

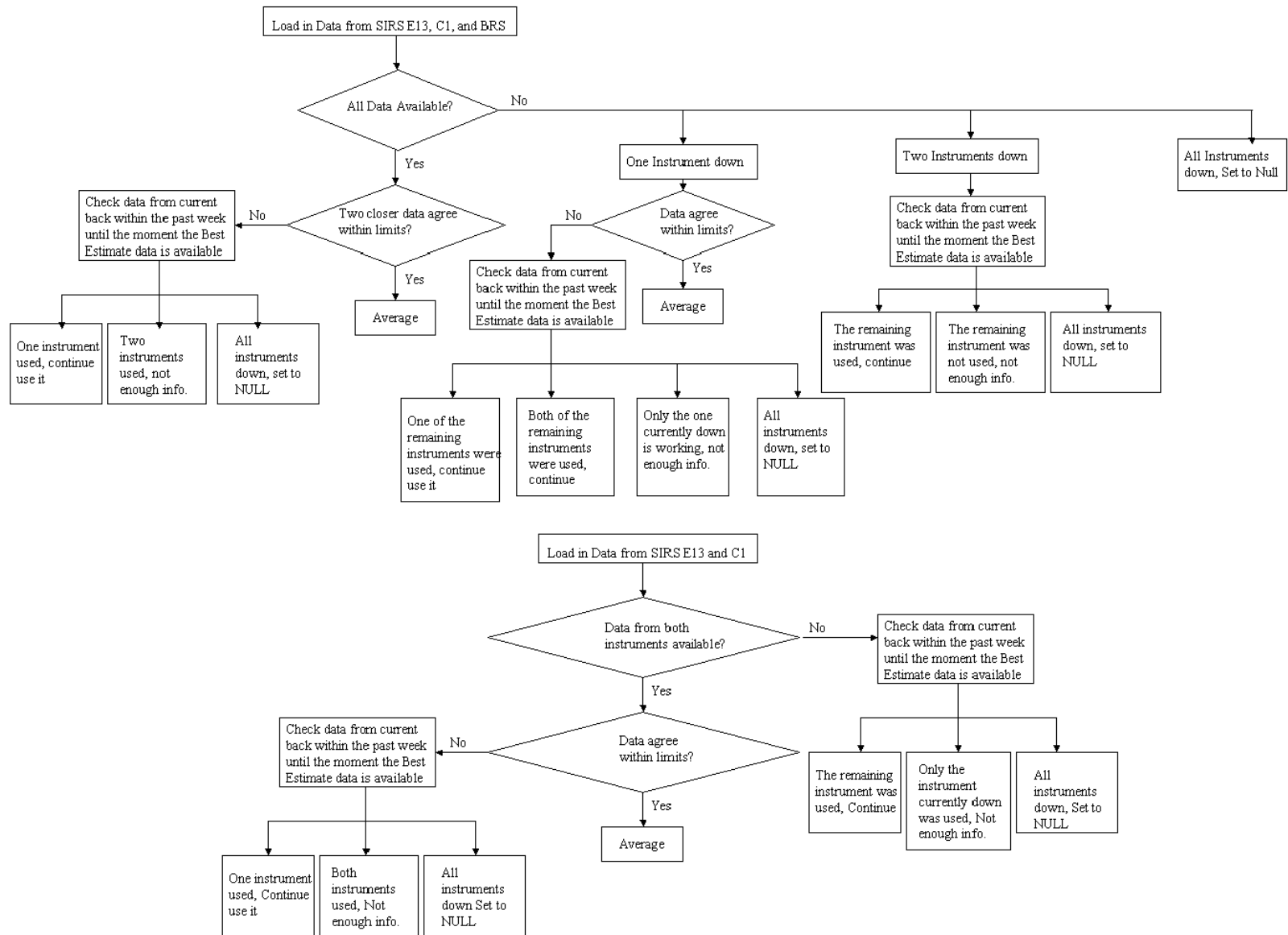
# Techniques and Methods Used to Determine the Best Estimate of Radiation Fluxes at SGP Central Facility

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## Algorithm and Methodology

The Best Estimate Flux value-added product (VAP) processes data started on March 22, 1997, when data from the three central facility (CF) radiometer systems, Solar Infrared Station (SIRS) E13, C1, and baseline surface radiation network (BSRN) (sgpsirs1duttE13.c1, sgpsirs1duttC1.c1, and sgpbsrn1duttC1.c1), were all available. In 2001, the diffuse shortwave (SW) instruments were switched to shaded black and white instruments, and the name BSRN was switched to broadband radiometer station (BRS). Before that time, this VAP uses corrected diffuse SW from the DiffCorr1Dutt VAP as input. Table 1 lists the fields being calculated in this VAP and the input platforms involved. The 1-minute input data are compared to decide which will be used for averaging to get the best estimate. The output data are saved in two NetCDF files containing the best estimate values, quality control (QC) flags, and the difference fields. Figure 1 shows the beflux1long VAP logic flow.

<b>Table 1.</b> Best estimate fields and input platforms.	
<b>Field Names</b>	<b>Input Platforms</b>
Downwelling Shortwave Diffuse Hemispheric Irradiance	SIRS E13, C1, & BSRN/BRS
Shortwave Direct Normal Irradiance	SIRS E13, C1, & BSRN/BRS
Downwelling Shortwave Hemispheric Irradiance	Sum of Direct & Diffuse
Downwelling Longwave Hemispheric Irradiance	SIRS E13, C1, & BSRN/BRS
Upwelling Shortwave Hemispheric Irradiance	SIRS E13 & C1, MFR10M
Upwelling Longwave Hemispheric Irradiance	SIRS E13 & C1, IRT
Net Surface Radiation	(Downwelling SW - Upwelling SW) + (Downwelling LW - Upwelling LW)
Broadband Shortwave Surface Albedo	Upwelling/Downwelling SW
LW = longwave SW = shortwave	



**Figure 1.** Best estimate logic flow. Upper chart: diffuse and direct normal SW, and downwelling longwave (LW). Lower chart: upwelling LW and SW. The limits for each field are listed in Table 2.

**Table 2.** Best estimate limits and criteria used for data QC testing.

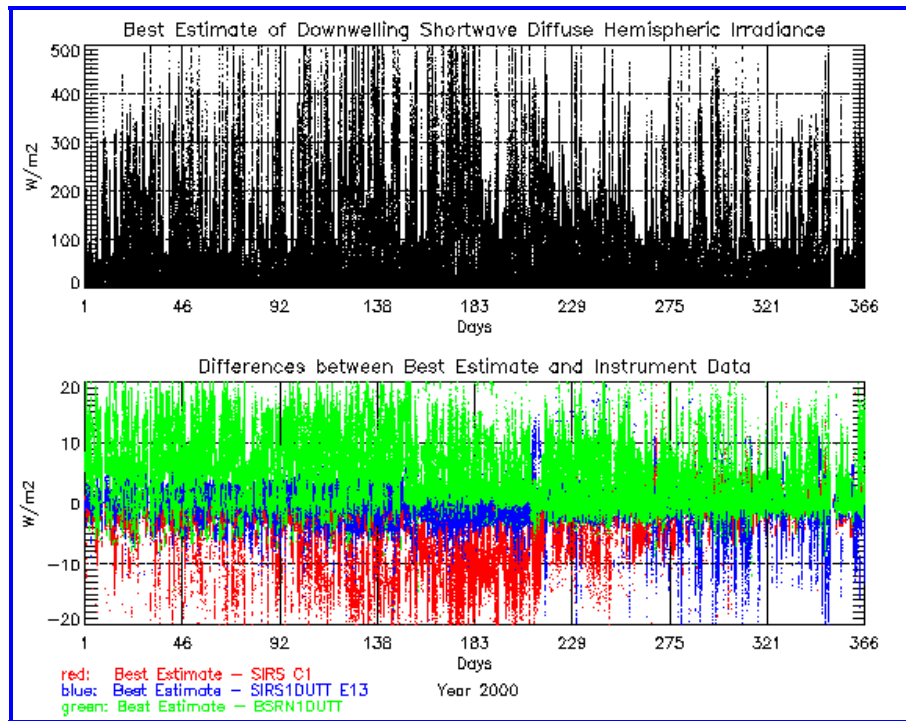
Field Name	Data to Meet Criteria (%)		Criteria	Data to Meet Criteria (%)		Criteria	Data to Meet Either Criteria (%)	
	1999	2000		1999	2000		1999	2000
Diffuse SW	54.8	54.3	Data difference <10%	93.6	86.1	Data difference <5 W/m <sup>2</sup>	99.6	99.9
Direct Normal SW	46.0	43.2	Data difference <5%	96.5	86.4	Data difference <5 W/m <sup>2</sup>	99.5	99.5
Downwelling LW	99.6	99.2	Data difference <2%	98.8	94.9	Data difference <5 W/m <sup>2</sup>	99.7	99.2
Upwelling SW	98.8	97.9	ABS (C1/E13-1) <0.2 for zenith <80	99.5	99.7	Data difference <10% or 5 W/m <sup>2</sup> for zenith ≥80	98.8	97.9
Upwelling LW	99.7	90.5	Data difference <4%	C1: 98.0	E13: 99.0	STD DEV <0.01	99.7	90.5

## Best Estimate and Differences Time Series

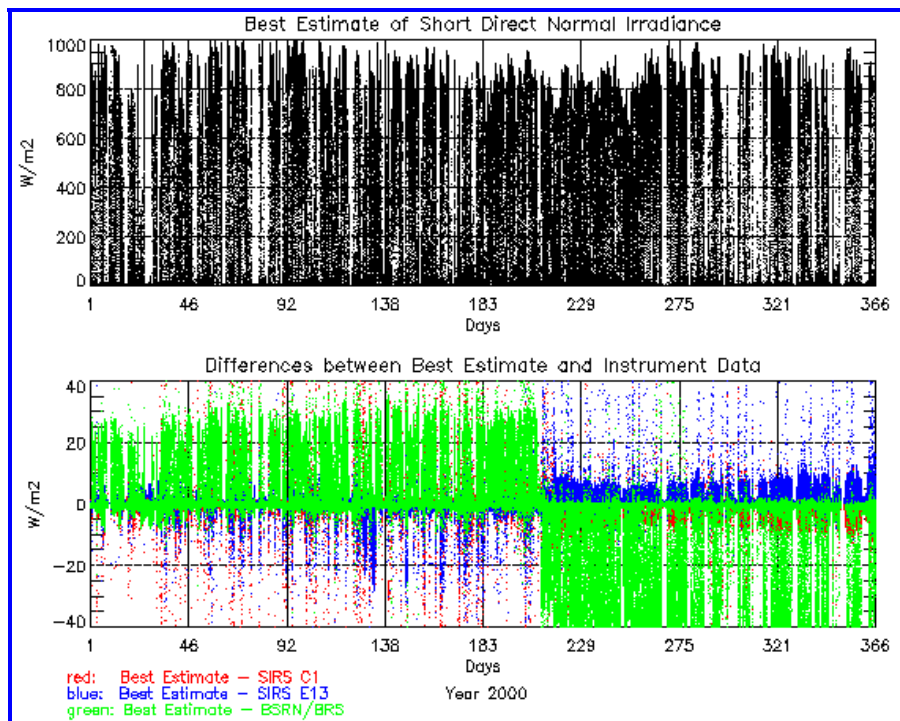
Figure 2 shows the best estimate and differences between the best estimate and instrument data for the diffuse SW, direct normal SW, upwelling SW, and downwelling and upwelling LW in the year 2000. The top plots of the pairs are the best estimate value of each field and the bottom plots are the differences between the best estimate and instrument data. For the diffuse SW, direct normal SW, and downwelling LW, three measurements from SIRS E13, C1, and BRS were used in the best estimate evaluation. In Figures 2a, 2b, and 2c the red curve shows the differences between best estimate and SIRS C1 data, the blue curve shows differences between best estimate and SIRS E13 data, and the green curve shows differences between best estimate and BRS data. Note: **SIRS1DUTT E13** and **BSRN1DUTT** marked on the plots indicate diffuse corrected data were used for platforms SIRS E13 and BRS. Since only two measurements from SIRS E13 and C1 are involved in the best estimate calculation of upwelling SW and LW, the difference plots (bottom part of Figures 2d and 2e) shown here are the differences between these two instruments.

## Cumulative Frequency of Instrument Differences

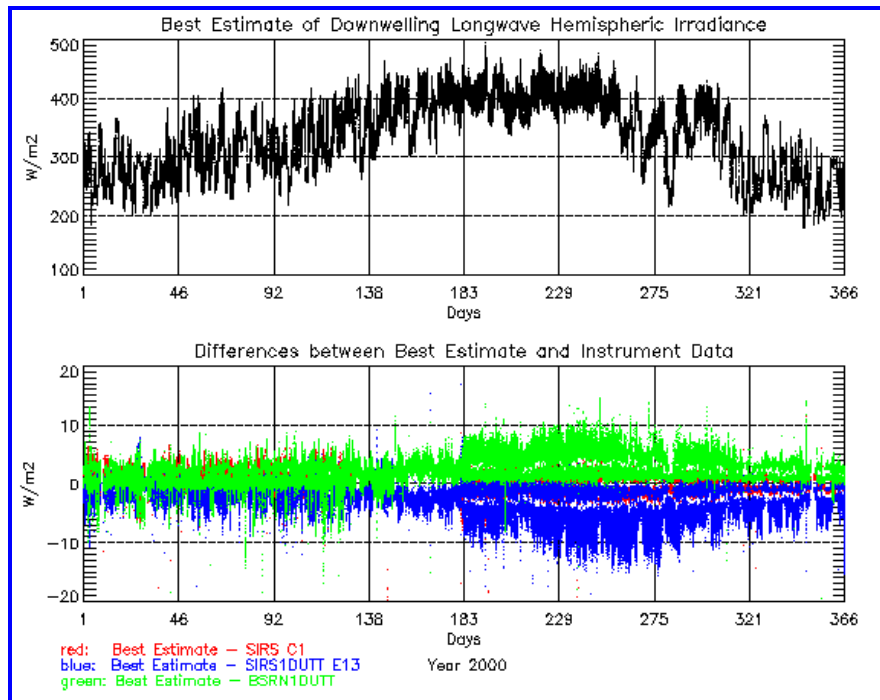
Figure 3 shows the cumulative frequency of instrument differences for Diffuse SW, Direct Normal SW, and Downwelling LW in the year 2000. The plots mark where the differences of the two instrument data reach the 95% level in Wm<sup>-2</sup>. Figure 3a shows the results for all the available data for, from left to right, the Diffuse SW, direct normal SW, and downwelling LW. Figure 3b shows the same results as 3a, but for QC Flag = 0. In this case, the best estimate is calculated by the average of BRS and SIRS E13 data. Figure 3c shows the same results for QC Flag = 1, when the best estimate is the average of BRS and SIRS C1. Figure 3d shows the case when QC Flag = 2 and the best estimate is the average of SIRS E13 and C1.



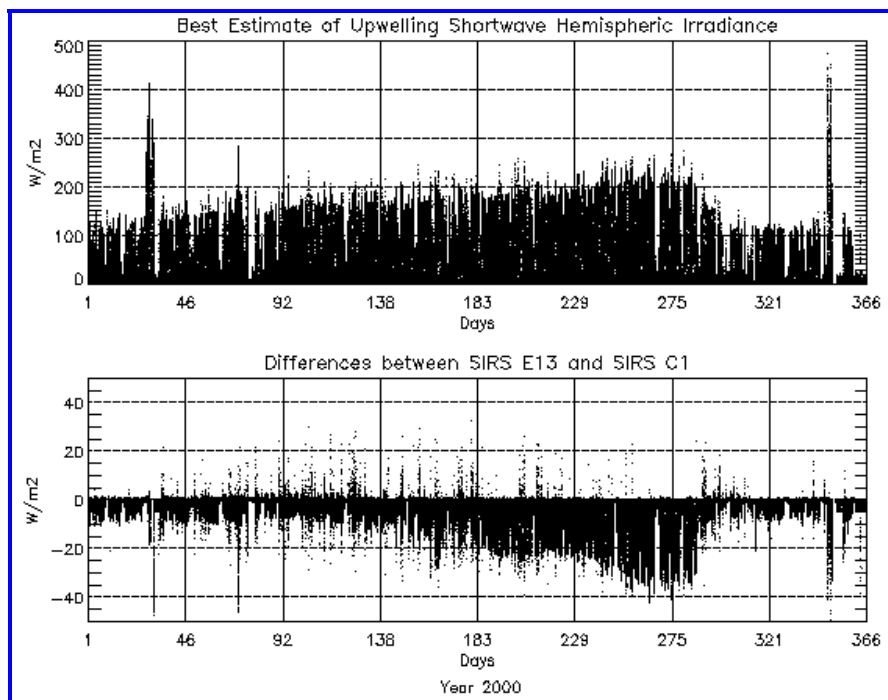
**Figure 2a.** Best estimate of diffuse SW (top plot) and differences between best estimate and instrument data (bottom plot), year 2000.



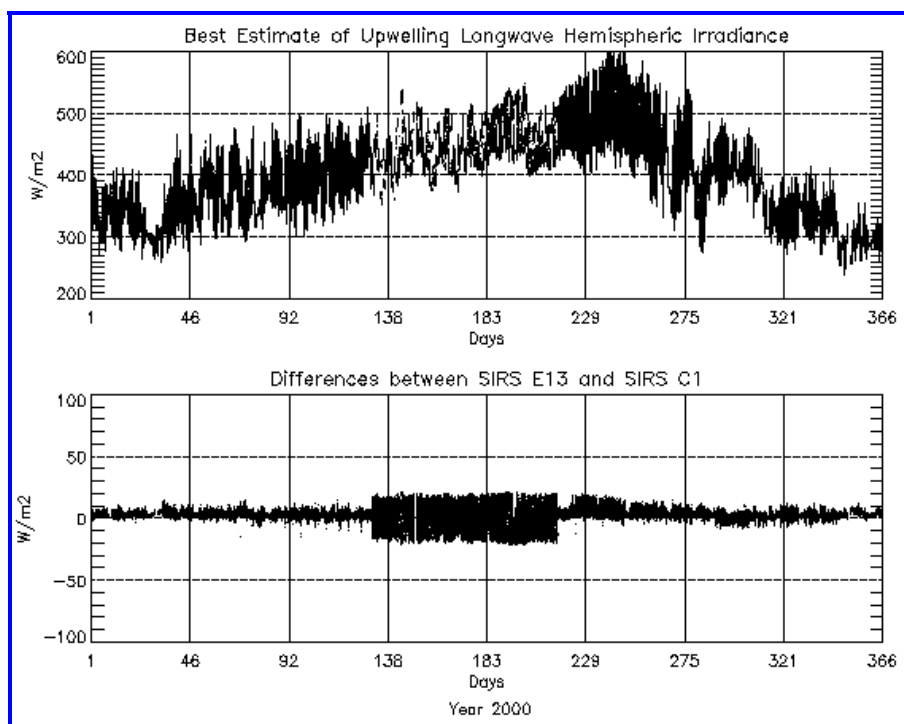
**Figure 2b.** Best estimate of direct normal SW (top plot) and differences between best estimate and instrument data (bottom plot), year 2000.



**Figure 2c.** Best estimate of downwelling LW (top plot) and differences between best estimate and instrument data (bottom plot), year 2000.



**Figure 2d.** Best estimate of upwelling SW (top plot) and differences between SIRS E13 and C1 (bottom plot), year 2000.



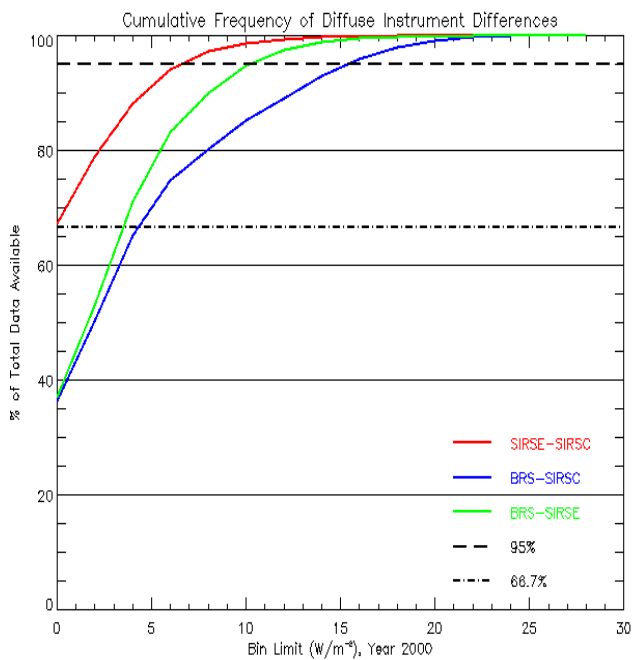
**Figure 2e.** Best estimate of upwelling LW (top plot) and differences between SIRS E13 and C1 (bottom plot), year 2000.

## Criteria/Limits Used in Best Estimate Calculation

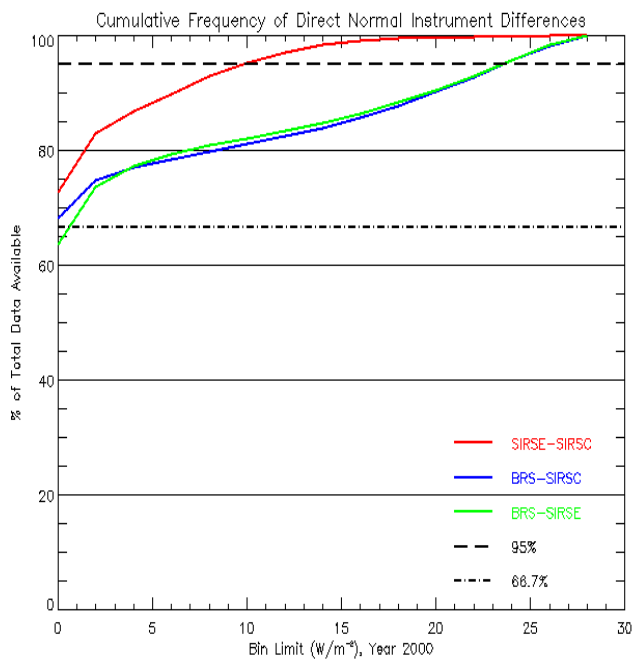
The criteria/limits used in the best estimate calculation were obtained by statistical analysis with two years of data in 1999 and 2000. Frequency distributions of agreement between the two that agreed the best over these two years were examined. In general, it was easy to pick out a percent or  $Wm^{-2}$  level where the agreement covered the “good” data, as shown in Table 2. For upwelling SW, only two instruments were used for these measurements and we do not have a third measurement as a reference. After comparing the two measurements from SIRS E13 and SIRS C1, we decided the ratio of these two measurements is the best indicator of data agreement during daytime (zenith < 80). For upwelling LW, the two measurements from SIRS E13 and C1 were compared with the downward facing infrared thermometer (IRT) measurement. The results show that the standard deviation of the ratio of brightness temperature calculated from the upwelling pyrgeometer over the corresponding downward facing IRT measurement is the best indicator of data agreement.

## Input Data Availability

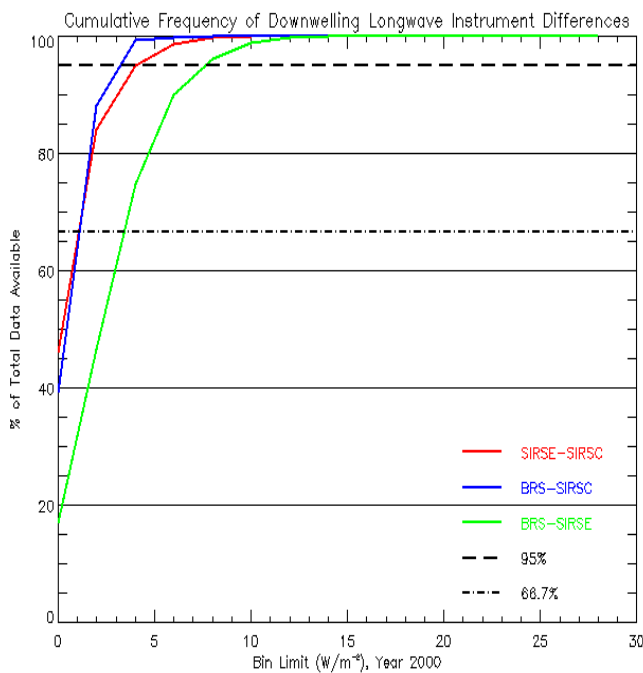
Figure 4 shows the percent of possible data available during daytime for SIRS E13, SIRS C1, and BRS spanning the years 1997 to 2001. For SIRS E13 (blue curve), the data availability varies from 94.5% in 1997 to 99.7% in 2000. For SIRS C1 (red curve), the data availability ranges from 93.9% in 1999 to 99.4% in 2001. BRS data (green curve) has the least data available, ranging from 82.7% in 2001 to 98.7% in 2000.



(1)

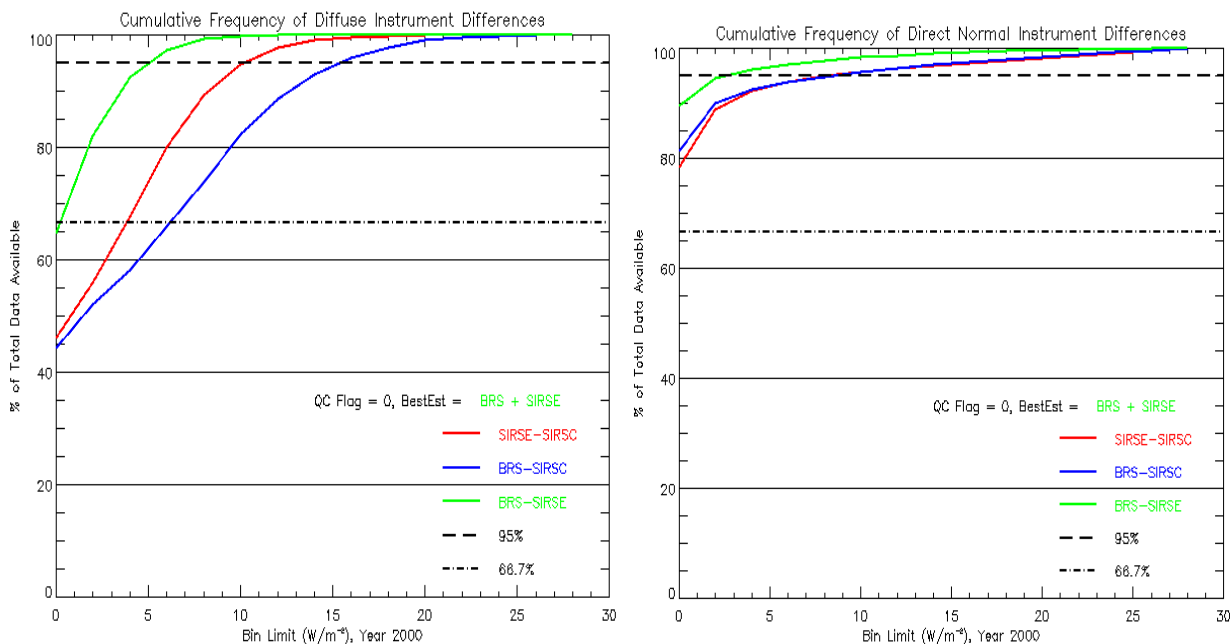


(2)



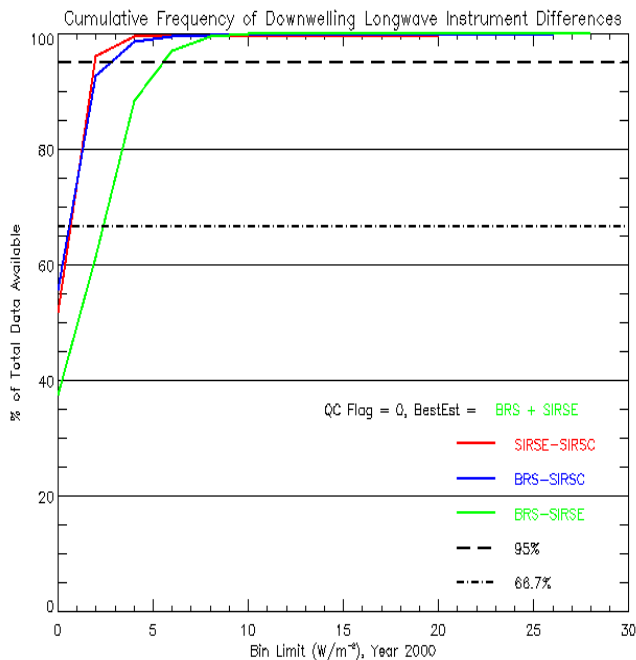
(3)

**Figure 3a.** Cumulative frequency of instrument differences for year 2000. (1) Diffuse SW; (2) Direct Normal SW; (3) Downwelling LW. Red: Differences between SIRS E13 and SIRS C1; Blue: Differences between BRS and SIRS C1; Green: Differences between BRS and SIRS E13.



(1)

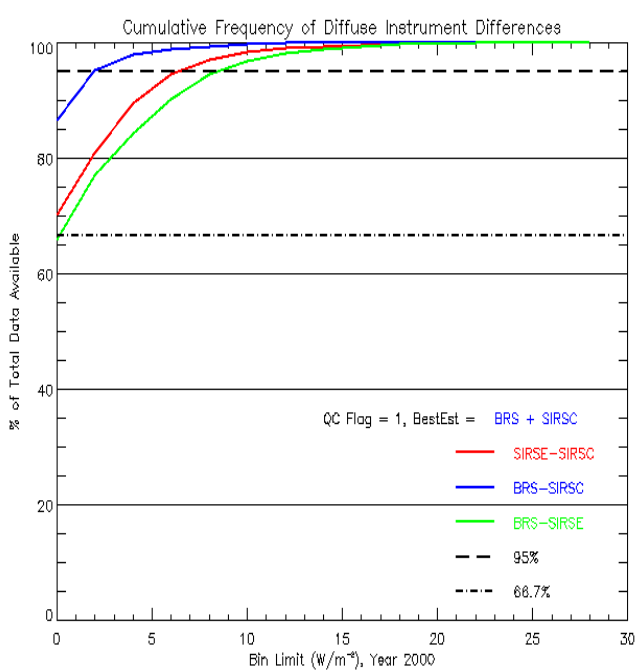
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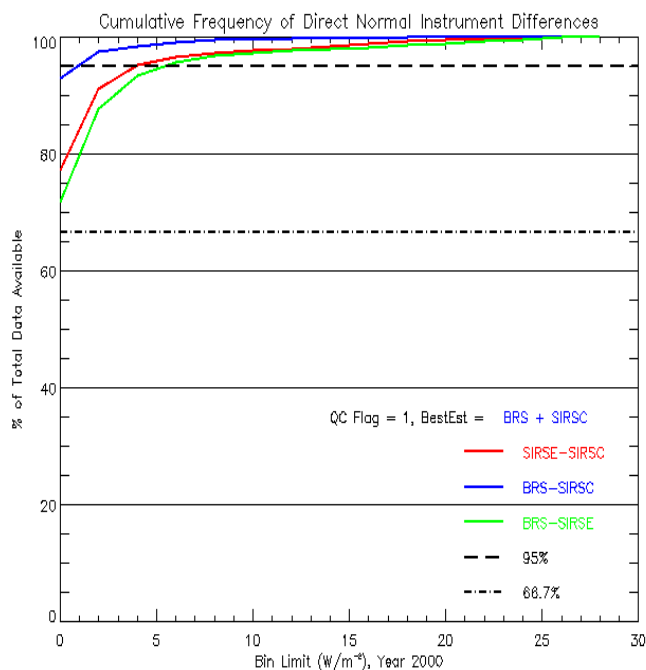
(3)

**Figure 3b.** Cumulative frequency of instrument differences for year 2000. (1) Diffuse SW; (2) Direct Normal SW; (3) Downwelling LW. QC Flag = 0, i.e., the best estimate is the average of BRS and SIRS E13, Red: Differences between SIRS E13 and SIRS C1; Blue: Differences between BRS and SIRS C1; Green: Differences between BRS and SIRS E13.

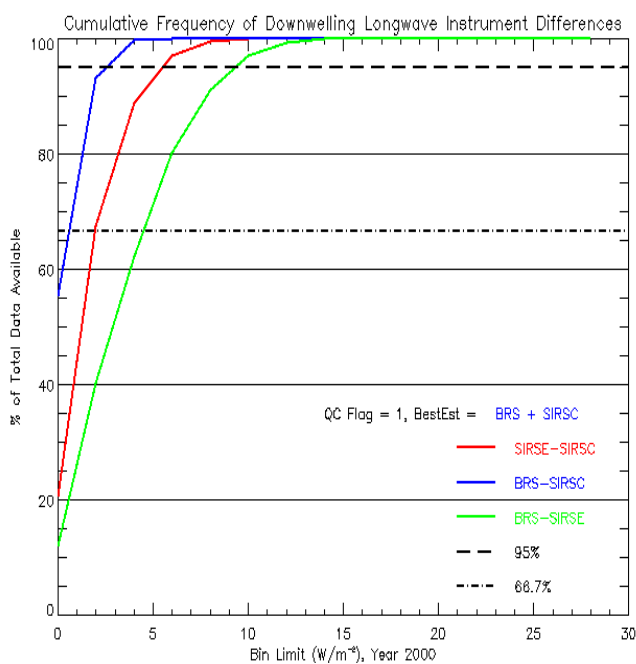




(1)

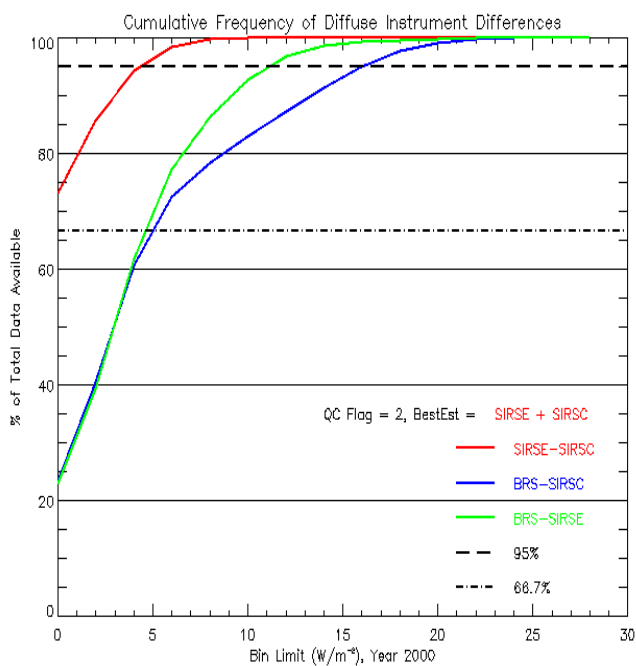


(2)

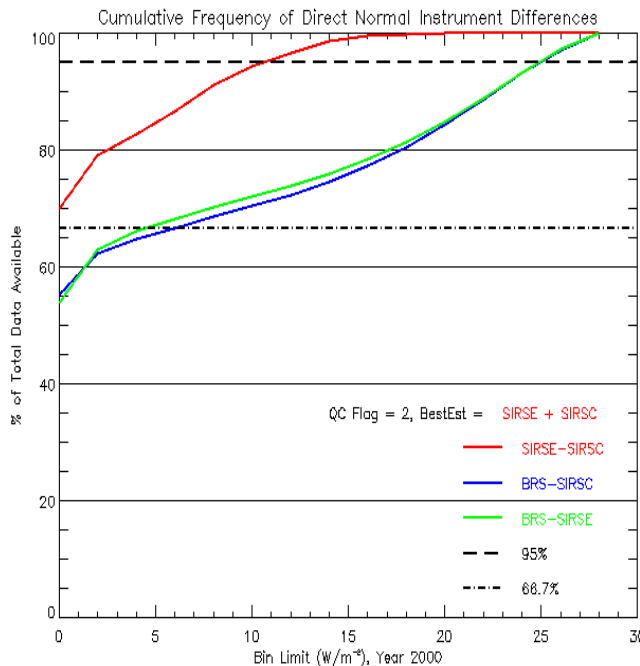


(3)

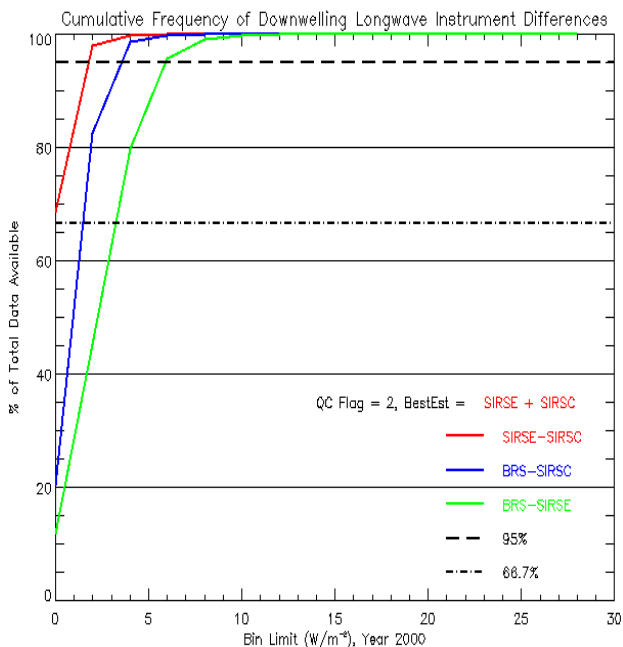
**Figure 3c.** Cumulative frequency of instrument differences for year 2000. (1) Diffuse SW; (2) Direct Normal SW; (3) Downwelling LW. QC Flag = 1, i.e., the best estimate is the average of BRS and SIRS C1, Red: Differences between SIRS E13 and SIRS C1; Blue: Differences between BRS and SIRS C1; Green: Differences between BRS and SIRS E13.



(1)



(2)



(3)

**Figure 3d.** Cumulative frequency of instrument differences for year 2000. (1) Diffuse SW; (2) Direct Normal SW; (3) Downwelling LW. QC Flag = 2, i.e., the best estimate is the average of SIRS E13 and C1, Red: Differences between SIRS E13 and SIRS C1; Blue: Differences between BRS and SIRS C1; Green: Differences between BRS and SIRS E13.

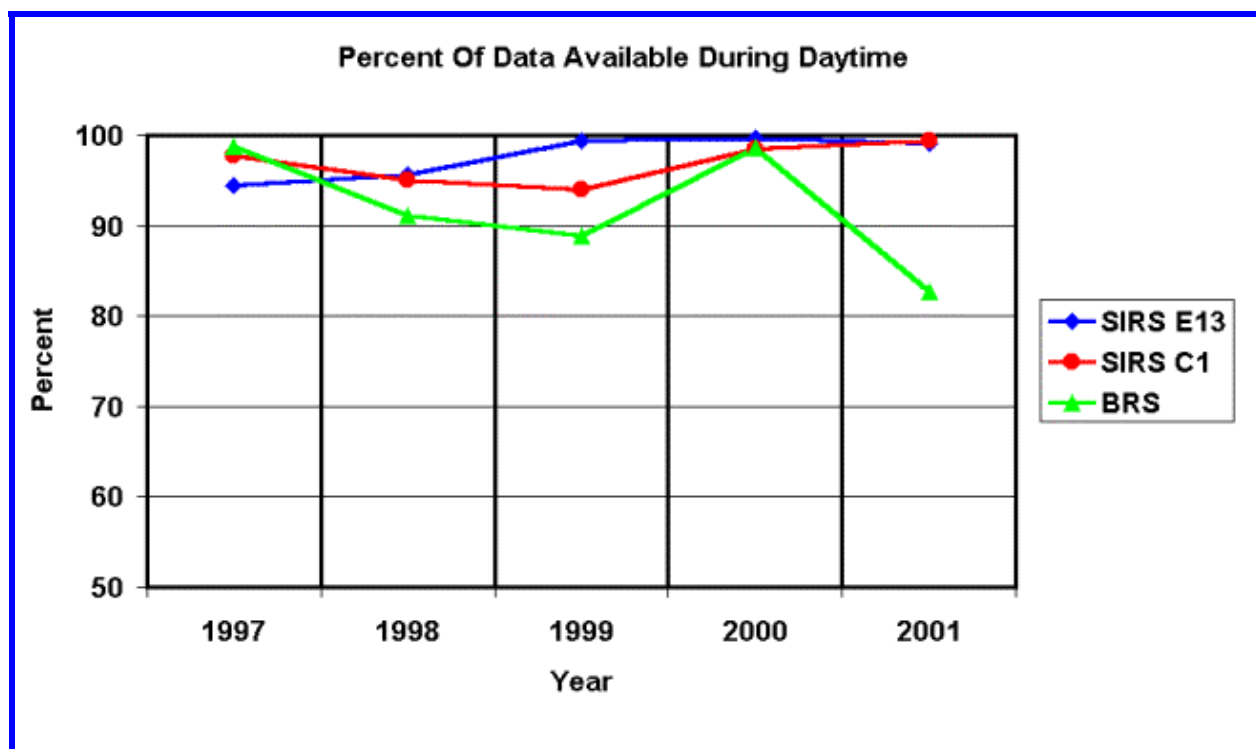


Figure 4. Percent of input data available by year and platform.

## Uncertainty Assessment

Table 4 is the summary of the 95% level agreement from 1997 to 2001. The accuracy estimates (Table 3) are based on calibration data, and represent how well we can calibrate these instruments. The values in Table 4 represent operational agreement from long-term field-deployed instruments. When added to the Ohmura et al. values, this represents the “accuracy” we can expect in our Archived data. “Best” is the best we can do, “Typical” is what one might expect on average for ARM extended facilities and BSRN data, while “Worst” is what one has to consider as the possible uncertainty of extended facility and BSRN data.

## Conclusion

The Best Estimate Flux VAP uses the data available from the three collocated surface radiometer platforms at the Southern Great Plains (SGP) CF to automatically determine the best irradiance measurements available. The comparative uncertainty of the resulting Best Estimate Fluxes approach the accuracy cited as the best possible for calibrating the instruments themselves (Ohmura et al. 1998).

**Table 3.** BSRN accuracy requirements and estimated capabilities. These errors are nonsystematic errors; they are estimated from standard deviations of the calibration coefficients (from Ohmura et al. (1987)).

Irradiance	Accuracy Requirement Set in 1990 ( $\text{Wm}^{-2}$ )	Estimated Capability ( $\text{Wm}^{-2}$ )	
		1990	Achieved by 1995
Global Irradiance	5	15	5
Direct Solar Irradiance	2	3	2
Diffuse Sky Irradiance	5	10	5
Longwave Down Irradiance	20	30	10

**Table 4.** Summary of the 95% level agreement from 1997 – 2001.

	Best	Typical	Worst
Diffuse SW	$4.0 \pm 1.4$	$9.0 \pm 3.1$	$12.0 \pm 3.8$
Direct Normal SW	$6.3 \pm 3.3$	$13.6 \pm 6.3$	$15.0 \pm 6.7$
Downwelling LW	$3.1 \pm 0.4$	$5.1 \pm 1.2$	$7.1 \pm 1.4$
Upwelling SW	$11.1 \pm 2.8$		
Upwelling LW	$9.6 \pm 3.0$		

Our analysis during development of the VAP required an assessment of typical agreement between the collocated radiometers to determine agreement limits for data QC. The results of this analysis serve as an assessment of the added uncertainty (in addition to the calibration accuracy) of long-term field-operated BSRN-type systems. This “operational uncertainty” is about 4 to 6 times the values (Ohmura et al. 1998) for the diffuse and direct normal SW, and about half the (Ohmura et al. 1998) value cited for the downwelling LW.

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## Reference

Ohumra et al., 1998; BAMS **79**:10, 2115-2136.