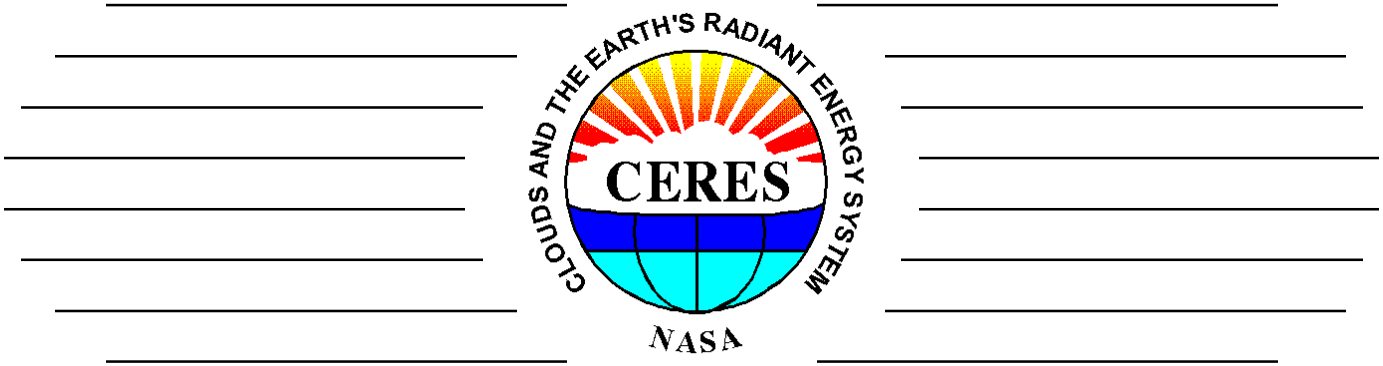
CERES Instrument Overview / Calibration



Kory J. Priestley

CERES Data Products Workshop

28 January, 2003
Norfolk, Virginia

Agenda

- Role and responsibilities of the Instrument Working Group in the CERES Project
- CERES Instrument Overview
- Radiometric Calibration Goals and on-orbit performance
- Comprehensive on-orbit Cal/Val plan/protocol
- Instrument Working Group Web page demo

Instrument Working Group

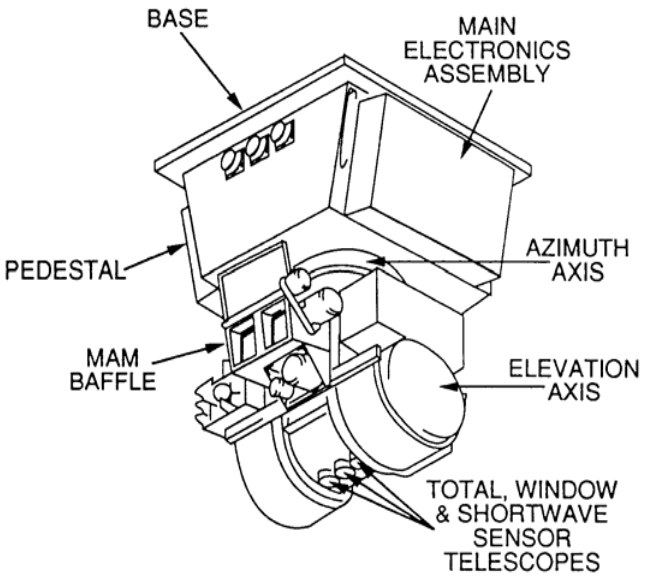
- **5 CERES instruments launched to date on 3 platforms**

Platform	Instrument	Orbit	Launch date
TRMM	PFM	35-deg inclination	11/27/97
Terra	FM1 and FM2	10:45 am	12/18/99
Aqua	FM3 and FM4	1:30 pm	5/4/02
-	FM5	-	-

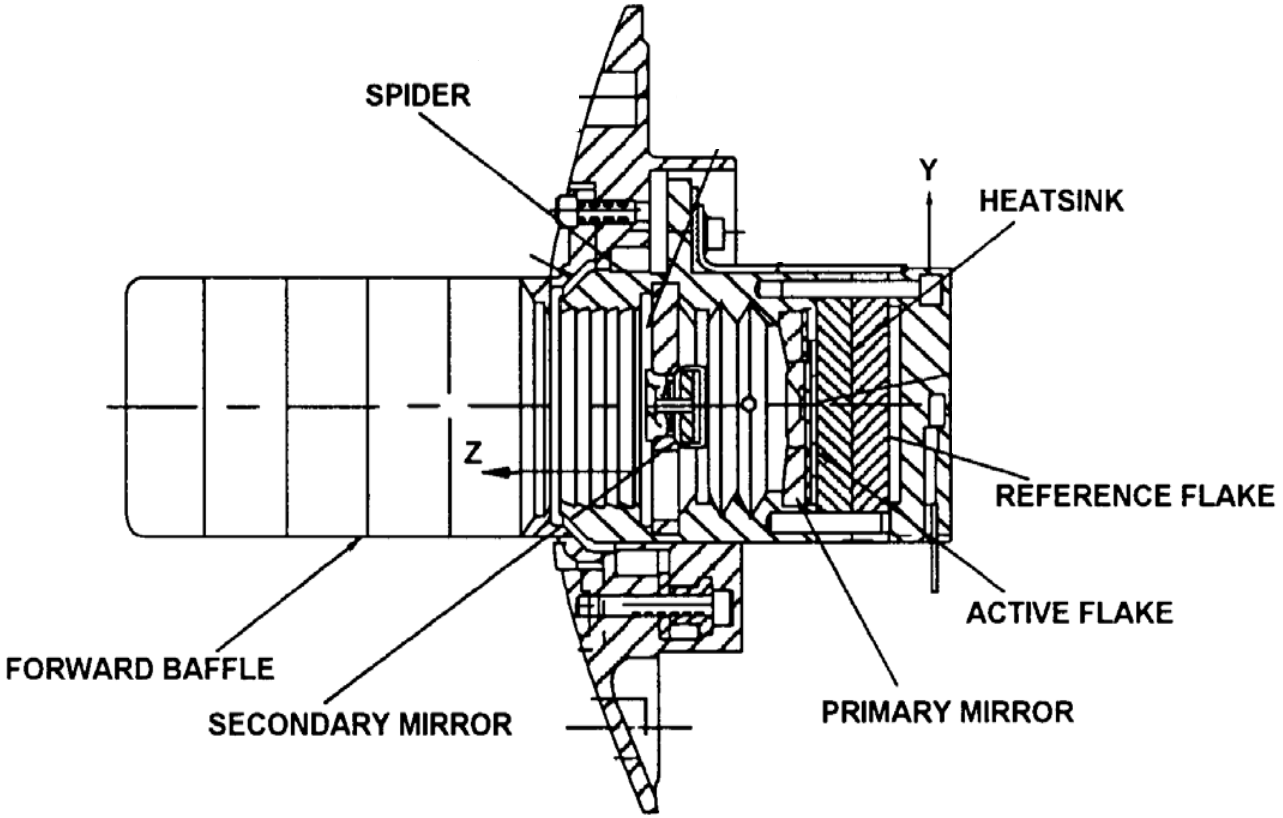
- **Characterize and calibrate the instrument spectrally, spatially,temporally and radiometrically**
- **Responsible for ensuring instrument performance is in consonance with all science objectives**
- **Continually looking at ways to improve measurement technology to maximize scientific return**
- **Long term goal is to minimize the dichotomy between science and engineering**

CERES Instrument

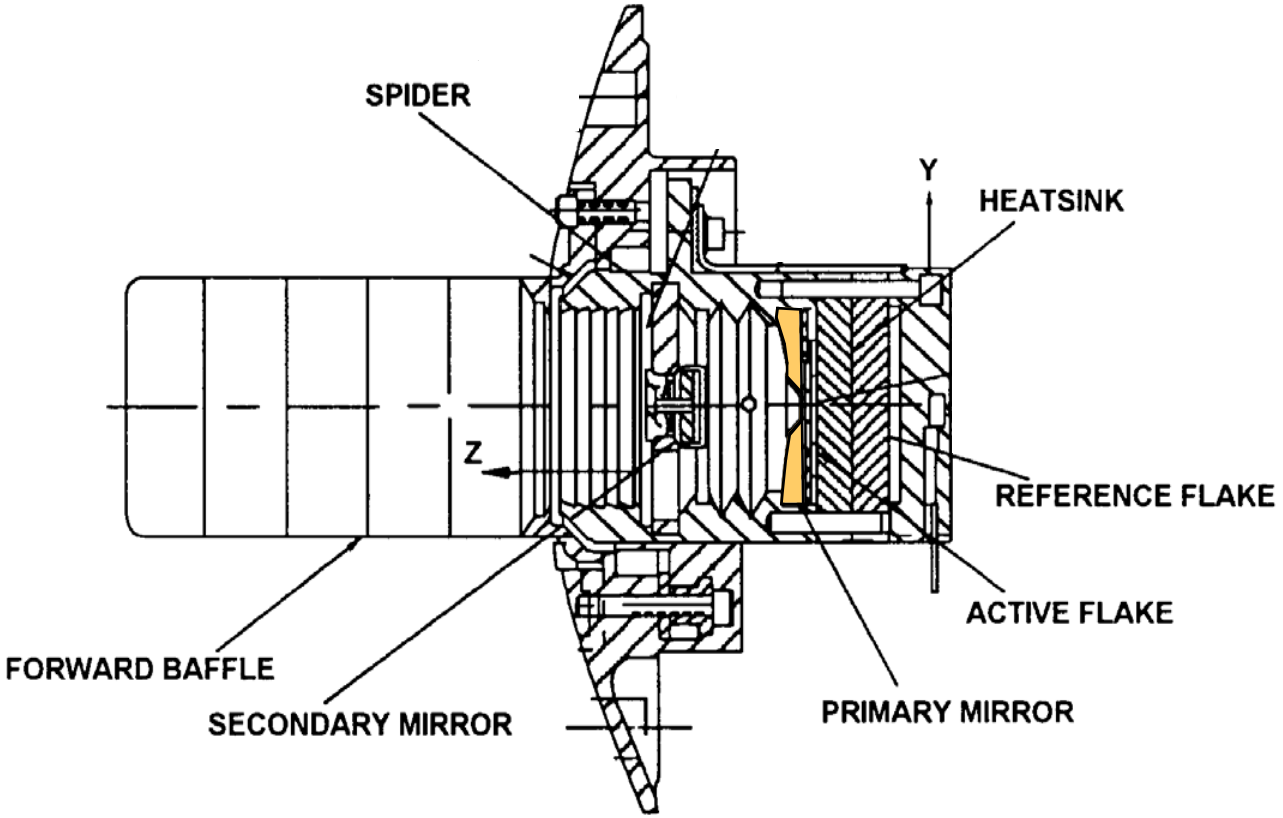
- Design is based upon the Earth Radiation Budget Experiment (ERBE) philosophy
- Instrument was designed, manufactured and tested by TRW (Redondo Beach, CA)
- Contains three sensor assemblies with cassegrain optics and thermistor bolometer detectors
- Sensors measure thermal radiation in the near-visible through far-infrared spectral region
- Three sensor channels are coaligned and mounted on a spindle which rotates about the elevation axis
- Hemispherical sampling obtained with an azimuthal axis drive system
- Channel fields of view overlap by <98%
- On-board calibration capability



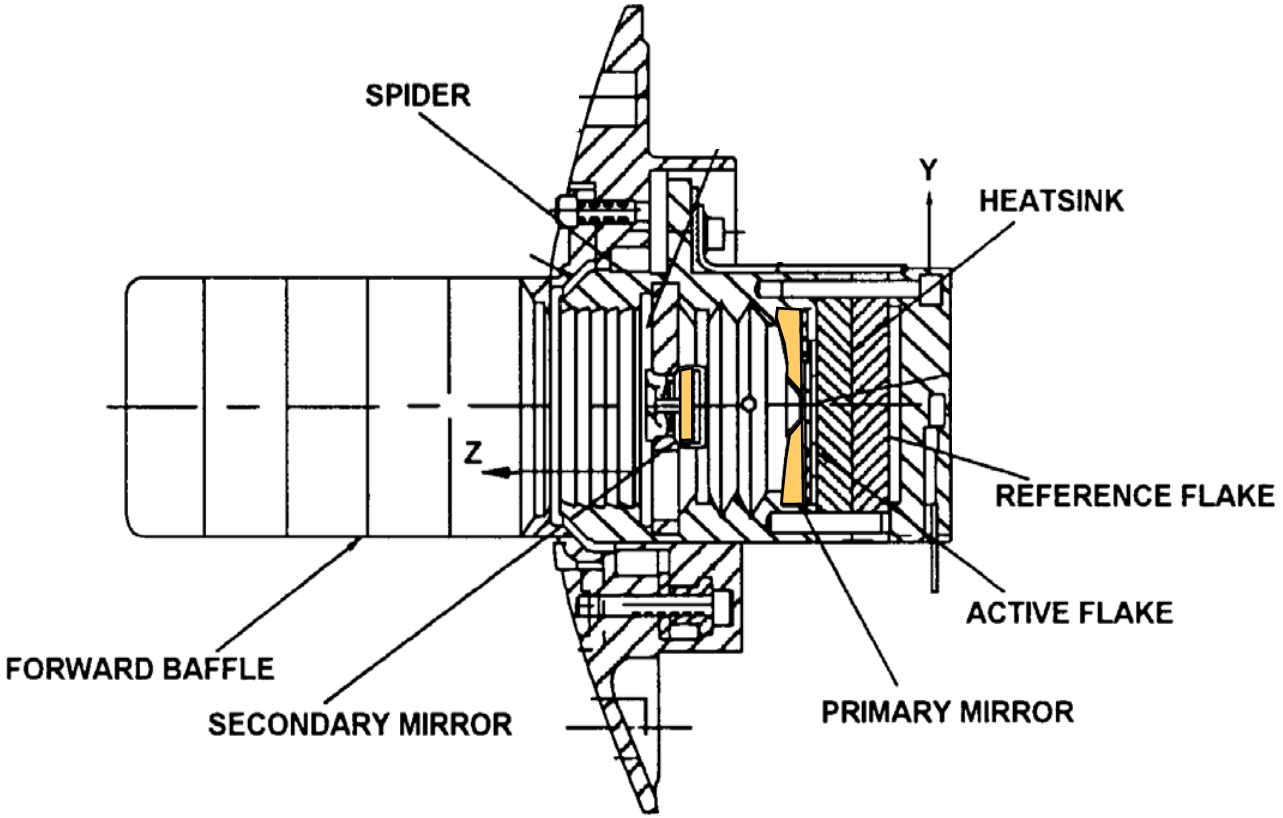
CERES Sensor



CERES Sensor



CERES Sensor



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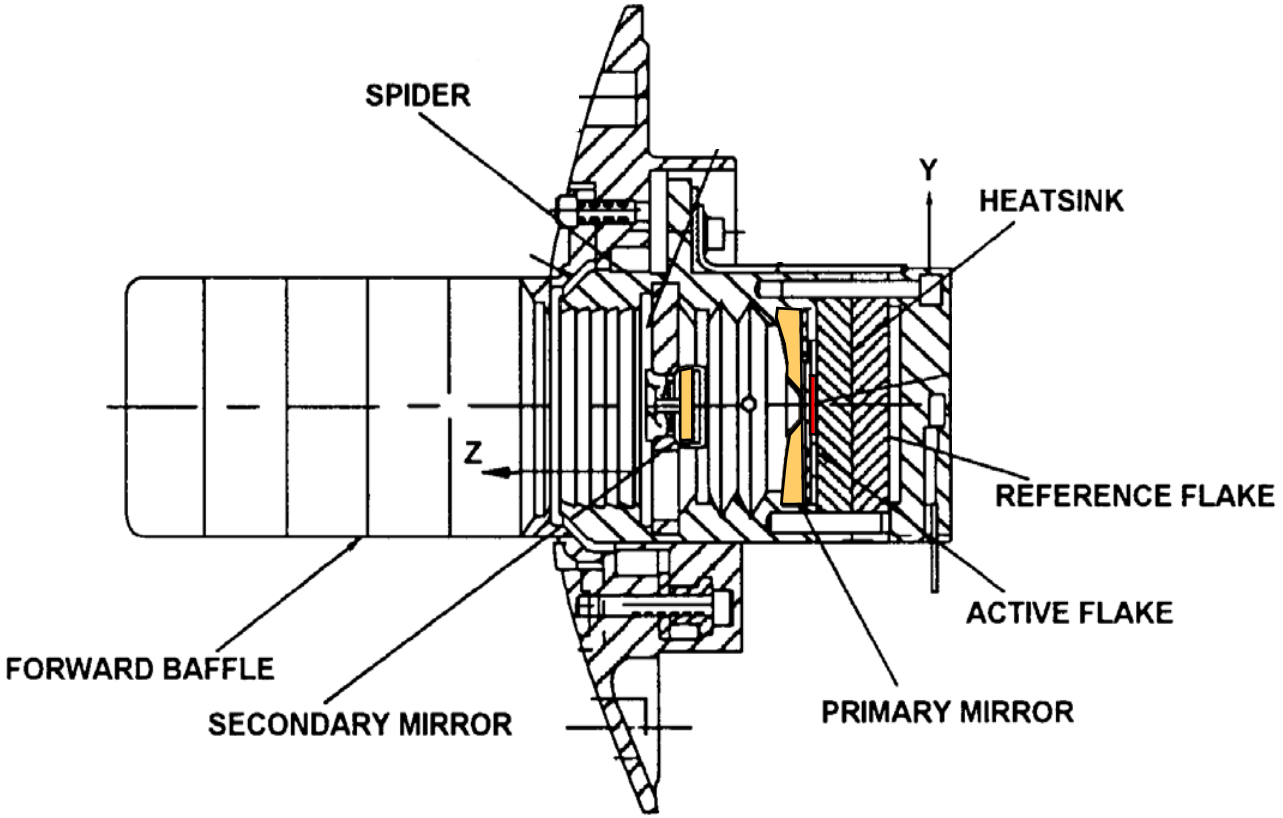

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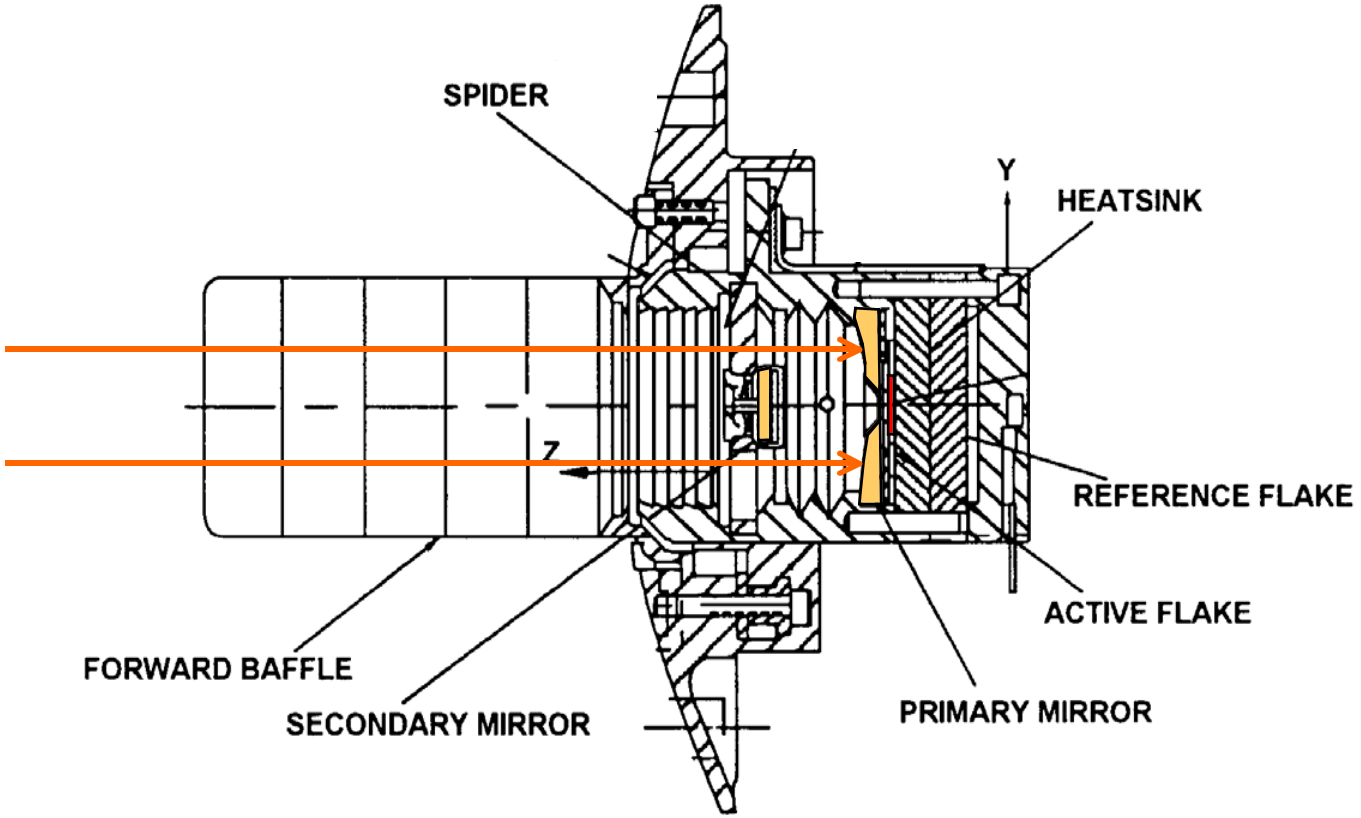

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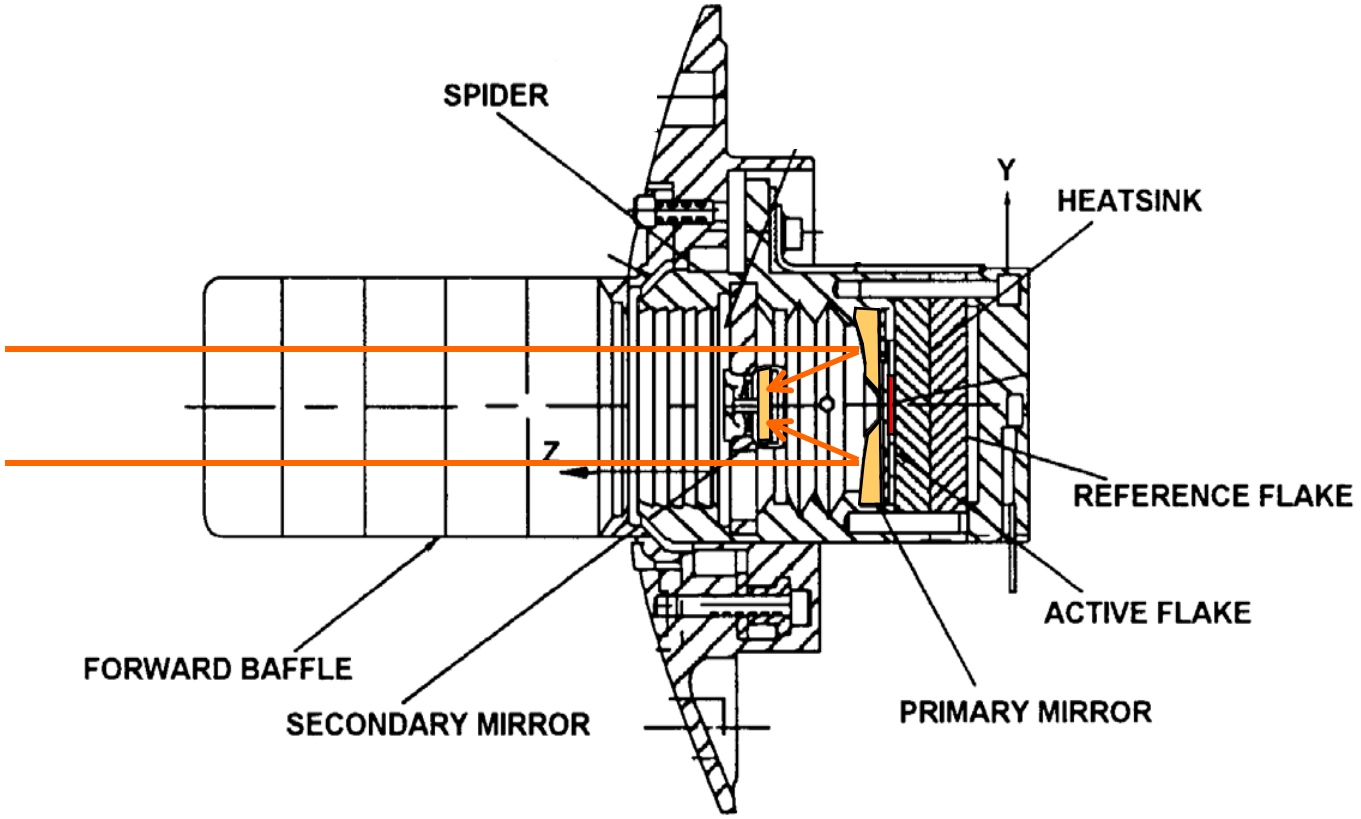

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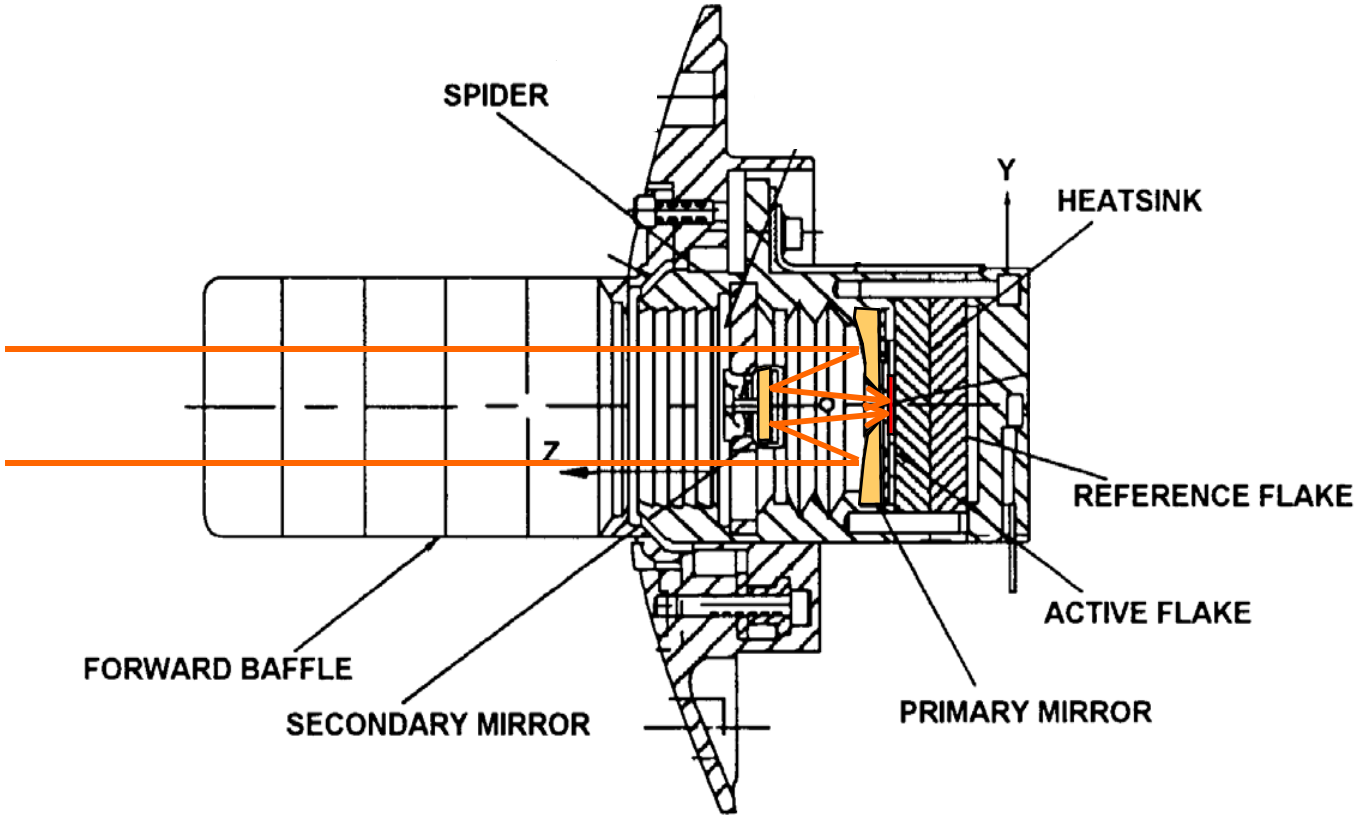
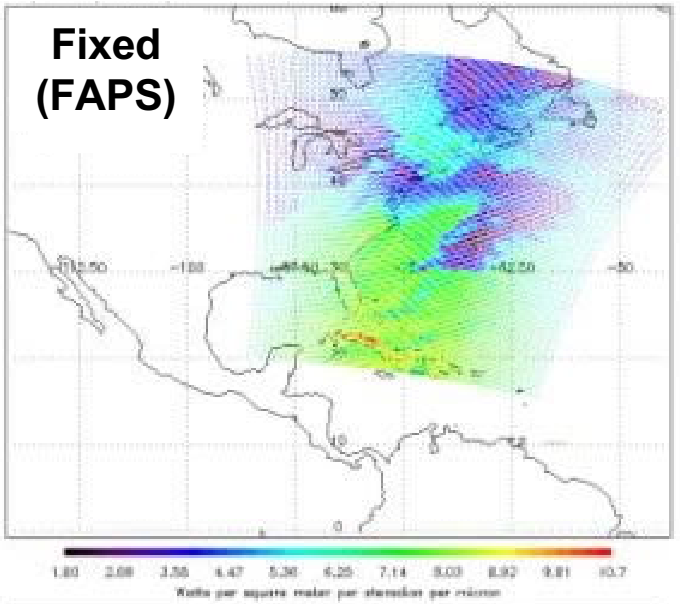
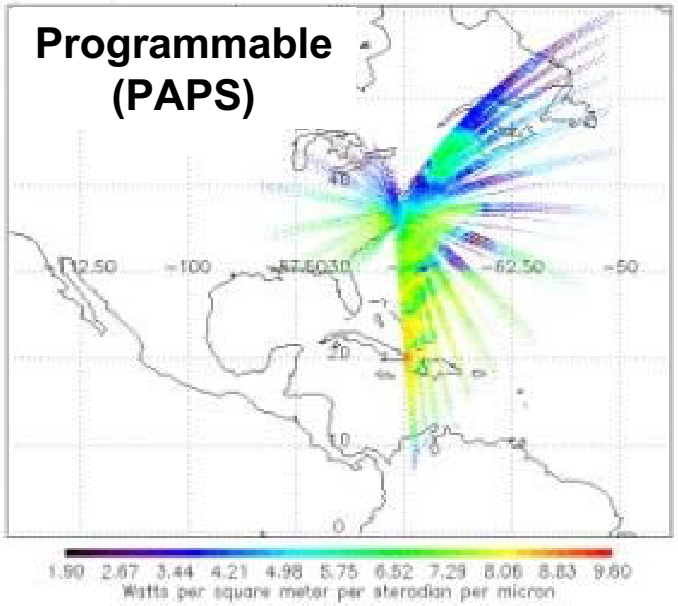
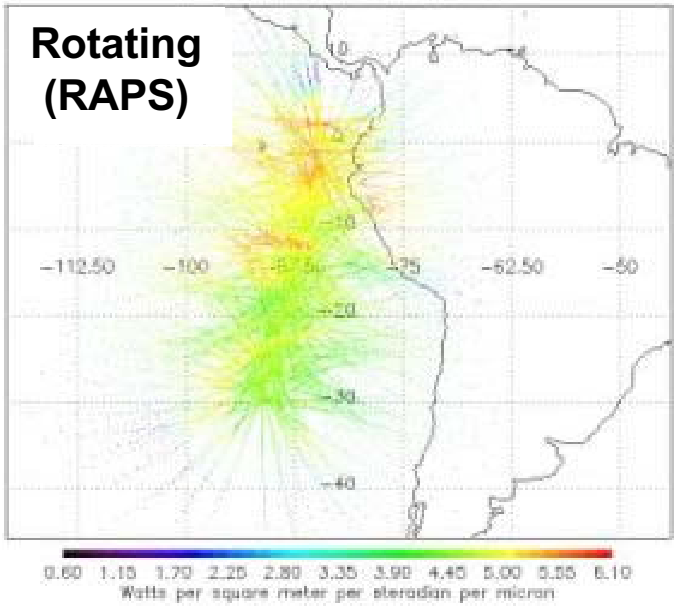


CERES Azimuth Plane Scan Modes







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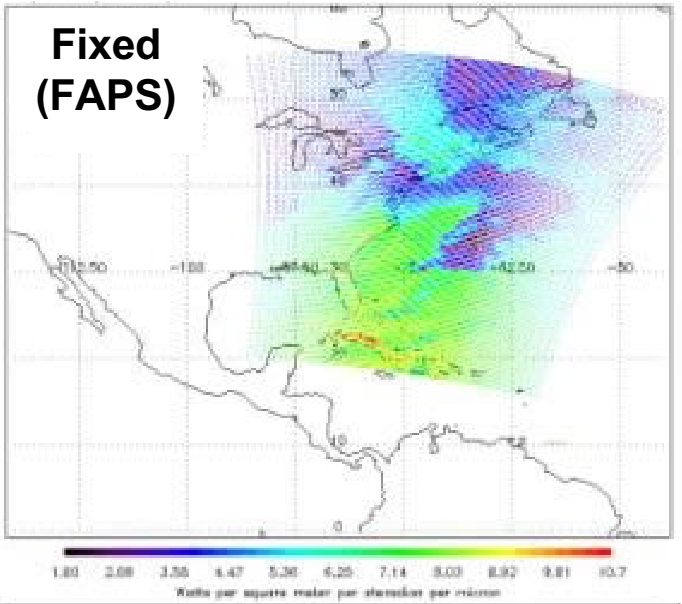

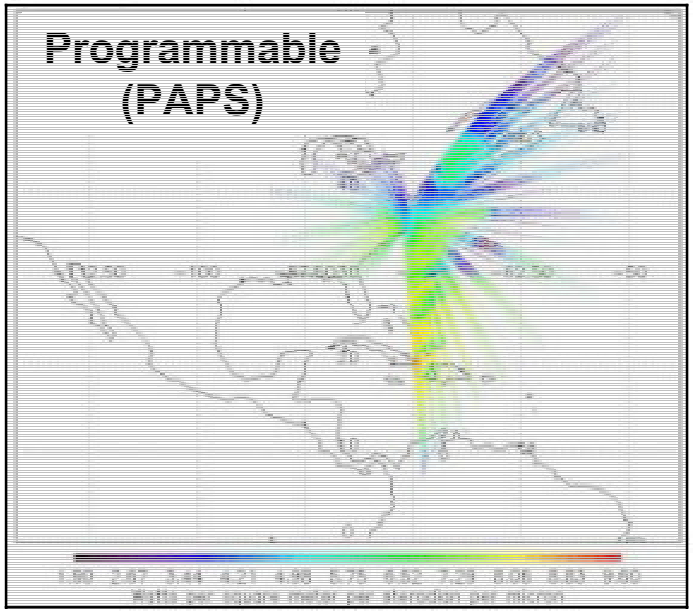

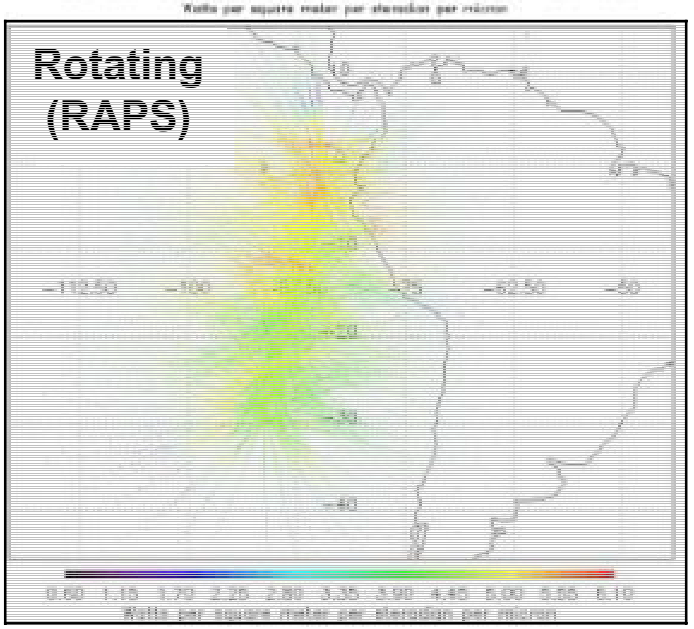

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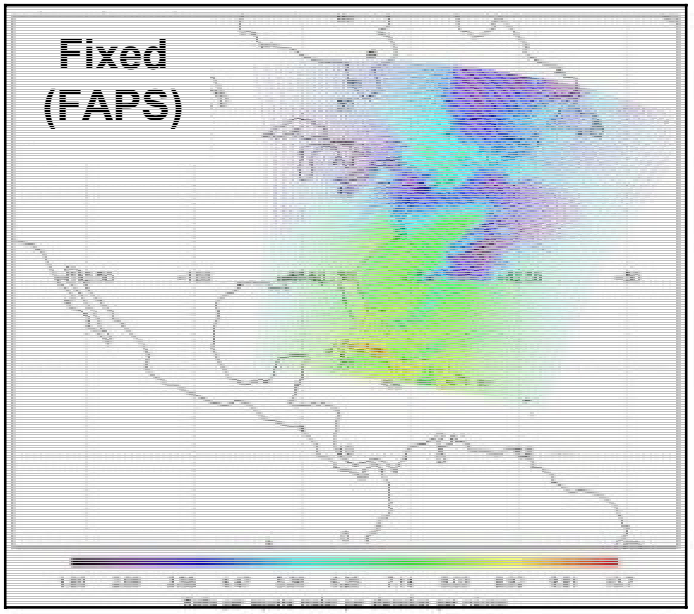

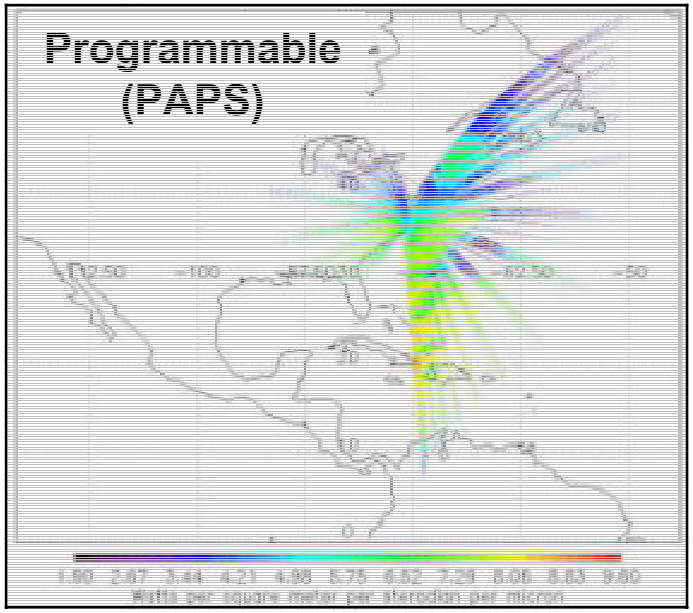

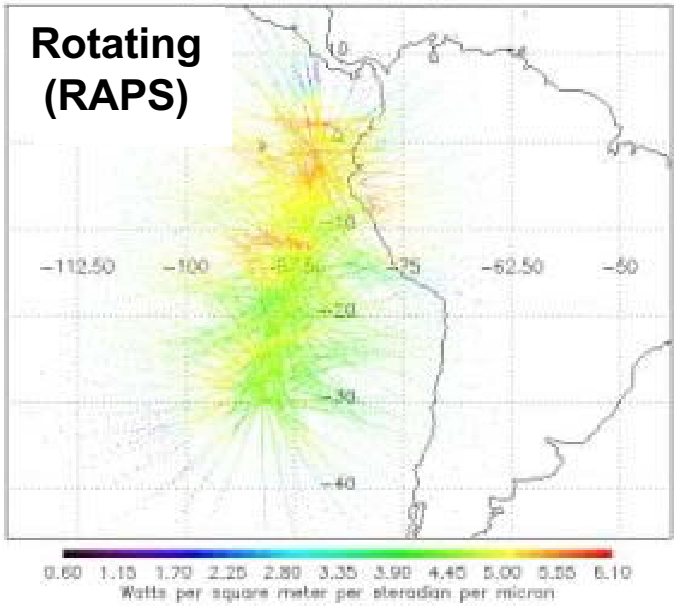

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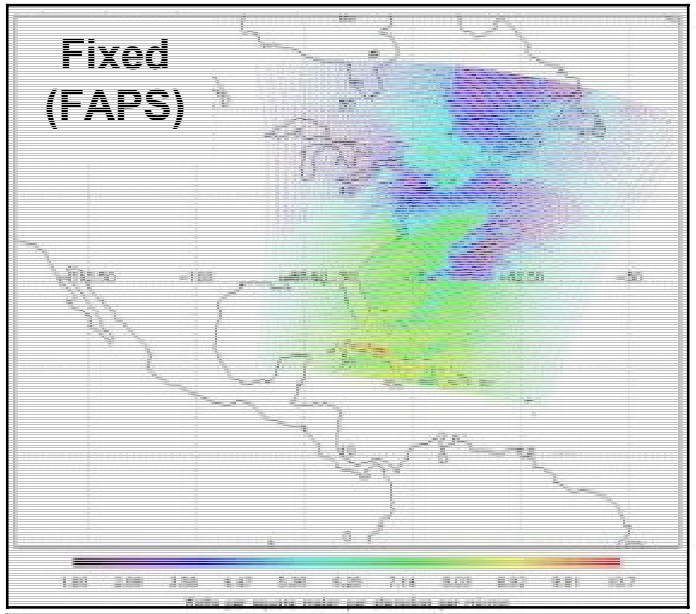
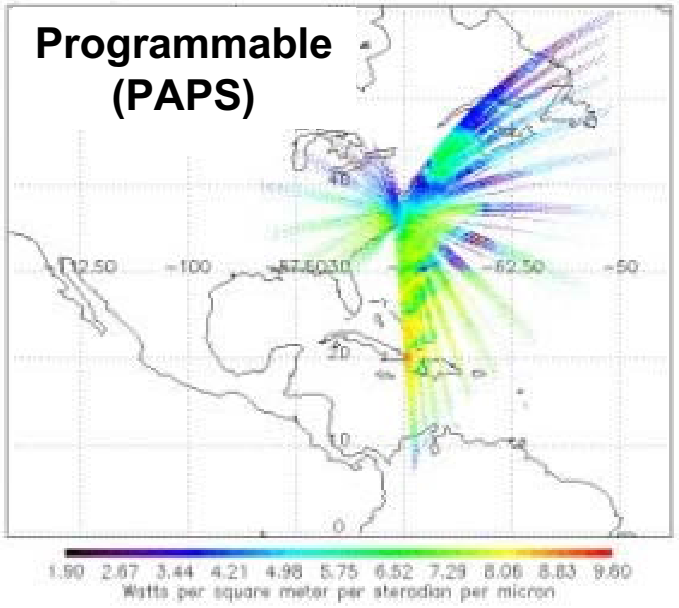
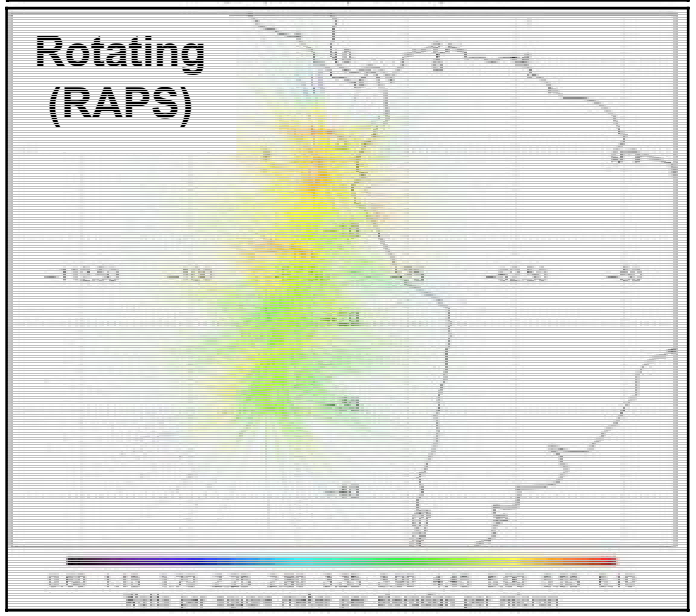
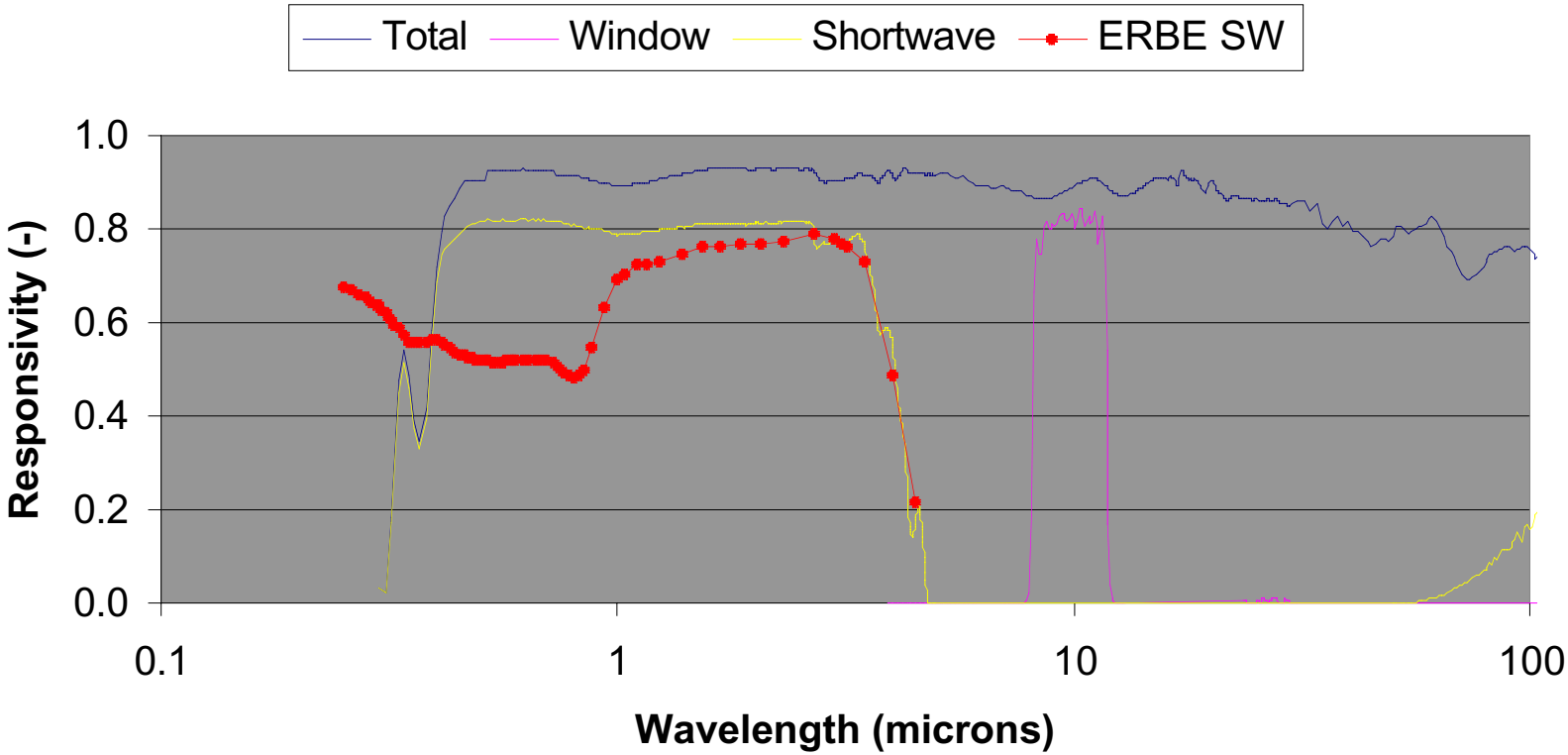






CERES Spectral Response Function

TRMM/PFM Edition1 Data Products



Note: LW_{DAY} = Total - Shortwave

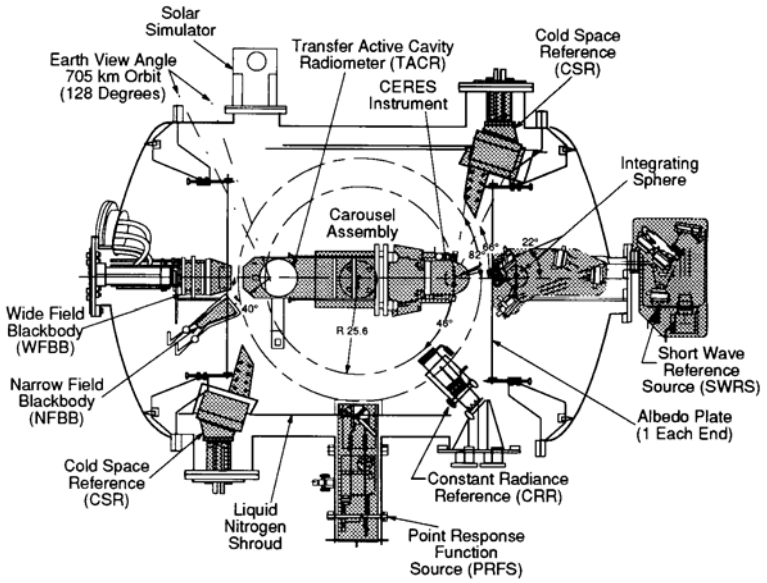
Radiometric Performance Requirements

Spectral Regions	Solar		Terrestrial		Atmospheric Window
Wavelengths	0.3 - 5.0 μm		5.0 - 200 μm		8 - 12 μm
Scene Levels	<100 w/m^2-sr	>100 w/m^2-sr	<100 w/m^2-sr	>100 w/m^2-sr	All Levels
Accuracy requirements	0.8 w/m^2-sr	1.0 %	0.8 w/m^2-sr	0.5%	0.3 w/m^2-sr

- **Requirements for CERES are more stringent than ERBE s by a factor of 2**

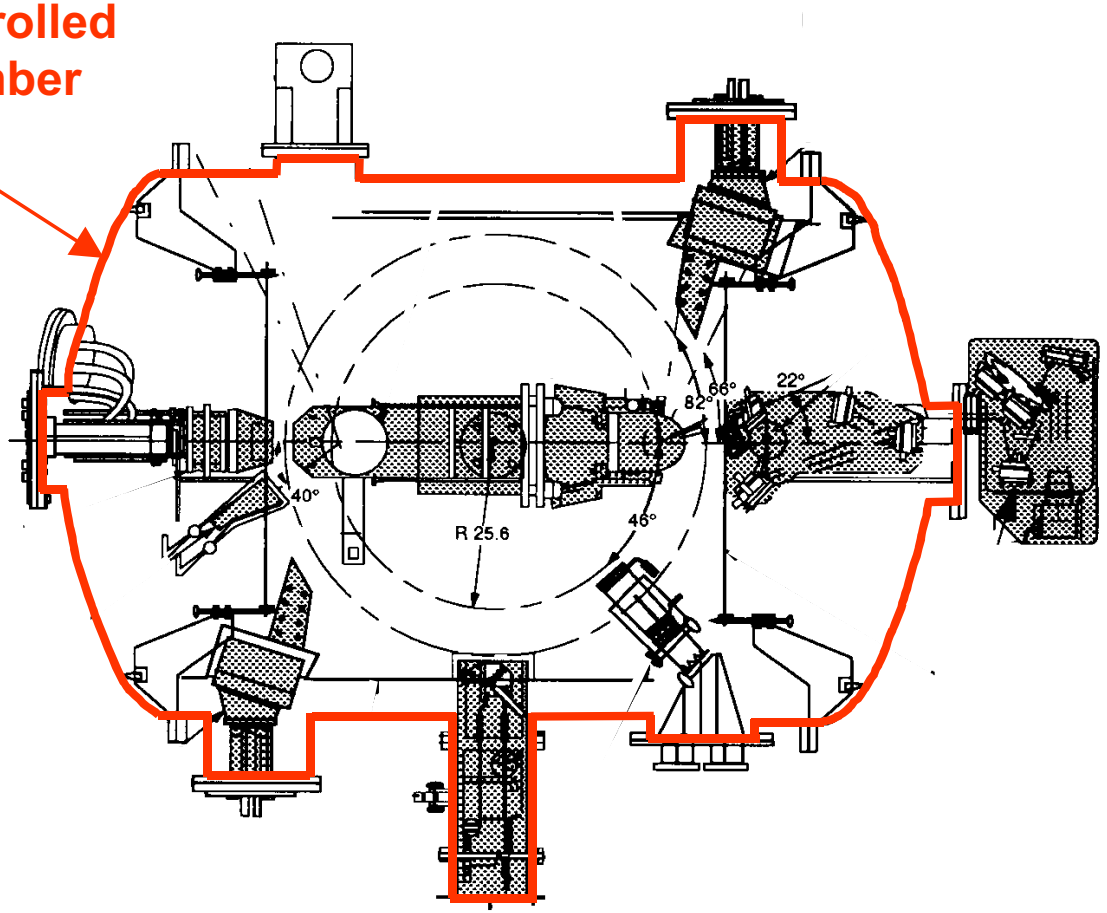
Radiometric Calibration Facility

- Narrow Field of View Blackbody (NFBB) is primary standard (Emissivity of greater than 0.9999)
- 12.5 cm Wide Field of View Blackbody (WFBB)
- Cold Space Reference (CSR) blackbodies
- New SW reference source (SWRS) with minimum LW variations and better spectral characterization
- 5 cm i.d. integrating sphere with associated optics
- Cryogenically cooled Transfer Active Cavity Radiometer (TACR)
- Point Response Function characterization source
- Constant Radiance Reference to determine scan dependent offsets
- Earth infrared radiation simulators
- Liquid nitrogen cooled shroud wall

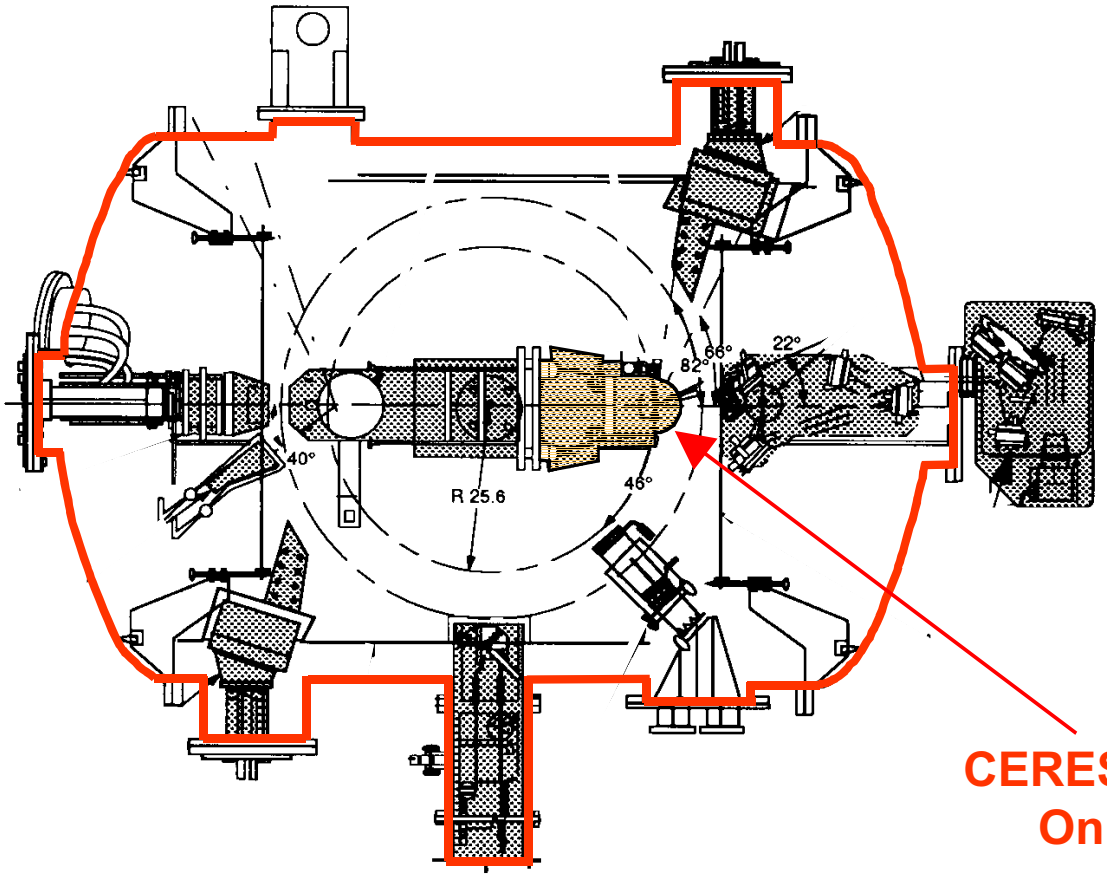


Radiometric Calibration Facility

Thermally Controlled Vacuum Chamber

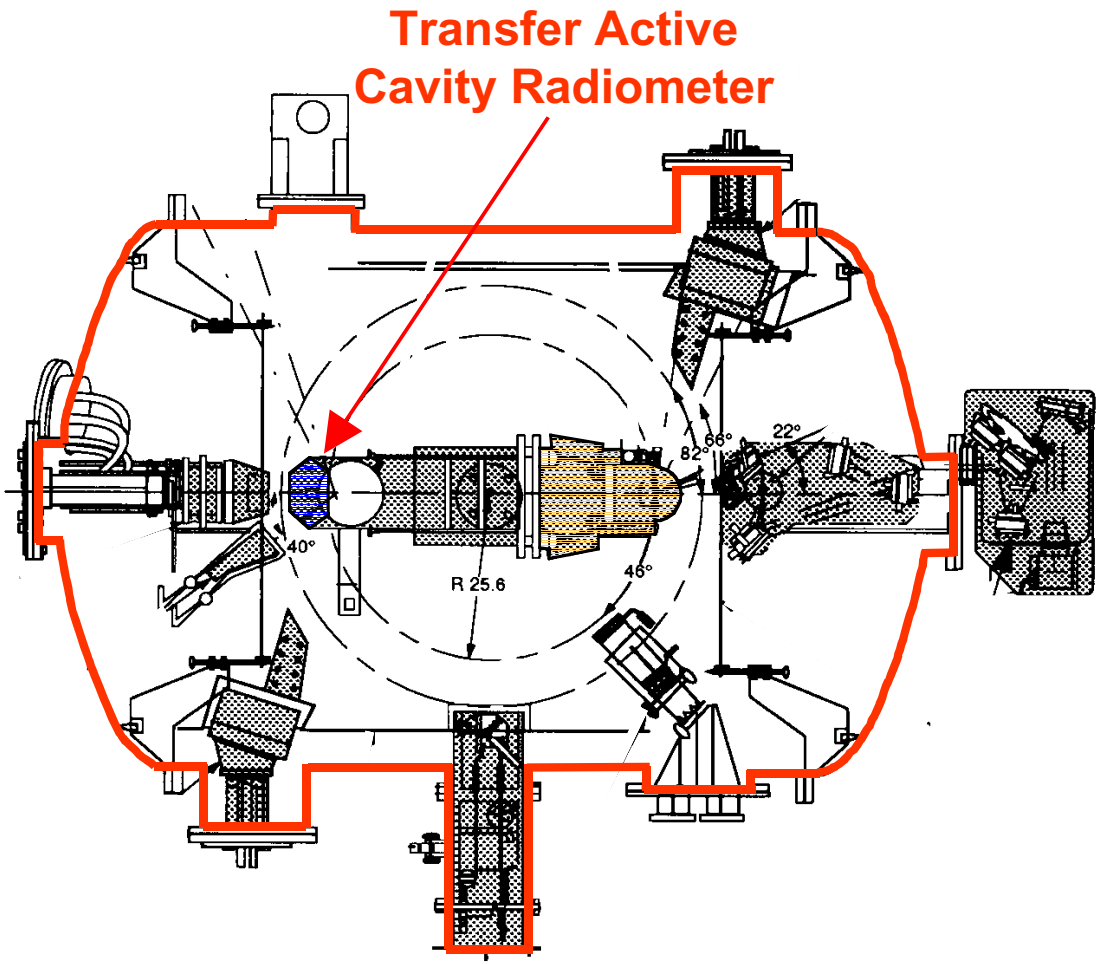


Radiometric Calibration Facility

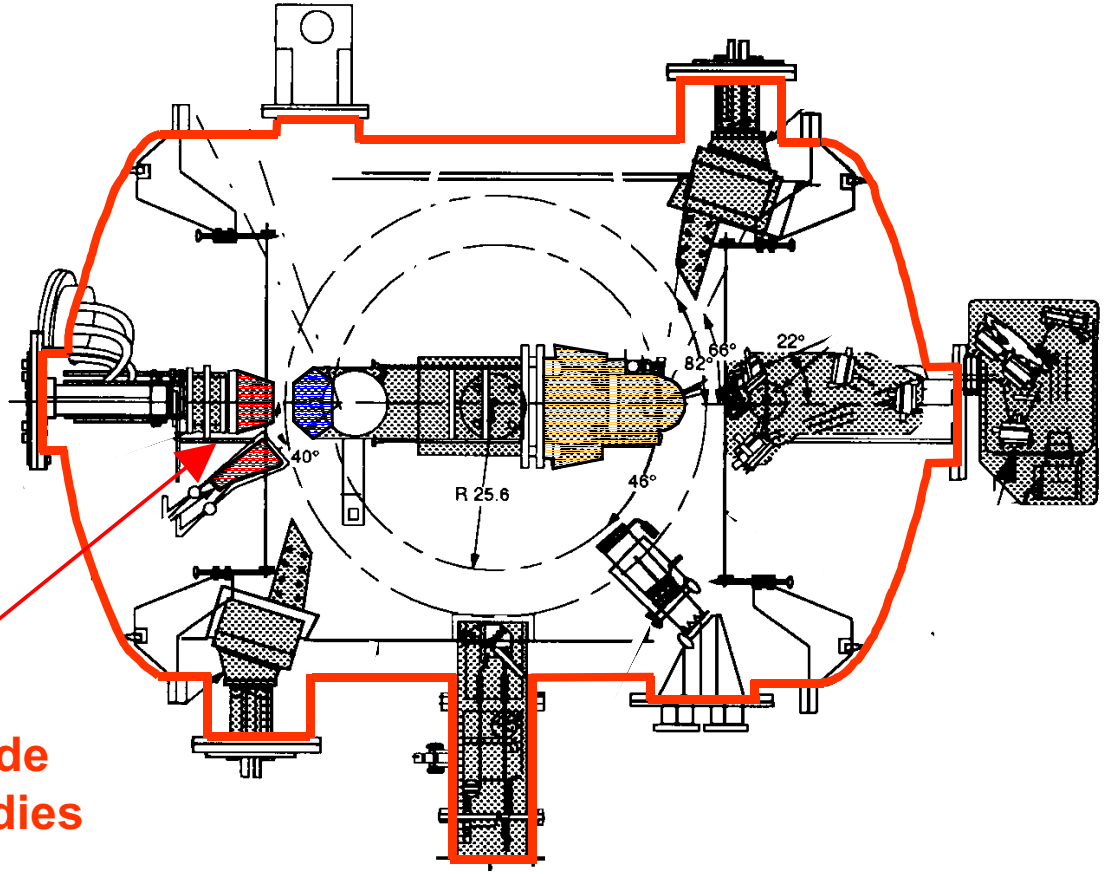


CERES Instrument On Pedestal

Radiometric Calibration Facility

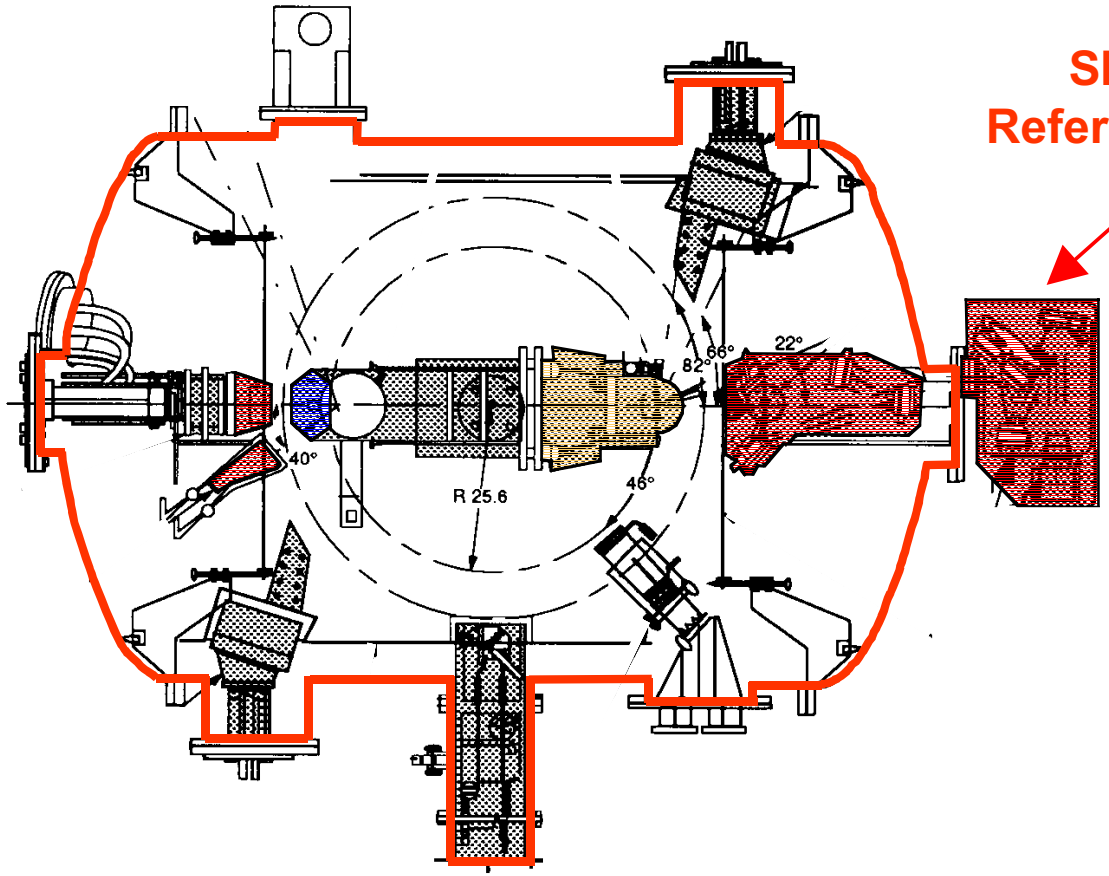


Radiometric Calibration Facility

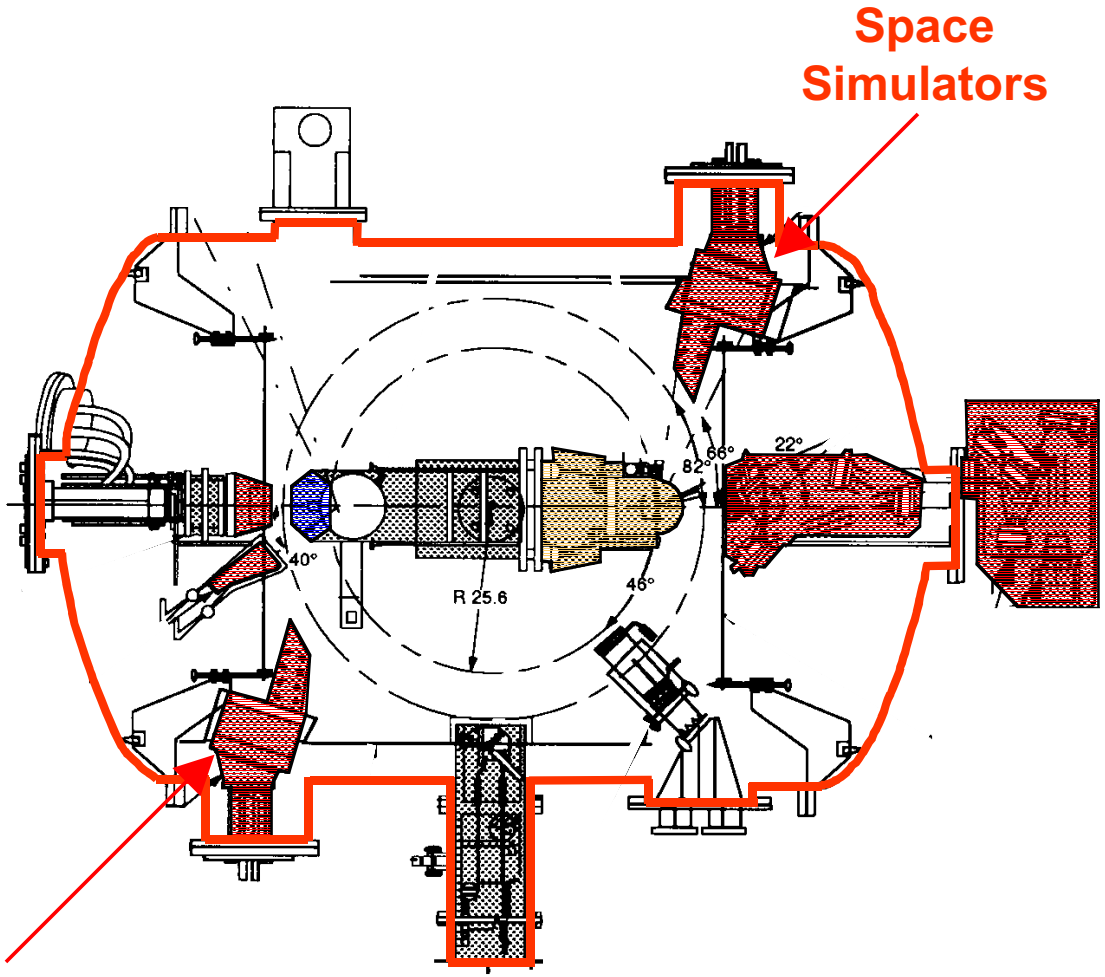


Narrow & Wide Field Blackbodies

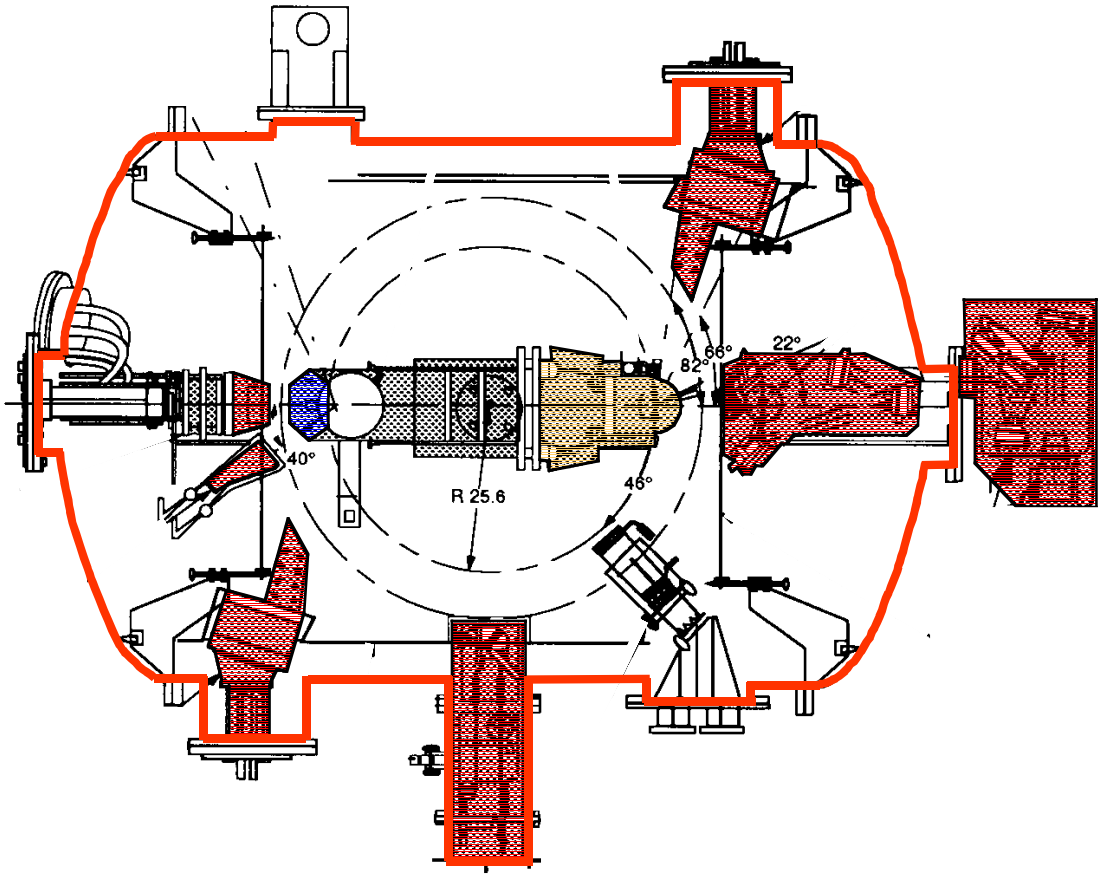
Radiometric Calibration Facility



Radiometric Calibration Facility



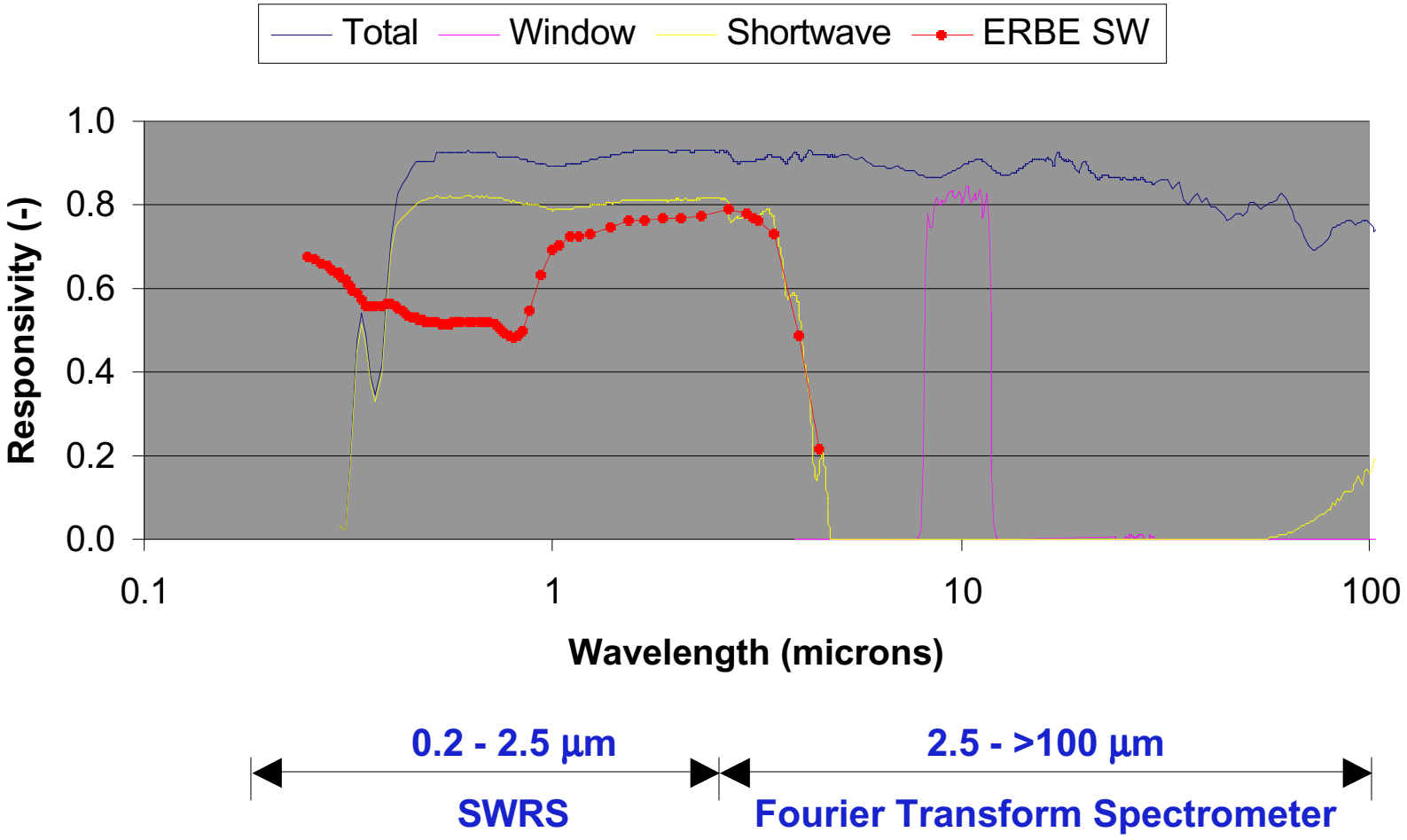
Radiometric Calibration Facility



Point Response Function Measurement System

CERES Spectral Response Function

TRMM/PFM Edition1 Data Products



Mathematical Model

The Spectral Response, S_λ, may be mathematically modeled as

$$S_\lambda^j \equiv \rho_\lambda^2 \tau_\lambda \alpha_\lambda \qquad j = \text{tot}, \text{sw}, \text{wn}$$

where

- **ρ_λ is the spectral reflectance of the silvered mirrors**
- **τ_λ is the spectral transmittance of any optical filters**
- **α_λ is the spectral absorptance of the detector**

Theoretically, the ratio of the spectral response functions of any two given channels results in cancellation of the spectral characteristics of common components, Thus

$$\frac{S_\lambda^{\text{tot}}}{S_\lambda^{\text{sw}}} = \frac{1}{\tau_\lambda}$$

Practically, this is only true to the extent of repeatability in the manufacturing process

Shortwave Spectral Characterization

(0.2 - 2.5 μm)

- Shortwave Reference Source (SWRS) uses filters to provide 13 narrow band sources between 0.4 and 2.0 μm
- A cryogenically cooled Transfer Active Cavity Radiometer (TACR) places these sources on the same radiometric scale as the Narrow Field Blackbody (NFBB)
- By ratioing CERES measurements to TACR measurements, the relative SW spectral response, S^{sw}, is defined in each of these narrow spectral bands, $\Delta\lambda$, for both the SW channel and SW portion of the Total channel

$$S^{sw}_{\Delta\lambda,\,CERES} = \frac{m_{\Delta\lambda,\,CERES}}{m_{\Delta\lambda,\,TACR}}$$

- Spectral measurements of the optical components are used to complete the spectral response curve between the narrowband SW sources and extend the curve down to the UV region (0.2 μm)
- Component measurements from 0.2 - 2.5 μm are made using a CARY5 grating spectrometer with the witness samples in a nitrogen purged chamber

Determination of S_λ in the Longwave region

(2.5 - >100 μm)

FTS Vacuum Chamber Facility

- BIO-RAD Fourier Transform Spectrometer 60A Dual Source/Dual Detector system with an 896 interferometer and flip mirror.
- The first detector is a CERES sensor, including the entire optical train.
- Second detector is a spectrally flat Lithium Tantalate (α > 99%) Pyro-electric Reference Detector (PRD) with a trap configuration.
- S_λ is obtained by normalizing the transformed interferogram measurements of the CERES sensor to those of the spectrally flat reference detector...

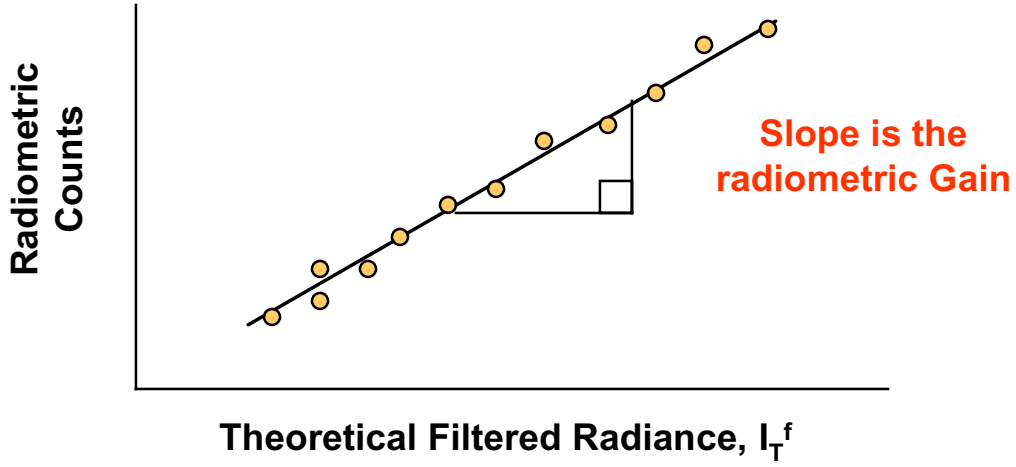
$$S_\lambda = \frac{m^f_{\lambda,\,CERES}}{m^f_{\lambda,\,PRD}}$$

- Six combinations of beamsplitter and sources are used to completely cover the IR spectral regime
- Beyond approximately 30 microns the SNR of the FTS data decreases rapidly

Longwave Spectral Characterization

(2.5 - > 100 μm)

Regressing sensor output (radiometric counts) as a function of theoretical filtered radiance, I_T^f, for each of the 12 calibration NFBB temperatures over the range of 205 to 315K yields



$$I_T^f = \int_{\phi=0}^{\phi_1} \int_{\theta=0}^{\theta_1} \int_{\lambda=0}^{\infty} S_\lambda \, I_{\lambda,T_{NFBB}} \, d\lambda d\theta d\phi$$

- **The final LW spectral response, S_λ, is determined by optimizing this regression**
- **By optimizing we mean adjusting the estimate of S_λ within the understood FTS measurement uncertainty such that the residuals in the regression are minimized.**
- **This methodology ensures that CERES is optimally calibrated against longwave radiance sources that have Planck like spectral distributions.**

CERES Instrument Radiometric Validation Activities

		Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	Theoretical Line-by-Line	Filtered Radiance	> 20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Tropical Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N —20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel consistency, stability	TOT, SW
	Tlme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW

CERES Instrument Radiometric Validation Activities

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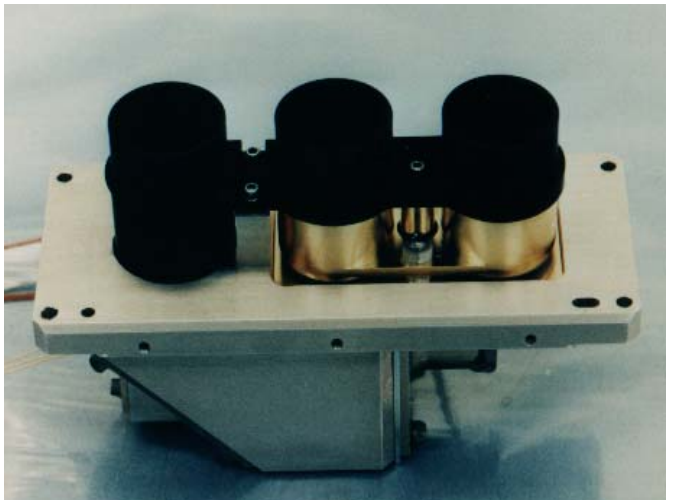
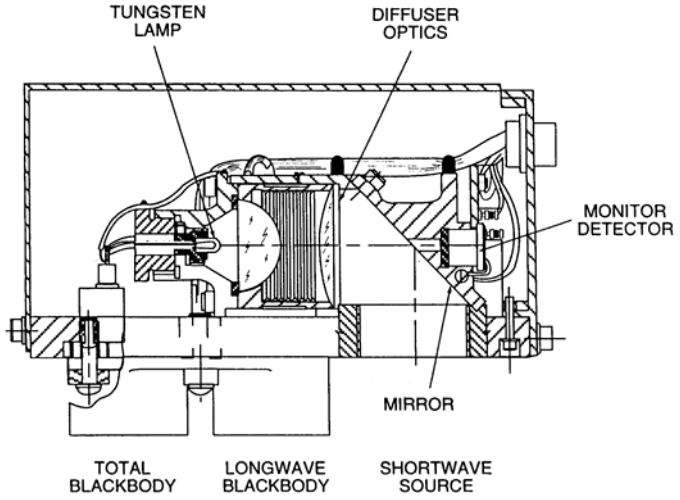
CERES Onboard Calibration Sources

Internal Calibration Module (ICM)

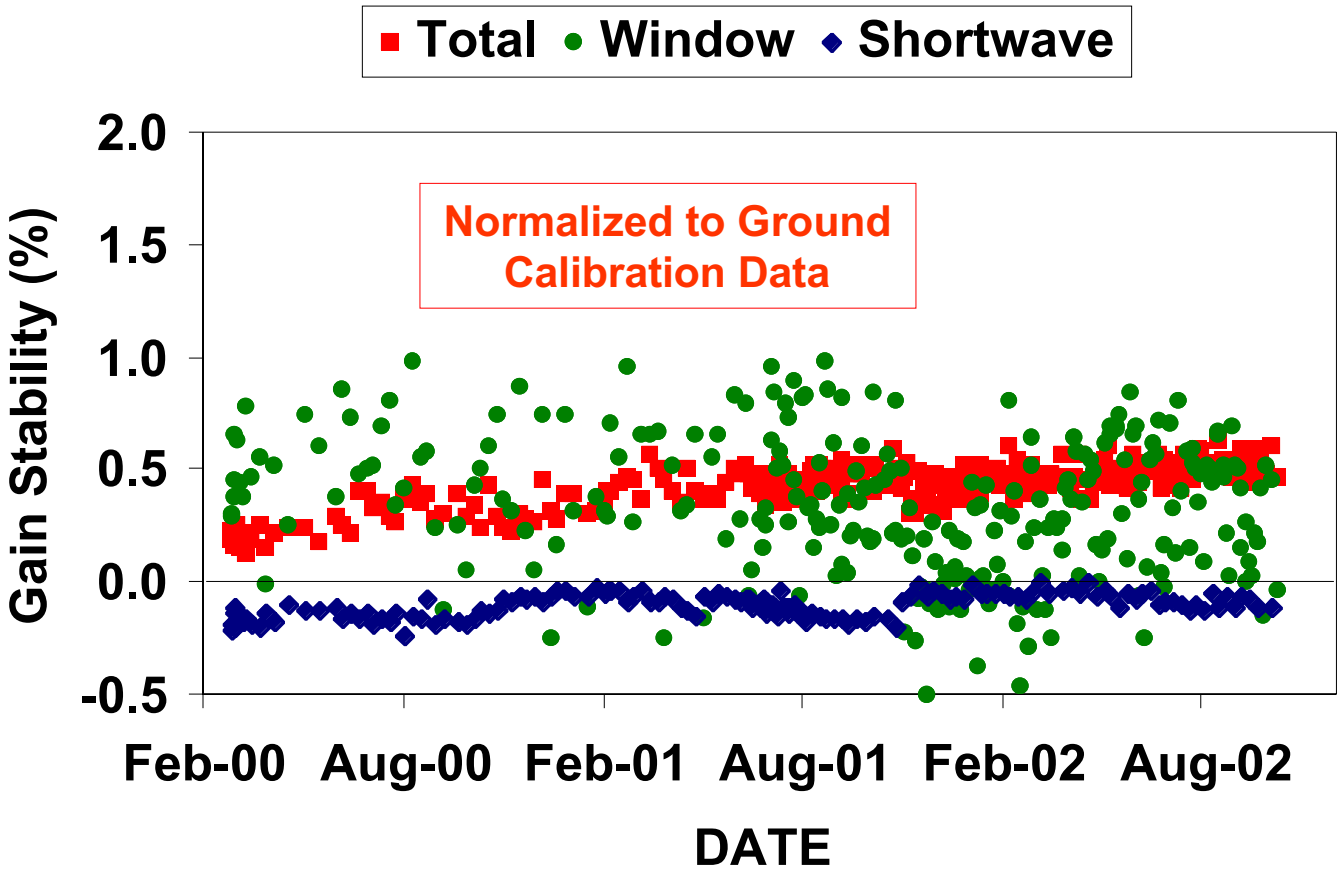
- Blackbodies for the Total and Window channels
- Temperature knowledge obtained via Platinum Resistance Thermometers (PRTs)
- Quartz-halogen tungsten lamp for the Shortwave channel
- ICM Provides 3 unique radiance levels for the SW and LW sources





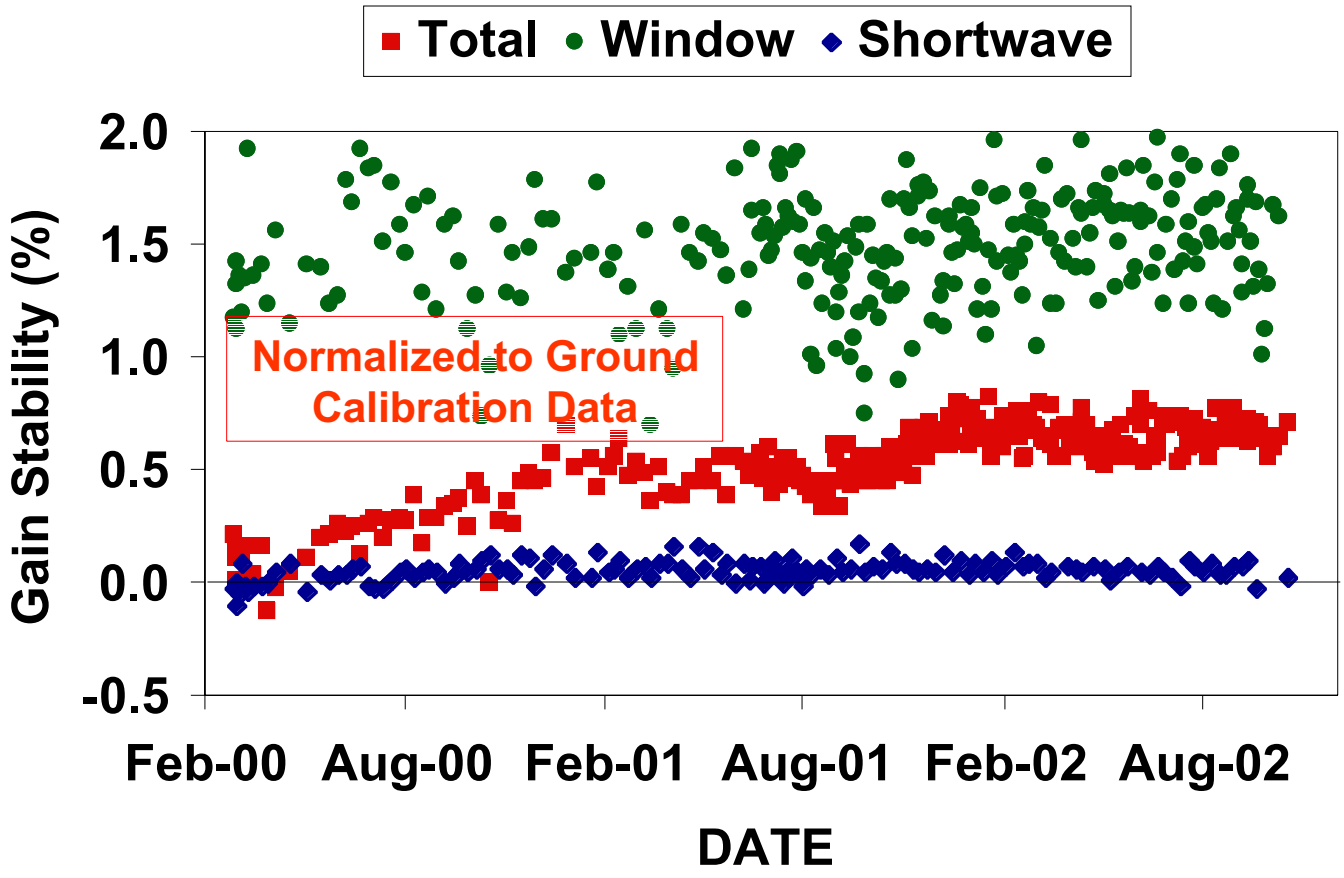
Terra/Flight Model 1
Lifetime Radiometric Stability

Determined with the Internal Calibration Module



Terra/Flight Model 2
Lifetime Radiometric Stability

Determined with the Internal Calibration Module



Internal Calibrations
Key Results

- **Ground to Flight Calibration Stability**
  - Determined with Internal Calibration Module
    - TOT: 0.20 and 0.12% for FM1 and FM2
    - WN: 0.48 and 1.3% for FM1 and FM2
    - SW: -0.26 and 0.16% for FM1 and FM2

- **On-Orbit Calibration Stability (%/year)**
  - Internal Calibration Module
    - TOT: 0.125 and **0.28*** %/yr for FM1 and FM2
    - WN: -0.06 and -0.02 %/yr for FM1 and FM2
    - SW: 0.09* and 0.08* %/yr for FM1 and FM2
      - * statistically significant
      - All internal calibrations have been executed in daytime portion of orbit
  - Solar Calibrations
    - Terra MAM s have continued to drift with time and results are suspect

CERES Instrument Radiometric Validation Activities

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	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
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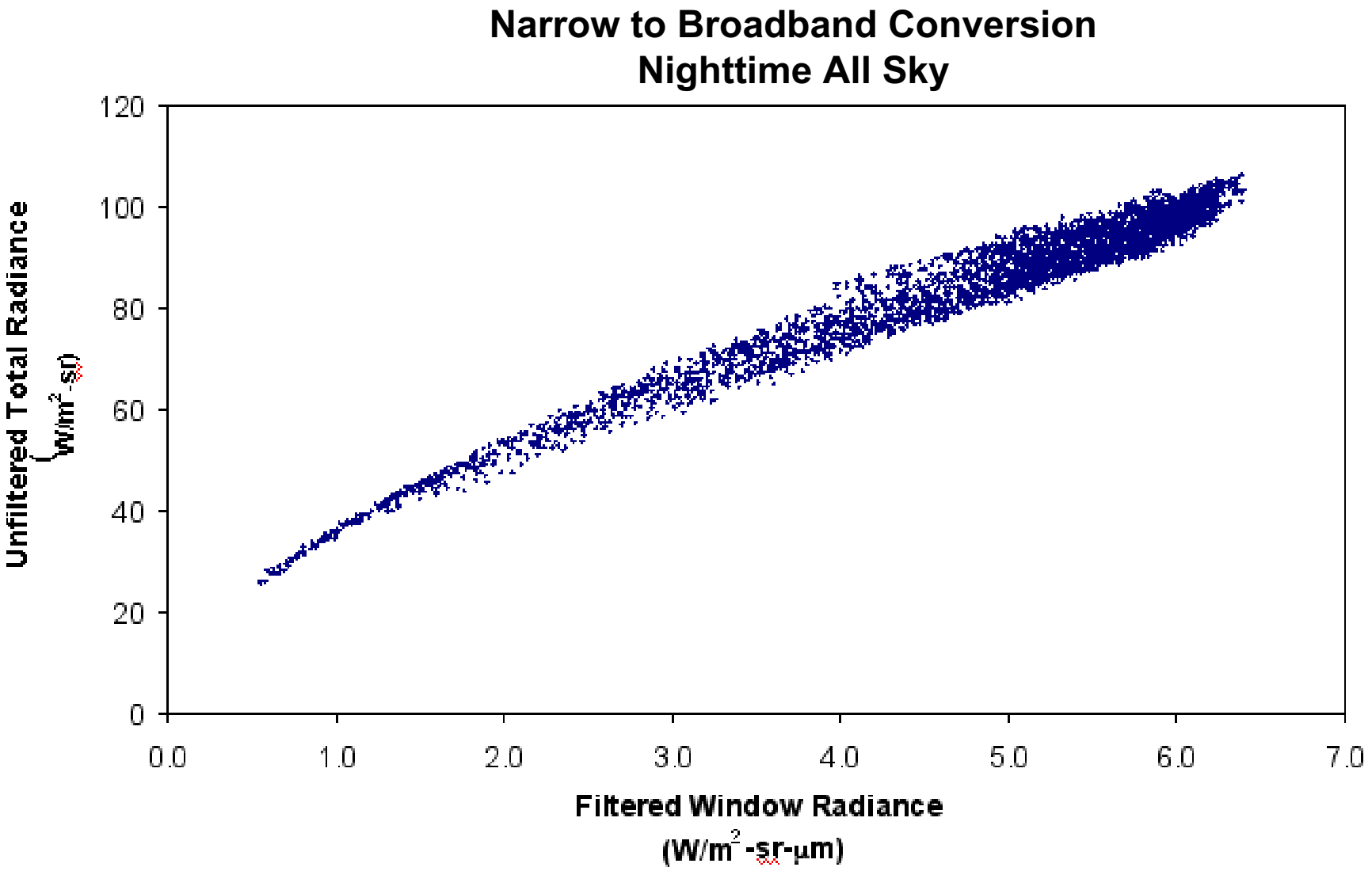
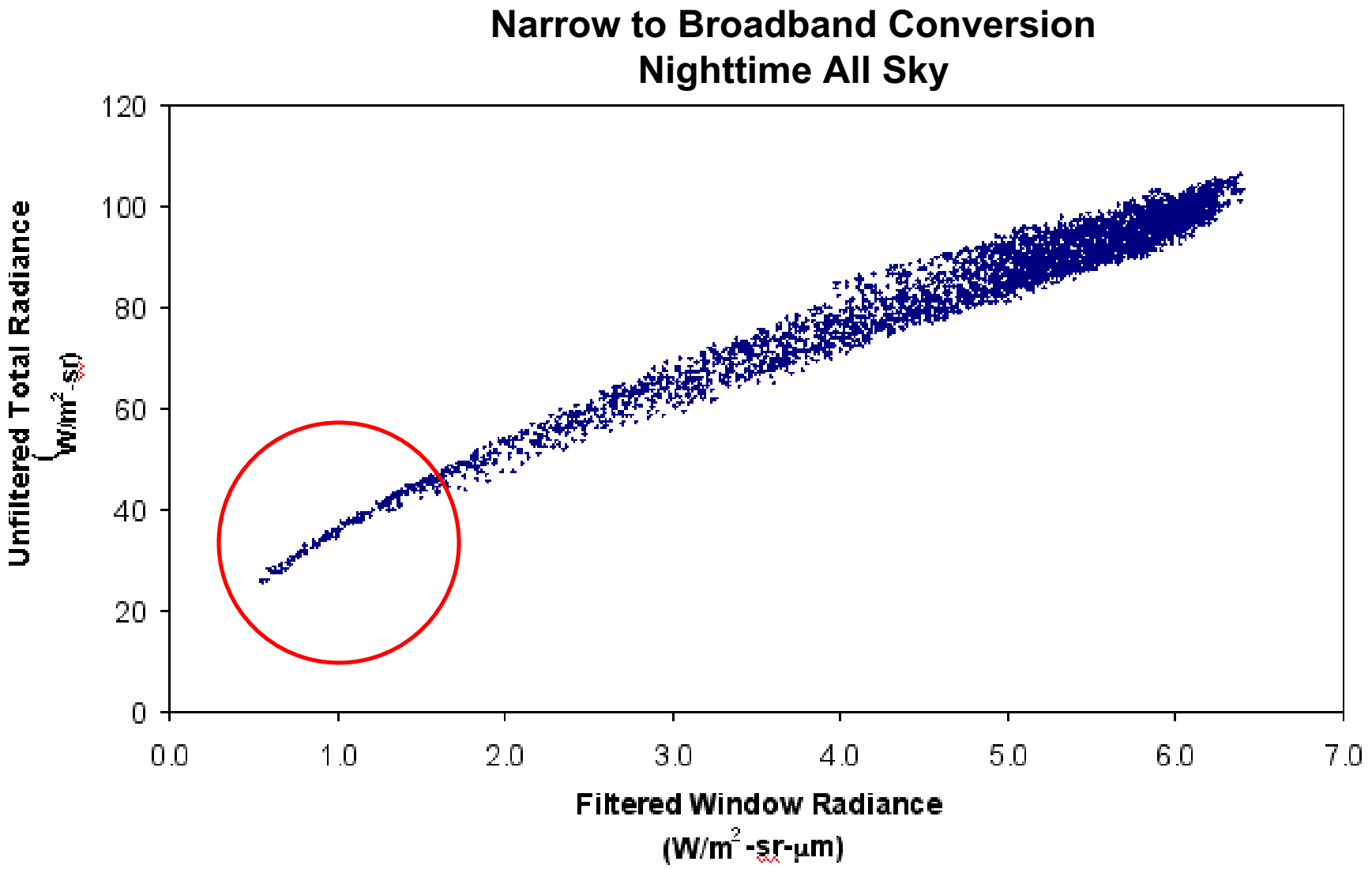
	Tlme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW

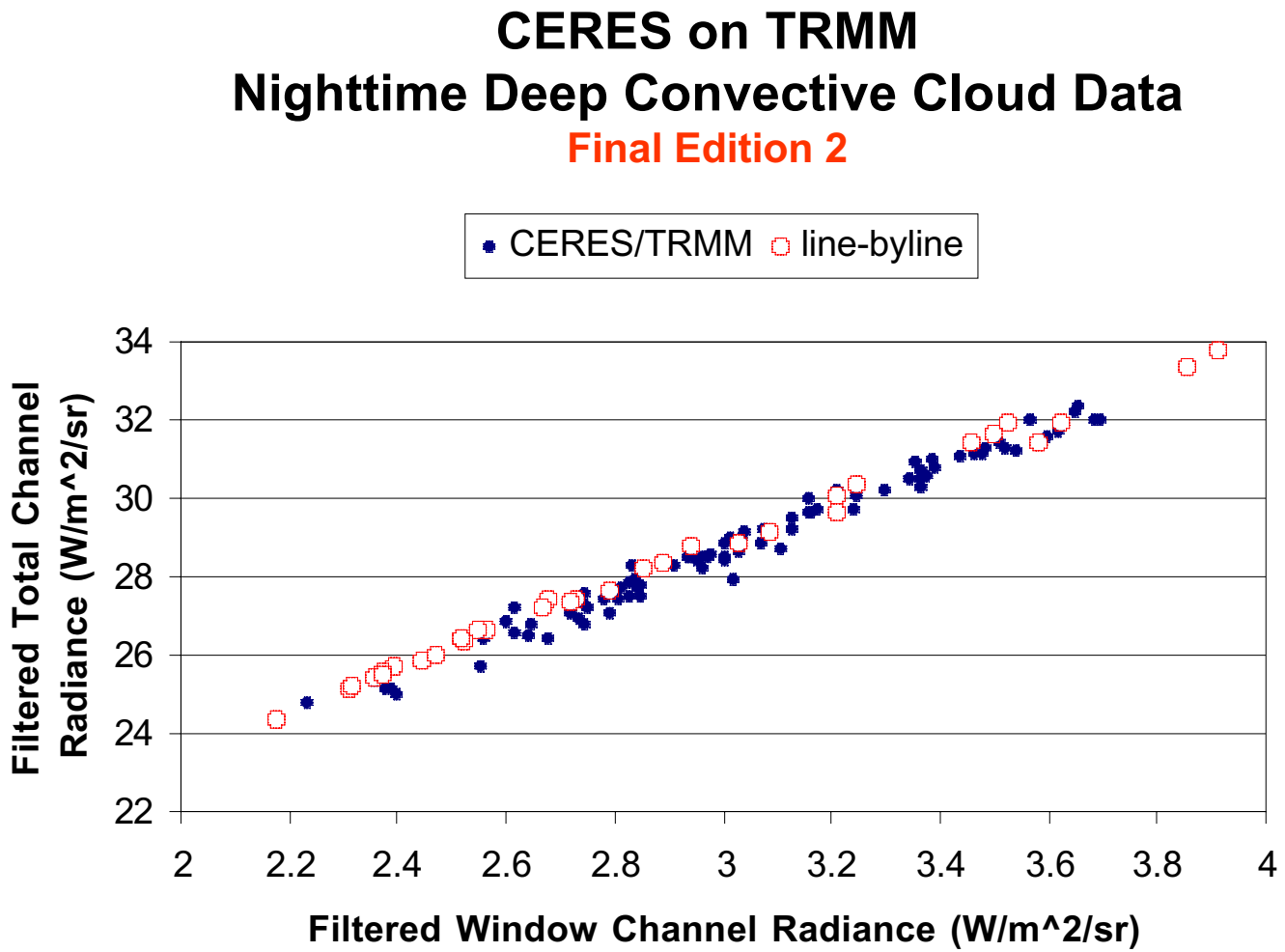
Why Deep Convective Clouds?



Why Deep Convective Clouds?



Line by Line Radiative Transfer Code Comparison

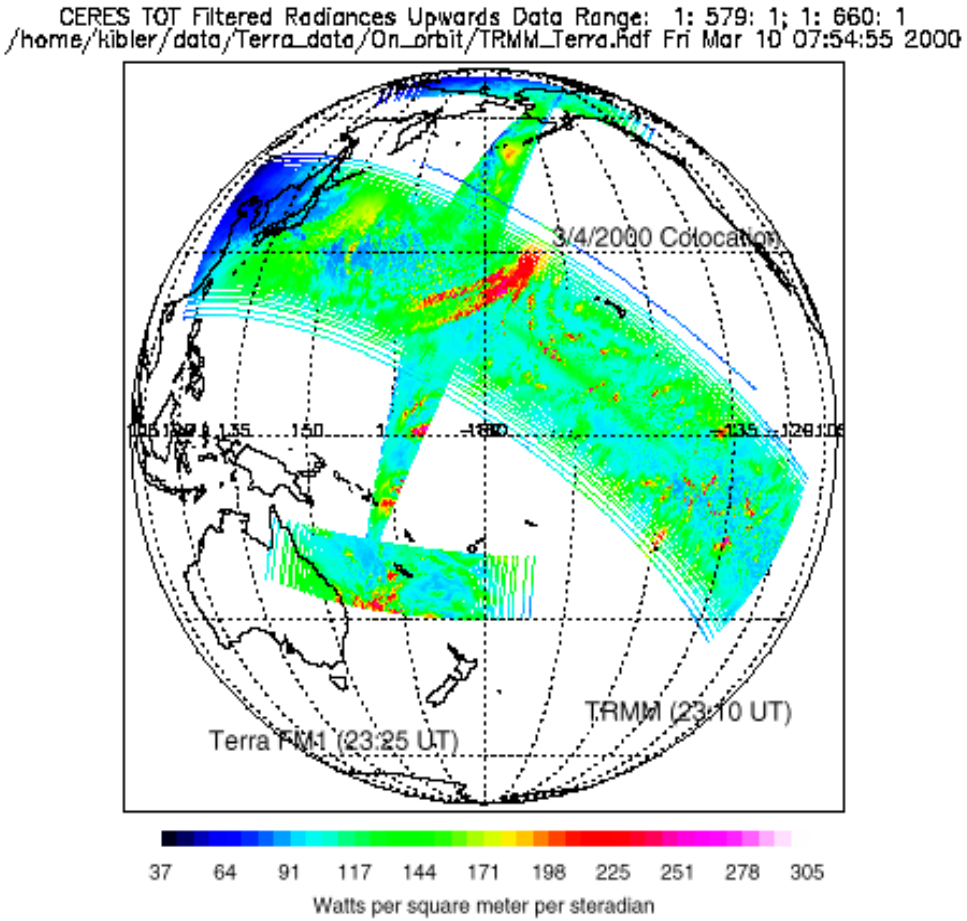


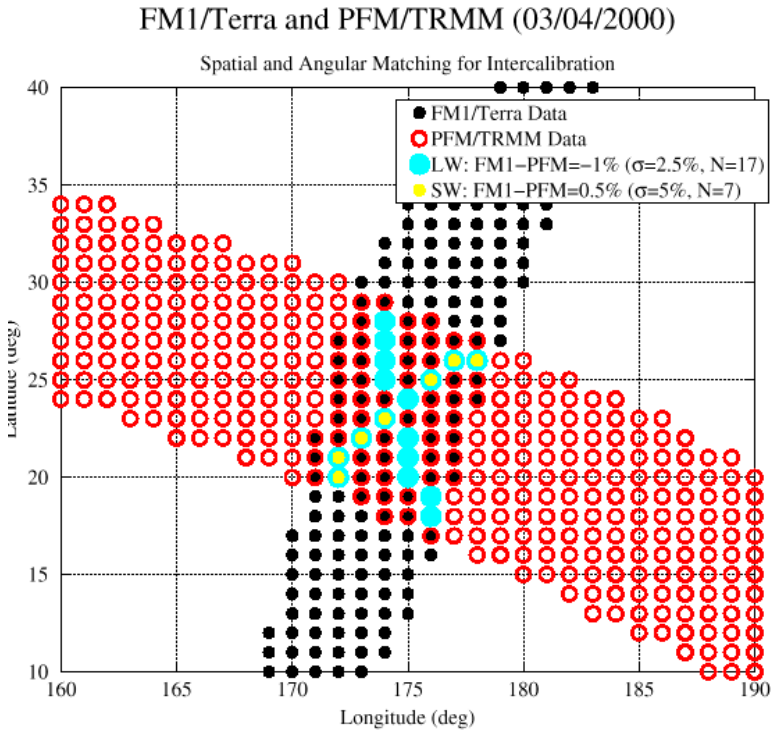
CERES Instrument Radiometric Validation Activities

		Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	Theoretical Line-by-Line	Filtered Radiance	> 20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Tropical Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N —20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel consistency, stability	TOT, SW
	Tlme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW

TRMM / Terra Intercomparison

Co-located Radiances using PAPS Mode





Co-located FM1/FM2 and PFM Longwave Radiances

	Radiance $Wm^{-2}sr^{-1}$	FM1 - PFM $Wm^{-2}sr^{-1}$ (%)	FM2 - PFM $Wm^{-2}sr^{-1}$	95% Conf. Interval $Wm^{-2}sr^{-1}$	Population Size
LW Day	86.5	-0.4 (-0.5)	-0.4 (-0.5)	0.1	146
LW Night	83.6	0.1 (0.1)	-0.3 (-0.4)	0.1	122
Consistency	-	0.5 (0.6)	0.1 (0.1)	-	-
WN Day	7.1 / µm	0.01 (0.1)	0.07 (1.0)	0.01	64/38
WN Night	6.6 / µm	0.03 (0.5)	0.10 (1.5)	0.01	122
Consistency	-	0.02 (0.4)	0.03 (0.5)	-	-

March 01 - 31, 2000

1-deg gridded unfiltered radiances, ΔVZA = -0.4-deg, ΔRAZ = -0.4-deg

Co-located FM1/FM2 and PFM Shortwave Radiances

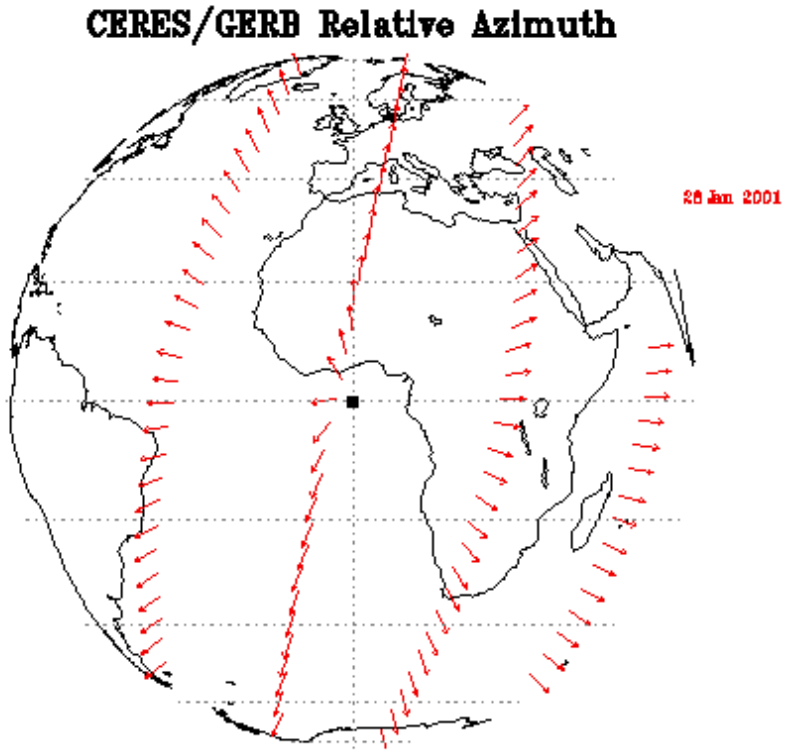
	Radiance $Wm^{-2}sr^{-1}$	Difference $Wm^{-2}sr^{-1}$	95% Conf. Interval $Wm^{-2}sr^{-1}$	Population Size
FM1 - PFM	81.3	-0.3 (-0.4)	0.4	123
FM2 - PFM	70.8	-0.1 (-0.2)	0.4	38
FM 1/2 - PFM	78.8	-0.3 (-0.4)	0.3	161

March 01 - April 19, 2000

1-deg gridded unfiltered radiances, ΔVZA = --0.5-deg, ΔRAZ = -0.4-deg

Proposed CERES/GERB Intercalibration

CERES to serve as transfer standard for GERB detectors



Co-located Radiances

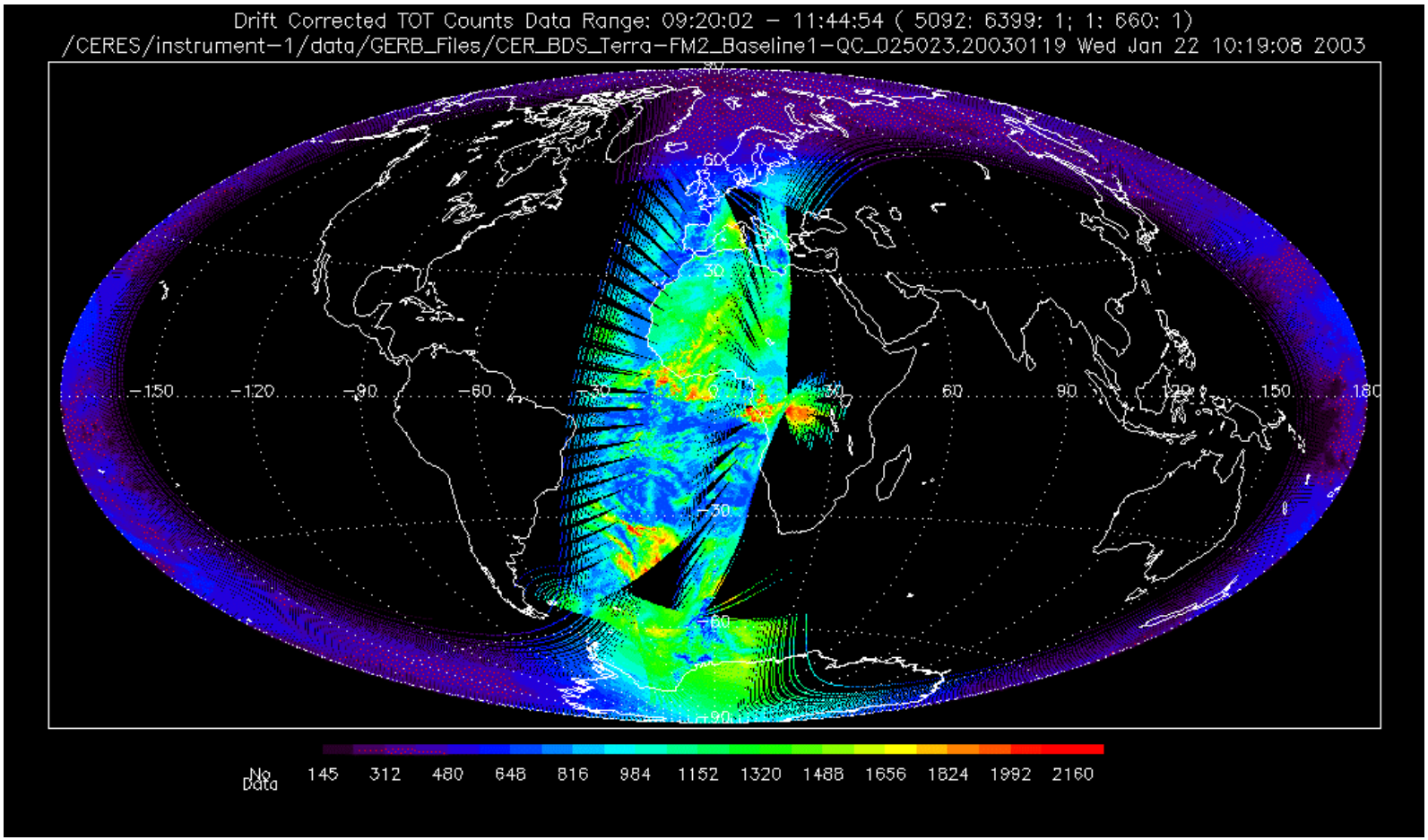
Temporally, Spatially, Angularly matched pixels

CERES PAPS Mode

10-day Intensive Data Collect Period

Proposed CERES/GERB Intercalibration

CERES to serve as transfer standard for GERB detectors



Intersatellite comparison Key Results

- Significance level in LW and WN: 0.1%, SW: 0.4%
- FM1 and FM2 daytime LW radiances 0.5% smaller than PFM
- FM1 nighttime LW radiances not significantly different from PFM
- FM2 nighttime LW radiances 0.5% lower than PFM
- FM1 WN radiances not significantly different from PFM
- FM2 WN radiances 0.5% higher than PFM
- FM1 and FM2 SW radiances not significantly different from PFM
- Differences are not found to be scene dependent

CERES Instrument Radiometric Validation Activities

		Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	Theoretical Line-by-Line	Filtered Radiance	> 20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Tropical Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N —20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel consistency, stability	TOT, SW
	Tlme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW

3-Channel Intercomparison

GOAL

Assess agreement between the SW channel and the SW portion of the Total Channel.

DATASET

Product: **ES-8 s for the months of January-August**

View Zenith: **Nadir footprints only**

Latitude: **~30 N to ~30 S**

Desired Scene Type: **High, cold deep convective clouds**

Filtered Radiance Threshold: **<1.13 W/m^2-sr-µm (Window Channel)**
(i.e. ~215K Blackbody)

3-Channel Intercomparison

Methodology

- **Regress Filtered Window against Unfiltered Total (i.e. LW) radiances at night.**
- **Predict daytime LW with two methods**

$$LW_{day} = Total_{day} - SW_{day} \qquad LW_{day} = C_1 * WN_{day} + C_2$$

- **Difference these two estimates and plot as a function of Filtered SW, I_f^{sw}.**

$$\Delta LW_{day} = (Total_{day} - SW_{day}) - (C_1 * WN_{day} + C_2)$$

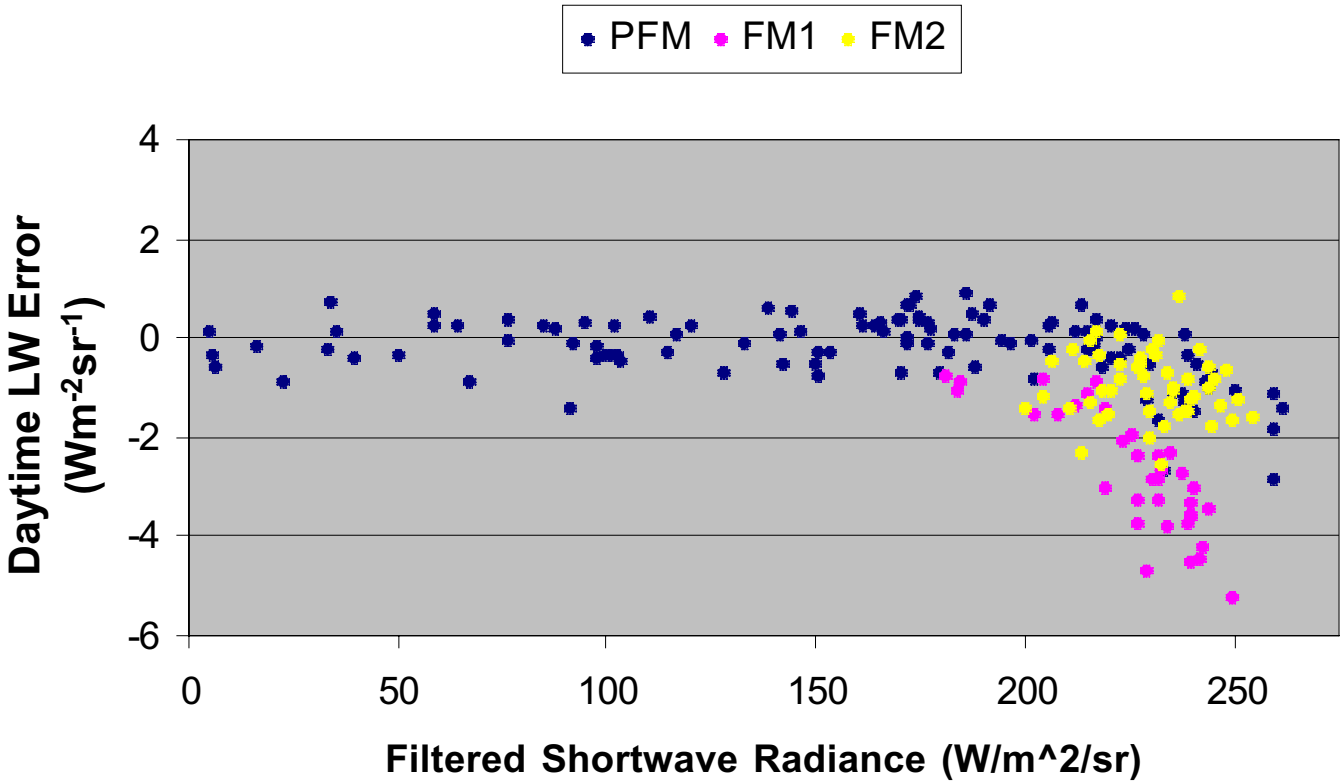
- **Any error in the unfiltering process (either due to errors in S_λ, or in detemining the unfiltering coefficients) may be represented by**

$$error = -\frac{\left(\frac{d\Delta}{dI_f^{sw}}\right)}{a^{lw/tot}\left(\frac{a^{sw}}{a^{sw/tot}}\right)} * 100$$

- **where the a s are the spectral unfiltering coefficients for the longwave channel (lw), shortwave channel (sw) and the shortwave portion of the total channel (sw/tot) for DCC.**

3-Channel Deep Convection Results

March 2000



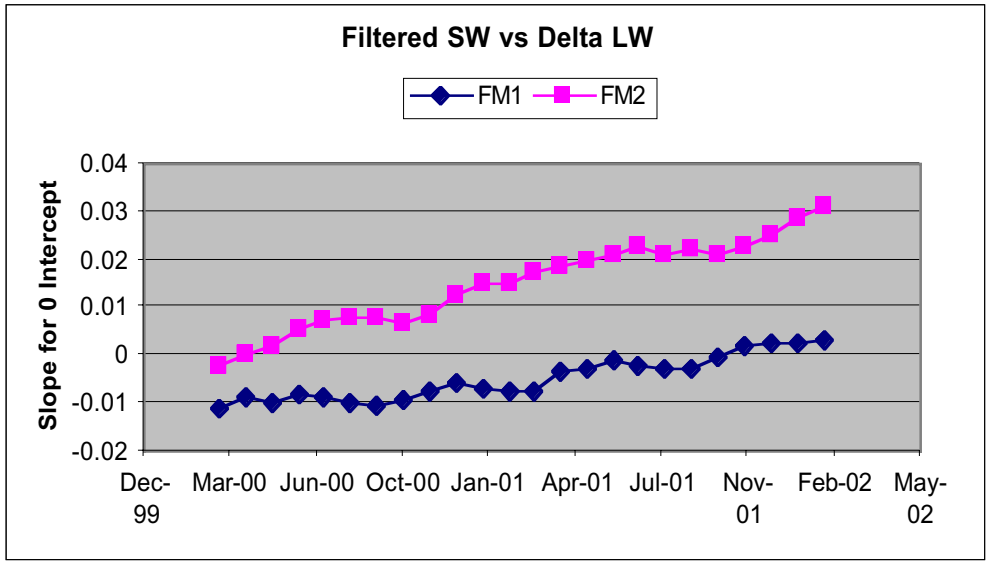
Daytime LW Error = (Total $_{day}$ — SW_{day}) — (C_1*WN_{day} + C_2)

Where C_1 and C_2 are found by regressing the Unfiltered WN against the unfiltered Total channel at night.

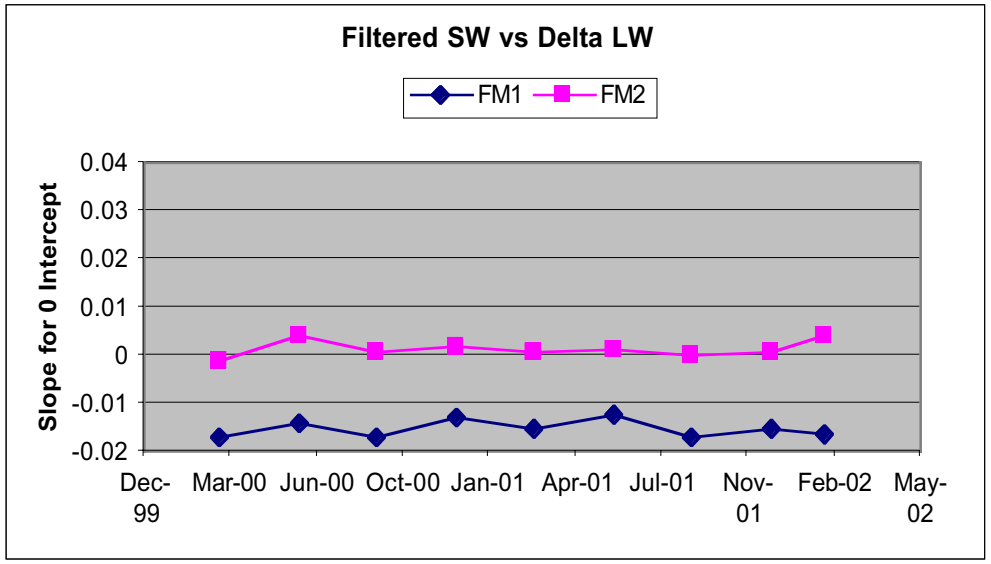
Non-linearity in FM1 is due to SW leak in WN channel

3-Channel Intercomparison

Monthly Unfiltering Error



Edition 1



Edition 2

DCC 3-Channel Intercomparison Key Results

- **3-Channel Intercomparison**
  - FM-1
    - Time varying inconsistency in FM-1 Total channel beginning 3/01 (0.5% / yr)
      - Direct Comparison suggests error is in the SW portion of the Total Channel
  - FM-2
    - Time varying inconsistency in FM-2 Total channel (total change ~2%)
      - Direct Comparison suggests error is in the SW portion of the Total Channel

Terra Edition2 BDS and ERBE-Like Summary

3/00 - 9/01

Actions

Updated initial flight gains to account for shifts during launch.

Acounted for on-orbit drifts in detector responsivites, or gains.

Accounted for changes in spectral coloration of the SW/TOT channels

Results (for All-Sky cases, 3/00 - 9/01)

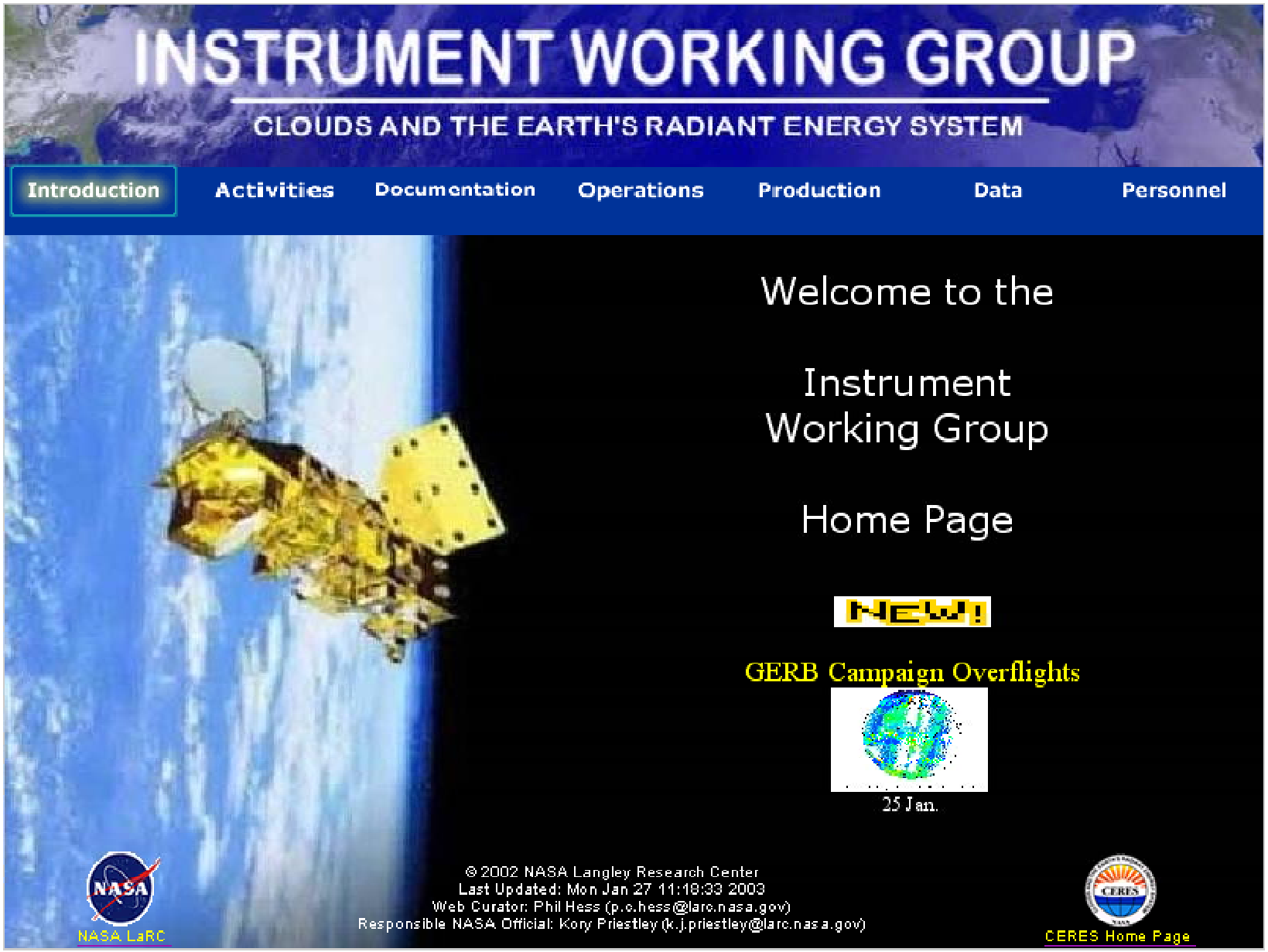
		LW$_{day}$		LW$_{night}$		SW		WN$_{day}$		WN$_{night}$	
		Ed2	Ed1	Ed2	Ed1	Ed2	Ed1	Ed2	Ed1	Ed2	Ed1
Stability	**W/m^2**	**<.5**	**2.5**	**-**	**-**	**0.1**	**0.5**	**-**	**-**	**-**	**-**
	%	**<.2**	**1.0**	**-**	**-**	**<.1**	**.25**	**-**	**-**	**-**	**-**
Bias	**W/m^2**	**<1**	*******	**.5**	**.8**	**<.1**	**1.0**	**.01**	**.06**	**.01**	**.05**
	%	**<.5**	*******	**<.2**	**<.4**	**<.1**	**.25**	**0.2**	**1.0**	**0.2**	**1.0**

Instrument Working Group Summary

CERES has successfully met or exceeded all performance goals to date

- **Comprehensive Calibration/validation plan is in place**
  - Incorporates experiments of all temporal, spatial scales
  - Utilizes instantaneous through zonal and regional mean data products
- **Demonstrated ability to remove instrument drifts by an order of magnitude**
  - Nighttime LW, SW, and WN fluxes are stable at better than 0.1%/yr (Terra Ed2)
  - Daytime LW fluxes stable at 0.2%/yr level (Terra Ed2)

http://asd-www.larc.nasa.gov/Instrument/



INSTRUMENT WORKING GROUP

CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM

Introduction | Activities | Documentation | Operations | Production | Data | Personnel

ACTIVITIES

Choose from one of the links below:

Ground Calibration

Deep Space Calibration

Validation

Field Campaigns:

CLAMS CRYSTAL-FACE INDOEX

LaRC-ULDB GERB

Terra/Aqua Intercalibration

Solar Principal Plane Scans (PPS)

NASA LaRC

Last Updated: Fri Jan 17 12:24:34 2003
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CERES Home Page

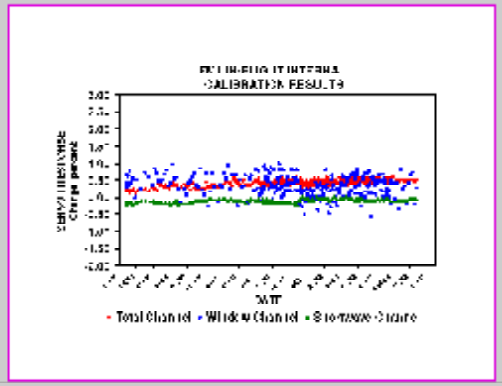
CERES Instrument Radiometric Validation Activities

Choose one of the Activity items below for a brief explanation of what it is and does.

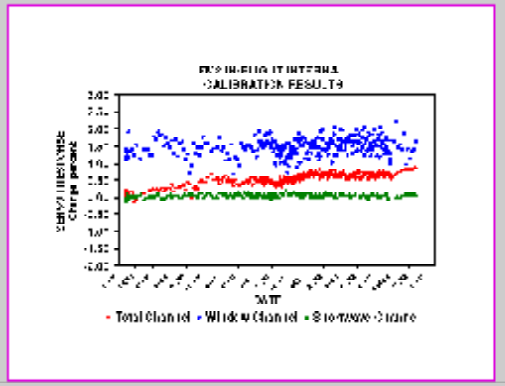
Type	Data Results	Activity	Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Plots	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Plots	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	na	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	na	Theoretical Line-by-Line	Filtered Radiance	>20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	na	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	na	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Aqua Plots Terra Plots	Inter-Instrument (Direct Comparison)	N/A	N/A	N/A	N/A	N/A
	na	Global Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	na	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N - 20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	na	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument Agreement, Stability	SW
	na	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel Consistency, Stability	TOT, SW
	na	Time Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW
Calibration	na	Coastline Detection	Geo-Location	N/A	N/A	N/A	N/A
	na	Lunar Scanning	Pointing Knowledge	N/A	N/A	N/A	N/A
	na	Stow Dwell	Second Time Constant	N/A	N/A	N/A	N/A

Terra-Aqua Production
Internal Calibration Trend Plots

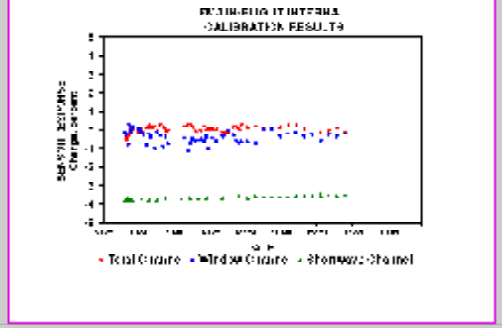
FM1



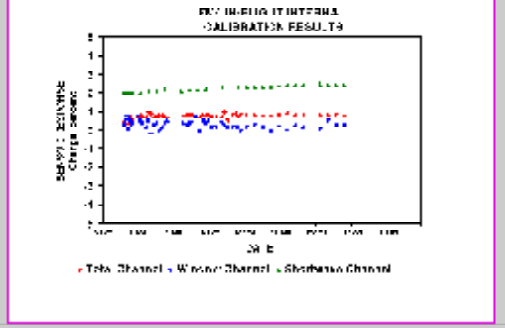
FM2



FM3



FM4



PFM

INSTRUMENT WORKING GROUP

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DOCUMENTATION

Choose from one of the links below:

ATBD's

Operation Manuals

Publications

Collection Guides

Image Library

NASA LaRC

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OPERATIONS

Choose from one of the links below:

Daily Statistics:
PFM FM1 FM2 FM3 FM4

Command Logs:
PFM FM1 FM2 FM3 FM4

Mode Sequences:
Terra Aqua

Instrument Operations:
TRMM Terra Aqua

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PRODUCTION

Choose from one of the links below:

QC-Reports

Input Parameters

Data Availability:

Terra-Monthly Terra-Daily

Aqua-Monthly Aqua-Daily

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DATA

Choose from one of the links below:

Housekeeping Statistics Color Plots: On Off

Monthly Filtered Radiance Plots

Groundtrack Plots

Beta Angle Plots:
Solar or Lunar
Monthly Yearly
Minute of the Day

Diagnostic Plots Index

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PERSONNEL

Click on the link below for a list of
Instrument Subsystem Contacts:

Contacts

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