ADVANCES IN EARTH RADIATION BUDGET OBSERVATIONS FROM CERES TERRA

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The goal of the Clouds and the Earth's Radiant Energy System (CERES) project is to provide a long-term record of radiation budget at the top-of-atmosphere (TOA), within the atmosphere, and at the surface with consistent cloud and aerosol properties at climate accuracy [1]. CERES consists of an integrated instrument-algorithm-validation science team that provides development of higher-level products (Levels 1-3) and investigations. It involves a high level of data fusion, merging inputs from 25 unique input data sources to produce 18 CERES data products. Over 90% of the CERES data product volume involves two or more instruments.

At the heart of the CERES project are the CERES instruments. Thus far, five CERES instruments (PFM, FM1-FM4) have flown on three different spacecraft: TRMM, EOS-Terra and EOS-Aqua. CERES FM5 is scheduled for launch on the NPP spacecraft, and FM6 will fly on NPOESS C1. Each CERES instrument is a scanning broadband radiometer that measures filtered radiances in the SW (wavelengths between 0.3-5 μm), total (TOT) (wavelengths between 0.3-200 μm) and WN (wavelengths between 8-12 μm) regions. On *Terra*, CERES has a spatial resolution of approximately 20 km (equivalent diameter). To correct for the imperfect spectral response of the instrument, the filtered radiances are converted to unfiltered reflected solar, unfiltered emitted terrestrial LW and WN radiances [2]. These are then used to determine SW, LW and WN TOA radiative fluxes by applying Angular Disitrbution Models (ADMs) [3] constructed from two years of CERES Terra biaxial scan data using MODIS cloud property retrievals for scene identification [4]. MODIS cloud and aerosol retrievals, meteorological data from the Global Modeling and Assimilation Office—Goddard Earth Observing System Model, and aerosol assimilation data from the Model of Atmospheric Transport and Chemistry (MATCH) are used as input to a modified version of the [5] radiative transfer code to provide computed SW, LW and net radiative fluxes at several levels within the atmosphere and at the surface. Surface radiative fluxes are also estimated using simpler parameterizations [6]. In order to account for diurnal variations in clouds and radiation, the CERES and MODIS observations on Terra are combined with data from five geostationary instruments to produce 1°×1° gridded TOA, within-atmosphere and surface radiative fluxes at 3-hourly, daily, and monthly time scales. Considerable effort is spent on verifying the consistency of the many instruments and inputs to ensure that the CERES data product reflect real changes in the climate system as opposed to artificial changes associated with the input data.

The CERES data continue a critical record of TOA radiation following the successful Earth Radiation Budget Experiment (ERBE). One of the more interesting scientific results of the past 10 years is based upon both ERBE and CERES. Fig. 1 shows how the interannual variability of the net flux anomalies between 1993-2003 from the ERBS Nonscanner WFOV and CERES Terra Scanner instruments agree with the interannual variability of the ocean heat storage data to within the ocean heat storage sampling uncertainties. The two times series are in phase with each other, consistent with the constraint of planetary energy balance. The result is remarkable given the totally independent physical measurement and sampling of the ocean heat storage data and the radiation datasets. The net flux anomalies within a single decade can be as large as 1.5 Wm^{-2} according to both the ERB and the ocean storage data. The variability is most likely due to changes in cloudiness. Fig. 2 provides the SW, LW and net TOA radiation variations for the period from March 2000 to August 2009. SW radiation shows a gradual decrease with time while LW radiation shows negative anomalies early in the mission and from the mid-2007 to 2009. The LW changes are closely tied with ENSO events in the tropics, as indicated in Fig. 3. It is interesting to note that during 2008 net TOA flux (Fig. 2) into the Earth-atmosphere system is generally positive even though that year was the coldest of the previous decade. This and other intriguing results will be further explored during this presentation.

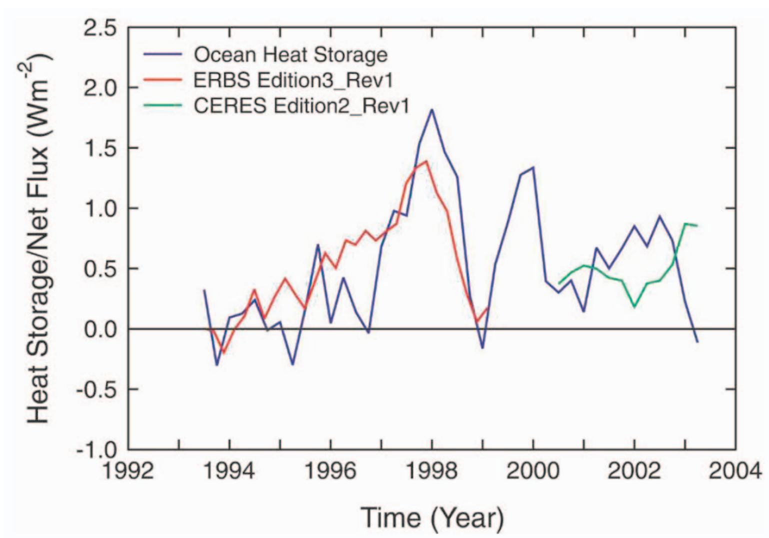
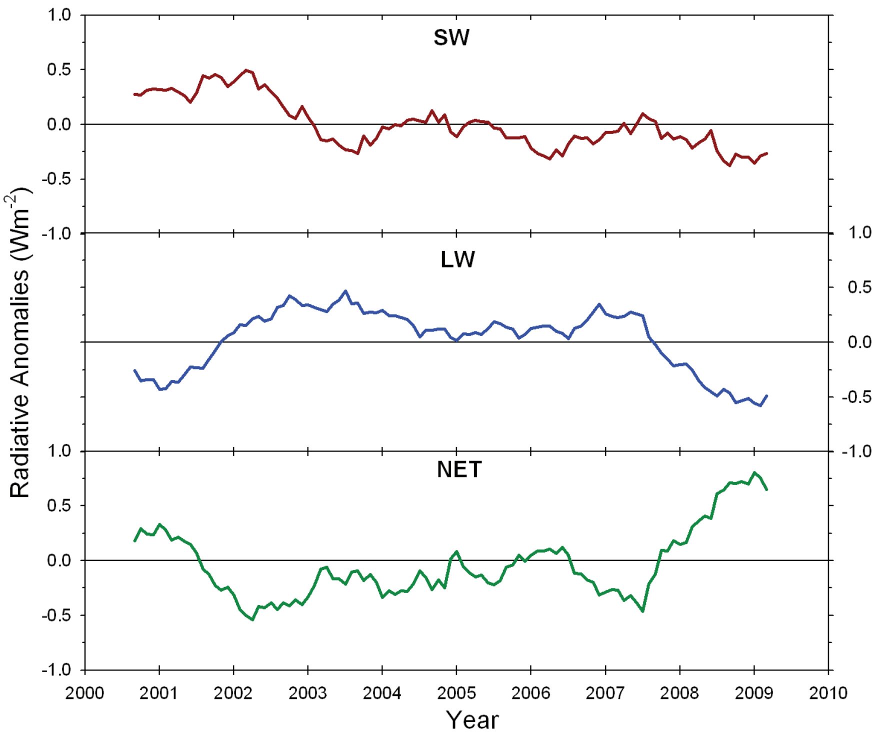


Figure 1 Interannual comparison of global ocean heat storage (blue) against global net flux anomalies from ERBE/ERBS Nonscanner WFOV Edition3_Rev1 (red) and CERES/Terra FM1 Scanner ES4 Edition2_Rev1 (green) for a 10-yr period from 1993 to 2003. (From [7]).



iFigure 2 CERES Terra global TOA radiation deseasonalized anomalies from March 2000 through August 2009. A 12-month running mean was used in order to remove high-frequency variability in the data.

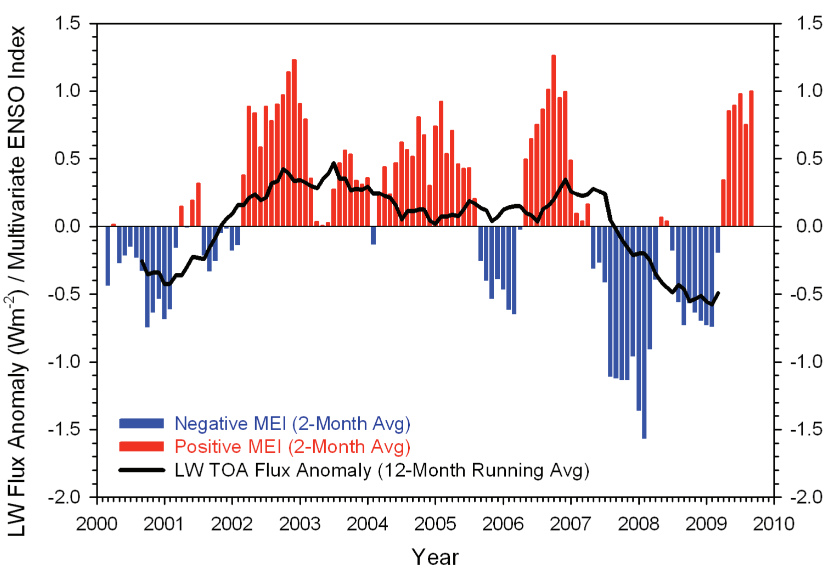


Figure 3 CERES Terra global LW TOA flux anomalies and Multivariate ENSO index for March 2000 through August 2009.

References

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