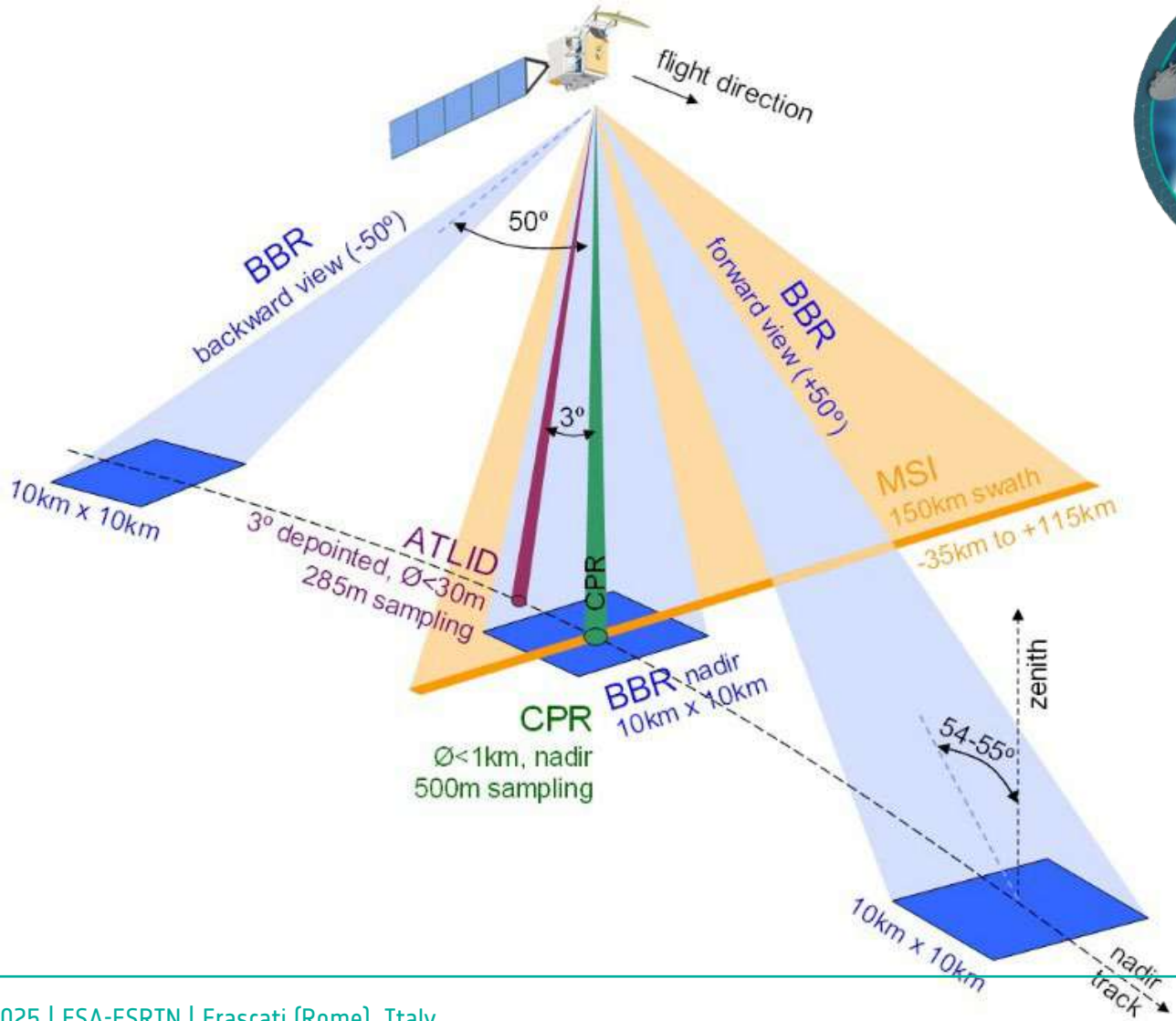
L2 BM-RAD and BMA-FLX products verification

Almudena Velázquez, Christine Aebi, Edward Baudrez, Nicolas Clerbaux – RMIB
Carla Salas, Carlos Domenech – GMV-ES

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

Outline

1. BM-RAD and BMA-FLX
2. Product resolutions
3. Reference Level & coregistration
4. Latitudinal means
5. Satellite comparisons
    1. GERB-1 radiances
    2. CERES rad.& fluxes
6. Summary
7. Recommendations

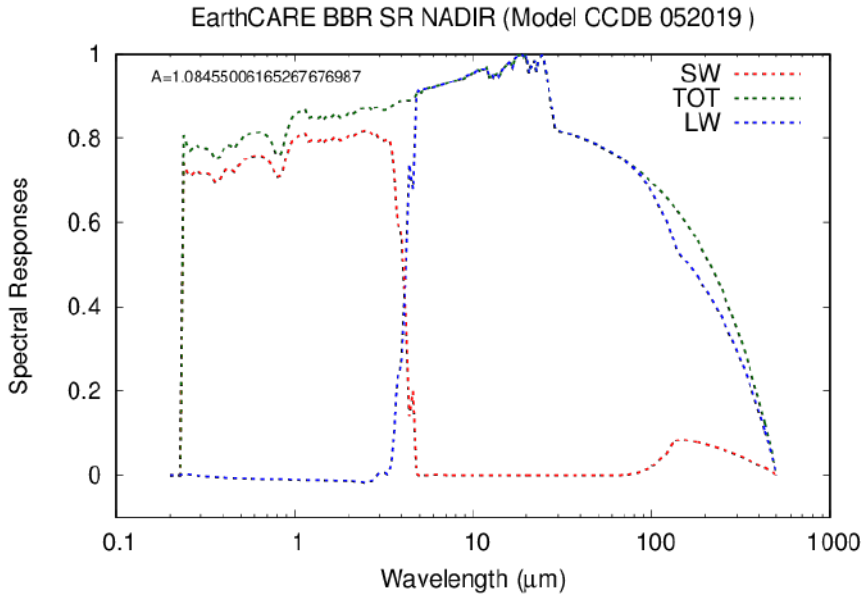


L2: BM-RAD & BMA-FLX

BM-RAD

- **BBR SW** and **TW** measurements are converted into **solar** and **thermal** **unfiltered radiances**

- Two unfiltering algorithms:
  - **Stand-alone** : BBR L1 and land use classification (SW & LW)
  - **SW MSI-based**: SW BBR L1 and MSI cloud mask and cloud phase



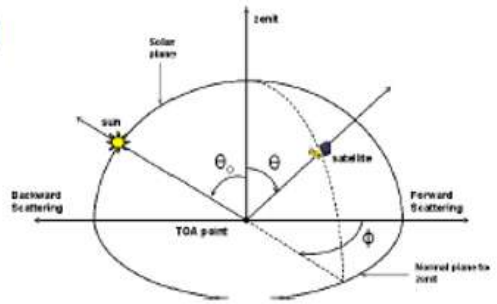
BMA-FLX

- **BBR solar** and **thermal radiances** are converted to **fluxes**

$$F(\theta_0) = \int_{\theta=0}^{\frac{\pi}{2}} \int_{\phi=0}^{2\pi} L(\theta,\phi)cos(\theta)sin(\theta)d\theta d\phi$$

- Need of Angular Dependency Models (R)

$$F = \frac{\pi L(\theta,\phi)}{R(\theta,\phi)}$$



- In the LW: $R(\theta) = a_0 + a_1 z_1 + a_2 z_2 + a_3 z_1^2 + a_4 z_1 z_2 + a_5 z_2^2$

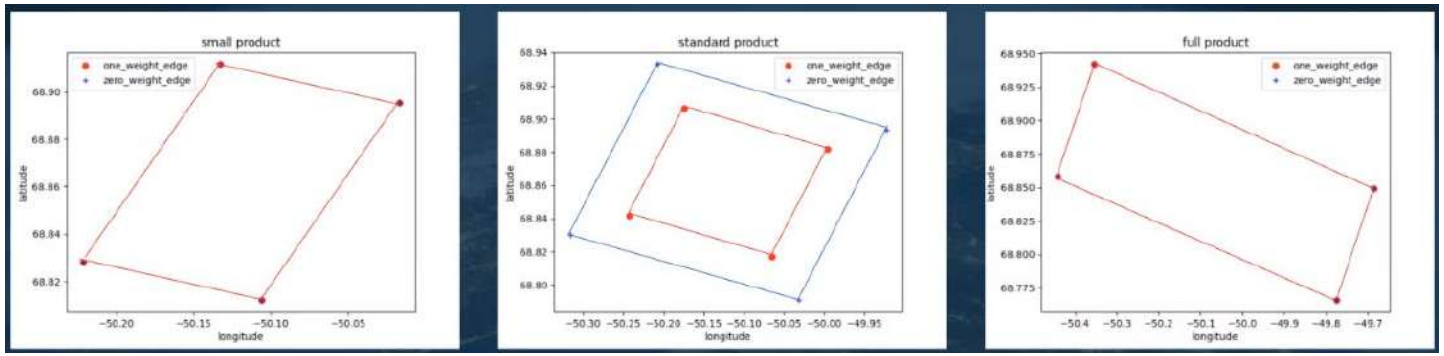
  $z_1 = BT_{10.8\,\mu m}$ and $z_2 = BT_{12.0\,\mu m} - BT_{10.8\,\mu m}$

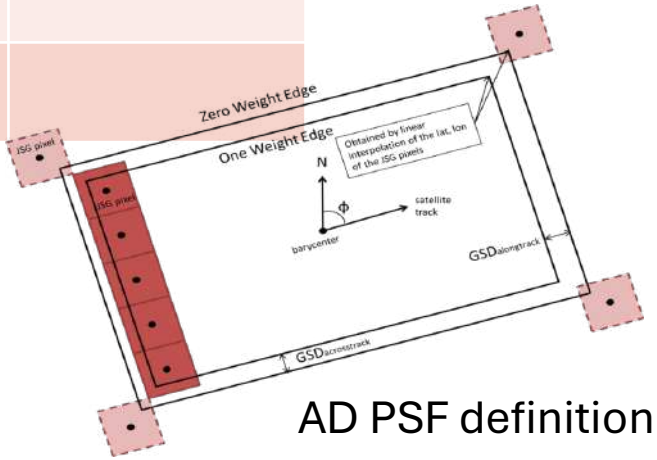
- In the SW: feed-forward back-propagation ANN using CERES and MODIS data

Inputs: BM-RAD, M-RGR, M-CM, M-COP, A-CTH, X-MET

BM-RAD / BMA-FLX product resolutions

L1 PSF	Size (across x along track)	Reference grid	L1 filtered radiances	BM-RAD unfiltered radiances	BMA-FLX fluxes	BMA-FLX combined flux
Standard	10x10 km2	BBR	B-NOM	✓	✓	✓
Small	5x10 km2	BBR	B-NOM	✓	✓	✓
Full	17x10 km2 (nadir) 28x10 km2	BBR	B-NOM	✓	✓	
Assessment domain	5x21 JSG (configurable)	JSG	B-SNG	✓	✓	✓
JSG*	1x1 JSG (or 3x3 JSG)	JSG	B-SNG	✓		





AD PSF definition

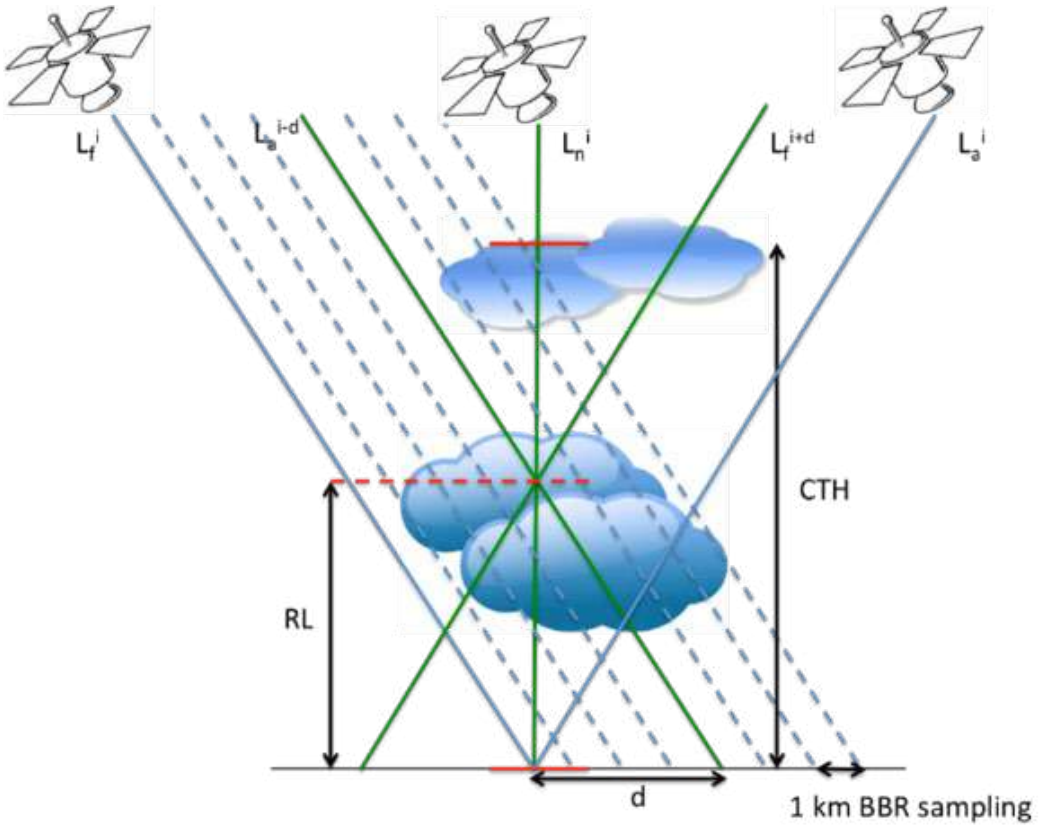
Reference level height for SW and LW radiances

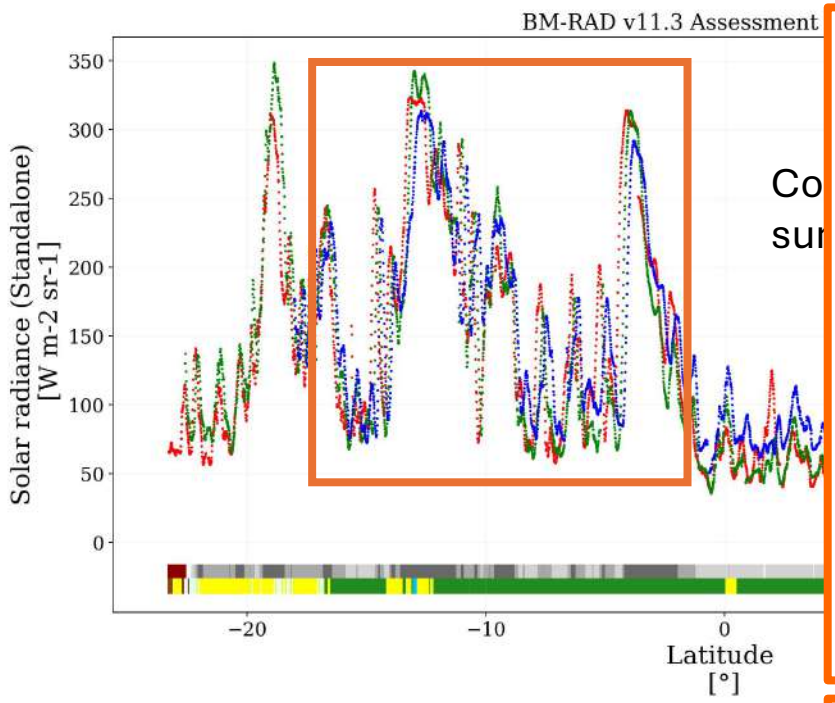
Co-registration of LW radiances

- The height defined by the CTH derived from brightness temperature (M-COP) is a good estimator to co-register the BBR radiances in LW.
- RL is defined as the 90th percentile of the altitude of the highest cloud in the BBR domain.

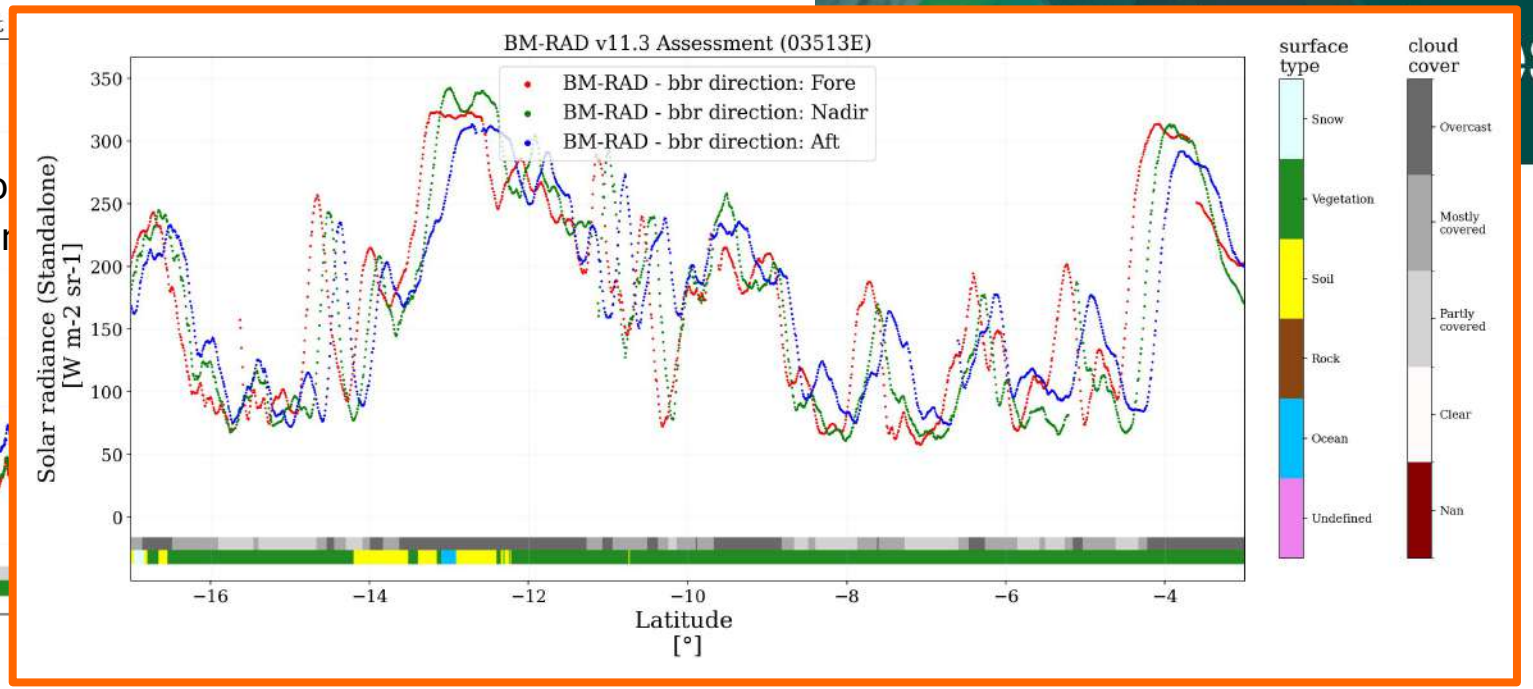
Co-registration of SW radiances

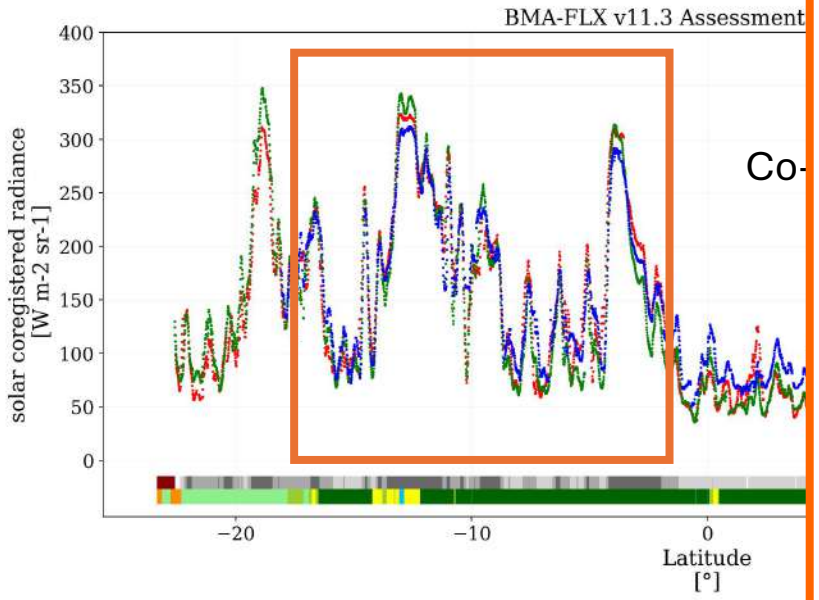
- SW radiances cannot be co-registered using BT-based CTH. In average co-registration errors are higher than using the default surface co-registration.
- Views are co-registered at a RL defined as the vertical level in the nadir domain that minimizes the flux differences between the nadir, aft and fore flux retrievals



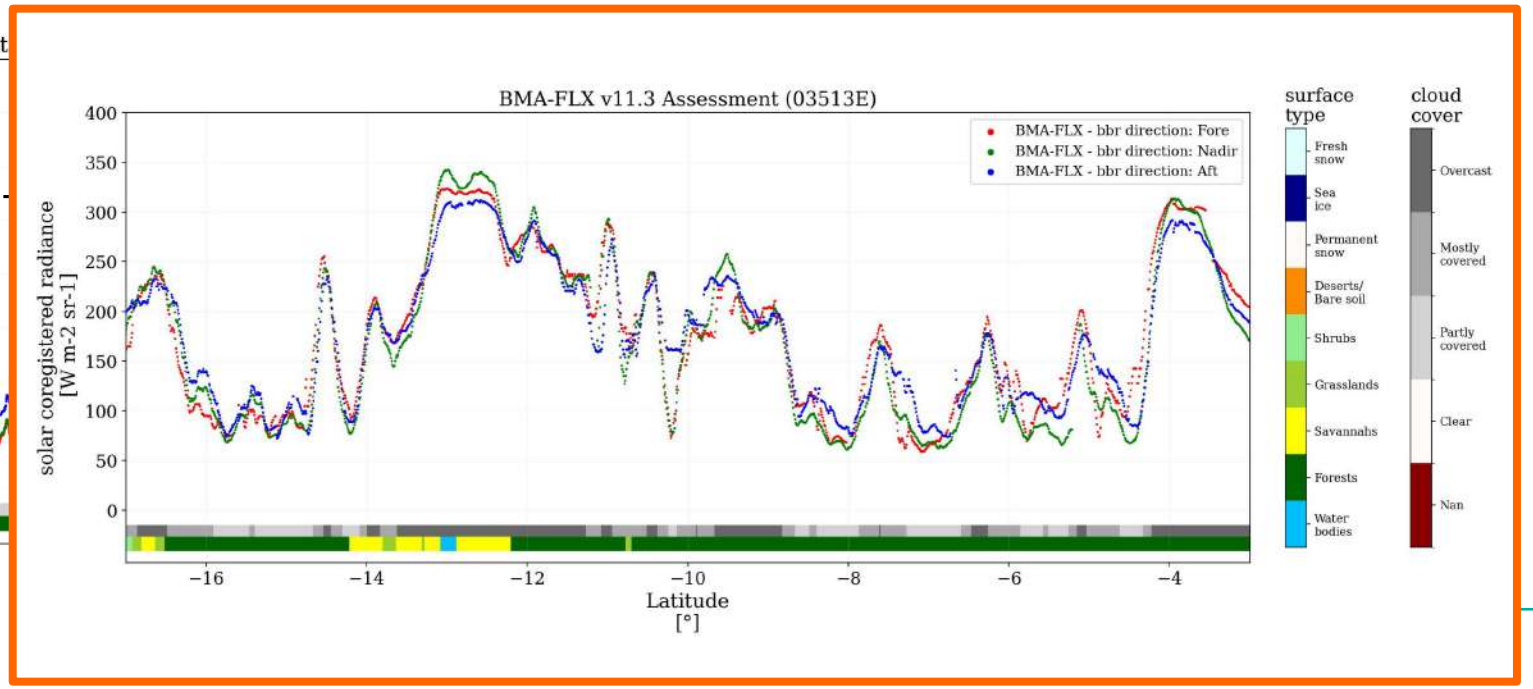

BM-RAD v11.3 Assessment
Solar radiance (Standalone) [W m-2 sr-1]
Latitude [°]

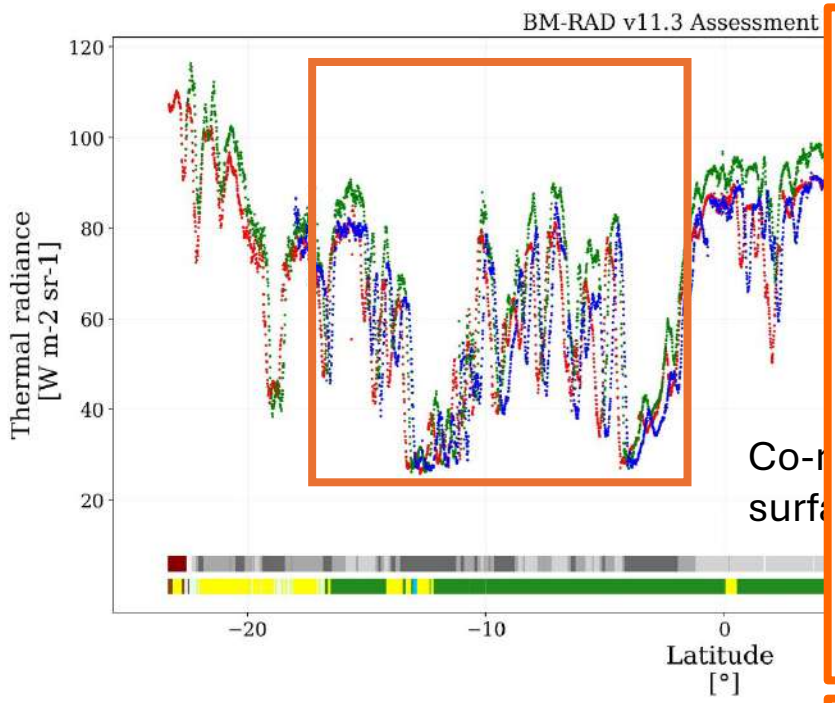
Co
sur

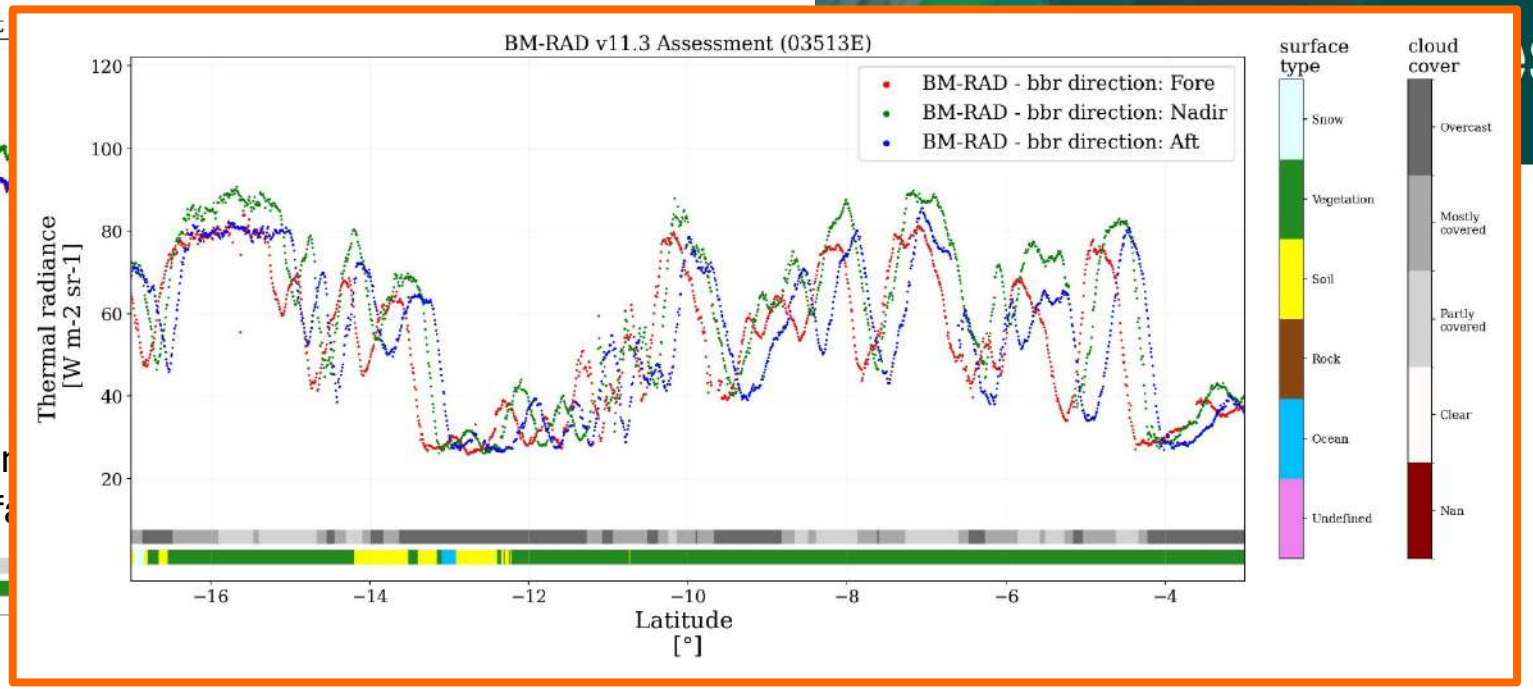

BM-RAD v11.3 Assessment (03513E)
BM-RAD - bbr direction: Fore
BM-RAD - bbr direction: Nadir
BM-RAD - bbr direction: Aft
Solar radiance (Standalone) [W m-2 sr-1]
Latitude [°]
surface type
Snow
Vegetation
Soil
Rock
Ocean
Undefined
cloud cover
Overcast
Mostly covered
Partly covered
Clear
Nan

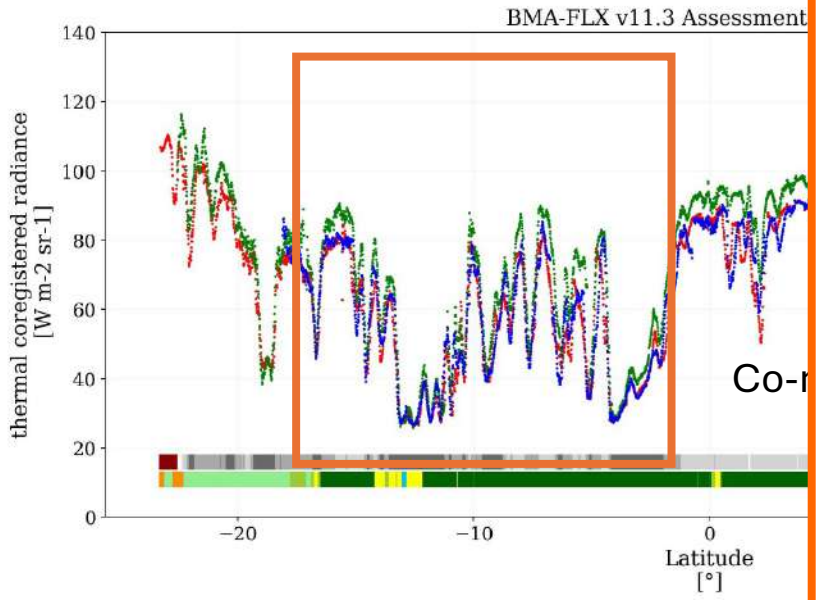

BMA-FLX v11.3 Assessment
solar coregistered radiance [W m-2 sr-1]
Latitude [°]

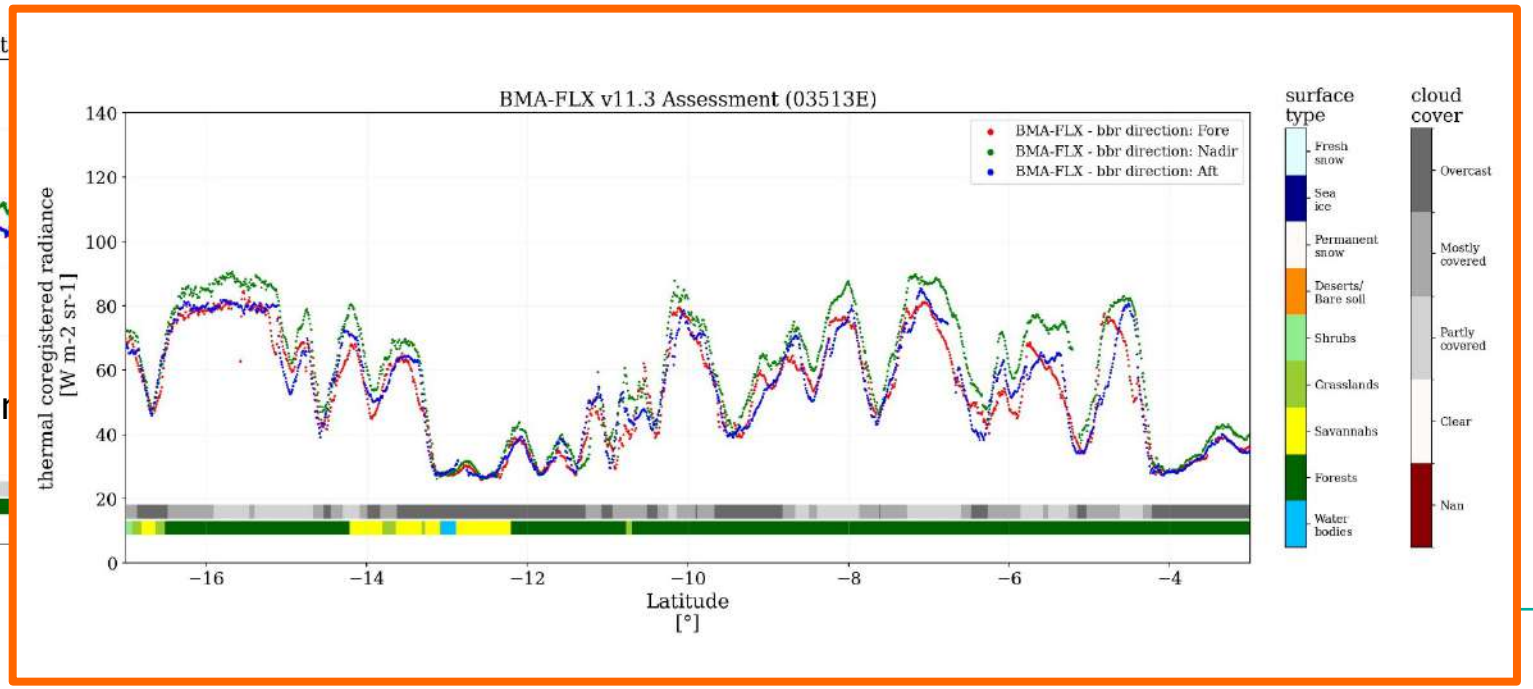
Co-


BMA-FLX v11.3 Assessment (03513E)
BMA-FLX - bbr direction: Fore
BMA-FLX - bbr direction: Nadir
BMA-FLX - bbr direction: Aft
solar coregistered radiance [W m-2 sr-1]
Latitude [°]
surface type
Fresh snow
Sea ice
Permanent snow
Deserts/ Bare soil
Shrubs
Grasslands
Savannahs
Forests
Water bodies
cloud cover
Overcast
Mostly covered
Partly covered
Clear
Nan

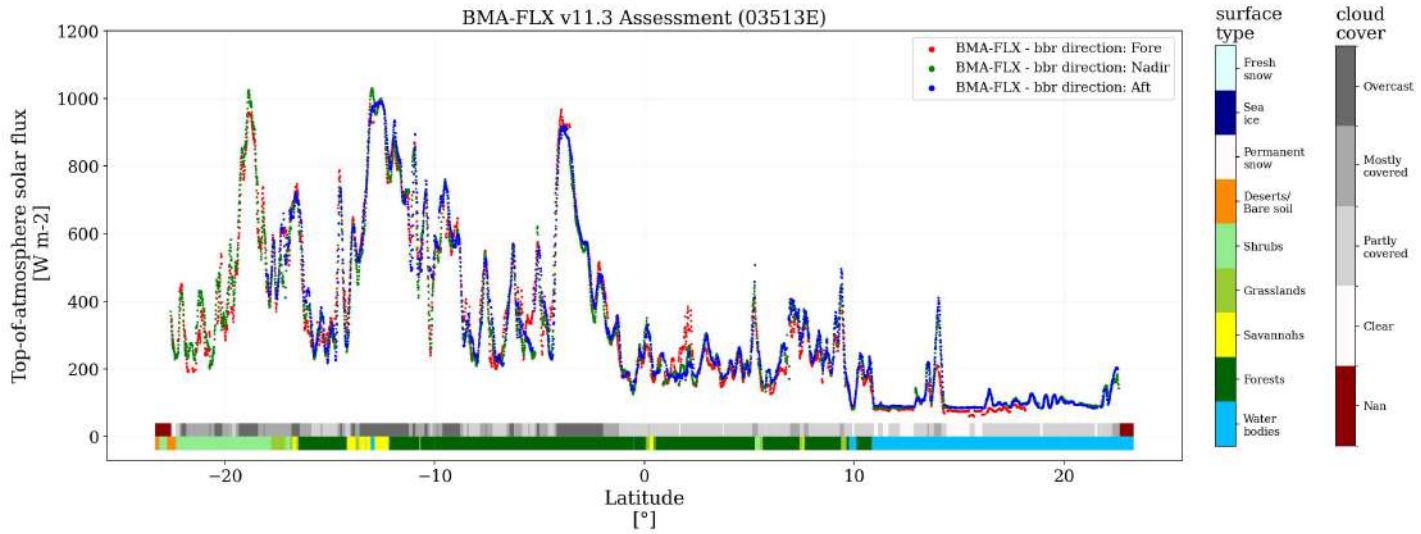

BM-RAD v11.3 Assessment
Thermal radiance [W m-2 sr-1]
Latitude [°]


BM-RAD v11.3 Assessment (03513E)
BM-RAD - bbr direction: Fore
BM-RAD - bbr direction: Nadir
BM-RAD - bbr direction: Aft
Thermal radiance [W m-2 sr-1]
Latitude [°]
surface type
Snow
Vegetation
Soil
Rock
Ocean
Undefined
cloud cover
Overcast
Mostly covered
Partly covered
Clear
Nan

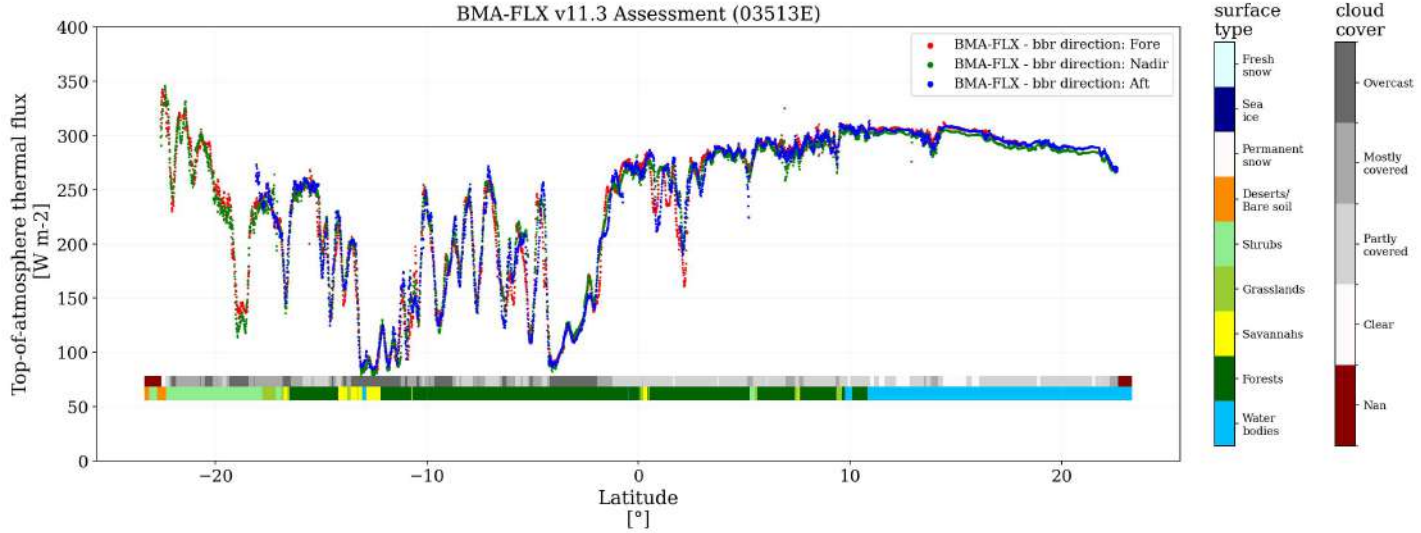

BMA-FLX v11.3 Assessment
thermal coregistered radiance [W m-2 sr-1]
Latitude [°]

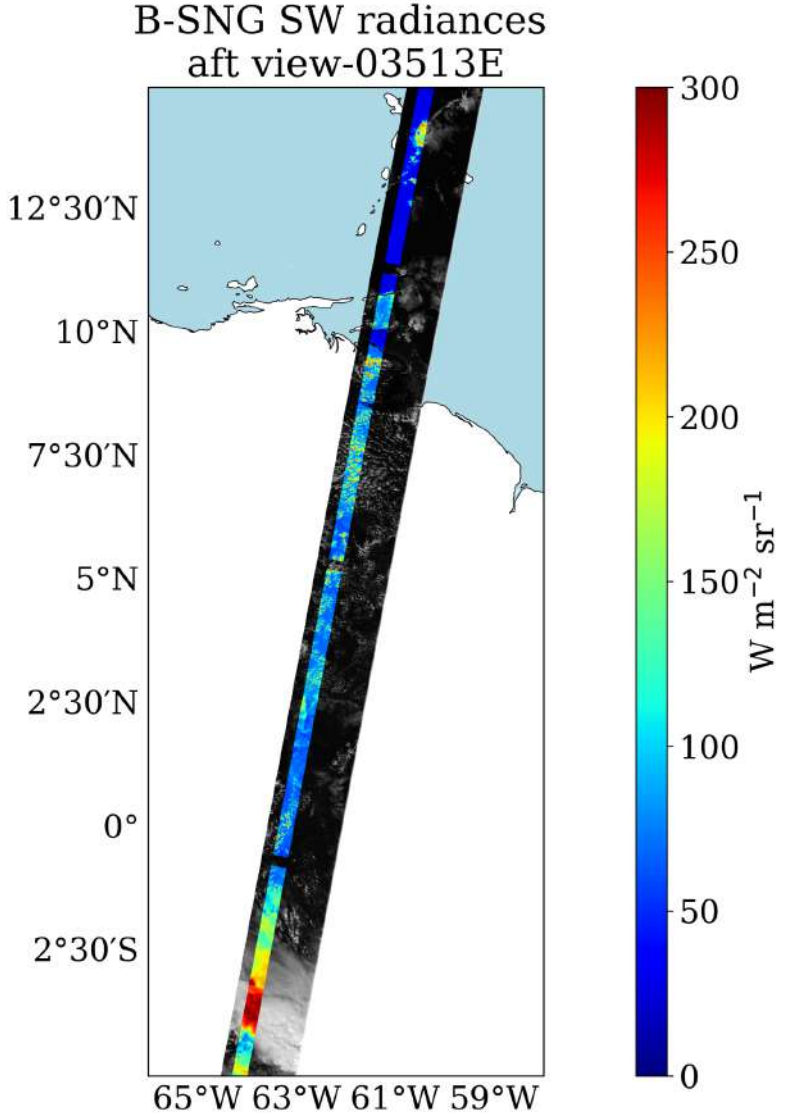

BMA-FLX v11.3 Assessment (03513E)
BMA-FLX - bbr direction: Fore
BMA-FLX - bbr direction: Nadir
BMA-FLX - bbr direction: Aft
thermal coregistered radiance [W m-2 sr-1]
Latitude [°]
surface type
Fresh snow
Sea ice
Permanent snow
Deserts/ Bare soil
Shrubs
Grasslands
Savannahs
Forests
Water bodies
cloud cover
Overcast
Mostly covered
Partly covered
Clear
Nan

SOLAR



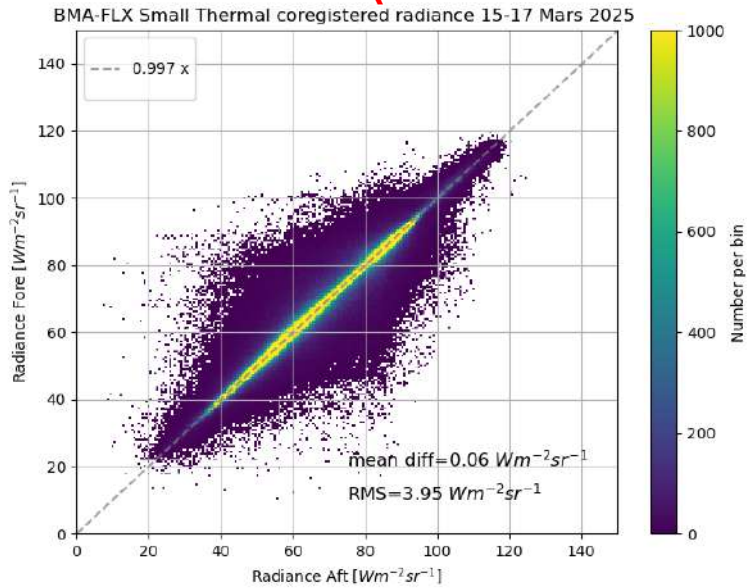
THERMAL

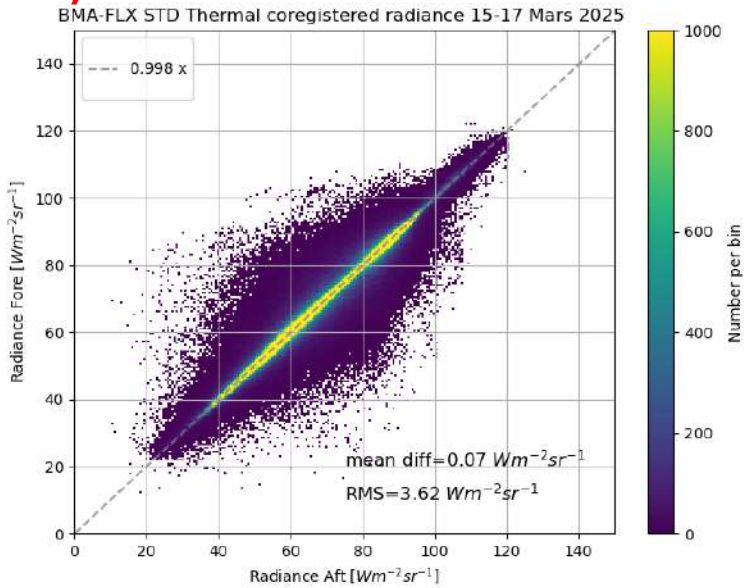


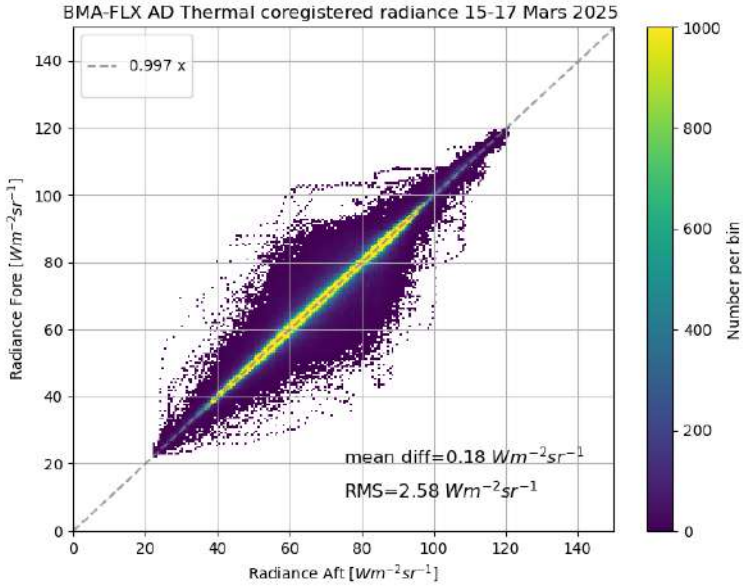


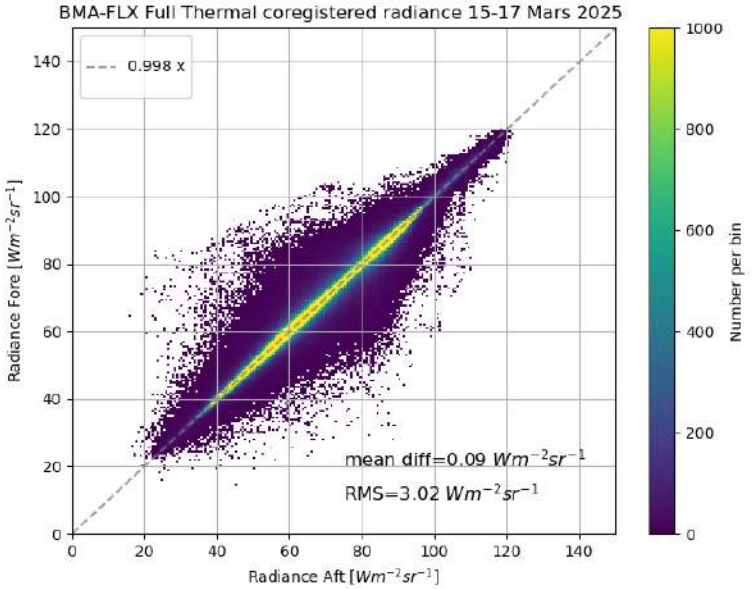
Off-nadir thermal radiances (BMA-FLX AA)

From B-NOM AD (as from 14th January 2025)

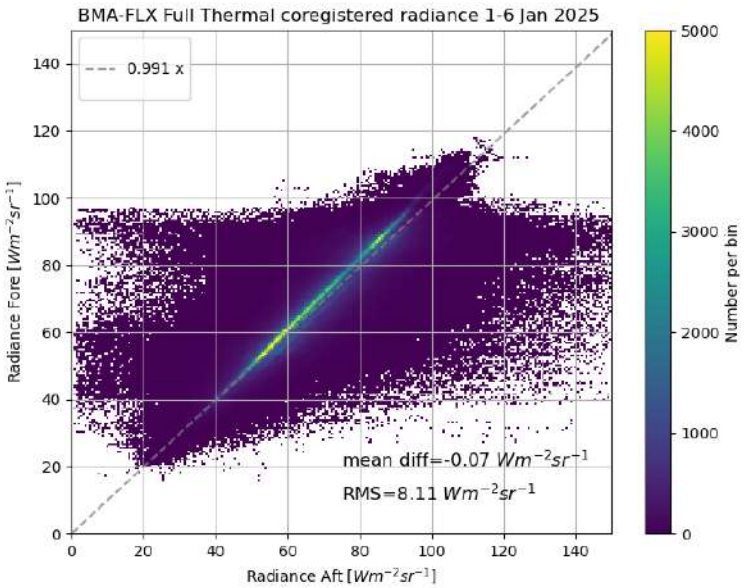








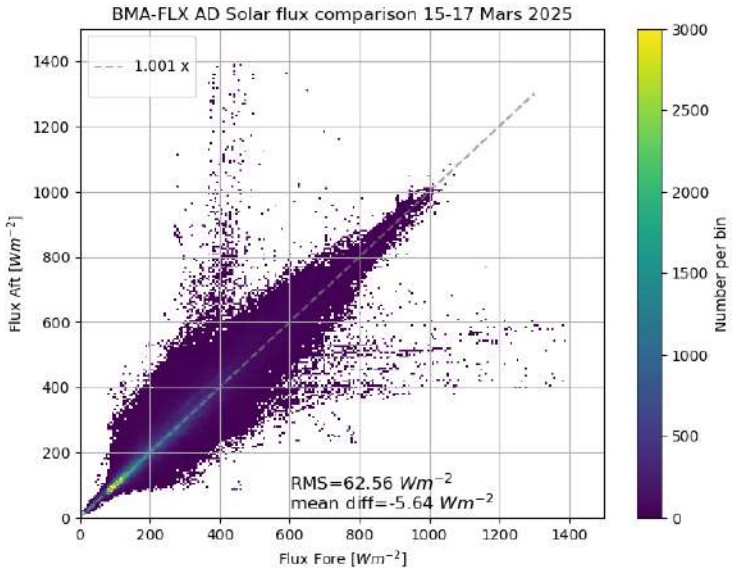
From B-NOM AC

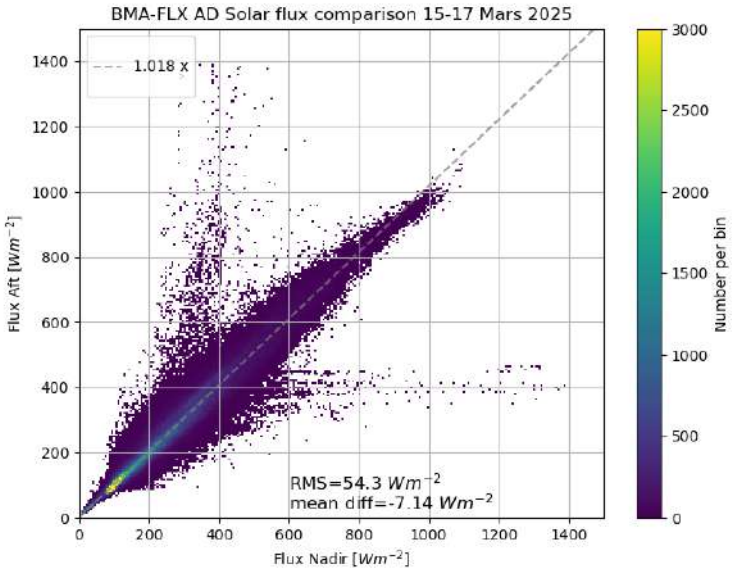


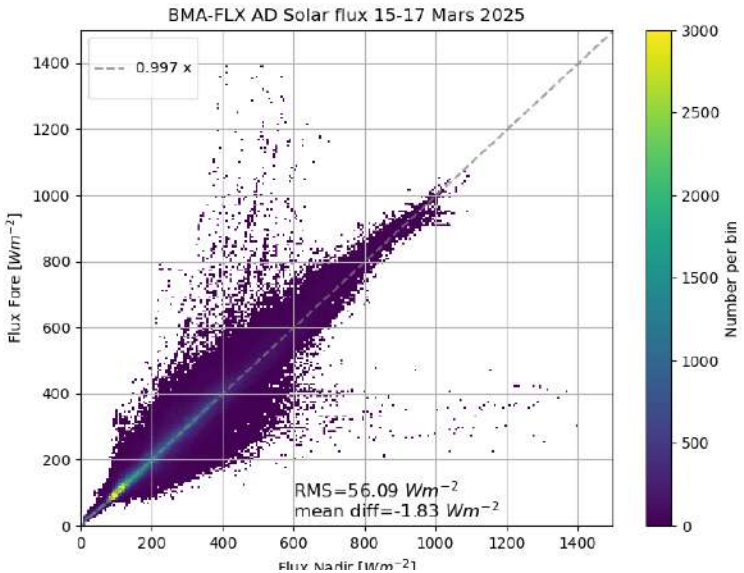
Unless reprocessed data, before 14th of January, risk that the dead pixel is used in the fore view for the STD and FULL resolutions in BM-RAD and BMA-FLX

BBR FLUXES COMPARISON: Assessment Domain

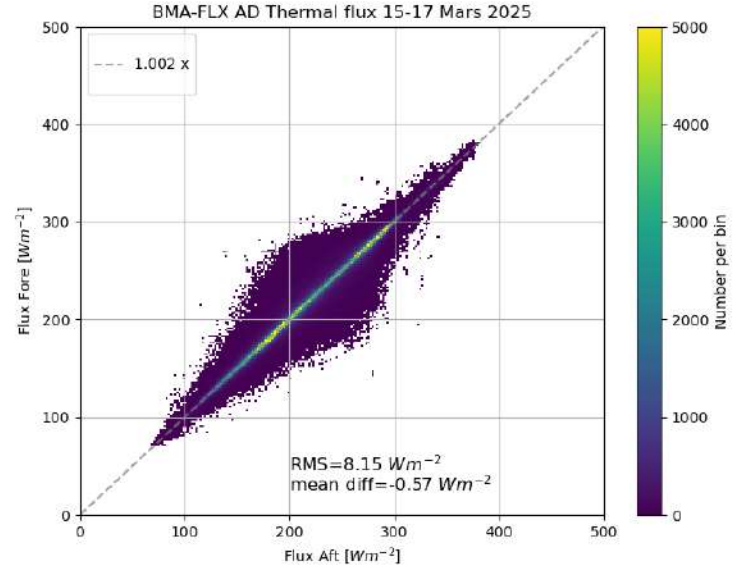
SOLAR

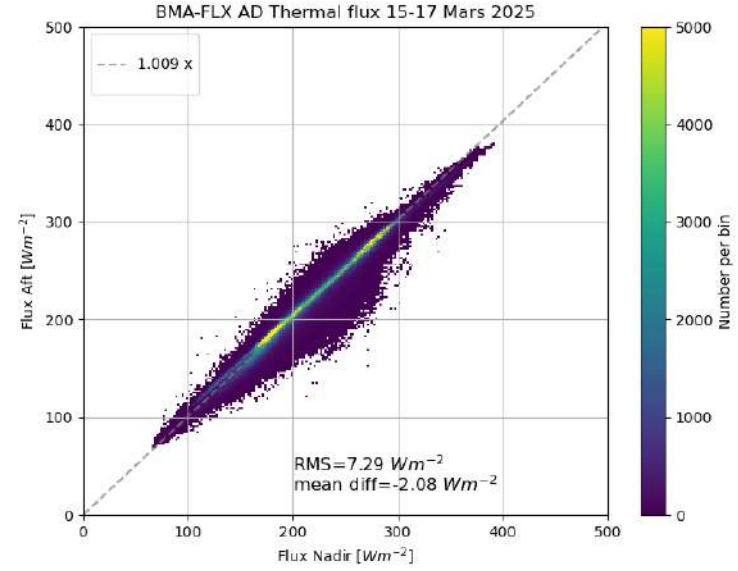


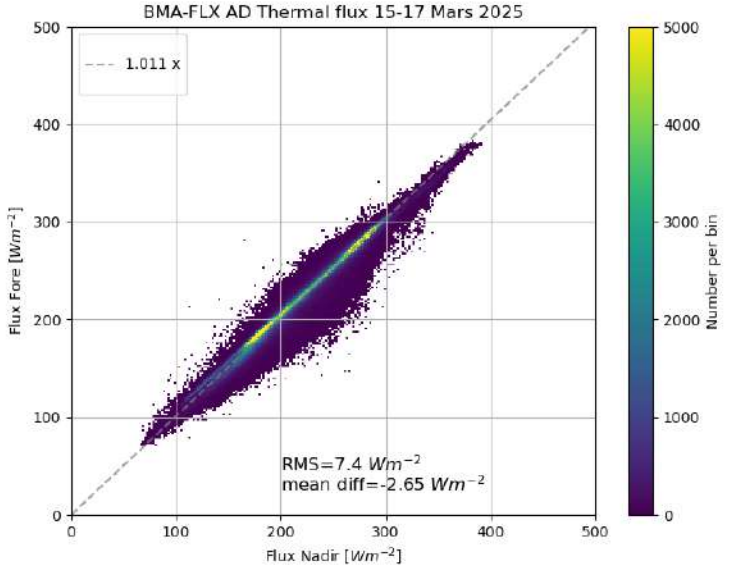




THERMAL

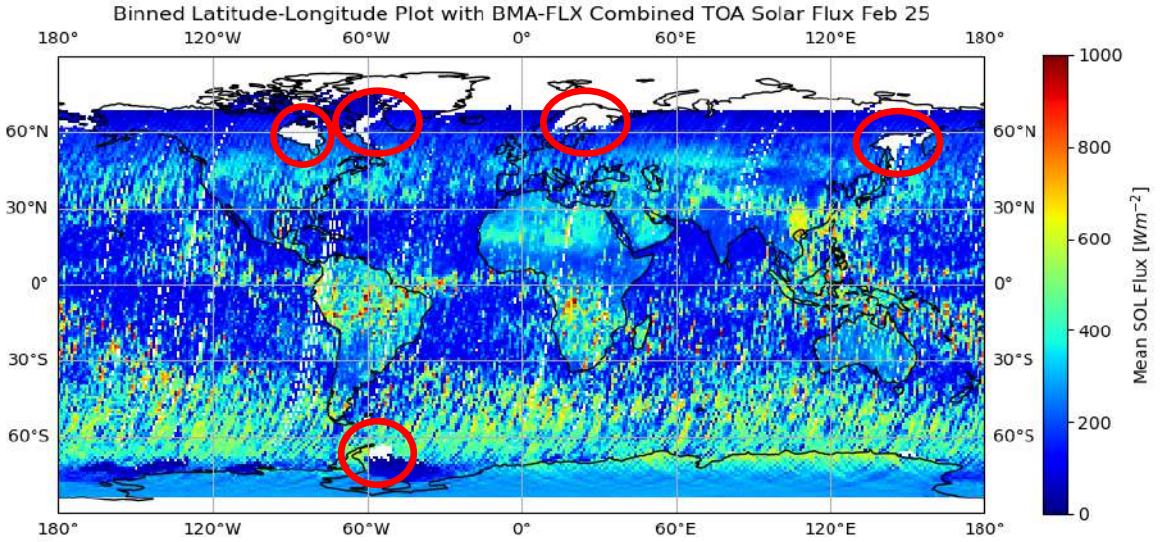


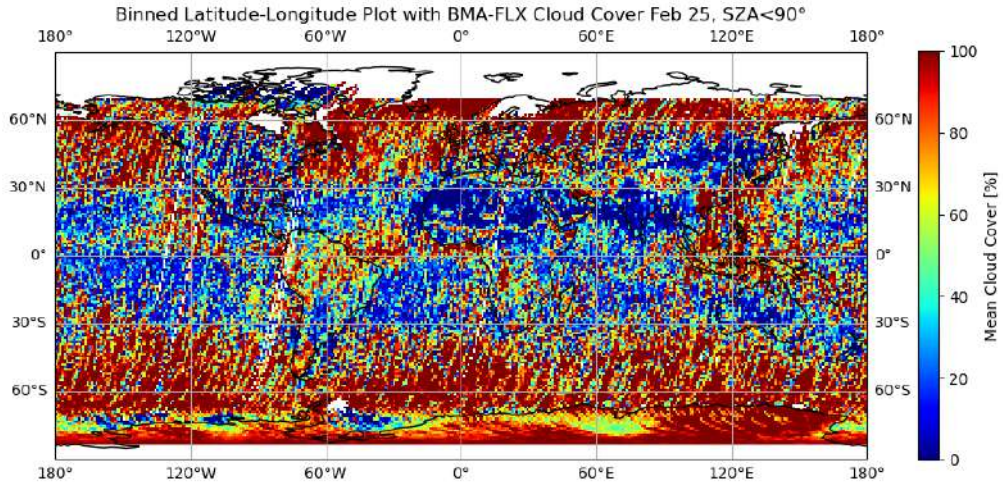




BBR SOLAR FLUXES

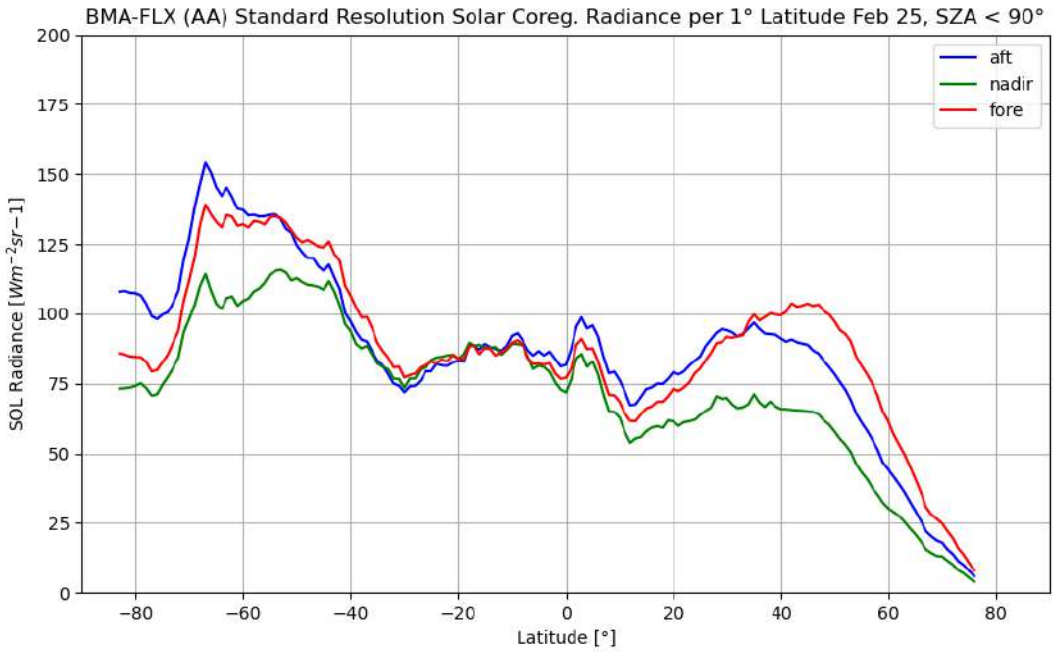
- Solar fluxes are very sensitive to the quality of the inputs used in the BMA-FLX processor.
- MSI L1 calibration → M-CM L2a & M-COP L2a
- Missing values in solar fluxes are due to:
  - Fill values in cloud cover (in red)
  - Unphysical solar fluxes over snow/ice surfaces
- Solar fluxes are expected to improve when MSI L1 calibration does.



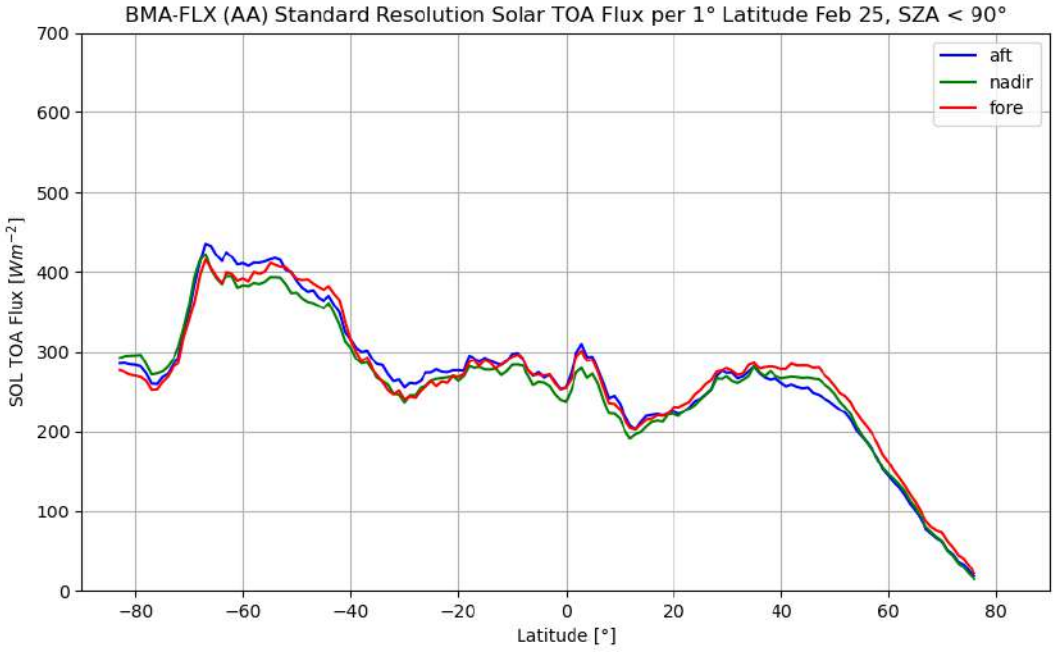


Latitudinal means: Solar radiances & fluxes

Radiances

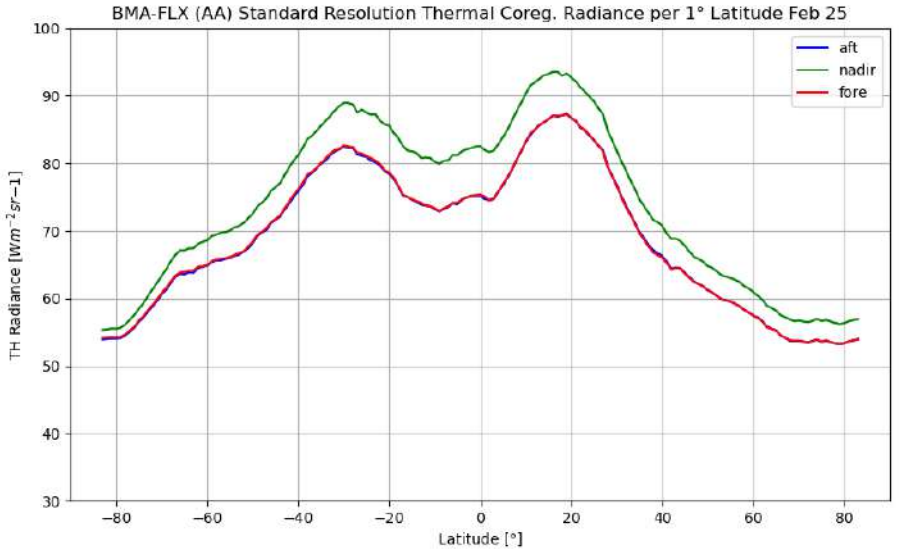


Fluxes

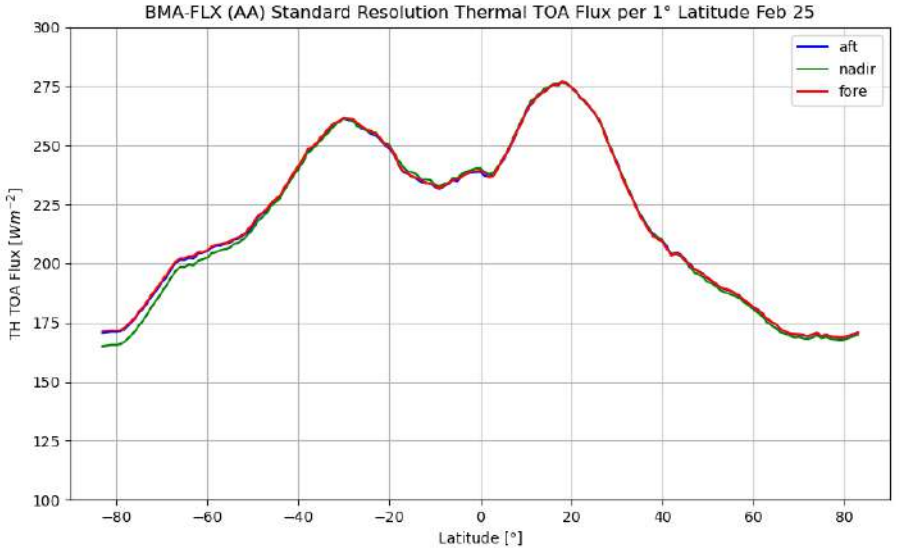


Latitudinal means: Thermal radiances & fluxes

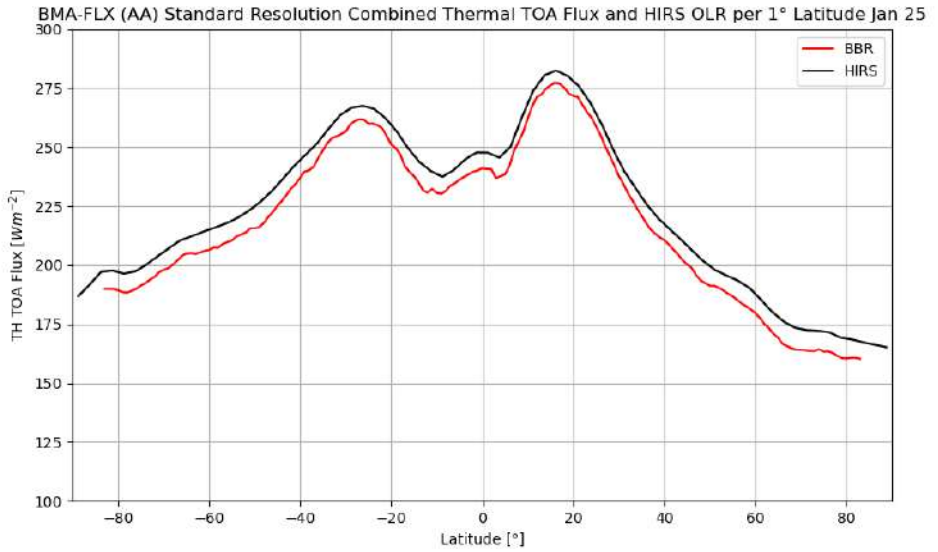
Radiances



Fluxes



HIRS NOAA OLR daily mean
BBR 14:00 Descending node

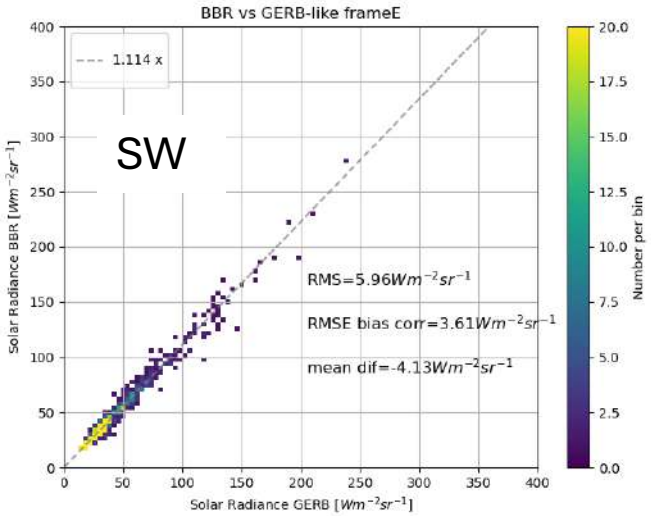


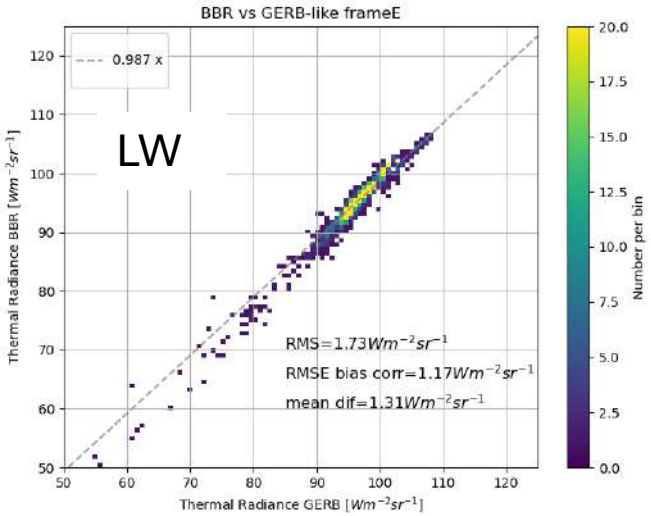
GERB-like/ BBR comparisons: SW and LW Radiances

- **GERB-1 is over the Indian ocean**
- **Data from October 2024 to February 2025**
- **Only nadir comparisons**

GERB VZA < 3 deg
Δdist < 3 km
Δtime < 5 min

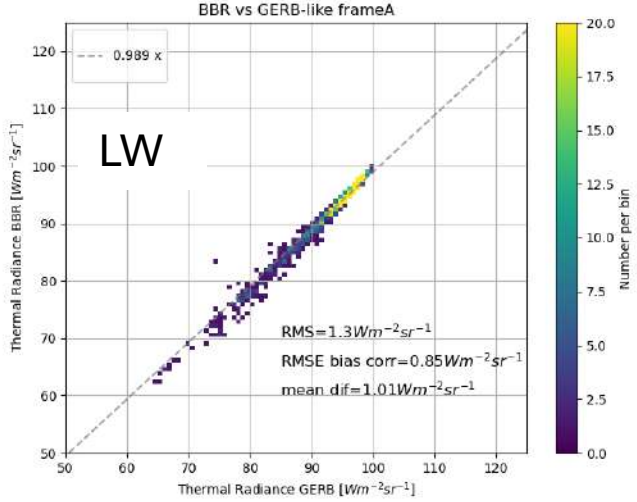
Daytime





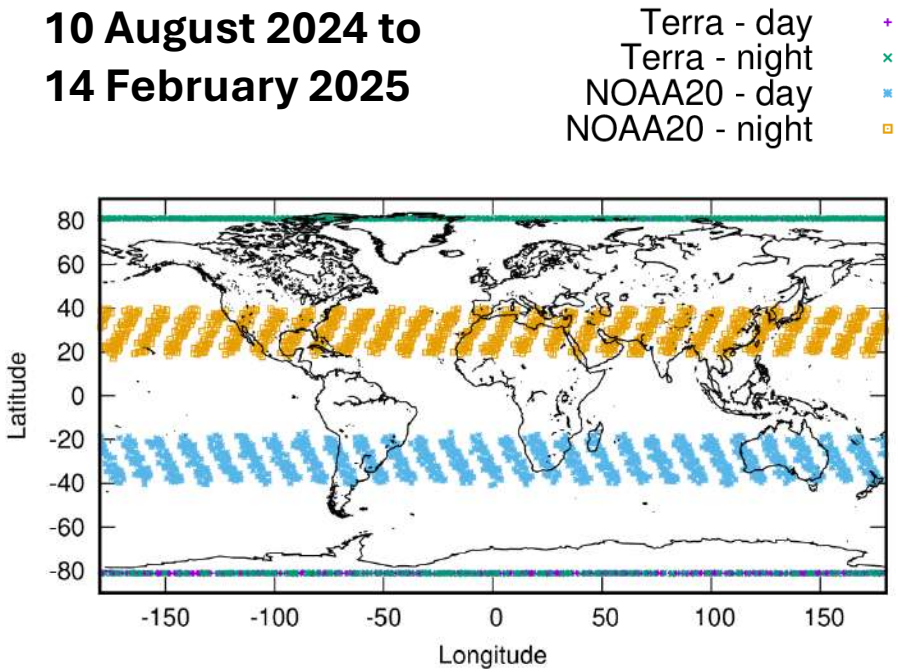
Nighttime

- BBR solar radiances are higher than GERB-like
- BBR thermal radiances are lower



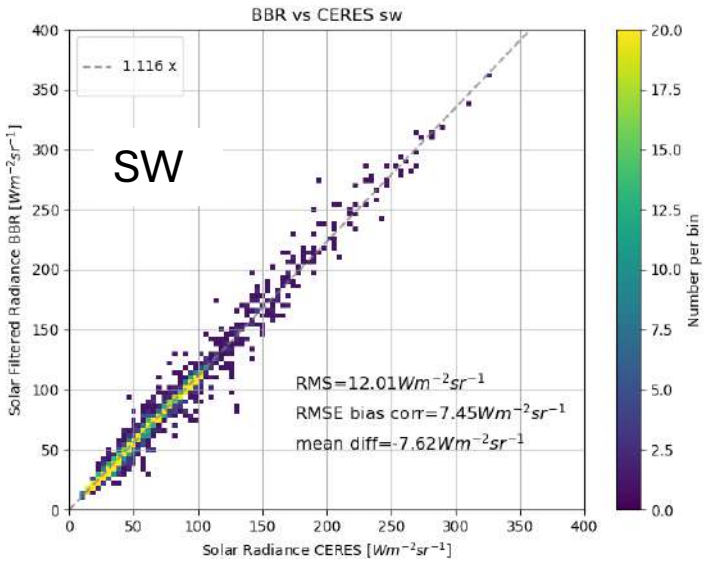
CERES FLASHflux comparison: SW and LW Radiance

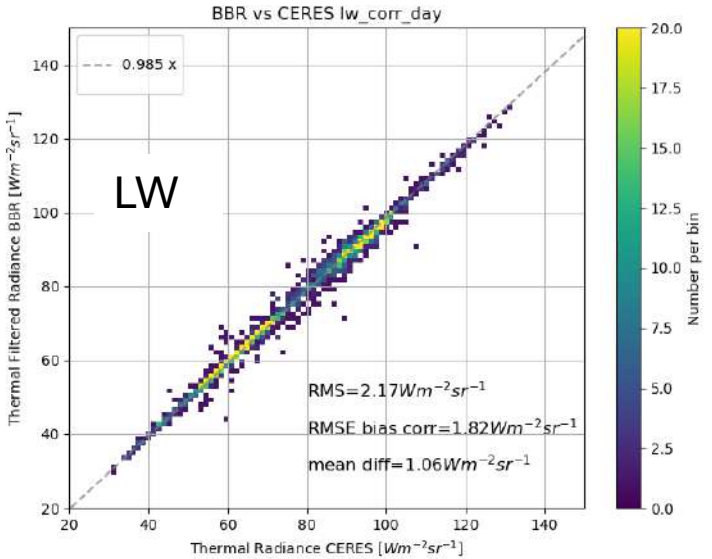
10 August 2024 to
14 February 2025

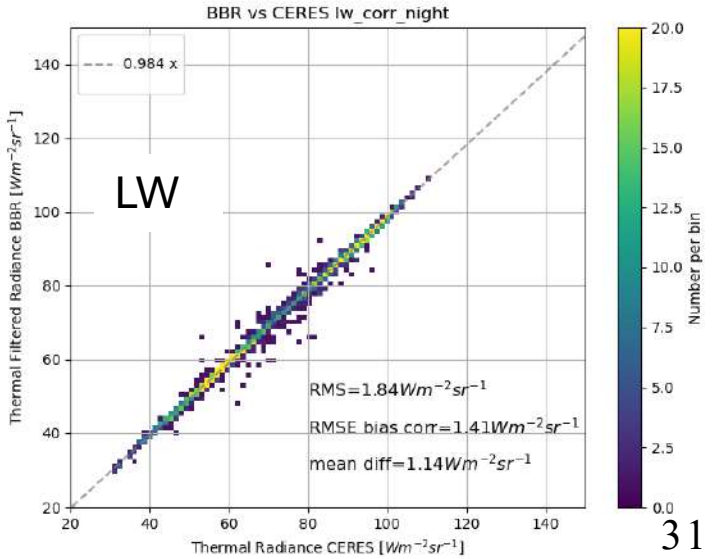


CERES VZA < 3°
Δdist < 3 km
Δtime < 5 min

Daytime **Nighttime**



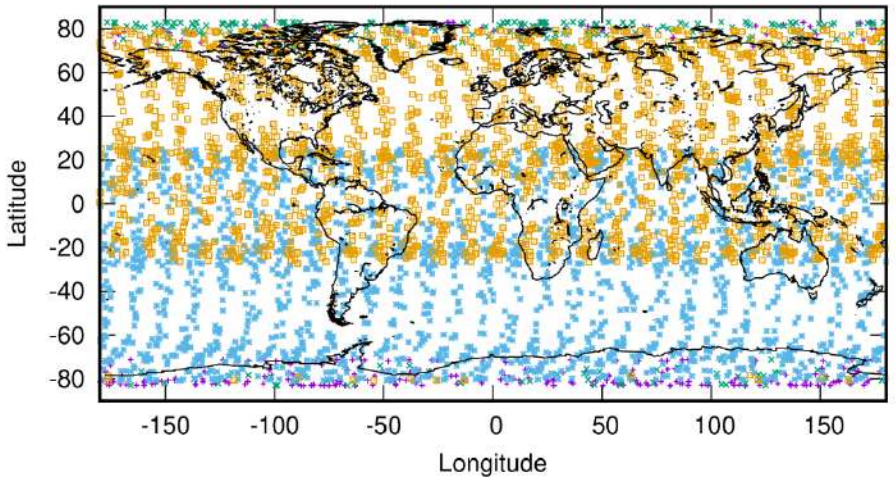




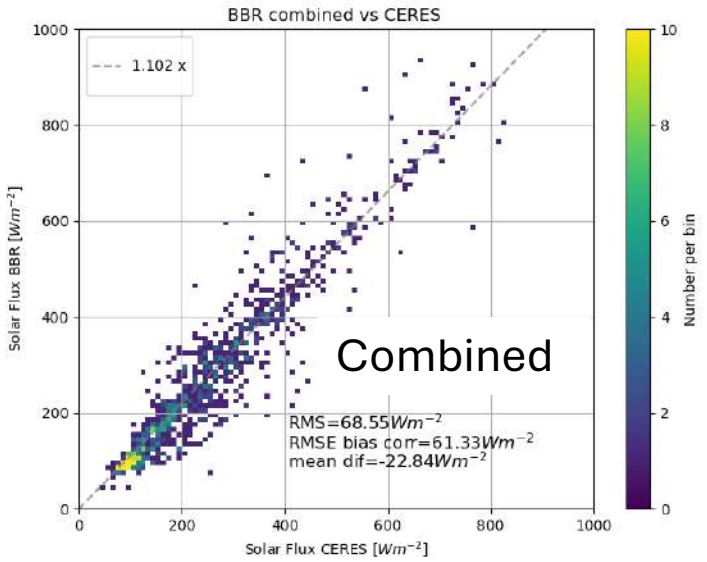
CERES FLASHflux comparison: SW Flux, Daytime

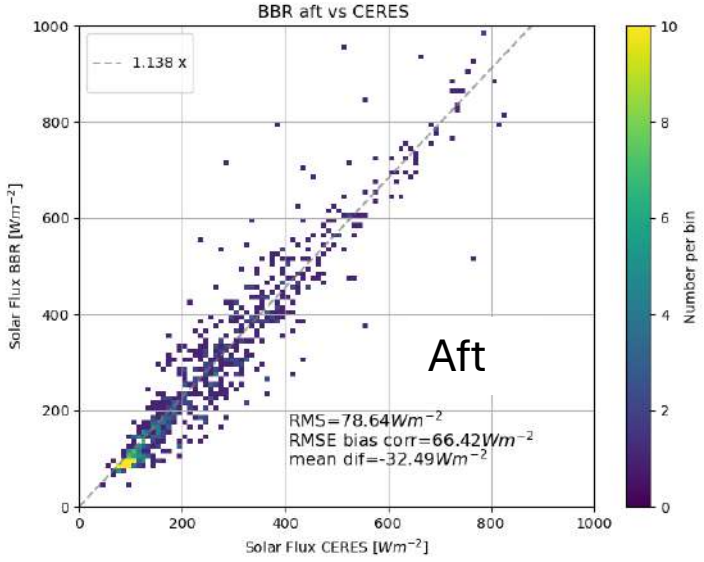
10 August 2024 to
14 February 2025

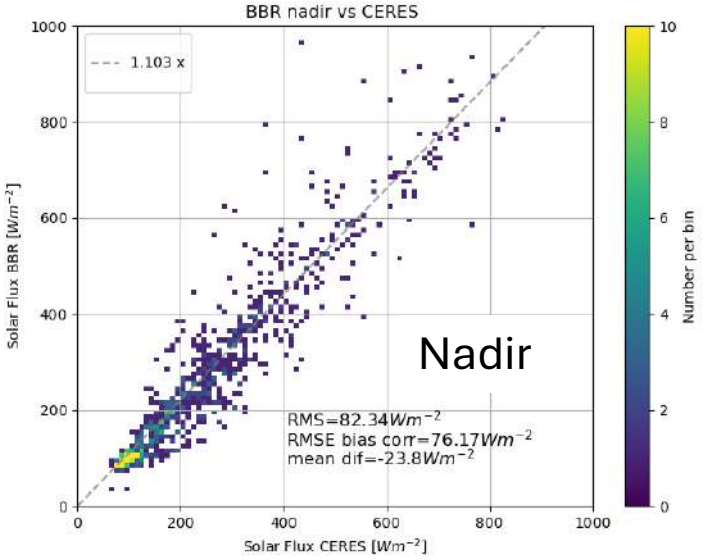
Terra - day
Terra - night
NOAA20 - day
NOAA20 - night

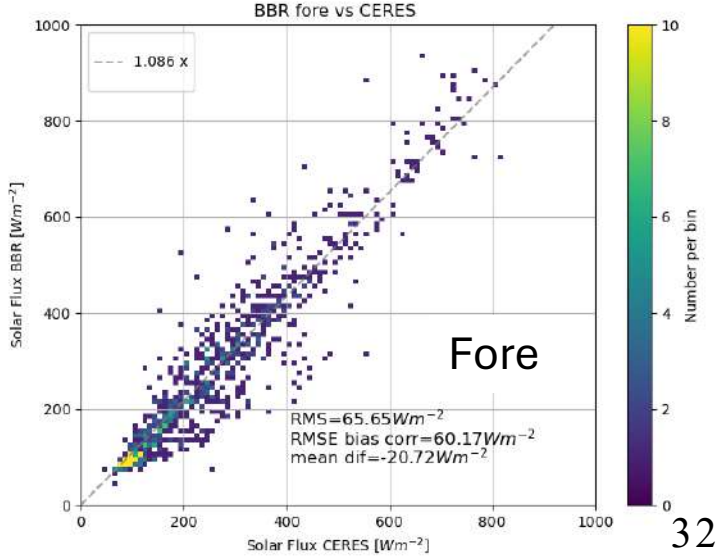


CERES VZA < 50°
Δdist < 3 km
Δtime < 5 min



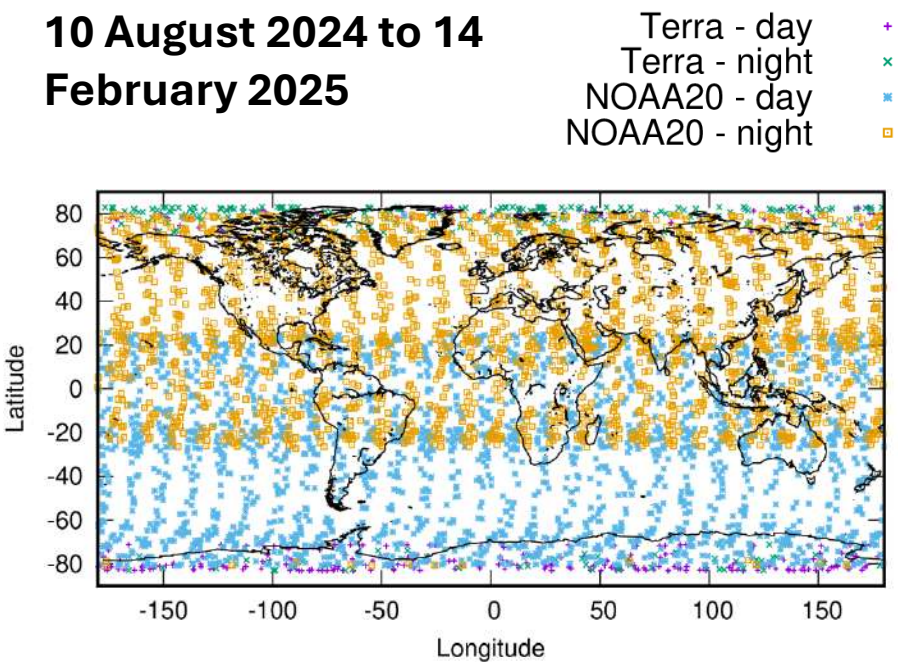




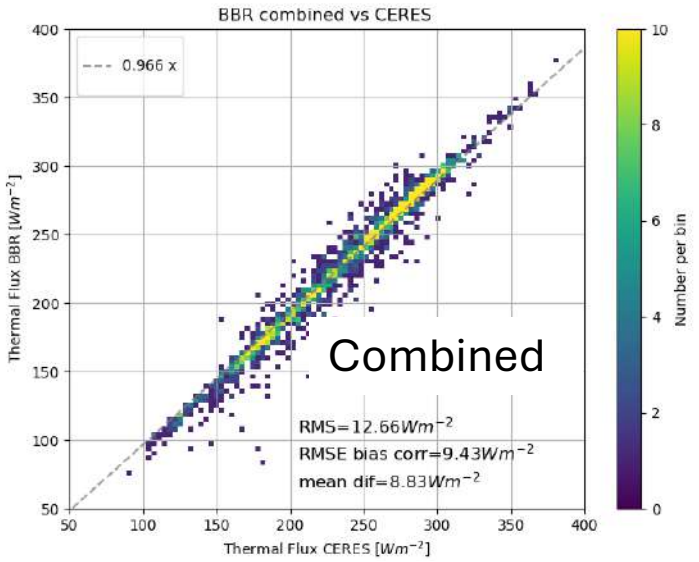


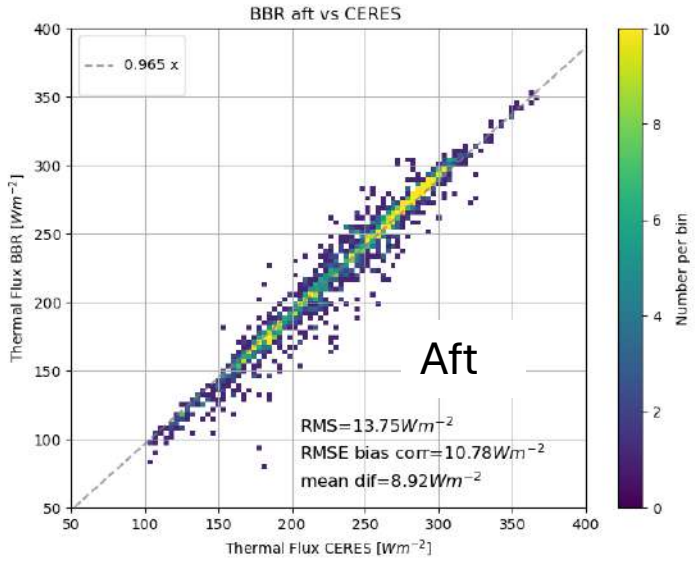
CERES FLASHflux comparison: LW Flux

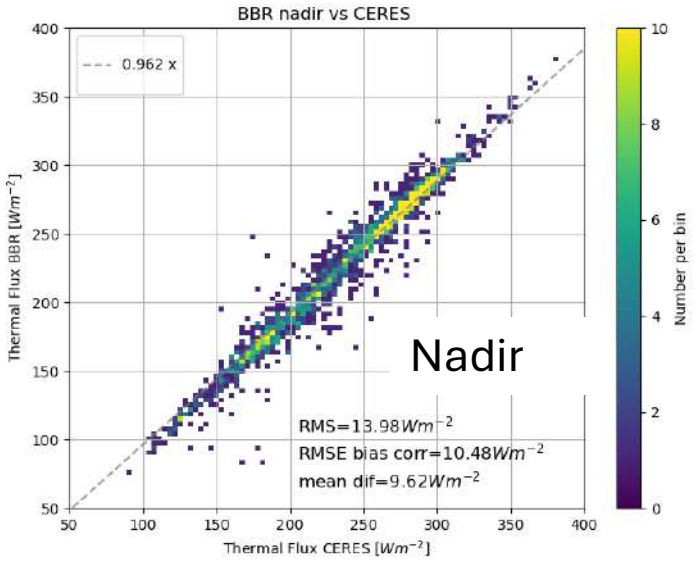
10 August 2024 to 14 February 2025

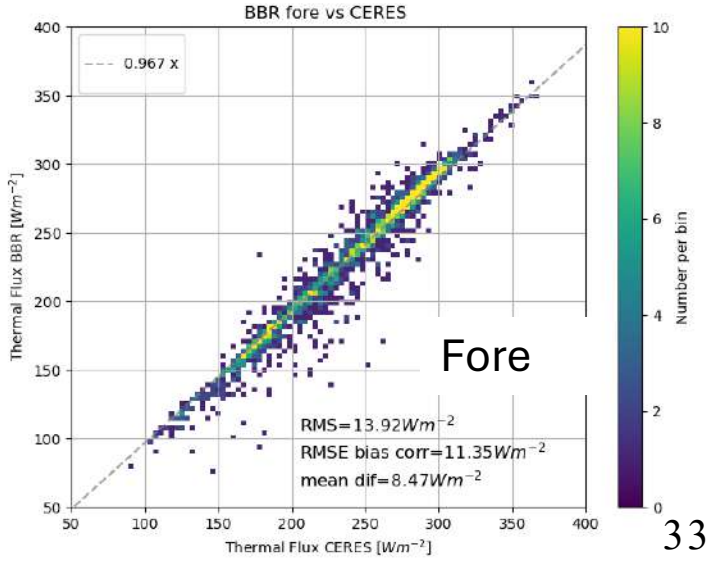


CERES VZA < 50°
Δdist < 3 km
Δtime < 5 min









Summary

- Very good agreement for the BBR LW off-nadir radiances in all the resolutions (STD, Small and AD and Full Resolution)
  - New baseline available (AD) for BBR L1 since 13/01/2025 frame 3571B masking the dead pixel

- LW fluxes show very good agreement between the 3 views

- SW fluxes comparison is more complicated→Sensitive to co-registration of the off-nadir views, cloud mask/properties, CTH, MSI radiances, ADMs, etc.

- Preliminary comparisons with CERES FLASHflux suggest that BBR SW fluxes are brighter than CERES and BBR LW fluxes are lower → to be verified when CERES SSF data is available.
  - RMSE in the SW likely affected by collocation and not representative of the instantaneous combined flux error

- Good agreement with GERB-1 radiances over Indian Ocean. BBR solar radiances brighter than GERB, thermal lower.

- Future work: evaluate impact of proposed update on the BBR L1 calibration on the radiances and fluxes.

Recommendations to users

- Choose resolution -> No combined flux in the Full resolution
- If radiance comparisons using the 3 BBR-views -> BMA-FLX co-registered radiances
- Check quality status flags
- Read disclaimers for BM-RAD (available in ECVT) and BMA-FLX (to be published soon)
- BM-RAD and BMA-FLX description in:

Velázquez Blázquez, A., Baudrez, E., Clerbaux, N., and Domenech, C.: Unfiltering of the EarthCARE Broadband Radiometer (BBR) observations: the BM-RAD product, Atmos. Meas. Tech., 17, 4245–4256, https://doi.org/10.5194/amt-17-4245-2024, 2024.

Velázquez Blázquez, A., Domenech, C., Baudrez, E., Clerbaux, N., Salas Molar, C., and Madenach, N.: Retrieval of top-of-atmosphere fluxes from combined EarthCARE lidar, imager, and broadband radiometer observations: the BMA-FLX product, Atmos. Meas. Tech., 17, 7007–7026, https://doi.org/10.5194/amt-17-7007-2024, 2024.

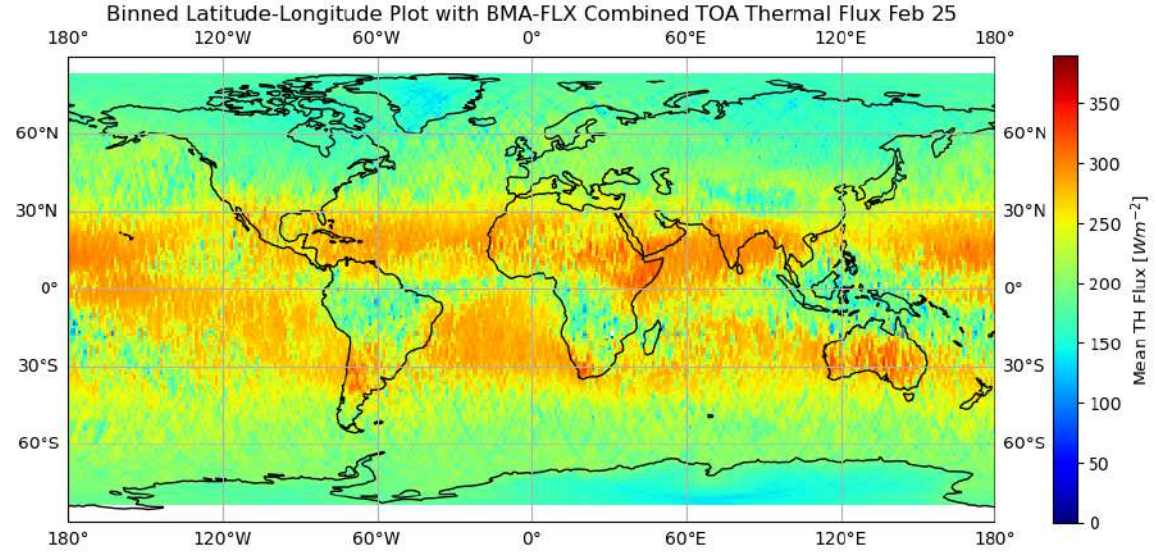
- Questions? https://ecvt.csde.esa.int/forum/
  almudena.velazquez@meteo.be

Thank you!

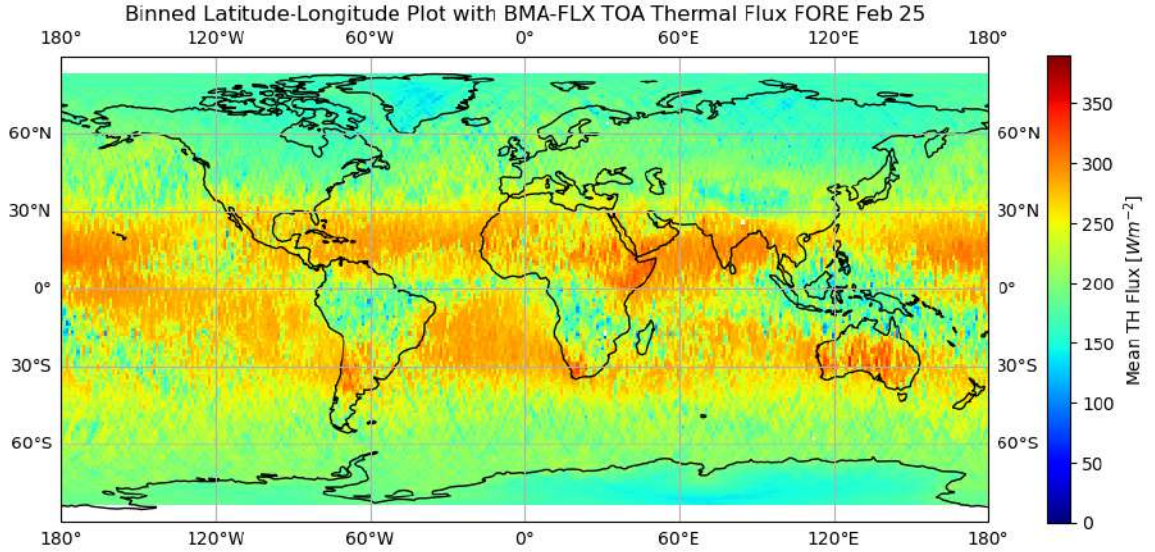
almudena.Velazquez@meteo.be

THERMAL

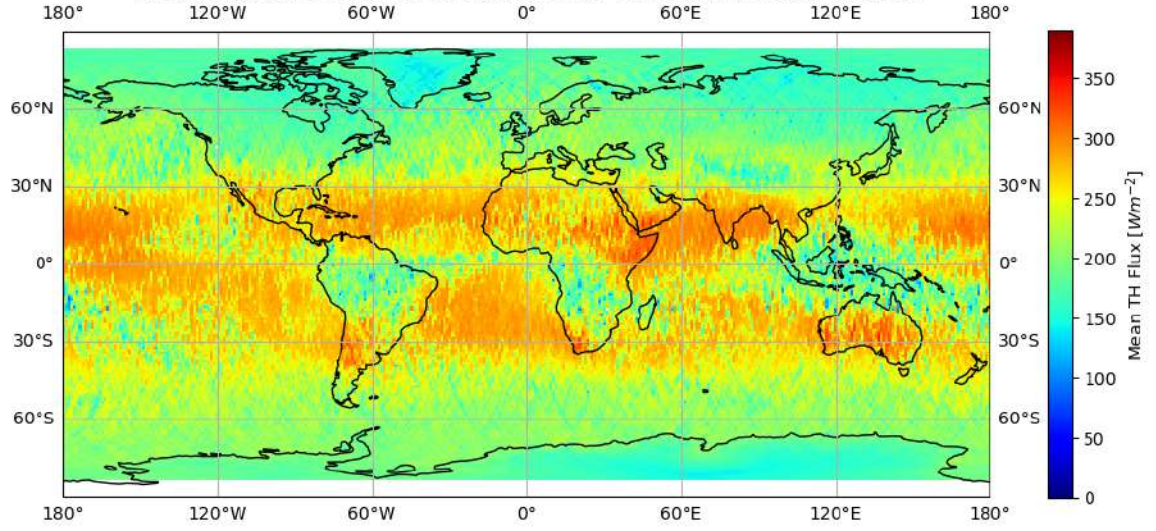
COMBINED



FORE



AFT



NADIR