EarthCARE Validation Workshop

Session on “Radiation” - 28 May 2021

Covered products:

- MSI L1 (M-NOM)
- BBR L1 (B-NOM, B-SNG)
- BBR L2 (BM-RAD, BMA-FLX)

Note : surface radiation in “Model” session !

2nd ESA EarthCARE Validation Workshop

25-28 May 2021 (online)

Session's Agenda – Proposals related to "Radiation"

28-MAY-2021	Chairs:	Nicolas Clerbaux, Jurgen Fischer, Almudena Velazquez, Tobias Wehr, Michael Eisinger		
	13:00	Radiation	Introduction	co-chairs
	13:05		Overview of MSI Level 1 validation by ECVT (AO PIs)	**Jurgen Fischer- FU Berlin**
	13:10		Lessons learned/Monitoring MSI L1 performance	**Noëlle Scott - LMD/IPSL**
	13:25		Overview BBR L1/L2 Cal/Val by ECVT (AO PIs)	**Nicolas Clerbaux - RMIB**
	13:30		Lessons learned from CERES	**Kory Priestley - NASA Langley**
	13:45		Lessons learned from GERB	**Jacqueline Russell - Imperial College**
	14:00		Discussion (under consolidation as PI responses are still coming in)	moderated by co-chairs
	14:45	Break (15 min)		

MSI L1 discussion here in the middle

BBR discussion at the end

ECVT 03 : German Initiative for the Validation of EarthCARE (GIVE), Dr Ulla Wandingen		MSI L1 + BBR L2
ECVT 29: Monitoring MSI/EarthCARE L1 Performances using concomitant intercalibration and stand-alone approaches (MMP) – Dr Noelle Scott		MSI L1
ECVT 20 : Validation of EarthCARE products in China - Dr Hu		MSI L1 + BBR L2
ECVT 23: Validation of EarthCARE products towards their homogenization with CALIPSO for consolidating the 3D long-term ESA-LIVAS climatology of aerosols, clouds and radiation (ACROSS) - Dr Vassilis Amiridis		BBR L2
ECVT 06 : Evaluation of EarthCARE Radiances and Fluxes with CERES Data Products – Dr Norman Loeb		BBR L2
ECVT 01: EarthCARE BBR L1 and L2 Products Assessment – Dr Nicolas Clerbaux		BBR L1 + BBR L2

MSI part of the “Radiation” session (chaired by J. Fischer)

BBR part of the “Radiation” session

- Introduction of proposals and feedbacks received (N. Clerbaux, RMIB)
- Lessons Learned from CERES (K. Priestley, NASA Langley)
- Lessons learned from GERB (Jacqui Russell, Imperial College London)
- Discussions

Overview and feedback - German Initiative for the Validation of EarthCARE (GIVE) – Ulla Wandingen

Summary

(…) The proposed activities will allow the validation of the **entire chain** of EarthCARE L1 and L2 products as well as the evaluation of related algorithms and instrument calibrations. The approaches include EarthCARE-to-ground, EarthCARE-to-aircraft and **EarthCARE-to-satellite** comparisons, supported by cloud, aerosol and radiative-transfer modelling. (…) Cross-satellite validation activities will enable the global assessment of EarthCARE products. These experiments will make use of data from **SEVIRI, MODIS, OLCI, SLSTR, AVHRR, MHS and other sensors** to validate EarthCARE aerosol, cloud and **radiation flux** products. (…) It is envisaged to synergistically explore ground-based, airborne and satellite-based Principal Investigator measurements in order to validate the EarthCARE product chain and the radiation closure concept as a whole. These activities will be supported by aerosol, cloud and radiation modelling aiming at the connection of observations and the investigation of spatial and temporal variances of the measured parameters.(…) The team is composed of well-experienced scientists from 11 German institutions with expertise in satellite, airborne and ground-based remote sensing as well as cloud, aerosol and radiation modelling.

Specific activities regarding TOA radiation :

- MSI-like radiances wrt MODIS (Fischer, FUB)
- **BBR radiances wrt CERES, GERB and ScaRaB (Fischer, FUB)**
- **MSI L1 and BBR L2 radiances wrt SEVIRI (Luca Bugliaro, DLR)**

Validation approaches

(…)

- Satellite: Geostationary observations to validate imager products

(…)

Overview and feedback - Validation of EarthCARE products in China - Dr Hu

Summary

The primary objectives of this proposal are to use the China ground-based or Chinese **FengYun polar-orbiting satellite** data to validate the corresponding EarthCare L1/L2 products. Main content includes: (1) Validation of ATLID L1 return signals and extinction coefficient vertical profiles by using ground-based lidar systems; (2) Validation of ATLID L2 integrated aerosol optical depth product using China ground-based sunphotometer network; (3) Radiometric calibration and validation of MSI visible and near infrared bands using Dunhuang China Radiometric Calibration Sites (CRCS) site; (4) Inter-comparison and mutual evaluation of EarthCARE with FY-3 satellite L1/L2 products. After this study, we hope to get some anticipated results: (1) The uncertainties of ATLID L1 products in the region of dust aerosols and polluted city aerosols in China; (2) The uncertainties of ATLID L2 aerosol products over China, which are validated using ground-based sunphotometer instruments; (3**) inter-comparison results between** MSI, **BBR L2**, and combined science products (including aerosol, cloud and radiation) and China **FengYun-3** corresponding products in globe; (4) During this program, the research results of both sides will be published as papers of academic journals, abstract or papers of conference and workshop, posters of meetings, and short articles of newsletters.
The research team is composed of National Satellite Meteorological Center, China Meteorological Administration (NSMC/CMA), Beijing Research Institute of Telemetry, Italian National Research Council (CNR), and University of Naples "Federico II".

Using the ERM instrument on FY-3x?

Overview and feedback - Validation of EarthCARE products towards their homogenization with CALIPSO for consolidating the 3D long-term ESA-LIVAS climatology of aerosols, clouds and radiation (ACROSS)- Dr Vassilis Amiridis

esa

Summary

The overarching objective of ACROSS is to perform thorough cal/val investigations on EarthCARE products **over Greece**, a region well-known for its complex atmospheric environment. The experiments will be designed such as to achieve the following core objectives:
(1) to perform a thorough validation of the EarthCARE stand-alone aerosol and cloud products employing sophisticated ground-based remote sensors and spaceborne observations derived from passive and active satellite instruments;
(2) to utilize the validated aerosol and cloud products **in Radiative Transfer Model (RTM) simulations for depicting radiation** and further intercompare with high-quality solar irradiance measurements at surface (ground-based actinometry) and **at TOA (space-borne radiometers, including BBR);**
(3) to expand ESA-LIVAS for including EarthCARE aerosol, cloud and radiation products, and to utilize the RTM developed in step 2 in order to include CALIPSO-based radiation estimations in the existing ESA-LIVAS aerosol and cloud climatic dataset. LIVAS will contribute on the evaluation of the EarthCARE performance in terms of reproducing well-known climatological patterns at global scale. The validation activities will involve:
•a continuous cal/val activity at three monitoring sites in Greece (Thessaloniki, Athens, Finokalia)
•3 Intensive Observational Periods (IOPs) of 3-month each, including targeted large-scale field experiments in Greece
•on-demand operation of mobile facilities that will be deployed at EarthCARE orbital crossing points in Greece
The project consortium will use quality-assured instrumentation including (…). For the **TOA EarthCARE product** validation, satellite multi-sensor synergies will be utilized, using aerosol and cloud retrievals from passive sensors in polar (e.g. MODIS, VIIRS) and geostationary (e.g. SEVIRI) orbits but also solar radiation retrievals acquired by **CERES and TOA Radiation GERB/SEVIRI product**. In terms of scientific requirements, (…)

Overview and feedback - Evaluation of EarthCARE Radiances and Fluxes with CERES Data Products – Dr Norman Loeb (NASA Langley)

Summary

(…) The proposed work consists of four parts,

1) evaluation of **broadband radiances observed by the BBR instrument** with co-located broadband radiances observed by **CERES** instruments,

2) evaluation of broadband **top-of-atmosphere (TOA) fluxes** derived from BBR radiance observations with co-located **CERES- and geostationary-derived TOA fluxes**,

3) evaluation of EarthCARE computed TOA and surface fluxes with fluxes derived from CERES algorithms and surface observations, and

4) evaluation of EarthCARE cloud properties with cloud properties derived from Moderate Resolution Imaging Spectroradiometer (MODIS) and geostationary satellites with the CERES cloud algorithm, and evaluation of other input variables such as surface albedos and temperature and humidity profiles used in flux computations.

The first part directly addresses the **calibration of the BBR instrument** relative to calibration of CERES instruments. The second part of the proposal examines how **angular distribution model** differences lead to **TOA flux differences**. Because EarthCARE uses shortwave and longwave angular distribution models that differ from those used by CERES, TOA flux differences will likely significantly exceed instrument calibration differences.

(…)

The above four proposed activities also provide an opportunity to evaluate the CERES radiance and flux products. The radiance comparisons provide an independent check on CERES calibration. Because BBR provides broadband radiances at three different angles from the same geolocation over its ground track, **BBR observations are unique** and provide **an ideal dataset to test CERES angular distribution models**. In addition, BBR-derived TOA fluxes provide an evaluation of TOA fluxes inferred from geostationary satellite imagers using narrowband to broadband conversions. Comparisons of surface fluxes and inputs used for flux computations also enable evaluation of CERES surface fluxes and inputs. (…).

Validation approaches and strategies:

BBR and CERES unfiltered radiance comparisons: Unfiltered radiances are compared using collocated footprints. We will use collocated BBR and CERES Aqua or S-NPP footprints near 80-degrees North. Similar comparisons have been made using CERES instruments on Terra and Aqua.

BBR and CERES TOA observed flux computations: Instantaneous shortwave and longwave TOA fluxes derived from BBR will be compared with CERES values from the level-2 CERES Ed4 SSF product. In addition, EarthCARE TOA fluxes derived from angular distribution models will be compared with TOA fluxes derived from geostationary satellite observations.

Computed TOA and surface flux computations: Instantaneous TOA and surface fluxes from EarthCARE products will be compared with CERES computed instantaneous TOA and surface fluxes using collocated footprints with observation time separation of less than 15 minutes.

Surface flux evaluation with surface observations: Currently, the CERES team uses surface flux observations at 46 buoys and 36 ground sites.

Overview and feedback - EarthCARE BBR L1 and L2 Products Assessment – Dr Nicolas Clerbaux (RMIB)

Summary

BRR instrument performance and **product quality** will be thoroughly assessed by a series of validation activities. These will establish the quality of **the level 1** instrument radiances at both **the nominal 10x10km²** spatially integrated scale (B-NOM) and **at detector level (B-SNG**). Assessment will address **spatial and radiometric accuracy**, **consistency**, **stability**, **noise** and **anomalous behaviour**. Both level 1 and level 2 product assessment will use Earth reference targets including **deep convective clouds** and **coastlines** and co-incident **MSI** observations to inform the analysis. The evaluation of the level 2 products (BM-RAD and BMA-FLX) will also involve comparisons against independent broadband measurements from **CERES**, **GERB** or **ScaRaB**. Level 2 evaluation will provide assessment of both the level 2 processing and the quality of the underlying level 1 data.

(…)

Assessment during the 6 months commissioning phase will put primary focus on the level 1 data to establish basic data integrity, noise characteristics, gain stability and the **effect of chopper drum speed** on the science products. Results will inform discussions on the optimum operating configuration and provide recommendations for the lifetime of the mission. A preliminary BBR validation report will document the results for the Commissioning Phase review.

Over the 3 year mission, products will be further evaluated and monitored, with **changes to instrument response** regularly assessed. Dedicated analysis of level 2 products may result in recommendations for updates to the level 2 processing (e.g. BBR radiance unfiltering or radiance to flux conversions). All findings will be consolidated in a BBR validation report provided to ESA at end of the project, 3 years after commissioning.

(…)

Proposal updates

- *Drift of Terra and Aqua will be investigated to improved collocation*

Common practices applied to QA/QC

- Simultaneous Nadir Overpass(SNO) (NOAA/NESDIS)
- Deep Convective Clouds
- Statistical analysis of BBR detector signals
- Comparison of BBR with MSI Narrowband-to-Broadband

Validation approaches and strategies:

- *CERES and BBR have different Spectral Responses. If errors in the comparison of unfiltered radiances are found, comparisons between filtered radiances will be considered after wavelength differences compensation.*
- *Matching of observations in place and time → ~NOAA-20 (CERES-FM6) DN 12:40 and BBR DN 14:00 Aqua AN 13:30 (drift in 2023?), Terra AN 10:30 (drift in 2021?),*
- *CERES PSF size is bigger than BBR swath (maximum 18 km nadir) : Need to use MSI to improve matching*
- *Statistical validation analysis according to scene type*
- *A priori CERES SSF will be used. EBAF-like corrections to be investigated with the CERES team.*
- *Selection of geophysical scenes for validation: Deep Convective Clouds, snow, desert, VAS site (Spain)*

BBR part of the "Radiation" session

- Introduction of proposals and feedbacks received (N. Clerbaux, RMIB)
- **Lessons Learned from CERES (K. Priestley, NASA Langley)**
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- Discussions

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BBR L1 & L2 Validation : Discussion Topics

- IOCV : adequacy of IOCV for BBR L1 (see presentation of Kostka Wallace). Are all the planned activities are sufficient ? Adequate? Why not to operate BBR during the first 2 months of commissioning? What about acquisition at different chopper drum mechanism speed?
- BBR L1 / L2 Cal/Val approaches : which reference instrument will be available? collocation, spatial-temporal matching? Drift of Terra and Aqua : problem or opportunity ?
- Synergies with MSI? Excellent for nadir view but quid off-nadir views?
- Ground Sites / Campaigns (Satellite overpass over Validation Sites): "the injection orbit will be established in September 2021 but nevertheless further details will be decided in a later state. Even once established the orbit will vary by +/- 25 km. Detailed orbit predictions can only be given several days in advance". Is it okay for Univ. Valencia and Dr. Hu?
- CERES campaign in PAPS? Is it possible with the limited swath of BBR?
- Foster collaboration : seek for possible synergies between the different ECVTs. (eg comparisons CERES – EarthCARE BBR). Define responsibilities? Working groups? Visiting scientist? Develop and share common tools (collocation, etc...)? Technical aspects: programming language, format, …
- Are there missing expertize ? Aluminum mirror degradation (expertize in ScaRaB?), aging of the forward view?
- BBR L2 "domains" : are they sufficient/adequate? Are there new requests/requirements for the BM-RAD JSG product?
- (…)

BBR IOCV slides from Kostka Wallace

BBR calibration concept

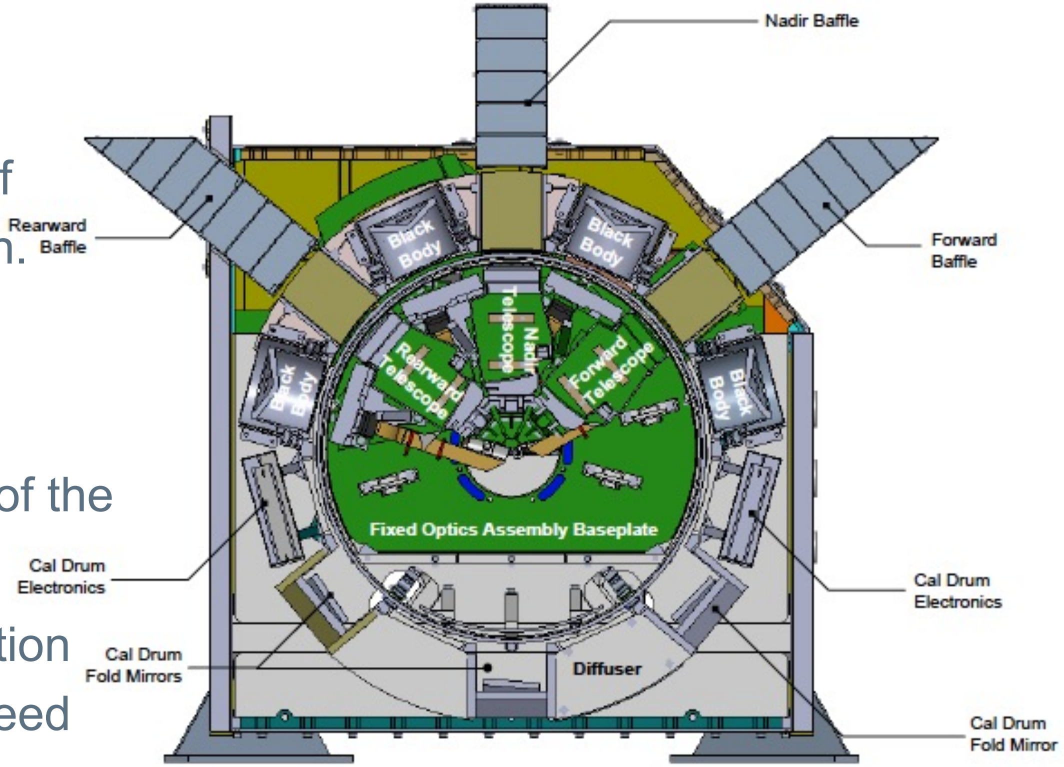
LW and SW data from 3 telescopes; LW data retrieved via subtraction of SW from TW channel.

- Requires knowledge of the instrument and scene spectral response.

Unfiltering can be enhanced with use of MSI data to improved the scene spectral correction factor

BBR calibration approach:

- TW: Two point calibration using hot & cold blackbodies
  - Performed on-board automatically, every 90 s, for removal of signals offset (instrument self emission) & gain determination.
- SW: SW aging data from solar illuminated diffusor.
  - Collected over 30 orbits, every 2 months.
  - Monitor Photo Diodes in the telescope baffles assess aging of the diffuser and filter.
  - L1B products used to plot SW gain ratio, LW spectral correction factor and filter transmission for expert assessment of any need to update CCDB parameters (review every 6 months)



BBR IOCV concept

During Commissioning:

- Switch on, decontamination (12 hr), health status check (telemetry in limits), functional check (mode changes, mechanism movements etc.)
- Detector raw data check (comparison of raw mode and processed output in the instrument ISP to verify on-board DSP.)
- LW performance check from standard L1b data product (gain, LW radiance noise, gain stability).

  Possible updates to blackbody power, calibration interval.
- SW calibration collects data for in-flight reference and any update of calibration parameters

  Performance check compares data against Visible Calibration (VisCal) system on-ground reference characterization and calibration 2 months later (MPD noise and collection of in-flight aging reference SW gain ratio, LW spectral correction factor and filter transmission)
- Detector linearity check via swap of powers to hot and cold BBs over several hours with instrument continuous operation

  Repeated 6 monthly, although no linearity change is expected

BBR key calibration parameters

	measured pre-flight	measured in-flight	applied in-flight	Data frequency
SW gain ratio, B	✓	Derived from BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo
LW spectral correction factor, A	✓	Derived from BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo
SW filter transmission, $<\tau>_{SW}$	✓	Derived from BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo
Detector linearity	✓	BBR_LIN_1B	✓ CCDB	6 mo
Detector gain, G_{LW}	✓	Derived from BBR_LIN_1B	✓ CCDB	90 s
TW calibration interval	✓	Derived from BBR_LIN_1B	On-board	90 s
Offset and gain stability	✓	Derived from BBR_LIN_1B	✓ CCDB	90 s
MPD noise	✓	BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo

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

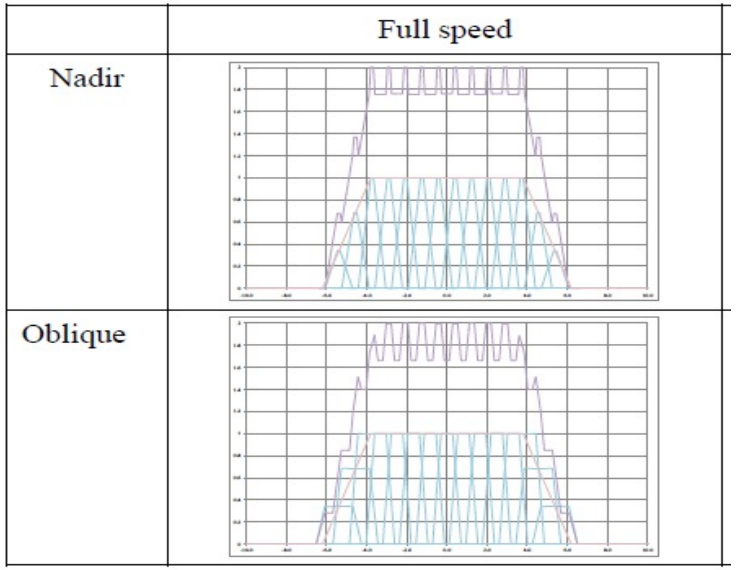
resolutions sampled @1km

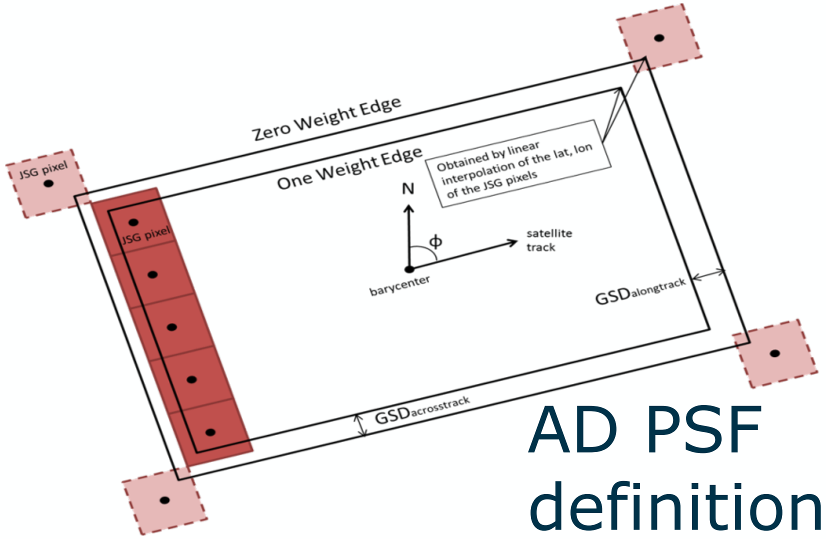
On **Joint Standard Grid** (JSG):

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

Resolutions sampled @ 1JSG

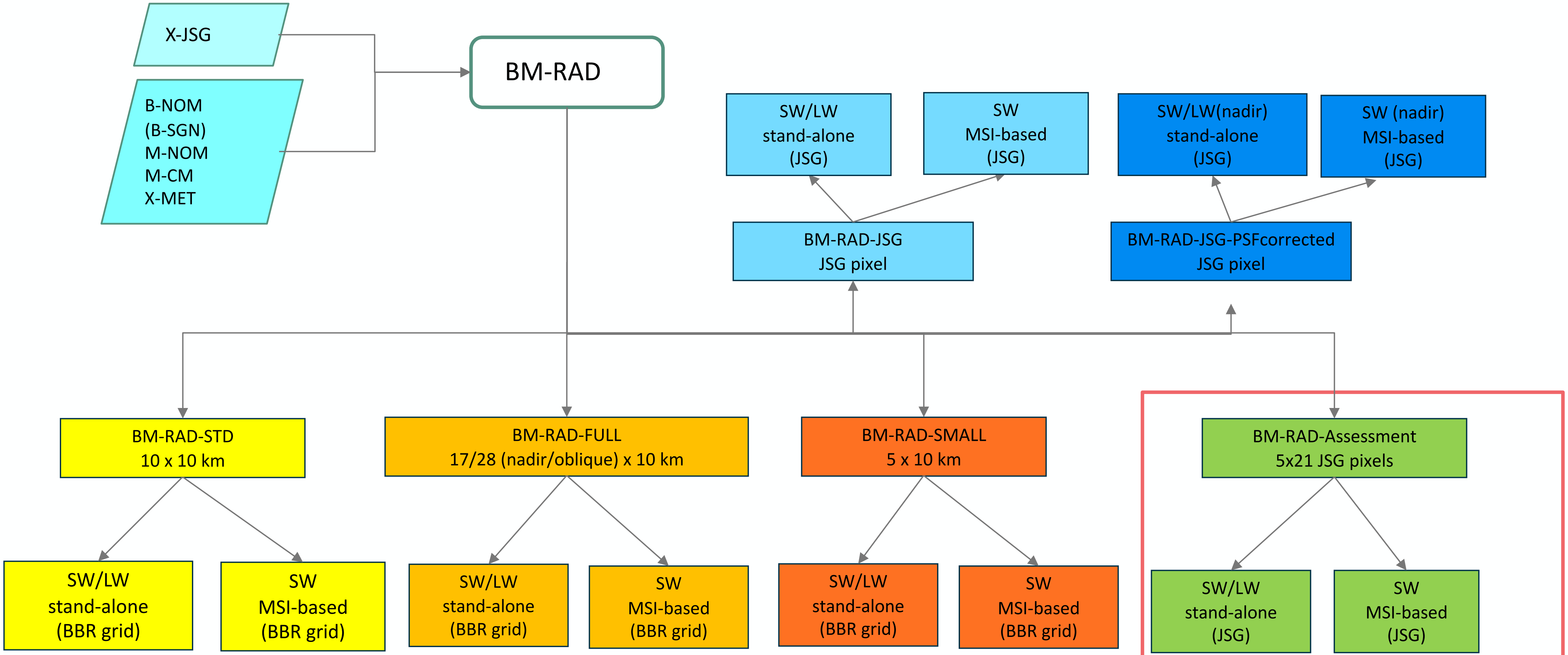
10 km along-track integration





AD PSF definition

BM-RAD product: spatial resolutions



BM-RAD radiances at **AD** (5x21 km) will be used in **BMA-FLX** and **ACMB-DF**