

<b>Listing of CERES Subsystems Validation Summary Charts:</b>	<b><u>Page No.</u></b>
<u>Subsystem 1.0 - Instrument Geolocate and Calibrate Earth Radiances</u> .....	2
<u>Subsystem 2.0 - ERBE-Like Inversion to Instantaneous TOA Fluxes</u> .....	4
<u>Subsystem 3.0 - ERBE-Like Averaging to Monthly TOA Fluxes</u> .....	6
<u>Subsystem 4.1 - Imager Clear-Sky Determination and Cloud Detection</u> <u>TBD</u> .....	--
<u>Subsystem 4.2 - Imager Cloud-Top Heights and Imager Cloud-Base Heights</u> .....	8
<u>Subsystem 4.3 - Validation of Imager Cloud Optical Properties</u> .....	10
<u>Subsystem 4.4 - Convolution of Imager Cloud Properties with CERES Footprint Point Spread Function</u> .....	12
<u>Subsystem 4.5 - CERES Inversion to Instantaneous TOA Fluxes</u> .....	13
<u>Subsystem 4.6 - Validation of CERES Surface Radiation Budget (SRB)</u> .....	14
<u>Subsystem 5.0 - Surface and Atmospheric Radiation Budget (SARB)</u> .....	15
<u>Subsystem 6.0 - Gridding and Spatial Averaging</u> <u>TBD</u> .....	--
<u>Subsystem 7.0 - Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites</u> .....	18
<u>Subsystem 8.0 - Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties</u> .....	20
<u>Subsystem 10.0 - Monthly Regional TOA and Surface Radiation Budget</u> .....	22

# **CERES VALIDATION SUMMARY**

Release 2.2 July 1997

## **Subsystem 1.0 - CERES Geolocate and Calibrate Earth Radiances**

### **Data Products**

- Earth radiances:
  - 1) Filtered broadband shortwave [0.3 - 5.0  $\mu\text{m}$ ]
  - 2) Total-wave [0.3 -  $>100 \mu\text{m}$ ]
  - 3) Water vapor window [8 - 12  $\mu\text{m}$ ]

### **Approach**

- Resolution/geometric sites used during the ERBE spacecraft missions
- Radiometric accuracy and precision in-flight calibration systems [demonstrated by ERBE] measurement accuracy via ground-to-orbit and precision via in-flight time series
- Radiometric precision/consistency checks among same and different types of CERES sensors using ERBE techniques
- Compare CERES radiances to earth validation targets calibrated with 5 years of ERBS data
- Three channel redundancy check for consistency
- Offsets validated using spacecraft pitch-up and monitored monthly against ERBS global limb-darkening

Release 2.2 July 1997

# **CERES VALIDATION SUMMARY**

## **Subsystem 1.0 - CERES Geolocate and Calibrate Earth Radiances (CONTINUED)**

### **Validation Activities**

- Prelaunch
  - 1) All validation and consistency checks will be based upon CERES sensor ground calibration data sets
  - 2) Establish radiation statistics of earth validation targets. Longwave target is tropical ocean at night. Shortwave target is desert region in daytime. Learn technique by applying to ERBE NOAA-9 data.
- Postlaunch
  - 1) Collection of in-flight calibration measurements and calculated filtered Earth radiances on designated calibration days
  - 2) Compare CERES radiances to historical ERBS radiances via earth validation targets.

### **Archive**

- In-flight calibrations will be archived in BDS format at EOSDIS
- Publications describing the sensor calibration and validation results as well as public science computing facility (SCF) files of the appropriate calibration and validation data.

Release 2.2 July, 1997

# **CERES VALIDATION SUMMARY**

## **Subsystem 2.0 - ERBE-like Inversion to Instantaneous TOA Fluxes**

### **Data Products and Parameters**

- Parameters: ERBE-like ADMs, ERBE-like TOA flux
- Product: CERES ES-8

### **Approach**

- Test ADMs with SAB Method (SAB monthly means independent of ADMs)
- Build new ADMs from CERES data
- Constant Flux Test (flux consistency with viewing zenith)
- Compare ERBE-like & CERES fluxes (same data, different scene ID & ADMs)
- Intercompare ERBE-like flux from TRMM and EOS AM-1.

### **Pre-Launch Validation Activities**

- Test ADMs with SAB Method using Nimbus-7 data
- Apply Constant Flux Test to ERBE along-track data
- Validate data processing system using CERES simulation
- Establish mean and variance of difference between ERBE-like flux and CERES flux from CERES simulation

Release 2.2 July, 1997

# **CERES VALIDATION SUMMARY**

## **Subsystem 2.0 - ERBE-like Inversion to Instantaneous TOA Fluxes (CONTINUED)**

### **Post-Launch Validation Activities**

- 1) Test ADMs with SAB Method using CERES RAP data
- 2) Build new ERBE-like ADMs from CERES data & compare with current ADMs.
- 3) Apply Constant Flux Test with CERES data
- 4) Determine flux difference between ERBE-like flux and CERES flux and test against prelaunch statistics

### **Archive**

- All validation tests are off-line.

Release 2.2 July, 1997

# **CERES VALIDATION SUMMARY**

## **Subsystem 3.0 ERBE-Like Averaging To Monthly Toa Fluxes**

### **Data Products/Parameters**

- ERBE-like clear-sky and all-sky radiative parameters at the TOA on various spatial (regional, zonal, and global) and temporal (daily, monthly-hourly, and monthly mean) scales.

### **Missions**

- TRMM, EOS AM-1, and EOS PM-1

### **Approach**

- Complete pre-launch science studies for improving and verifying TISA methods.
- Verify input/output operations and interface compatibility with other subsystems.
- Compare ERBE-like results with validation data sets.

### **Pre-Launch Validation Activities**

- Complete validation of the ERBE-like science algorithm.
- Finish testing of the ERBE-like data processing system.
- Verify ERBE-like TOA results with existing ERBE scanner data.
- Validate data processing system using CERES end-to-end simulation.

Release 2.2 July, 1997

# **CERES VALIDATION SUMMARY**

## **Subsystem 3.0 ERBE-Like Averaging To Monthly Toa Fluxes**

### **(CONTINUED)**

#### **Post-Launch Validation Activities**

- Primary comparison with geostationary data using narrowband-to-broadband conversion technique.
- Secondary direct verification (if available) with ERBE WFOV results, ScaRaB data, and GERB data.
- Additional intercomparison between TRMM, EOS AM-1, and EOS PM-1 data.
- Continuous monitoring of the quality of the input data product and detecting problems in the overall system.

#### **EOSDIS**

- Special processing of CERES ERBE-like data products containing validation sites.

# **CERES VALIDATION SUMMARY**

## **Subsystem 4.2 Imager Cloud-Top And Cloud-Base Heights**

### **Products/Parameters**

- Product: CERES SSF
- Parameters: Cloud-top and cloud-base heights for both single- and multiple-layered clouds

### **Missions**

- TRMM, EOS AM-1, & EOS PM-1

### **Approach:**

- First develop global and regional maps of retrieved cloud heights
- Show that global and regional analyses indicate consistent results moving from ocean to land, day to night, snow to water, desert to water, etc.
- Once results are consistent, compare retrieved cloud boundaries with ground-based, other satellite-based, or aircraft-based data of cloud boundaries (most appropriate for stratiform clouds)
- Comparisons of simultaneous retrievals from multiple satellites, aircraft and satellite, or surface with satellite



## **CERES VALIDATION SUMMARY**

### **Subsystem 4.2 Imager Cloud-Top And Cloud-Base Heights (CONTINUED)**

#### **Pre-Launch Validation Activities**

- Compare cloud boundary data from field programs with satellite retrievals
- Compare surface synoptic observations with satellite retrievals of single and multilevel cloud occurrences

#### **Post-Launch Validation Activities**

- Increase number of long-term monitoring sites to include midlatitude oceans, mountains, deserts, and tropical land
- Develop field programs over surface types where little if any data currently exist, such as deserts
- Perform quick-look global and regional analyses of cloud boundary products
- Compare CERES cloud boundary retrievals with validation sites

#### **EOSDIS**

- Perform subsetting of processed full-resolution CERES imager data stream
- Archive validation site cloud boundary data

Release 2.2, July 1997

# **CERES VALIDATION SUMMARY**

## **Subsystem 4.3 - Validation Of Imager Cloud Optical Properties**

### **Data Products**

- Cloud phase, effective particle size, water path, optical depth, emittance, radiating temperature, & thickness

### **Missions**

- TRMM, EOS AM-1, & EOS PM-1

### **Approach: Pre- & Post-launch**

- comparisons with in situ & surface/aircraft Remote sensing  
***Yields estimate of bias errors***
- simultaneous retrievals from multiple satellites or aircraft & satellite  
***Produces statistics, relative errors, & scene/angle dependence***
- model calculations to determine algorithm sensitivities to input & assumptions  
***Leads to physical understanding of observations***

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 4.3 - Validation Of Imager Cloud Optical Properties (CONTINUED)**

### **Pre-Launch Validation Activities**

- complete analyses of field program data & compare with satellite retrievals
- develop & analyze matched satellite datasets having appropriate spectral channels
- study algorithm sensitivity to cloud inhomogeneities, viewing & illumination conditions, background, & input
- identify key climate regimes needing further validation

### **Post-Launch Validation Activities**

- increase number of long-term monitoring sites
- develop field programs & instruments for long-term deployment
- perform quick-look analyses of global products
- combine full-resolution ceres and validation site datasets, perform comparisons
- compare retrievals to those from other satellites & instruments

### **EOSDIS**

- facilitate dataset acquisition
- archive combined CERES & correlative datasets

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 4.4 - Convolution Of Imager Cloud Properties With CERES Footprint Point Spread Function (PSF)**

### **DATA PRODUCTS/PARAMETERS**

CERES Product: SSF

Parameter: PSF sets location & size of CERES footprint & averaging weights.

### **MISSIONS**

TRMM, EOS AM-1, EOS PM-1

### **APPROACH**

Regress CERES & imager data, minimize variance with PSF centroid & dispersion.

### **PRE-LAUNCH**

Develop regression for best fit of CERES & imager data & develop statistics of minimum variance point. Use ERBS & AVHRR data for pre-launch studies.

### **POST-LAUNCH**

Apply regression technique to 1st month of CERES data from TRMM & EOS AM.

### **EOSDIS**

All validation tests off-line.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 4.5 - Inversion To Instantaneous TOA Fluxes**

### **DATA PRODUCTS/PARAMETERS**

CERES Product: SSF, Parameters: TOA flux, CERES 200 ADMs.

**MISSIONS:** TRMM, EOS AM-1, EOS PM-1

### **APPROACH**

Test ADMs with: SAB Method (monthly means, no ADMs)  
Along-track Test (flux growth with viewing zenith)  
MISR Comparison (compare to independent data)  
TOA flux bias and variance determined from ADM bias and variance.

### **PRE-LAUNCH**

Validate ERBE 12 ADMs for initial CERES inversion.

### **POST-LAUNCH**

Validate CERES 200 ADMs.  
Intercompare ERBE-like flux and CERES flux.

### **EOSDIS**

EOSDIS SSF product is data source. All validation tests off-line.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 4.6 - Surface Radiation Budget (SRB)**

**Output Data Parameters:** Net shortwave (SW) surface flux; Clear-sky downward longwave ( $> 5.0$  m), window (8.0 - 12.0 m) and non-window surface fluxes ( $\text{W/m}^2$ ); and Cloudy-sky downward and net longwave (LW) surface fluxes.

### **Validation Criteria:**

RMS errors: 20  $\text{W/m}^2$  for instantaneous retrievals  
10  $\text{W/m}^2$  for gridded monthly average SW & LW surface fluxes

### **Validation Data Sources:**

ARM/CART Southern Great Plains (SGP) available from CAGEX experiment  
ARM Tropical Western Pacific (TWP) & North Slope Alaska (NSA) data to be obtained  
NOAA Integrated Surface Irradiance Study (ISIS), including SURFRAD network (U.S.)  
WCRP Baseline Surface Radiation Network (BSRN) at selected sites around the globe.

### **Validation Procedure:**

gather measured TOA & surf. fluxes for SW & LW, & atmos. temp. & water vapor  
apply radiative transfer algorithms to TOA data for simulated surface radiation fluxes  
compare simulated fluxes with measured surface radiation fluxes  
conduct thorough error analysis of comparisons.

**Validation Archive:** Anonymous ftp and/or through the World Wide Web.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 5.0 - Surface and Atmospheric Radiation Budget (SARB)**

### **DATA PRODUCTS/PARAMETERS**

- Broadband SW and LW fluxes at surface, 500 hPa, tropopause, and TOA
- Photosynthetically active radiation at surface
- Adjustments to cloud, atmospheric, and surface properties to balance computed fluxes with TOA measurements

**MISSIONS:** TRMM, EOS AM-1, EOS PM-1

### **APPROACH**

- Long-term collection of non-EOS surface measurements
  - Sort observations and CERES products to common format
  - Issue validating data and products on www
  - Expand current pre-launch validation activities
  - CERES/ARM/GEWEX Experiment (CAGEX)  
<http://snowdog.larc.nasa.gov:8081/cagex.html>
- 3 categories of validation sites with continuous monitoring
  - Class 1 Remote Sensing Physics
    - Non EOS programs
    - Comprehensive measurements - ARM sites

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 5.0 - Surface and Atmospheric Radiation Budget (SARB) (CONTINUED)**

### **Class 2 Regional Climate Trend**

Non EOS programs, but NASA instruments needed

Require surface radiation, aerosols, cloud lidar, helicopter survey; desire cloud radar

Combine with CERES radiative transfer

Determine regional forcing of aerosols and surface

### **Class 3 Discrete Validation Sites**

Non EOS programs, Individual flux measurements in networks

- Extensive aircraft campaign at Class 1 sites

## **PRE-LAUNCH VALIDATION ACTIVITIES**

- Validation of pre-CERES global Release 1 (October 1986 data)  
Compare with other satellite data (i.e., GEWEX SRB)  
and available Class 3 sites (i.e., GEBA)
- Expand current CAGEX from ARM CART SGP site for GCIP
- ARESE October 1995 study with aircraft fluxes and CAGEX to determine sampling pattern of post-launch flights
- Helicopter survey of surface optical properties at key sites  
Whitlock spectral SW for MISR/MODIS/ASTER/CERES



# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 5.0 - Surface and Atmospheric Radiation Budget (SARB) (CONTINUED)**

### **POST-LAUNCH VALIDATION ACTIVITIES**

- CAGEX to cover all 3 ARM sites
- Aircraft fluxes and at ARM sites as needed
- Helicopter surveys of selected Class 2 sites (EOS-wide use)
- Determine climate forcing of aerosols, surface changes at Class 2 sites; extend regionally with satellite data
- Ship of opportunity with cloud lidar and pyrgeometer needed for cloud base height, surface LW flux
- Supplement oceanography campaigns with surface meas.

### **EOSDIS**

- Special processing of CERES data from regions containing Class 1, 2, 3 sites and for roving ship monitor
- Development of CAGEX-like data bases at selected sites

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 7.0 - Time Interpolation And Synoptic Flux Computation For Single And Multiple Satellites**

### **DATA PRODUCTS/PARAMETERS**

- TOA, in-the-atmosphere, and surface flux and clouds layer information in the atmosphere at 3-hourly GMT time resolution over the whole globe.

### **MISSION**

- TRMM, EOS AM-1, and EOS PM-1.

### **APPROACH**

- Complete pre-launch science studies for improving and verifying TISA methods.
- Verify input/output operations and interface compatibility with other subsystems.
- Compare results with validation data set.

### **PRE-LAUNCH VALIDATION ACTIVITIES**

- Complete validation of the science algorithm.
- Finish testing of the data processing system.
- Verify TOA results with historical ERBE TOA scanner data.
- Perform case study using geostationary data, CAGEX, and TOGA data to verify science algorithm.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 7.0 - Time Interpolation And Synoptic Flux Computation For Single And Multiple Satellites (CONTINUED)**

- Validate data processing system using CERES end-to-end simulation.
- TOA, in-the-atmosphere, and surface flux and clouds layer information at 3-hourly GMT time resolution over the whole globe.

## **POST-LAUNCH VALIDATION ACTIVITIES**

- Primary comparison of TOA fluxes with geostationary data using narrowband-to-broadband conversion technique.
- Secondary direct verification of TOA fluxes (if available) with ERBE WFOV results, ScaRaB data, and GERB data.
- Comparison with cloud and radiation data from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV experiment).
- Comparison with cloud and radiation data collected from special validation regions; including class 1 and class 2 sites (i.e., Walker Tower, Boulder Tower, NOAA sites, and BSRN sites).
- Additional intercomparison between TRMM, EOS AM-1, and EOS PM-1 data.

## **EOSDIS**

- Special processing of CERES SYN data products containing validation sites.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 8.0 Monthly Regional, Zonal, And Global Radiation Fluxes And Cloud Properties**

### **DATA PRODUCTS/PARAMETER**

- Monthly regional radiative fluxes and clouds data product (AVG) and monthly zonal and global radiative fluxes and cloud data product (ZAVG) contain monthly means and monthly-hourly means on regional, zonal, and global scales.

### **MISSION**

- TRMM, EOS AM-1, and EOS PM-1.

### **APPROACH**

- Complete pre-launch science studies for improving and verifying TISA methods.
- Verify input/output operations and interface compatibility with other subsystems.
- Compare results with validation data set.

### **PRE-LAUNCH VALIDATION ACTIVITIES**

- Complete validation of the science algorithm.
- Finish testing of the data processing system.
- Verify TOA results with historical ERBE TOA scanner data.
- Perform case study using CAGEX and TOGA data to verify science algorithm.
- Validate data processing using CERES end-to-end simulation.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 8.0 - Monthly Regional, Zonal, And Global Radiation Fluxes And Cloud Properties (CONTINUED)**

### **POST-LAUNCH VALIDATION ACTIVITIES**

- Primary comparison of TOA fluxes with geostationary data using narrowband-to-broadband conversion technique.
- Secondary direct verification of TOA fluxes (if available) with ERBE WFOV results, ScaRaB data, and GERB data.
- Comparison with cloud and radiation data from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV experiments).
- Comparison with cloud and radiation data collected for special validation region; including class 1 and class 2 sites (i.e., Walker Tower, Boulder Tower, NOAA sites, and BSRN sites)
- Additional intercomparison between TRMM, EOS AM-1, and EOS PM-1 data.

### **EOSDIS**

- Special processing of CERES AVG and ZAVG data products containing validation sites.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 10.0 - Monthly Regional TOA And Surface Radiation Budget**

### **DATA PRODUCTS/PARAMETERS**

- Monthly and monthly-hourly regional, zonal, and global averages of the TOA and surface LW and SW fluxes and the observed cloud conditions for each of the CERES region.

### **MISSION**

- TRMM, EOS AM-1, and EOS PM-1.

### **APPROACH**

- Complete pre-launch science studies for improving and verifying TISA methods.
- Verify input/output operations and interface compatibility with other subsystems.
- Compare results with validation data set.

### **PRE-LAUNCH VALIDATION ACTIVITIES**

- Complete validation of the science algorithm.
- Finish testing of the data processing system.
- Verify TOA results with historical ERBE TOA scanner data.
- Perform case study using CAGEX data to verify science algorithm.
- Validate data processing system using CERES end-to-end simulation.

# **CERES VALIDATION SUMMARY**

Release 2.2, July 1997

## **Subsystem 10.0 - Monthly Regional TOA And Surface Radiation Budget (CONTINUED)**

### **POST-LAUNCH VALIDATION ACTIVITIES**

- Primary comparison of TOA fluxes with geostationary data using narrowband-to-broadband conversion technique.
- Secondary direct verification of TOA fluxes (if available) with ERBE WFOV results, ScaRaB data, and GERB data.
- Comparison with cloud and radiation data from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV experiments).
- Comparison with cloud and radiation data collected for special validation regions; including class 1 and class 2 sites (i.e., Walker Towers, Boulder Tower, NOAA sites, and BSRN sites).
- Additional intercomparison between TRMM, EOS AM-1, and EOS PM-1 data.
- Continuous monitoring of the quality of the input data product and detecting problems in the overall system.

### **EOSDIS**

- Special processing of CERES SRBAVG data products containing validation sites.