Overview of the BroadBand Radiometer (BBR) instrument on EarthCARE, its products and plans for the commissioning

Nicolas Clerbaux, Almudena Velazquez Blazquez, Edward Baudrez - Royal Meteorological Institute of Belgium

Carlos Domenech , Raquel G. Marañon, Carla Salas Molar – GMV Spain

Nils Madenach – Freie Universität Berlin

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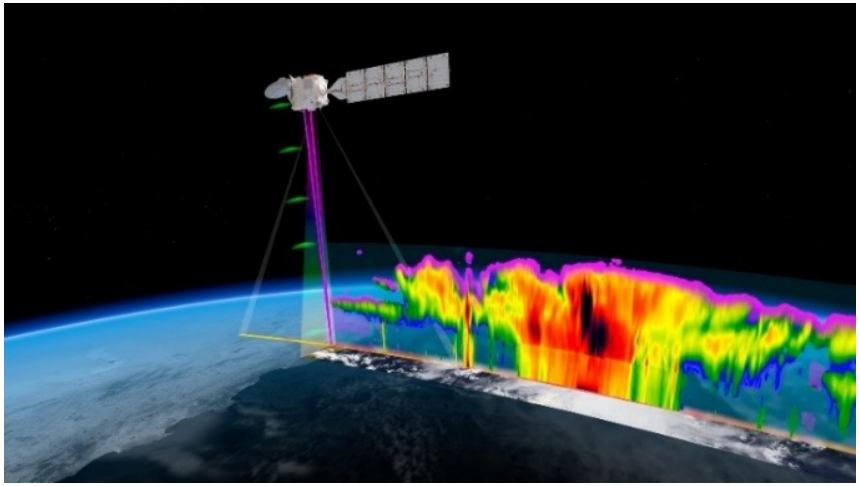
Content

- EarthCARE mission overview
- The Broadband radiometer (BBR) instrument
- The BBR products (Level 1, Level 2)
- EarthCARE commissioning plans
  - Instrument Commissioning Team (ICT)
  - EarthCARE Validation Teams
- Project BRAVO
- Summary



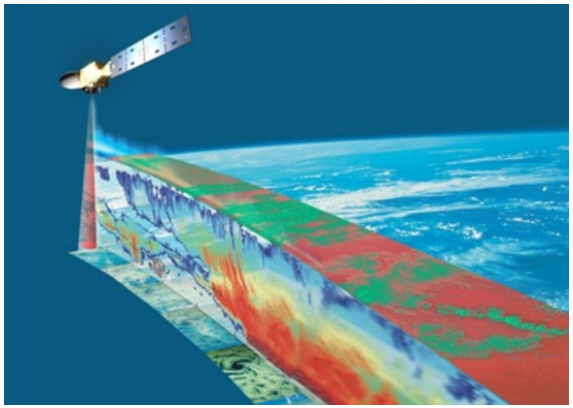
Earth Cloud Aerosol Radiation Explorer (EarthCARE)

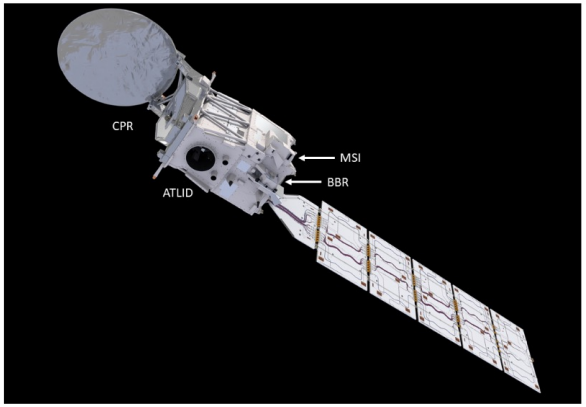
The scientific objectives of the mission are:

- To observe vertical profiles of natural and anthropogenic aerosols on a global scale, their radiative properties and interaction with clouds
- To observe vertical distributions of atmospheric liquid water and ice on a global scale, their transport by clouds and their radiative impact
- To observe cloud distribution, cloud-precipitation interactions and the characteristics of vertical motions within clouds
- To retrieve profiles of atmospheric radiative heating and cooling through the combination of the retrieved aerosol and cloud properties

Payload:

- The **Atmospheric Lidar** (ATLID, 355nm) provides vertical profiles of aerosols and thin clouds. It has a high-spectral resolution receiver and depolarisation channel.
- The **Cloud Profiling Radar** (CPR, 94GHz) provides vertical profiles measurements of clouds and has the capability to observe vertical velocities of cloud particles through Doppler measurements.
- The **Multi-Spectral Imager** (MSI) provides across-track information on clouds and aerosols with channels in the visible, near infrared, shortwave- and thermal infrared.
- The **Broad-Band Radiometer** (BBR) provides measurements of top-of-the-atmosphere radiances and fluxes. It has three fixed viewing directions pointing in fore/nadir/aft directions.

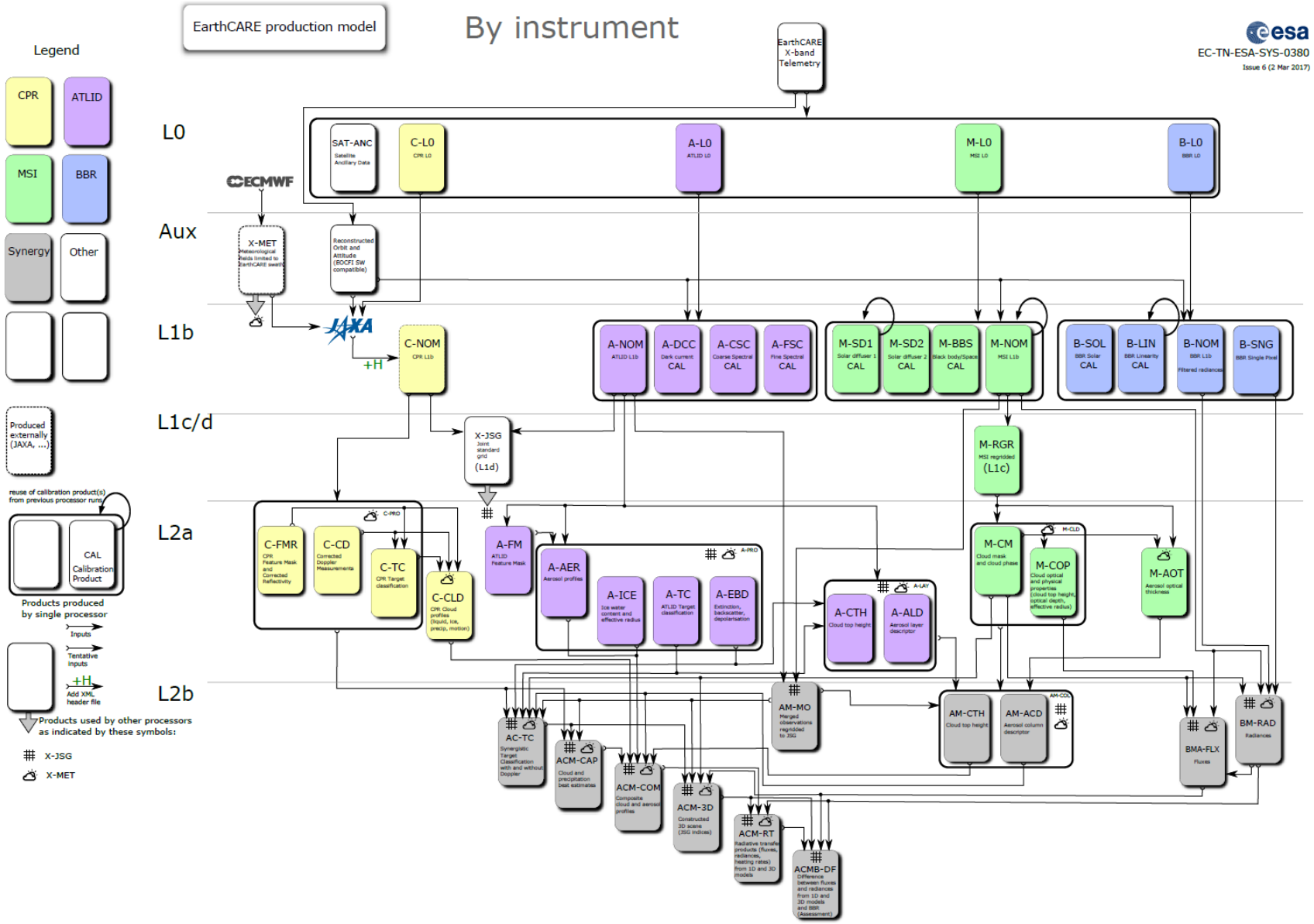




Mission orbit:

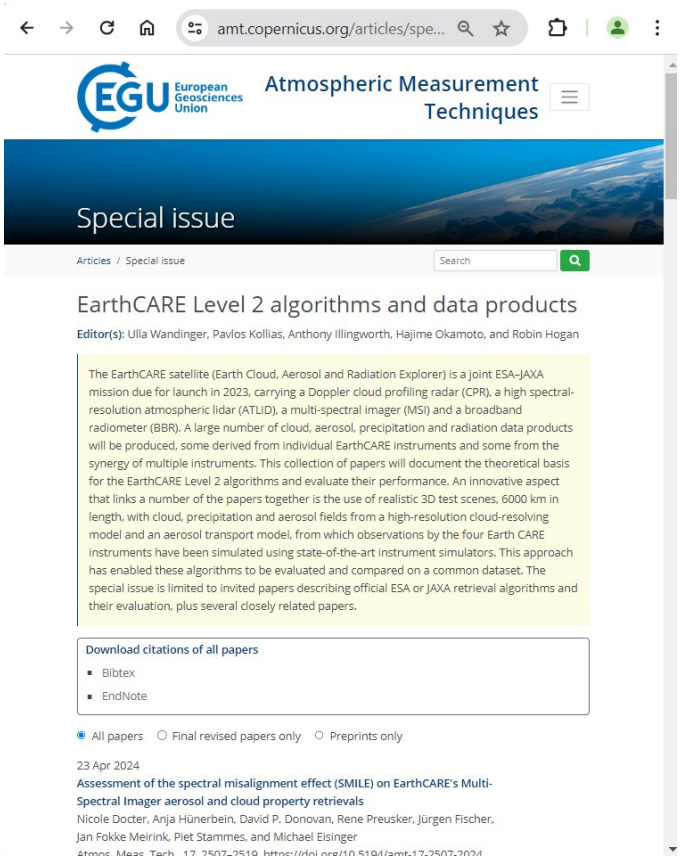
- **Orbit:** Sun-synchronous
- **Mean solar local time:** 14:00
- **Mean spherical altitude:** 393.14 km
- **Inclination:** 97.05 degrees
- **Repeat cycle:** 25 days/389 orbits 9 days/140 orbits
- **Orbital duration:** 5552.7 sec 5554.3 sec

EarthCARE – Production model (ESA part!)



EarthCARE – Status

- Instruments and satellite ready for launch
- Reference orbit fully defined -> Longitude of the Ascending Node Crossing (ANC) of 0.6° East.
- Consolidation of the L1 and L2 processors (v11)
- Full chaining of the processors using EarthCARE end-to-end simulations (E3SIM)
- Documentation via a special issue in Atmospheric Measurement Techniques (AMT): *EarthCARE Level 2 algorithms and data products* (open access)
- Commissioning rehearsal exercise performed
- Communication material ready (video, …)
- Launch planned on 28th May 22:20 UTC (to be confirmed some days before)



The BBR instrument - Geometry

- Along track sampling with 3 telescopes : nadir, fore and aft (@55° VZA at surface)
- Array of 30 x 1 detectors
- Across track sampling: 600m (nadir) , 1000m (fore, aft)
- Swath : 18km (nadir), 30km (fore, aft)
- Along track sampling : 0.8 km (1.05km at 75% CDM speed)

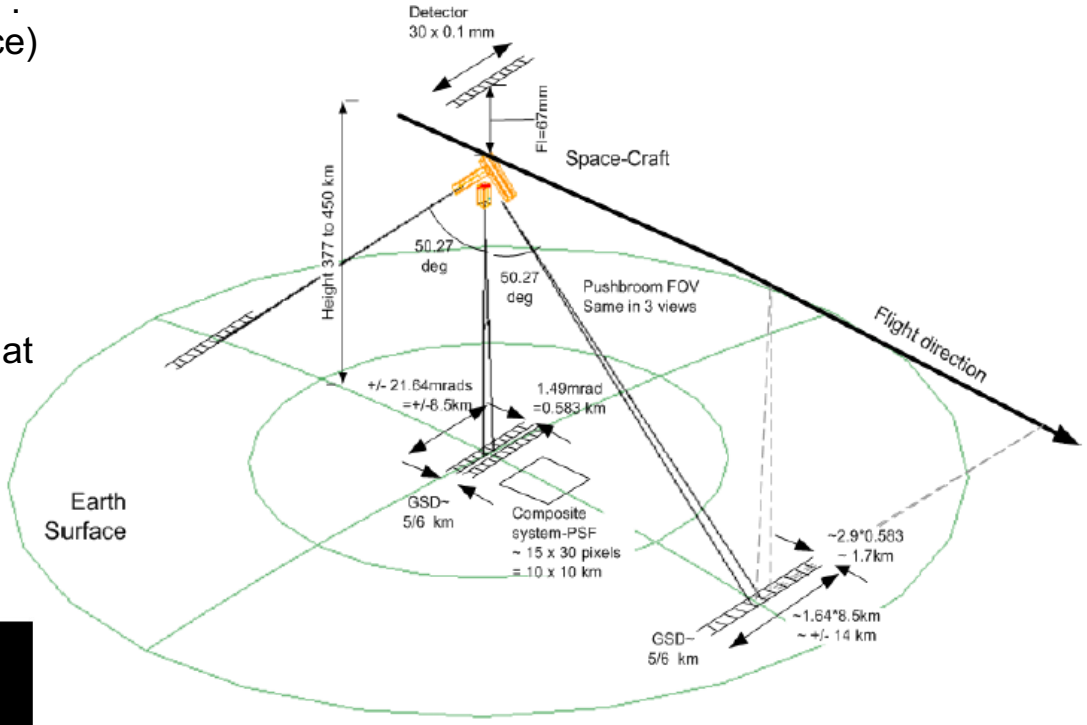
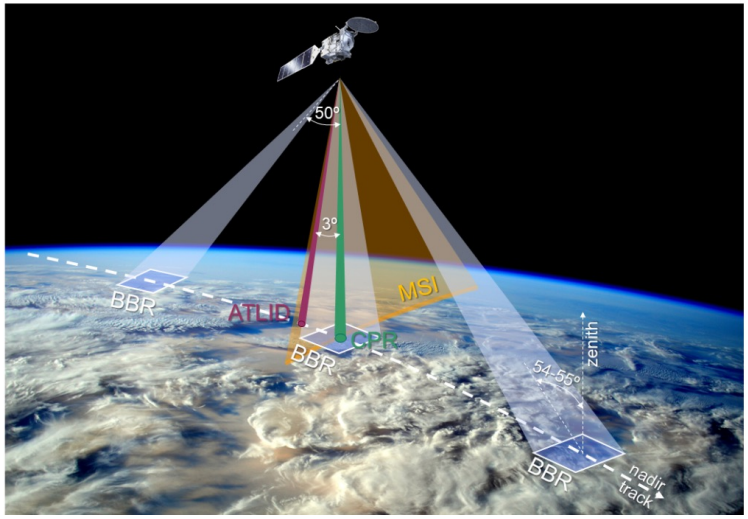
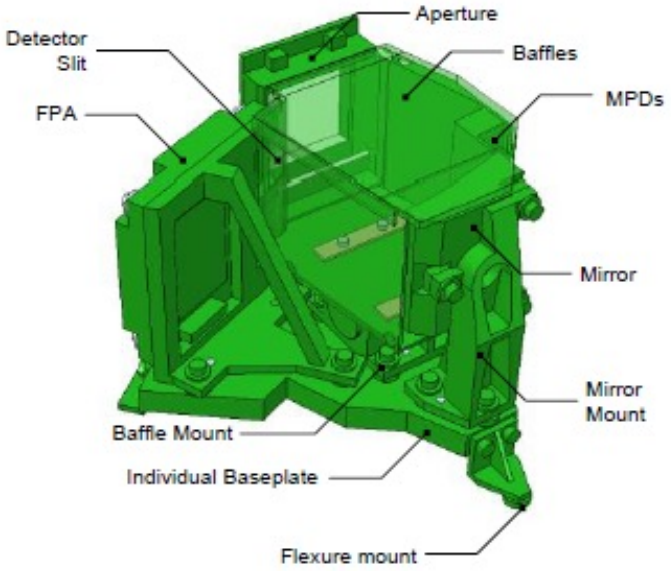
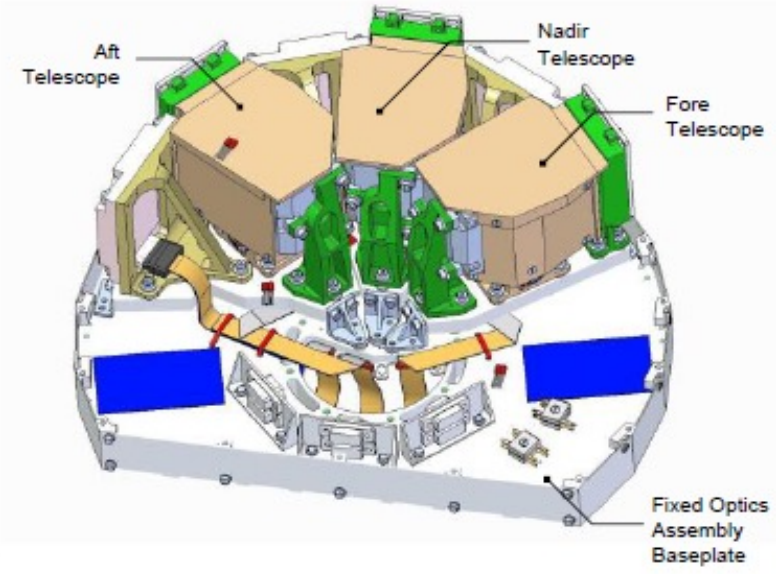


Figure 1-3 : Viewing geometry

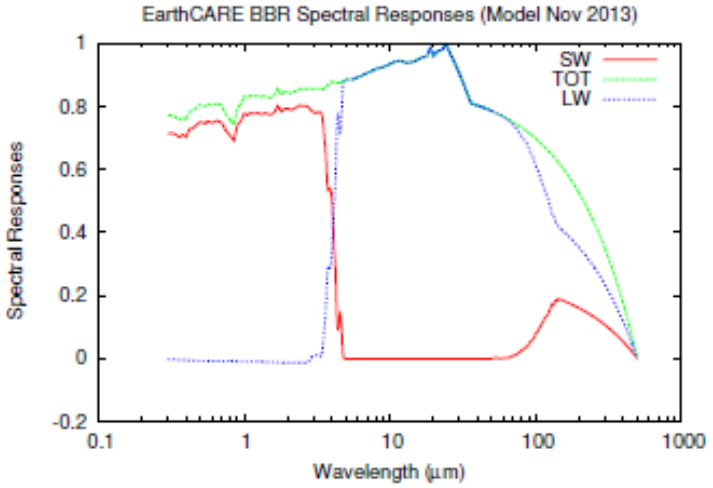


The BBR instrument – Telescope detail and assembly





- Detectors : 30 x 1 Vanadium Oxide microbolometer array
- Single mirror optics (Aluminium coating)
- Two spectral channels: TW (0.2 – 50 µm) & SW (0.2 – 4 µm)
- Radiometric accuracy :
  - SW : 2.5 W/m²/sr
  - LW : 1.5 W/m²/sr



The BBR instrument - Chopper and Calibration Drums

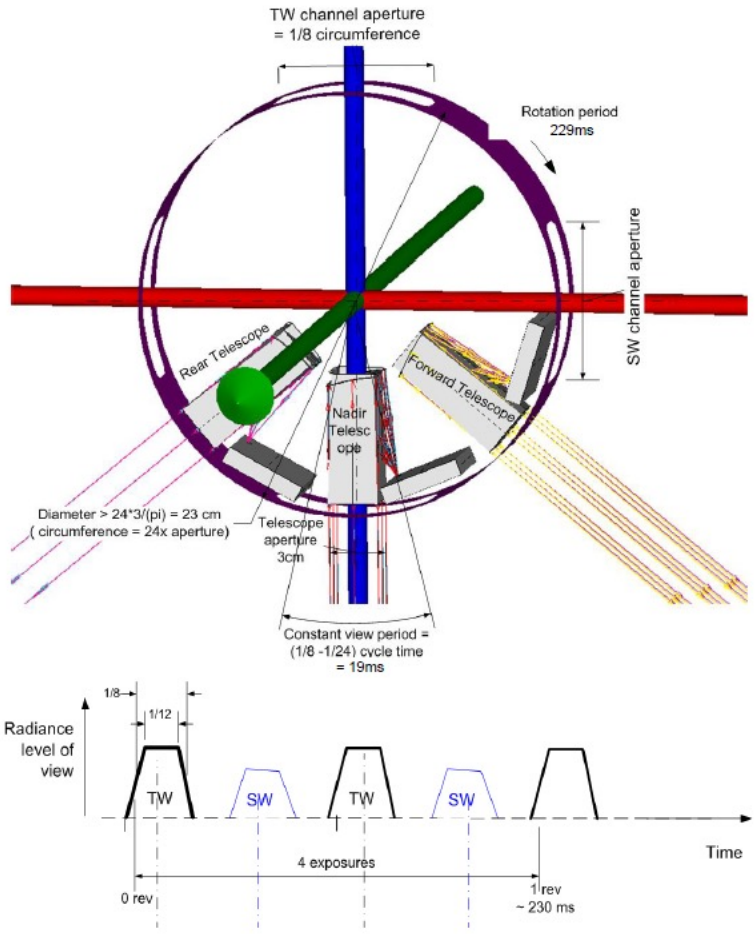


Figure 1-4 : Chopper and chopper operation

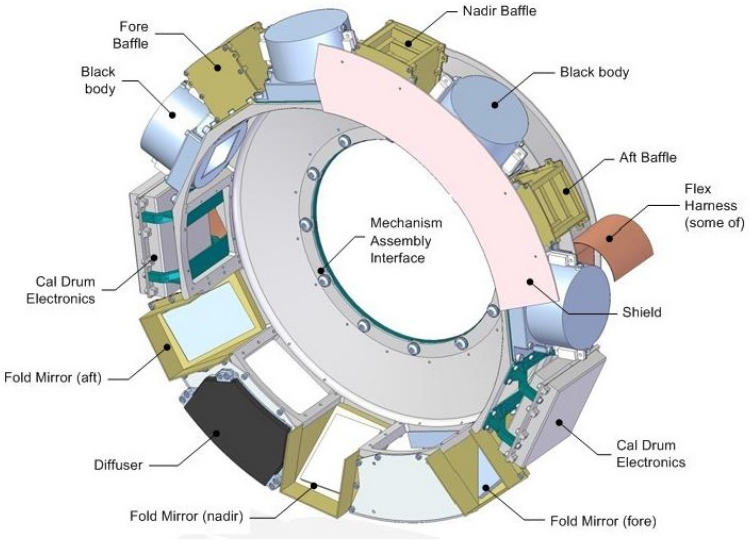


Figure 1-6 : Calibration Drum Layout.

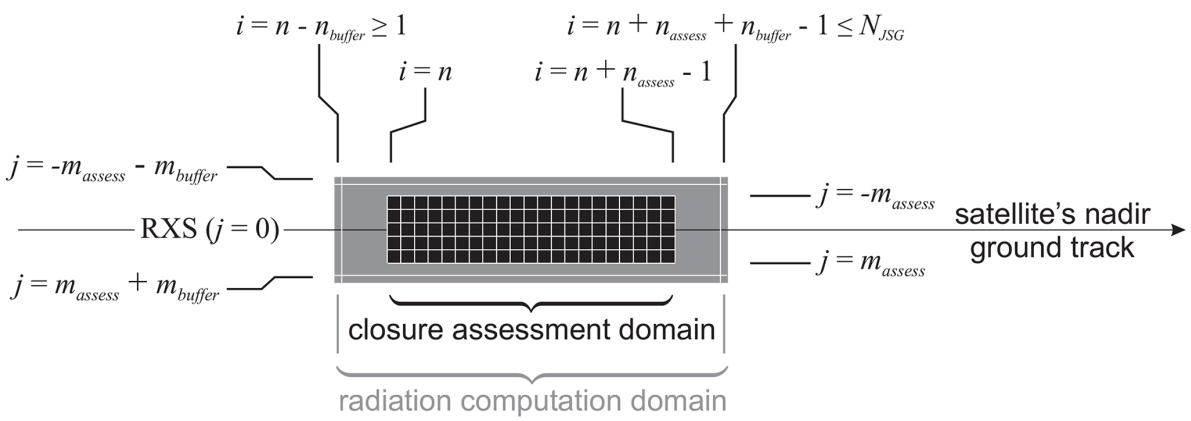
The BBR integration domains

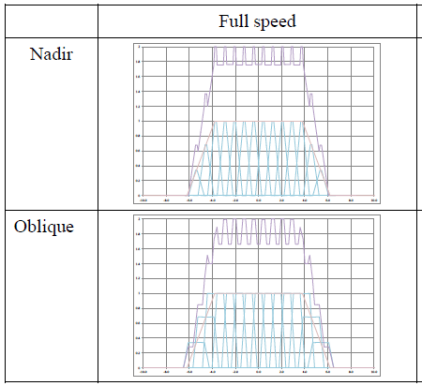
Level 1 PSF	Size (across x along track)	Ref.	Level 2 unfiltered rad	Level 2 fluxes	Level 2 combined flux
Standard	10x10km	BBR	x	x	x
Small	5x10km	BBR	x	x	x
Full	18 x 10km 30 x 10km	BBR	x	x	
Assessment Domain	5 x 21 km	JSG	x	x	x
JSG	*1 x 1 km*	*JSG*	*x*		

Notes

- all regions sampled @ 1km
- all dimensions are configurable

Not yet implemented

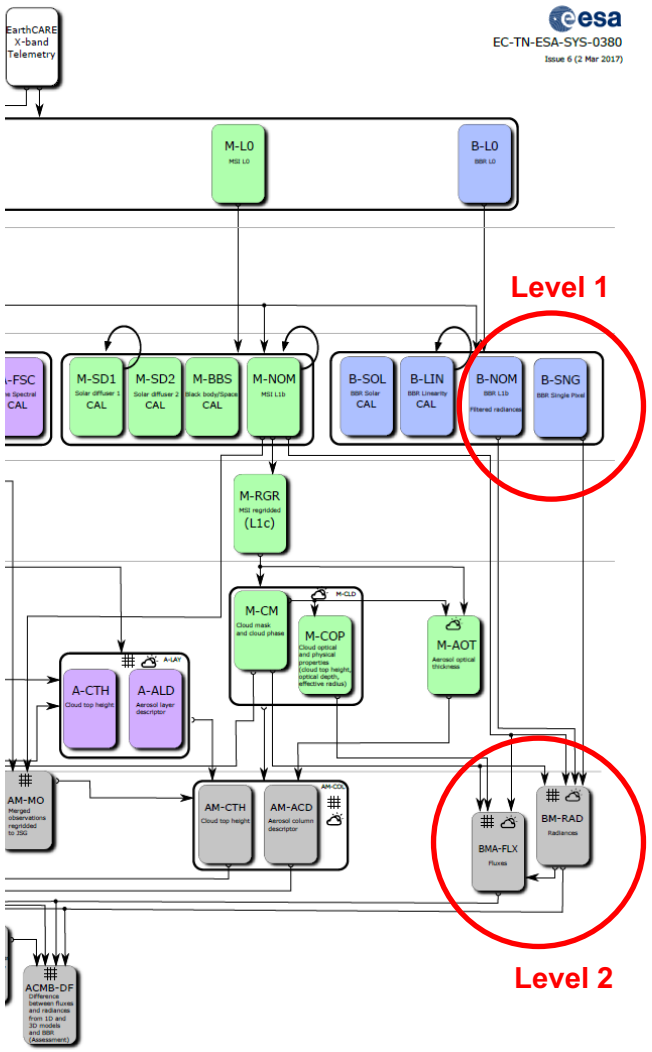




The BBR products

- All products are NetCDF4 (HDF5) files
- In frame of 1/8 of orbit (~5000km)
- Level 1b products:
  - B-SNG : SW and TW for all the detectors
  - B-NOM : SW and LW after domain integration
- Level 2b products:
  - BM-RAD : Unfiltered radiances for the 3 views
  - BMA-FLX : Fluxes for the 3 views + combined flux
- Processors described in 2 AMT papers:
  - Velazquez Blazquez et al., 2024: Unfiltering of the EarthCARE Broadband Radiometer (BBR) observations: the BL-RAD product.
  - Velazquez Blazquez et al., 2024:Retrieval of top-of-atmosphere fluxes from combined EarthCARE lidar, imager and broadband radiometer observations: the BMA-FLX product. (in preparation)

Note: no similar development on JAXA side (they use the ESA L2 products).



Commissioning timeline and data release

Data level	Target date(*) release to EarthCARE Cal/Val Team	Target date public release
Level 1	3 months after launch	6 months after launch
Level 2a and Level 2b two-sensor products	6 months after launch	9 months after launch
Level 2b three-sensor and four-sensor synergy products	9 months after launch	18 months after launch

Launch	May 2024
Preliminary Validation Results Workshop Part 1, Part 2, Part 3	L+6M (online), L+9M(Europe), L+18M (Japan)

Commissioning Tools (Logistics):

- JIRA
- Confluence
- WebMUST
- Commissioning Server

Note : L1 and L2 products (from E3SIM) are already available on the commisioning server for format familiarisation and test of server access.

The BBR In Orbit Commissioning by ICT

- Done by the Instrument Commissioning Team (ICT): ESA, Industry, L2 scientists.
- The BBR commissioning is divided in 7 main phases:
  - PHASE 1 → BBR Switch-ON Activities
  - PHASE 2 → BBR In-orbit Health Status and Characterization
  - PHASE 3 → BBR In-orbit Health Status and Calibration
  - PHASE 4 → BBR Instrument and Level-1 In-Orbit Performance Analysis
  - PHASE 5 → Silent Configuration
  - PHASE 6 → AOCS Zero Doppler Check
  - PHASE 7 → Small Delta-V Check

Commissioning by validation teams

Funding received for the BRAVO project (1FTE, 31 months)

Preparation (June – first L1 data) – based on simulated data

- Analysis of the occurrence of collocated/coangular observations with CERES and GERB instruments.
- Prepare CERES RAPS/PAPS data matching campaigns in collaboration with the CERES team
- Develop algorithms to enable BBR-like filtered and unfiltered broadband estimates from MSI (i.e. narrowband-to-broadband).
- Definition, selection and characterization of relevant Earth targets for calibration tracking and transfer (e.g. deep convective clouds, desert, ocean).
    - Develop/Select Deep Convection Reflectance model for the BBR sun-Earth-sat geometry
    - Implement ‘off line’ unfiltering for B-NOM and B-SNG
- Prepare tool for statistical comparison of the 3 views (e.g. histograms)
- Prepare tool for statistical comparison of the different detectors (e.g. histograms)

BRAVO project

Commissioning (~Sept. - ~Dec) – based on L1 B-NOM and B-SNG data

- Visualization of actual BBR products over several orbits, with context given by the MSI (color composite)
- Statistical analysis of data from several orbits to highlight outliers, effect of observational conditions and differences between telescopes and pixels.
- Verification of B-NOM – B-SNG constancy (radiances, geolocation, flags, ….) : does a validation of one product applies to the other?
- Analysis/visualisation of ratio between BBR and MSI-based BBR-like data.
- Additional studies to address extreme and challenging conditions e.g. sun glint, high contrast changes during or close to the acquisition period.
- First evaluation of the SW/LW calibration using ‘off line’ unfiltering and DCC (SW) and GERB-1/3 data (SW/LW)

Summary

- EarthCARE ready for launch
- We are likely ahead of many problems, challenges, …
- BBR instrument and products designed mostly for the EarthCARE closure but could be of more general interest, e.g.;
  - possibility to integrate over any domains, e.g. for evaluation of ISCCP-NG radiative fluxes (0.05° x 0.05)
  - fine spatial resolution, e.g.: study the clear region around the clouds, contrails and aviation-induced cloudiness, …
- Preparation of the commissioning and data release
- EarthCARE is very complex / complete observation system:
  - current L2 products are ‘baseline’
  - likely improvements and new products as day-2.

A Falcon-9 rocket

Some videos about EarthCARE:

https://www.esa.int/ESA_Multimedia/Videos/2024/02/Coming_soon_EarthCARE

https://www.esa.int/ESA_Multimedia/Search?SearchText=EarthCARE&result_type=videos

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