The Geostationary Earth Radiation Budget (GERB) experiment

Status report

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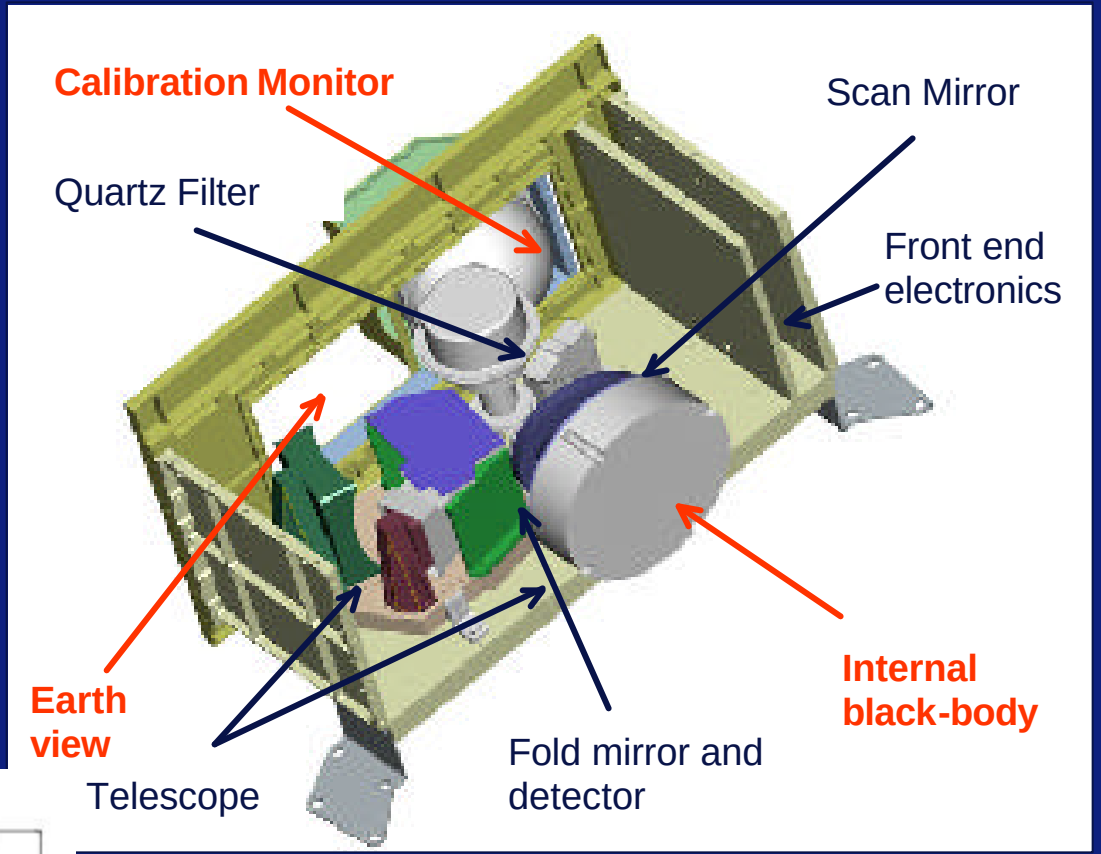
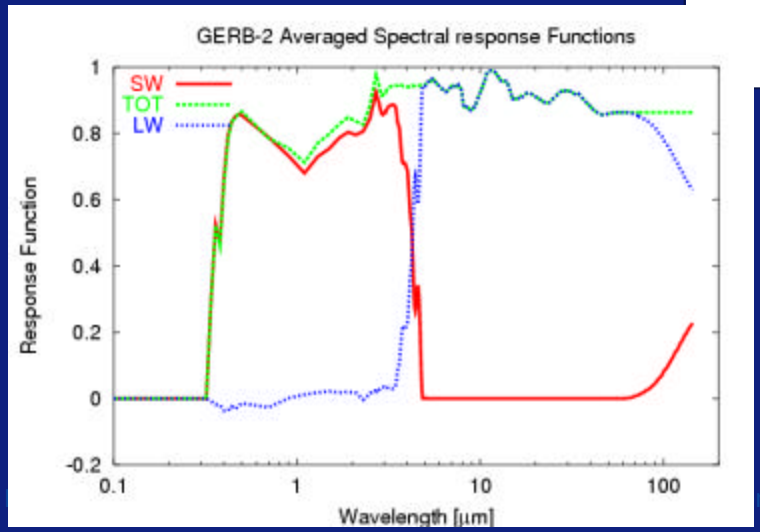
GERB Instrument

Broadband scanning radiometer

- MSG-1 is spin-stabilised (0.6 sec)
- ~18G force on GERB
- De-spin mirror





Total (TOT) channel: 0.32µm - >100µm

ShortWave (SW) channel: 0.32µm - 4µm

LongWave (LW) channel: TOT - SW

Calibration and requirements

Ground calibration:

- Spectral response
- Point spread function
- Blackbody characterisation
- Instrument gains/sensitivity

In-flight calibration:

- LW: Blackbody (every rotation)
- SW: Integrating sphere (long-term)

RADIOMETRY	SW	LW
Absolute Accuracy:	< 1.0 %	< 1.0 %
Signal/Noise:	1250	400
Dynamic Range: (W m-2 sr-1)	0-380	0-90

SPATIAL SAMPLING

44.6 × 39.3 km (NS × EW) at nadir

TEMPORAL SAMPLING 15 minute SW and LW fluxes

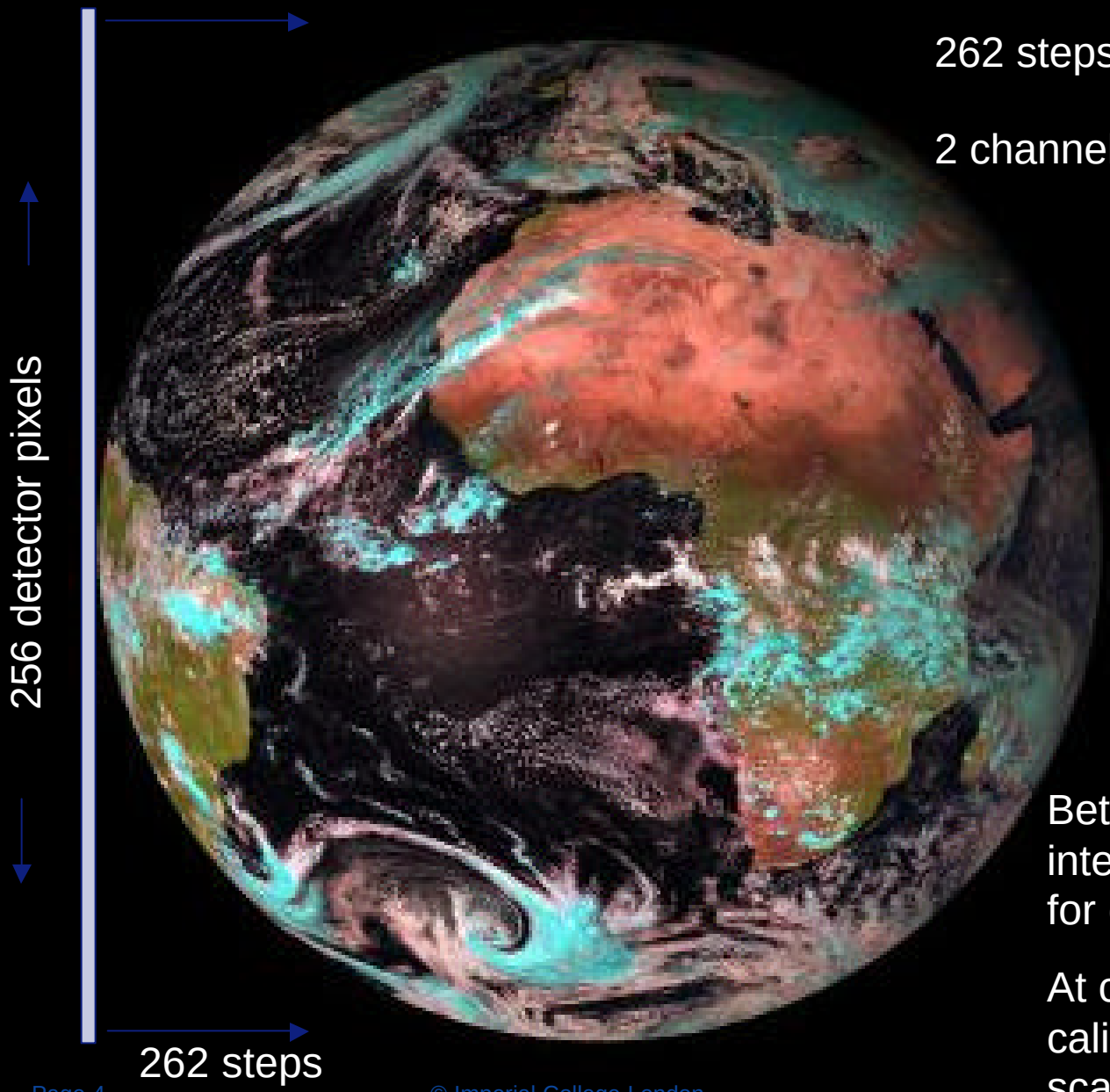
CYCLE TIME

Full Earth disc, both channels in 5 minutes

CO-REGISTRATION

Spatial: 3 km wrt SEVIRI at satellite sub-point

Temporal: Within 15 min of SEVIRI at each pixel



Satellite rotation period = 0.6 s

262 steps for full Earth disc = 157.2 s

2 channels: Total
Total+quartz filter (SW)

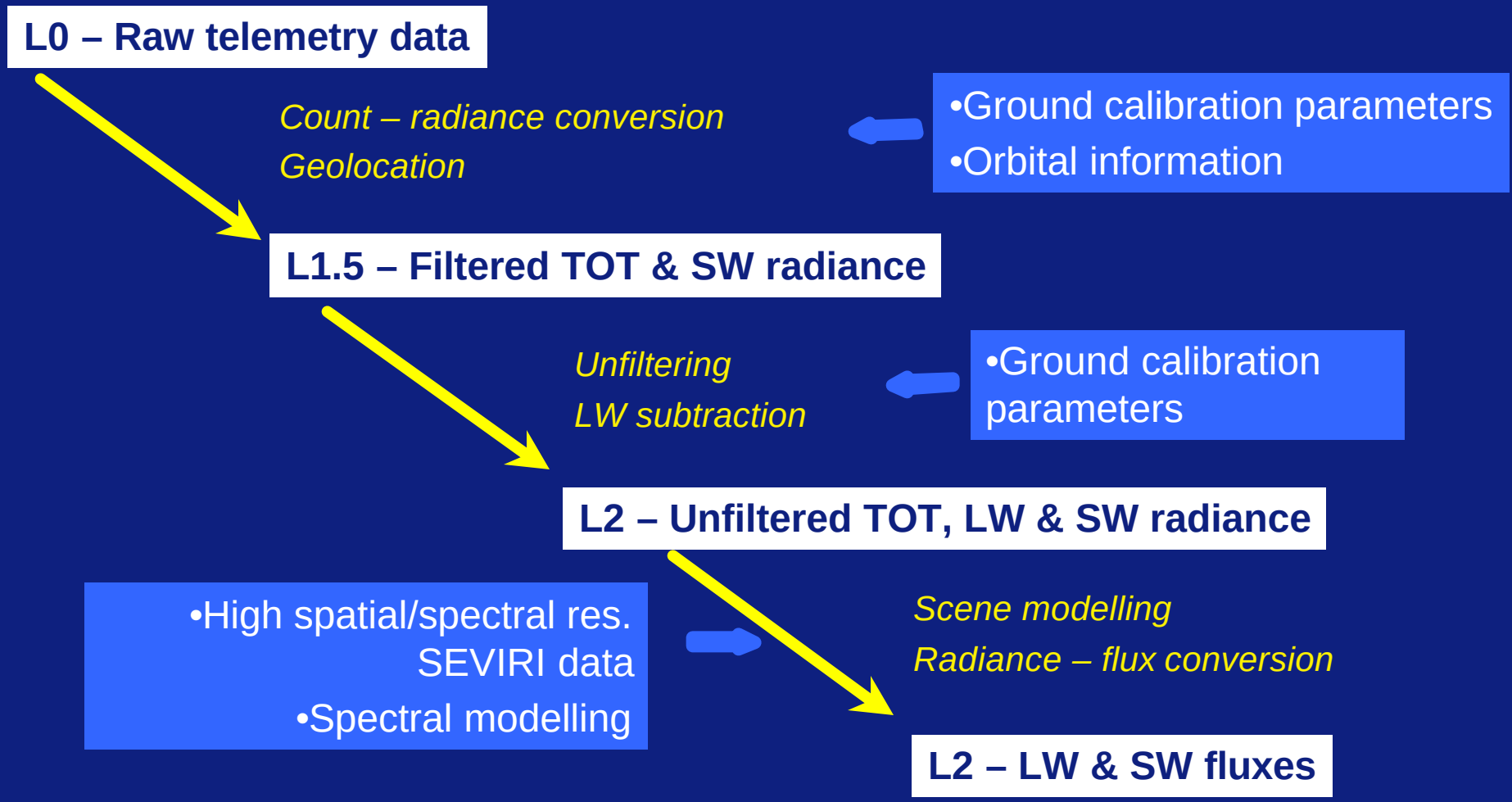
Average three scans in each channel to improve S/N

Total repeat time = 157.2*6 ~ 15 min.

Between each Earth scan, internal BB measurement taken for calibration

At correct viewing geometry, calibration monitor records scattered solar light as a relative measure over time

Processing summary



Calibration algorithms

$$G_{TOT} = \frac{(V_{space} - V_{IBB})}{-L^{F}_{IBB}} \qquad G_{SW} = BG_{TOT}$$

$$L^{F,TOT}_{scene} = \frac{V^{TOT}_{scene} - V^{TOT}_{IBB}}{G_{TOT}} + L^{F,TOT}_{IBB}$$

$$L^{F,SW}_{scene} = \left(\frac{V^{SW}_{scene} - V^{SW}_{IBB}}{G_{SW}} \right) + L^{F,SW}_{IBB}$$

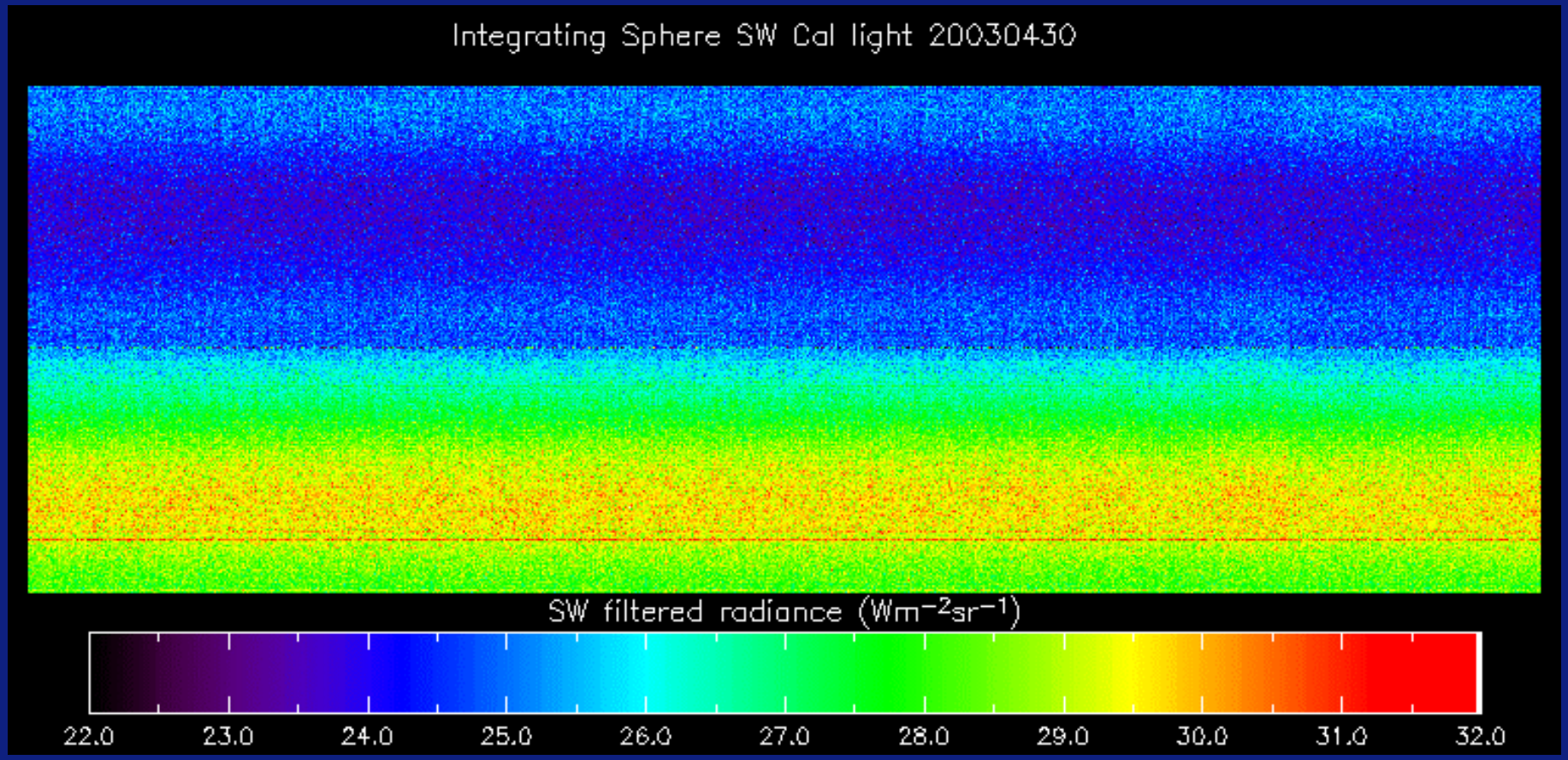
Calibration Commissioning Tests

- Alpha values test
  - Investigating GERB digital signal processing parameters
- Deep space mode
  - To determine temperature dependence of pixel gains
- Integrating sphere mode
  - Monitors long-term degradation in SW filter transmission
- Lunar mode
  - Vicarious calibration mode
- PSF mode
  - Monitors changes in point spread function since launch
    - optical distortion since ground calibration
    - satellite platform manouevres

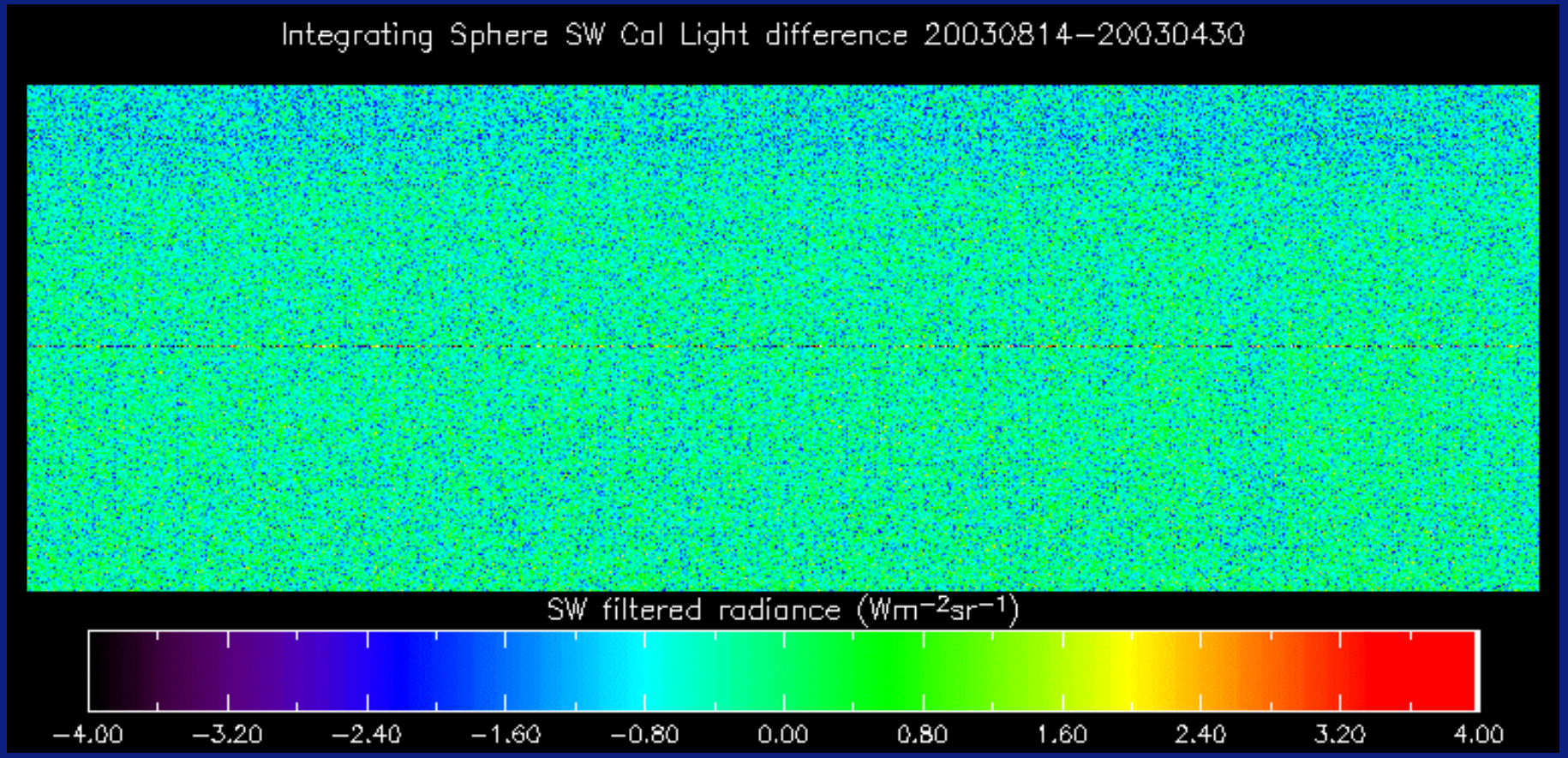
Integrating Sphere

- Aim: to monitor possible degradation in shortwave channel over mission lifetime
- Results to date:
  - IS reflectance varies with solar hemisphere.
  - Test relies on thermal stability of sphere, which is constant, to first order.
  - No detectable degradation has occurred in first 9 months of mission

Integrating Sphere result April 2003



Integrating Sphere difference August - April



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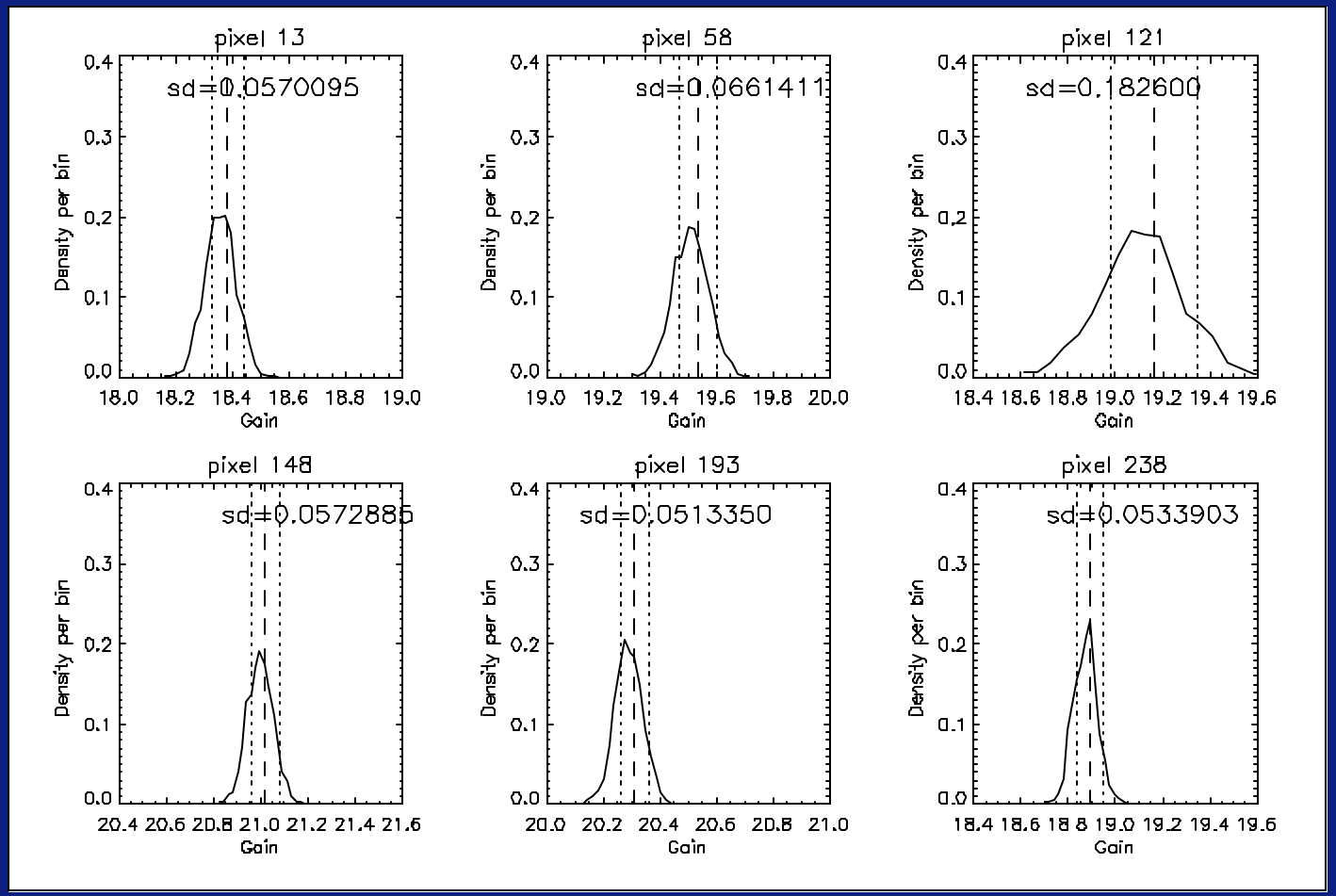
Deep space mode

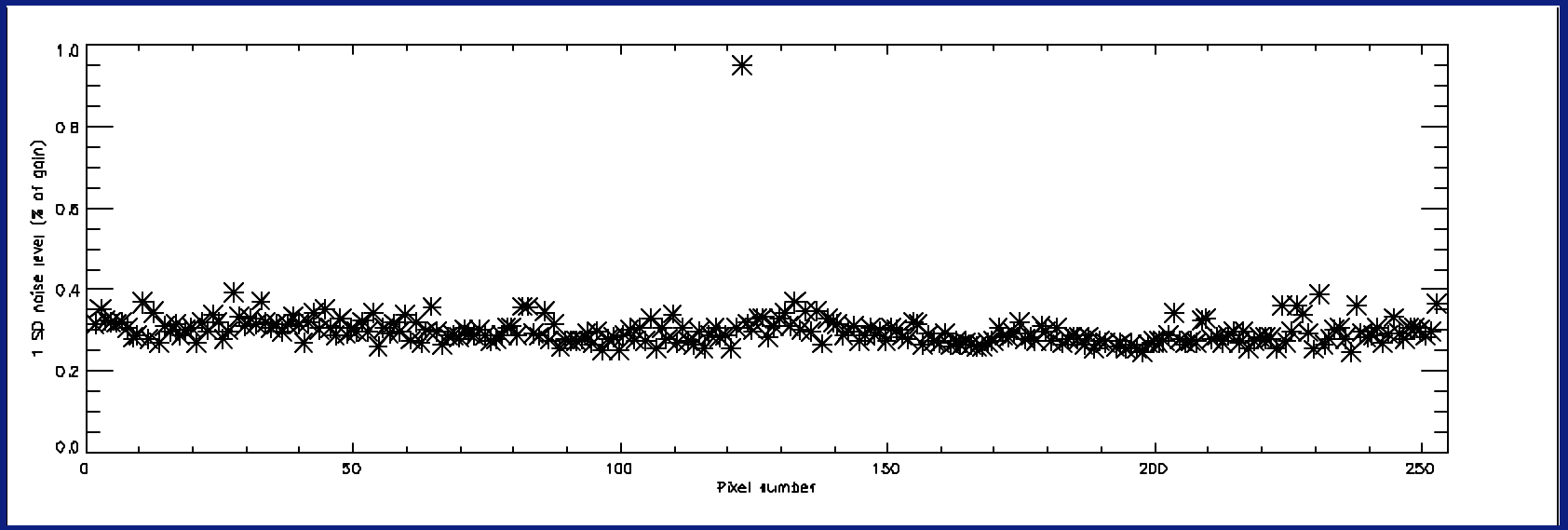
- Aim: to check gain stability
  - BB temperatures are varied to determine temperature dependence of gains
- Results to date:
  - Estimate of detector noise
  - BB look up radiances improved
  - BB & earth view straylight detected

Distribution of pixel gain (17/01/03)

Distribution of instrument gain calculated for columns 1 to 6 & 274 to 279 deep space data from 6am to 6pm (1523 samples per pixel) for a selection of pixels. Noise (SD) generally < 0.3%



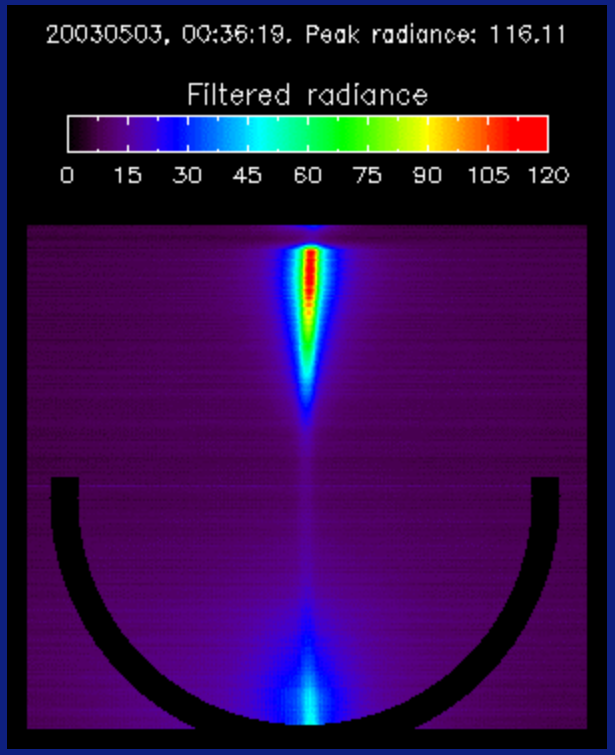
Deep space mode – detector noise



Gains very stable in time

Std dev. of gain gives estimate of pixel noise:

- **< 0.4% in TOTAL channel for most pixels**
- **Pixel 124: nosier**
- **Pixel 192: Too noisy to use measurements (off scale)**



Stray light from sun

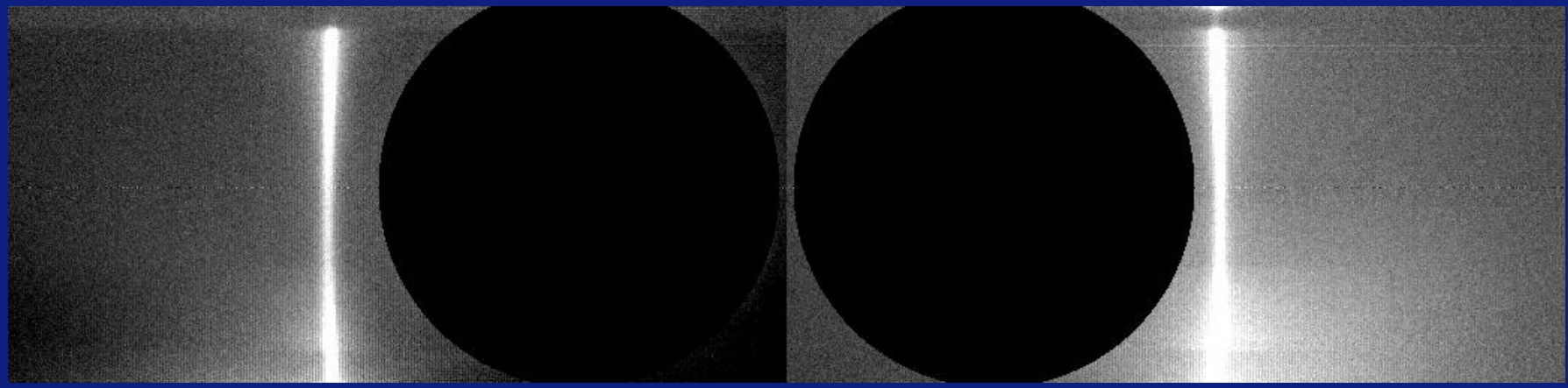
Common issue for geostationary instruments

GERB data affected:

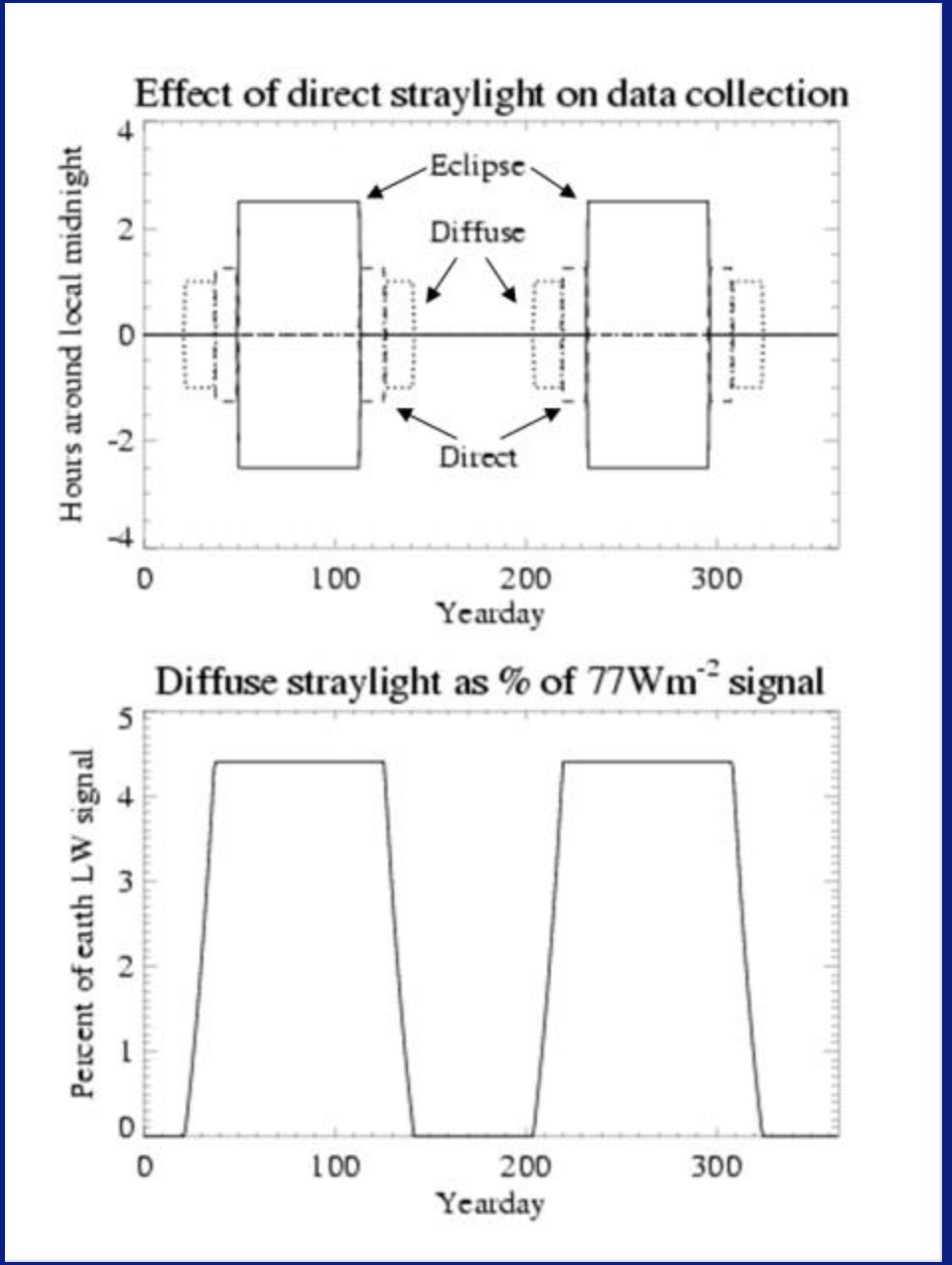
- +/- 1 hour of local midnight
- +/- 16° solar declination

Possible solutions:

- characterisation
- modelling
- processing fix



GERB stray light contamination timeline



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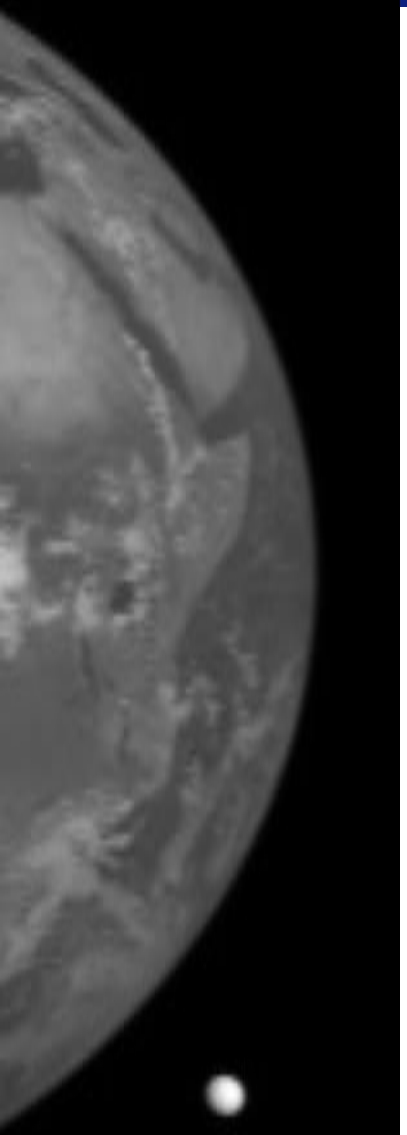
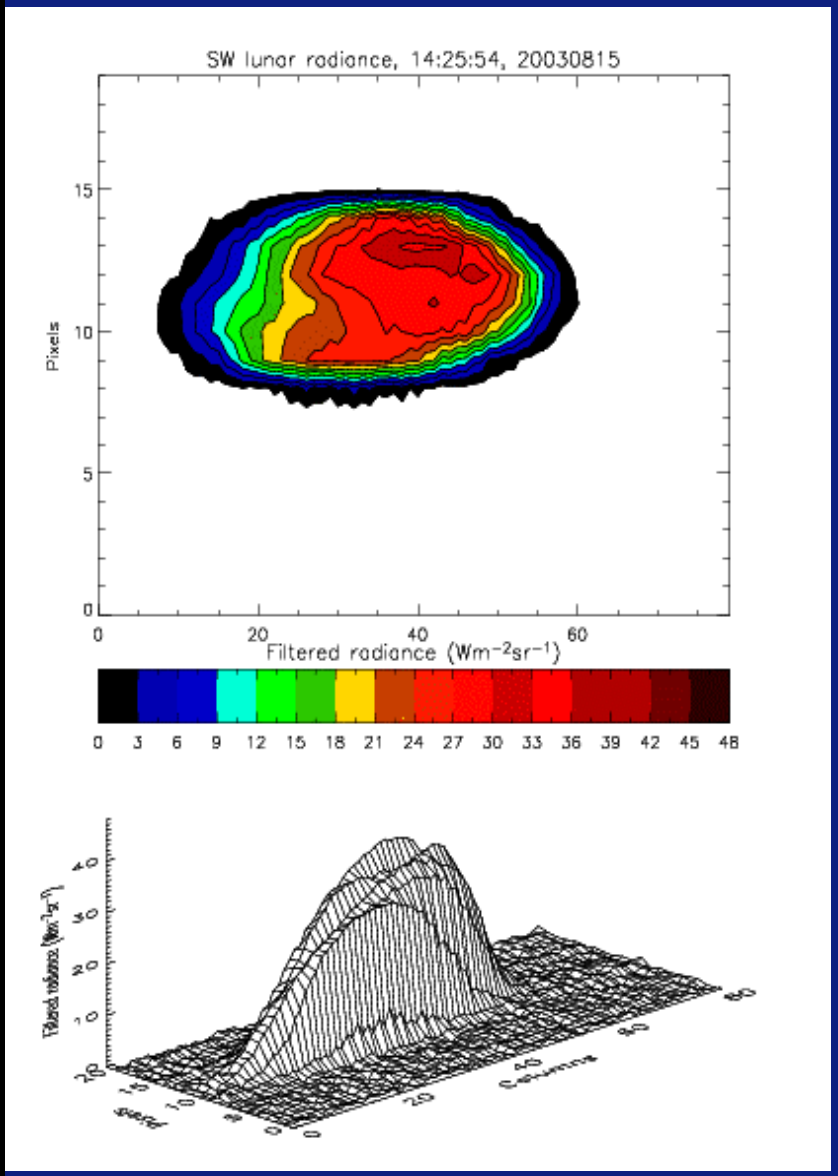
Lunar Scans




SW lunar radiance, 14:25:54, 20030815
Pixels
0
5
10
15
0
20
40
60
Filtered radiance (Wm⁻²sr⁻¹)
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48

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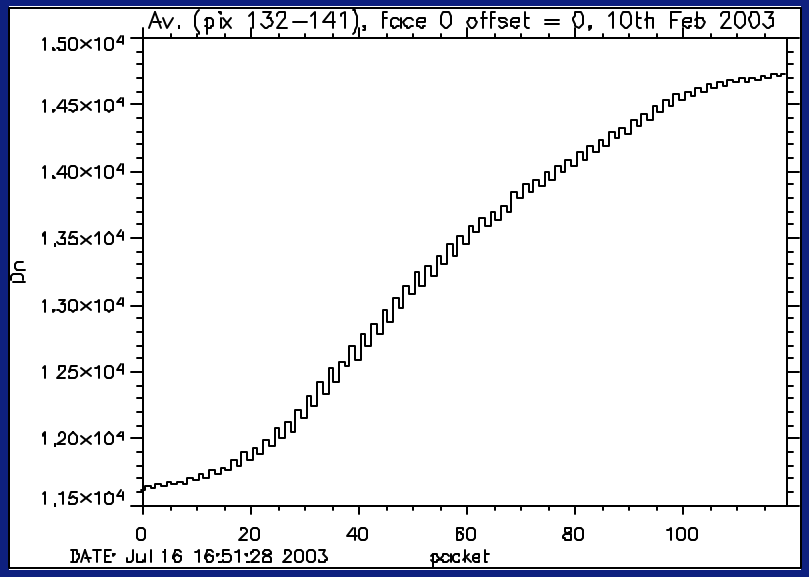
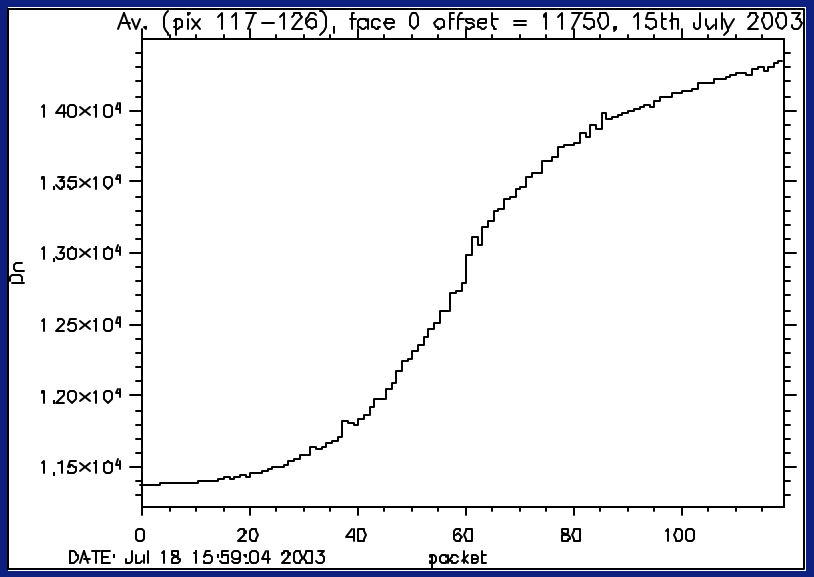


Mirror performance

- Both sides of mirror used for consecutive scanlines
- Systematic differences noted in very fine limb scans

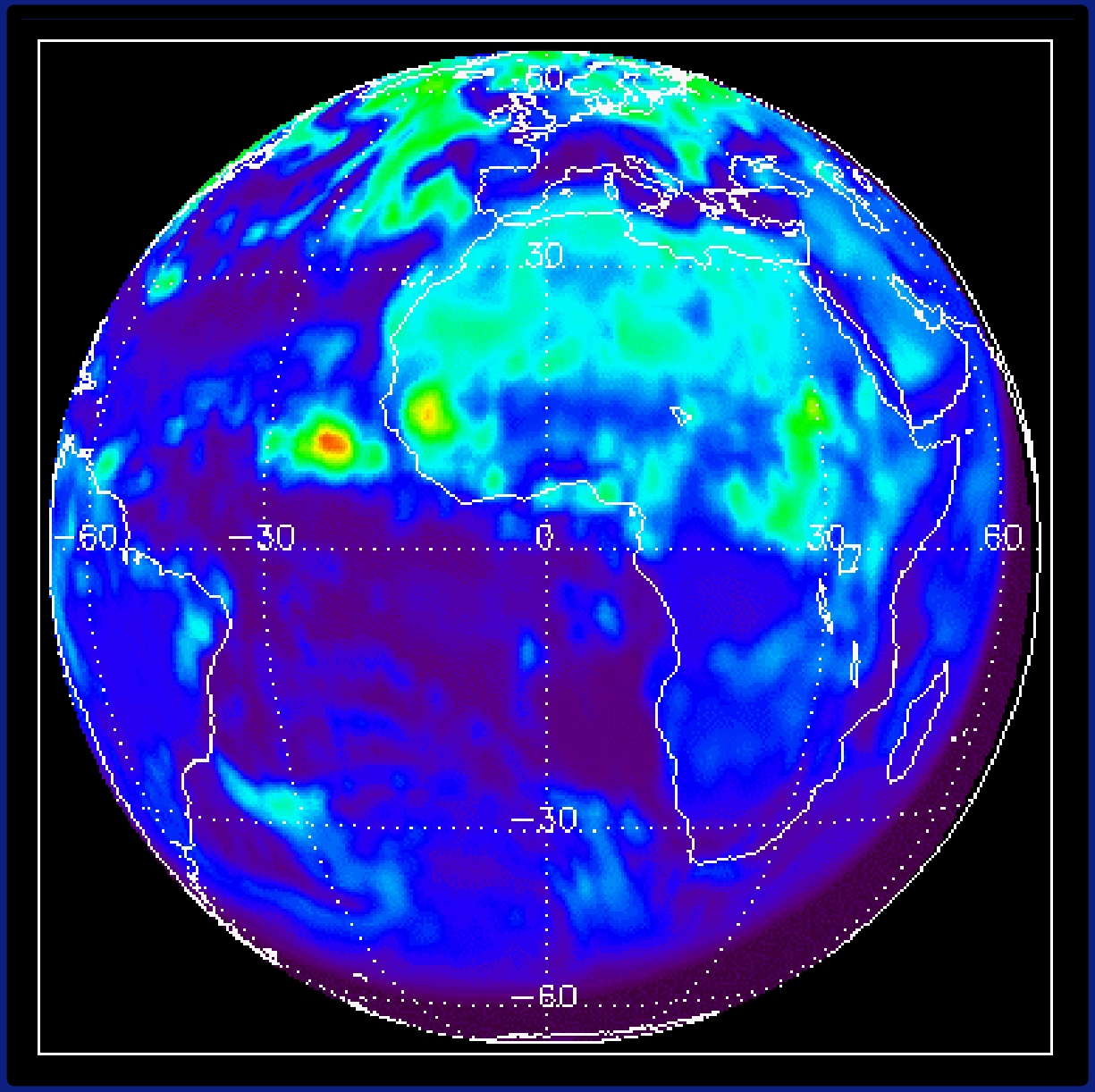
500 scanlines



- Correction for mirror side made in on-board software
- Pointing accuracy now <0.1 pixel

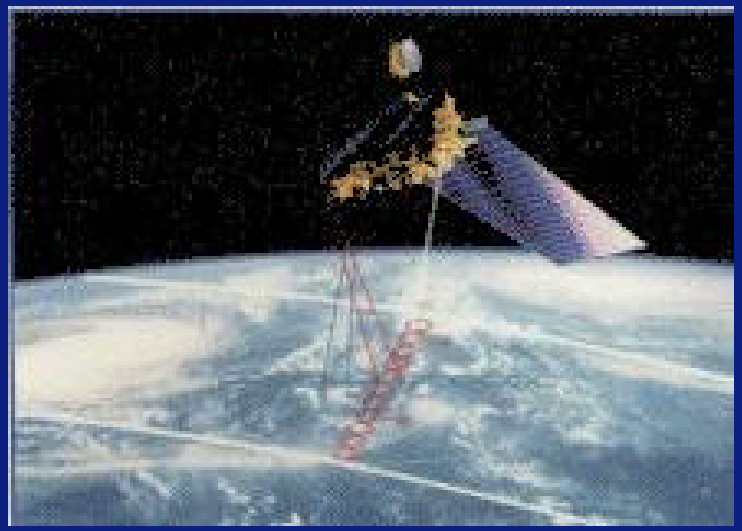
Geolocation issue

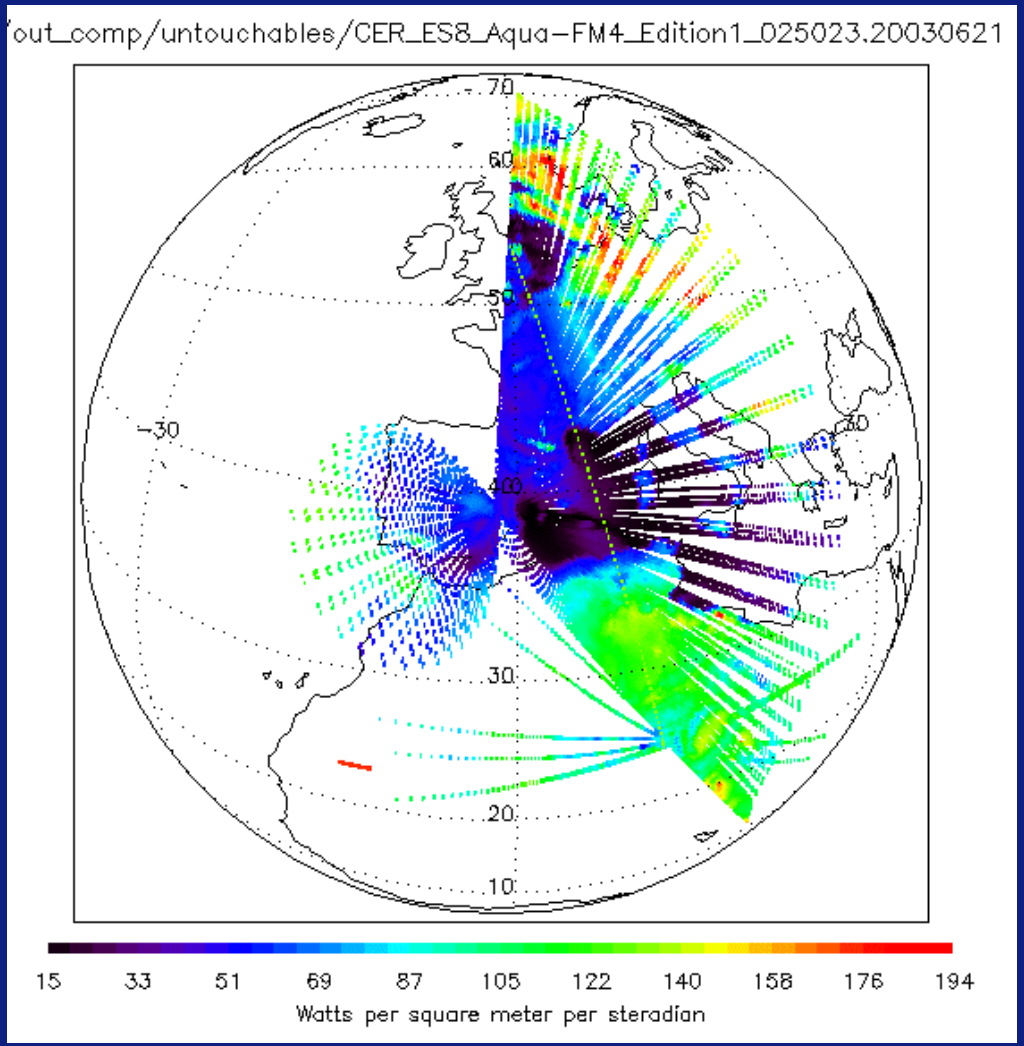
- GERB geolocation requires input from MSG-1
- Systematic ‘features’ due to different sensors
- Geolocation accuracy reduced from >1 pixel to 2-4 pixels
- Solutions:
  - extra information provided from SEVIRI to processing
  - modelling of features to remove them in processing
  - interim solution in place is not ideal and computationally more demanding for processing

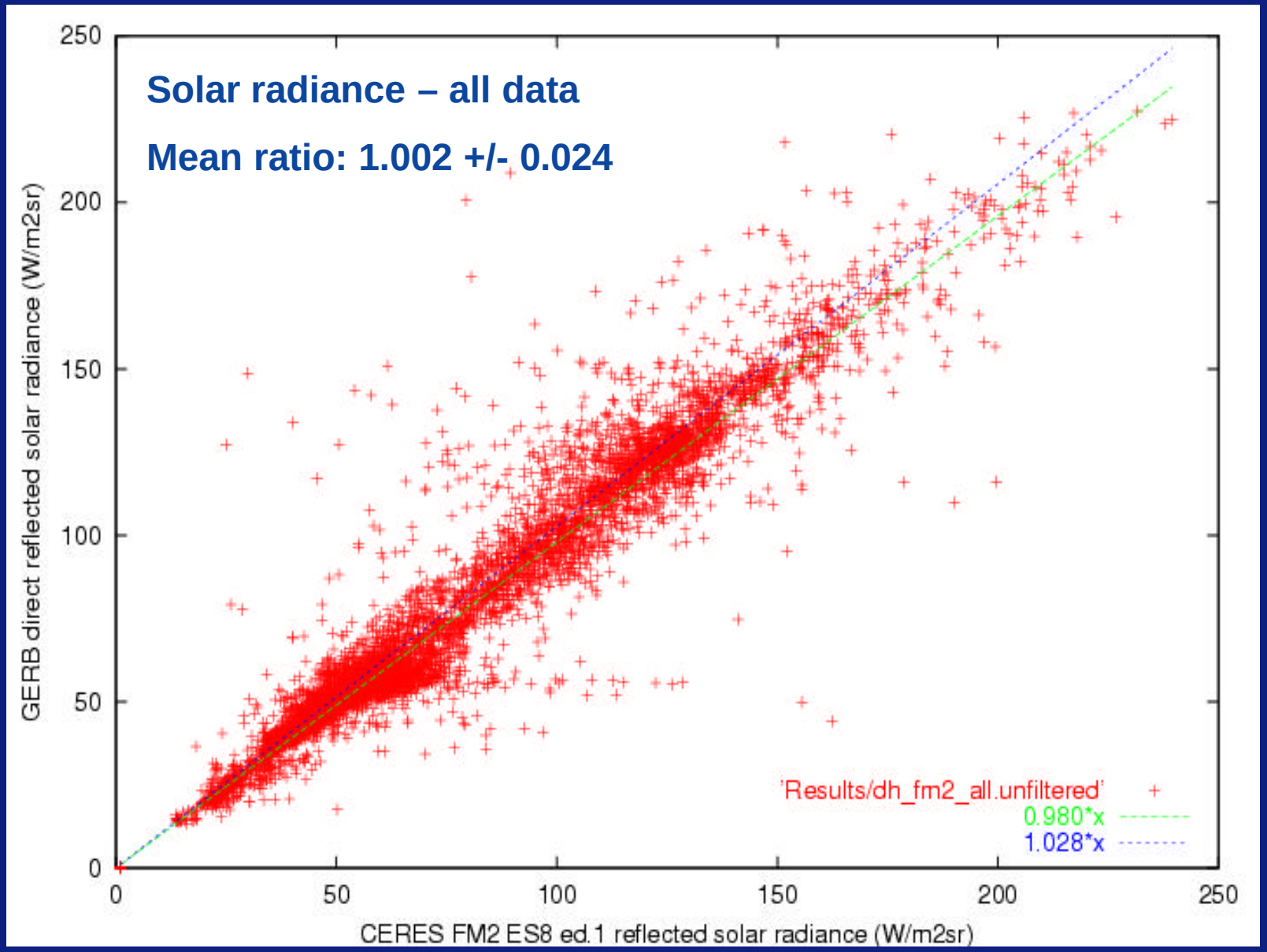


CERES – GERB comparisons

- CERES Rotating azimuth plane mode
- Co-angular measurements
- Comparison of radiances

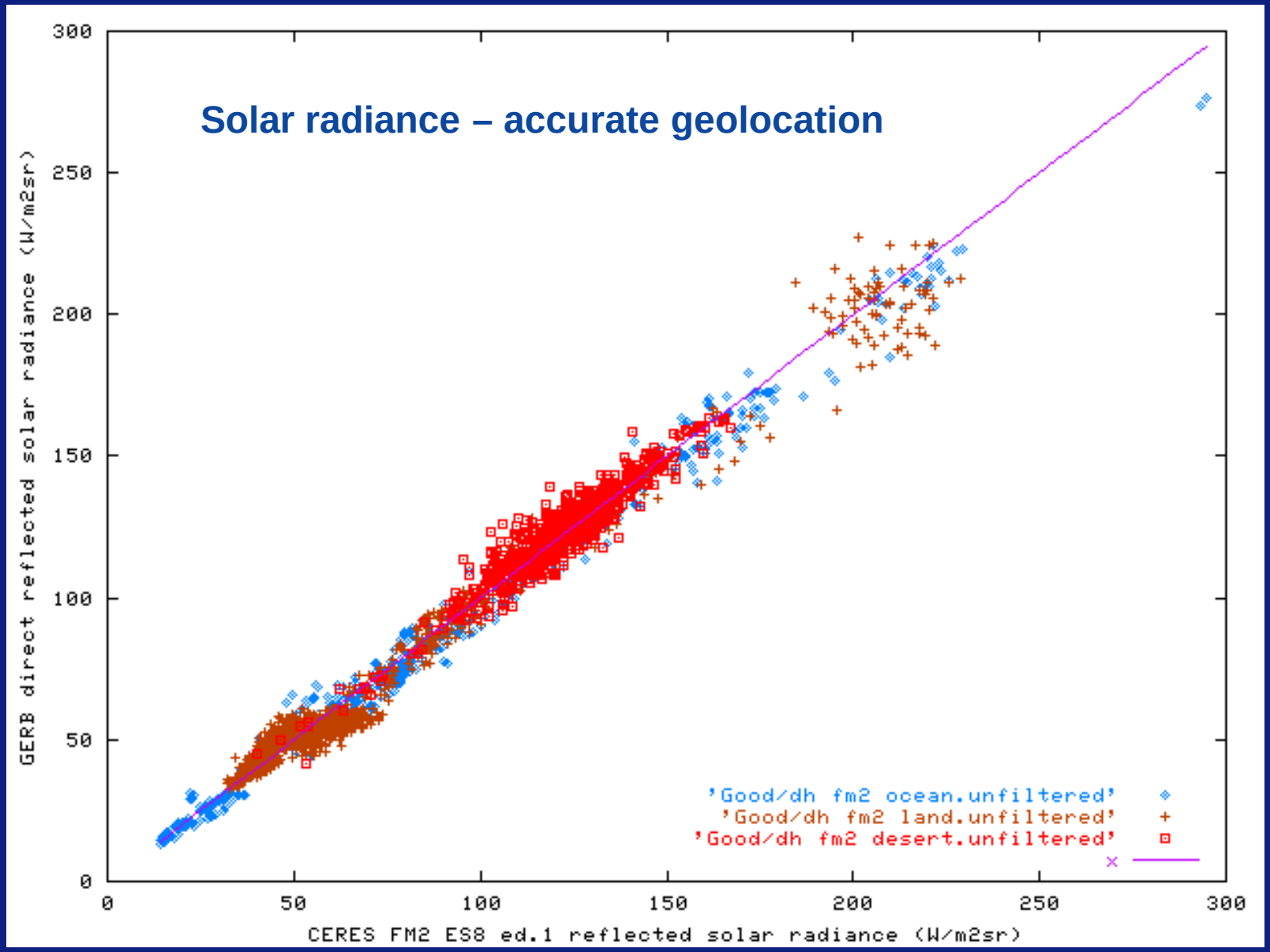






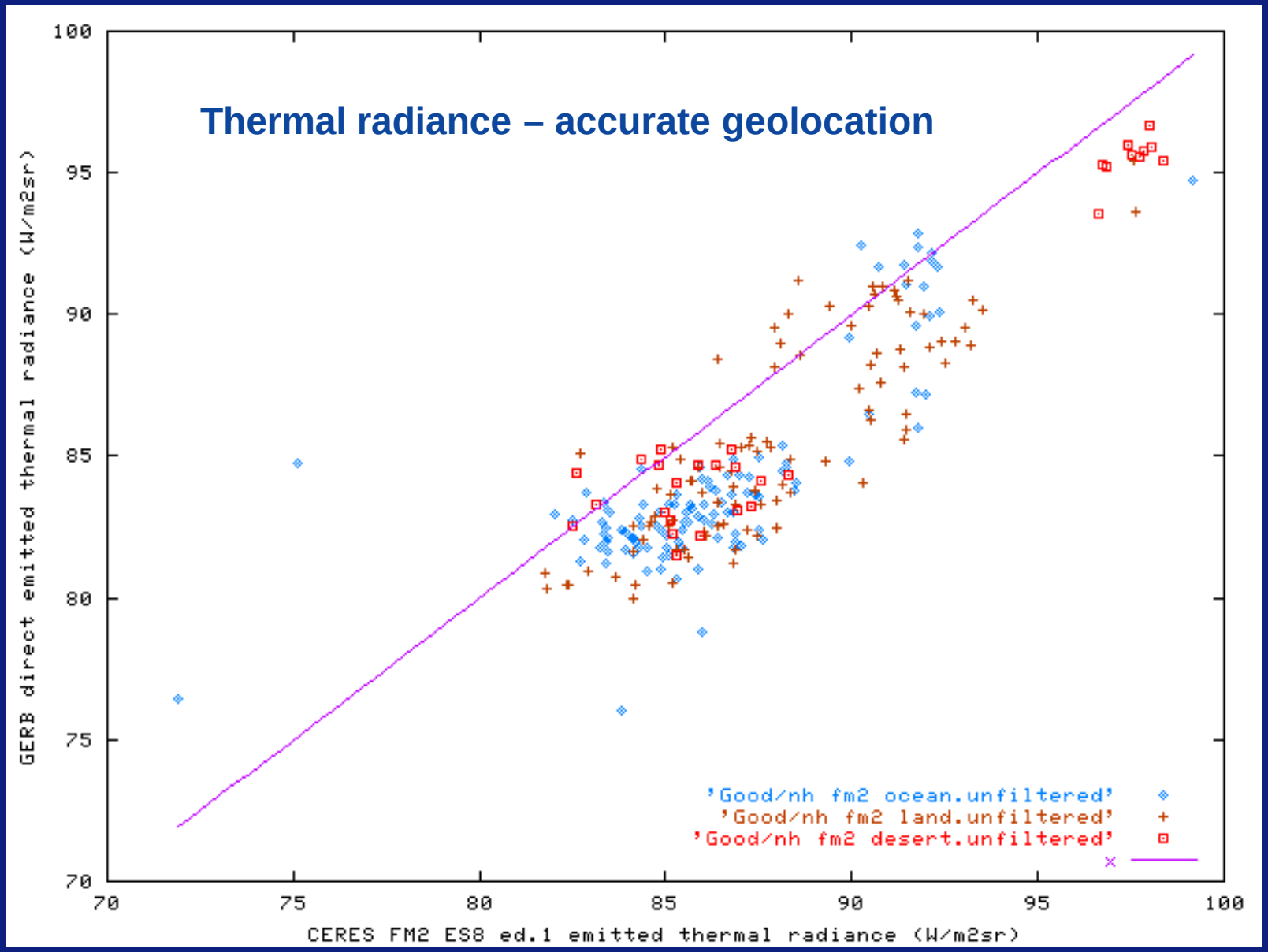
Courtesy Royal Meteorological Institute Belgium

Solar radiance – accurate geolocation



Courtesy Royal Meteorological Institute Belgium

Thermal radiance – accurate geolocation



Courtesy Royal Meteorological Institute Belgium

GERB CERES intercomparison

- Comparison made by RMIB are subject to
  - ‘better’ geolocation selection
  - ‘homogenous’ regions as exact matching still not possible. This excludes some scene types such as clouds which needs to be addressed
- Even after selection of good geolocation data, there is an offset between the GERB and CERES longwave measurements
- An improved GERB spectral response is expected and the comparison will be repeated once this has been received.

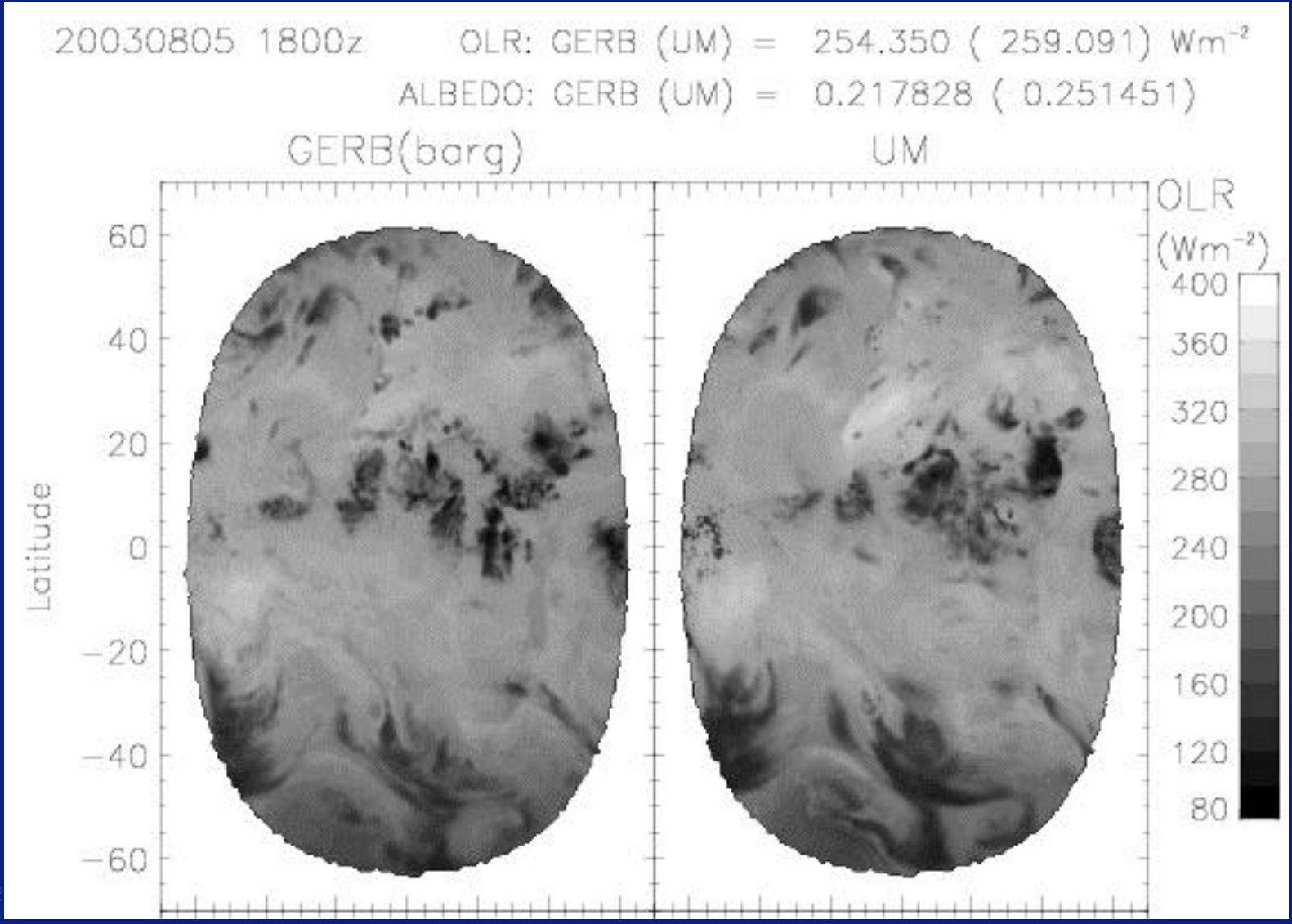
Comparison of GERB and Met Office UM broadband fluxes: SINERGEE project results

Richard Allan, Tony Slingo

ESSC, Reading University

SINERGEE project – Univ. Reading

Met office forecast from Unified Model (UM) used to calculate TOA fluxes
GERB data interpolated to UM grid (0z, 06z, 12z, 18z)



SINERGEE Project comparisons

- DATA problems seen in comparisons
  - Geolocation: offsets and artefacts introduced by processing with mis-matched METEOSAT
  - Resolution: the ARG data looks much smoother than model although both are nominally the same grid spacing (this is because the ARG is not corrected for GERB PSF)
  - Albedo diurnal cycle (problems at 06z)
  - Limb darkening in East (this is a consequence of METEOSAT data being used instead of SEVIRI – MSG is at +10W and METEOSAT at 0)
  - Horizontal stripes (light and dark) are METEOSAT artefacts
- Model problems seen in comparisons
  - Too much stratocumulus
  - 12z Convection (too early, lack of organisation)
  - Dark Sahara / Hot Sahara
  - ITCZ positioning

Summary

- GERB in-flight performance is within spec so far
  - Mirror performance (pointing accuracy) >0.1 pixel
  - An interim solution for MSG geolocation information should be available soon
  - Detector noise < 0.4% of instrument gain
- Validation against CERES data provides transfer standard to ~30 years of ERB data
- Winter validation campaign
  - CERES, other satellite sensors
  - Ground validation site in Valencia, Spain
- Official data release planned mid-2004