

Clouds and the Earth's Radiant Energy System (CERES) Clouds and Radiation Swath (CRS) Data Set Abstract



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Data Set Description:

The Clouds and Radiative Swath (CRS) product contains one hour of instantaneous Clouds and the Earth's Radiant Energy System (CERES) data for a single scanner instrument. The CRS contains all of the CERES SSF product data. For each CERES FOV on the SSF, the CRS also contains vertical flux profiles evaluated at five levels in the atmosphere: the surface, 500 hPa, 200 hPa, 70 hPa, and TOA. These through-the-atmosphere fluxes are computed by making two passes through a radiative transfer model. After an initial pass through the model, the modeled TOA results are compared against the CERES TOA results produced by the CERES inversion process and contained on the SSF. Inputs to the model are adjusted accordingly, and a second pass is made through the model. The results of the second, or constrained, pass are more consistent with the CERES TOA values.

The CRS contains the following constrained vertical flux profiles for both clear sky and total sky conditions evaluated at the surface, 500 hPa, 200 hPa, 70 hPa, and TOA, along with pristine and aerosol-free total sky fluxes evaluated at the surface and the TOA. (Please note that the aerosol-free total sky flux data are not available on the TRMM CRS granules.) Pristine denotes a theoretical sky condition that is free of both aerosols and clouds. Aerosol-free total sky denotes a theoretical sky condition that includes clouds but is free of aerosols.

- Longwave upward and downward.
- Shortwave upward and downward.
- Window channel upward and downward.

The initial flux profiles are not contained on the CRS; however, the adjustments between the constrained and initial profiles for the following are included for clear sky, total sky, pristine, and aerosol-free total sky conditions:

- Longwave upward at the surface and TOA, and downward at the surface.
- Shortwave upward at the surface and TOA, and downward at the surface.
- Window channel upward at the surface and TOA, and downward at the surface.

The adjustments to the radiative transfer model input parameters between the initial and the constrained passes are also contained on the CRS. These parameters include:

- Surface albedo and skin temperature.
- Total column precipitable water and upper tropospheric relative humidity.
- Aerosol optical depth.
- Cloud optical depth, fractional area, and effective temperature.

Additional information about the format and content of the CRS can be found in the CERES Data Products Catalog. The CRS Quality Summary briefly describes the algorithms used for radiative transfer and constraint (tuning), as well as the data inputs.

Summary of Changes:

The CERES Data Management Team and the Atmospheric Science Data Center (ASDC) at Langley use a Sampling Strategy, a Production Strategy, and a Configuration Code (CCode) to track versions of CERES primary data products. In general, minor reprocessing changes are tracked by increasing the Configuration Code while major reprocessing changes result in a new Production Strategy. The Sampling Strategy identifies the satellite and instruments which acquired the data in the product.



A summary of changes made to the CERES CRS product is shown in the following tables.

Modification History for: Aqua | [Terra](#) | [TRMM](#)

Modification History of the CERES Aqua CRS Archival Product

Also see [Modification History for CERES SSF Aqua FM3 and FM4](#)

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on Aqua CRS Product
Aqua-FM3-MODIS_Edition2C ⁽⁴⁾ Aqua-FM4-MODIS_Edition2C ⁽⁴⁾	021033	September 2008	<ul style="list-style-type: none"> • No changes to the CERES SARB software. • Switched MODIS input files for CRS processing from collection 004 to collection 005. • See corresponding SSF documentation and CRS Data Quality Summary for impacts of switch of MODIS inputs from Collection 004 to Collection 005.
Aqua-FM3-MODIS_Edition2B ⁽⁴⁾ Aqua-FM4-MODIS_Edition2B ⁽⁴⁾	021031	March 2008	<ul style="list-style-type: none"> • A new ancillary data file was added for Aqua processing which eliminates the use of the monthly MODIS aerosol map. This solved infrequent problems caused by treatment of default data in MODIS files.
Aqua-FM3-MODIS_Edition2A ⁽⁴⁾ Aqua-FM4-MODIS_Edition2A ⁽⁴⁾	021028	August 2006	<ul style="list-style-type: none"> • Photosynthetically active radiation over surface values were modified to include spectral weighting factors that convert the spectral band 7-10 (557.5 - 689.6nm) output to 400 - 700nm (CRS SDS 161). • Surface albedo retrievals were corrected for instances where the associated MATCH value is less than 0.0001 to avoid division by zero. • The definition of surface albedo over cloudy-sky coast was modified to use the SAH cloudy land albedo value from the monthly SSF-based surface albedo history map for ocean coverage of less than 1% to correct unrealistically large surface albedo values for cloudy-sky coastal FOVs. • The definition of surface albedo for clear-sky coast was modified to use Zhonghai Jin's ocean look-up table value to correct the resulting modeled TOA albedo that was larger than the CERES value for clear-sky coast. • Cloudy sky over snow



			<p>surface albedo retrievals were modified to include a more complex look-up table to account for the influence of more available input parameters. Sulfate aerosol optical depth is used for the retrieval model. Ocean surface albedo is assumed for out-of-range low retrieval and Snow is assumed for out-of-range high retrieval.</p> <ul style="list-style-type: none"> • The spectral shape in the UV region was modified to include revised values for the closed shrubs, woody savanna, savanna, grassland, cropland, crop mosaic, and tundra IGBP scene types. • The direct/diffuse definition for ice clouds was corrected to improve the handling of the ice cloud forward scattering peak for the 2-stream solver. • Time varying trace gas concentrations for CO₂, CH₄, and N₂O were included to account for trace gas increases that have been observed. • The water percentage thresholds to 20:99% were treated as coast for surface albedo logic. FOVs that are mostly land (1:20%) are better served by using the monthly SSF-based surface albedo history map than a water percent weighted IGBP default surface albedo.
<p>Aqua-FM3-MODIS_Beta1 ⁽⁴⁾ Aqua-FM4-MODIS_Beta1 ⁽⁴⁾</p>	<p>020027</p>	<p>July 2005</p>	<ul style="list-style-type: none"> • The Aqua Beta1 CRS data set was the first CRS data set produced from Aqua data. This data set was produced using the same software and ancillary input data sets as the Terra Edition2B CRS data set. • For FOVs where the MATCH data is the sole source of aerosol optical depth information, the MATCH 0.55 mm data instead of the MATCH 0.63 mm data will be applied in the Fu-Liou model. Using the wrong wavelength causes constituents with extinction decreasing with wavelength (sulfate, water soluble, soot) to have a reduced effect, and



			<p>causes constituents that have extinction increasing with wavelength (mineral dust, insoluble) to have an increased effect.</p> <ul style="list-style-type: none"> • The Langley Fu-Liou model was updated to add new Lacis dust aerosol data for the aerosol scene type indexes 19-23 for 0.5mm, 1.0mm, 2.0mm, 4.0mm, and 8.0mm dust, respectively. The FLSA table was also modified accordingly. The new dust properties are less absorbing than the earlier (1996) version. • Aerosols are now allowed in the stratosphere above 15km, which allows for full use of the MATCH aerosol profile data which is provided up to 1 hPa or ~50Km. • Modified interpretation of the ADMgeo parameter to take advantage of new information added by the ADM group for the Terra Edition2B SSF delivery. Default values are now clearer and new non-default data provided information regarding the location of the centroid of the FOV in relation to the microwave imager retrievals. • CRS Parameters Affected: Terra CRS 161-163, 172-183, 193-235
Availability: (1) not available; (2) restricted to CERES analysts; (3) restricted to CERES Science Team and analysts; (4) public			

Modification History for: [Aqua](#) | Terra | [TRMM](#)

Modification History of the CERES Terra CRS Archival Product

Also see [Modification History for CERES SSF Terra FM1 and FM2](#)

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on Terra CRS Product
Terra-FM1-MODIS_Edition2G ⁽⁴⁾	029034	August 2010	<ul style="list-style-type: none"> • No changes to the CERES SARB software. • Continued with MODIS input files for CRS processing from collection 005 (as Ed2F). • Switched input files from GEOS-4 (Ed2B and Ed2F) to GEOS-5 (Ed2G). • See corresponding SSF documentation and CRS Data Quality Summary for impacts of switch to GEOS-5.
Terra-FM1-MODIS_Edition2F ⁽⁴⁾ Terra-FM2-MODIS_Edition2F ⁽⁴⁾	020030	September 2008	<ul style="list-style-type: none"> • No changes to the CERES SARB software. • Switched MODIS input



			<p>files for CRS processing from collection 004 to collection 005.</p> <ul style="list-style-type: none"> • See corresponding SSF documentation and CRS Data Quality Summary for impacts of switch of MODIS inputs from Collection 004 to Collection 005.
Terra-FM1-MODIS_Edition2B ⁽⁴⁾ Terra-FM2-MODIS_Edition2B ⁽⁴⁾	021028	September 2006	<ul style="list-style-type: none"> • No science impact.
Terra-FM1-MODIS_Edition2B ⁽⁴⁾ Terra-FM2-MODIS_Edition2B ⁽⁴⁾	018024	May 2005	<ul style="list-style-type: none"> • For FOVs where the MATCH data is the sole source of aerosol optical depth information, the MATCH 0.55 mm data instead of the MATCH 0.63 mm data will be applied in the Fu-Liou model. Using the wrong wavelength causes constituents with extinction decreasing with wavelength (sulfate, water soluble, soot) to have a reduced effect, and causes constituents that have extinction increasing with wavelength (mineral dust, insoluble) to have an increased effect. • The Langley Fu-Liou model was updated to add new Lacis dust aerosol data for the aerosol scene type indexes 19-23 for 0.5mm, 1.0mm, 2.0mm, 4.0mm, and 8.0mm dust, respectively. The FLSA table was also modified accordingly. The new dust properties are less absorbing than the earlier (1996) version. • Aerosols are now allowed in the stratosphere above 15km, which allows for full use of the MATCH aerosol profile data which is provided up to 1 hPa or ~50Km. • Modified interpretation of the ADMgeo parameter to take advantage of new information added by the ADM group for the Terra Edition2B SSF delivery. Default values are now clearer and new non-default data provided information regarding the location of the centroid of the FOV in relation to the microwave imager retrievals. • CRS Parameters Affected: Terra CRS 161-163, 172-183, 193-235



- The use of the Gridded Daily MODIS land angstrom exponent with the $0.55\mu\text{m}$ AOT was incorporated to produce a spectral AOT for desert scene types. The angstrom exponent previously derived from the fit to the three wavelengths for land given by the MOD08_d3 product produced large negative (physically unrealistic) angstrom exponents in many locations.
- A new version of Fu-Liou radiative transfer model that includes a Gamma Weighted Two-Stream Algorithm (GWTS) SW code that deals with inhomogeneous clouds was incorporated. The new model configuration is a more efficient, one time computation of cloud and aerosol optical properties, necessary for the more complex GWTS solver.
- The SW downward spectral weights for an adjustment of the initial spectral albedo to match the retrieved TOA-based broadband surface albedo was modified to include tables for desert and snow surfaces where spectral insolation weights are different from those for low albedo surfaces. This corrected for significant differences at low sun angles.
- The definition for out of range cloudy sky TOA-based retrievals was updated to default to the broadband surface albedo and spectral shape of the sea ice. The previous approach of defaulting to the ocean broadband surface albedo and spectral shape was incorrect.
- The surface properties algorithm was updated to treat sea ice coverage over the range of 0 to 100 percent. Previously, the ocean albedo algorithm was only called when the ocean area coverage was greater than 50 percent.
- The spectral emissivity for desert and open shrub scene types for the $10\text{-}11\mu\text{m}$ and $11\text{-}12\mu\text{m}$ Fu-

Liou bands was revised to reflect the yearly scene type mean of the Cloud WG ISCCP-based emissivity maps to produce more consistent results between Clouds and SARB.

- The software was modified to process FOVs for which the CERES Observed SW TOA is bad but the CERES Observed LW TOA is good through the radiative transfer model. The increased number of processed FOVs provides more LW results for analysis.
- The SSF ADMgeo parameter was included in the logic that adjusts the IGBP scene vector when the cloud coverage is greater than 95 percent to be consistent with the Cloud WG retrieval assumption of cloud properties over a snow or ice surface. The Instantaneous SARB logic uses the IGBP scene vector to decide the surface spectral albedo and emissivity as well as the mode of obtaining the broadband surface albedo.
- The look-up table values for fresh snow and permanent snow surface albedo used in the computation of surface albedo were modified to include values for different snow grain sizes (50 μ m for fresh snow and 1000 μ m for permanent snow).
- The diffuse angle for cloudy scenes was corrected from 60 degrees to 53 degrees.
- The ocean surface albedo lookup table was updated. The new table values are based on improved ocean optics data (sea water absorption data from Pope and Fry (1997) and parameterizations for the optical properties of Phytoplankton particles based on Morel and Mariterena (2001)).
- SARB SDS 75, Sigma table version number, was redefined as FuLiou model error code. SARB SDS 75 now indicates the error status returned from the



			<p>radiative transfer algorithm. The new SDS is the same type as the old SDS. (CERES SCCR #498)</p> <ul style="list-style-type: none"> • Use of the GFDL aerosol climatology was replaced with the use of a new MATCH-based climatology that varies with month. The MATCH-based climatology is only used if there is no daily MATCH data. The proportion of absorbing aerosol over the Northern Polar regions was too large in the GFDL climatology.
Terra-FM1-MODIS_Beta5 ⁽³⁾ Terra-FM2-MODIS_Beta5 ⁽³⁾	014017 014017	October 2003	<ul style="list-style-type: none"> • No changes were made to the SARB algorithms from those used for the Terra-FM1-MODIS_Beta4 data set.
Terra-FM1-MODIS_Beta4 ⁽¹⁾ Terra-FM2-MODIS_Beta4 ⁽¹⁾	013016 013016		<ul style="list-style-type: none"> • The cloudy-sky over snow albedo retrieval algorithms were modified to correctly use the snow/ice percentage flag provided on the SSF input product. • Corrections were made to the use of aerosol optical thickness over land from the backup source, the MODIS MOD08-based Interpolated Daily Maps. Previous use resulted in invalid OLR values. • Aerosol-free total sky flux profile data at the surface and the TOA were added to the CRS product.
Terra-FM1-MODIS_Beta3 ⁽¹⁾ Terra-FM2-MODIS_Beta3 ⁽¹⁾	011014 / 012015 011014 / 012015		<ul style="list-style-type: none"> • Two new sources for aerosol optical thickness data were incorporated into the CRS product. The first is an instantaneous aerosol optical thickness data set based on the MODIS MOD03 product and the second new source is aerosol optical thickness over land data from the MODIS MOD08-based Interpolated Daily Map product. • Algorithms for retrieving surface albedo over snow conditions were incorporated. • The modified version of the Fu-Liou model used by the CERES SARB Working Group was modified to include the Hitran2000 SW absorption.

Availability: (1) not available; (2) restricted to CERES analysts; (3) restricted to CERES Science Team and analysts; (4) public



Modification History of the CERES TRMM CRS Archival Product

Also see [Modification History for CERES SSF TRMM-PFM-VIRS](#)

Sampling Strategy and Production Strategy	CCode	Available at ASDC	Impact on TRMM CRS Product
TRMM-PFM-VIRS_Edition2C ⁽⁴⁾	012015	March 2003	<ul style="list-style-type: none"> • No changes were made to the SARB algorithms from those used for the TRMM-PFM-VIRS_Edition2B data set. • Software errors encountered when converting from a binary format to an HDF format were corrected. The parameters affected include the CERES Observed TOA and surface fluxes, the number of levels included in the vertical profiles, and the aerosol constituency flags. In the TRMM-PFM-VIRS_Edition2B data set these parameters were erroneously defined according to the CERES default values.
TRMM-PFM-VIRS_Edition2B ⁽⁴⁾	010011	September 2002	<ul style="list-style-type: none"> • The limit for the allowable sunglint percentage per FOV was increased from zero to 90%, allowing more FOVs to be processed through the SARB algorithms. • The SARB Constraint algorithm was modified to "freeze" cloud parameters for skies that are less than 5% cloudy. • New water spectral surface albedo look up table values were incorporated.
TRMM-PFM-VIRS_Beta3 ⁽¹⁾	009009		<ul style="list-style-type: none"> • A new ocean spectral surface albedo look up table, the result of a discrete ordinate model with coupled ocean and atmosphere optics, was incorporated. • To improve accuracy of the Outgoing Longwave Radiation (OLR) results over hot surfaces, the radiative transfer model was modified to include two bands in the thermal IR/Solar transition region to cover wavelengths 2200 to 2850 cm⁻¹. • The water vapor continuum parameterization was updated from CKD 2.1 to



			<p>CKD 2.4. CKD2.4 is more transparent in the 400 to 1000 cm⁻¹ wavelength range, leading to increased OLR by approximately 1 Wm⁻².</p> <ul style="list-style-type: none"> • A bug in previous CRS results for ice clouds was corrected. The ice particle diameter is now converted from the mean effective diameter (De) obtained from the input SSF product to a generalized effective diameter (Dge) that is required by the Fu-Liou radiative transfer model. • An inconsistency between cloud height and temperature between the initial and constrained passes was corrected by constraining to the cloud top temperature instead of to the cloud effective temperature. • Scene-dependent spectral curves for wavelengths greater than 1.5 microns were modified for consistency with results from MODIS, which showed a lower surface reflectance than that which SARB had been using. • Instead of calculating vertical flux profile values for the TOA at 1.0 hPa, modeled TOA fluxes are now calculated at 0.1 hPa.
TRMM-PFM-VIRS_Beta2 ⁽¹⁾	008008		<ul style="list-style-type: none"> • Due to the advances in the TRMM ADMs that yield more accurate instantaneous CERES TOA flux values, the sigma values used in the constraint process were modified so that the modeled TOA fluxes are more tightly constrained to the Total flux provided on the SSF product, and less tightly to the radiances and window channel flux also provided as input on the SSF.
TRMM-PFM-VIRS_Beta1 ⁽¹⁾	008007		<ul style="list-style-type: none"> • Corrected aerosol constituency scale heights and default value
TRMM-PFM-VIRS_Subset-VaIR4 ⁽¹⁾	007006	May 2001	<ul style="list-style-type: none"> • Use of a monthly surface albedo history product was added. • Access to a climatology for the total aerosol optical depth whenever such data were unavailable from the SSF input product was added. The aerosol data



			<p>provided by either the SSF or the climatology were divided into multiple aerosol scene-dependent constituencies, with constituency scale heights and percent ratios obtained through the climatology.</p> <ul style="list-style-type: none"> • The archived vertical flux profiles for clear and total sky conditions were expanded to include a fifth level at 200 hPa. • Pristine fluxes at the surface and TOA were added.
TRMM-PFM-VIRS_ValidationR3 (1)	006004	April 1999	<ul style="list-style-type: none"> • One month (January 1998) of data only • First software delivery to produce CRS data at ASDC
Availability: (1) not available; (2) restricted to CERES analysts; (3) restricted to CERES Science Team and analysts; (4) public			

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The requested form of acknowledgment for any publication in which these data are used is:

"These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center."

The Langley Data Center requests a reprint of any published papers or reports or a brief description of other uses (e.g., posters, oral presentations, etc.) of data that we have distributed. This will help the Data Center determine the use of data distributed, which is helpful in optimizing product development. It also helps us to keep our product related references current.

Reference:

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

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

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