

**CERES\_SSF1deg-lite\_Ed2.6**  
**CERES\_SYN1deg-lite\_Ed2.6**  
**Data Quality Summary (8/2/2011)**

Investigation: **CERES**  
Data Product: **SSF1deg-Lite**

Data Set: **Terra (Instruments: CERES-FM1 or CERES-FM2)**  
**Aqua (Instruments: CERES-FM3 or CERES-FM4)**

Data Set Version: **Edition2.6**

Subsetting Tool Availability: <http://ceres.larc.nasa.gov>

The purpose of this document is to inform users of the accuracy of this data product as determined by the CERES Science Team. The document summarizes key validation results, provides cautions where users might easily misinterpret the data, provides links to further information about the data product, algorithms, and accuracy, and gives information about planned data improvements. This document also automates registration in order to keep users informed of new validation results, cautions, or improved data sets as they become available.

This document is a high-level summary and represents the minimum information needed by scientific users of this data product. It is strongly suggested that authors, researchers, and reviewers of research papers re-check this document for the latest status before publication of any scientific papers using this data product.

***NOTE: To navigate the document, use the Adobe Reader bookmarks view option.  
Select "View" "Navigation Panels" "Bookmarks".***

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 Nature of the CERES_SSF1deg and CERES_SYN1deg lite_Ed2.6 Products .....	1
2.0 Cautions and Helpful Hints.....	3
3.0 Version History .....	6
3.1 Changes between Edition 2.5 and 2.6 .....	6
3.2 Changes between Edition 2 and Edition2.5 .....	7
4.0 Accuracy and Validation.....	9
4.1 Edition 2.6 .....	9
4.2 Edition 2.5 .....	9
4.2.1 Deseasonalized Anomaly Comparisons.....	9
4.2.2 Regional Comparisons .....	10
4.2.3 Global Means .....	11
4.2.4 Global Mean Edition2.5 and Edition2 calibration differences .....	12
4.2.5 Concluding Remarks.....	13
5.0 References.....	22
6.0 Expected Reprocessing .....	23
7.0 Attribution.....	24
8.0 Feedback and Questions .....	25

## **1.0 Nature of the CERES\_SSF1deg and CERES\_SYN1deg lite\_Ed2.6 Products**

The CERES\_SSF1deg\_lite\_Ed2.6 and CERES\_SYN1deg\_lite\_Ed2.6 products are a small subset of radiation and cloud parameters and available only on a monthly/daily dataset, which is easily processed outside of the CERES production framework. This allows the CERES project to incrementally incorporate the latest CERES instrument calibration improvements, algorithm enhancements and the removal of coding bugs. These updates also benefit the user community by providing the most current CERES data. CERES is now processing Edition3 full parameter, spatial and temporal resolution data products, through the usual production environment and is anticipated to complete within in a year (June 2012), for a complete Terra and Aqua 11-year data record. With the completion of the Edition3 CERES dataset the Edition 2.X products will be obsolete.

CERES SSF1deg and SYN1deg provide CERES-observed temporally interpolated top-of-atmosphere (TOA) radiative fluxes and coincident MODIS-derived cloud and aerosol properties. Each parameter is available at daily and monthly 1°-regional, zonal and global time-space scales. TOA fluxes are provided for clear and all-sky conditions in the longwave (LW), shortwave (SW), and window (WN) regions. The regional means are determined for 1° equal-angle grid boxes calculated by first interpolating each parameter between the times of the CERES observations in order to produce a complete 1-hourly time series for the month. After interpolation, the time series is used to produce mean parameters. Monthly means are calculated using the combination of observed and interpolated parameters from all days containing at least one CERES observation.

CERES SSF1deg TOA fluxes are interpolated using the assumption of constant meteorological conditions (termed non-GEO) similar to the process used to average CERES ERBE-like data. In contrast, in all-sky conditions CERES SYN1deg uses 3-hourly radiance and cloud property data from geostationary imagers to more accurately model variability between CERES observations. To use GEO data to enhance diurnal sampling, several steps are involved. First GEO radiances are cross-calibrated with the MODIS imager using only data that is coincident in time and ray-matched in angle. Next, the GEO cloud retrievals are inferred from the calibrated GEO radiances. The GEO radiances are converted from narrowband to broadband using empirical regressions, and then broadband GEO TOA fluxes using ADMs and directional models. To ensure GEO and CERES TOA fluxes are consistent, a normalization technique is used. Instantaneous matched gridded fluxes from CERES and GEO are regressed against one another over a month from the 5°×5° latitude-longitude regions. The regression relation is then applied to all GEO fluxes to remove biases that depend upon cloud amount, solar and view zenith angles as well as regional dependencies. The all-sky GEO-LW TOA fluxes use the same approach as in Edition2 and employ regional instantaneous normalization.

Input to CERES SSF1deg includes CERES Edition3 Instrument gains and time-varying spectral response functions, Edition1-CV ES8 radiances, and gridded daily files derived from the Edition2 Single Scanner Footprint TOA/Surface Fluxes and Clouds (SSF) archival data product. CERES SYN1deg uses the same inputs but also includes geostationary data.

We urge users to visit the new CERES Data subsetting/visualization/ordering tool, which provides vastly improved user interface and a wider range of data formats (e.g., ASCII, netCDF) than is available with the ASDC ordering tool, which is limited to HDF.

<http://ceres.larc.nasa.gov>

## 2.0 Cautions and Helpful Hints

The CERES Science Team notes several CAUTIONS regarding the use of CERES\_SSF1deg-lite\_Ed2.6 and CERES\_SYN1deg-lite\_Ed2.6:

- A full list of parameters on the CERES SSF1deg and SYN1deg is contained in the CERES Data Product Catalog (PDF).
- Note that with CERES SSF1deg and SYN1deg it is no longer necessary to use the user-applied revisions that were recommended when analyzing Edition2 SW TOA fluxes.
- The cloud property averages are now provided for daytime-only conditions as well as for the traditional 24-hour average. Only the total cloud properties are available. Cloud properties are not stratified by 4 pressure layers as in Edition2.
- Cloud effective height was added to the list of cloud retrieved parameters.
- Processing is performed on a nested grid. This grid uses 1° equal-angle regions between 45°N and 45°S and maintains area consistency at higher latitudes. The product contains a complete 360x180 1° grid created by replication.
- Zonal means are the average of all non-default regional values along a latitude band. Caution must be taken when using zonal means, where there are many regional default values. No spatial interpolation is performed.
- Daily means are only available regionally (see edition2.6 revisions). No daily zonal/global means are not available.
- The global mean is the area weighted average of all 180 zonal means. Zonal means, where all the regional values are default, are interpolated between neighboring zones. This interpolation occurs most frequently with SW flux near the polar night terminator. For SW flux the interpolation assumes constant albedo from the last available latitude. SW flux is calculated as the product of this albedo with analytically computed monthly mean solar insolation.
- When the solar zenith angle is greater than 90°, twilight flux (Kato and Loeb, 2003) is added to the SW flux take into account the atmospheric refraction of light. The magnitude of this correction varies with latitude and season. In general, the regional correction is less than 0.5 Wm<sup>-2</sup> and the global mean correction is 0.2 Wm<sup>-2</sup>. The albedo is defined as a daytime quantity and is computed from the SW flux without the contribution of the twilight flux, divided by the incoming solar. There will be cases near the terminator that will have a greater SW flux than the incoming solar, and this is due to the contribution of twilight. The all-sky and clear-sky twilight flux are estimated independently and are not equivalent.

- Albedo is defined as a daytime parameter. The albedo multiplied by the solar incoming flux can be used to estimate the daytime SW flux, which does not include the twilight flux, discussed in the previous paragraph.
- The solar irradiance is from SORCE that are updated daily (SORCE Level 3 Total Solar Irradiance Version 10 available from: [http://lasp.colorado.edu/sorce/data/tsi\\_data.htm](http://lasp.colorado.edu/sorce/data/tsi_data.htm)). The SORCE total solar irradiance is  $\sim 1361 \text{ Wm}^{-2}$ .
- Geodetic or oblate spheroid weighting was used to derive the global flux mean from the zonal values. The geodetic weights the tropics slightly more than the poles. See Table 1 in the Version History section.
- Only the CERES instrument that is in cross-track mode is used, since it provides uniform spatial distribution of footprints. No Rotating Azimuth Plane Scan (RAPS) is used. There are two CERES instruments on the Terra and Aqua satellites. All CERES Terra/Aqua instruments were calibrated to be on the same radiometric scale. For Terra, the FM1 instrument spent the most time in crosstrack mode. For Aqua, FM4 was the prime crosstrack instrument prior to March 2005, when the SW channel failed. After March 2005, FM3 was permanently placed in crosstrack mode. For a month-to-month summary of the CERES operational scan modes on Terra and Aqua please see: [http://eosweb.larc.nasa.gov/PRODOCS/ceres/SRBAVG/Quality\\_Summaries/srbavg\\_ed2d/recommendedInstrument.html](http://eosweb.larc.nasa.gov/PRODOCS/ceres/SRBAVG/Quality_Summaries/srbavg_ed2d/recommendedInstrument.html)
- For clear-sky fluxes, if the region did not observe a single clear-sky (cloud fraction  $<0.1\%$ ) footprint for the month the monthly mean is default.
- Users should be aware that some of the key inputs used to produce SSF1deg and SYN1deg changed at various times during the data record. Such changes, if large enough, may introduce spurious, unphysical jumps in the record. In the past, these changes were reflected in each CERES data product's version through a letter change (e.g., SRBAVG Edition2A, Edition2B, etc.). However, this proved cumbersome and confusing to many users. Therefore, for SSF1deg and SYN1deg, letter changes will only reflect a reprocessing of the data record (e.g., due to a code bug). Changes to inputs will instead be documented in this DQS. [Figure 2-1](#) provides a time-line of all input data source changes to date used to produce the SSF1deg and SYN1deg data products. Users are advised to use this table as reference in their analysis of SSF1deg and SYN1deg.

## CERES Input Datasets

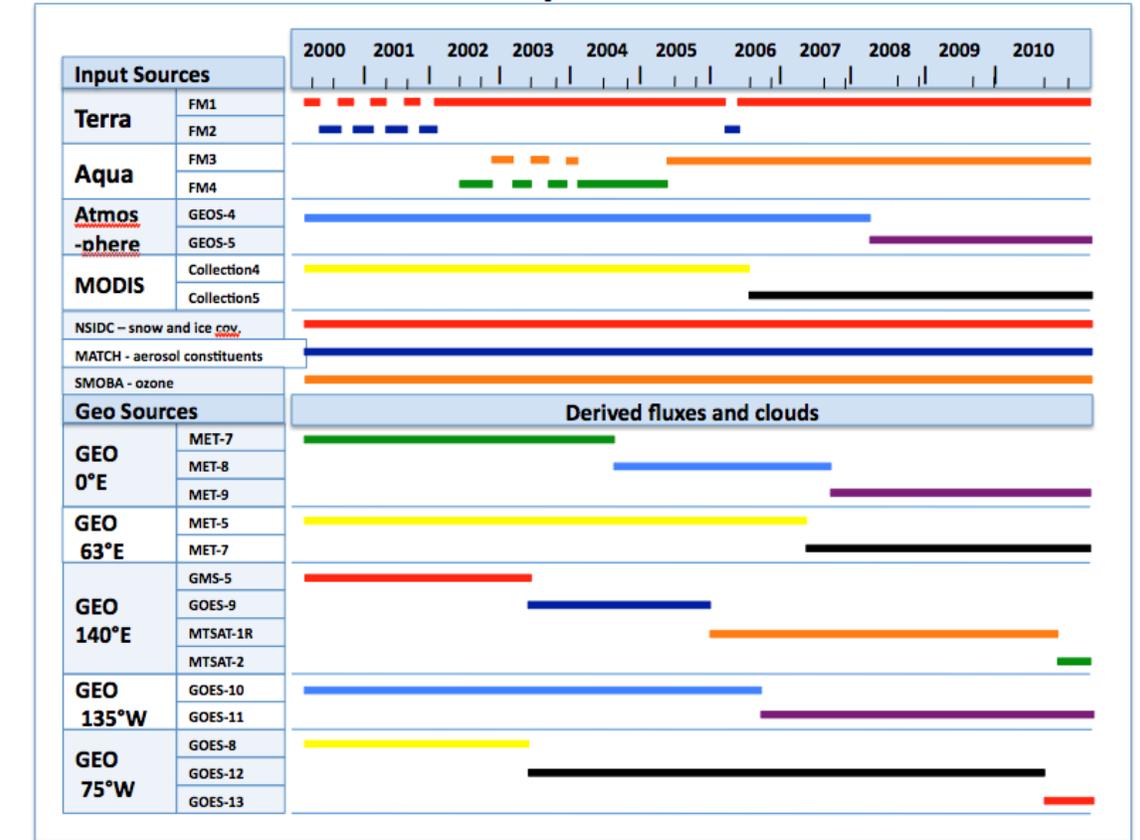


Figure 2-1. CERES input datasets used to produce CERES\_SSF1deg-lite\_Ed2.6 and CERES\_SYN1deg-lite\_Ed2.6.

- Coverage by geostationary satellites is between 60°S and 60°N. Outside this region, TOA fluxes from SYN1deg and SSF1deg are identical. Also GEO calibration coefficients were updated incrementally in 3 year segments to facilitate production and may cause an unphysical jump.

### 3.0 Version History

#### 3.1 Changes between Edition 2.5 and 2.6

The record was extended in Edition 2.6 to include March 2010 to December 2010.

Geodetic or oblate spheroid weighting was used to derive the global flux mean from the zonal values. CERES SRBAVG Edition2D assumes a spherical Earth when averaging TOA insolation over the Earth's surface. This gives the well-known  $S_0/4$  expression for mean solar irradiance, where  $S_0$  is the instantaneous solar irradiance at the TOA. When a more careful calculation is made by assuming the Earth is an oblate spheroid instead of a sphere, and the annual cycle in the Earth's declination angle and the Earth-sun distance are taken into account, the division factor becomes 4.0034 instead of 4. Consequently, the mean solar irradiance for CERES SSF1deg and SYN1deg is  $\sim 1361/4.0034 = 340 \text{ Wm}^{-2}$ , compared to  $1365/4 = 341.3 \text{ Wm}^{-2}$  for CERES SRBAVG Edition2.

The geodetic minus spherical earth annual global mean fluxes are expressed in [Table 3-1](#). The geodetic weights the tropics slightly more than the poles.

Table 3-1. The Geodetic minus spherical earth annual global flux means

(Wm-2)	SW reflected	LW emitted	Net	Solar incoming
All-sky	-0.18	+0.05	-0.16	-0.30
Clear-sky	-0.11	+0.06	+0.07	

Redefined albedo as a daytime quantity. The albedo is defined as the SW reflected flux divided by the solar incoming and is computed before adding twilight flux. Edition 2.5 the albedo was computed after adding in twilight. The twilight flux is described in the “cautions and helpful hints” section.

The zonal and global fluxes were not computed for the daily means. The geographical distribution and number of clear-sky regions was considered insufficient for a representative zonal and global mean. Fluctuations in the global mean were more likely to be artifacts from sampling differences rather than from natural variation.

Daily SYN (CERES+GEO) LW, WN, and net regional fluxes are computed whenever there is either a CERES or GEO measurements for the day. For Edition 2.5 LW, WN, and net daily fluxes were only computed if there was a CERES measurement for the day. Daily SW regional fluxes were computed from both CERES and GEO for both editions. This is most noticeable where large data gaps of CERES occur, during two weeks for Terra June 2001 and the first 14 days of Aqua October 2004.

A bug has been fixed to compute the constant albedo in the terminator zones. A constant albedo from the last observed  $1^\circ$  zonal albedo poleward to the terminator is used to estimate the SW monthly flux, where the incoming flux is greater than zero, but where there were no CERES observations.

The liquid and ice cloud properties were properly weighted by the liquid and ice cloud fractions rather than by the total cloud fraction in Edition2.5.

Daytime is defined as solar zenith angles less than  $89^\circ$  rather  $82^\circ$  for Edition2.5.

### **3.2 Changes between Edition 2 and Edition2.5**

The record was extended in Edition 2.6 to include November 2005 to February 2010.

CERES SRBAVG-GEO Edition2D assumes a solar constant of  $1365 \text{ Wm}^{-2}$ . Edition2.5 uses time-varying solar irradiance from SORCE that are updated daily (SORCE Level 3 Total Solar Irradiance Version 10 available from: [http://lasp.colorado.edu/sorce/data/tsi\\_data.htm](http://lasp.colorado.edu/sorce/data/tsi_data.htm)). The SORCE total solar irradiance is  $\sim 1361 \text{ Wm}^{-2}$ .

CERES SRBAVG Edition2D assumes a spherical Earth when averaging TOA insolation over the Earth's surface. This gives the well-known  $S_0/4$  expression for mean solar irradiance, where  $S_0$  is the instantaneous solar irradiance at the TOA. When a more careful calculation is made by assuming the Earth is an oblate spheroid instead of a sphere, and the annual cycle in the Earth's declination angle and the Earth-sun distance are taken into account, the division factor becomes 4.0034 instead of 4. Consequently, the mean solar irradiance for CERES SSF1deg and SYN1deg is  $\sim 1361/4.0034 = 340 \text{ Wm}^{-2}$ , compared to  $1365/4 = 341.3 \text{ Wm}^{-2}$  for CERES SRBAVG.

TOA and cloud properties in CERES SSF1deg and SYN1deg are derived using the same approach as that used in SRBAVG Edition2D non-GEO and GEO, respectively. A major difference is that clear-sky TOA fluxes in both SSF1deg and SYN1deg use the nonGEO (constant meteorology) approach in Edition2.6. Despite the use of GEO narrow-to-broadband regressions and the above normalization technique, large biases in clear-sky LW TOA fluxes with GEO were observed in SRBAVG-GEO Edition2D\_rev1 as well as in off-line testing with SYN1deg. The large biases observed over desert regions are mainly due to the 3-hourly GEO input, for some longitudes the GEO input captures the diurnal maxima, whereas longitudes shifted by  $15^\circ$  (one hour) does not. Therefore, in this release of SYN1deg-lite\_Ed2.6, clear-sky TOA fluxes are the same as those provided in SSF1deg-lite\_Ed2.6.

Another departure from SRBAVG Edition2D is that CERES\_SSF1deg and SYN1deg use the latest Edition3 Instrument gains (see Edition3 BDS Quality Summary) and time-varying instrument spectral response functions. Furthermore, all 4 CERES instruments were placed on a common radiometric scale at the start of each mission (March 2000 for Terra; July 2002 for Aqua). For a detailed description of the Edition3 Instrument improvements, please see the following link (slides 20-70):

[http://ceres.larc.nasa.gov/documents/STM/2010-04/2\\_Priestley\\_0410\\_STM\\_Newport\\_News.pdf](http://ceres.larc.nasa.gov/documents/STM/2010-04/2_Priestley_0410_STM_Newport_News.pdf)

## 4.0 Accuracy and Validation

### 4.1 Edition 2.6

Only minor changes exist between versions Edition2.5 and Edition2.6. Edition 2.5 results are valid for Edition 2.6. [Table 4-1](#) represents the updated global means for Edition 2.6, which can be compared with Edition 2.5 and Edition2 in [Table 4-2](#). The 9-year all-sky SSF1deg Terra – Aqua difference is the satellite sampling time, since both instruments are on the same radiometric scale. The inclusion of 3-hourly geostationary completes the diurnal cycle and reduces the Terra-Aqua difference.

Table 4-1. Global mean TOA fluxes for clear and all-sky SW, LW and net from CERES Terra and Aqua SSF1deg-lite\_Ed2.6 and SYN1deg-lite\_Ed2.6

Dataset	All-Sky				Clear-Sky		
	S <sub>o</sub>	SW	LW	Net	SW	LW	Net
CERES Terra SSF1deg-lite_Ed2.6 (01/01-12/10)	340.4	96.7	239.4	4.4	50.1	267.6	22.6
CERES Terra SYN1deg-lite_Ed2.6 (01/01-12/10)	340.4	97.8	238.9	3.7	50.2	267.6	22.6
CERES Terra SSF1deg-lite_Ed2.6 (01/03-12/10)	340.3	96.6	239.4	4.4	50.0	267.6	22.7
CERES Terra SYN1deg-lite_Ed2.6 (01/03-12/10)	340.3	97.7	238.9	3.7	50.1	267.6	22.7
CERES Aqua SSF1deg-lite_Ed2.6 (01/03-12/10)	340.3	96.4	239.0	5.0	48.9	267.6	23.9
CERES Aqua SYN1deg-lite_Ed2.6 (01/03-12/10)	340.3	97.7	238.9	3.8	49.0	267.6	23.8

### 4.2 Edition 2.5

#### 4.2.1 Deseasonalized Anomaly Comparisons

We compare the stability of the CERES Terra SW TOA flux record from CERES Terra SSF1deg-lite-Ed2.5 with SeaWIFS Photosynthetically Active Radiation (PAR) using the approach described in Loeb et al. (2007). Briefly, deseasonalized CERES SW TOA flux anomalies are plotted against deseasonalized anomalies in SeaWIFS PAR. The SeaWIFS PAR anomalies are then multiplied by the slope of the regression line ( $-6.09 \text{ W m}^{-2}$  per  $\text{E m}^{-2} \text{ day}^{-1}$ ) in order to place the two records on the same radiometric scale. Results, plotted in [Figure 4-1](#), show agreement in monthly anomalies to  $0.26 \text{ Wm}^{-2}$ , and agreement in the overall slope to  $< 0.3 \text{ Wm}^{-2}$  per decade at the 95% confidence level. After late 2008, SeaWIFS spacecraft anomalies resulted in significantly reduced sampling resulting in a far noisy comparison. Stability in CERES Terra LW TOA flux is compared with that from the AIRS OLR data product in [Figure 4-2](#). Monthly anomalies

are consistent to  $0.16 \text{ Wm}^{-2}$ , and agreement in the slope is better than  $0.3 \text{ Wm}^{-2}$  per decade at the 95% confidence level.

Figure 4-3 provides comparisons between Terra and Aqua global anomalies for SW, LW and WN channels from CERES Terra SSF1deg-lite-Ed2.5. While global Terra and Aqua SW TOA flux anomalies are consistent to  $0.1 \text{ Wm}^{-2}$  per decade, the CERES Terra TOA flux anomalies show a steeper decrease than CERES Aqua by  $0.62 \text{ Wm}^{-2}$  per decade and  $0.35 \text{ Wm}^{-2}$  per decade for LW and WN, respectively, over the July 2002-August 2008 period.

Figure 4-4 compares CERES Terra SYN1deg-lite-Ed2.5 with CERES Terra SSF1deg-lite-Ed2.5 from March 2000 through February 2010. In the SW, SYN1deg shows a stronger decrease compared to SSF1deg by  $0.52 \text{ Wm}^{-2}$  per decade, whereas LW TOA flux anomaly trends are within  $0.15 \text{ Wm}^{-2}$  per decade. While changes in diurnal cycle cannot entirely be ruled out as the underlying cause of these differences, it is more than likely that they are due to uncertainties in the geostationary observations used in the SYN1deg data product. As the following section will show, geostationary artifacts can be quite large at regional scales, and these may impact global mean anomaly trends.

#### 4.2.2 Regional Comparisons

While both SSF1deg and SYN1deg provide SW, LW and WN TOA fluxes for clear and all-sky conditions, the processing used differs considerably, as noted earlier. For SSF1deg, CERES observations are interpolated using the assumption of constant meteorological conditions (termed non-GEO), while CERES\_SYN1deg-lite\_Ed2.5 uses 3-hourly radiance and cloud property data from geostationary imagers to more accurately model variability between CERES observations (termed GEO). Consequently, monthly mean SW and LW TOA flux differences between these two are most pronounced in regions with strong diurnal cycles, such as marine stratus and convective regions. This is illustrated in Figure 4-5 for December 2004, which shows the SYN1deg minus SSF1deg SW and LW TOA flux differences for Terra. Negative SW TOA flux differences occur in marine stratus regions because cloud amount is greater during the morning Terra overpass time. Conversely, SW TOA flux differences are positive for land convection, which peaks in the afternoon. In the LW, the largest differences occur over the Saharan desert and central Asia. The striping pattern over the Saharan desert is an artifact resulting from the time difference between 3-hourly geostationary observations and CERES Terra, which is used in the normalization of the geostationary data described earlier in this document. In spite of efforts to normalize the GEO TOA fluxes to CERES, we still see GEO artifacts that are mainly due to the coarse time-sampling of GEO (3-hourly). It is hoped that once a merged CERES Terra+Aqua+GEO dataset is produced in Spring 2011, such artifacts will be reduced. Plans are also underway to test how 1-hourly GEO time-sampling improves the results.

Ten-year linear trends in SW and LW TOA fluxes by region for SSF1deg and SYN1deg for March 2000 through February 2010 are shown in Figure 4-6 and Figure 4-7, respectively. The top panels show results for SYN1deg, the middle panels show SSF1deg, and the bottom show the difference SYN1deg minus SSF1deg. In the SW (Figure 4-6), the basic pattern is quite similar for SYN1deg and SSF1deg over the Pacific

and Atlantic Oceans. Both show negative anomalies in the South Pacific Convergence Zone (SPCZ), as well as the Americas. In the equatorial Atlantic, there are large regions of positive SW TOA flux changes that appear more pronounced in SSF1deg. GEO artifacts are evident over the south and central portions of Africa, as well as in the Indian Ocean just west of Australia. The GEO artifacts show up more clearly in the bottom panel (note the change in scale) particularly to the east of 60°W. SYN1deg and SSF1deg trend differences are generally smaller to the west of 40°W because geostationary satellites positioned at 75°W (GOES-8, GOES-12, GOES-13) and 135°W (GOES-10, GOES-11) were more stable both in their performance and uniform in spectral characteristics (channels, spectral response function), satellite operations such as scan cycles as well as their equatorial position. Meteosat-7 (first generation MFG), Meteosat-8 (second generation MSG) were positioned at 0° E, but have very different imagers characteristics. The MFG 3-channel imager had nearly broadband visible spectral channels and a single window channel on a 30-minute scan cycle and 8-bit dynamic range, whereas the MSG has very narrow visible and IR window channels on a 15-minute scan cycle and 10-bit dynamic range, with minimal observed visible channel degradation over time. Over the Indian Ocean Meteosat-5 and Meteosat-7 are similar in performance, however Meteosat-5 was positioned at 63° E and Meteosat-7 at 57° E. Over the tropical western Pacific, 4 different geostationary satellites were operational, GMS-5, GOES-9, MTSAT-1R, and MTSAT-2. GMS-5 was an older broadband 4-channel poorly navigated imager positioned at 140° E. GOES-9 was positioned at 160°E with a noisy visible narrowband channel, with a slightly offset scan schedule from GMS-5. MTSAT-1R located at 140° E, which has 336 visible nearly broadband detectors with an unconventional scan pattern, which overestimates the dark radiances when compared with MODIS. MTSAT-2, also located at 140° but with characteristics similar to GOES. All geostationary visible imagers do not have onboard calibration and must be vicariously calibrated. CERES uses MODIS as a reference for consistent GEO derived broadband radiances across and satellite boundaries and as they are replaced. Optimally all the GEO would have the same channel spectral response functions with the calibration stable over time at the same equatorial position and scan schedule. In the LW ([Figure 4-7](#)), the largest differences between SYN1deg and SSF1deg occur over Africa and Central Asia, where the striping is due to the mismatch in time of CERES and GEO 3-hourly observations and the GEO not capturing the peak of the diurnal cycle.

### 4.2.3 Global Means

[Table 4-2](#) compares global mean clear and all-sky TOA fluxes for SSF1deg and SYN1deg as well as Terra SRBAVG Edition2D\_rev1. The most remarkable difference between the two sets of Ed2.5 and Edition2\_rev1 results is in the LW. All-sky LW TOA fluxes for SYN1deg are 1.7 Wm<sup>-2</sup> larger than SRBAVG-GEO. This increase occurs because for Edition3 the CERES Instrument team reassessed the spectral response functions (SRFs) for the SW and TOT sensors determined prior to launch. Little change was found in the SW SRF and SW portion of the TOT SRF, but a large change was made to the LW portion of the TOT SRF after reanalysis of ground-based Fourier Transform Spectrometer (FTS) measurements between 2 and 200 μm. Other contributing factors for the difference include a change in the ground-to-flight shift used in Edition3 compared to Edition2, and improvements in how in-flight calibration changes are accounted for. Because the Ed2.5 datasets use solar irradiance data from Kopp et al. (2003), where the

mean solar irradiance is  $1361 \text{ Wm}^{-2}$  instead of  $1365 \text{ Wm}^{-2}$  (assumed in Edition2), the net TOA flux in SYN1deg Ed2.5 decreases to  $3.6 \text{ Wm}^{-2}$  compared to  $6.5 \text{ Wm}^{-2}$  for SRBAVG-GEO Edition2D. The SYN (GEO) all-sky SW flux is  $\sim 1 \text{ Wm}^{-2}$  greater than the SSF (CERES-only) for both Terra and Aqua datasets, since increase in late afternoon convection and decrease in early morning maritime stratus is not observed during Terra or Aqua overpass times. The SYN all-sky LW flux is  $\sim 0.5 \text{ Wm}^{-2}$  less than SSF because the Terra overpass does not take into account the LW minima over land from afternoon convection. The impact is less for the Aqua dataset. However the difference between Terra and Aqua SYN all-sky LW is half of that from SSF, suggesting that GEO captures the diurnal signal.

Table 4-2. Global mean TOA fluxes for clear and all-sky SW, LW and net from CERES Terra and Aqua SSF1deg-lite\_Ed2.5 and SYN1deg-lite\_Ed2.5

Dataset	All-Sky				Clear-Sky		
	S <sub>o</sub>	SW	LW	Net	SW	LW	Net
CERES Terra SSF1deg-lite_Ed2.5 (03/00-02/10)	340.4	96.6	239.3	4.5	50.1	267.6	22.7
CERES Terra SYN1deg-lite_Ed2.5 (03/00-02/10)	340.4	97.7	238.8	3.9	50.1	267.6	22.7
CERES Terra SSF1deg-lite_Ed2.5 (07/02-06/08)	340.4	96.5	239.4	4.4	50.1	267.7	22.6
CERES Terra SYN1deg-lite_Ed2.5 (07/02-06/08)	340.4	97.6	239.0	3.8	50.1	267.7	22.6
CERES Aqua SSF1deg-lite_Ed2.5 (07/02-06/08)	340.4	96.4	238.9	5.1	48.8	267.6	23.9
CERES Aqua SYN1deg-lite_Ed2.5 (07/02-06/08)	340.4	97.5	238.8	4.1	48.8	267.6	23.9
CERES Terra SRBAVG-nonGEO Ed2_rev1 (03/00-02/05)	341.3	96.6	237.7	7.0	51.2	266.4	23.7
CERES Terra SRBAVG-GEO Ed2_rev1 (03/00-02/05)	341.3	97.7	237.1	6.5	51.1	264.1	26.2

#### 4.2.4 Global Mean Edition2.5 and Edition2 calibration differences

To understand the impact of the CERES instrument improvement with respect to absolute calibration and stability the SRBAVG-nonGEO\_rev1 Edition2 monthly mean fluxes minus the SSF1deg Edition2.5 were plotted in [Figure 4-8](#). The SRBAVG-nonGEO is the equivalent SSF1deg product for Edition2. The difference in the SW is minor after applying the SW rev1 correction to the Edition2 dataset. As mentioned in the global mean section the Ed2.5 LW is  $1.7 \text{ Wm}^{-2}$  greater than Ed2 and the Ed2.5 Net is nearly  $3.0 \text{ Wm}^{-2}$  less than Edition 2. However all global trend differences between Ed2.5 and 2 are within  $0.3 \text{ Wm}^{-2}/\text{decade}$ .

[Figure 4-9](#) shows the SSF1deg Ed2.5 minus ERBELike\_rev1 Ed2 trends similar to [Figure 4-8](#). For the SW and Net a seasonal cycle is clearly observed and is due to the

differences in the CERES and ERBE angular directional models (ADM) to convert the observed radiance to a flux and to derive to the diurnal mean flux. The CERES scene identification based on the MODIS imager and Rotating Azimuth Plane Scan (RAPS) instrument capability allowed improved ADMs to be incorporated. The SSF1deg diurnal averaging assumes constant meteorology as does ERBE but with improved SW directional (SZA vs albedo) models, especially over snow regions as indicated in the SW plots. The user of ERBELike data should be aware of the ADM difference and its impact on the long-term differences. ERBELike dataset was designed to be compared with the historical ERBE fluxes during the 1985-1989 time period with the same ERBE type algorithms.

#### 4.2.5 Concluding Remarks

The GEO-enhanced SYN1deg clearly adds value in regions with strong diurnal cycles, such as over marine stratus and land convection. Monthly mean TOA fluxes can differ by  $20 \text{ Wm}^{-2}$  or more depending on whether or not the diurnal cycle is explicitly taken into account (see Figure 4-5). For studies examining interannual variability and trends at regional scales, the choice between SYN1deg and SSF1deg is not so obvious. As noted earlier, GEO artifacts are a function of the quality of the GEO instruments in the region, as well as the 3-hourly GEO time-sampling relative to the actual strength of the diurnal cycle in the region. In regions with strong diurnal cycles where GEO instruments have been relatively stable, SYN1deg is preferred over SSF1deg as it provides a more complete observation of regional changes in the diurnal cycle. In regions that have weak diurnal cycles or at large spatial scales (e.g., tropical, global), where the variability is much smaller and diurnal effects are less pronounced compared to regional scales, SSF1deg is likely more reliable than SYN1deg since SSF1deg is free of any GEO calibration/sampling artifacts. It is hoped that future versions of SYN1deg that combine CERES Terra and Aqua with 1-hourly GEO data will further improve the accuracy.

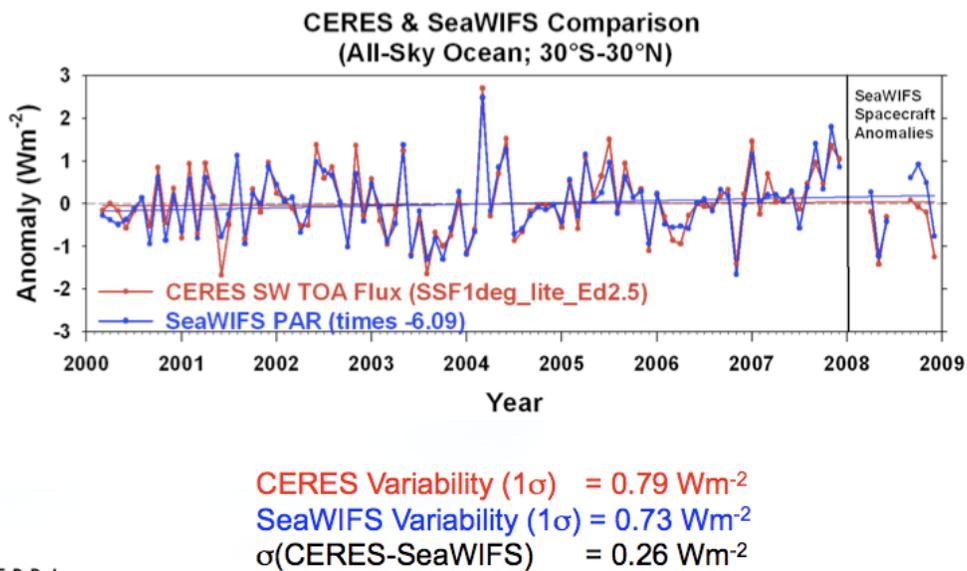
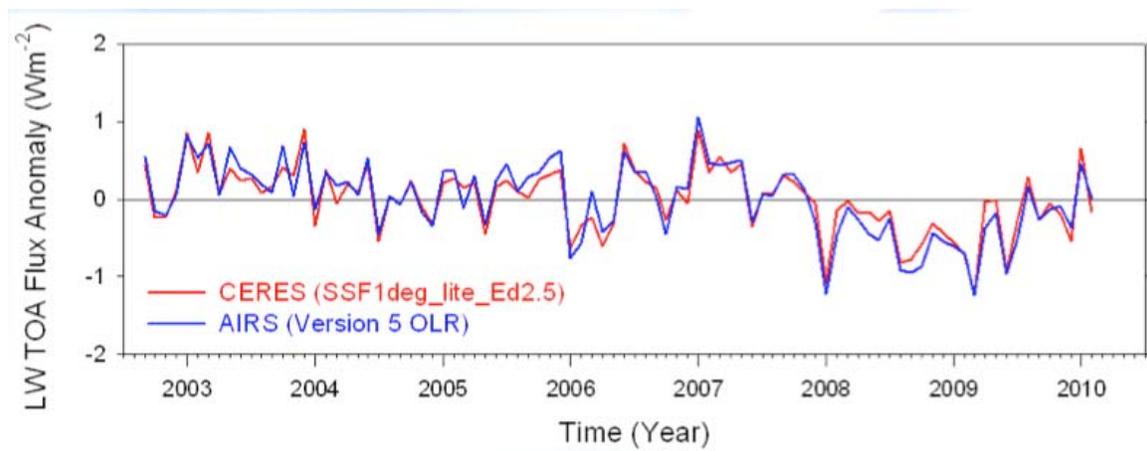


Figure 4-1. Comparison of stability in CERES Terra SW TOA flux from CERES Terra SSF1deg-lite-Ed2.5 and SeaWIFS PAR product (2009 reprocessing).



**CERES Variability ( $1\sigma$ ) =  $0.43 \text{ Wm}^{-2}$**   
**AIRS Variability ( $1\sigma$ ) =  $0.48 \text{ Wm}^{-2}$**   
 **$\sigma(\text{CERES-AIRS}) = 0.16 \text{ Wm}^{-2}$**

TERRA

Figure 4-2. Comparison of stability in CERES Terra LW TOA flux from CERES Terra SSF1deg-lite-Ed2.5 and AIRS LW TOA flux product (Version 5). Results are for global all-sky conditions.

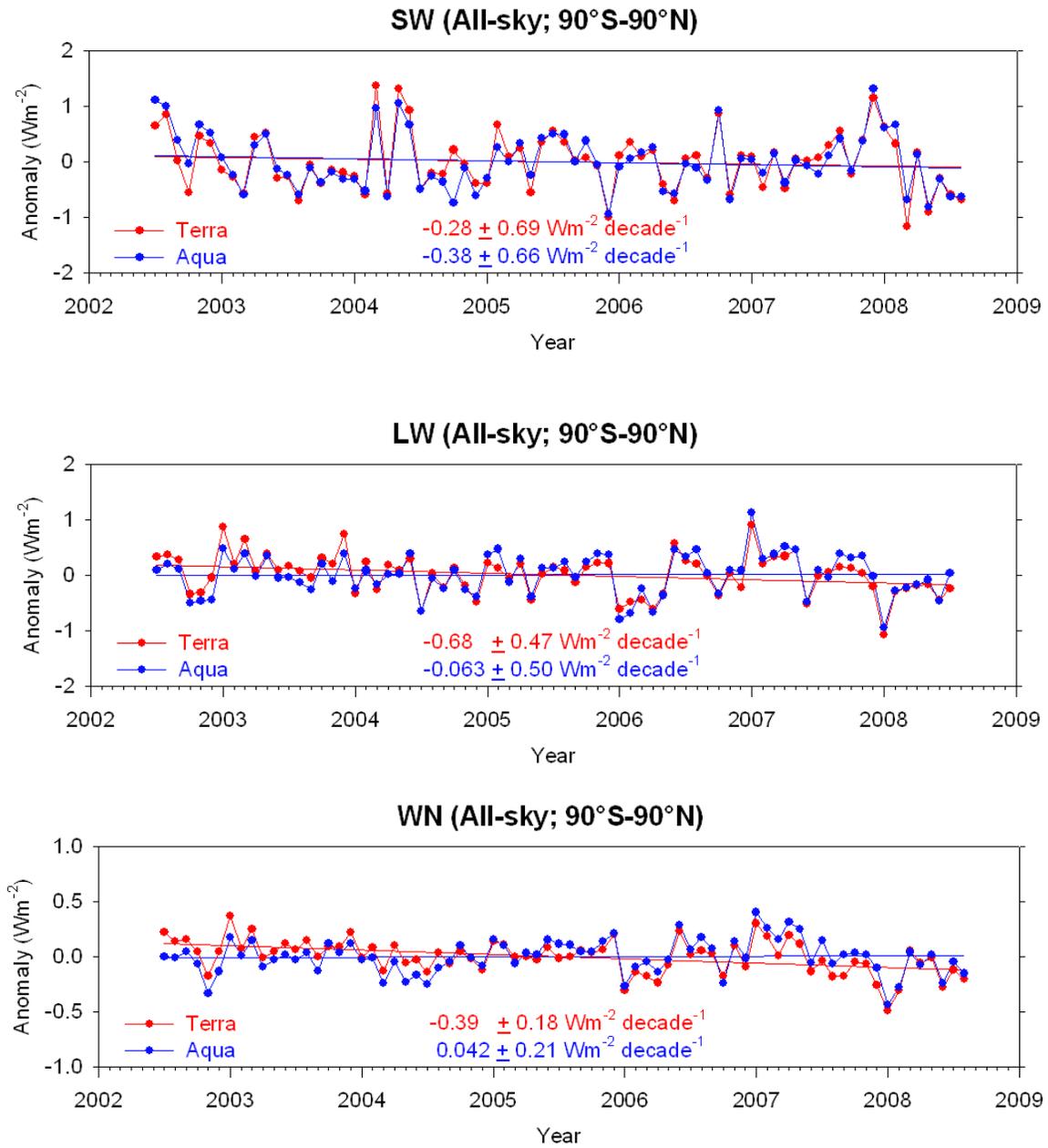


Figure 4-3. Global all-sky TOA flux anomalies for Terra and Aqua for SW (top), LW (middle), and WN (bottom) from CERES Terra SSF1deg-lite-Ed2.5.

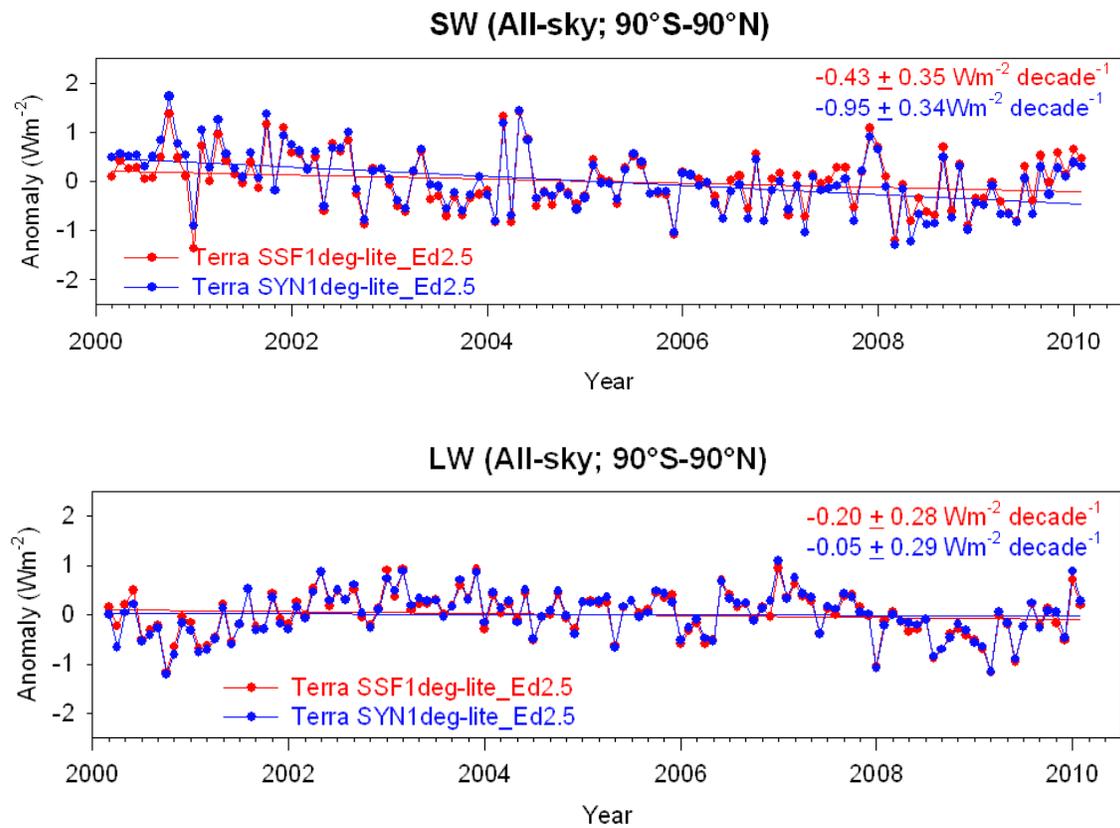


Figure 4-4. Global all-sky TOA flux anomalies for Terra SW (top), LW (middle), and WN (bottom) from CERES Terra SSF1deg-lite-Ed2.5 and CERES Terra SYN1deg-lite-Ed2.5.

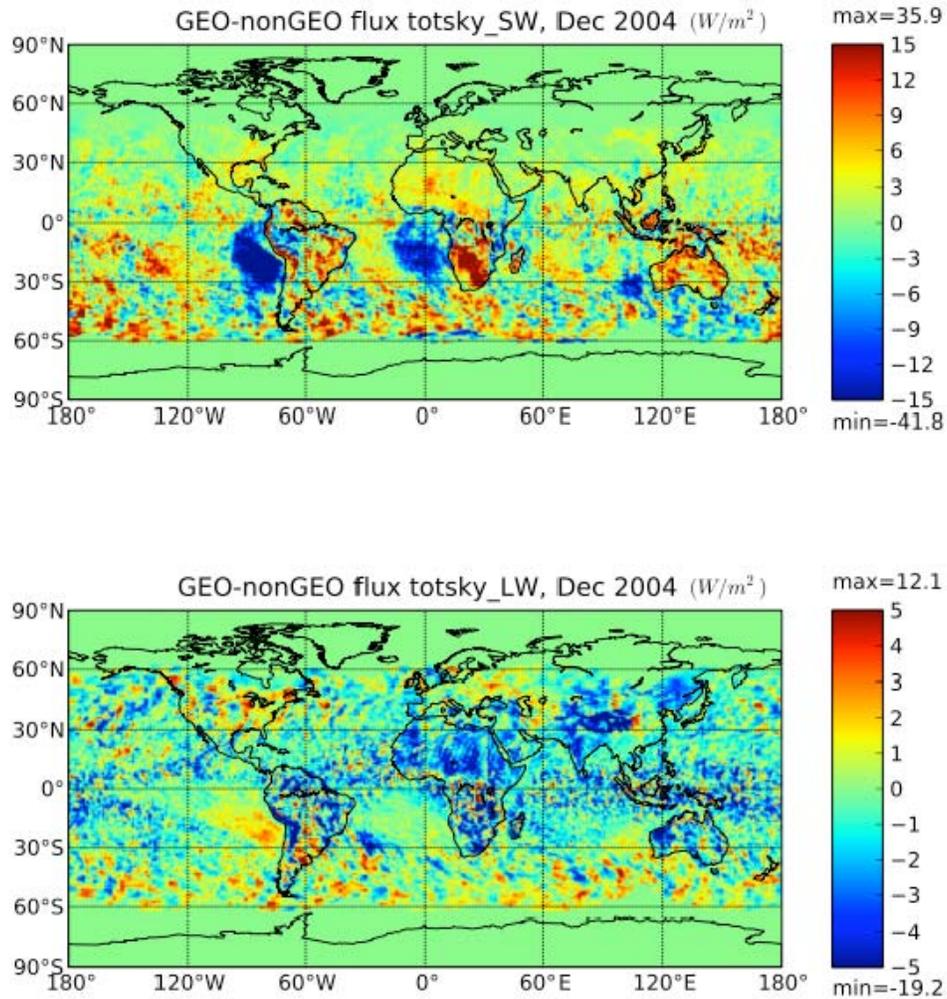


Figure 4-5. All-sky SW (top) and LW (bottom) TOA flux differences between SYN1deg and SSF1deg from Terra observations for December 2004.

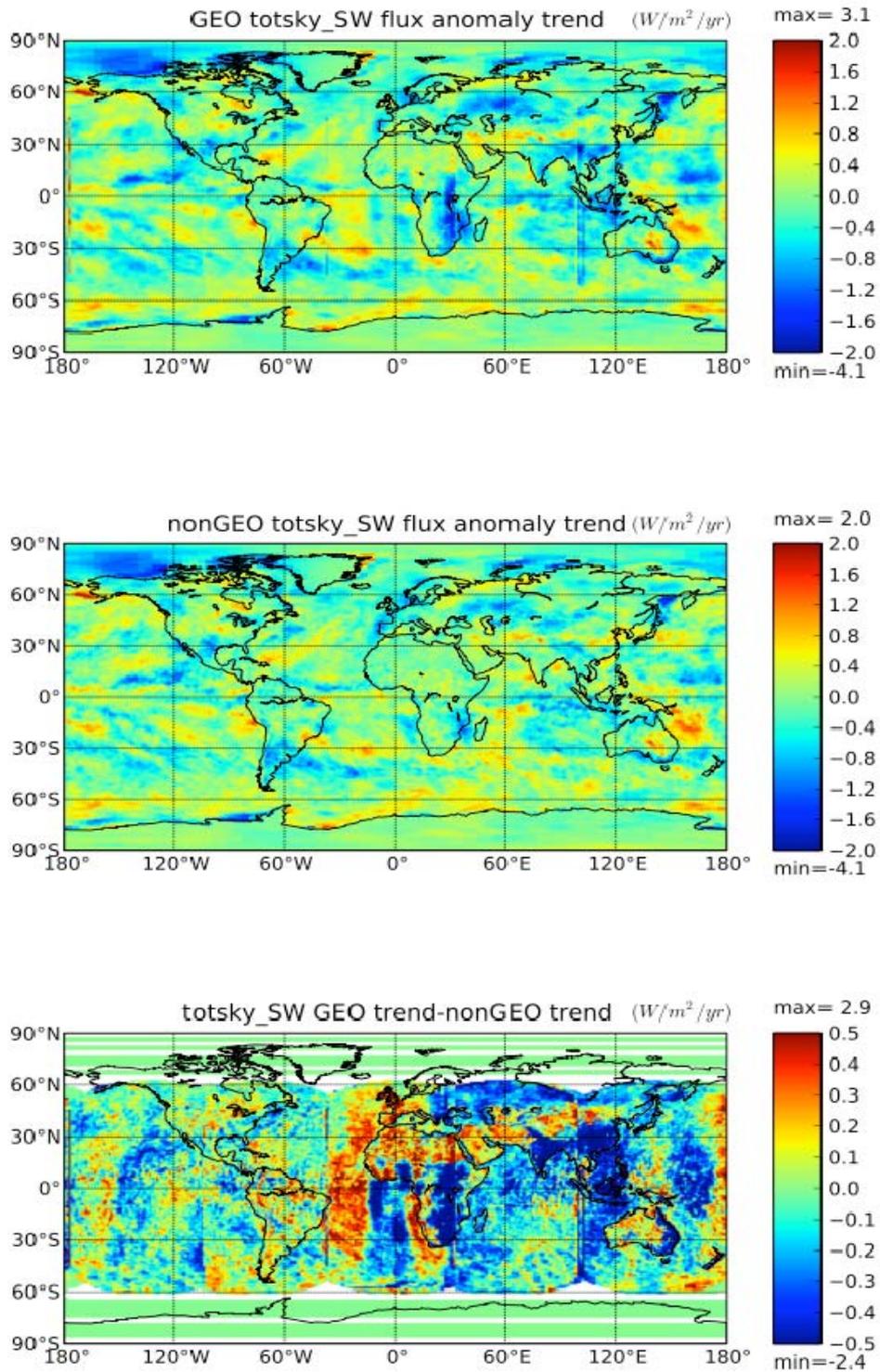


Figure 4-6. Ten-year regional linear trends in SW TOA flux anomalies from SYN1deg (top) and SSF1deg (middle). Bottom figure shows the SYN1deg minus SSF1deg trend difference. (Units:  $Wm^{-2}$  per year).

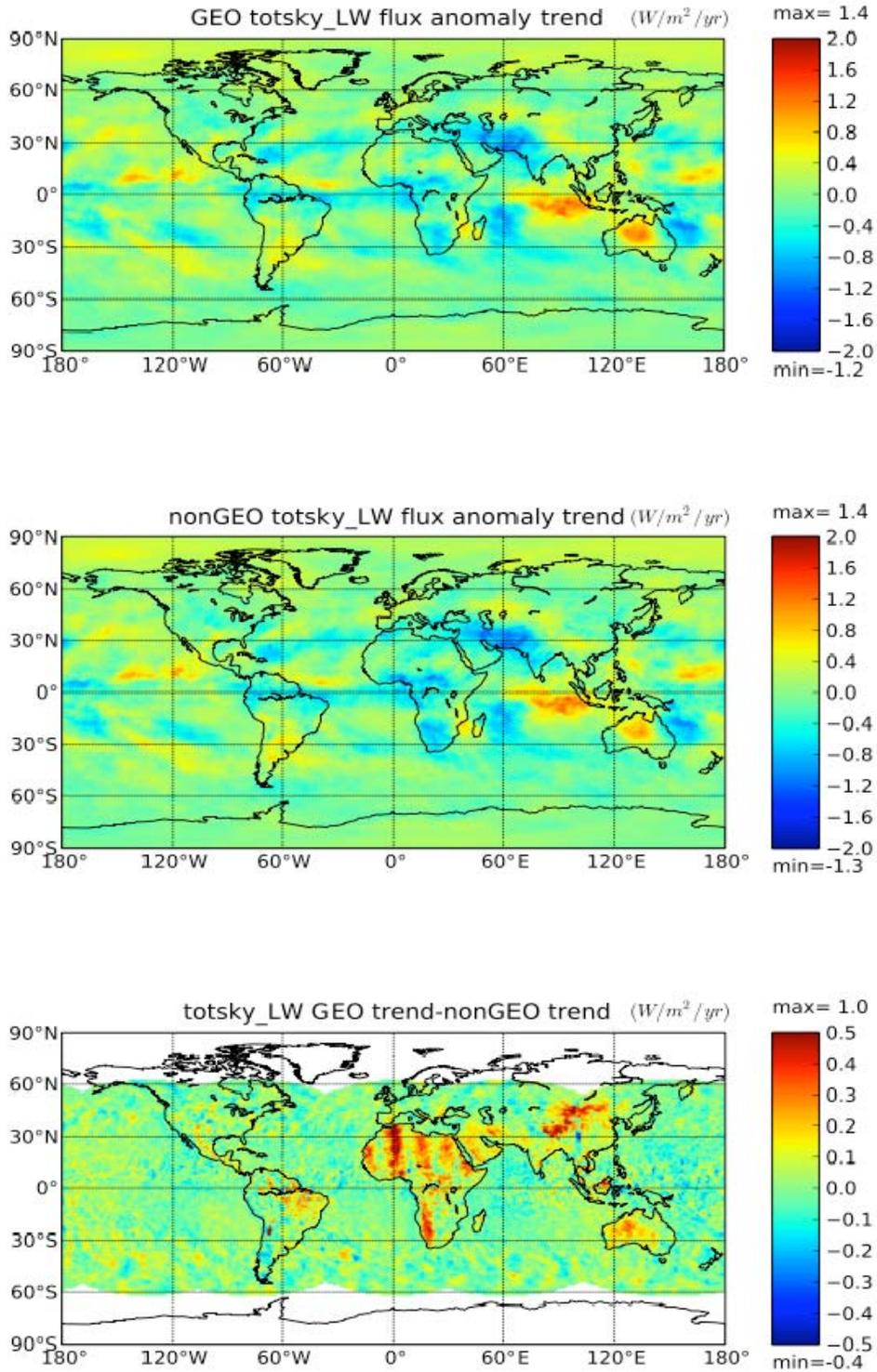


Figure 4-7. Ten-year regional linear trends in LW TOA flux anomalies from SYN1deg (top) and SSF1deg (middle). Bottom figure shows the SYN1deg minus SSF1deg trend difference. (Units:  $Wm^{-2}$  per year).

Edition2.5 - SRBAVGnonGEO\_Ed2

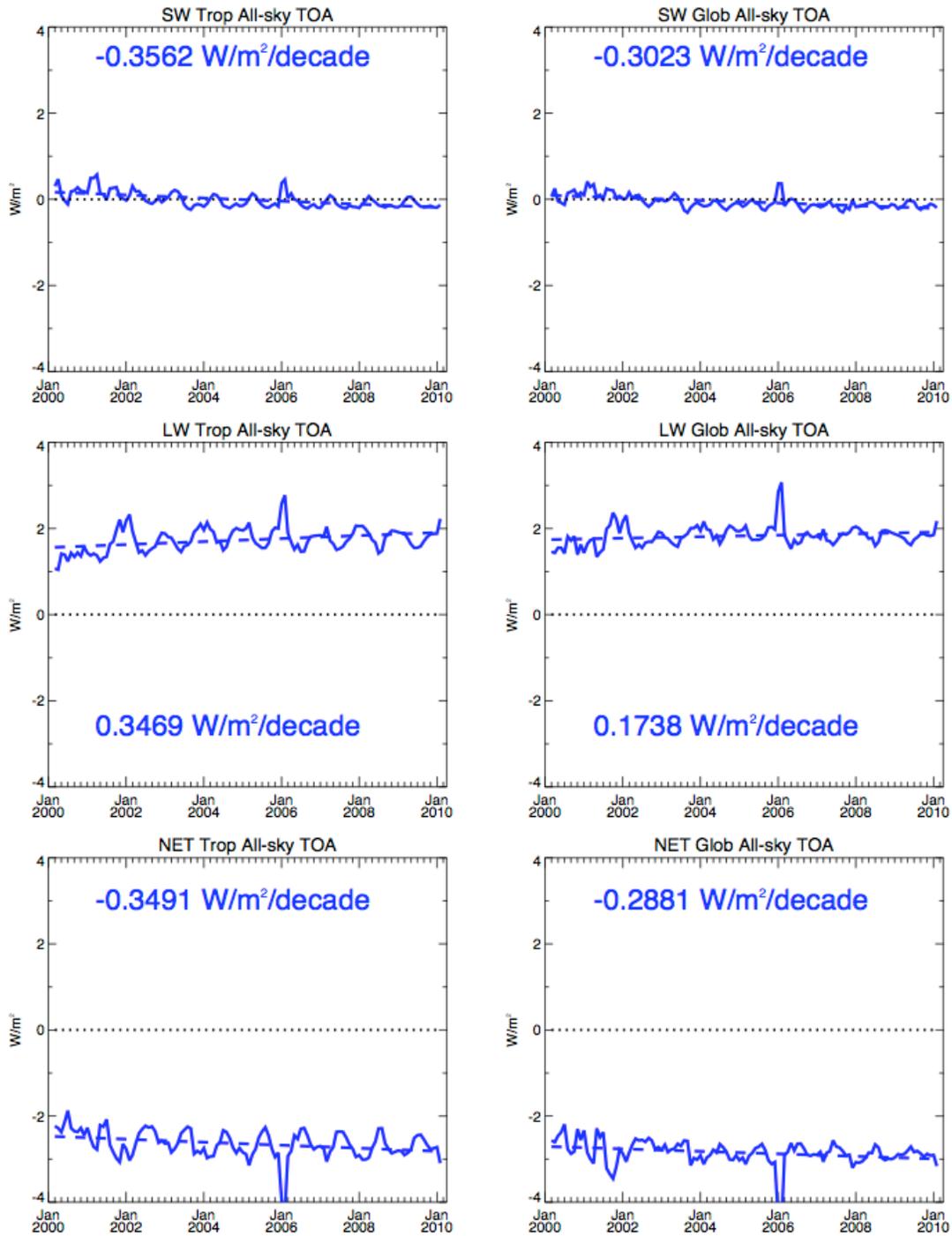


Figure 4-8. The Ten-year regional monthly mean flux difference between SSF1deg (Ed 2.5) minus SRBAVG-nonGEO\_rev1 (Ed 2) for TOA SW (top) LW (middle) and Net (bottom). The trend difference is also given. (Units:  $Wm^{-2}$  per decade). The left panel plots are for the Tropics ( $\pm 30^\circ$  latitude) and the right is for global.

Edition2.5 - ERBElite\_Ed2

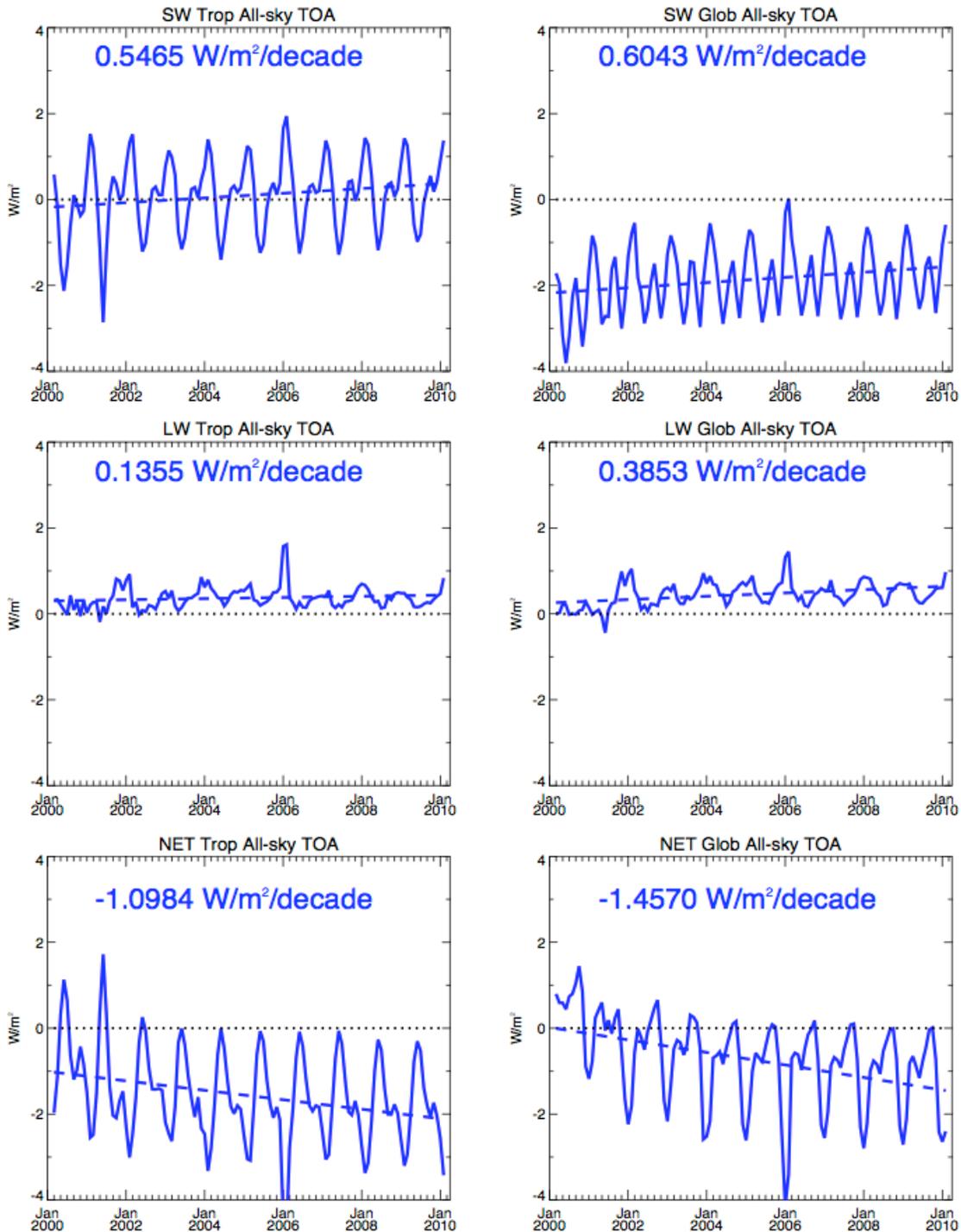


Figure 4-9. The Ten-year regional monthly mean flux difference between SSF1deg (Ed2.5) minus ERBElite\_rev1 (Ed 2) for TOA SW (top) LW (middle) and Net (bottom). The trend difference is also given. (Units:  $Wm^{-2}$  per decade). The left panel plots are for the Tropics ( $\pm 30^\circ$  latitude) and the right is for global.

## 5.0 References

- Kopp, G., G. Lawrence, and G. Rottman, 2005: The Total Irradiance Monitor (TIM): Science Results, *Solar Physics*, **230**, 129-140.
- Loeb, N.G., B.A. Wielicki, W. Su, K. Loukachine, W. Sun, T. Wong, K.J. Priestley, G. Matthews, W.F. Miller, and R. Davies, 2007: Multi-instrument comparison of top-of-atmosphere reflected solar radiation, *J. Climate*, **20**, No. 3, 575-591.

## **6.0 Expected Reprocessing**

There is a scheduled reprocessing of the Terra and Aqua levels 2 and 3 data products starting in Fall 2010. CERES\_SSF1deg-lite\_Ed2.6 will be superseded with CERES\_SSF1deg\_Edition3 that will be processed at the ASDC using a processing strategy very similar to CERES\_SSF1deg-lite\_Ed2.6 but will include the full suite of cloud, TOA and surface flux parameters. This updated version will be available for subsetting/visualization/ordering at: [http://ceres.larc.nasa.gov/order\\_data.php](http://ceres.larc.nasa.gov/order_data.php).

## **7.0 Attribution**

When referring to a CERES SSF1deg and SYN1deg, please include the data set version, and the data product. Depending upon what mission is considered, these data sets may be referred to as "CERES Terra SSF1deg-lite\_Ed2.6", "CERES Aqua SSF1deg-lite\_Ed2.6", "CERES Terra SYN1deg-lite\_Ed2.6", "CERES Aqua SYN1deg-lite\_Ed2.6".

The CERES Team has gone to considerable trouble to remove major errors and to verify the quality and accuracy of this data. Please provide a reference to the following paper when you publish scientific results with the

CERES Terra SSF1deg-lite\_Ed2.6  
CERES Aqua SSF1deg-lite\_Ed2.6  
CERES Terra SYN1deg-lite\_Ed2.6  
CERES Aqua SYN1deg-lite\_Ed2.6

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee III, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment, *Bull. Amer. Meteor. Soc.*, 77, 853-868.

When Langley ASDC data are used in a publication, we request the following acknowledgment be included: "These data were obtained from the NASA Langley Research Center EOSDIS Distributed Active Archive Center."

The Langley ASDC requests two reprints of any published papers or reports which cite the use of data that we have distributed. This will help us determine the use of data that we distribute, which is helpful in optimizing product development. It also helps us to keep our product related references current.

## **8.0 Feedback and Questions**

For questions or comments on the CERES Quality Summary, contact the User and Data Services staff at the Atmospheric Science Data Center. For questions about the CERES subsetting/visualization/ordering tool at [http://ceres.larc.nasa.gov/order\\_data.php](http://ceres.larc.nasa.gov/order_data.php), please click on the feedback link on the left-hand banner.