

Comparison of the Earth's short-wave radiation measured by ERB instruments (CERES/GERB)

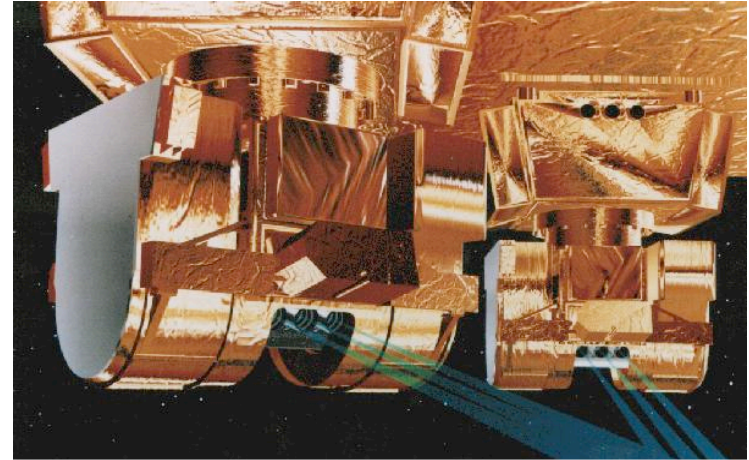
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ESA/ESTEC Workshop, The Netherlands

Presentation Outline

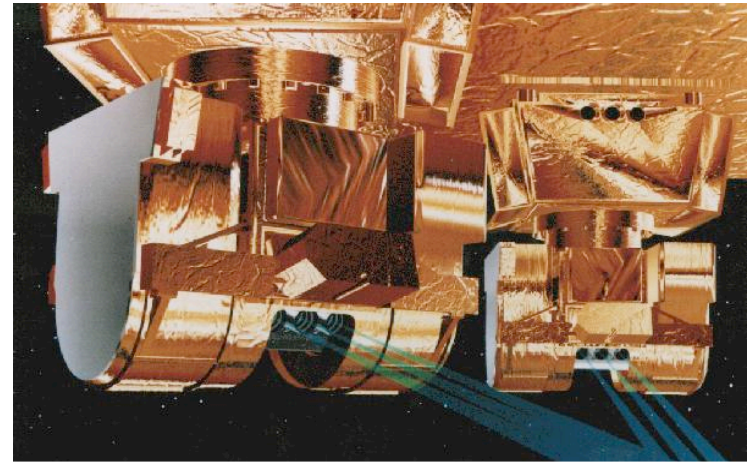
- Special mode of a CERES instrument
- Comparing FM1 and FM4 for the ERB dataset
- Matching GERB instrument geometry
- Comparison of CERES/GERB unfiltered SW radiances for the ERB dataset

Clouds and the Earth's Radiant Energy System Instrument



- Narrow field-of-view (15x30km at nadir) scanning radiometer:
 - Shortwave channel (0.3-5 μm),
 - Total channel (0.3-100 μm),
 - Window channel (8-12 μm)
- PFM on board TRMM (1998, failed 06/2000)
- FM1 & FM2 on board Terra (in service from 03/2000)
- FM3 & FM4 on board Aqua (in service from 06/2002)

CERES



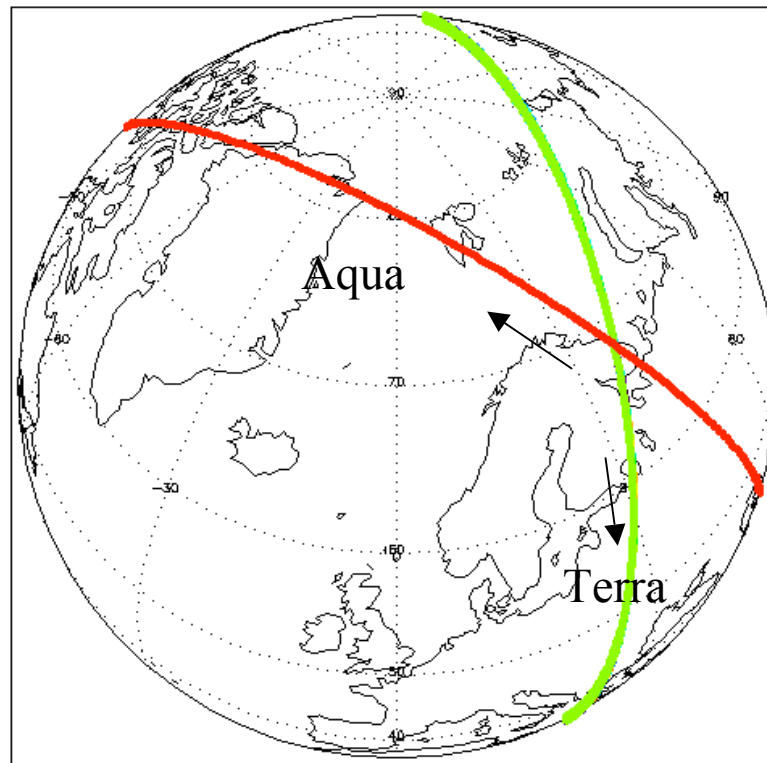
Calibration stability monitored with:

- On-board calibration sources (blackbodies, lamps, solar)
- Multi-channel and multi-instrument consistency
- Geophysical validation

Gain drifts can be detected at the 0.1% level, and corrected!

A part of validated data set for the radiation budget since 1984

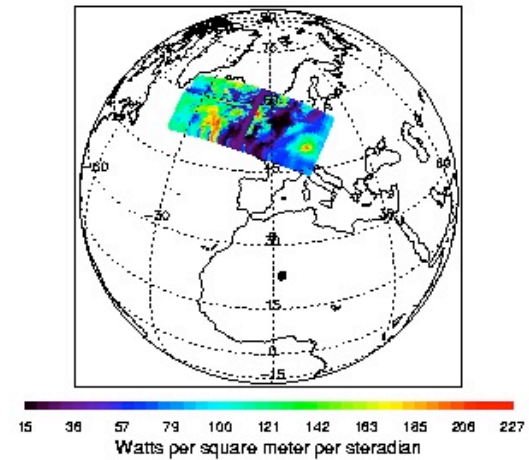
Terra & Aqua orbits



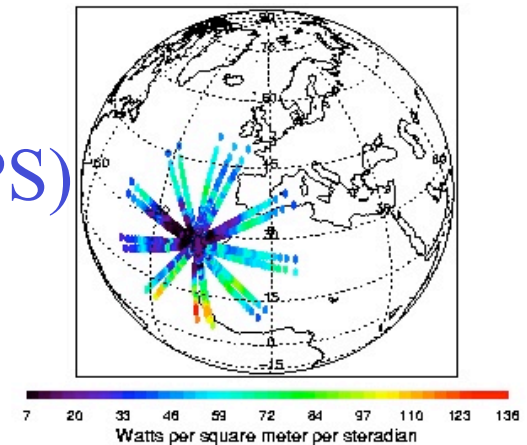
- Sun-synchronous, inclination angle 98.2° and 81.8°
- Equatorial crossing time: 10:30AM and 1:30PM
- about 15 minutes apart at nodes

CERES normal operation modes

- Cross-track (XT) Scan



- Rotational Azimuth Plane Scan (RAPS)



Special mode

Programmable Azimuth Plane Scan (PAPS) mode:

- Scanning plane orientation follows a prescribed schedule
 - ✓ Step-wise changes of the azimuth angle
 - ✓ Time and angle changes depend on satellite position in an orbit
- Increases sampling by an order of magnitude

PAPS applications:

- Special observations
 - ✓ Earth targets
 - ✓ Matching viewing geometry of other instruments
 - ✓ Sampling within required scan plane orientation

Comparing remote sensing instruments

*Comparison of instrument measurements
should be performed
under the most ideal conditions*

FM1/FM4 comparison

To validate FM4 (Aqua) radiances for ERB dataset

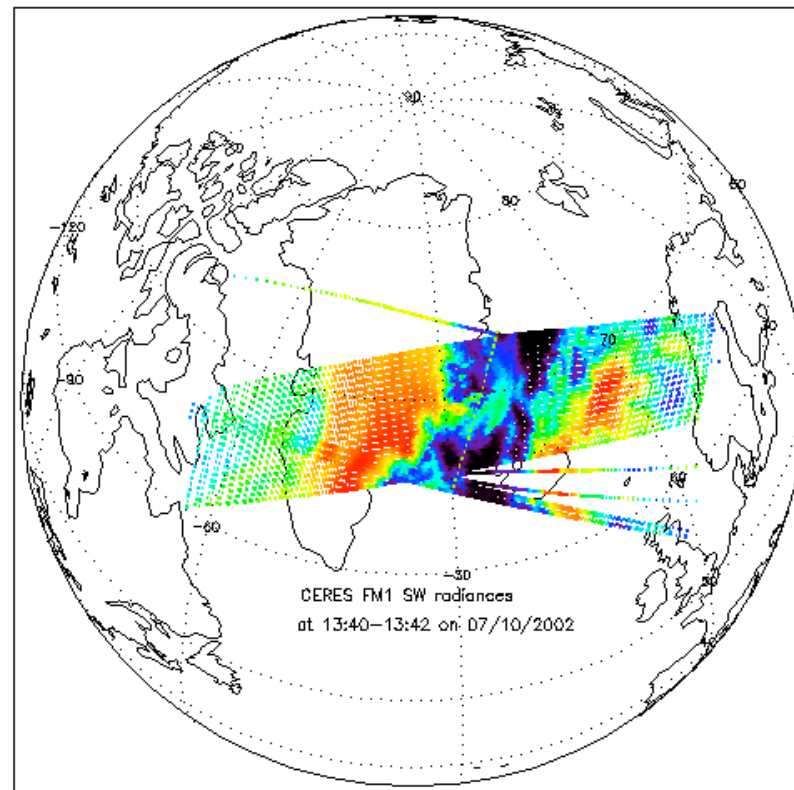
Campaign around the summer solstice of '02 and '03

Greenland appears to be the most homogenous:

- FM1 (Terra) and FM4 (Aqua) 15 minutes apart
- Scans orthogonal to the solar plane
- VZA matched within 10° , RAZ within 1°
- About 90 sec of data per orbit

FM1 scan over Greenland

Unfiltered shortwave radiances at 13:40 on 07/10/2003



0

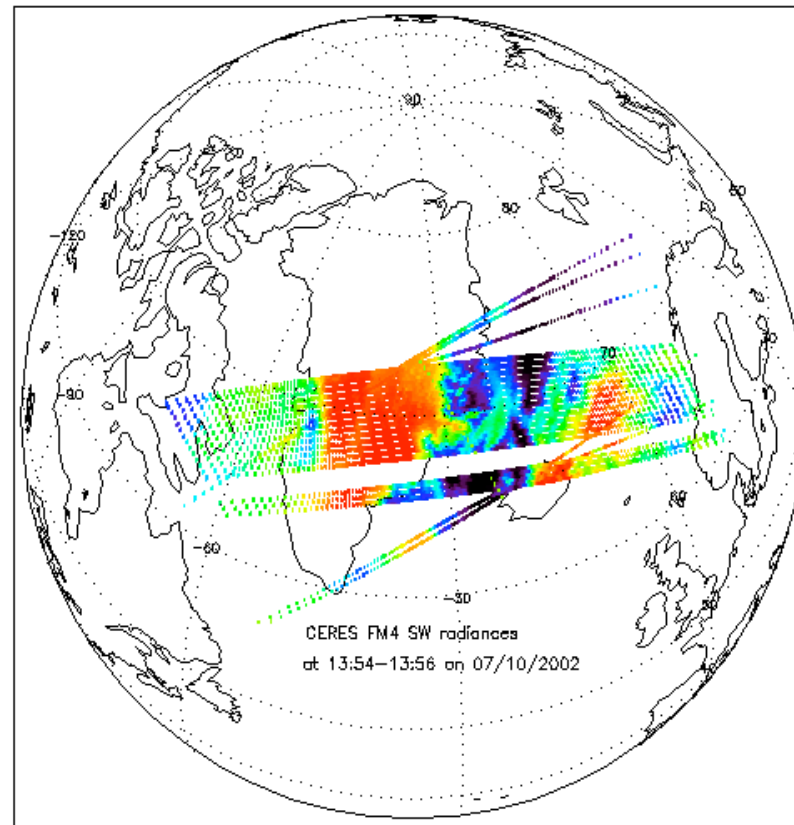
100

203

Watts per square meter per steradian

FM4 scan over Greenland

Unfiltered shortwave radiances at 13:54 on 07/10/2003



0

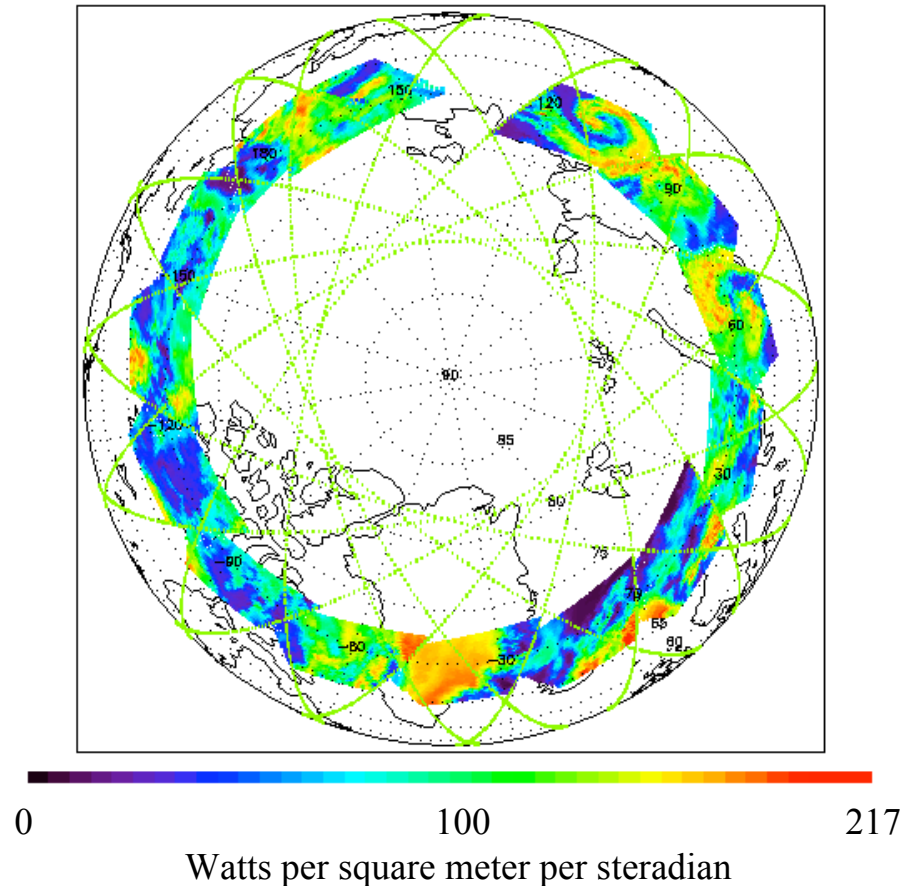
100

200

Watts per square meter per steradian

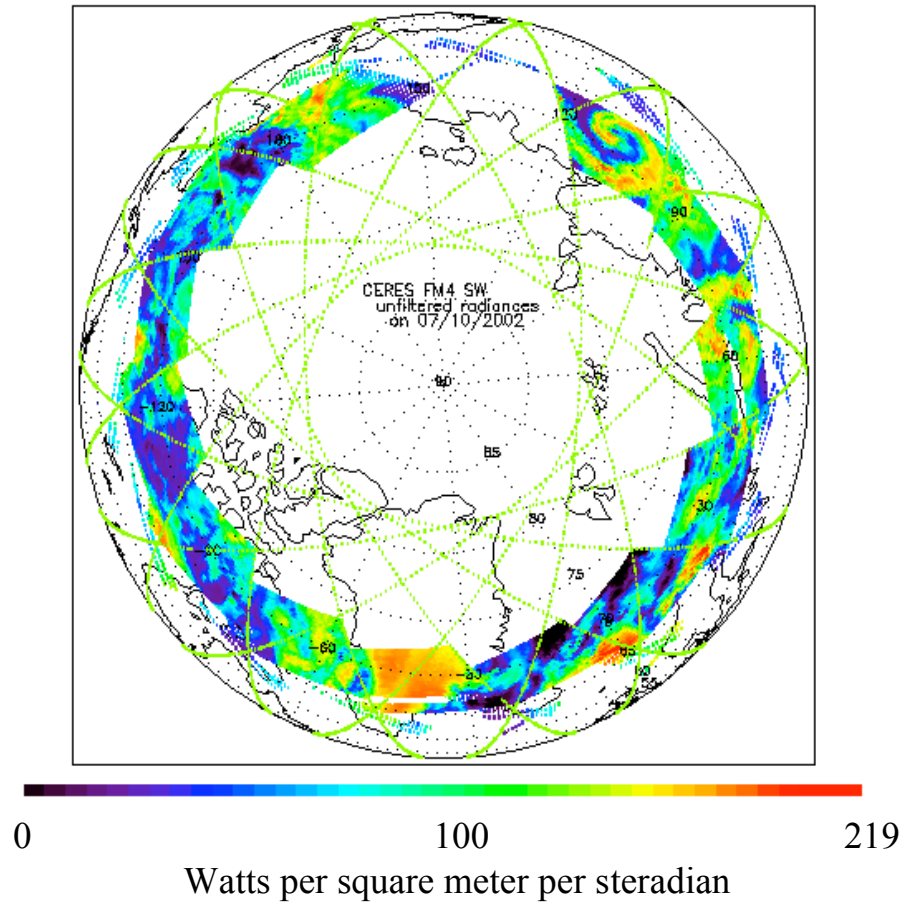
FM1 scanning pattern

Unfiltered shortwave radiances on 07/10/2003



FM4 scanning pattern

Unfiltered shortwave shortwave on 07/10/2003



Data processing constraints

Direct comparison of radiances:

- difference of averages

No time issue:

- Terra – Aqua 15 minutes apart

Spatial noise dominates:

- averaging over $1^\circ \times 1^\circ$ grid-boxes
- at least 20 footprints or 75% of area covered

Matching geometry:

- 10° tolerance for the VZA for all three channels
- 1° tolerance for the relative azimuth for shortwave

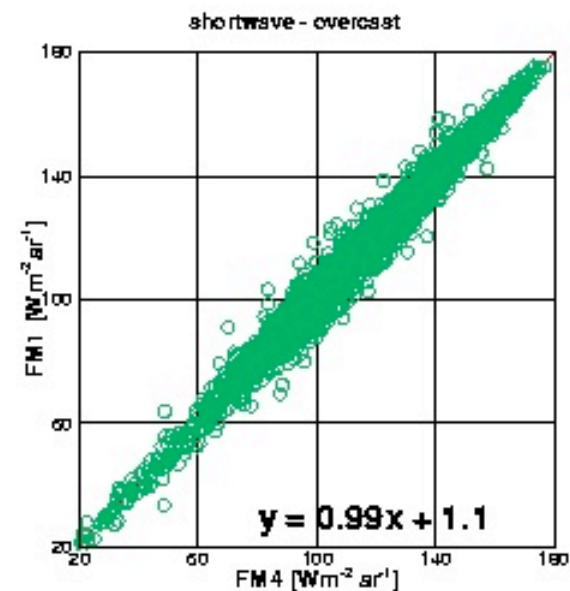
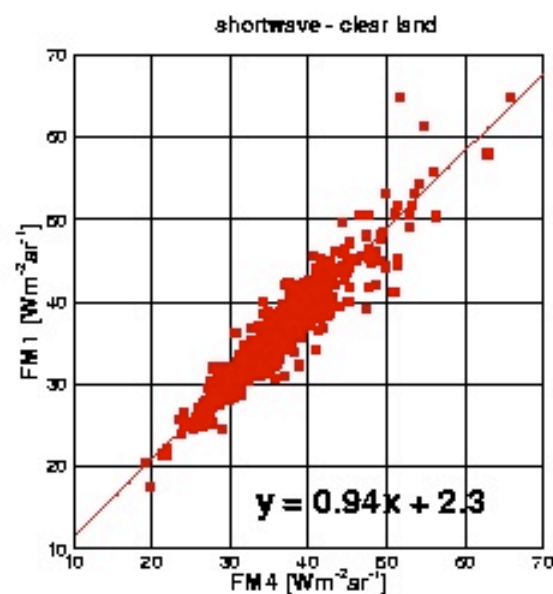
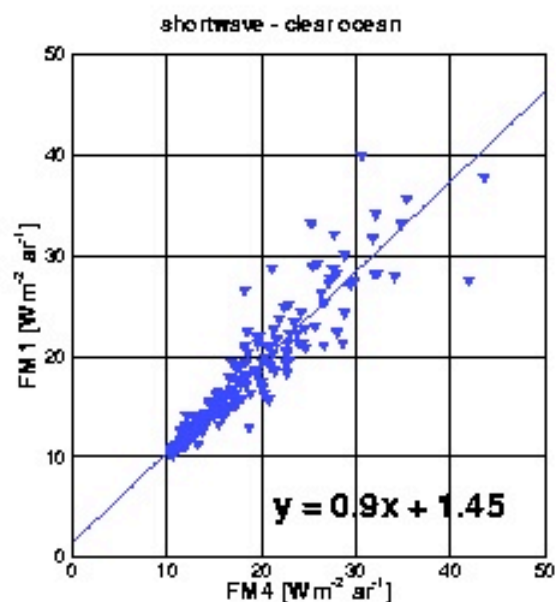
Statistics

Direct comparison of radiances:

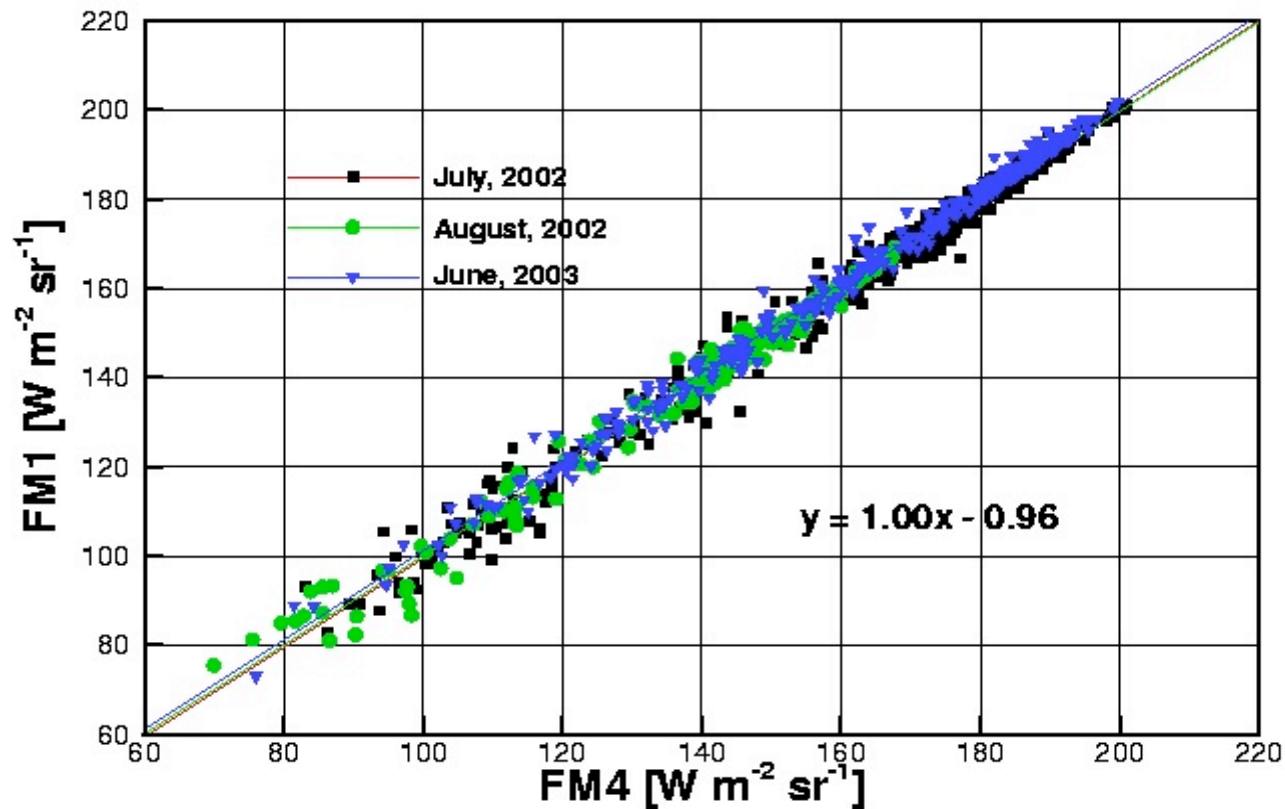
- Each orbital crossing is an independent sample
- Difference computed over a grid-box and orbital crossing
- Uncertainty estimated using a 95% confidence level

α – test: $\varepsilon = \frac{t_{\alpha/2}\sigma}{\sqrt{N}}$

Shortwave radiances



SW radiances over Greenland



Results for Greenland

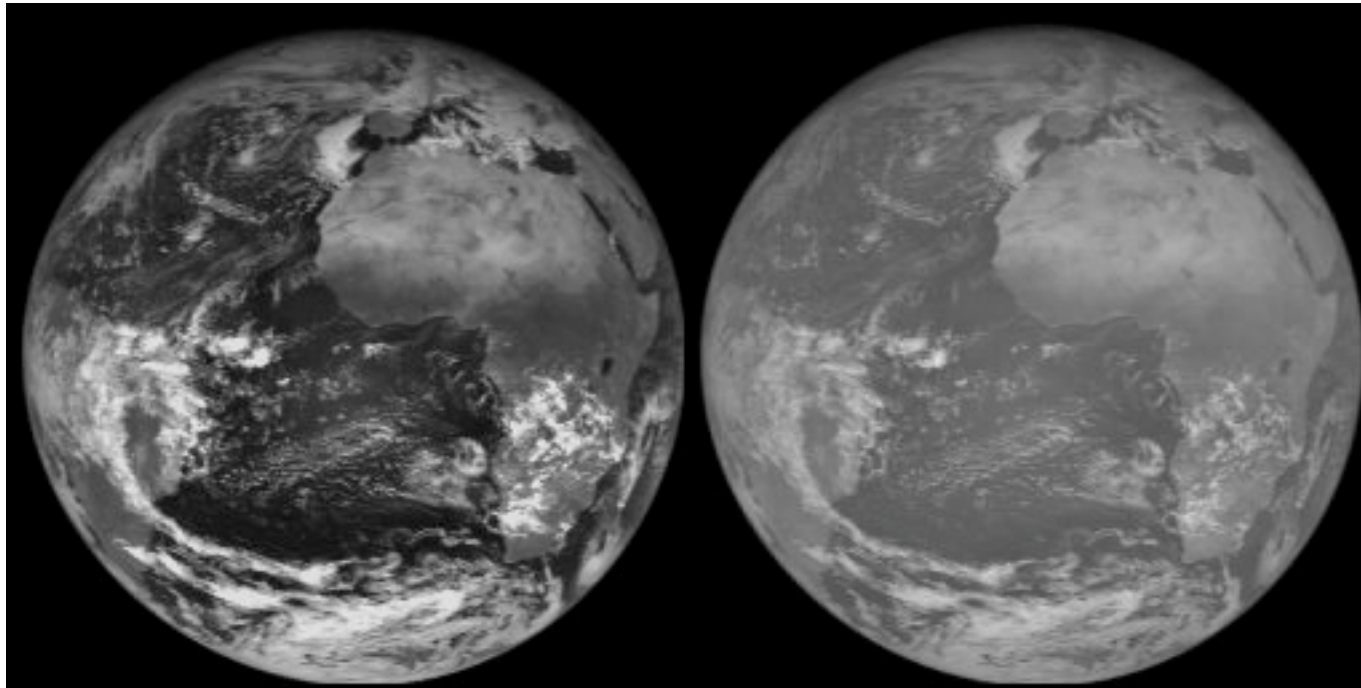
Period	Mean FM4 [Wm ⁻² sr ⁻¹]	Δ mean [Wm ⁻² sr ⁻¹]	Δ mean [%]	$\Delta\sigma$ [%]	N _{orbX}	α -test [%]
July, 2002	157.3	0.33	0.2	1.20	30	0.4
August, 2002	145.1	0.21	0.1	0.90	13	0.4
June, 2003	156.9	-0.87	-0.6	0.60	25	0.2

FM1/FM4 summary

- Comparison procedure for FM1 and FM4 was shown to be well planned and executed
- Data analysis fully demonstrated **the 1% consistency** in radiance measurements (small spread)
- Experiment is repeated during the summer solstice every year in an effort to monitor the CERES performance
- CERES instruments have delivered a high quality Earth radiation budget (ERB) data set **since 1998**

GERB measurements

- **Geo-stationary Earth Radiation Budget instrument**
 - ✓ On board MSG located at 3.4W (10.5 W)
 - ✓ Array of 256 detectors covering the visible portion of the Earth
 - ✓ Short and long-wave radiation image every 15min.



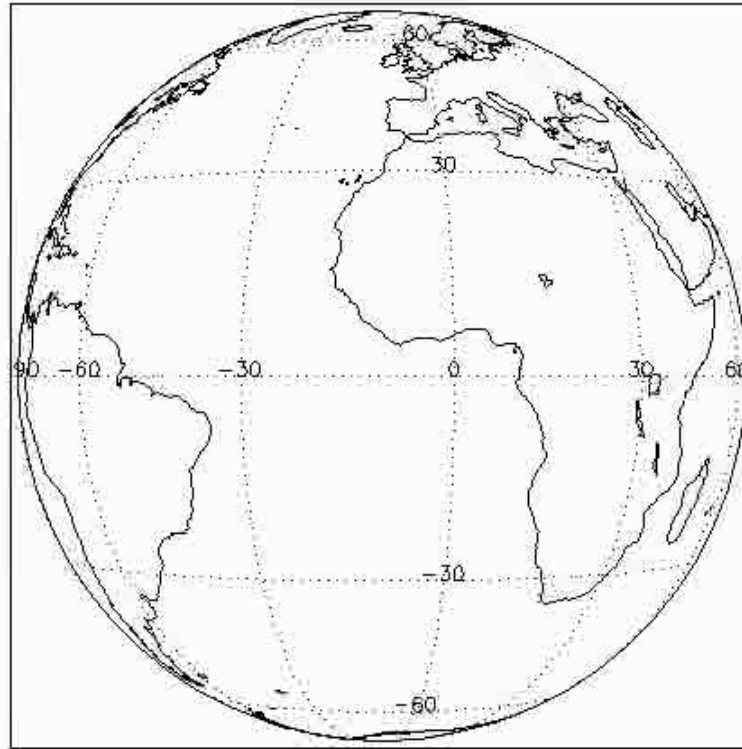
CERES/GERB comparison

To validate GERB radiances for ERB dataset

- Campaign around the winter solstice of 2003
 - ✓ PAPS matches GERB viewing geometry
 - ✓ FM2 on Terra in this special mode for about 15 days
 - ✓ 4 daytime orbits per day for about 85 min scanning
 - ✓ Unfiltered shortwave radiances are produced by RMIB for this study
 - ✓ GERB pointing accuracy is improved using SEVIRI data
 - ✓ GERB geolocation error is about a half of its footprint without bias

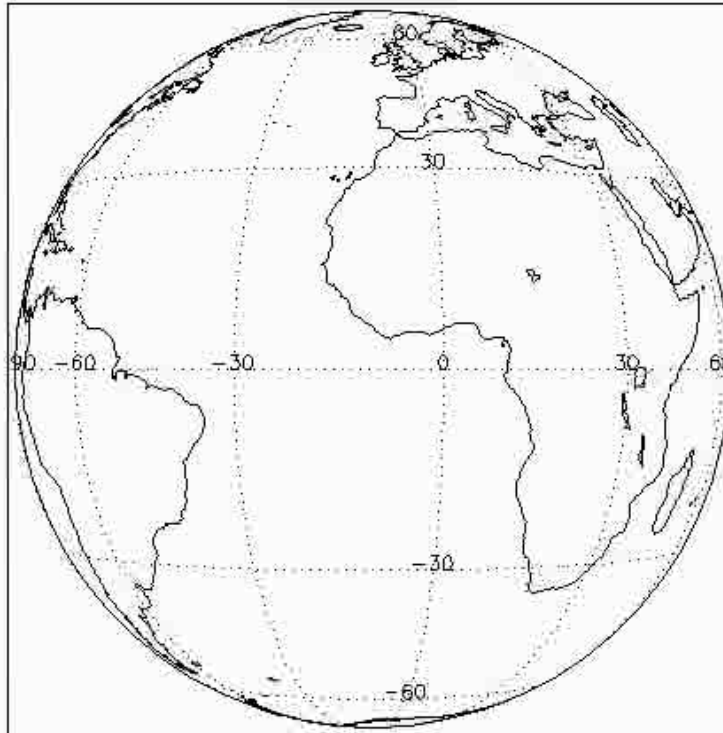
CERES/GERB daily scanning

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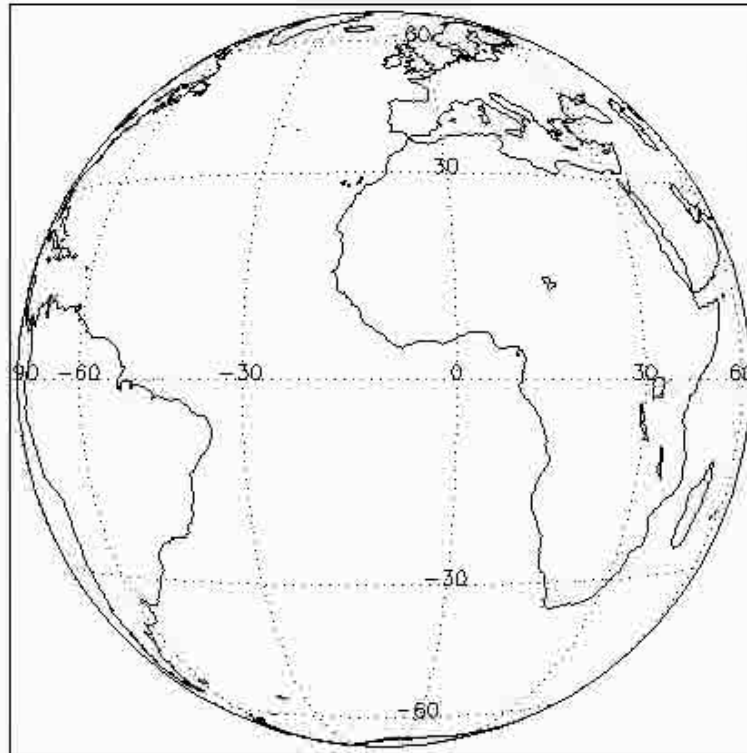
CERES/GERB daily scanning

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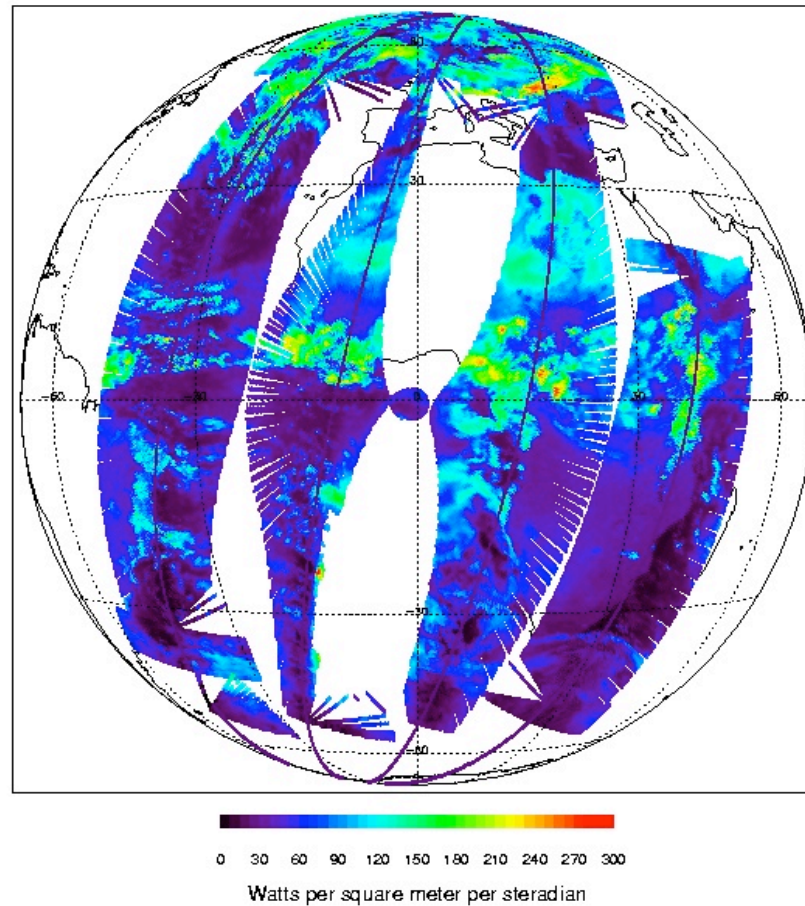


CERES/GERB daily scanning

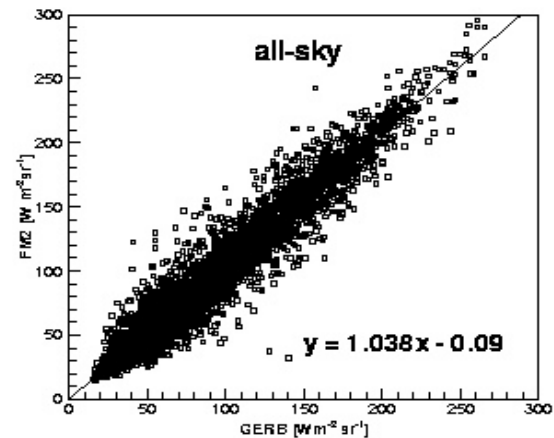
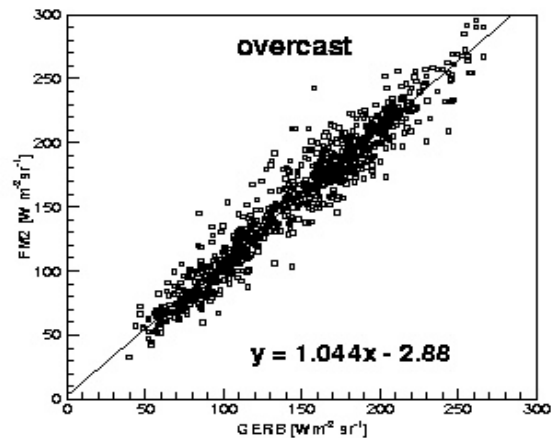
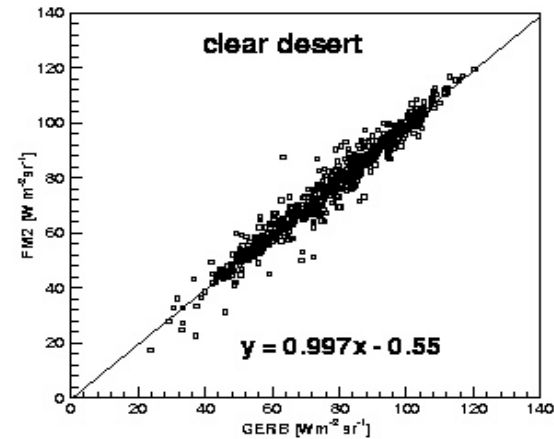
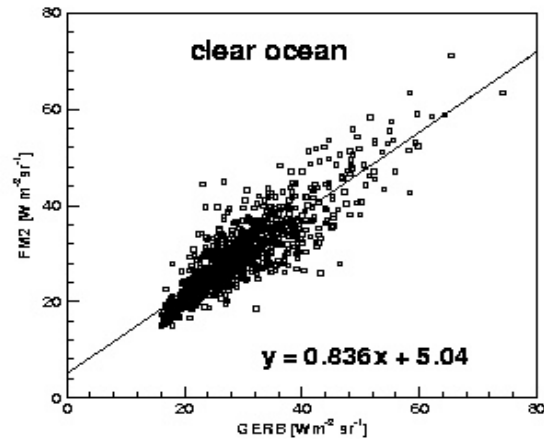
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CERES/GERB daily scanning



CERES/GERB comparison



Preliminary results for SW

Scene ID	Mean FM2 [Wm ⁻² sr ⁻¹]	Δ mean [Wm ⁻² sr ⁻¹]	Δ mean %	$\Delta\sigma$	N _{orbX}	α -test
Clear ocean	30.8	0.2	0.7	3.2	140	0.37
Clear desert	75.3	0.7	1.0	2.2	42	0.65
Overcast	145.5	- 8.9	- 6.2	7.4	166	1.14
All-sky	81.0	- 2.8	- 4.0	11.3	621	0.92

CERES/GERB summary

- Preliminary results presented
- Large amount of data using the PAPS mode
- 1% consistency in the middle of spectrum
- More bias for bright scenes
- GERB's improved pointing accuracy is a key to promising results
- Further improved geolocation needed!

Concluding remarks

- CERES participated in variety of campaigns
- PAPS mode for special observations
- Planning tools reside on a website
- Rapid response due to automation
- Free service to the science community

<http://asd-www.larc.nasa.gov/PAPS/cgi-bin/rygar.cgi>