Unfiltering of the EarthCARE BBR instrument

BM-RAD processor

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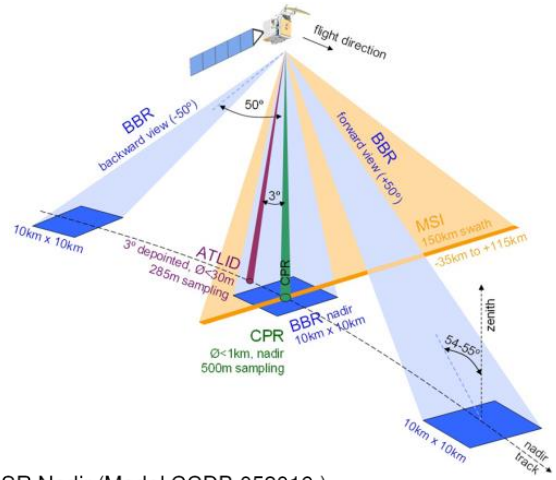
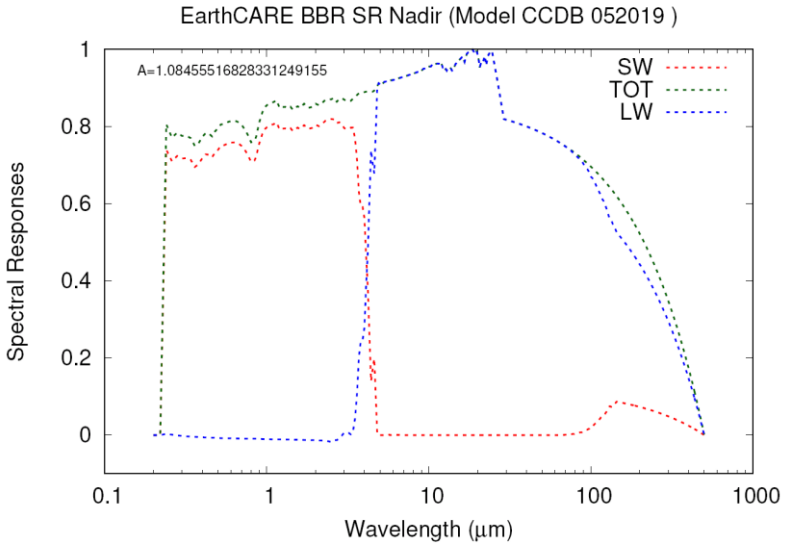
BBR instrument unfiltering



- The BBR will measure **SW** (0.2 - 4µm) and **TW** (0.2 - >50µm) radiances at three fixed viewing zenith angles
- Filtered radiances are converted into **unfiltered radiances**: correction of the limited and non-uniform ϕ(λ)
- Accurate characterization of the Spectral Response, ϕ(λ), needed
- Information (assumption) about scene spectral signature is also needed
- Errors introduced in the unfiltering are related to the spectral variability of the ϕ(λ)
- Unfiltering method based on theoretically simulated filtered and unfiltered radiances (LibRadtran 1.4)



$$\phi_{tot}(\lambda) = \phi_{\det}(\lambda) \cdot \phi_{teles}(\lambda)$$

$$\phi_{sw}(\lambda) = \phi_{\det}(\lambda) \cdot \phi_{teles}(\lambda) \cdot \phi_{quartz}(\lambda)$$

$$L_{LW} = L_{TOT} - A \cdot L_{SW}$$

$$\phi_{LW}(\lambda) = \phi_{tot}(\lambda) - A \cdot \phi_{SW}(\lambda)$$

BM-RAD product: Unfiltering

Input Products	▪ B-NOM, B-SNG ▪ M-RGR, M-CM ▪ X-JSG ▪ X-MET
Output Products	▪ Filtered BBR SW and LW radiances ▪ **Unfiltered BBR SW and LW radiances** ▪ IGBP surface types in the BBR PSFs ▪ BBR PSF-weighted MSI cloud products
6 Spatial resolutions	▪ BBR grid Small, Full, Standard ▪ JSG Assessment Domain, JSG and JSG PSF corrected (only nadir)

Integration areas (PSF)

On **BBR grid**:

- 10 km x 10km : **Standard** resolution
- 5 km x 10km : **Small** resolution
- Full swath x 10km : **Full** resolution, no combined flux

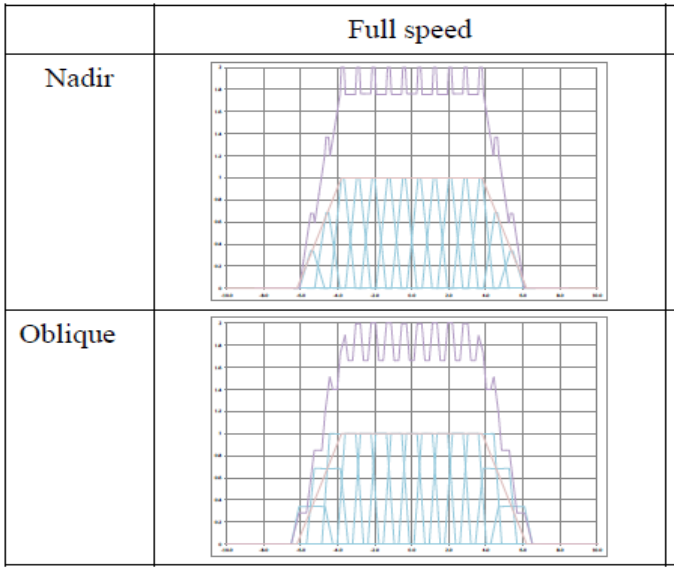
resolutions sampled @1km

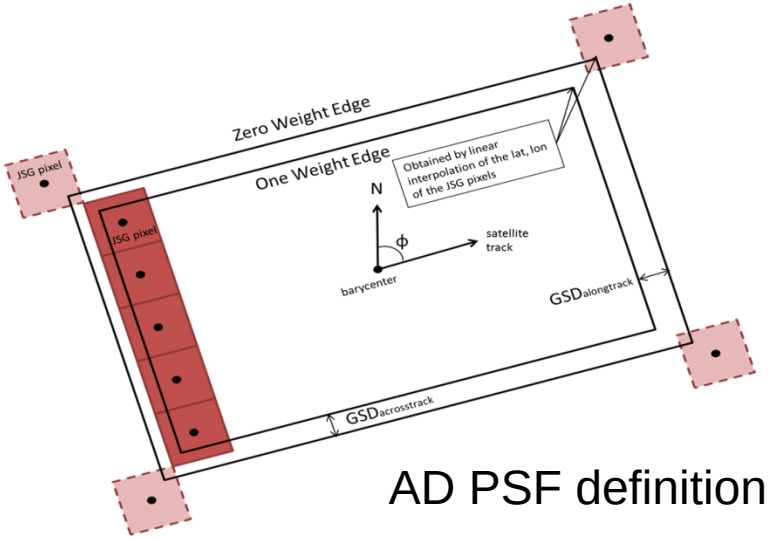
On **Joint Standard Grid** (JSG):

- 5 JSG x 21 JSG : **Assessment Domain (configurable)**
- **JSG pixel**: only SW and LW radiances

Resolutions sampled @ 1JSG

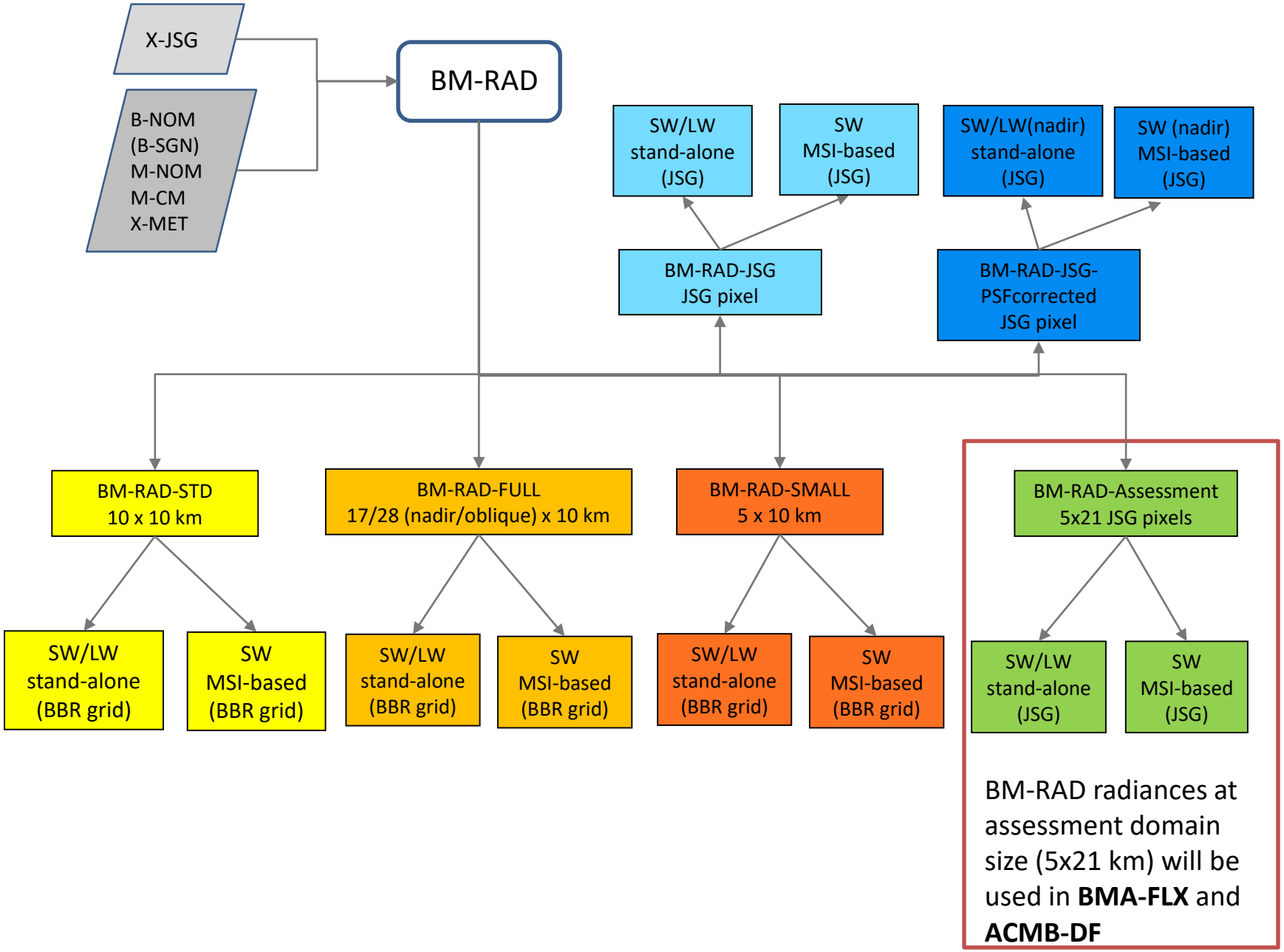
10 km along-track integration





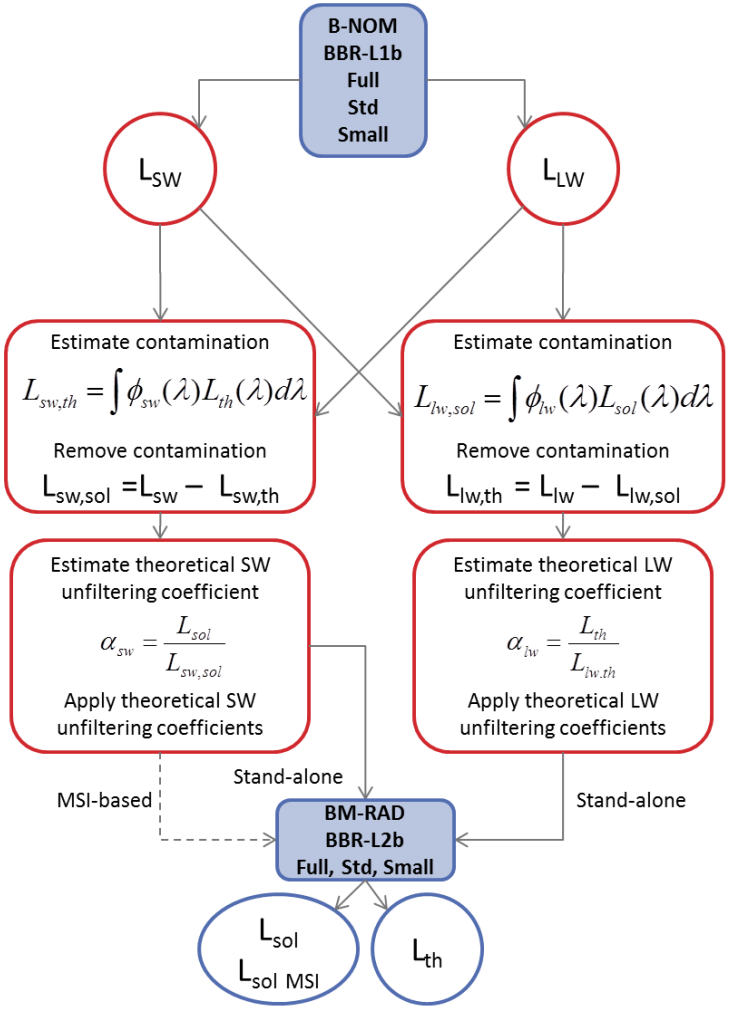
AD PSF definition

BM-RAD product: spatial resolutions

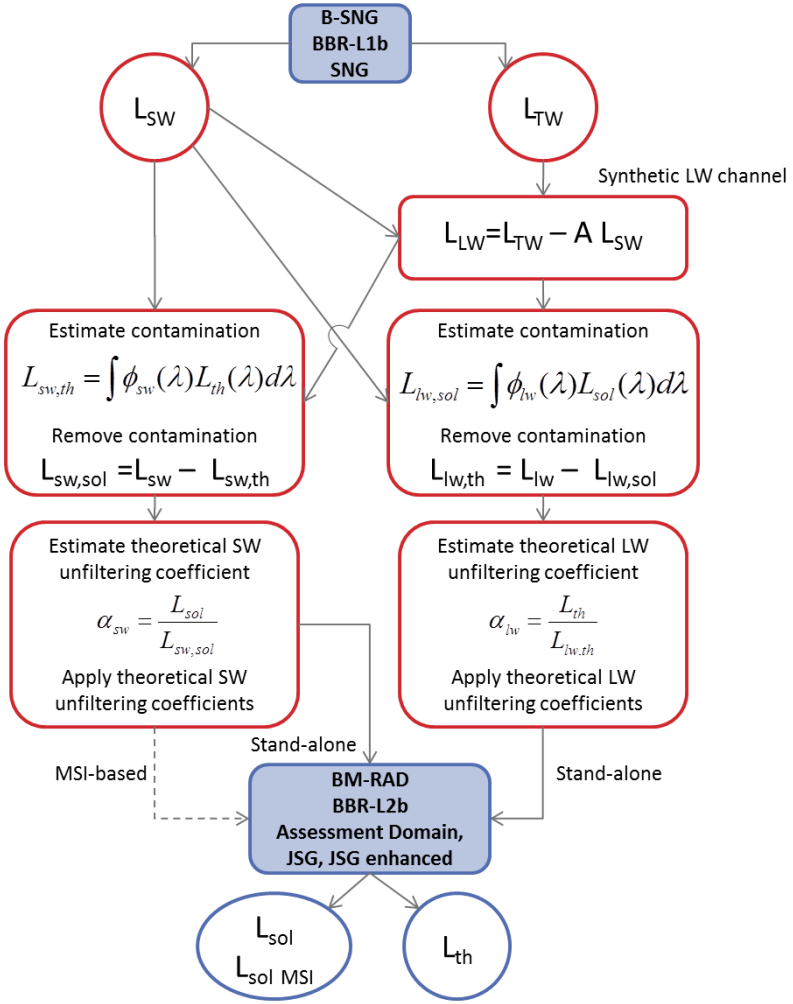


Unfiltering scheme

Full, Standard and Small resolutions

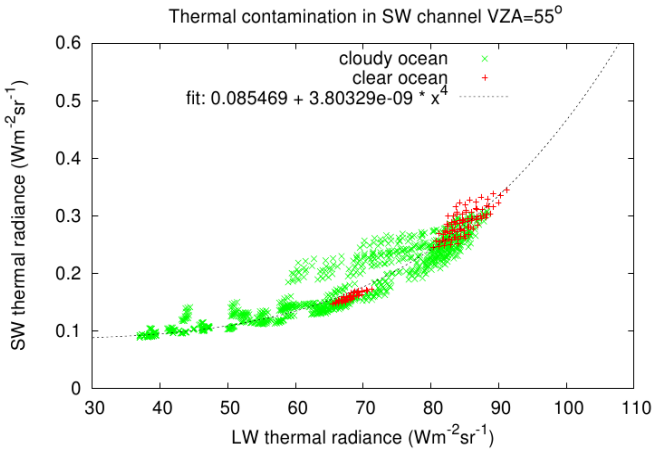


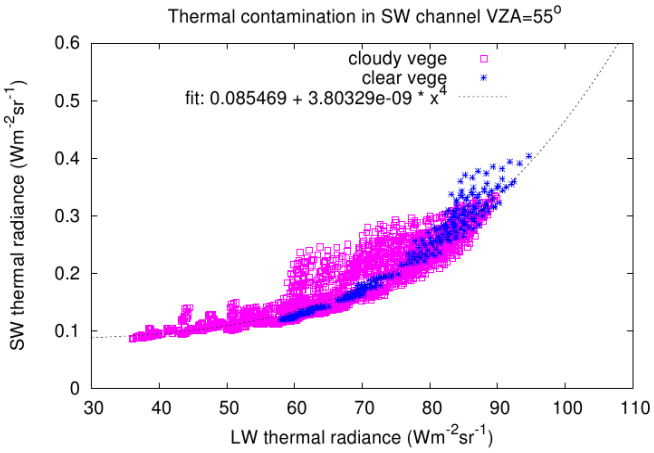
Assessment Domain and JSG resolutions

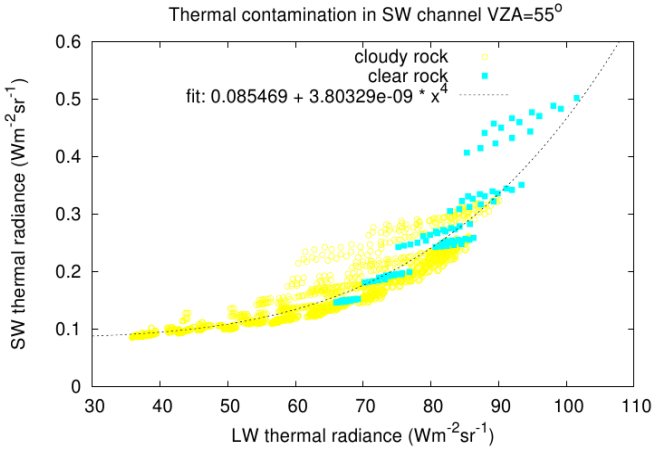


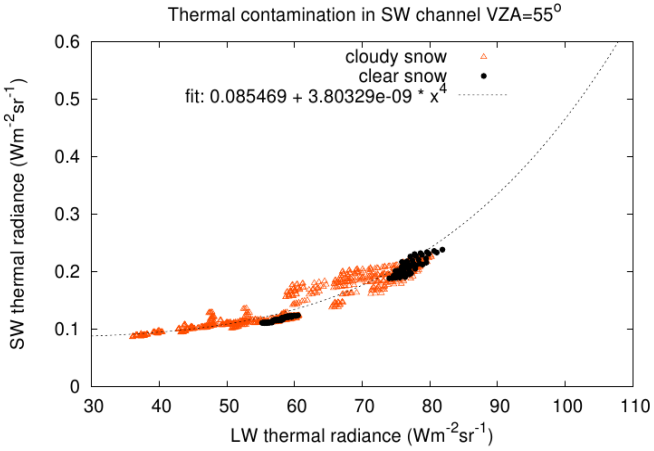
BM-RAD: Thermal contamination in the SW channel

$$L_{sw,th} = a + L^4_{lw,th}$$









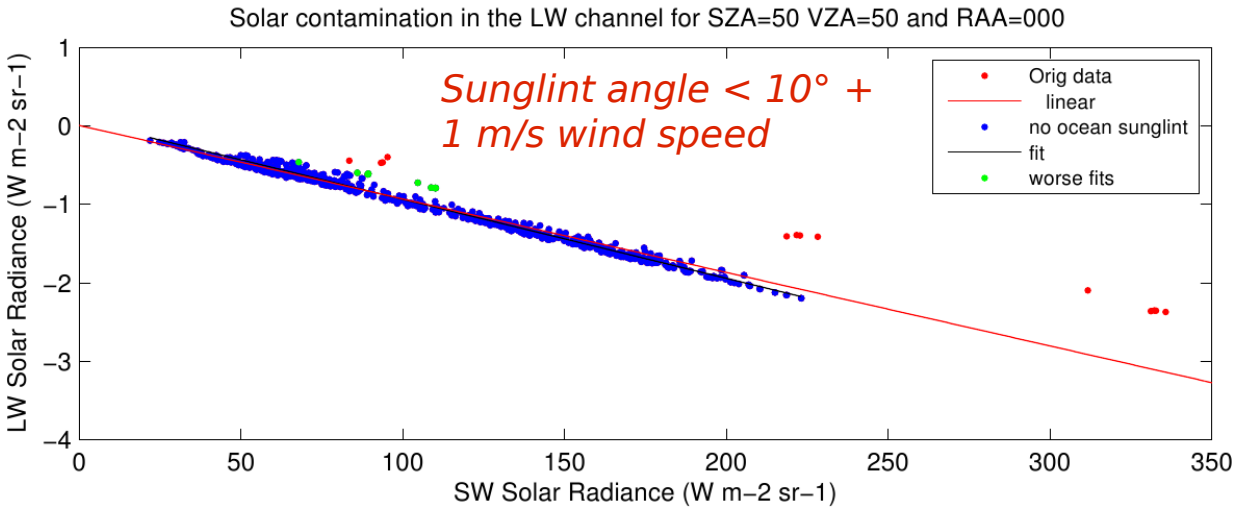
Higher errors:

- Scenes with higher temperature (bright desert scenes) + scenes with high content of water vapor in warm atmospheres (tropical and mid-latitude summer)

- Ice-phase high clouds (placed at 12 km)

Full description of the method and results in "ATBD"

BM-RAD: Solar contamination in the LW channel

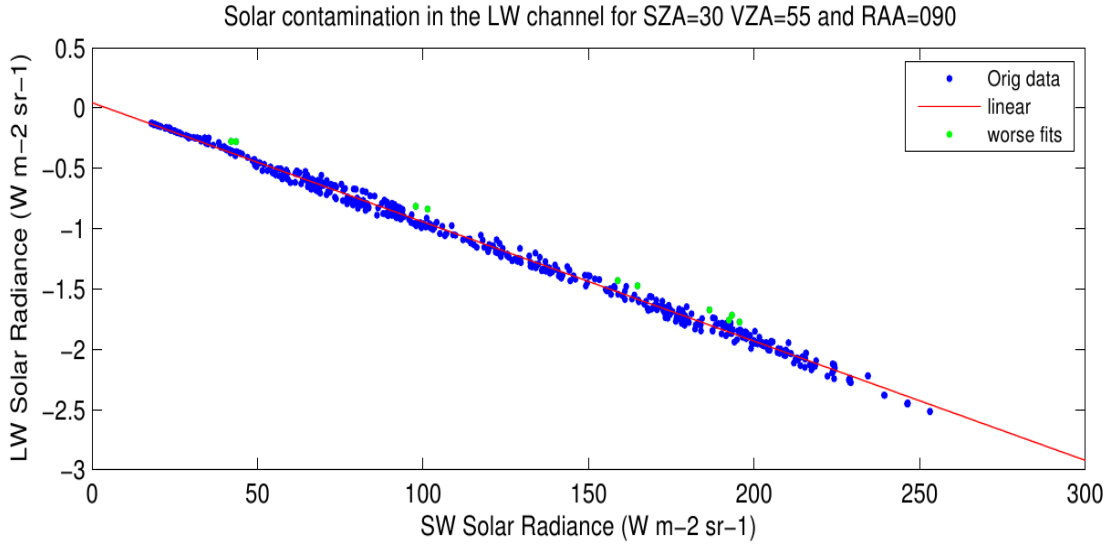


Higher errors:
sunglint situations over flat ocean surface (low wind speed)
For sunglint cases the error estimated is about 0.5 Wm−2sr−1 for a typical ocean
clear sky LW radiance of 80 Wm−2sr−1 (thus ~ 0.6 % error)

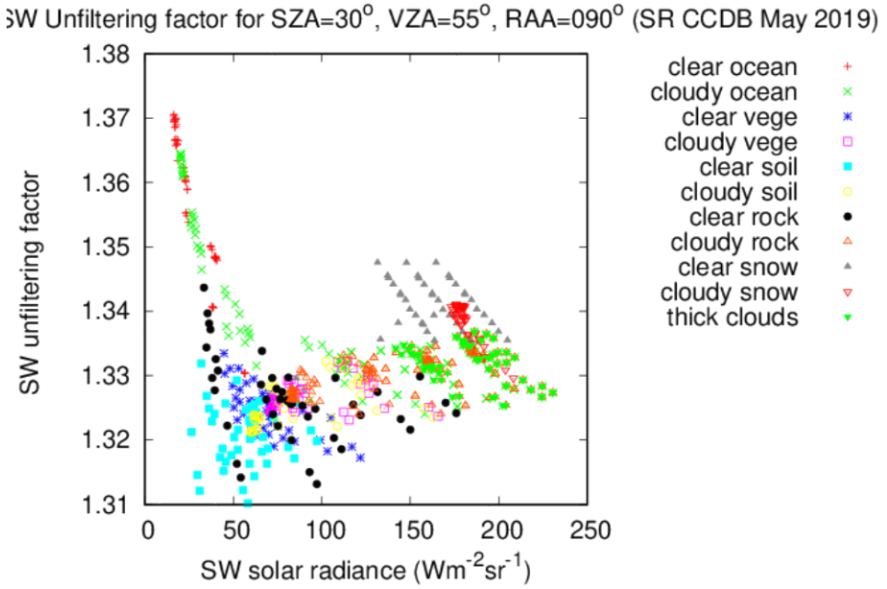
RMS error is 0.039 Wm−2sr−1 typical signal in the LW channel (~60 Wm−2sr−1)

$$L_{lw,sol} = a \cdot L_{sw,sol}$$

Full description of the method and r

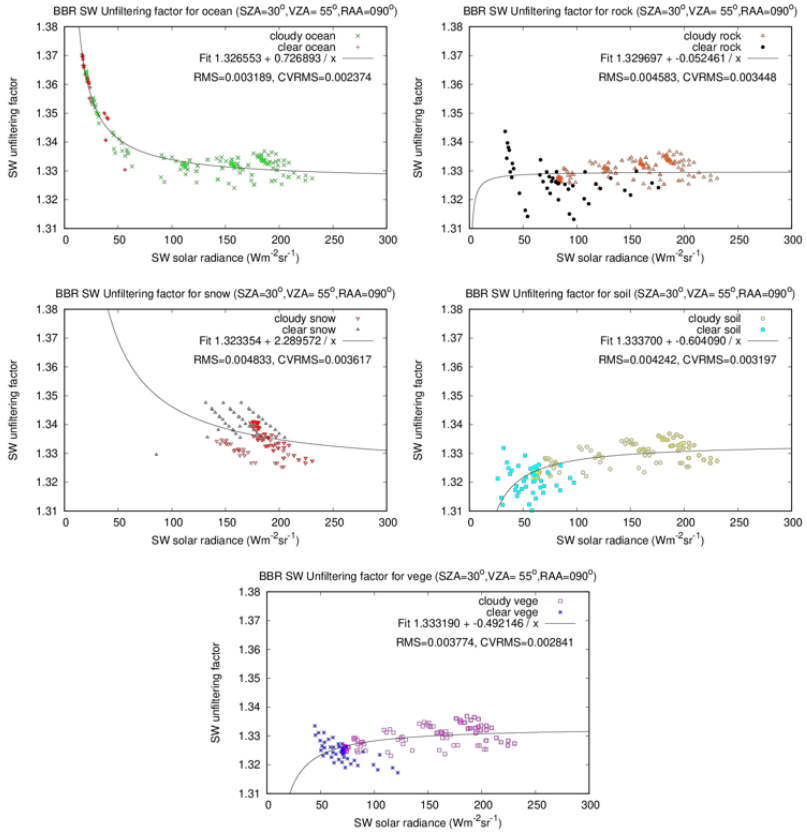


BM-RAD: Stand Alone SW Unfiltering



Surface type dependent
Hyperbolic fit

$$\alpha_{sw} = a + b/L_{sw,sol}$$



Surface type	<RMS α_{sw} >	$E_{5\%}$	$E_{95\%}$
ocean	0.0043	0.0036	0.0051
vege	0.0046	0.0035	0.0051
soil	0.0056	0.0040	0.0065
rock	0.0055	0.0039	0.0063
snow	0.0059	0.0044	0.0069

Coef. Dependent on SZA, VZA, RAA

Full description of the method and results in "ATBD"

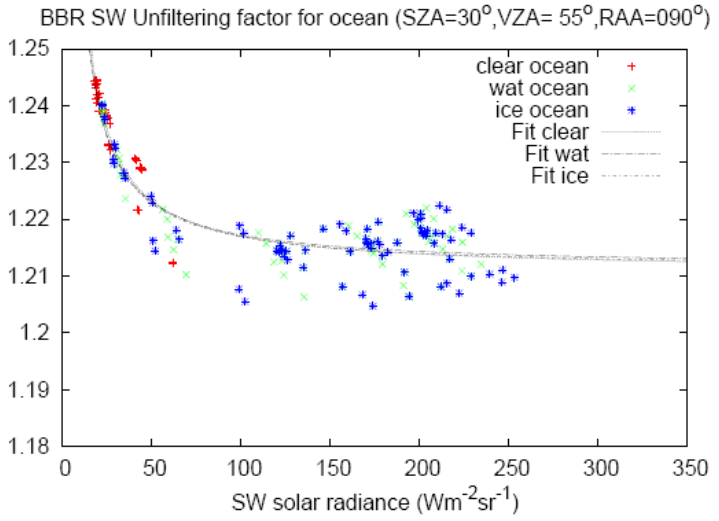
BM-RAD: MSI based SW Unfiltering

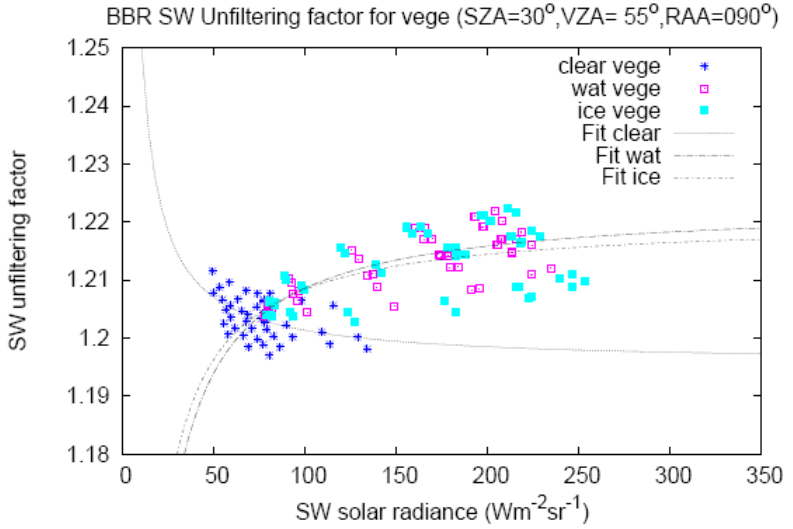
Cloud phase and cloud mask dependent (M-CM)

Hyperbolic fit:

$$\alpha_{sw} = a + b/L_{sw,sol}$$

Slightly better results than Stand-Alone





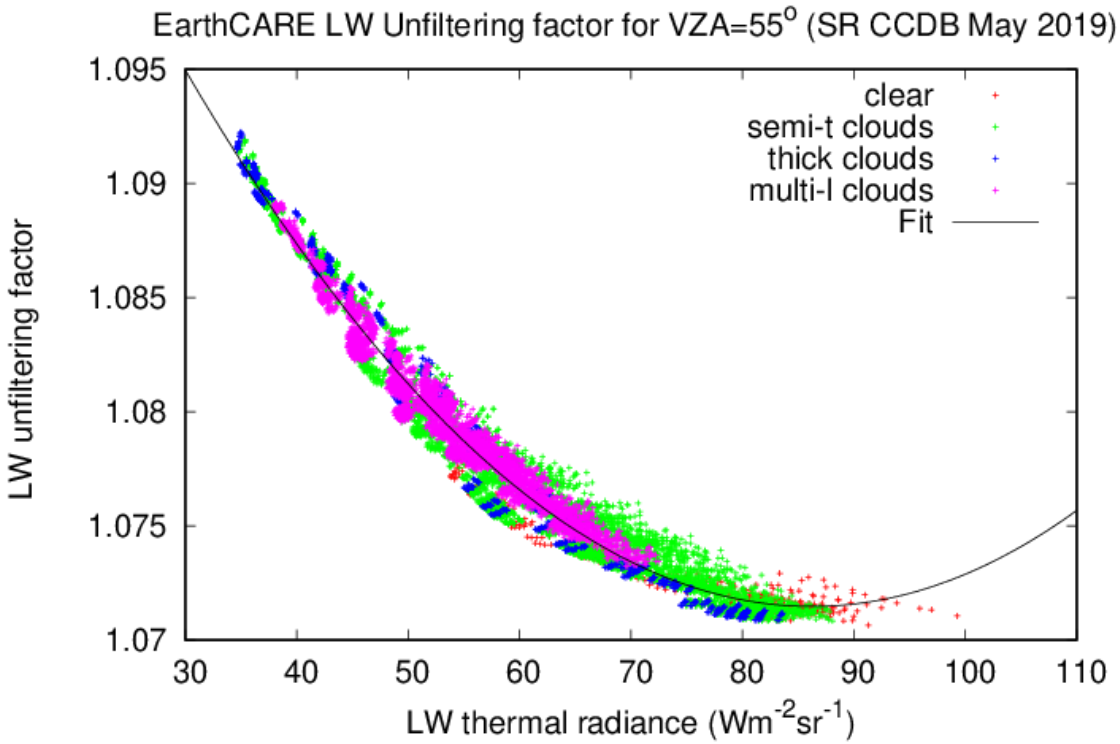
Coef. Dependent on SZA, VZA, RAA

Full description of the method and resul

Stand Alone LW Unfiltering

Surface type independent
Parabolic fit

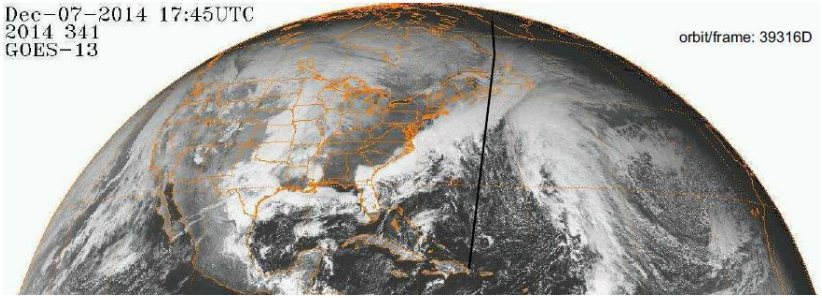
$$\alpha_{lw} = a + b \cdot L_{lw,th} + c \cdot L_{lw,th}^2$$



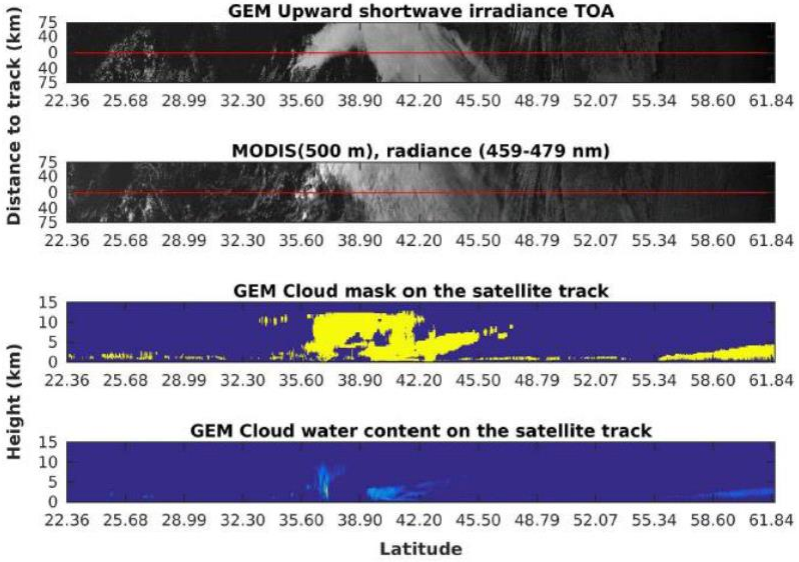
RMS error on factor ~ 0.0008
RMS error on radiance ~ 0.05 W/m²/sr

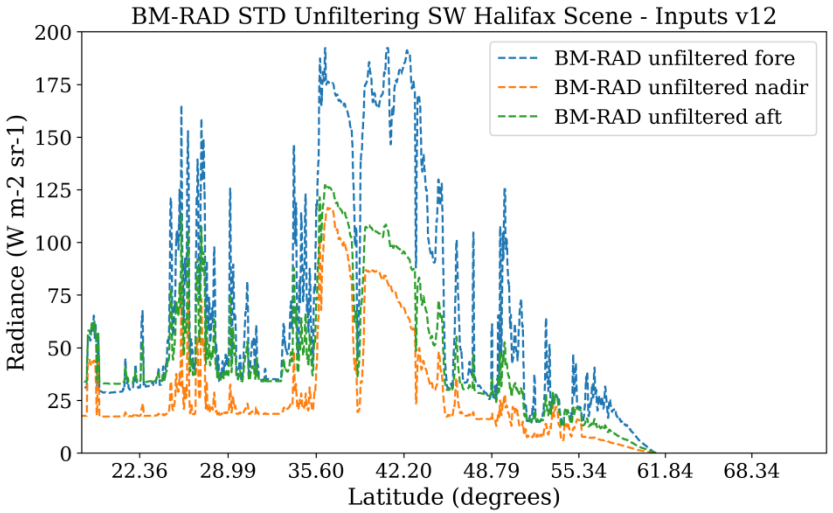
Full description of the method and results in "ATBD"

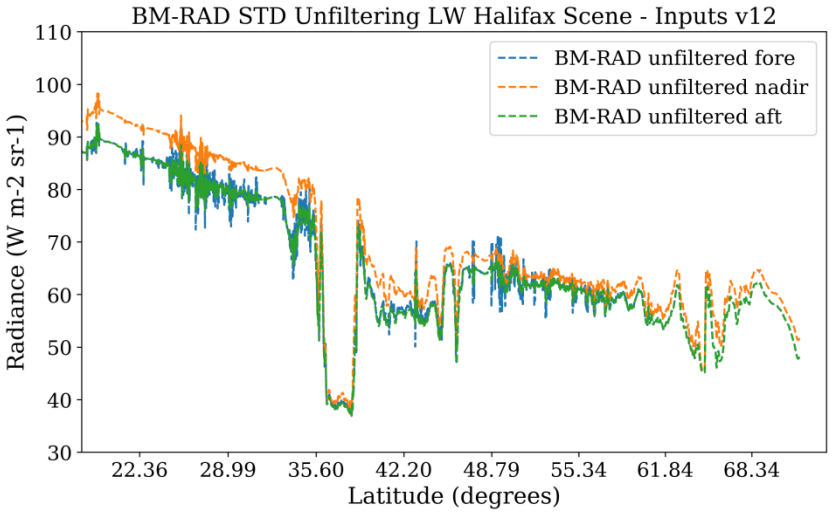
Unfiltering Halifax Scene v12

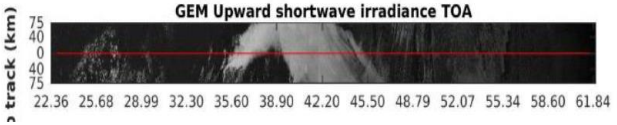


This case includes Sun just below the horizon over Greenland, cold air over Labrador, a cold-front near Halifax, dense overcast south of Halifax, and scattered shallow convection south of Bermuda.

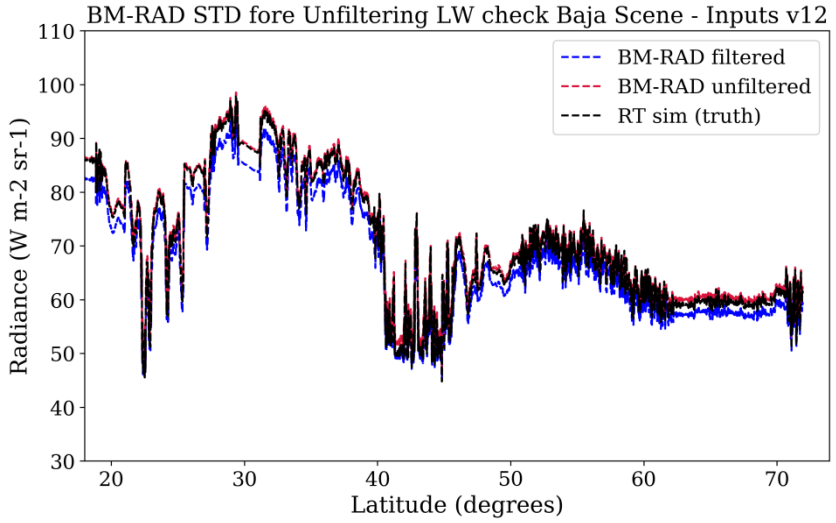


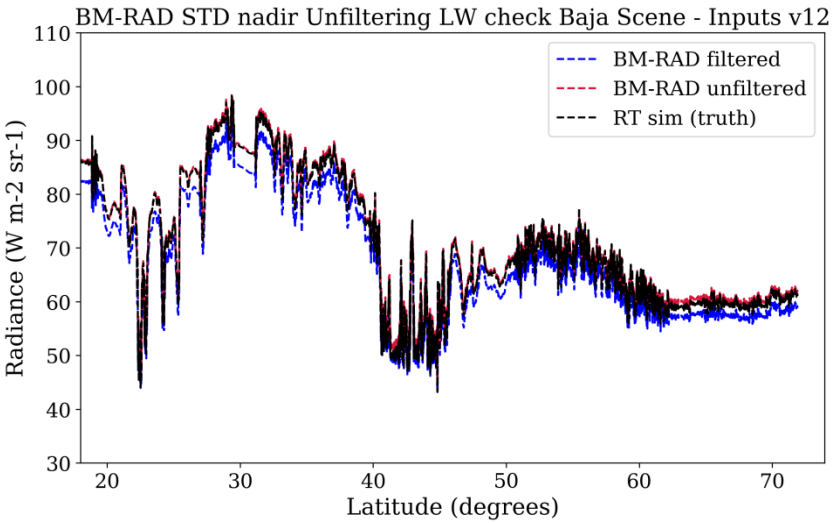


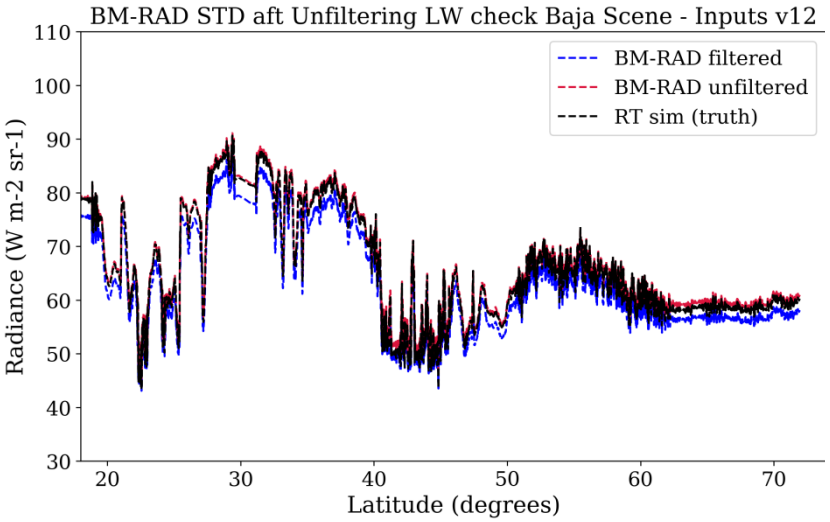


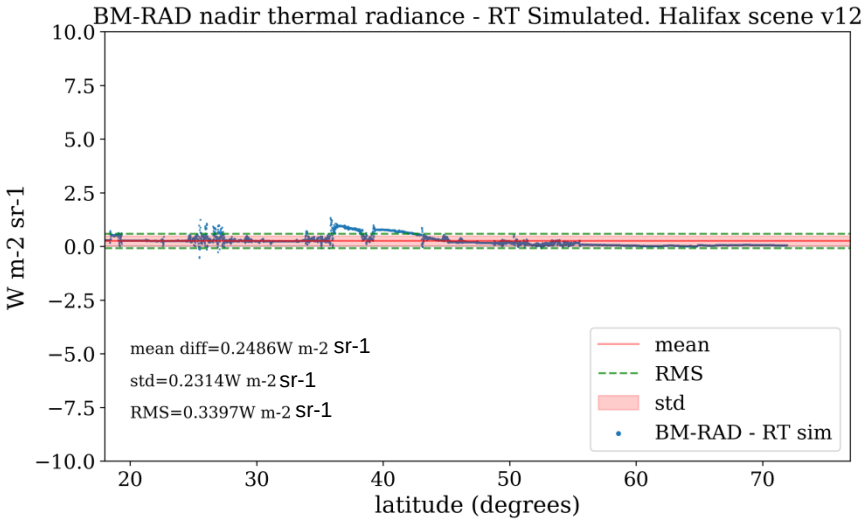


LW Unfiltering check: BM-RAD vs Baja integrated radiances in the STD domain

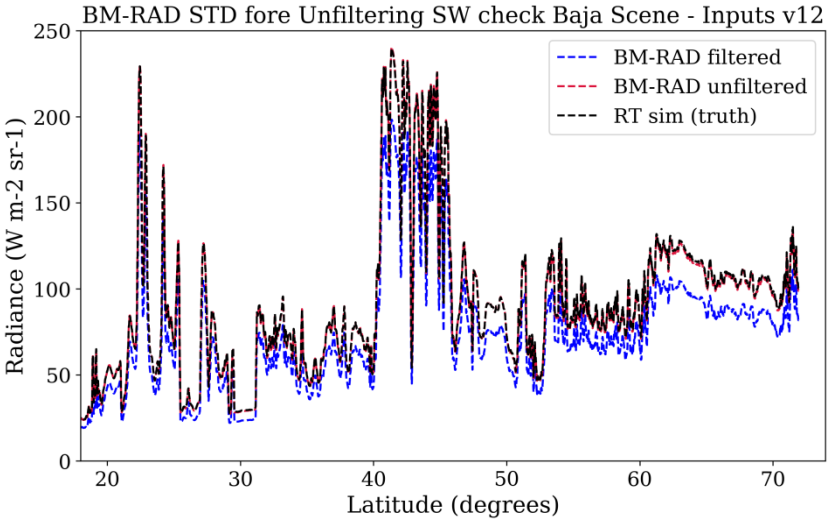


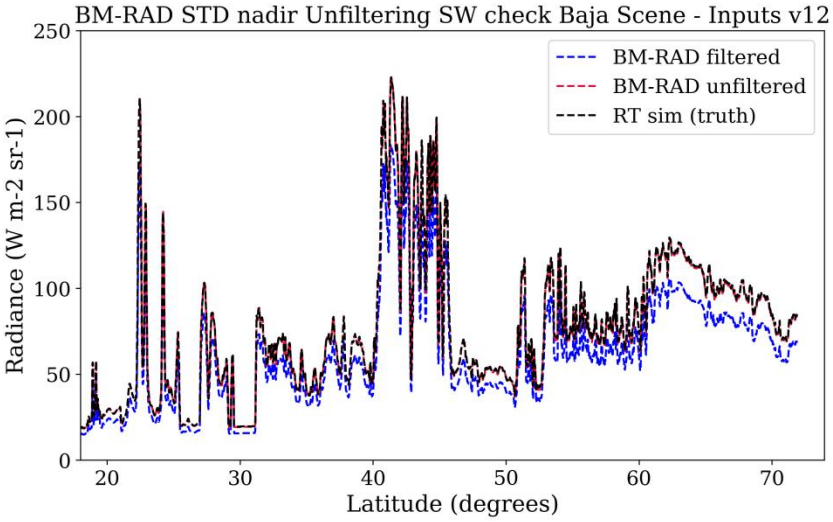


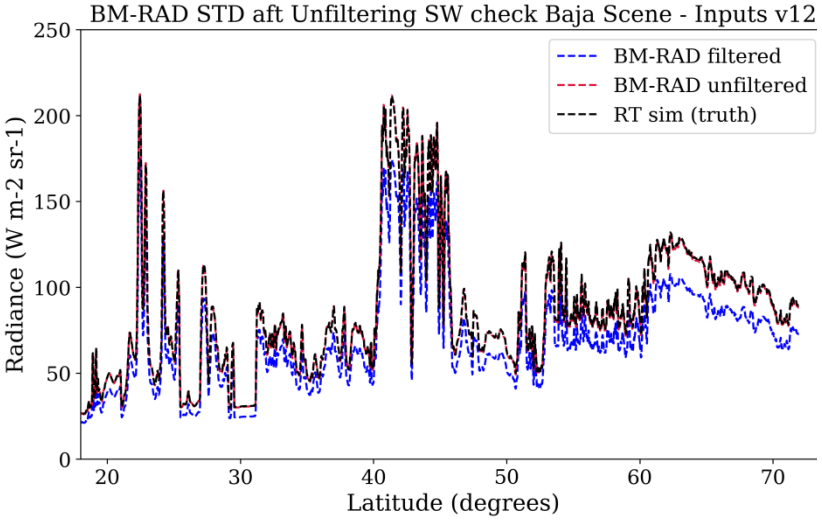


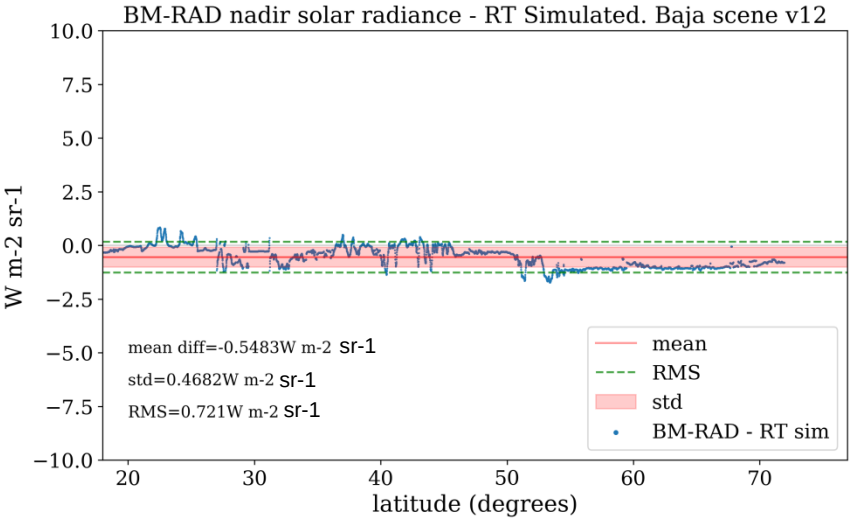


SW Unfiltering check: BM-RAD vs Baja integrated radiances in the STD domain









Summary

- **Unfiltering** algorithm performing as expected.
- Very good agreement between output of BM-RAD processor and RT simulated Radiances from GEM scenes
  - RMS < 0.5 W m-2 sr-1 in the LW
  - RMS < 1 W m-2 sr-1 in the SW Standalone Unfiltering / MSI based
- Chaining with **BMA-FLX processor** successfully tested during CLARA and ICERAD activities
- **Thermal contamination in the SW channel** can be further validated during Commissioning since during night time the measurement of the SW channel will correspond to the Thermal contamination.
- **Spectral response considerations** :
  - The flatter the SR, the simpler and more accurate the unfiltering.
  - Any change in the spectral response will consequently lead to a change in the contamination, unfiltering coefficients and errors associated

  → to be monitored during commissioning by monitoring reference scene observations
- Unfiltering is **key** in the BBR processing -> Error in the unfiltering propagate to fluxes (**BMA-FLX**)
- **JSG pixel resolution** to be implemented during CARDINAL.
- Coangular co-incident observations with **GERB** and **CERES** will be analysed to assess the Unfiltering process.
- **V8.0** of the software delivered and accepted