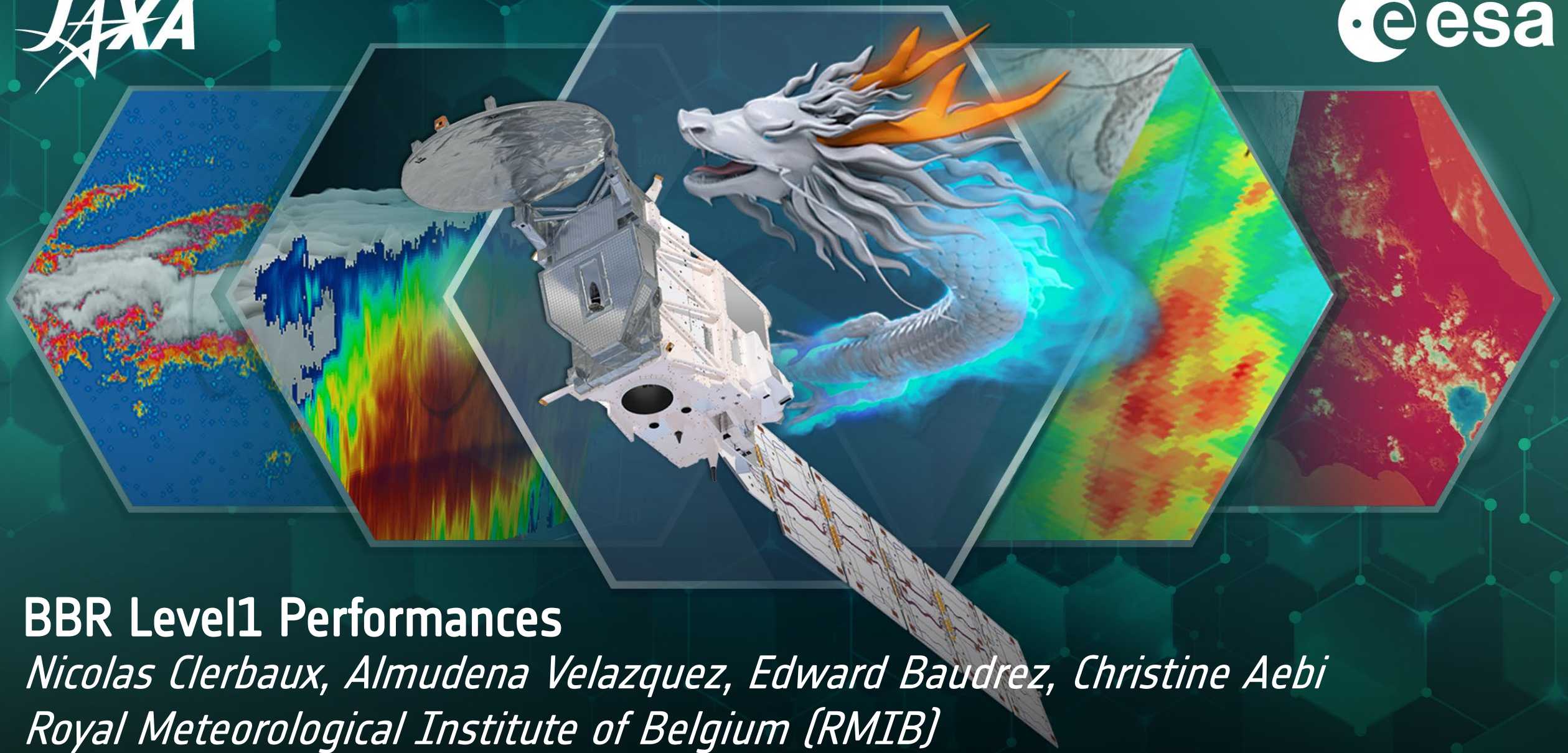


BBR Level1 Performances

Nicolas Clerbaux, Almudena Velazquez, Edward Baudrez, Christine Aebi
Royal Meteorological Institute of Belgium (RMIB)

2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

DISC “BBR” team present at this Workshop

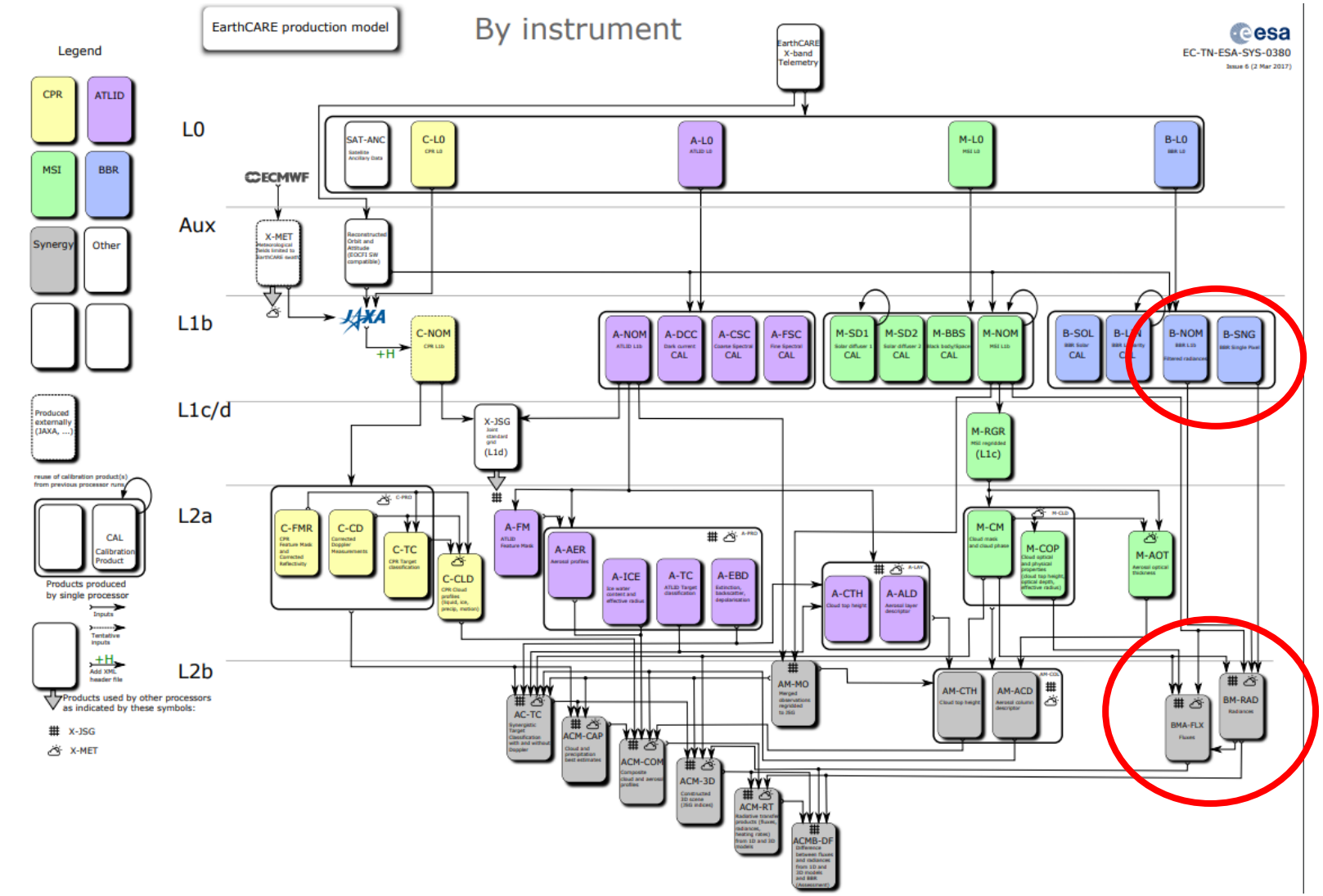
Almudena Velazquez Blazquez
- BM-RAD processor
- BMA-FLX processor (LW part)

Carla Salas Molar
- BMA-FLX processor (SW part)

Edward Baudrez
- BM-RAD and BMA-FLX processors (soft.)
- BBR geolocation

Christine Aebi
- Independent evaluation of the BBR L1 & L2 products (Prodex Cal/Val activity “BRAVO”).

BBR in the Production Model (European part)



BBR Level 1 :

- B-SNG product : detector's SW and TW radiances
- B-NOM product : SW and LW radiances in integration domains (e.g. 10x10km)

BBR Level 2 :

- BM-RAD : unfiltered SW and LW radiances
- BMA-FLX : TOA SW and LW fluxes + fluxes combining the 3 views

Content : BBR Level 1 Performances

Content:

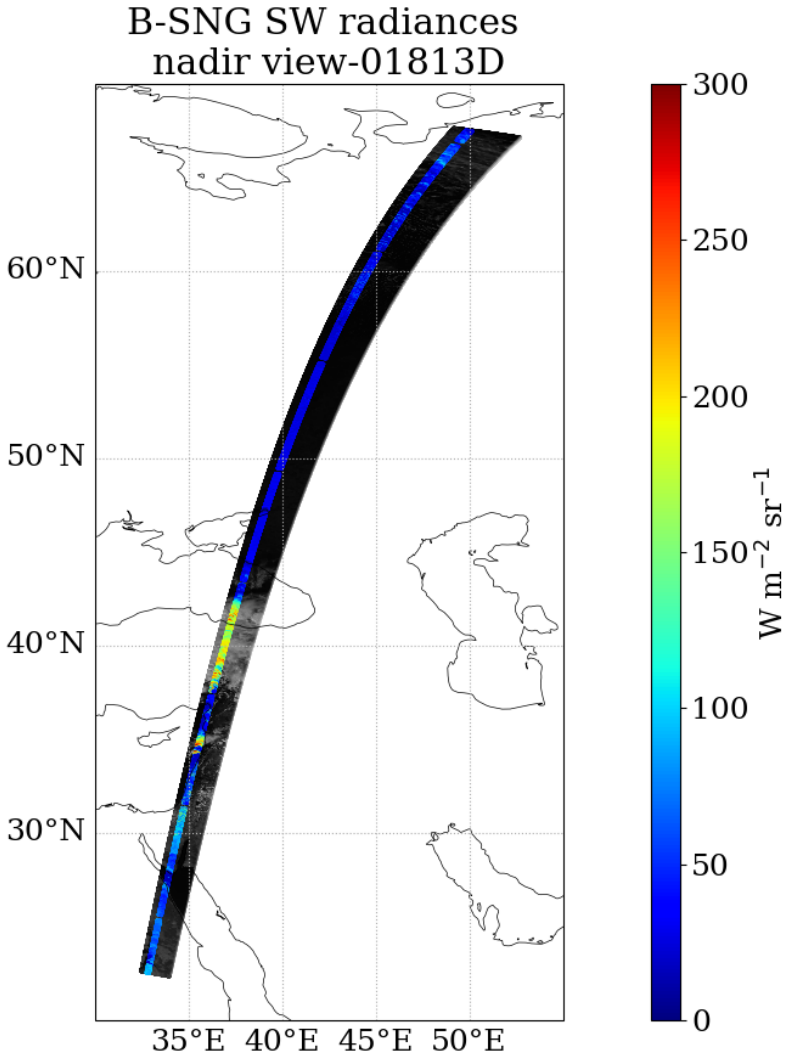
- Overview B-SNG product
- BBR sampling
- BBR calibration strategy
- B-SNG detector noise analysis
- B-SNG detector radiometric consistency analysis
- Proposed update of ‘B’ values

Directly a second talk on

- B-SNG comparison with CERES FLASHflux
- BBR level 1 evolution
- Summary

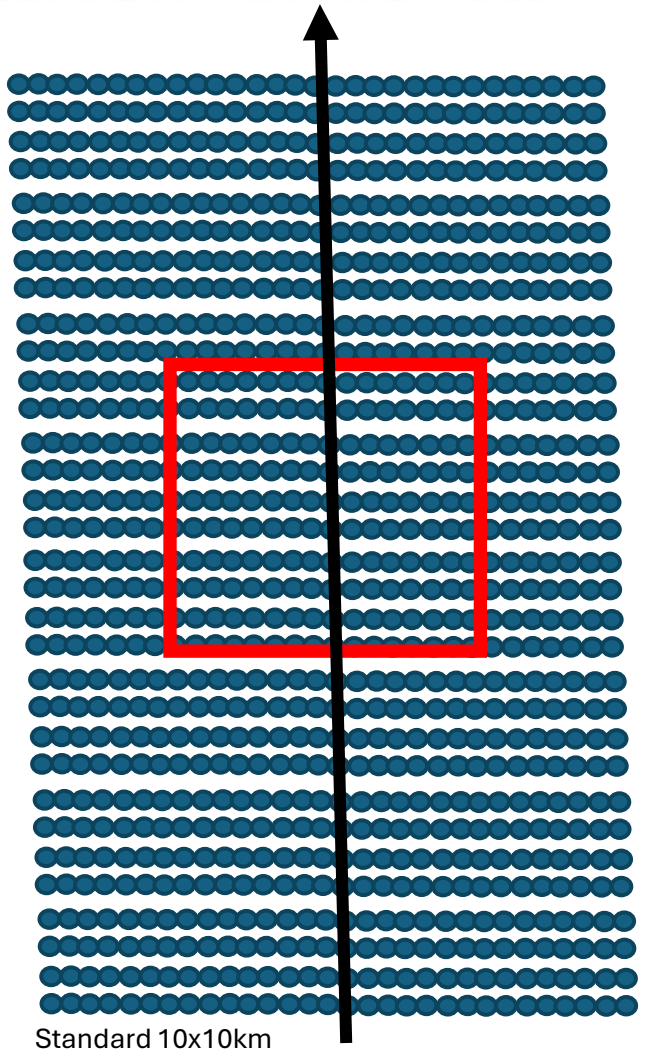
Other BBR contributions during the WS:

- MSI and BBR geolocation and coregistration performance assessment: an update, poster #2, Edward Baudrez.
- EarthCARE BBR Validation Results within the BRAVO project, poster #39, Christine Aebi
- Validation of BBR TOA broadband irradiance by high altitude airborne solar and thermal-infrared radiometer measurements, poster #38, André Ehrlich
- L2 BM-RAD and BMA-FLX products verification, Wed., Almudena Velazquez
- Radiative Closure Verification with EarthCARE BBR Solar and Thermal Fluxes, Wed., Carla Salas



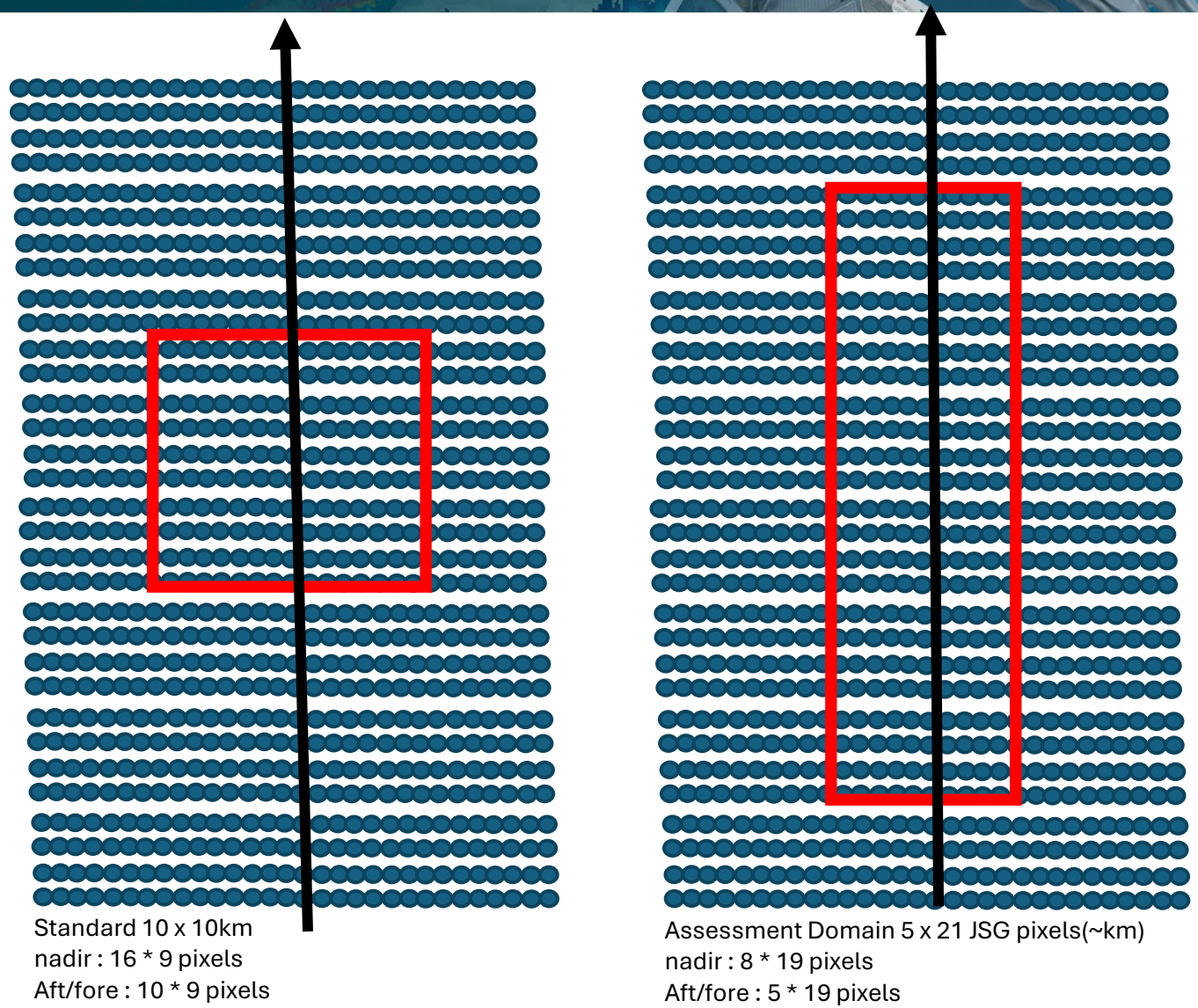
Overview B-SNG Product

- 3 views along-track: aft, nadir, fore
- 30 detectors for each view
- 2 interleaved spectral bands: TW, SW (quartz filter)
- BBR instrument operated mostly at 75% of the CDM speed (configurable). For a same band (TW or SW):
  - dt = 0.1532 sec
  - along track sampling ~1113m
- Initially B-SNG was not foreseen to be released as a product (only B-NOM).
- B-SNG interesting for integration over other domains (e.g. the elongated assessment domain)
- B-SNG provides filtered TW and SW radiances



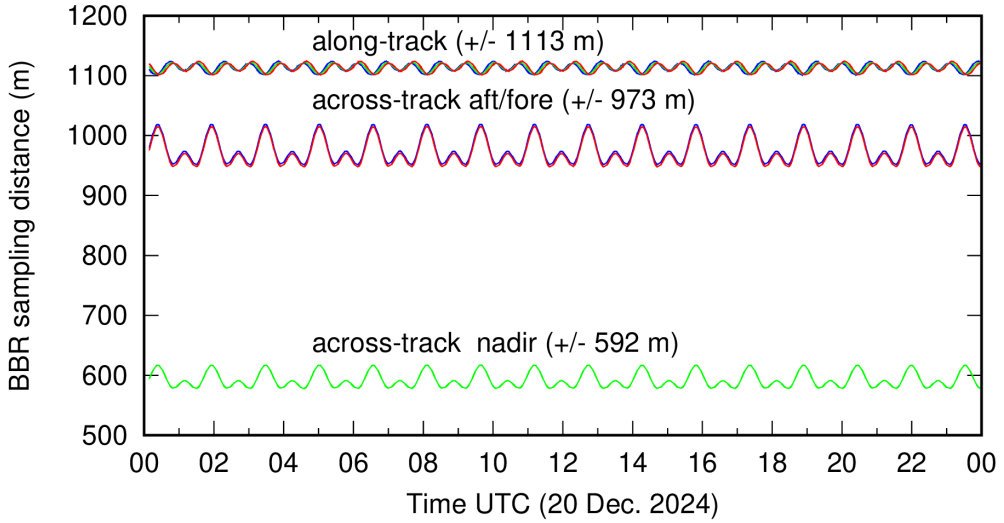
Standard 10x10km
nadir : 16 * 9 pixels
Aft/fore : 10 * 9 pixels

B-SNG sampling (CDM speed 75%)



Standard 10 x 10km
nadir : 16 * 9 pixels
Aft/fore : 10 * 9 pixels

Assessment Domain 5 x 21 JSG pixels(~km)
nadir : 8 * 19 pixels
Aft/fore : 5 * 19 pixels



View	Across-track	Along track
Aft	975m ± 21m [950m:1020m]	1113m ± 7m [1101m:1124m]
Nadir	592m ± 12m [577m:618m]	1113m ± 6m [1102:1122m]
Fore	971m ± 21m [946m:1016m]	1113m ± 7m [1101m:1124m]

BBR calibration strategy

Longwave calibration each 88s

- Observation of warm and cold blackbodies:
  → LW gain (G_{LW}) and offset for each of the 3 x 30 detectors

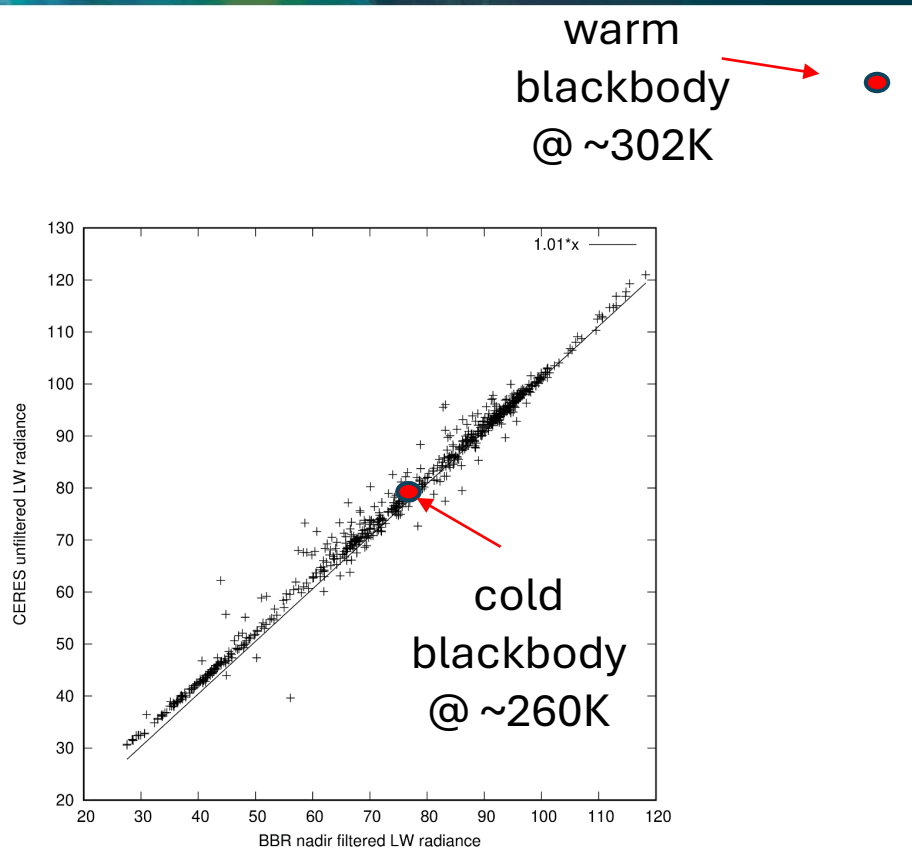
Shortwave calibration, each 88s

- Update the SW gain using 'fixed' B factors:
  → $G_{SW} = B * G_{LW}$
- Offset via observation of the cold blackbody

Solar calibration, every 2 months

- Monitoring using the sun diffuser (NDM)
- Spectral degradation via Monitoring Photo-Diodes (MPDs)

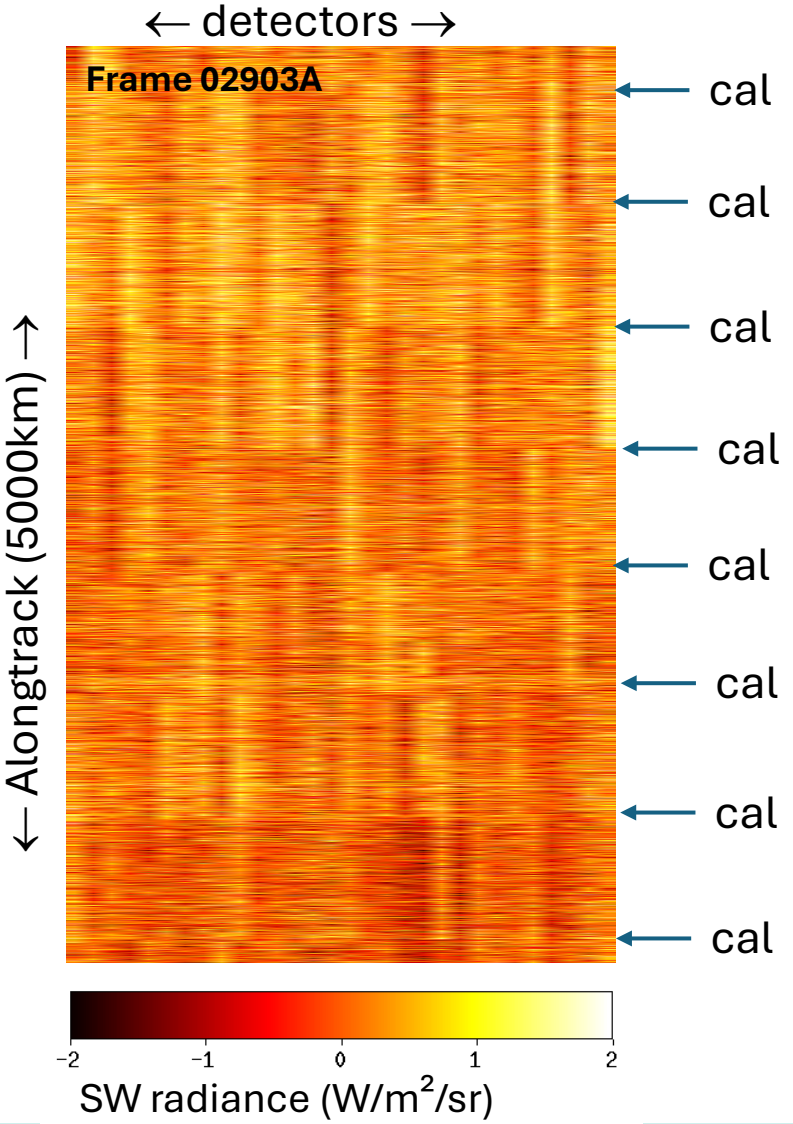
  -> Done, results under analysis by ICMF



B-SNG detector noise

- Using nighttime SW images (frame ‘A’)
- Small overall bias due to thermal contamination (~0.15 $W/m^2/sr$)
- About $\varepsilon \sim 0.8\ W/m^2/sr$
  -> $\varepsilon \sim 0.75\ W/m^2/sr$ det. noise
  -> $\varepsilon \sim 0.30\ W/m^2/sr$ cal. noise

→ significant detector noise that has also systematic effect via the calibration



B-SNG detector noise

- Noise level similar between the detector and stable during commissioning, except:
  - Fore det #6 : “broken”
  - Nadir det #20 : bias low.

- Noise reduction in integration domains:

  - Standard domain (10x10km, i.e. 10/16 x 9 pix):

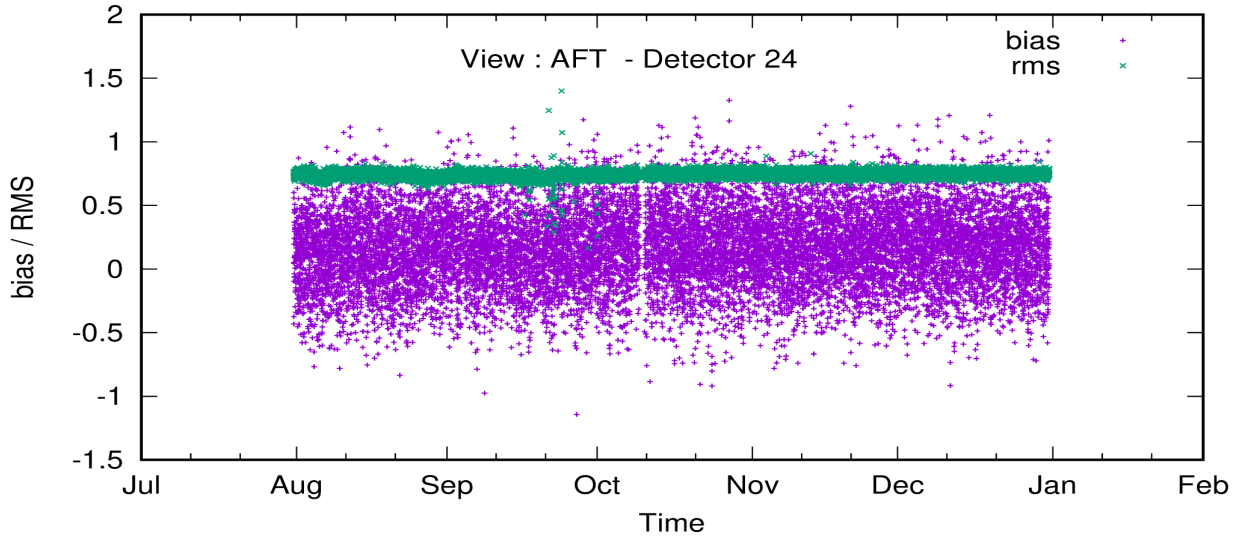
$$\varepsilon = sqrt(\ (\frac{0.75}{\sqrt{90}})^2 + (\frac{0.30}{\sqrt{10}})^2) = 0.12\ \text{W/m}^2\text{/sr (aft/fore)}$$

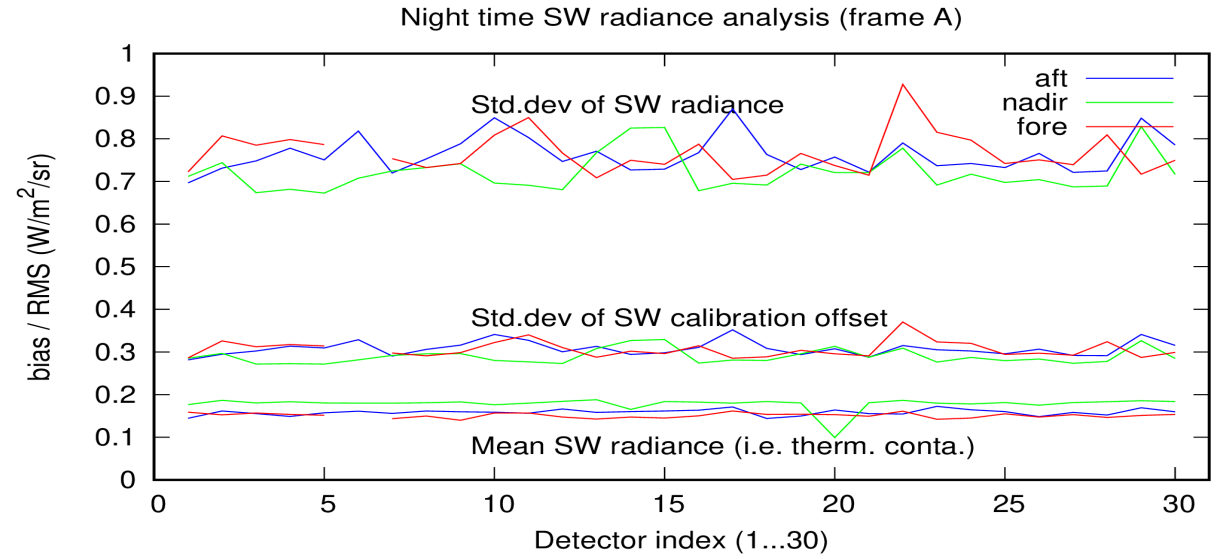
$$\varepsilon = sqrt\left((\frac{0.75}{\sqrt{154}})^2 + (\frac{0.30}{\sqrt{16}})^2\right) = 0.10\ \text{W/m}^2\text{/sr}\quad \text{(nadir)}$$

  - Assessment domain (21x5km, i.e. 5/8 x 19 pix)

$$\varepsilon = sqrt((\frac{0.75}{\sqrt{95}})^2 + (\frac{0.30}{\sqrt{5}})^2) = 0.15\ \text{W/m}^2\text{/sr (aft/fore)}$$

$$\varepsilon = sqrt((\frac{0.75}{\sqrt{152}})^2 + (\frac{0.30}{\sqrt{8}})^2) = 0.12\ \text{W/m}^2\text{/sr}\quad \text{(nadir)}$$





B-SNG detector radiometric consistency

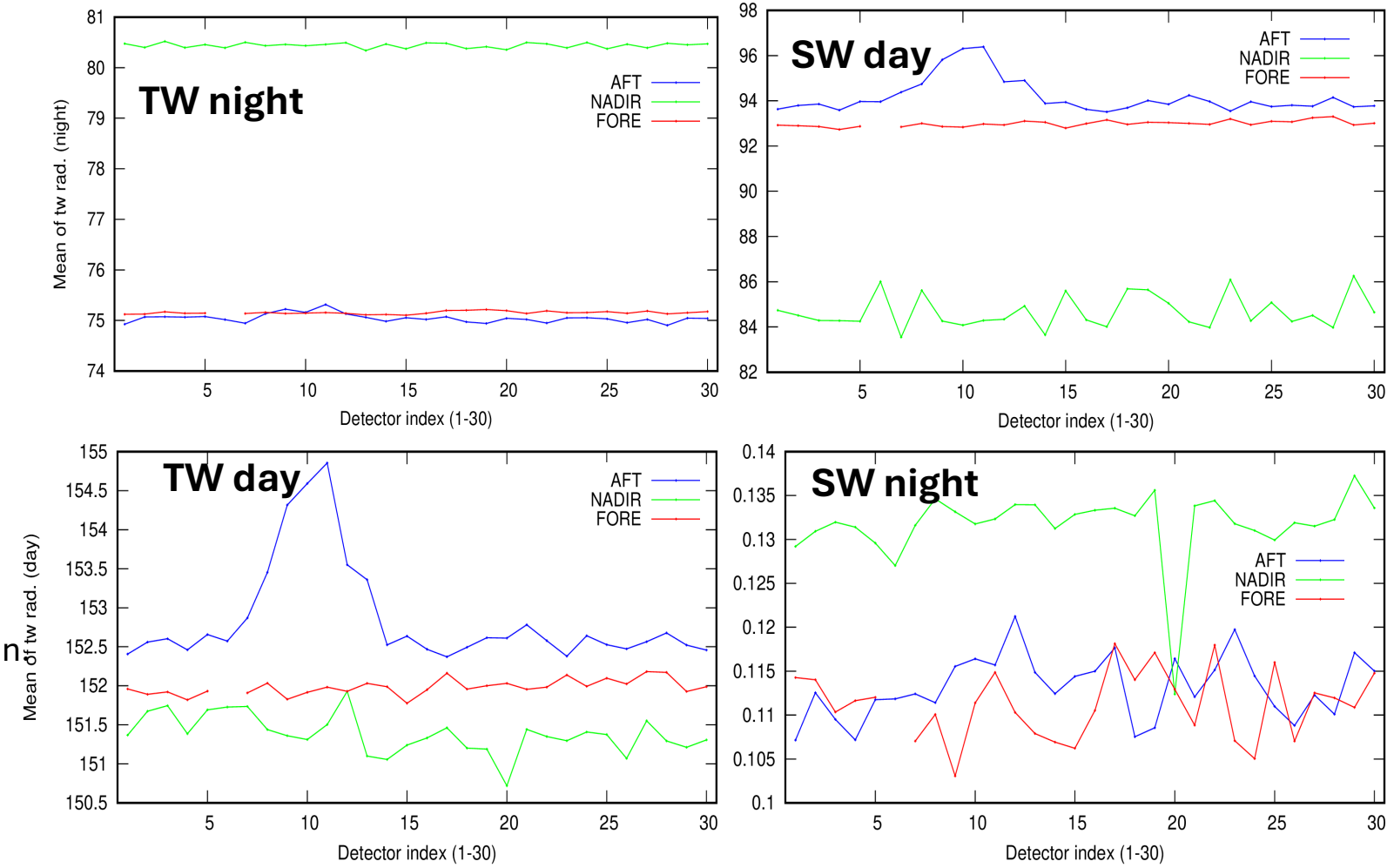
Input : 19953 B-SNG files (26 July 2024 to 5 Jan. 2025)

TW night (LW radiation)
- consistent detector LW calibration
- Consistent fore/aft views

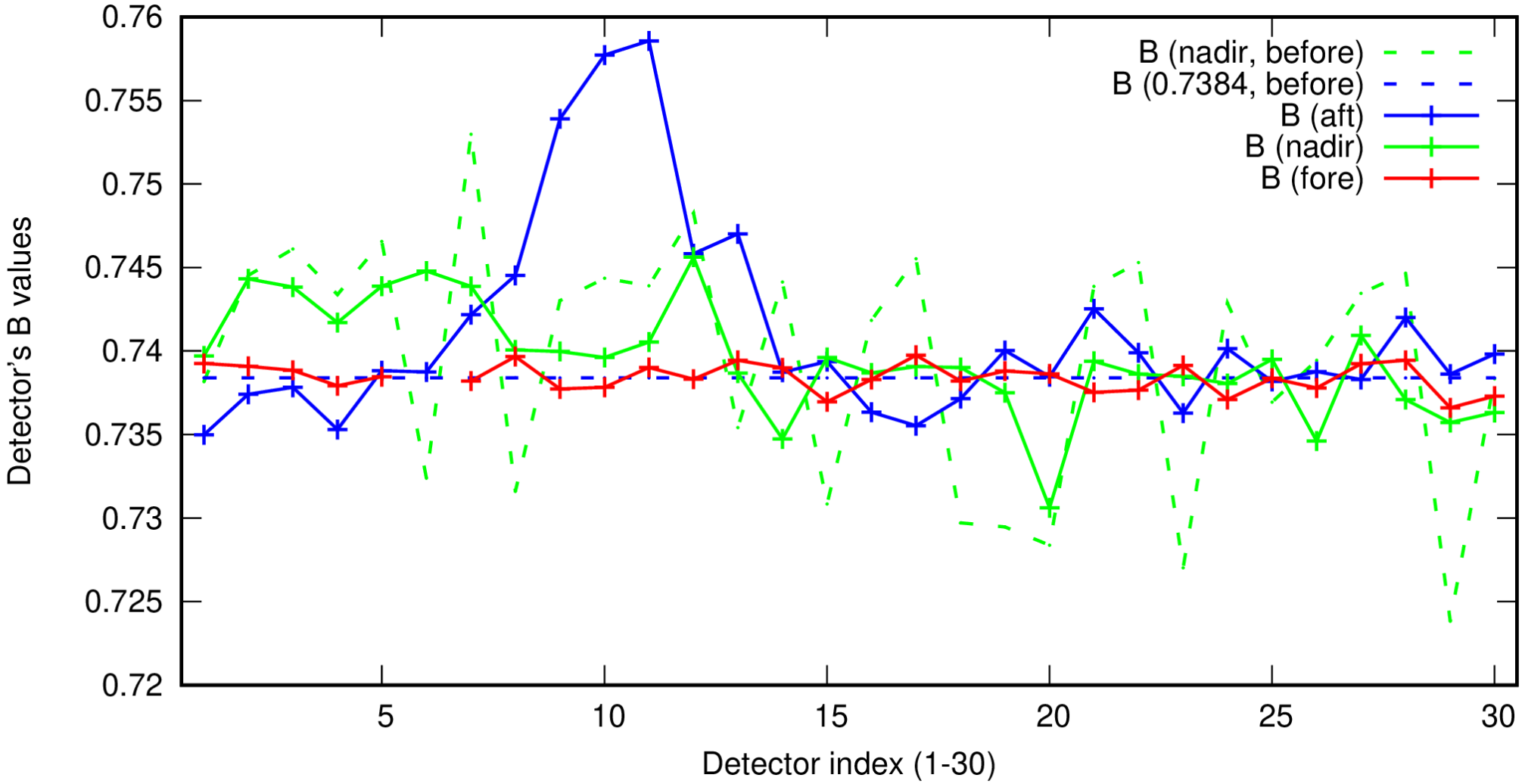
SW day
- Aft/det.8-13 too sensitive to SW
- Det-to-det variability for the nadir view (due to B factors in the CCDB)

TW day (LW+SW)
- Aft det. 8-13 too sensitive to SW
- Nadir variability (to be investigated)

SW night (therm contamination + noise)
- Consistent with expected thermal contamination
- Nadir det #20 to be investigated.

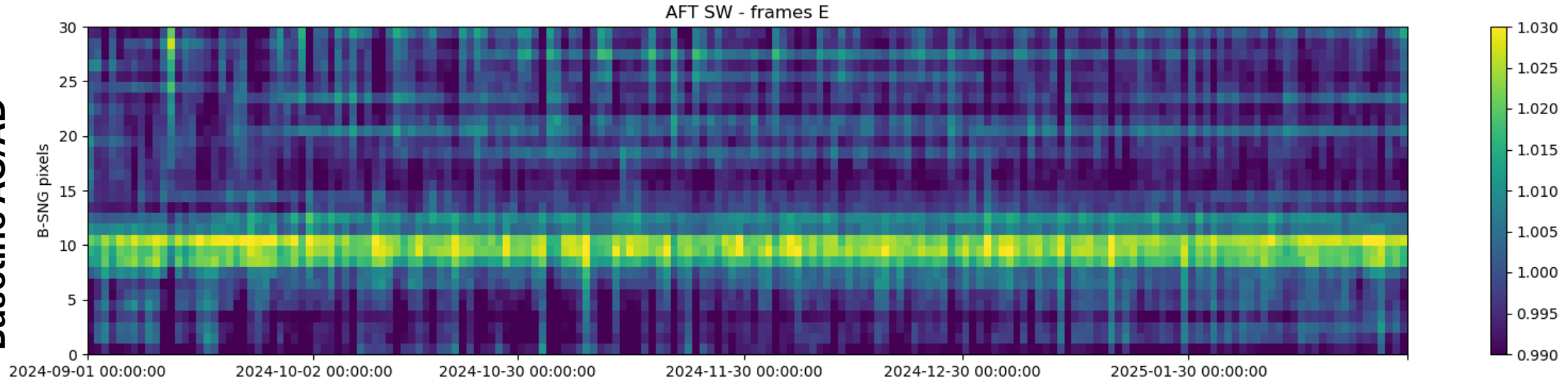


Proposed update of the ‘B’ factors

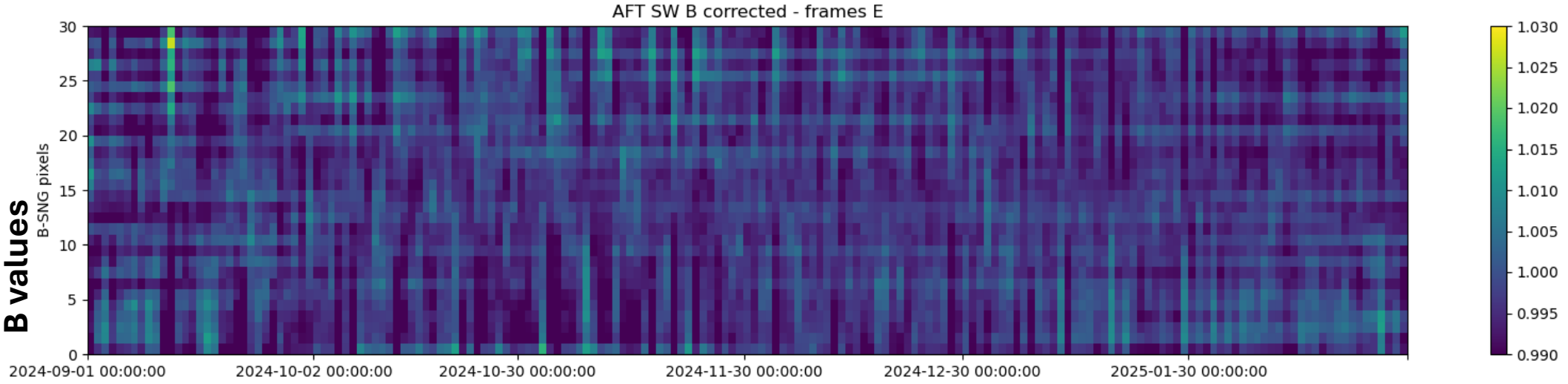


B_SNG detector radiometric consistency : daily analysis - AFT

Baseline AC/AD

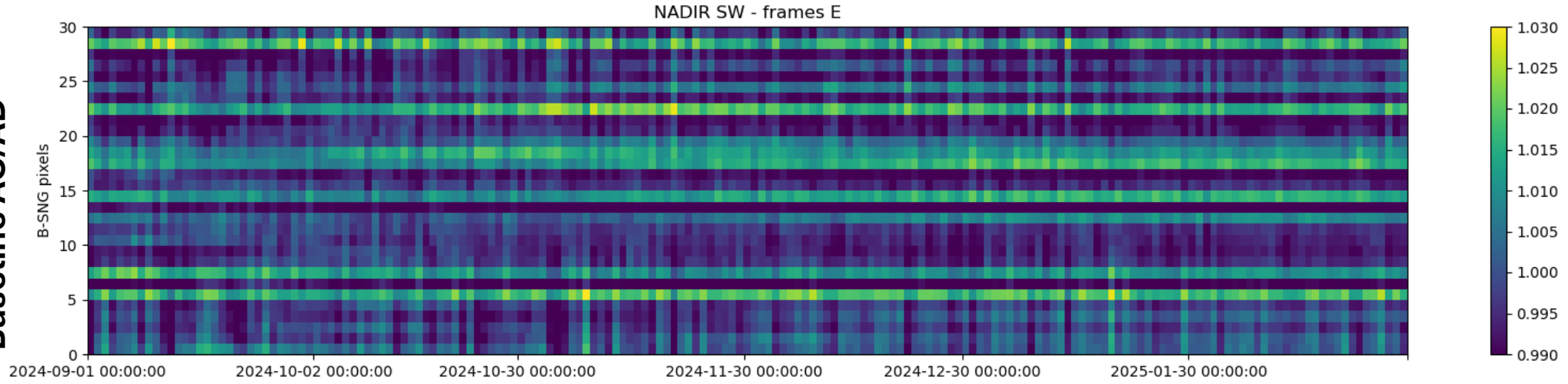


Evolution with tuned B values

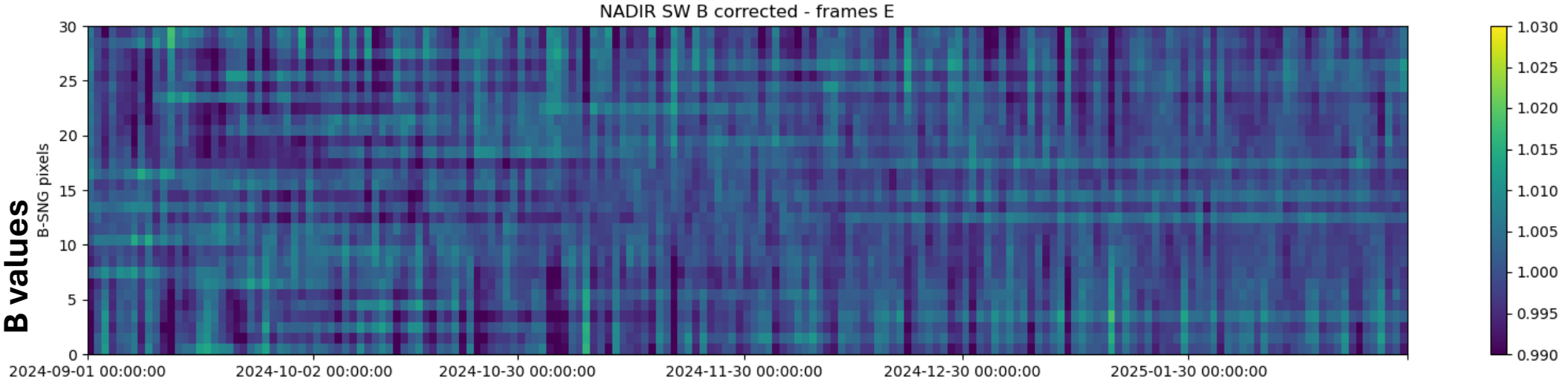


B_SNG detector radiometric consistency : daily analysis - NADIR

Baseline AC/AD

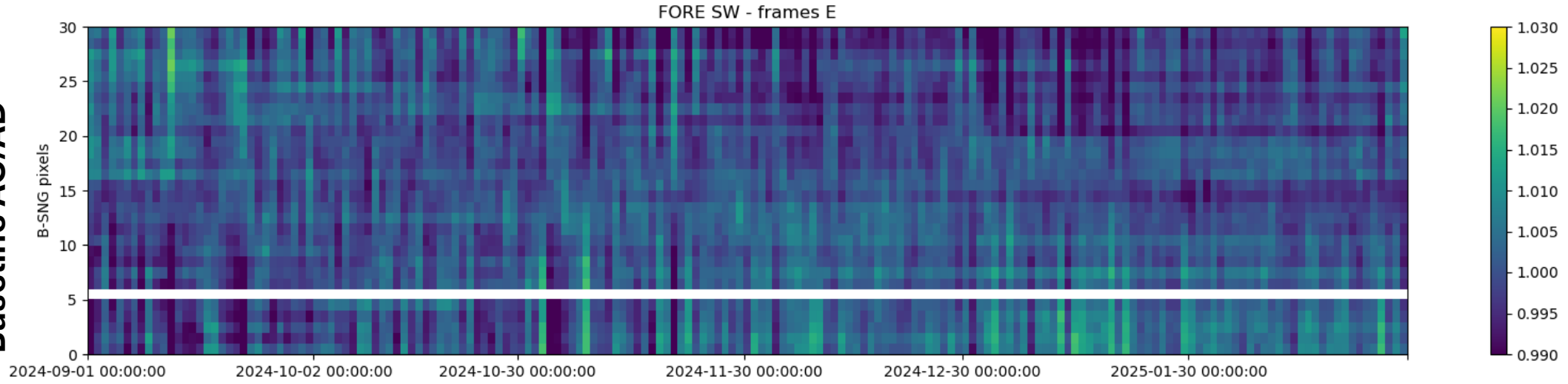


Evolution with tuned B values

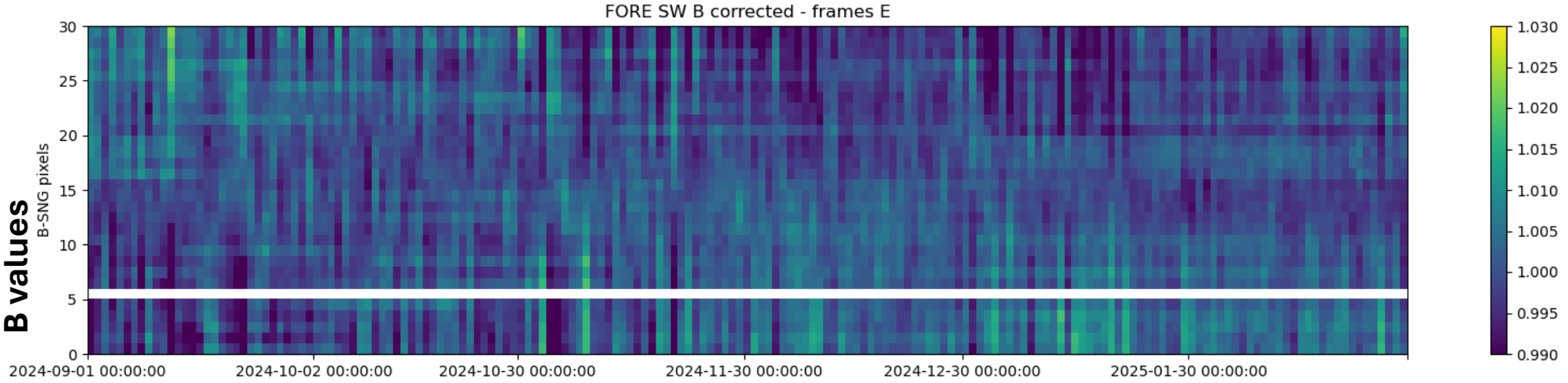


B_SNG detector radiometric consistency : daily analysis - FORE

Baseline AC/AD

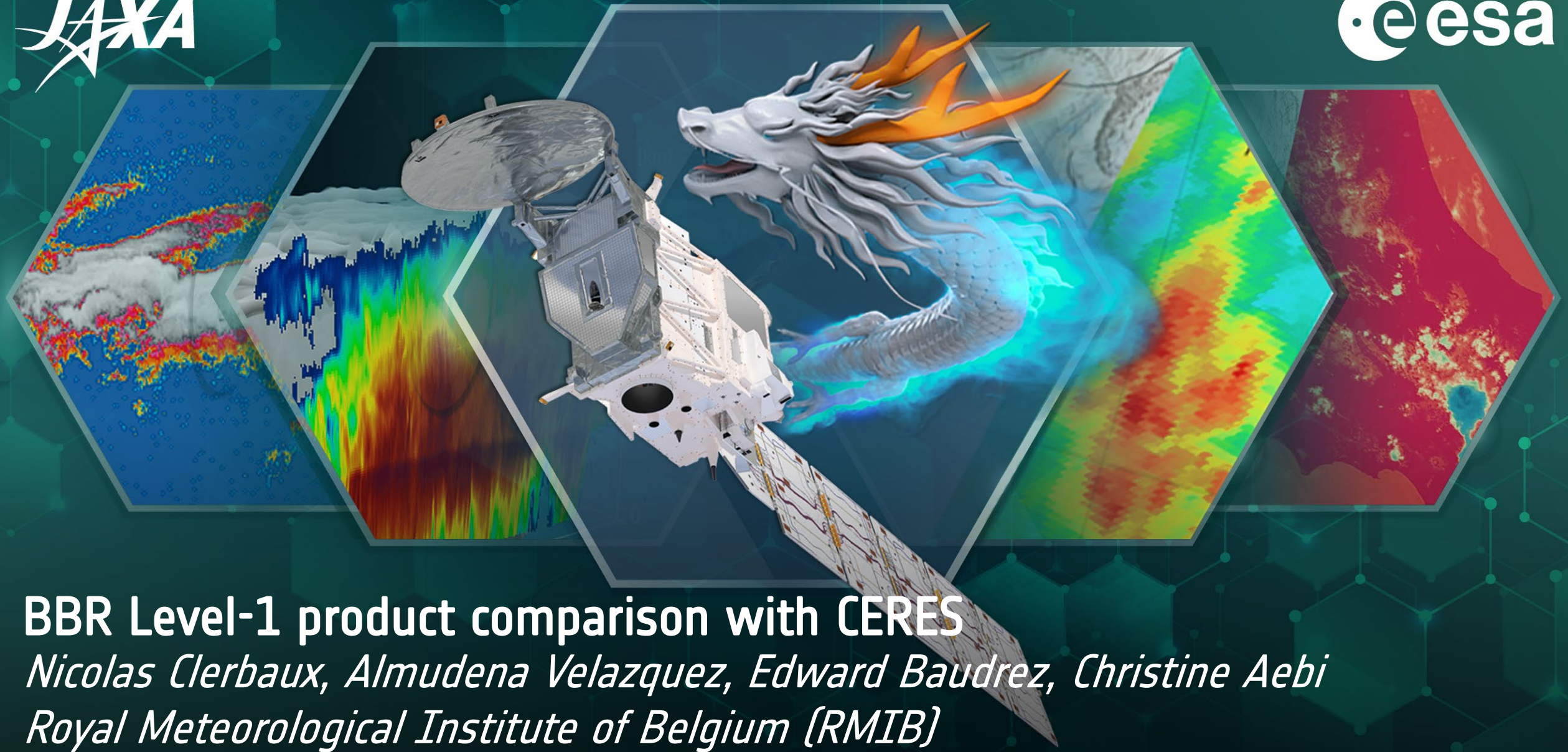


Evolution with tuned B values



Summary - B-SNG L1 product

- Overall good quality and excellent availability since 18/06/2024, main interruptions are for calibration:
  - LW calibration during ~4s each 88s
  - Solar calibration each 2 months (at high latitude)
- Recently (Jan+Feb) several missing L1 science data due a threshold reached with the CTM encoder. The science data will be recovered in the next reprocessing.
- Important detector noise level but reduced in domain integration
- Detectors radiometric consistency: recommend to update the ‘B’ factors at detectors’ level to improve the consistency
- Aft and fore views look consistent, no evidence of problem with the nadir view



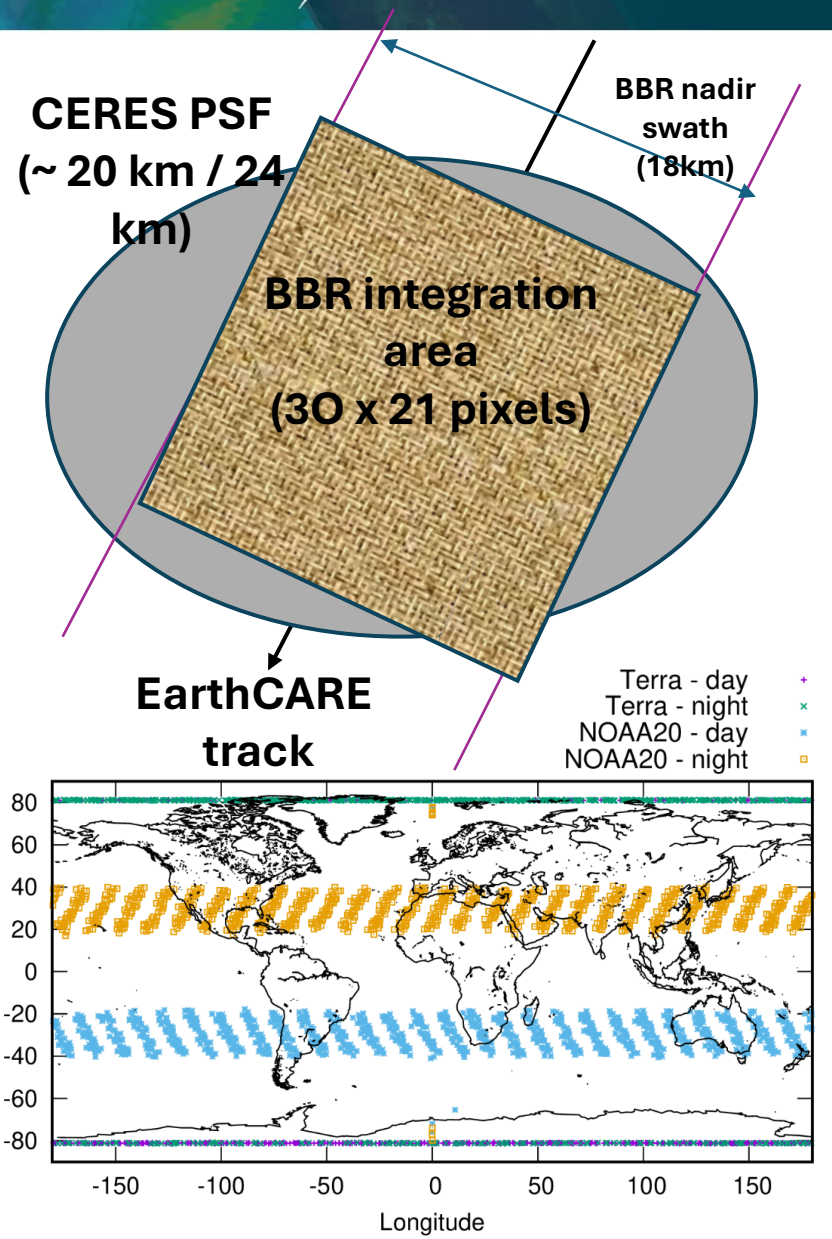
BBR Level-1 product comparison with CERES

Nicolas Clerbaux, Almudena Velazquez, Edward Baudrez, Christine Aebi
Royal Meteorological Institute of Belgium (RMIB)

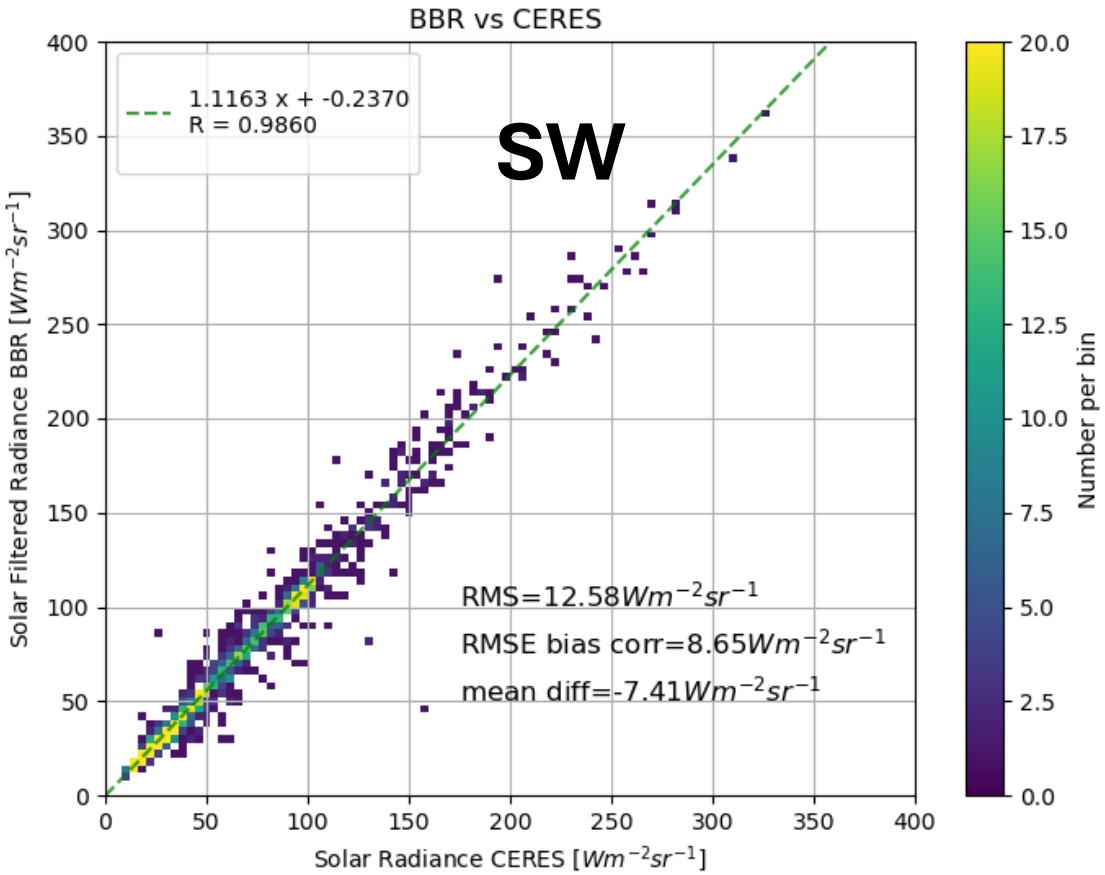
2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

BBR-SNG Comparison with CERES FLASHflux - method

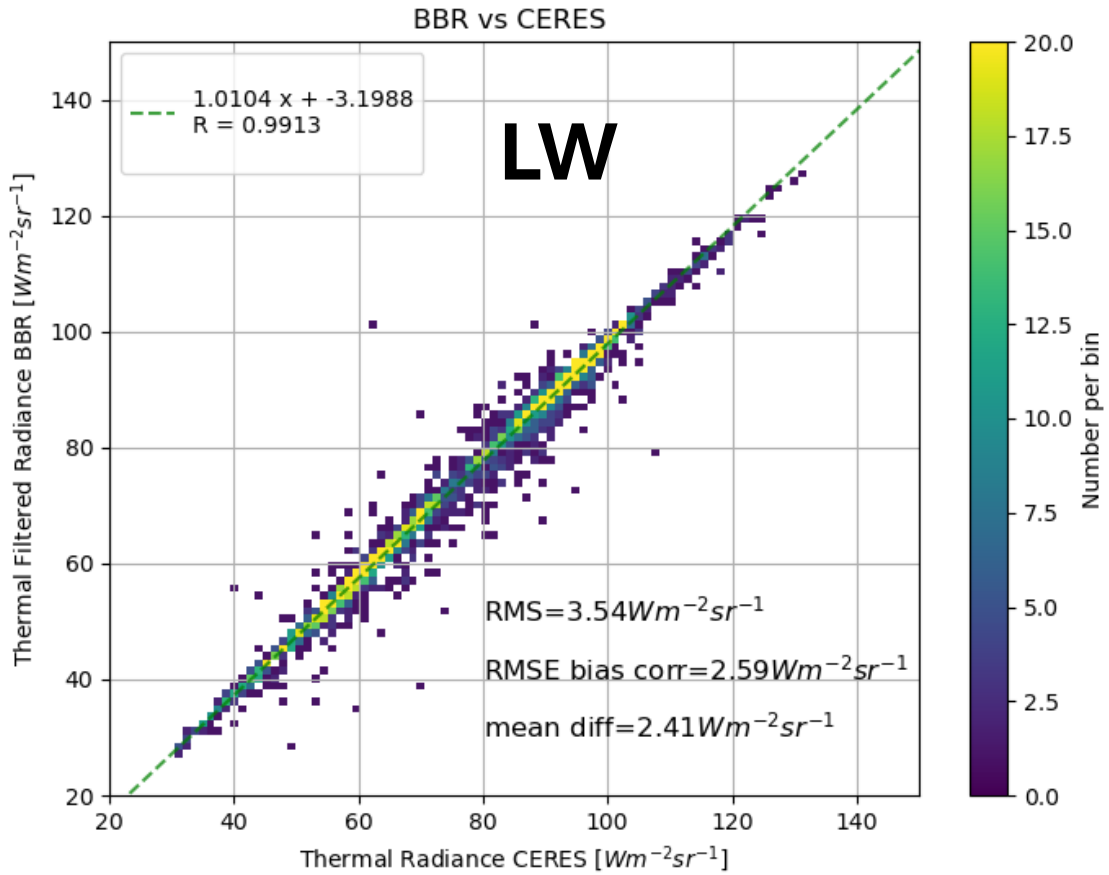
- CERES : Cloud and Earth Radiant Energy System
- Level 2 SSF (Single Scanner Footprint) product
- Currently only FLASHFlux (Fast Longwave And SHortwave Flux) products available from across-track instruments on:
  - FM1 on Terra (descending 10:30 morning drifting)
  - FM6 on NOAA20 (ascending 13:25 afternoon)
- CERES PSF of ~20 km (Terra, Aqua) or ~ 24 km (SNPP, NOAA20) -> larger than the BBR swath (~18km)
- B-SNG integration area : 30 (across track) x 21 (along-track)
- Collocation criteria
  - Time difference < 300 seconds
  - distance between PSF centers < 3km
  - Angle between viewing directions < 3°
- Dates : 10 Aug. 2024 – 03 March 2025



B-SNG Comparison with CERES FLASHflux - Results

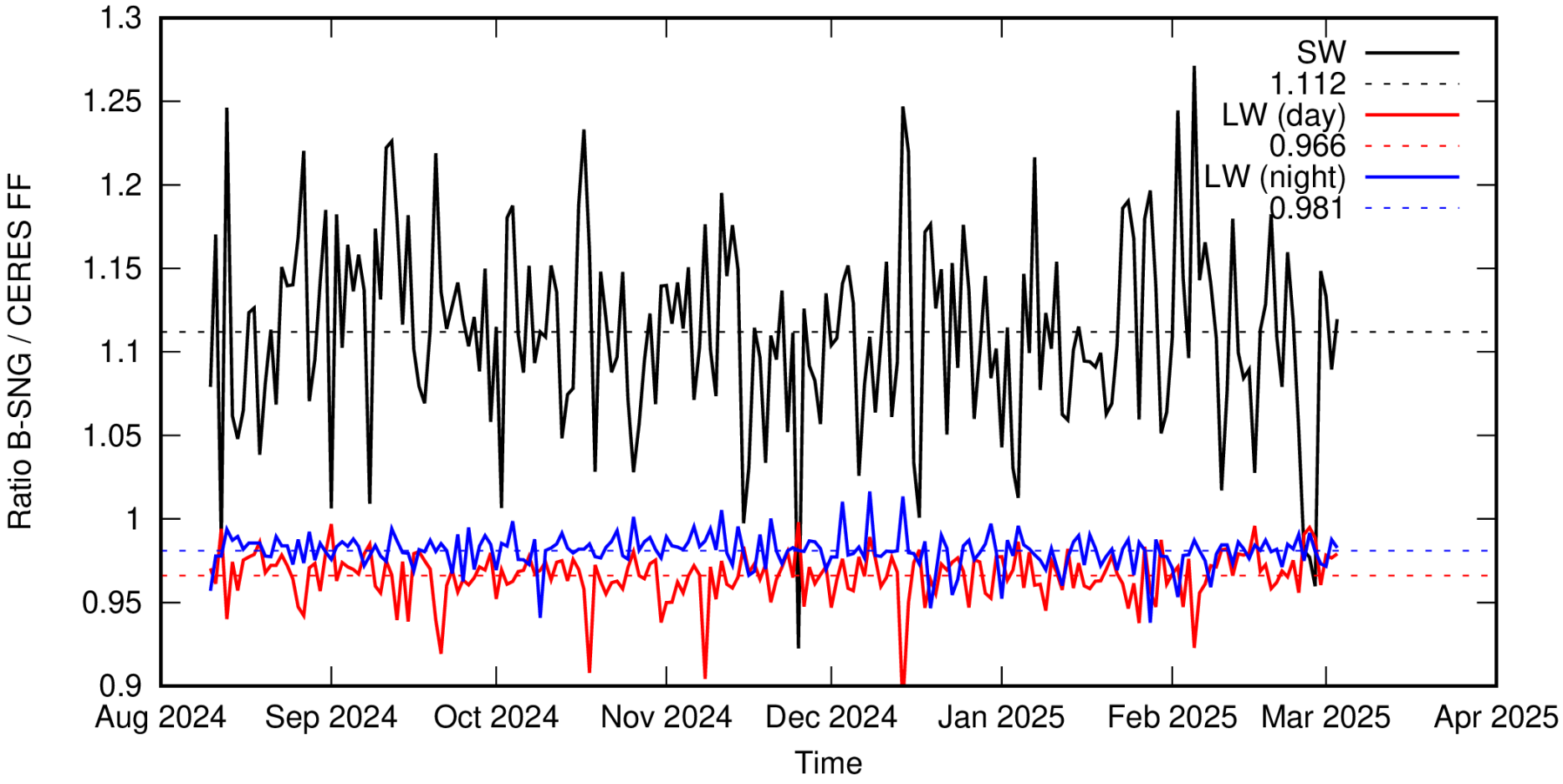


SW brighter ~9%



LW lower ~ 3% (~2.4 W/m^2/sr)

Temporal Stability – BBR versus FM6/NOAA20



→ **No indication of temporal degradation so far.**

Shortwave ground calibration revisit

- SW ground calibration done using a reference laser source at λ=0.532 µm
- Need to convert gain G_{laser} to G_{SW}= C * G_{laser}
- A value of C=0.9278 seems to have been used in the CCDB instead of C~1.0 obtained with latest spectral response.

$$G^{S}_{SW} = \frac{G_{laser}}{r_{SW}(\lambda_{laser})} \frac{\int r_{SW}(\lambda).L_{Planck}(\lambda,5800).d\lambda}{\int L_{Planck}(\lambda,5800).d\lambda}$$

- Using C=1 will reduce the SW radiances and flux by ~7.2%
  → Better agreement with CERES

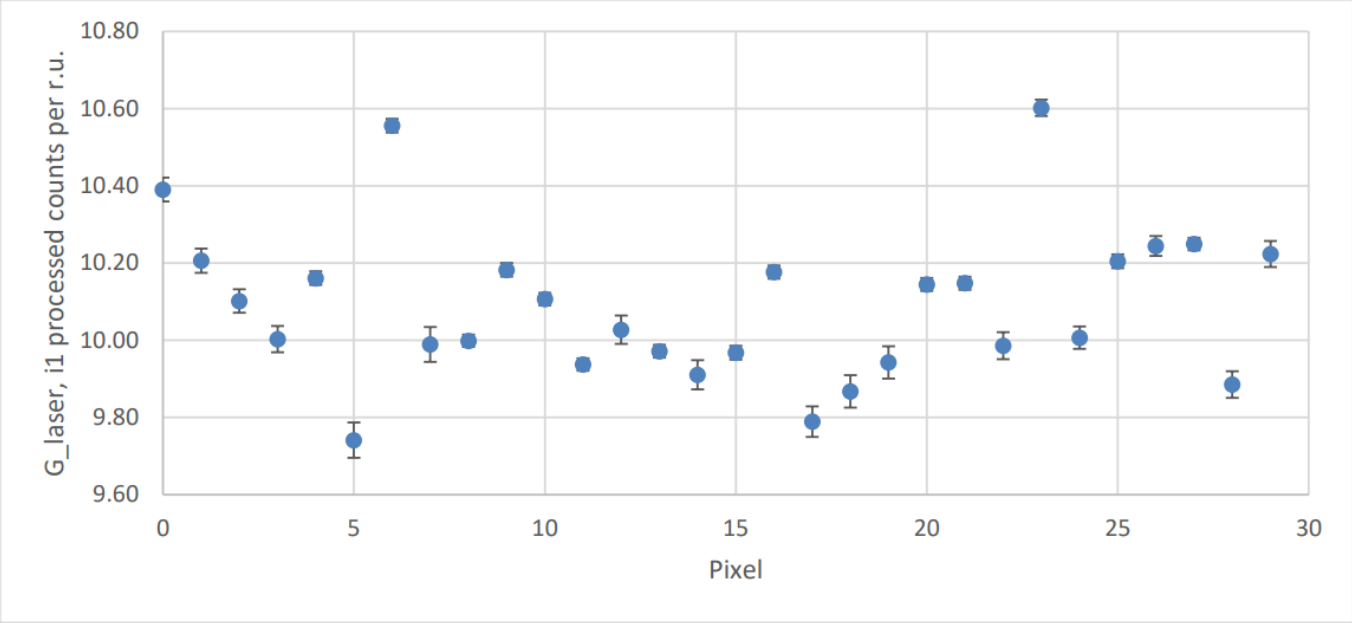
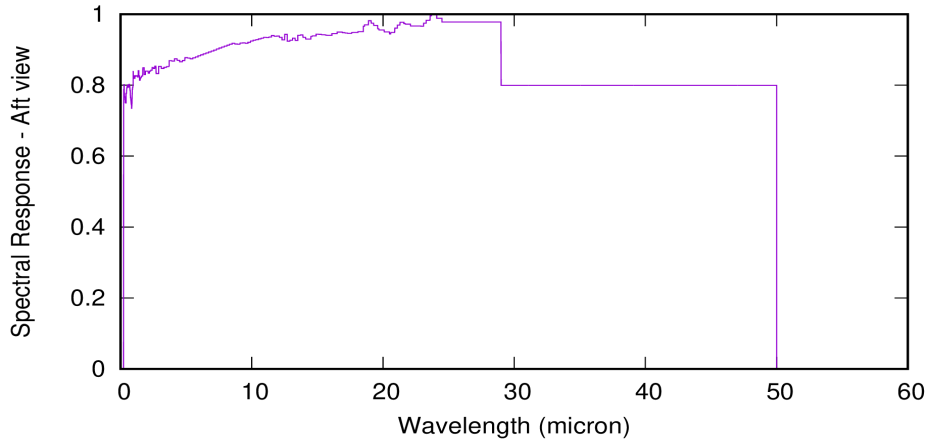


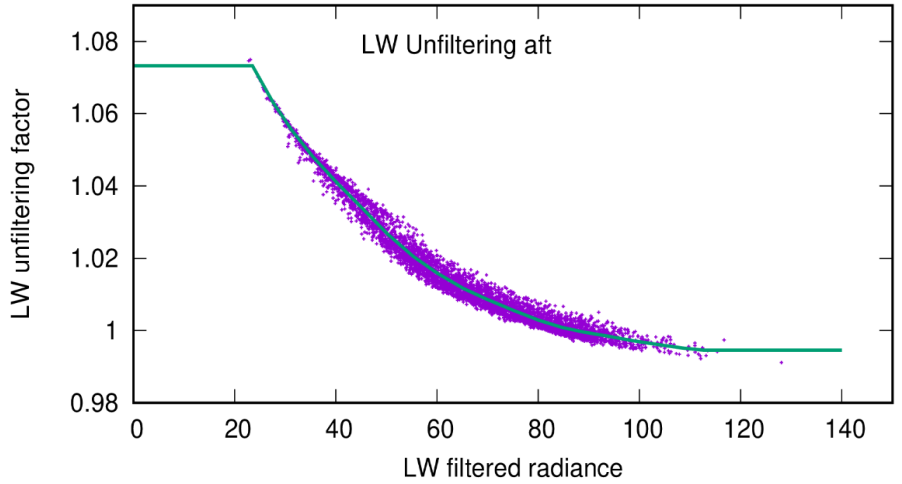
Figure 6-7: Gain of each pixel at the wavelength of the laser source, and averaged for all TestIDs

Longwave calibration revisit

- The LW calibration uses a CCDB table between filtered radiances and blackbody temperature
- To construct this table there was no interpolation of spectral response, and no sensitivity in the far IR (λ>50μm)
- This assumption necessitates higher unfiltering factor, especially for cold scene (up to 7%-8% unfiltering correction)

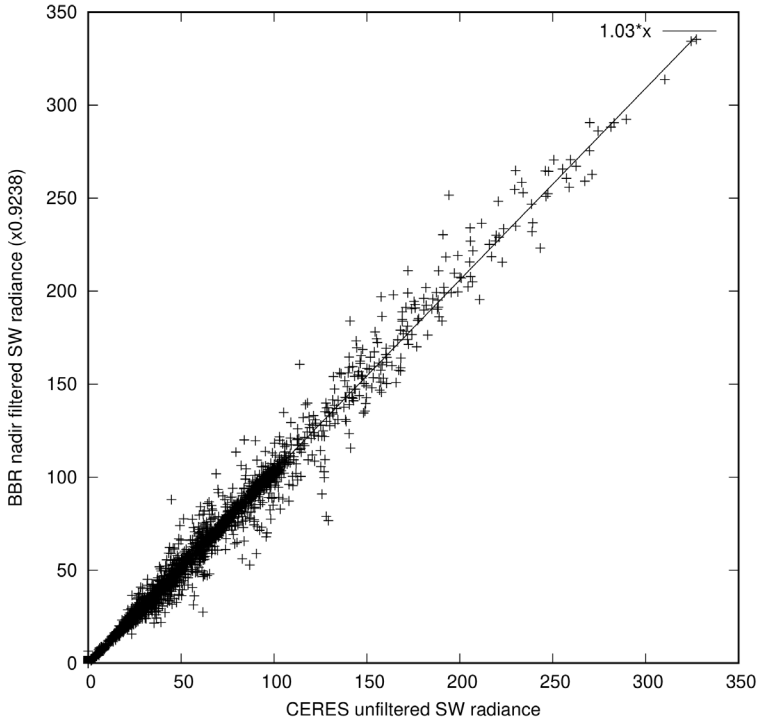
Propose to rebuild the CCDB table with interpolation and extrapolation up to λ=500μm
→ Better agreement with CERES (lower difference and scene type dependency)





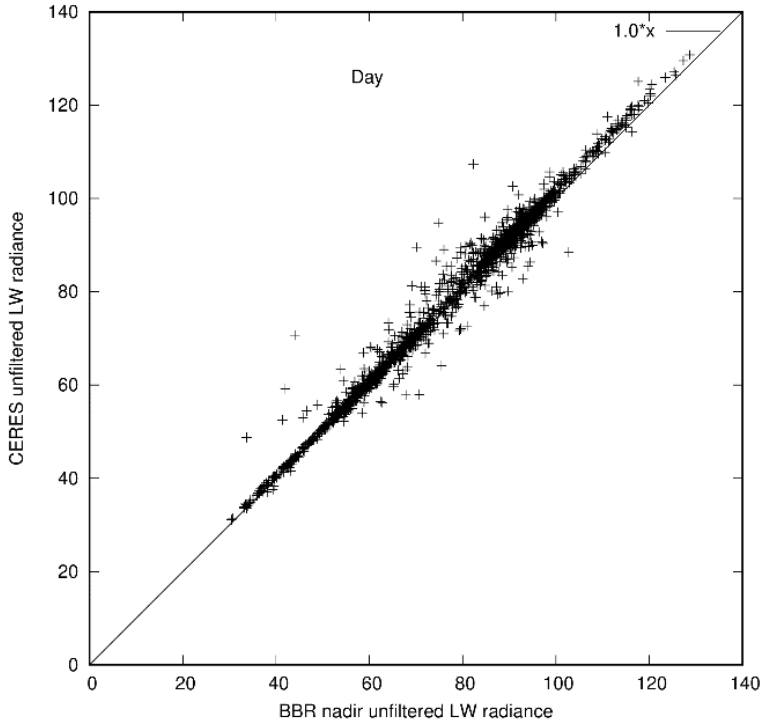
Shortwave and Longwave calibration revisit

Shortwave (day)



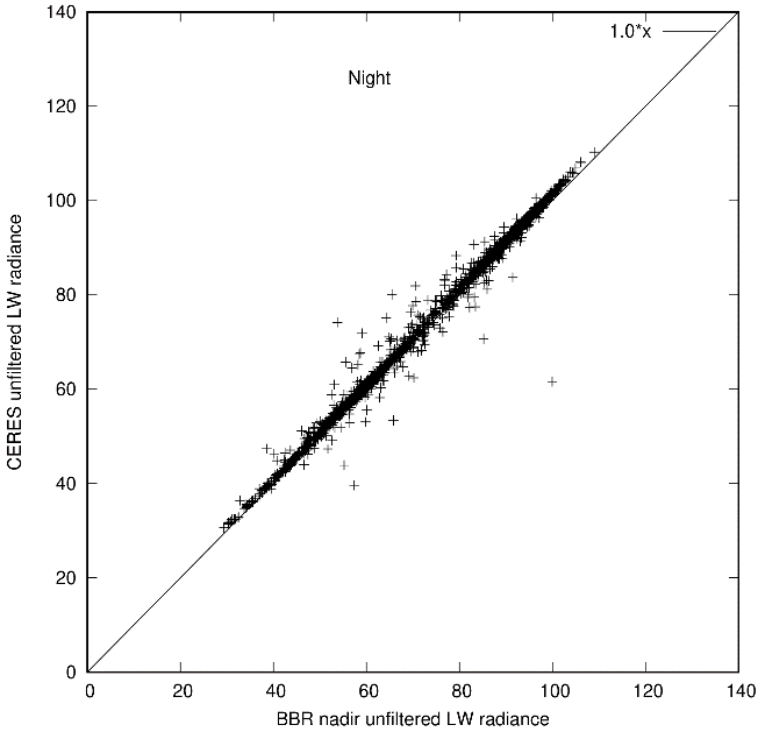
best fits day: $L_{BBR} = 1.03\ L_{CERES}$

Longwave (day)



best fits day: $L_{BBR} = 0.984\ L_{CERES}$

Longwave (night)



best fit night: $L_{BBR} = 0.985\ L_{CERES}$

→ Target to have the CCDB update ready for end of March.

Summary – comparison with CERES

- CERES is the best BB measurements available for BBR validation (GERB also used but less reliable).
- Simultaneous Nadir Overpasses (SNO) with NOAA2 for each orbit crossing.
- Significant biases with respect to CERES FLASHflux the current L1 baseline (AD).
- Will be reduced by CCDB updates. Expected improvements:
  - BBR SW ~9% -> ~2% brighter
  - BBR LW ~3% -> ~1.5% lower