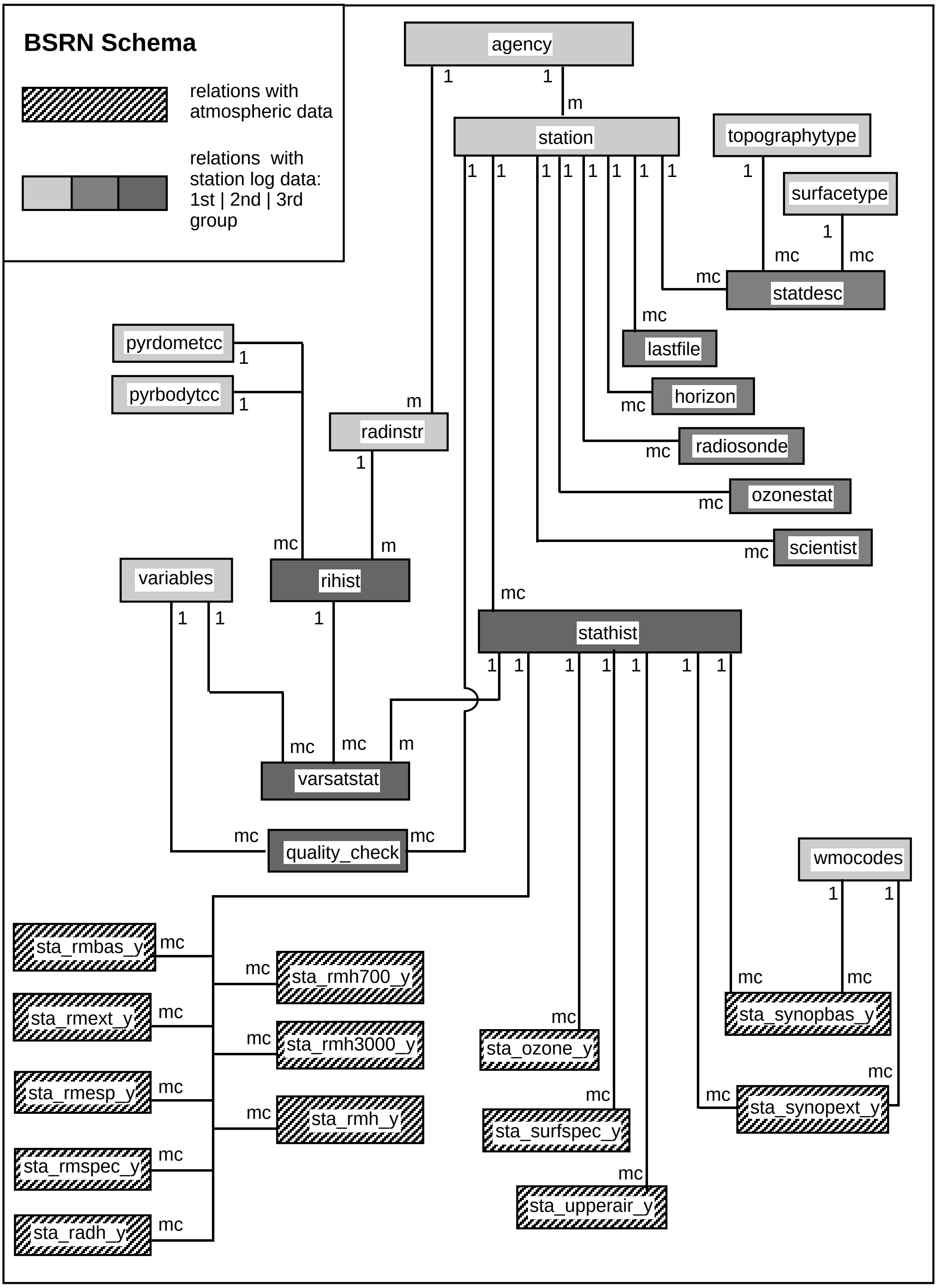

Figure 3.1: Schema of the BSRN database

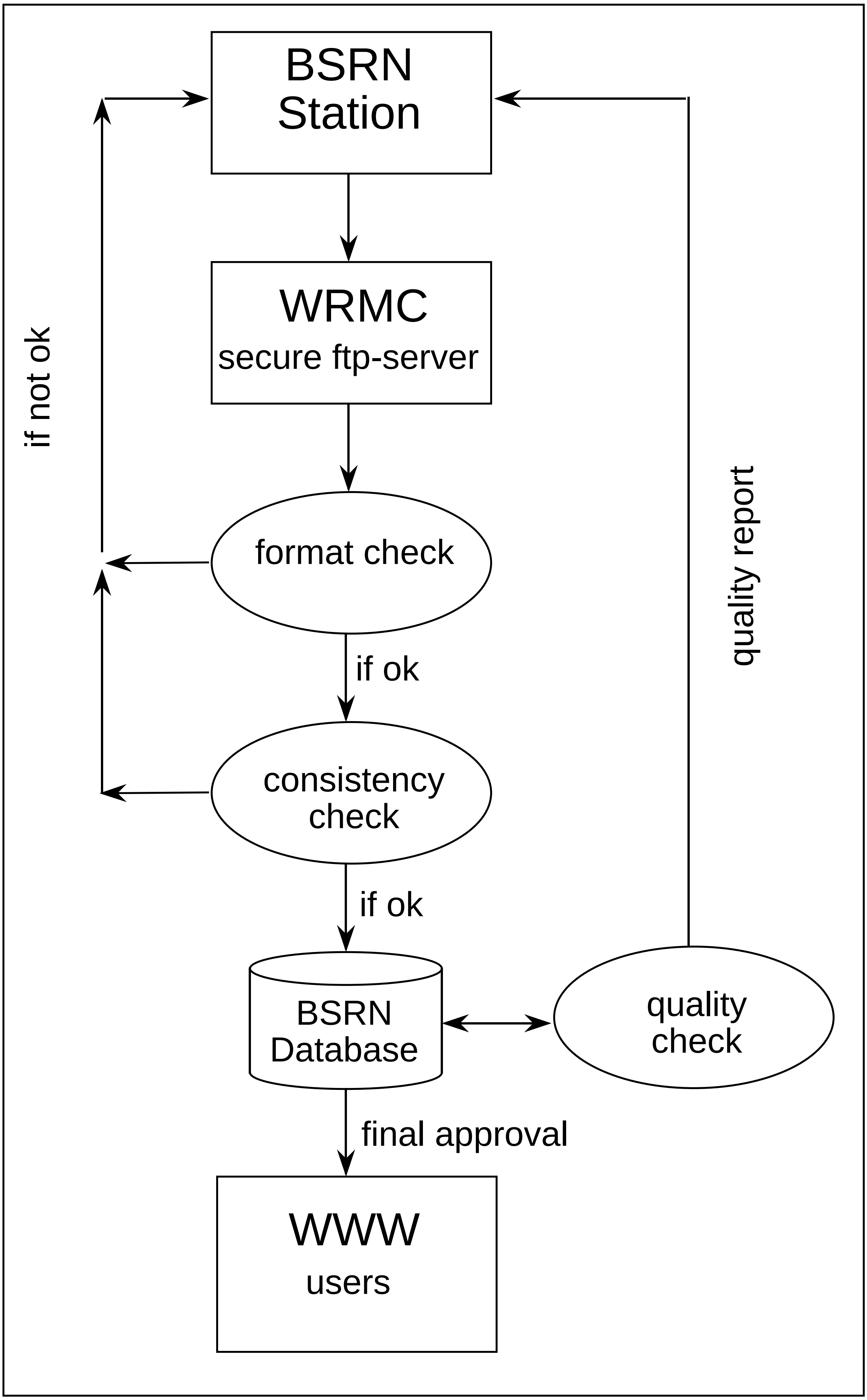

Figure 3.2: Flow of a station-to-archive file sent to the WRMC

3.4 Data Redistribution

The redistribution of the data occurs according to Chapter 2.2 (Gilgen et al., 1995). The following conditions for data release are effective after the BSRN sub-group on data policy has decided on the data policy:

"BSRN data can be made available to external users for bona fide research purposes at no cost. However, use of a particular station's data and the World Radiation Monitoring Center (WRMC) must always be explicitly acknowledged. Further interaction with the originating site scientists is encouraged because of the potential benefit to the data user. BSRN data sets provided by the WRMC must not be passed to a third party without the agreement of the WRMC. The above restriction shall not apply to any BSRN data which are made public through publication, presumably with some added value, and/or incorporation into additional project(s) for wide release. In such events all BSRN data should be clearly identified as such in that release, with information as to how to obtain the original data directly from the BSRN archive. A copy of the publication is to provide to the originator, directly or, preferably via WRMC. BSRN data must not be used for commercial applications.

All data are subject to change without notice. It is therefore recommended to renew downloaded BSRN data after a few months or when you start a new project."

Please refer to the detailed BSRN data policy on the copyright page of the retrieval menu of the webpage.

BSRN station scientists have unlimited read privileges on the database. External users are given access to data in the database which has been approved by the BSRN scientific review panel. Thus data are available to external scientific institutions with a delay of approximately 18 months and at no cost. For details see 'Technical Report 1'.

The Web Interface

The BSRN *data retrieval software* (WWW-Interface) is ready for retrieval of radiation data with standard queries. In a standard query one year's data from one station can be selected at a time. The time period can be limited and a single radiation component or a group of them can be chosen.

For access to the database use the "Application form for access to the BSRN database" on the webpage or contact the WRMC data manager.

The data retrieval interface is linked to the *BSRN/WRMC homepage* but access will be partially password protected. BSRN station scientists can access the database with their known username and password. External persons will receive an accountname and a password for temporary access to the protected area.

The "Data retieval" sub-menu of the "Database" menu consists of the entries "Conditions", which is the summary of the BSRN data policy, the application form and the "Connect" and "Restart" buttons. The "Connect" button connects you with the database after inserting username and password.

There are three main parts; *Quality Info*, *Data Retrieval* and *Plot*. The button "Display Stations Variables" submits the request.

At the *Quality Info* page, a list of the measured quantities and the years from which data are available as well as a quality graphics for the radiation measurements of that station appears. One line plot for each measured radiation component (e.g. global, direct, diffuse and so forth) gives information on the number of measured values in that year and their quality according to the quality check described in Chapter 8 of (Gilgen et al., 1995) and Chapter 4 of this report.

On the *data retrieval* page, one or more measured quantities can be chosen from a pulldown menu. The data appear on the browser, below the filled in form, together with a file header that contains information on the current data retrieval. From there they can be saved to the local disk. "Data Retrieval (Multi)" allows for retrieval of all variables of one group (cf. (Gilgen et al., 1995), page 5) by choosing one of them. "Data Retrieval (Single)" allows for retrieval of one particular component.

On the *Plot* page one or more measured quantities can be chosen from a pulldown menu similar to the data retrieval form. The graphics appear on the browser, below the filled in form. From there it can be saved to the local disk in "gif" format. "Multi Plot" and "Single Plot" have a similar effect to that described above.

Non-standard queries

As the data retrieval interface on the webpage allows for retrieval of the radiation data in their original time resolution only, specific data requests have to be carried out by the data manager. The database allows for retrival of different aggregated or combined data. It is possible to retrieve hourly, daily, monthly or yearly means (simple averages) or sums of the data. Also "clear sky data sets" that means radiation values measured only under clear sky conditions, can be produced. The combination of the same radiation values from different stations may also be interesting. All these retrievals and all retrievals of non-radiation-data are done by SQL queries.

BSRN station scientists and external persons may send their inquieries for such requests to the data manager. This can be done by e-mail, fax, phone or mail. Data requests should contain the stations, the time periods and a detailed list of the measured quantities and their specifications.

4 Quality Check

This chapter describes the quality checks which are applied to the BSRN radiation data at the WRMC. The WRMC does not correct the radiation data in the BSRN database. However, the WRMC does flag the radiation data suspected of being erroneous, and reports the flagged data to the BSRN station scientists. The station scientists use the reports on the quality check as a basis for an eventual reevaluation of the radiation data. If the source of the error is found and the data have been reevaluated, they are then forwarded once again to the WRMC as a higher version of a monthly batch of data. The higher version data replace the previous data version in the BSRN database and undergo once again the quality check procedures. This entire process will be repeated until the data can be regarded as satisfactory.

The system of the quality checks with the procedures "physically possible", "extremely rare", "across quantities", "comparison with a model" and "eye check of time series plots" as well as the quality codes are described in the previous report (Gilgen et al., 1995). The next two sections contain changes in the first three procedures and the data quality statistics.

4.1 Quality Check Procedures

After checking almost all data in the database the intervals of the three first procedures have been slightly adapted. Following is a brief description of each of the three procedures.

The "Physically Possible" Procedure is intended to detect extremely large errors in the measurements and the large random errors introduced during data handling. The radiation values falling in the intervals defined in the updated Table 4.1 are considered "physically possible". This procedure is so rough and fundamental that it can be applied to each radiation quantity independently of other radiation fluxes or meteorological data.

In the "Extremely Rare" Procedure the interval limits are narrower than those of the "physically possible" test. The radiation values which might violate these limits can actually occur over a very short time period and under extremely rare conditions. The interval bounds of the "extremely rare" procedure are given in the updated Table 4.2.

For this second quality control procedure, the observation of more than one radiative flux, such as global radiation and longwave incoming and outgoing radiation, are necessary. If one of the requested values is missing, the procedure can not be applied to all com-

Table 4.1: "Physically possible" intervals of the radiation quantities.
Update of Table 8.2 (Gilgen et al., 1995). *So* is the solar constant of $1368 Wm^{-2}$, *itop* is the solar irradiance at the top of the atmosphere as a function of latitude and time and Z is the solar zenith angle.

lower bound	radiative flux	upper bound
0	$\leq$ DSGL2	$< So$
0	$\leq$ DSDFS	$< itop + 10$ if $Z \leq 93.9$
		≤ 0 if $Z > 93.9$
0	$\leq$ DSDIR	$< So$
0	$\leq$ USR	$< itop + 10$ if $Z \leq 93.9$
		≤ 0 if $Z > 93.9$
$50 Wm^{-2}$	$<$ DL	$< 700 Wm^{-2}$
$50 Wm^{-2}$	$<$ UL	$< 700 Wm^{-2}$

Table 4.2: "Extremely rare" bounds of the radiation quantities
Update of Table 8.3 (Gilgen et al., 1995). *So* and *itop* are defined in the previous section, m is the Kasten (1966) optical air mass.

radiative flux	upper bound
DSGL2	$\leq itop$ if $Z < 80$
	$\leq itop + 0.56(Z - 93.9)^2$ if $Z \geq 80$
USR	$\leq 0.95 \cdot$ DSGL2 if $Z \leq 89$
	$<$ DSGL if Z $>$ 89
DSDFS	$\leq 700 Wm^{-2}$
DSDIR	$\leq So \cdot E0 \cdot 0.9^m$
DL	$<$ UL + 30
UL	$>$ DL + 30

ponents. If this happens, the test flag will have the value of 5.

With the "Across Quantities" Procedure, much smaller errors, which can escape the previous tests, are caught. This test is based on empirical relations of the different quantities measured.

The intervals applied by the "across quantities" procedures are defined in the updated Table 4.3.

In the first two rows of Table 4.3, the longwave radiative fluxes are compared with the longwave fluxes calculated with the screen-level air temperature. This is simultaneously measured and also stored in the BSRN database. The effective emissivity of the sky for screen-level air temperature is seldom smaller than 0.7. A larger effective emissivity is frequently observed due to high water vapour content of the atmosphere or cloud as well as water film on the domes of the pyrradiometer or pyrgeometer. The silicon dome of the pyrgeometer is more susceptible to this problem, as silicon is more hygroscopic than polyethylene. The effective emissivity, 0.7, can be underscored however, in the high altitude plateau on Antarctica.

4.2 Statistics of quality of data in the database

The format of the BSRN quality report is shown in Table 4.4. There were no changes to Table 8.5 in the previous report (Gilgen et al., 1995).

In Table 4.5 an example of a quality report (partial) is shown and can be interpreted as follows. The first line of the "flagged data" (RMBAS DLM 1 0 298 00259), means that the value (298) passed procedure 1 (fifth digit of the flag is 9), procedure 2 could not have been performed (fourth digit of the flag is 5) and the value is suspected of being erronous by procedure 3 (third digit of the flag is 2).

Such a report is sent to the stations for each month of data checked by the WRMC. It is meant as a base for an eventual reevaluation of the radiation data by the station scientist.

The results of the quality checks are summarized in the WRMC data quality diagrams. These colored diagrams are available on the BSRN/WRMC web page. An example in greyscale is shown in Fig. 4.1. The WRMC data quality diagrams show the same information as the quality report table but for one station and one year and aggregated to monthly sums. The colors show the part of the radiation values complained by the different procedures. Negative values during the night are ignored for this graphic. Thus, the diagrams contain a short overview on the quality of the data. More information is available from the WRMC or the corresponding station.

Table 4.6 is a summary of all BSRN data checked by the first three procedures through December 1997. It shows that the diffuse sky radiation (variable key = 4) has been flagged most frequently by procedure 1.

Most of the errors occur in the shortwave components detected by procedures 1 and 2. Almost all of these errors are small positive or negative values occuring at night, and generated by the instruments (nighttime offsets).

Table 4.3: "Across quantities" intervals of the radiation quantities
Update of Table 8.4 (Gilgen et al., 1995). Z is the solar zenith angle and T is the air temperature in K at the height of the downward longwave instrument. This temperature is calculated from the values in the attributes *dlat* and *dlath...* in relations *rmbas* and *rmh...* in Table 4.1 (Gilgen et al., 1995).

lower bound		radiative flux		upper bound
$0.7\sigma T^4$	$\leq$	DL	$\leq$	σT^4
$\sigma(T-10)^4$	$\leq$	UL	$\leq$	$\sigma(T+10)^4$
$(\text{DSGL2} - \text{DSDFS}) - 50$	$\leq$	direct horizontal ($\text{DSDIR}\cos Z$)	$\leq$	$(\text{DSGL2} - \text{DSDFS}) + 50$
$\text{DSDIR}\cos Z - 50$	$\leq$	direct horizontal ($\text{DSGL2} - \text{DSDFS}$)	$\leq$	$\text{DSDIR}\cos Z + 50$

Table 4.4: Definition of the BSRN quality report.
This report consists of three parts, the header, the data and the summary. In the summary, procedure no. is the number of the data quality check procedure, nox and noy are the number of values flagged to be erroneous by this procedure.

part of report	line no.	description	format
header	1	-------------	A40
	2	station number	I2
	3	month, year	I2,X,I2
	4	-------------	A40
flagged data	1	relation, attribute, day, minute, value, quality code	A10,X,A10,X,I2,X,I4,F6.1,X,A5
as many lines as values were found to be erroneous, but not more than 200			
summary	1	------------	A40
	2	relation, attribute, procedure no., nox, noy	A10,X,A10, 3(X,I4)

Table 4.5: Example of a quality report (partial).

```
-----------------------------------------------------
13
12 96
-----------------------------------------------------
RMBAS     DLM      1       0  298  00259
RMEXT     USRM     1      15   17  00029
RMBAS     DLM      1      20  299  00259
RMBAS     DLM      1      35  299  00259
RMBAS     DLM      1      55  299  00259
RMEXT     USRM     1      55   18  00029
RMBAS     DLM      1      60  300  00259
RMBAS     DLM      1      65  300  00259
RMEXT     USRM     1      65   18  00029
RMBAS     DLM      1      70  300  00259
...
RMEXT     USRM     2       0   15  00029
RMEXT     USRM     2       5   17  00029
RMEXT     USRM     2      10   18  00029
RMEXT     USRM     2      20   16  00029
RMEXT     USRM     2      25   16  00029
RMEXT     USRM     2      40   16  00029
RMEXT     USRM     2      45   15  00029
RMEXT     USRM     2      50   14  00029
RMEXT     USRM     2      55   14  00029
RMEXT     USRM     2      60   15  00029
...
RMBAS   DSDIRM     3       0  431  00029
RMEXT     USRM     3       0   53  00029
RMBAS   DSDIRM     3       5  431  00029
RMEXT     USRM     3       5   51  00029
RMBAS   DSDIRM     3      10  431  00029
RMEXT     USRM     3      10   47  00029
RMBAS   DSDIRM     3      15  434  00029
RMEXT     USRM     3      15   48  00029
RMBAS   DSDIRM     3      20  431  00029
RMEXT     USRM     3      20   47  00029
...
------------------------------------------------
RMBAS   DSGL2M   1       0      0
RMBAS   DSGL2M   2       0     87
RMBAS   DSGL2M   3       0      0
RMBAS   DSDFSM   1       0      0
RMBAS   DSDFSM   2       0     22
RMBAS   DSDFSM   3       0      0
RMBAS   DSDIRM   1     433      0
RMBAS   DSDIRM   2     433    479
RMBAS   DSDIRM   3     978      6
RMEXT   USRM     1       0      3
RMEXT   USRM     2       0    504
RMBAS   DLM      1       0      0
RMBAS   DLM      2       0      0
RMBAS   DLM      3      94    250
RMEXT   ULM      1       0      0
RMEXT   ULM      2       0      0
RMEXT   ULM      3       0      0
```

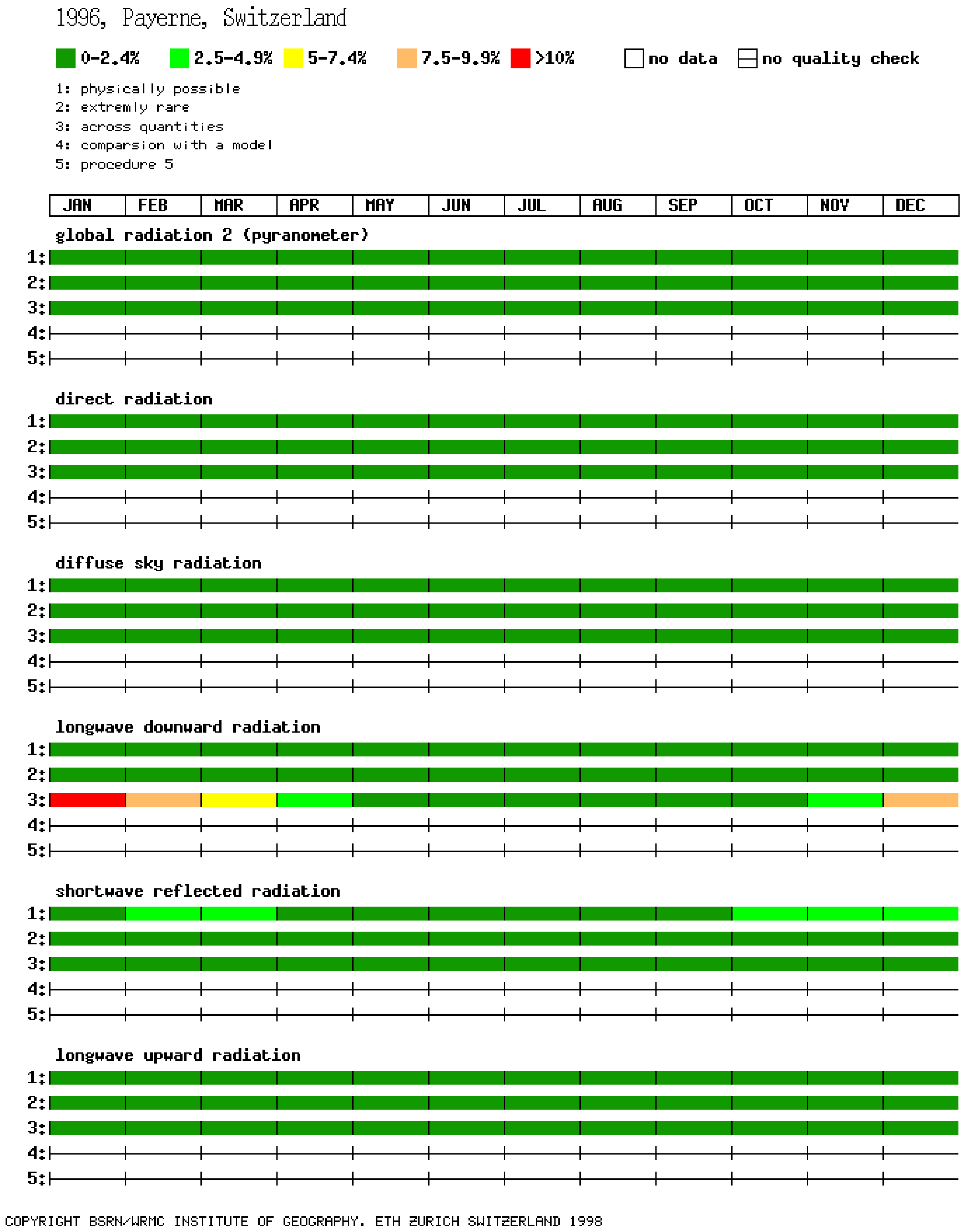

Figure 4.1: Example of a WRMC data quality diagram

Table 4.6: Summary of the quality check of all data in the BSRN database
477 files, December 1997. Procedures 1 to 3 have been performed. In the table, the variable key is the number of the measured quantity from Table 4.13 and the procedure key is the number of the procedure from Table 8.1 both (Gilgen et al., 1995).

variable key	total number of values checked	procedure key	number of values above boundaries	number of values below boundaries	percentage of values above boundaries	percentage of values below boundaries
2	8008928	1	29	774606	0.00	9.67
2	8008928	2	340884	774606	4.26	9.67
2	8008928	3	0	0	0.00	0.00
3	5001620	1	0	597886	0.00	11.95
3	5001620	2	180366	597886	3.61	11.95
3	5001620	3	7392	123024	0.15	2.46
4	4685843	1	374390	672068	7.99	14.34
4	4685843	2	1063	672068	0.02	14.34
4	4685843	3	0	0	0.00	0.00
5	7776396	1	1	18	0.00	0.00
5	7776396	2	84857	0	1.09	0.00
5	7776396	3	215902	118933	2.78	1.53
131	4464778	1	140304	265349	3.14	5.94
131	4464778	2	20651	0	0.46	0.00
131	4464778	3	0	0	0.00	0.00
132	4445020	1	0	0	0.00	0.00
132	4445020	2	0	84857	0.00	1.91
132	4445020	3	2338	3223	0.05	0.07

5 State of the Project

The BSRN is under continuous developement. New stations are set up, others are expanding their measurements and data processing applications at the WRMC are improving.

5.1 Stations

In total, the national organizations participating in the BSRN intend to establish some 20 - 30 stations world-wide. These are listed in Table 5.1 and shown in Fig. 5.1. Since the publishing of the Technical Plan for BSRN Data Management, Version 2.1 (Gilgen et al., 1995) there have been some changes in the list of stations. Seven stations have been crossed off the list, namely “Eureka” (Canada), “Ping Chuan” and “Wangdaoliang” (China), “Aswan” (Egypt), “Tarawa” and “Pukekohe” (New Zealand) and “Franz Josef Land” (Russia). The station of “Saskatoon” (Canada) has changed to “Regina”, “Manaus” (Brazil) was moved to “Balbina” and “Al Soodah” (Saudi Arabia) was moved to “Riyadh”. The stations “Billings” (OK), “Fort Peck” (MO), “Bondville” (IL), “Goodwin Creek” (MI), “Boulder SURFRAD” (CO) and “Chesapeake” (VA) from the United States as well as “Pilar” (Argentina), “Hefei” (China), “Si Samrong” (Thailand), “Hermosillo” (Mexico), “Xilinhat” (Mongolia), “Ilorin” (Nigeria), “Lerwick” and “Camborne” (Great Britain), “Maldives” (Maldives) and “Momote Island” (Papua New Guinea) have been added to the list as “candidate” and “De Aar” (South Africa) as “pending”. In July 1997 the stations of “Regina” and “Ilorin” and in January 1998 the station of “Billings” joined the data archive as operational stations.

The above stations are carrying out their measurements on many different levels. Some perform only the “basic measurements” with or whitout synoptic and upperair observations while others include “expanded” and “other measurements”. The different sets of measurements are described in the Technical Plan for BSRN Data Management, Version 2.1 . The time intervals are 1, 2, 3 and 5 minutes for the radiation measurements. Information on the measured quantities and the time intervals, as well as a physical description and the amount of data in the database for each station can be found on the BSRN/WRMC homepage on the WWW.

Full definition of "status" in Table 5.1:

Operational: stations contributing to the BSRN archive, and from which at least one record has been accepted and is available for extraction from the archive.

Pending: stations which are currently obtaining data and which are expected to begin submission to the BSRN archive in the near future (months).

Candidate: stations which are not yet submitting data, but which could do so in the future. This can include sites where no station currently exists but which could become part of the BSRN in the future, or stations which are obtaining data to BSRN standards, for purposes other than BSRN, which might begin contributing to the archive at some future time.

5.2 Data in the Database

Since the start of the BSRN measurements in 1992 more then 600 monthly files have been sent to the WRMC. Until now 642 files have passed the consistency checks and have been inserted into the BSRN database. Table 5.2 shows the present content of the database. A more detailed list which is continuously updated can be found on the BSRN/WRMC Web page.

Table 5.1: Stations in the BSRN, September 1998
Stations ordered North - South

Meaning of "status"

Status of station	Key	Description	Number
Operational	**o**	**at least one datafile in archive**	**15**
Pending	p	no data sent to archive	7
Candidate	c	different status	16
Total	-	-	38

Station name	Abbrev.	Sponsor	Latitude	Longitude	Status
Ny Alesund, Spitsbergen	**NYA**	Germany/Norway	78.93 N	11.93 E	o
Barrow, Alaska	**BAR**	USA	71.32 N	156.61 W	o
Lerwick Shetland Is.	LER	Great Britain	60 N	1 W	c
Toravere Observatory	TOR	Estonia	58.27 N	26.47 E	p
Lindenberg	LIN	Germany	52.21 N	14.12 E	p
Regina	**REG**	Canada	50.20 N	104.72 W	o
Camborne	CAM	Great Britain	50 N	5 W	c
Fort Peck, Montana	FPE	USA	48.31 N	105.12 W	c
Xilinhat	XIL	Mongolia/USA	47.90 N	109.98 E	c
Budapest-Lorinc	BUD	Hungary	47.50 N	19.05 E	p
Payerne	**PAY**	Switzerland	46.82 N	6.95 E	o
Carpentras	**CAR**	France	44.05 N	5.05 E	o
Boulder SURFRAD, Co.	BOS	USA	40.13 N	105.24 W	c
Bondville,Illinois	BON	USA	40.06 N	88.37 W	c
Boulder,Colorado	**BOU**	USA	40.05 N	105.01 W	o
Chesapeake,Virginia	CHE	USA	36.09 N	75.07 W	c
Billings,ARM/CART, Ok.	**BIL**	USA	36.53 N	97.45 W	o
Tateno	**TAT**	Japan	36.05 N	140.13 E	o
Goodwin Creek, Mi	GCR	USA	34.25 N	89.87 W	c
Hefei (China)	HEF	Japan	32.55 N	116.78 E	c
Bermuda	**BER**	USA	32.30 N	64.75 W	o
Sede Boqer	SBO	Israel	30.87 N	34.77 E	p
Hermosillo	HER	Mexico	29 N	111 W	c
Riyadh	RIY	Saudi Arabia	24.65 N	48.77 E	c
Colima	COL	Mexico	19.83 N	103.50 W	c
Si Samrong (Thailand)	SSA	Japan	17.17 N	99.87 E	c
Kwajalein, Marshall Is.	**KWA**	USA	8.71 N	167.73 E	o
Ilorin	**ILO**	Nigeria/USA	8.32 N	4.43 E	o
Maldives	MAL	Maldives/USA	5 N	73 E	c
Momote, Manus Is. (Papua N. Guinea)	MOM	USA	2.06 S	147.43 E	c
Balbina	BAL	Brazil	3.10 S	60.00 W	c
Alice Springs	ASP	Australia	23.70 S	133.87 E	p
Florianopolis	**FLO**	Brazil	27.58 S	48.52 W	o
De Aar	DAA	South Africa	30.40 S	24.01 E	p
Pilar	PIL	Argentina	31.40 S	63.53 W	c
Syowa, Antarctica	**SYO**	Japan	69.00 S	39.58 E	o
Georg von Neumayer, Ant.	**GVN**	Germany	70.39 S	8.15 W	o
South Pole, Antarctica	**SPO**	USA	90.00 S	0.00 W	o

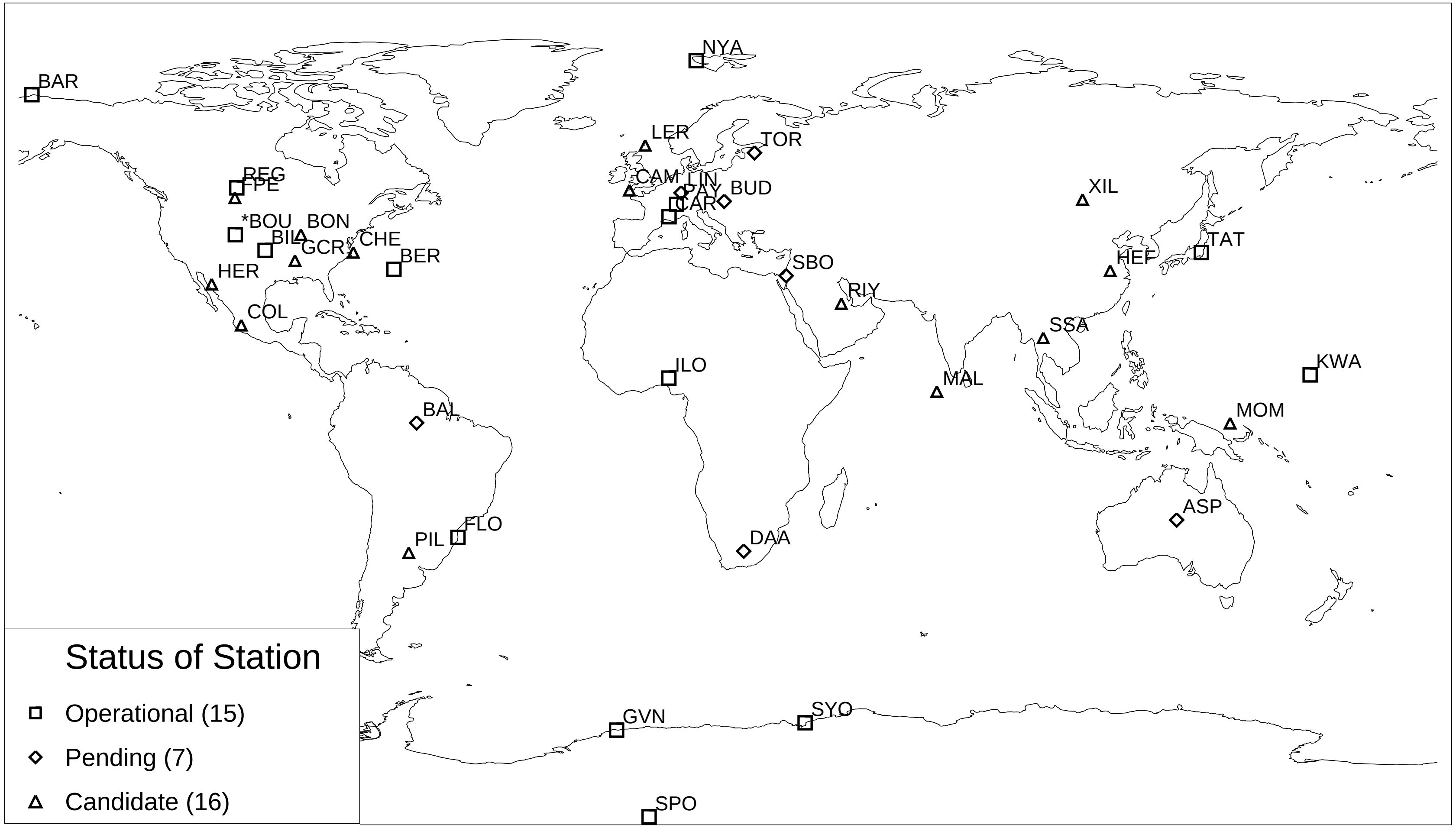

Figure 5.1: All existing and planned BSRN Stations September 1998

Table 5.2: Status of the BSRN/WRMC database
Number of monthly files inserted into the database, September 1998.

Station	1992	1993	1994	1995	1996	1997	1998	Total
Ny Alesund	5	12	12	12	12	6	-	59
Barrow	12	12	12	12	12	-	-	60
Regina	-	-	-	-	3	-	-	3
Payerne	3	12	12	12	12	12	8	71
Carpentras	-	-	-	-	4	1	-	5
Boulder	12	12	12	12	12	-	-	60
Billings	-	-	-	12	12	12	-	36
Tateno	-	-	-	-	12	12	8	32
Bermuda	12	12	12	12	12	-	-	60
Kwajalein	9	12	12	12	12	-	-	57
Ilorin	4	12	9	-	-	-	-	25
Florianopolis	-	-	6	12	12	12	8	50
Syowa	-	-	12	12	-	-	-	24
Georg von Neumayer	9	12	12	12	12	6	-	63
South Pole	12	12	12	12	12	-	-	60
Total	78	108	123	132	140	61	24	**665**

6 Applications of BSRN Data

Some scientific work has already been done with BSRN data and several publications have been printed or submitted for print. A compilation of current work that the WRMC is aware of is presented below.

Ken Knapp is a graduate student at Colorado State University. He is referenced by Dr. Ellsworth Dutton, the BSRN project manager from NOAA. He is currently working on his thesis, to be published at a later date. Ken Knapp received on request, Radiation data from Billings (OK) from May to August 1995 retrieved from the BSRN database March 21, 1996.

Abstract of the work:

Aerosols scatter incoming solar radiation, affecting the energy balance of the earth-atmosphere system, by reflecting more shortwave radiation to space. This has a two-fold effect: 1) The increase in outgoing solar radiation is detectable by meteorological satellites, and 2) the increase of the overall earth albedo decreases the available solar energy, causing a cooling effect for the system. Polar orbiting satellites, with the advantage of high resolution imagery, have been the primary tool in estimating aerosol optical depths. The recent line of GOES-NEXT satellites provide higher signal-to-noise ratios, spatial resolution and quantization than previously available from geostationary orbit. An adding/doubling radiative transfer model is used to infer aerosol optical depths from imagery over the Eastern United States. These retrieved optical depths are validated using various surface data – pyrheliometer, transmissometer, nephelometers, and National Weather Service visibility reports. The optical depth retrievals are also used in a two-stream RT model to calculate the aerosol forcing (direct effect).

Roberta DiPasquale works with Charlie Whitlock at NASA Langley Research Center. Their group received on request all radiation data from 1992 retrieved from the BSRN database as hourly means and all 1992 synop and upper air data as raw files as of April 2, 1996.

Her group members, Shashi Gupta and Fred Rose, have used the BSRN data in support of the GEWEX/SRB project at NASA Langley.

Shashi Gupta has used hourly BSRN data (downward longwave fluxes only) for 4 months of 1992 (January, April, July, and October) from the sites of Barrow, Bermuda, Boulder, Georg von Neumayer, Kwajalein, Ny Alesund and Payerne. Fred Rose has used the data in the same manner as for the Wang Longwave algorithm.

Abstract of the work:

Data were available for 20 (out of possible 28) site-month combinations. We averaged hourly values to daily values, and then the daily values to monthly values. These daily and monthly averages are being used for validating corresponding results from Gupta LW model derived using ISCCP D1 meteorological data. The monthly comparisons look quite good. Comparisons of daily averages are being worked on.

In a more recent work members of the same group worked on the "Validation of Surface Longwave Fluxes Derived from Satellite Data" (Gupta et al., 1997).

Abstract of the work:

Longwave (LW) and shortwave (SW) radiative fluxes at the surface are important components of the surface energy budget. They affect, in varying measures, the surface temperature fields, the fluxes of latent and sensible heat, the atmospheric and oceanic general circulation, and the hydrological cycle (Suttles and Ohring 1986). In recognition of such scientific significance, the World Climate Research Program (WCRP) established within the framework of the Global Energy and Water Cycle Experiment (GEWEX), the Surface Radiation Budget (SRB) project with the goal of developing long-term global datasets of LW and SW radiative fluxes at the Earth's surface preferably using satellite data.

The WCRP also initiated the establishment of the Baseline Surface Radiation Network (BSRN) for making high-quality measurements around the globe, primarily for validating the satellite algorithms for deriving surface radiative fluxes.

A surface LW algorithm based on a fast radiation parameterization (Gupta 1989; Gupta et al. 1992) and satellite-derived meteorological data was recommended by the GEWEX/SRB Workshop (WCRP 1994) for producing, on an experimental basis, long-term datasets of surface LW fluxes for use by the scientific community involved in climate studies. In this paper, two studies are presented in which downward longwave fluxes (DLF) derived from the above algorithm are validated with high-quality surface measurements.

In the first study, DLF values from the algorithm were compared with surface measurements obtained under the CERES/ARM/GEWEX Experiment (CAGEX; Charlock and Alberta 1996) from the ARM/CART site in Oklahoma for the April 1994 Intensive Observing Period. Meteorological data used in the algorithm are from the National Weather Service soundings. Coincident cloud parameters were produced from GOES-7 radiances by Minnis et al. (1995). Comparisons of 30-minute averages of surface measurements over a period of 26 days and corresponding results from the algorithm show a bias of 3 Wm-2 and a rms difference of 20 Wm-2.

In the second study, monthly averages of surface-measured DLF for three months from seven sites located in different climate regimes around the globe were compared with corresponding algorithm results. Surface-measured fluxes for January, July, and October 1992 were obtained from the BSRN. Coincident meteorological parameters used in the algorithm are from the ISCCP-D1 data.

Comparison of 15 site-month pairs showed a bias of 6 Wm-2 and a rms difference of 21 Wm-2.

Gert Koenig-Langlo is the station scientist of the two german BSRN stations Ny Alesund, Spitsbergen (NO) and Georg von Neumayer, Antarctica. He and his co-authors used their own data which are part of the BSRN in the following works.

1.) Parameterization of the Downward Long Wave Radiation at the Earth's Surface in Polar Regions (Koenig-Langlo and Augstein, 1994).

Abstract of the work:

Various parameterization schemes for the downward long-wave radiation at the Earth's surface which have been frequently applied in sea ice and snow cover models are tested with the aid of one year's measurements at the German stations "Koldewey' and "Neumayer' in the Arctic and Antarctic, respectively. All of these concepts are based on the Stefan-Boltzmann radiation law with an empirically derived effective atmospheric emissivity ε_A. Our data confirm the distinct dependency of the latter on cloudiness. But no other influences e.g. due to falling ice crystals (diamond dust) could be detected as significant. And the low level athmospheric water vapour pressure needs not be considered explicitly in the formulae. Thus, we propose a rather simple scheme for ε_A which is compatible to the more sophisticated ones at least for polar regions. Our parameterization reproduces the observations with root mean square (RMS) deviation of less than 16 Wm^{-2}.

2.) The Meteorological Data of the Neumayer Station (Antarctica) for 1992, 1993 and 1994 (Koenig-Langlo and Herber, 1996).

Abstract of the work:

Since March 1981 a meteorological observatory program is carried out at Georg-von-Neumayer Station (70°37'S, 8°22'W) continuously. Data reports have been presented by Gube-Lenhardt et al. (1986), Gube-Lenhardt (1987), Helmes (1989), Koenig-Langlo (1992) and Schmidt et al. (1994). On 16 March 1992 the program was transferred to the new Neumayer Station (70°39'S, 8°15'W) in a close neighbourhood of the former one.

Neumayer Station is located 8 kilometers southeast of Georg-von-Neumayer Station, (Fig.1). Both establishments are situated at the Ekström Ice Shelf which has a homogeneous, flat surface, sloping gently upwards to the south. Thus the environment of both stations is similar. Nevertheless the different distances to the free ocean in the north and to the Atka Bay in the east may become obvious in some atmospheric quantities.

Starting with the new station the meteorological observatory programme was extended mainly in two points:

- The surface radiation measurements were improved significantly (see Chapter 2.3) to fulfill the demands of the "**B**aseline **S**urface **R**adiation Network' **BSRN**, (WMO, 1991).

- The ozone soundings started in 1985 at the Georg-Forster Station (70°46'S, 11°41'E) are carried out at Neumayer Station since 1992.

The station's annual course of the sun elevation (without refraction) is shown in Fig.2. The maximum incidence angle is 42.8°at the 22nd of December. The sun stays permanently above the horizon from 19th of November to 24th of January (polar day) and permanently below the horizon from 19th of May to 27th of July (polar night).

This report presents a description of the meteorological data obtained during the years 1992 through 1994. The full data sets are archived in the **M**eteorological **I**nformation **S**ystem at the **A**lfred-**W**egener-**I**nstitute (**MISAWI**). This information system provides a quick and easy access to all data, data subsets, statistics and derived quantities for all users.

Additionally MISAWI offers an interactive interface to the internet which is implemented in the World Wide Web under the address of the AWI home page (http://www.awi-bremerhaven.de).

3.) Evaluation of Clear-sky Downward Longwave Irradiances as Observed in Arctic Atmospheres (Miskolczi and Koenig-Langlo, 1996).

Abstract of the work:

At the Antarctic meteorological station of Neumayer (Germany), the ground observations made during 1992-93, included longwave radiative fluxes, measured with pyrgeometers. The objective of this study was to evaluate those observations against theoretical computations. Line-by-line and LOWTRAN7 computations of downward longwave irradiances were made for clear sky conditions.

For this study, 36 clear-sky radiosonde and Eppley pyrgeometer observations were selected. The results indicate a relatively large negative bias between the theoretical estimates and the measurements, -23 Wm^{-2} for the line-by-line and -16.7 Wm^{-2} for the LOWTRAN7 computations, respectively Because of the harsh environmental conditions that exist at Antarctica, we attribute these differences to the performance of the pyrgeometer. The experiment was repeated in 1994, and the calibration of the pyrgeometer was monitored closely. Results from this latter evaluation will be also discussed.

Martin Wild is a research scientist at the Department of Geography, ETH Zurich. He used BSRN data for the following works together with his co-authors.

1.) Validation of GCM simulated radiative fluxes using surface observations (Wild et al., 1995).

Abstract of the work:

The surface radiative fluxes of the ECHAM3 General Circulation Model with T21, T42 and T106 resolutions have been validated using observations from the Global Energy Balance Archive (GEBA, World Climate Program - Water Project A7). GEBA contains the most comprehensive dataset now available for worldwide instrumentally-measured surface energy fluxes.

The GCM incoming shortwave radiation at the surface has been compared with more than 700 long-term monitoring stations. The ECHAM3 models show a clear tendency to overestimate the global annual mean incoming shortwave radiation at the surface due to an underestimation of atmospheric absorption. The model-calculated global mean surface shortwave absorption around 165 Wm^{-2} is estimated to be too high by 10 - 15 Wm^{-2}. A similar or higher overestimate is present in several other GCMs. Deficiencies in the clear sky absorption of the ECHAM3 radiation scheme are proposed as a contributor to the flux discrepancies. A stand alone validation of the radiation scheme under clear sky conditions revealed overestimates of up to 50 Wm^{-2} for daily maximum values of incoming shortwave fluxes. Further the lack of shortwave absorption by the model clouds is suggested to contribute to the overestimated surface shortwave radiation.

There are indications that the incoming longwave radiation is underestimated in ECHAM3 and other GCMs. This largely offsets the overestimated shortwave flux in the global mean, so that the 102 Wm^{-2} calculated in ECHAM3 for the surface net radiation is considered to be a realistic value. A common feature of several GCMs is therefore a superficially correct simulation of global mean net radiation, as the overestimate in the shortwave balance is compensated by an underestimate in the longwave balance.

Seasonal and zonal analyses show that the largest overestimate in the incoming shortwave radiation of ECHAM3 is found at low latitudes year round and in mid-latitude summer while at high latitudes and in mid-latitude winter the solar input is underestimated. As a result, the meridional gradient of incoming shortwave radiation becomes too large. The zonal discrepancies of the fluxes are consistent with differences between the simulated cloud amount and a cloud climatology based on surface observations. The shortwave discrepancies are further visible in the net radiation where the differences show a similar latitudinal dependency including the too strong meridional gradient.

On the global and zonal scale the simulated fluxes are rather insensitive to changes in horizontal resolution. The systematic large scale model deviations dominate the effects of increased horizontal resolution.

2.) Observational evidence for revised surface and atmospheric radiation budgets in GCMs (Wild et al., 1996).

Abstract of the work:

The surface and atmospheric radiation budgets of the latest version of the Max-Planck Institute GCM, the ECHAM4, differ considerably from the earlier version ECHAM3 and other GCMs in both short- and longwave ranges. The absorbed shortwave radiation at the surface is substantially smaller (147 Wm^{-2}) than typically found in current GCMs, due to a larger atmospheric absorption of 90 Wm^{-2}. The enhanced shortwave atmospheric absorption is related to an increase of both simulated clear-sky and cloud absorption. Observational evidence is presented that this revised disposition of shortwave absorption is more realistic than typically found in current GCMs. This conclusion is based on a comparison of the model radiative fluxes with a large number of surface and collocated top-of-atmosphere observations, as well as stand-alone validations of the radiation scheme. In contrast to other GCMs which show a smaller atmospheric and a larger surface shortwave absorption, respectively, the ECHAM4 shortwave absorption is closer to the observations.

The clear-sky surface insolation of the ECHAM4 radiation scheme is shown to be very accurately calculated in a stand-alone validation, compared to other schemes which tend to overestimate these fluxes. This suggests that the global mean ECHAM4-calculated clear-sky shortwave absorption of 72 Wm^{-2} within the atmosphere and 214 Wm^{-2} at the surface are realistic values. Further, the ECHAM4-calculated cloud amount is in good agreement with surface-based observations. The above findings imply that the increase in the cloud absorption in ECHAM4 (TOA-to-surface cloud radiative forcing ratio R of 1.35) is consistent with the available observations on the global scale.

Zonally, observational evidence for a necessity to increase cloud absorption in GCMs is found in the low latitudes in agreement with other recent studies, but not so in the higher latitudes: the comparisons favour a value of R near 1.3 - 1.4 in the tropics but closer to 1 in the extratropics.

Overall, this study indicates that not only an increased solar absorption by clouds but also by the cloud-free atmosphere is essential to reduce the discrepancies between GCM-calculated atmospheric shortwave absorption and observations.

The smaller surface insolation and associated reduction of the available energy at the surface is partly compensated for by an increased downward longwave flux at the surface (344 Wm^{-2} in ECHAM4), which is considerably larger than in other GCMs. The larger downward longwave flux is supported by surface measurements and by a stand-alone valdidation of the radiation scheme for clear-sky conditions. The enhanced downward longwaveflux allows to maintain the level of available energy at the surface needed for a realistic intensity of the global hydrological cycle.

3.) The water vapor continuum and its representation in ECHAM4 (Giorgetta and Wild, 1995).

Abstract of the work:

The water vapor absorption of long wave radiation in the atmosphere is still insufficiently understood. For this reason it is common to split the computation in two parts, the theoretically derived line absorption and the empirically determined continuum absorption. An often used continuum parameterization was proposed by Roberts et al. already in 1976. Parameters of that empirical correction have been modified in this study following the new findings by Ma and Tipping concerning the line shape wings. Two parameters have been modified and tested in the Morcrette radiation scheme implemented in the ECHAM4 general circulation model. The first parameter describes the strength of the self continuum at standard conditions as a function of the band number. The change consists in the frequency averaging method used to derive the wide band values. The second parameter defines the foreign to self continuum ratio at standard conditions. This parameter was originally given as a frequency independent value and is now derived from the Ma and Tipping study for each band separately. The new parameters have been applied in single column integration using clear sky radio-sonde profiles of temperature and humidity in order to verify the computed downward flux against observations. The results show a significant increase of the clear sky long wave downward flux of the order of 10Wm^{-2} and a hence reduction of systematic differences between observed and computed fluxes. Integrations of the full climate model show that the land surface temperature increases by approximately 2-4°C in tropical subsidence regions.

Members of the LABSOLAR of the Departamento de Engenharia Mecanica Federal University of Santa Catarina which operates the Florianopolis BSRN station used BSRN data for the following works.

1.) Estimativa de Radiacao solar na presenca de nuvens (Melo and Rzatki, 1993).

Abstract of the work:

The objective of this work is to present a model to simulate the diffuse and direct solar radiation intensity, considering cloudy sky conditions. It is shown that clear sky models overestimate the solar radiation intensity, and their use may lead to relevant errors in estimating building's cooling load.

2.) Survey of incident solar radiation in Brazil by use of METEOSAT satellite data (Pereira et al., 1996).

Abstract of the work:

Meteosat-2 satellite data in the visible band were used to calculate monthly averages from daily mean incident solar radiation over Brazil, using IGMK physical model for the period 1985-86. Satellite estimates are compared with ground data from 22 national stations. The global root mean square error between model and ground results for all data points was 13%, and the mean bias error was 1.23 MJm^{-2}. About 68% of the individual errors were bellow 10% and clustered around 8%. Global radiation estimated by the model ranged from 9.0 to 27 MJm^{-2} with the diffuse to global ratio faling into the 0.2-0.5 interval. Enhanced inverted zonal trends were found for both satellite predictions and the ground station results.

3.) Determinacao para uma correlacao para o calculo da radiacao solar difusa incidente a partir da radiacao solar global (Pereira et al., 1996).

Abstract of the work:

This work presents a model to estimate the diffuse radiation from experimental data of global radiation. The model was adjusted for Brasil and takes in account the solar elevation angle and the climatic variables of air temperature and relative humidity. The validation of the model was done using experimental data of diffuse radiation measured between 1994 and 1995 in Florianopolis (lat 27 deg. 36' S long. 48 deg 34' W) and the relative global RMSE was about 0.3.

4.) Validacao do modelo de estimacao de radiacao solar incidente na superficie utilizando imagens de satelite (de Abreu et al., 1995).

Abstract of the work:

This model reports the validation and the first results of a computation model to estimate the incident solar radiation by using geostationary satellite data. This model is a result of a joint collaboration between UFSC/LABSOLAR and the GKSS (Germany). Results show errors of the order of 10% in 60.5% of the days, and errors not greater than 15% in 72.8 % of the days.

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