

Surface Cloud Grid (SfcCldGrid) Value-Added Product: Algorithm Operational Details and Explanations

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Contents

1.	Introduction.....	1
2.	Input Data.....	2
3.	Configuration Files	3
3.1	SFCCLDGRID1LONG_main.info	3
3.2	SFCCLDGRID1LONG_retriever.info.....	3
3.3	SFCCLDGRID1LONG_maker.info	4
3.4	Configuration File (Optional)	5
4.	Algorithm.....	8
5.	Criteria/Limits.....	9
5.1	Stations.....	9
5.2	Fraction Sky Cover	9
5.3	Ratio of Measure over Clear-Sky Total SW Down	10
5.4	Ratio of Measure over Clear-Sky Direct SW Down.....	10
5.5	Ratio of Measure over Clear-Sky (Direct+Diffuse) SW Down.....	10
5.6	Estimated Clear-Sky Fit Total SW Down.....	10
5.7	Estimated Clear-Sky Fit Direct SW Down	10
6.	Data QC Tests and QC Flags.....	10
7.	Output Files.....	10
8.	Results.....	11
9.	Analysis: Uncertainty Assessment.....	18
10.	Summary	19
11.	References.....	20

Figures

1. The logic/data flow for the sfcldgrid1long VAP.....	9
2. Fractional sky cover.....	12
3. The ratio of measured over clear-sky total SW down.....	13
4. The ratio of measured over clear-sky direct SW down.....	14
5. The ratio of measured over clear-sky (direct+diffuse) SW down.....	15
6. The estimated clear-sky fit total SW down.....	16
7. The estimated clear-sky fit direct SW down.....	17

Tables

1. Field name and description retrieved from the input netCDF files.	3
2. Field names, units, and description for sgp15swfeldfac1longN1.c1.yyyymmdd.hhmmss.cdf files.	4
3. Field names, units, and description for sgp15swfeldgrid1longN1.c1.yyyymmdd.hhmmss.cdf files.....	5
4. Production of components of downwelling SW from output grids.....	18
5. Yearly average grid difference between normal and site omitted runs.	18
6. Weekly average grid difference between normal and site omitted runs.....	18
7. Daily average grid difference between normal and site omitted runs.	19
8. Hourly average grid difference between normal and site omitted runs.....	19
9. 15-min. average grid difference between normal and site omitted runs.....	19

Surface Cloud Grid (SfcCldGrid) Value-Added Product: Algorithm Operational Details and Explanations

1. Introduction

This document describes the algorithm used for the Surface Cloud Grid Value-Added Product (VAP). This VAP uses as input the 15-min. output from the Shortwave (SW) Flux Analysis VAP (see Long 2001; Long and Ackerman 2000; Long et al. 1999) from the Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) Southern Great Plains (SGP) Central Facility and extended facilities. This network of 21 sites is unevenly spaced over northern Oklahoma into southern Kansas, covering an area from 95.5° to 99.5° west longitude and 34.5° to 38.5° north latitude. For research applications such as single-column modeling, an estimate of the cloud and cloud effects distribution over this entire domain is desirable. The Surface Cloud Grid VAP applies a multi-pass weighted sum analytic approximation technique (Caracena 1987), which uses Gaussian weighting and an imposed scale length, to interpolate to a 0.25° by 0.25° lat/long grid over the SGP domain. The output, like the input, includes solar elevation angles of 10° or greater.

The Surface Cloud Grid VAP produces gridded output for cloud fraction, the ratio of measured over clear-sky SW total (both unshaded pyranometer and sum of direct+diffuse) and direct irradiance, the estimated clear-sky fit total SW irradiance, and the estimated clear-sky fit direct SW irradiance. The ARM SGP extended facilities are not maintained as well as the Central Facility. The clear-sky irradiance accuracy is dependent on the instruments, but does include climatological column water vapor and aerosol effects. In practice, because the direct and diffuse measurements are dependent on a tracking system and two separate instruments, the unshaded pyranometer ratio data is sometimes more consistent. On the other hand, the sum of the direct+diffuse SW is recognized as the more accurate measurement of the two, given good performance of the tracker and the two instruments used for the measurements. The ratio of measured over clear-sky direct SW, in conjunction with the total SW ratio and clear-sky total and direct irradiance, allows for component evaluation of the irradiance and cloud effects.

These output variables were chosen because the intent is to use the Surface Cloud Grid VAP output for model comparisons, as well as climatological and statistical research. As is shown in Long and Ackerman (2000), using the ratio of measured over clear-sky fit SW irradiance effectively removes instrument characteristics such as cosine response errors and calibration drifts. This same ratio can be produced with a model, (i.e., the ratio of cloudy model calculations over cloudless model calculations) thus eliminating model-measurement discrepancies in the comparison. Comparisons with the Surface Cloud Grid VAP output allow one to effectively separate the problem into the following three components:

1. Do the model and measurements agree (the clear-sky case is the “easiest”)?
2. Do the model and measured cloud amounts agree (i.e. are the model cloud predictions right)?
3. If the model can generate the proper amount of clouds in the correct places, then does the model produce the right cloud properties and treat the clouds correctly (i.e., do the cloudy/clear ratios agree)?

2. Input Data

The input data for this VAP are standard ARM netCDF files created from the SW Flux Analysis VAP, the current Solar Infrared Station (SIRS) data, and the historical Solar and Infrared Observing Station (SIROS) data. Data for these platforms are only available during daylight, which implies that the netCDF files contain more samples during the summer months when daylight periods are longer.

The algorithm uses a technique to calculate the value used at the Central Facility where three stations (i.e., `sgp15swfanalsirs1longC1.c1`, `sgp15swfanalsirs1longE13.c1`, and `sgp15swfanalbsrn1longC1.c1`) are available. If all three stations report, we take the average of the closest two values. If only two stations report, then we use the average. Otherwise, use the only station that reports a value. (Note: These data have already had data quality control (QC) applied during processing by the SW Flux Analysis VAP. See Long 2001 for details.) The input netCDF files contain 15-min. data. To produce gridded data, values from at least 15 different locations must be present (with the Central Facility counting as one). Because of this last limitation, the VAP only produces output starting in 1997, when there were sufficient extended facilities installed to fairly consistently have at least 15 locations available.

The input files involved in this VAP are as follows:

- (1) `sgp15swfanalbsrn1longC1.c1`¹ – used to determine value for Central Facility
- (2) `sgp15swfanalsirs1longC1.c1`¹ – used to determine value for Central Facility
- (3) `sgp15swfanalsirs1longE1.c1`² – always used (if data exists)
- (4) `sgp15swfanalsirs1longE2.c1`² – always used (if data exists)
- (5) `sgp15swfanalsirs1longE3.c1`² – always used (if data exists)
- (6) `sgp15swfanalsirs1longE4.c1`² – always used (if data exists)
- (7) `sgp15swfanalsirs1longE5.c1`² – always used (if data exists)
- (8) `sgp15swfanalsirs1longE6.c1`² – always used (if data exists)
- (9) `sgp15swfanalsirs1longE7.c1`² – always used (if data exists)
- (10) `sgp15swfanalsirs1longE8.c1`² – always used (if data exists)
- (11) `sgp15swfanalsirs1longE9.c1`² – always used (if data exists)
- (12) `sgp15swfanalsirs1longE10.c1`² – always used (if data exists)
- (13) `sgp15swfanalsirs1longE11.c1`² – always used (if data exists)
- (14) `sgp15swfanalsirs1longE12.c1`² – always used (if data exists)
- (15) `sgp15swfanalsirs1longE13.c1`¹ – used to determine value for Central Facility

- (16) **sgp15swfanalsirs1longE15.c1²** – always used (if data exists)
- (17) **sgp15swfanalsirs1longE16.c1²** – always used (if data exists)
- (18) **sgp15swfanalsirs1longE18.c1²** – always used (if data exists)
- (19) **sgp15swfanalsirs1longE19.c1** – always used (if data exists)
- (20) **sgp15swfanalsirs1longE20.c1²** – always used (if data exists)
- (21) **sgp15swfanalsirs1longE22.c1²** – always used (if data exists)
- (22) **sgp15swfanalsirs1longE24.c1²** – always used (if data exists)
- (23) **sgp15swfanalsirs1longE25.c1** – always used (if data exists)

¹ Indicates that only one value is used for the Central Facility.

² Indicates that historical SIROS platforms can be used in place of the current SIRS.

This VAP uses Bozzel Works (BW) library, which standardizes input and output between automated procedures and the netCDF files. It is a standard library used by developers in the ARM Experiment Center and External Data Center.

The desired fields from each input file are listed in the SFCCLDGRID1LONG_retriever.info file described in the next section. All the above files can be ordered online from the ARM Data Archive Center (<http://www.archive.arm.gov>).

3. Configuration Files

The following three configuration files for this VAP are used.

- SFCCLDGRID1LONG_main.info
- SFCCLDGRID1LONG_retriever.info
- SFCCLDGRID1LONG_maker.info

3.1 SFCCLDGRID1LONG_main.info

The default is for the file to contain “measurement.” This file is hardly edited.

3.2 SFCCLDGRID1LONG_retriever.info

This file specifies what input platforms and fields should be retrieved by the VAP. The fields retrieved for all platforms (including historical data) are listed in Table 1.

Table 1. Field name and descriptions retrieved from the input netCDF files.	
Field Name	Description
cloudfraction	Estimated average fractional sky cover over the hemispheric dome.
gswfluxdn_measured	Measured downwelling global SW irradiance.
gswfluxdn_clearskyfit	Clear-sky fit estimated downwelling global SW irradiance.
dirfluxdn_measured	Measured downwelling direct SW irradiance.

Table 1. (cont'd)	
Field Name	Description
dirfluxdn_clearskyfit	Clear-sky fit estimated downwelling direct SW irradiance.
sswfluxdn_measured	Measured downwelling summed SW irradiance (direct + diffuse).
sswfluxdn_clearskyfit	Clear-sky fit estimated downwelling summed SW irradiance (direct + diffuse).

3.3 SFCCLDGRID1LONG_maker.info

This file describes the format for the two output files generated by the VAP, including filename, fields, and attributes (global or field). The output platforms created are sgp15swfldfac1longN1.c1.yyyymmdd.hhmmss.cdf and sgp15swfldgrid1longN1.c1.yyyymmdd.hhmmss.cdf. (See Section 4 for more details about the contents of these two output files.) Table 2 lists the field names, along with their respective units and descriptions, for sgp15swfldfac1longN1.c1.yyyymmdd.hhmmss.cdf netCDF files. Table 3 is similar to Table 2, but for the sgp15swfldgrid1longN1.c1.yyyymmdd.hhmmss.cdf netCDF files.

Table 2. Field names, units, and descriptions for sgp15swfldfac1longN1.c1.yyyymmdd.hhmmss.cdf files.		
Field Name	Units	Description
base_time	Seconds since 1970-1-1 0:00:00 0:00	
time_offset	Seconds	time offset from base_time
time	seconds	time offset from midnight
cloudfraction	unitless	fractional Sky cover
tswfluxdn	unitless	ratio of measured over clear-sky total SW down
dirfluxdn	unitless	ratio of measured over clear-sky direct SW down
sswfluxdn	unitless	ratio of measure over clear-sky (direct + diffuse) SW down
clrfluxdn	W/m ²	estimated clear-sky fit total SW down
cdirfluxdn	W/m ²	estimated clear-sky fit direct SW down
lat	degrees	north latitude for all input platforms
lon	degrees	east longitude for all input platforms
Alt	meteres	altitude
Plat	unitless	abbreviated names of the stations

Table 3. Field names, units, and descriptions for sgp15swfclldgrid1longN1.c1.yyyymmdd.hhmmss.cdf files.

Field Name	Units	Description
base_time	Seconds since 1970-1-1 0:00:00 0:00	
time_offset	seconds	time offset from base_time
time	seconds	time offset from midnight
cloudfraction	unitless	fraction Sky Cover
tswfluxdn	unitless	ratio of measured over clear-sky total SW down
dirfluxdn	unitless	ratio of measured over clear-sky direct SW down
sswfluxdn	unitless	ratio of measure over clear-sky (direct + diffuse) SW down
clrfluxdn	W/m ²	estimated clear-sky fit total SW down
cdirfluxdn	W/m ²	estimated clear-sky fit direct SW down
lat	degrees	north latitude of grid points
lon	degrees	east longitude of grid points
azimuth	degrees	solar azimuth referenced to the Central Facility
alt	meters	altitude

3.4 Configuration File (Optional)

An additional and optional feature to the sfccldgrid1long VAP is running the program without using the command-line options. This VAP has more command-line options than usual, which allows the user to customize the VAP without having to recompile the source code.

The configuration file should be named sfccldgrid1long.cnf and placed in the directory \$VAP_HOME/conf. The format for this file is <key>=value. Lines that begin with '#' are considered to be comment lines and are omitted. You can have as many comments as you would like, before, between, and after valid lines. To use the configuration file, the user should run the VAP without any command-line options (e.g., 'sfccldgrid1long'). If no arguments are specified, the VAP looks in the appropriate directory for a configuration file; if it finds one, it begins to process the file else it aborts the program abnormally without causing any core dumps.

The <key>s should be followed by an '=' with or without any blank spaces followed by the value. <key>s that are not valid will not cause any harm to the program and its values are discarded. Valid keys are listed below with their proper use in the configuration file and corresponding command-line argument.

1. scale=value

This key corresponds to the scale length in kilometers.

The default is 100 km. To set this value to 150, you can use the following:

scale=150

Command-line argument: -l 150

2. pass={m,o}

The default value is m for “multi-pass” as opposed to o for “optimal.” In order to use type of pass as optimal, the user should use:

pass=o

Command-line argument: -p o

3. npass=value

This value indicates to the VAP how many passes to use if using “multi-pass.” The default value is 16.

Valid values are: 1,2,3,4,8,16,32. To use 4 passes, use:

npass=4

Command-line argument: -n 4

4. minimum=value

This key corresponds to the minimum number of stations necessary to create grid data.

The default value is 15.

To have at least 12 stations present, use:

minimum=12

Command-line argument: -m 12

5. max_cf=value

This key changes the maximum allowable value to use for the cloudfraction variable. To change the max value to 1.1 use:

max_cf=1.1

Command-line argument: -f 1.1

6. max_tsw=value

This key changes the maximum allowable value to use for the ratio of measured clear-sky total short wave down variable.

To change the max value to 1.3 use:

max_tsw=1.3

Command-line argument: -t 1.3

7. max_ssw=value

This key changes the maximum value to use for the ratio of measured over clear-sky (direct + diffuse) short wave down variable. To change the max value to 1.5 use:

max_ssw=1.5

Command-line argument: -w 1.5

8. max_dir=value

This key changes the maximum value to use for the ratio of measured over clear-sky direct short wave down variable. To change the max value to 1.45 use:

max_dir=1.45

Command-line argument: -r 1.45

9. max_clr=value

This key changes the maximum value to use for the estimated clear-sky fit total short wave down variable.

To change the max value to 1450 use:

max_clr=1450

Command-line argument: -c 1450

10. max_cdir=value

This key changes the maximum value to use for the estimated clear-sky fit direct short wave down variable.

To change the max value to 1450 use:

max_clr=1450

Command-line argument: -c 1450

11. date=value

This specifies the day to run the VAP on. If using a configuration file, this variable has to be present otherwise the VAP will not read in any data files.

The value for this is in the form of: [yy]yymmdd.

To run on October 12, 1999 use:

date=19991012 or date=991012

Command-line argument: -d 19991012 or -d 991012

12. text=value*

Enabling this option causes the VAP to create text files corresponding to the netCDF files that are generated. This value is disabled by default.

To enable this option, use:

text=1

Command-line argument: -T

13. plot_only=value*

This option intends to create quick-look images only without processing any data. This option is disabled by default. To enable, use:

plot_only=1

Command-line argument: -P

14. quicklook=value*

This disables the VAP from creating quick-look images. This option is generally enabled by default. To disable, use:

quicklook=1

Command-line argument: -N

15. use_x=value*

This key causes the VAP to use the X device for the quick-look images instead of creating png or mng images.

To set this value, use:

use_x=1

Command-line argument: -X

* Any values used set the corresponding keys.

Note that not all command-line options have valid keys in the configuration file.

4. Algorithm

The SFCCLDGRID1LONG VAP uses a 2-pass technique to produce grid data. During the first pass, the VAP retrieves the data from the input platforms and performs the necessary calculations. Then, valid samples containing the minimum number of stations are captured into a netCDF file called sgp15swfcldfac1longN1.c1.yyyymmdd.hhmmss.cdf. The set of data created during this pass is better known as “trim” data. During the second pass, the VAP processes the “trim” data to create “grid” data and captures this output dataset in the netCDF file, sgp15swfeldgrid1longN1.c1.yyyymmdd.hhmmss.cdf. See Section 1 for more information on the logic used to create “grid” data.

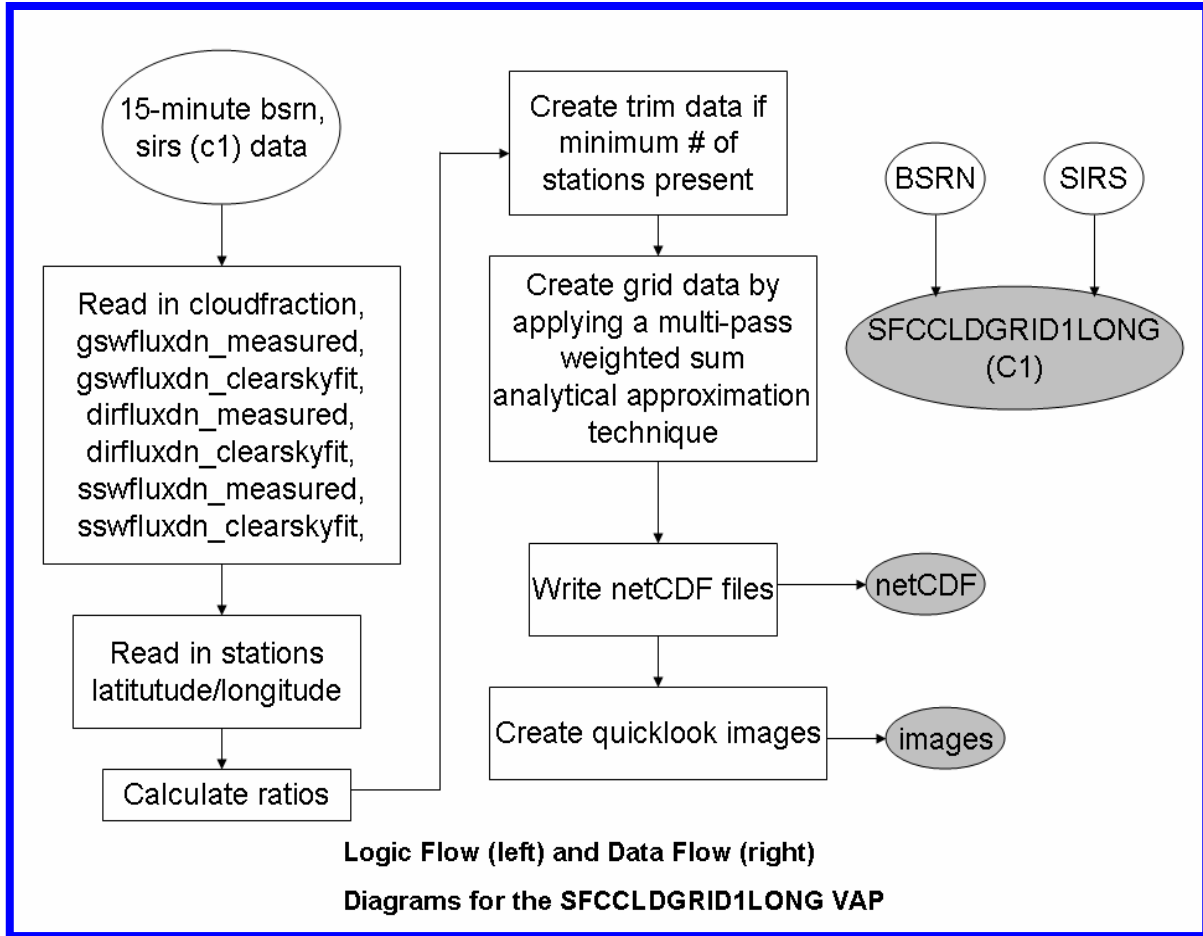


Figure 1. The logic/data flow for the sfccldgrid1long VAP.

After the grid data is produced, the VAP uses Interactive Data Language (IDL) to create contour plots for the newly created “grid” data and capture the results as Portable Network Graphics (png). The png images are then used to create Multi-image Network Graphics (mng) animations.

5. Criteria/Limits

5.1 Stations

At least 15 different locations must be present for a successful run of the VAP. Keep in mind that there are three instruments collocated at the Central Facility, but only one value will be used.

5.2 Fraction Sky Cover

Values greater than 1.0 or less than 0.0 are treated as missing data.

5.3 Ratio of Measure over Clear-Sky Total SW Down

Values that are greater than 25% of the maximum of 1.1 are truncated to the maximum. This allows for slight inaccuracy of the clear-sky fitting, and periods of moderate positive cloud forcing; to be included in the gridded output. Values greater than an additional 25% of the maximum of 1.1 or less than 0.0 are treated as missing data.

5.4 Ratio of Measure over Clear-Sky Direct SW Down

Values that are greater than 25% of the maximum of 1.1 are truncated to the maximum. This allows for slight inaccuracy of the clear-sky fitting to be included in the gridded output. Values greater than an additional 25% of the maximum of 1.1 or less than 0.0 are treated as missing data.

5.5 Ratio of Measure over Clear-Sky (Direct+Diffuse) SW Down

Values that are greater than 25% of the maximum of 1.1 are truncated to the maximum. This allows for slight inaccuracy of the clear-sky fitting, and periods of moderate positive cloud forcing, to be included in the gridded output. Values greater than an additional 25% of the maximum of 1.1 or less than 0.0 are treated as missing data.

5.6 Estimated Clear-Sky Fit Total SW Down

Values that are greater than an additional 25% of the maximum of 1300 are truncated to the maximum. Values greater than that or less than 0.0 are treated as missing data.

5.7 Estimated Clear-Sky Fit Direct SW Down

Values that are greater than an additional 25% of the maximum of 1300 are truncated to the maximum. Values greater than that or less than 0.0 are treated as missing data.

6. Data QC Tests and QC Flags

The data used in the Surface Cloud Grid VAP underwent various QC assessments in the SW Flux Analysis VAP (see Long 2001; Long and Ackerman 2000; Long et al. 1999). One example of a QA assessment is a maximum/minimum test. Other examples include sophisticated tests that lend assurance of data quality.

7. Output Files

The Surface Cloud Grid VAP produces two sets of 15-min. resolution output files. One file, called the `sgp15swfclfac1longN1.c1.yyyymmdd.hhmmss.cdf`, contains data with at least the

minimum number of stations required to produce the gridded results. The other file called the `sgp15swfeldgrid1longN1.c1.yyyymmdd.hhmmss.cdf`, contains the aforementioned gridded data over the entire SGP site.

The output files for this VAP have the following format:

```
sgp15swfeldfac1longN1.c1.yyyymmdd.hhmmss.cdf
sgp15swfeldgrid1longN1.c1.yyyymmdd.hhmmss.cdf
```

where:

`yyymmdd` represents the date of the run; `yyyy` is the 4-digit year, `mm` and `dd` are the 2-digit month and day, respectively.

`hhmmss` represents the time of day for the run; `hh`, `mm`, `ss` represent the 2-digit hour, minute, and seconds, respectively.

The output fields, units and descriptions are listed in Section 3.3, “`SFCCLDGRID1LONG_maker.info`”

8. Results

The plots below are sample quick-look images for each of the scientific quantities generated during the Surface Cloud Grid VAP for September 19, 2000, at 1500 Universal Time Coordinates (UTC). In the following figures, a “red” filled circle represents the Central Facility. An open “green” circle indicates that the particular facility did not report any data for that particular time sample. A filled “green” circle indicates the facility was present for the time sample and reported data. In Figure 2, the shaded “cyan” areas represent where the cloud fraction was 0.0, while the shaded “gray” areas represent overcast conditions. In Figures 3, 4, and 5, the shaded “gray” areas represent areas where the respective ratios were 1.0. The filled “yellow” circles in Figure 6, indicate the solar azimuth referenced to the Central Facility. Figure 2 shows an image of the fractional sky cover, Figure 3 shows the ratio of measured over clear-sky total SW down, Figure 4 shows the ratio of measured over clear-sky direct SW down, Figure 5 shows the ratio of measured over clear-sky (direct+diffuse) SW down, Figure 6 shows the estimated clear-sky fit total SW down, and Figure 7 shows the estimated clear-sky fit direct SW down.

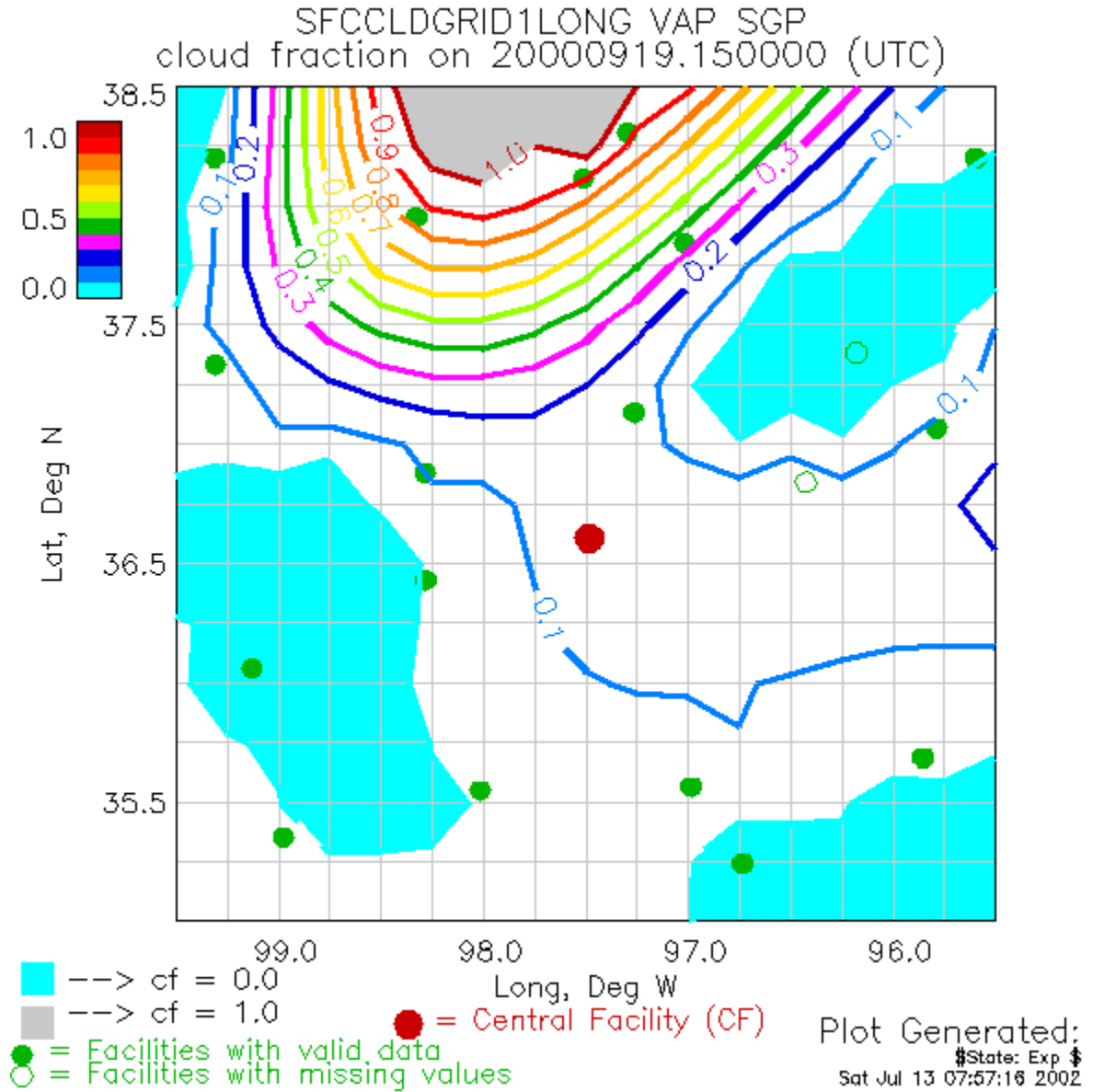


Figure 2. Fractional sky cover.

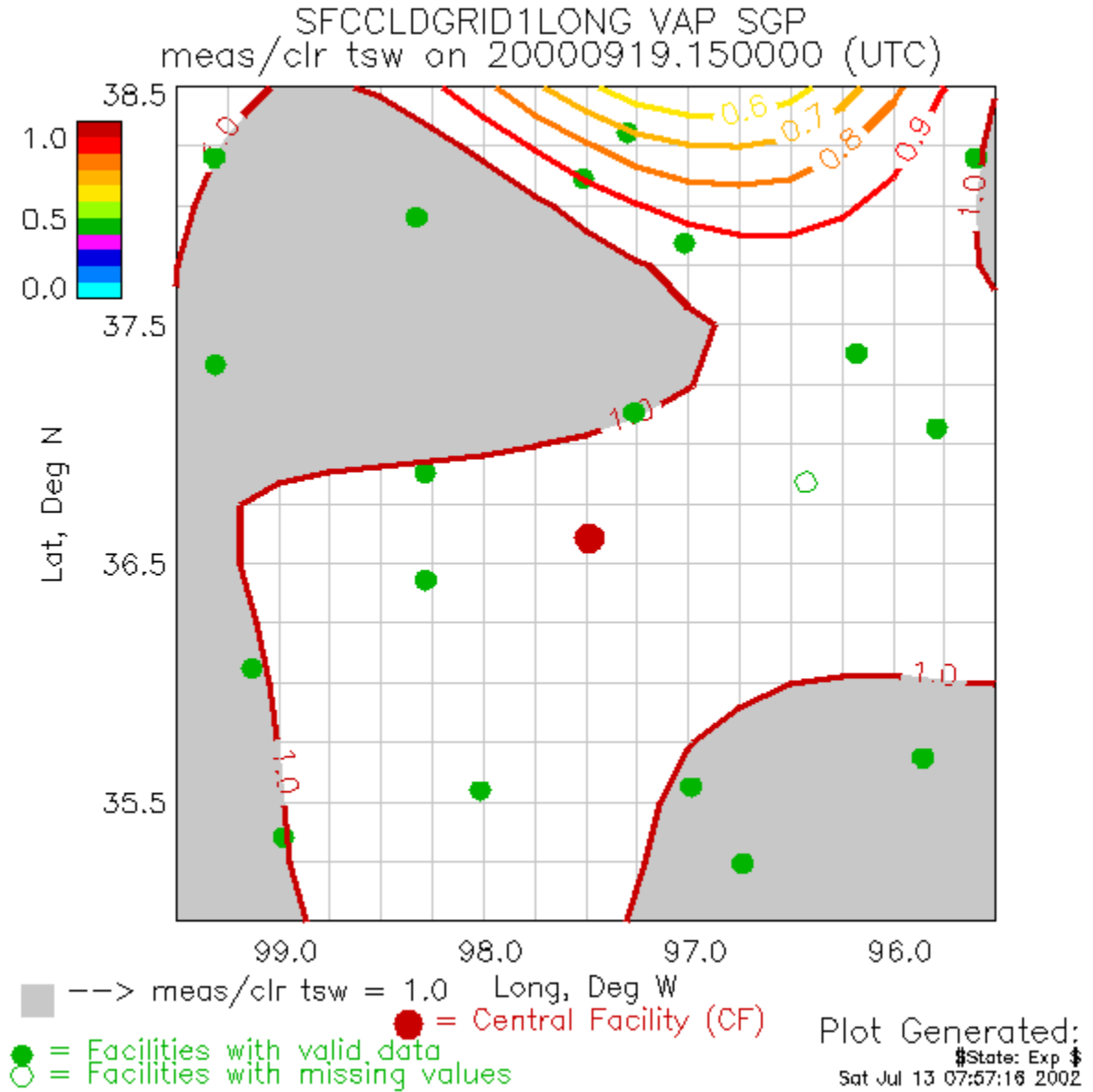


Figure 3. The ratio of measured over clear-sky total SW down.

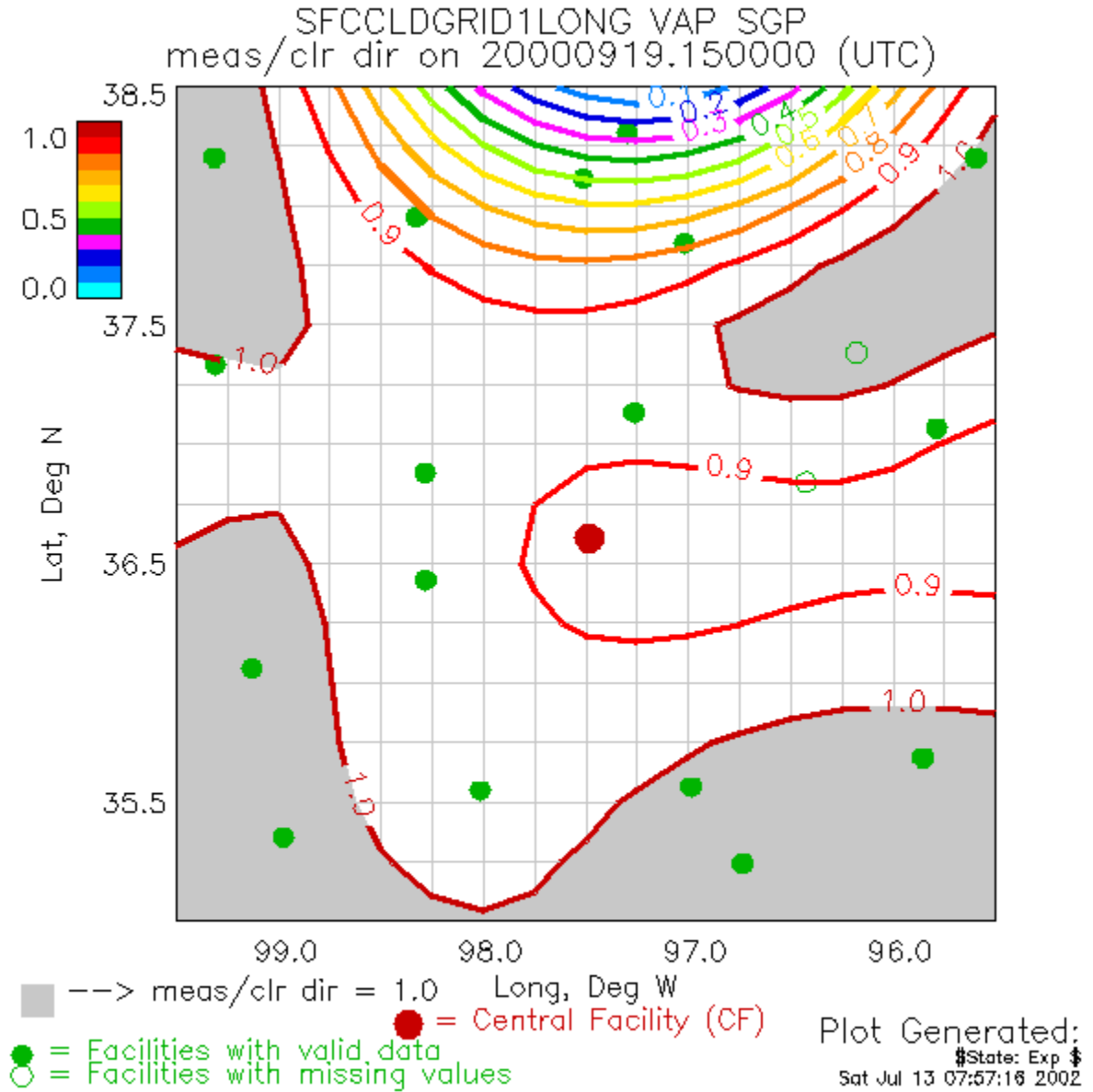


Figure 4. The ratio of measured over clear-sky direct SW down.

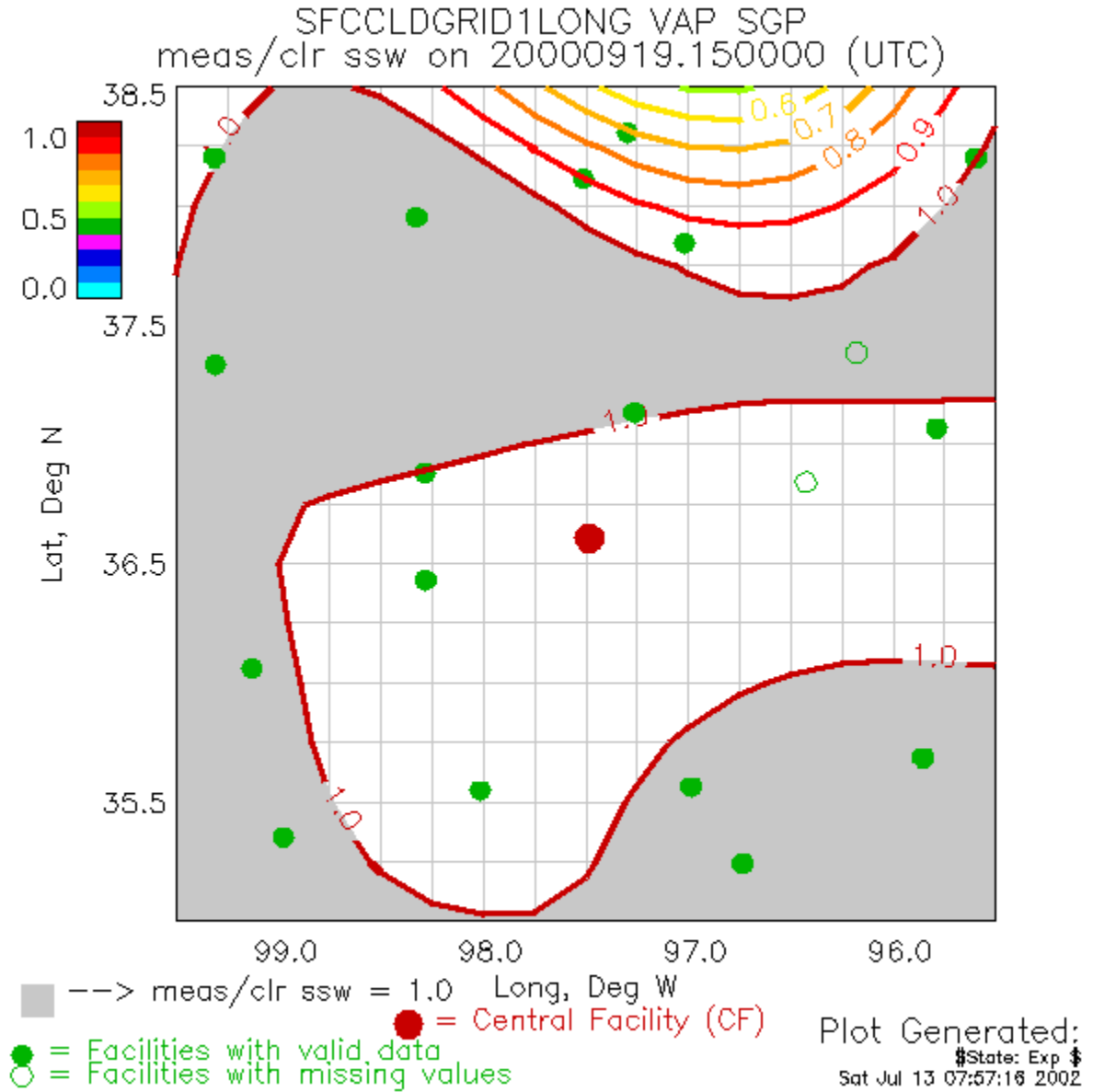


Figure 5. The ratio of measured over clear-sky (direct+diffuse) SW down.

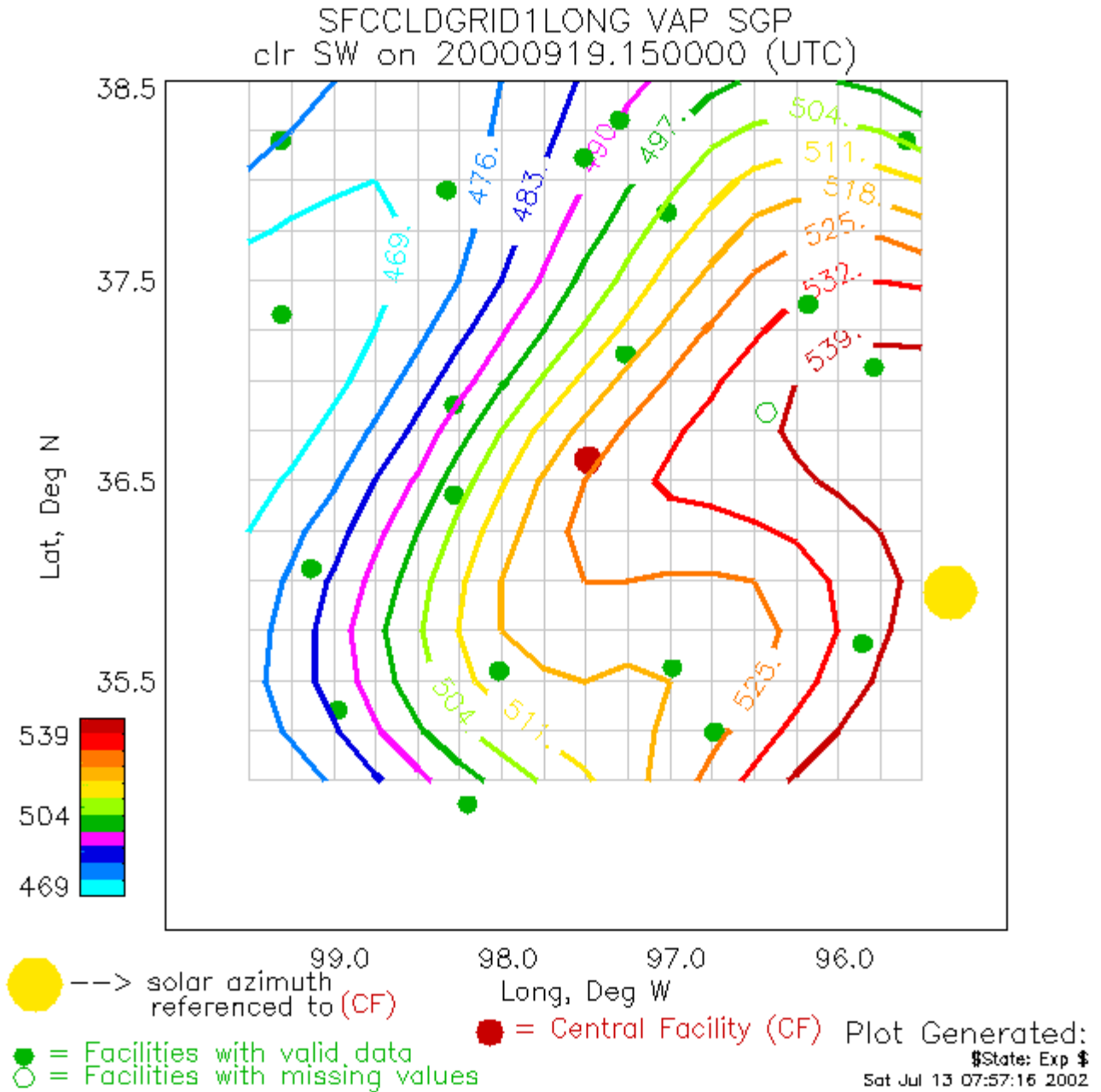


Figure 6. The estimated clear-sky fit total SW down.

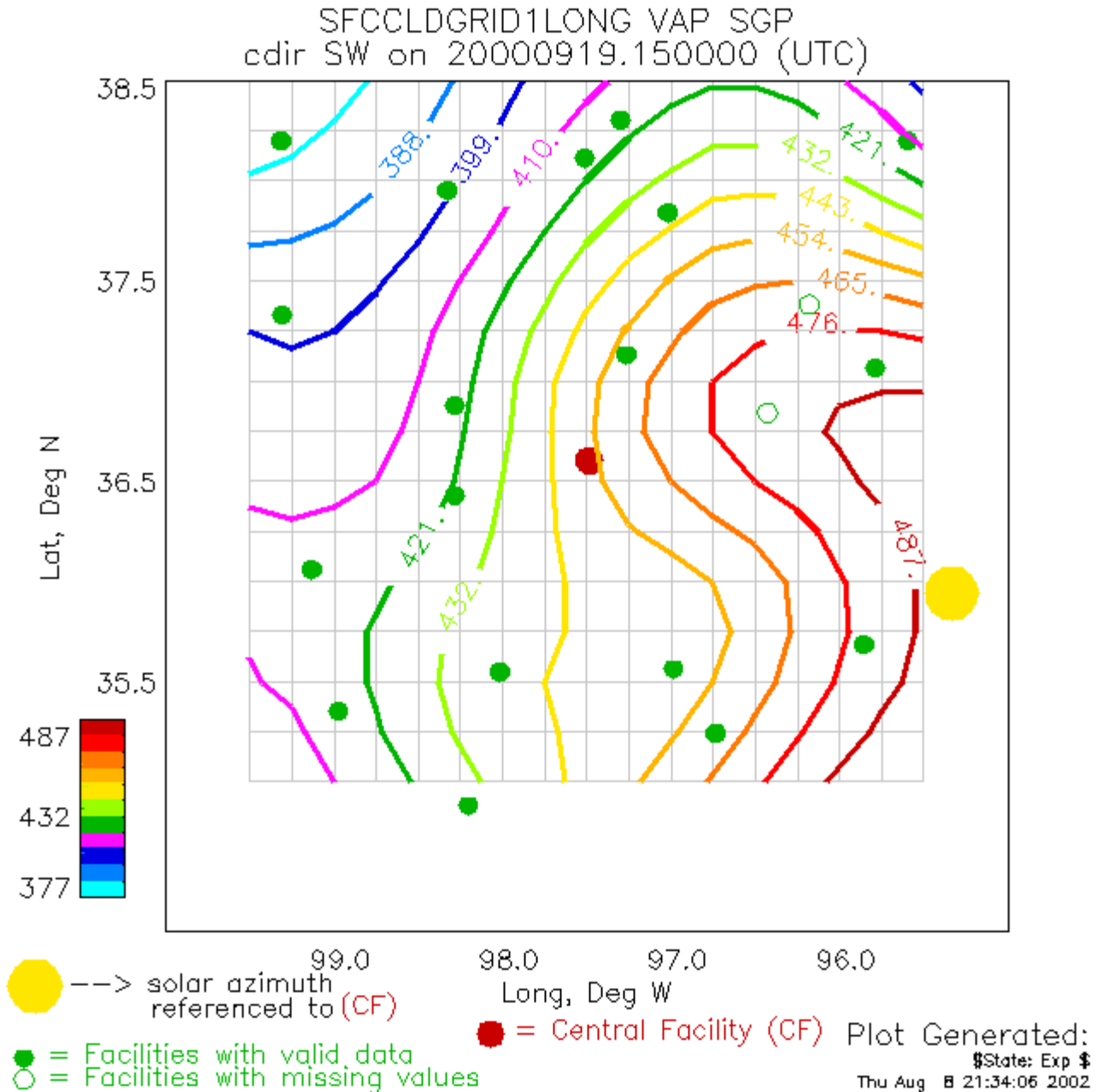


Figure 7. The estimated clear-sky fit direct SW down.

The VAP output values were chosen for maximum information in the most compact form. All clear-sky and all-sky values can be produced by simple mathematical manipulation of the output grids. For example, if the user would like the measured (all-sky) total downwelling SW, simply multiply the ratio of measured over clear-sky total SW (or Sum SW) grid by the estimated total clear-sky irradiance grid. Table 4 lists the value of interest and the corresponding mathematical process to produce all components of the downwelling SW.

Table 4. Production of components of downwelling SW from output grids.

Value of Interest	Produced by:
All-sky Total SW	(Total [or Sum] Meas/Clear SW ratio) X (Estimated clear-sky Total SW irradiance)
All-sky Direct SW	(Direct Meas/Clear SW ratio) X (Estimated clear-sky Direct SW irradiance)
All-sky Diffuse SW	(All-sky Total SW) - (All-sky Direct SW)
Clear-sky Diffuse SW	(Estimated clear-sky Total SW) - (Estimated clear-sky Direct SW)
All-sky Diffuse Ratio	(All-sky Diffuse SW) / (All-sky Total SW)
Clear-sky Diffuse Ratio	(Clear-sky Diffuse SW) / (Estimated clear-sky Total SW)

9. Analysis: Uncertainty Assessment

An analysis was performed on the Surface Cloud Grid VAP to calculate the uncertainty errors across the SGP site due to the interpolation. To calculate the uncertainties, two datasets were used: one from the normal VAP run, and the other for a VAP run with a particular facility omitted. Using the data for 2001, the 15-min. data was used to generate daily, weekly, monthly, and yearly magnitudes for the grid point closest to the omitted facility. To generate daily magnitudes, the average of the nearest grid points for each day of the year was calculated for each VAP run separately. To calculate the daily uncertainty, the difference between the daily magnitudes for both VAP runs was calculated. To generate the average nearest grid point difference, the average of the daily magnitude differences was calculated. This process was repeated for several variables at each of the time scales aforementioned. Tables 5 - 9 contain the average aforementioned time scale differences for the nearest grid point to the omitted facility.

Var = variable used

Fac = Omitted facility

Av Diff = Average time scale difference

Mag = Average time scale magnitude for the normal VAP run

Table 5. Yearly average grid difference between normal and site omitted runs.

Var	Fac	Av Diff	Mag	Fac	Diff	Mag	Fac	Diff	Mag
clr	E19	4.379	591	E8	6.771	586	E9	0.698	583
cf	E19	0.009	0.462	E8	0.004	0.431	E9	0.002	0.481
dir	E19	0.000	0.602	E8	0.010	0.644	E9	0.013	0.590
ssw	E19	0.001	0.760	E8	0.002	0.787	E9	0.004	0.754
tsw	E19	0.009	0.764	E8	0.001	0.790	E9	0.004	0.757

Table 6. Weekly average grid difference between normal and site omitted runs.

Var	Fac	Diff	Mag	Fac	Diff	Mag	Fac	Diff	Mag
cf	E19	0.025	0.475	E8	0.035	0.445	E9	0.019	0.491
tsw	E19	0.021	0.758	E8	0.033	0.784	E9	0.016	0.751
ssw	E19	0.020	0.754	E8	0.032	0.781	E9	0.017	0.747
dir	E19	0.027	0.587	E8	0.039	0.626	E9	0.020	0.576
clr	E19	7.3	573.1	E8	10.0	566.2	E9	5.6	563.1

Table 7. Daily average grid difference between normal and site omitted runs.

Var	Fac	Diff	Mag	Fac	Diff	Mag	Fac	Diff	Mag
cf	E19	0.051	0.469	E8	0.073	0.440	E9	0.039	0.490
tsw	E19	0.037	0.759	E8	0.064	0.784	E9	0.031	0.750
ssw	E19	0.038	0.754	E8	0.063	0.781	E9	0.032	0.747
dir	E19	0.051	0.583	E8	0.078	0.621	E9	0.037	0.567
clr	E19	7.6	575.8	E8	10.6	568.6	E9	6.1	565.5

Table 8. Hourly average grid difference between normal and site omitted runs.

Var	Fac	Diff	Mag	Fac	Diff	Mag	Fac	Diff	Mag.
cf	E19	0.108	0.464	E8	0.121	0.434	E9	0.084	0.483
tsw	E19	0.079	0.759	E8	0.117	0.786	E9	0.062	0.752
ssw	E19	0.095	0.754	E8	0.116	0.783	E9	0.078	0.749
dir	E19	0.192	0.589	E8	0.210	0.633	E9	0.155	0.577
clr	E19	7.9	564.5	E8	10.8	557.1	E9	6.5	549.4

Table 9. 15-min. average grid difference between normal and site omitted runs.

Var	Fac	Diff	Mag	Fac	Diff	Mag	Fac	Diff	Mag
cf	E19	0.133	0.462	E8	0.140	0.431	E9	0.110	0.481
tsw	E19	0.099	0.764	E8	0.143	0.790	E9	0.081	0.757
ssw	E19	0.130	0.760	E8	0.150	0.787	E9	0.112	0.754
dir	E19	0.276	0.602	E8	0.289	0.644	E9	0.237	0.590
clr	E19	8.2	591.0	E8	11.2	582.5	E9	6.8	574.0

As can be seen from the tables, as the time increases, the absolute difference between the two datasets decreases. For more information regarding this analysis, see Christy et al. (2002).

10. Summary

In conclusion, the Surface Cloud Grid VAP uses as input the 15-min. output netCDF files generated from the SW Flux Analysis VAP (Long 2001; Long and Ackerman 2000; Long et al. 1999). The Surface Cloud Grid VAP applies a multi-pass weighted sum analytic approximation technique (Caracena 1987), which uses Gaussian weighting and an imposed scale length to interpolate the SW Flux Analysis VAP results for the 21 sites in the SGP network to a 0.25° by 0.25° lat/long grid across the SGP domain. Scientific quantities generated by this VAP are gridded output for cloud fraction, the ratio of measured over clear-sky SW total (both unshaded pyranometer and sum of direct+diffuse) irradiance, the ratio of measured over clear-sky SW direct irradiance, the estimated clear-sky fit total SW irradiance, and the estimated clear-sky fit direct SW irradiance.

11. References

Caracena, F. 1987. "Analytic Approximation of Discrete Field Samples with Weighted Sums and the Gridless Computation of Field Derivatives." *Journal of Applied Meteorology* 3, 396-409.

Christy, JE, CN Long, and TR Shippert. 2002. [Interpolation Uncertainties Across the ARM SGP Area](#). In *Proceedings of the Twelfth ARM Science Team Meeting*, April 8-12, St. Petersburg, Florida (http://www.arm.gov/docs/documents/technical/conf_0204/christy-je.pdf)

Long, CN. 2001. "The Shortwave (SW) Clear-Sky Detection and Fitting Algorithm: Algorithm Operational Details and Explanations." Atmospheric Radiation Measurement Program Technical Report, ARM TR-004. (http://www.arm.gov/docs/documents/tech_reports/arm-tr-004.pdf)

Long, CN, and TP Ackerman. 2000. "Identification of Clear Skies from Broadband Pyranometer Measurements and Calculation of Downwelling Shortwave Cloud Effects." *Geophysical Research Letters* 105(D12):15,609-15,626.

Long, CN, TP Ackerman, JJ DeLuisi, and J Augustine. 1999. "Estimation of Fractional Sky Cover from Broadband SW Radiometer Measurements." In *Proceedings of the AMS Tenth Conference on Atmospheric Radiation*, June 28-July 2, Madison, Wisconsin.