AEROSOL, CLOUD AND RADIATION MEASUREMENTS FROM EARTH OBSERVING SATELLITES

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1. INTRODUCTION

The Atmospheric Science Data Center (ASDC) at NASA Langley Research Center processes, archives, and distributes data relating to the Earth's Atmospheric radiation budget, clouds, aerosols, and tropospheric chemistry. The Clouds and the Earth's Radiant Energy System (CERES), International Satellite Cloud Climatology Project (ISCCP), and Multi-angle Imaging SpectroRadiometer (MISR) instruments are key instruments in obtaining and producing several data products that provide global observations of radiation, cloud, and aerosol properties for climate monitoring and climate change studies.

The CERES experiment is one of the highest priority scientific satellite instruments developed for NASA's Earth Observing System (EOS). The CERES missions follow the successful Earth Radiation Budget Experiment (ERBE) mission that began in 1984. The first CERES instrument was launched in November 1997 on the Tropical Rainfall Measuring Mission Satellite. CERES instruments are also currently flying on the EOS Terra and Aqua satellites. These two sets of instruments provide long-term, overlapping radiation budget parameters including broadband shortwave (SW), longwave (LW) and net radiative fluxes for clear sky and cloudy conditions.

ISCCP focuses on the distribution and variation of cloud radiative properties to improve the understanding of the effects of clouds on climate, the radiation budget, and the long-term global hydrologic cycle. The ISCCP was established in 1982 as part of the World Climate Research Programme (WCRP) to collect weather satellite radiance measurements and to analyze them to infer the global distribution of clouds, their properties, and their diurnal, seasonal and interannual variations. The resulting data products are being used to study the role of clouds in climate, both their effects on radiative energy exchanges and their role in the global water cycle.

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The MISR instrument was built for NASA by the Jet Propulsion Laboratory (JPL) in Pasadena, California. It was launched into polar orbit on board the Terra satellite from Vandenberg Air Force Base on December 18, 1999. MISR measurements are designed to improve our understanding of the Earth's environment and climate with data collected using nine cameras, at different angles and four wavelengths (red, blue, green, near-infrared). Data products from MISR contain top-of-atmosphere (TOA) radiance, aerosol, and cloud measurements from regional and global scale environments.

2. CERES MEASUREMENTS

2.1 CERES Overview

The CERES instrument is a key component of NASA's EOS program. The CERES instrument provides radiometric measurements of the Earth's atmosphere from three broadband channels. Following the successful ERBE mission (1984–2005), two CERES instruments (FM1 and FM2) were launched into polar orbit on board the EOS Terra flagship on December 18, 1999, and two additional CERES instruments (FM3 and FM4) were launched on board EOS Aqua satellite on May 4, 2002.

The CERES instrument is a scanning radiometer with three channels: a SW channel (0.3 - 5.0 μm) to measure reflected sunlight, a LW channel to measure Earth-emitted radiation in the 8-12 μm window (WN) region, and a total channel to measure all wavelengths (0.3 to > 100 μm). The spatial resolution at nadir is 10 km from the TRMM platform and 20 km from the EOS Terra and Aqua platforms. Two scan modes are used in CERES operations. A cross-track scan mode takes measurements similar to those made by the ERBE instruments for long-term continuity. A rotating biaxial scan mode provides new angular flux information.

2.2 CERES Data Products

CERES instantaneous single scanner instrument data products contain TOA reflected SW, LW and WN radiances and TOA fluxes with temporally and spatially coincident imager-based radiances, cloud properties, and aerosols. The monthly averaged products such as the Monthly TOA/Surface Averages (SRBAVG) contain gridded global Earth Radiation Budget (ERB) data which provide climate quality monthly mean fluxes and cloud properties. These data contain monthly and monthly-hourly regional, zonal, and global averages of the TOA and surface SW, LW and WN fluxes, and the observed cloud conditions. Figure 1 shows the net flux for September 2001. The regional means for each 1° equal-angle grid box are 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 on two time scales. Monthly means are calculated using the combination of observed and interpolated parameters from all days containing at least one CERES observation. Monthly-hourly means are produced from the time series by dividing the data into 24 local hour bins to define a monthly mean diurnal cycle.

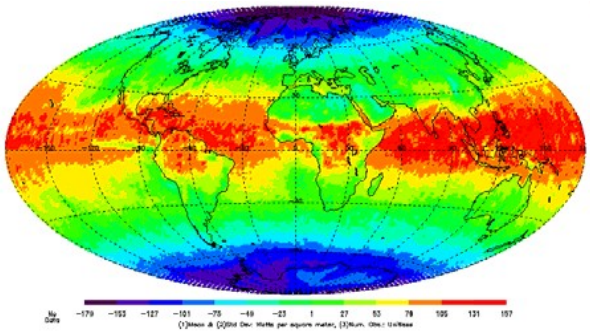

Figure 1. CERES Monthly Average TOA Net Flux for September 2001. Image credit: NASA/LaRC/ASDC

3. ISCCP MEASUREMENTS

3.1 ISCCP Overview

Global coverage for ISCCP is provided by the five geostationary meteorological satellites (GOES-EAST, GOES-WEST, GMS, INSAT, and METEOSAT) and at least one polar orbiting NOAA satellite. Data collection began on July 1, 1983 and is currently planned to continue through June 30, 2010. The resulting data sets and analysis products are being used to improve understanding and modeling of the role of clouds in climate, with the primary focus being the elucidation of the effects of clouds on the radiation balance. These data can also be used to support many other cloud and climate studies

3.2 ISCCP Data Products

ISCCP generates a 3-hourly pixel level cloud product containing calibrated radiances, cloud detection results, cloud and surface properties from radiative analysis on a 30 km grid. The 3-hourly gridded cloud product contains the spatial averages, statistical summaries, and cloud type properties on a 280 km equal-area grid. The climatological summary product averages the gridded data to generate monthly averages at each 3 hour interval and once for the entire month as shown in Figure 2 for September 2001.

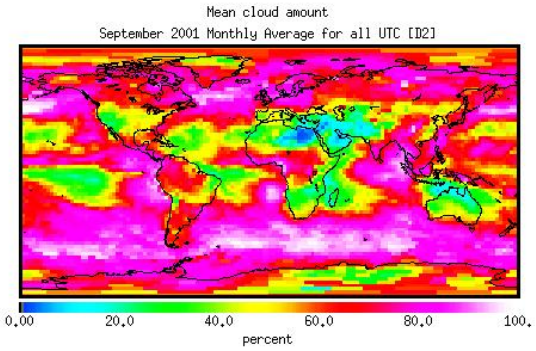

Figure 2. ISCCP-D2 Monthly Mean Cloud Amount for September 2001. Image credit: NASA/LaRC/ASDC

4. MISR MEASUREMENTS

4.1 MISR Overview

The MISR instrument provides a unique view of Earth, obtaining precisely calibrated images taken simultaneously at nine different angles. New types of information are provided by MISR for scientists studying Earth's climate, such as the partitioning of energy and carbon between the land surface and the atmosphere, and the regional and global impacts of clouds and different types of atmospheric aerosols, on climate. The change in reflection at different view angles provides the means to distinguish aerosol types, cloud forms, and land surface covers. Combined with stereoscopic techniques, this enables construction

of 3-D cloud models and estimation of the total amount of sunlight reflected by Earth's diverse environments. MISR has continuously provided data since February 24, 2000.

4.2 MISR Products

The MISR products include a range of parameters such as aerosol optical depth at 17.6 km resolution, radiances for each camera and band at 275 m resolution, and altitude-binned cloud classifications and cloud albedo values on a 1.1 km grid. The MISR global products provide gridded data averaged over daily, monthly, seasonal, and annual time scales.

The MISR gridded Radiance Product contains a statistical summary of spectral TOA radiances in four wavelengths. The gridded Aerosol product as shown in Figure 3 for September 2001 contains aerosol optical depth at 558 nm. The gridded Land/Surface product contains various surface reflectance and vegetation productivity parameters. Also available are gridded cloud albedo products.

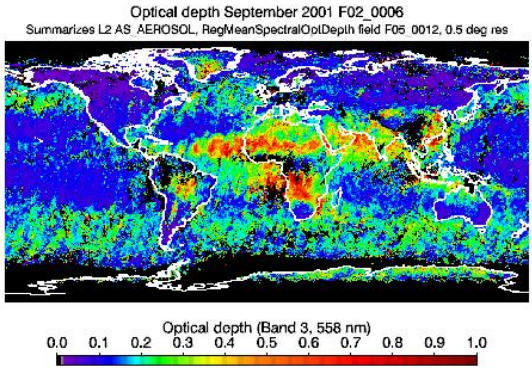

Figure 3. MISR Monthly Average Aerosol Optical Depth for September 2001.
Image credit: NASA/GSFC/LaRC/JPL, MISR Team

MISR also developed the "Clim-Likely" global 1° x 1°, monthly aerosol climatology product derived from 'typical-year' aerosol transport model results are available for individual grid boxes or as global files. Six component aerosols included in the model were medium and coarse mode mineral dust, sulfate, sea salt, black carbon, and carbonaceous aerosols. Five aerosol air mass "Mixing Groups" and thirteen sub-groups were identified from a cluster analysis of the entire set of data. Each Mixing Group contains the four most abundant component particles in the column for climatologically common aerosol air masses. Each sub-group identifies the dominant particles within the Mixing Group.

5. ADDITIONAL INFORMATION

ASDC at NASA Langley Research Center was established in 1991 to support EOS as part of NASA's Earth Science enterprise and the U.S. Global Change Research Program, and is one of several Distributed Active Archive Centers (DAACs) sponsored by NASA. The Data Center specializes in atmospheric data important to understanding the causes and processes of global climate change and the consequences of human activities on the climate. ASDC currently supports more than 40 projects and has over 1700 archived data sets. The current data archive volume is more than one Petabyte.

Customers of the NASA Langley Data Center include scientists; federal, state, and local governments; researchers; educational and commercial professionals; application users; the commercial remote sensing community; and the general public.

All ASDC data are available to the public free of charge. Detailed information about the data products, including documentation, ordering tools, and tools for working with the data, are available from http://eosweb.larc.nasa.gov .