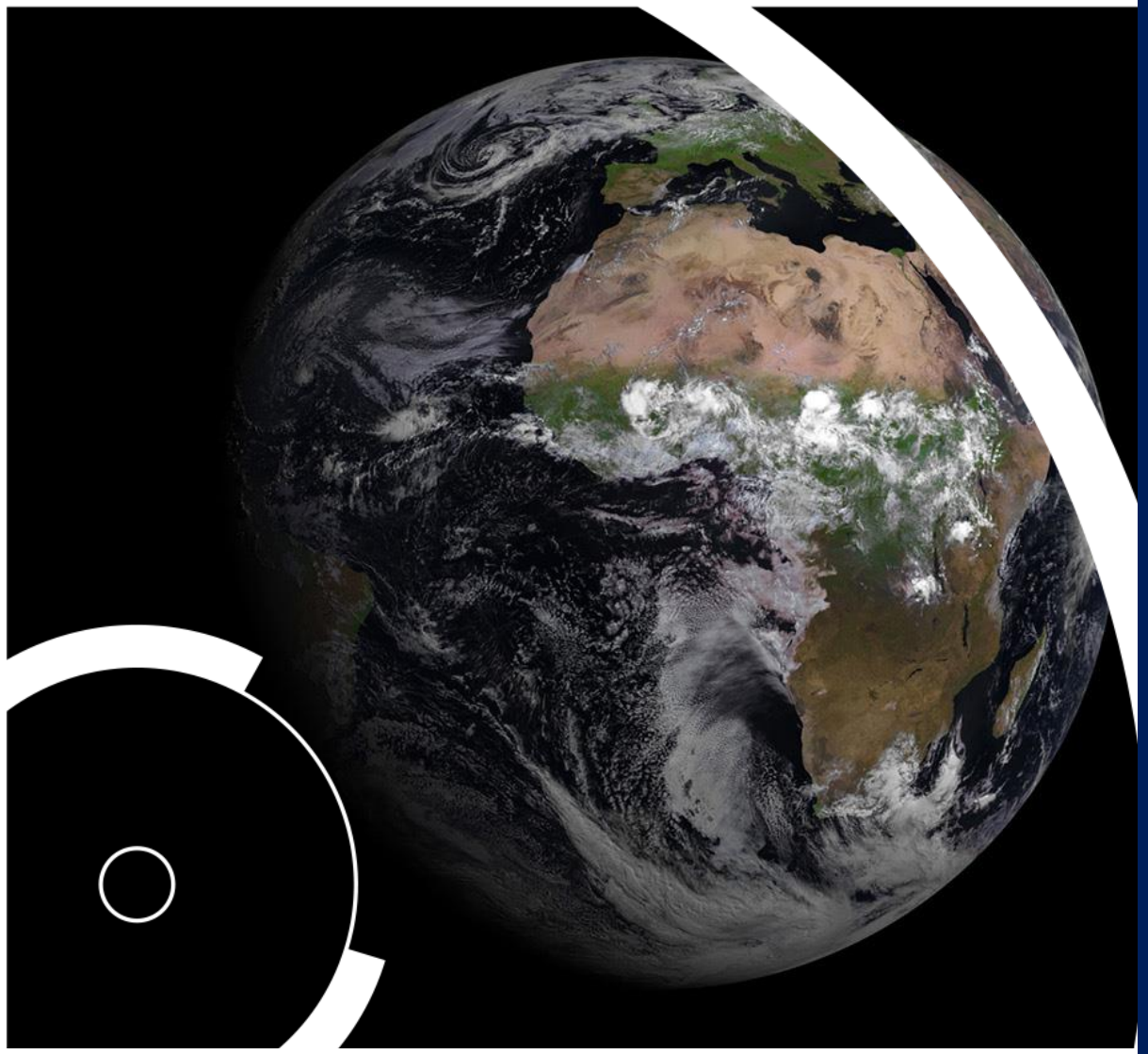
EUMETSAT

ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop
13-17 November 2023, ESA-ESRIN, Frascati (Rome), Italy



An overview of the use of EarthCARE products within the EUMETSAT validation facility for Level 2 Cloud and Aerosol products

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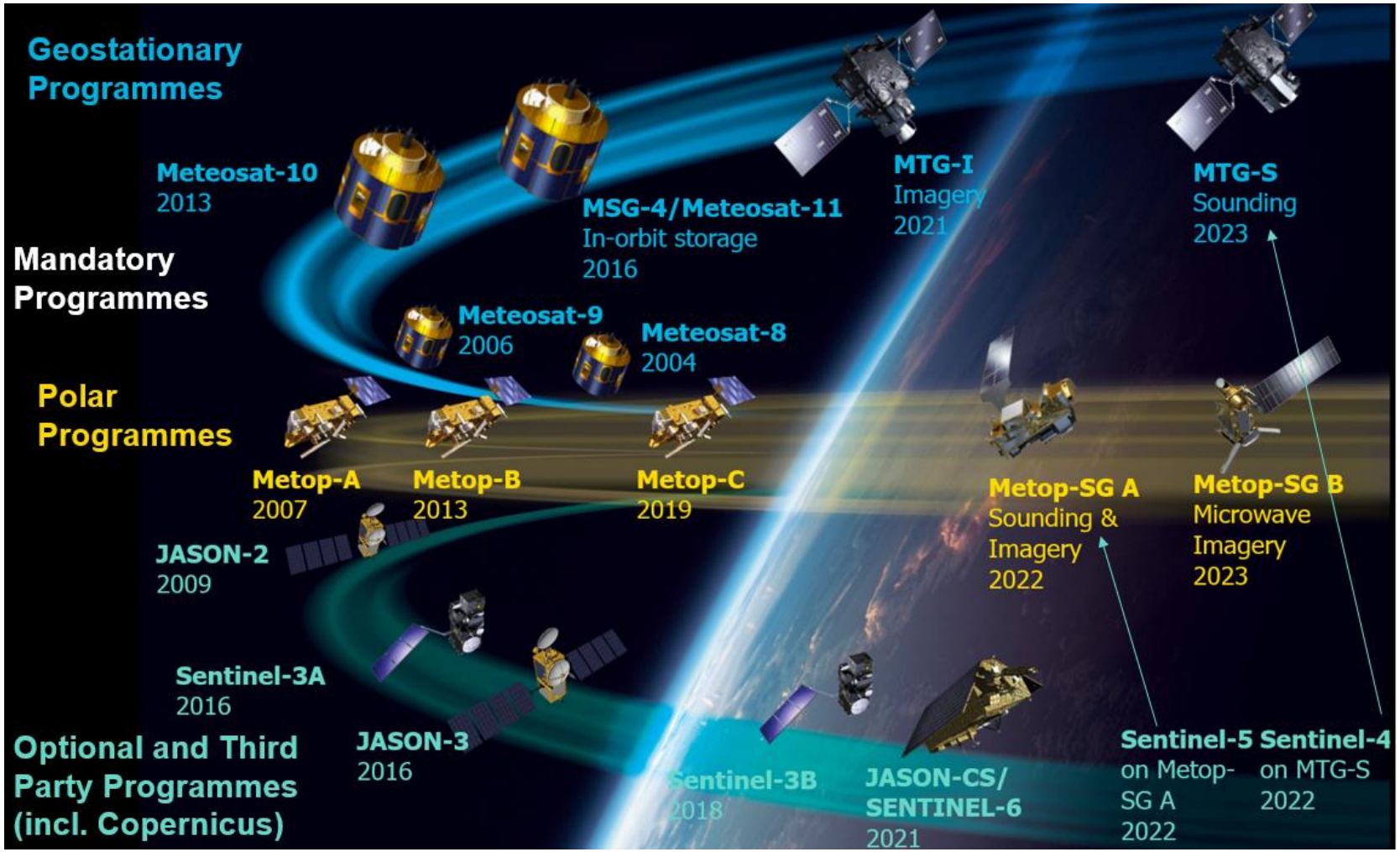
EUMETSAT - Remote Sensing & Products division-Clouds & Aerosols Competence Area

EUM/RSP/DOC/23/1386018, v1 Draft, 8 November 2023

EUMETSAT missions and operational requirements

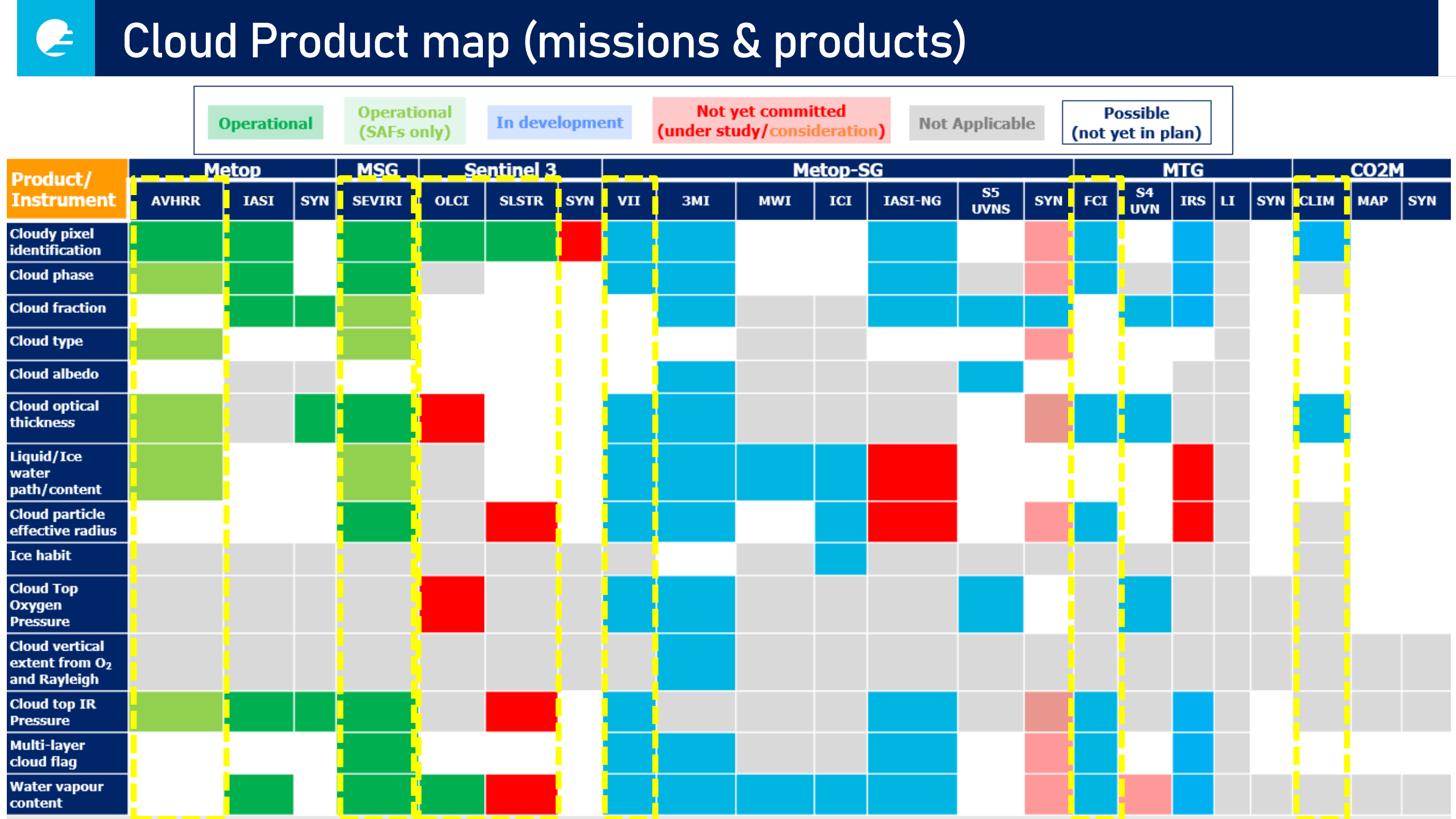
EUMETSAT provides operational atmospheric products, which implies:

- Reliability: more than 99% – 24/7
- Timeliness: Near Real Time dissemination from sensing time
  - ➢100 to 150min for LEO
  - ➢20min for GEO
- Quality control
- Continuity over the mission lifetime: maintenance of timeliness, quality standards, etc.
- Consistency between the different systems
- Maintenance of the accuracy of the retrieved geophysical parameters within user requirements (globally, day/night, all season, all surfaces, entire mission lifetime)



Some cloud and aerosol products at EUM **Satellite Application Facilities**: Nowcasting (NWC-SAF), Climate Monitoring (CM-SAF) and Atmospheric Composition (AC-SAF)

Cloud Product map (missions & products)



Aerosol Product Map (missions & products)

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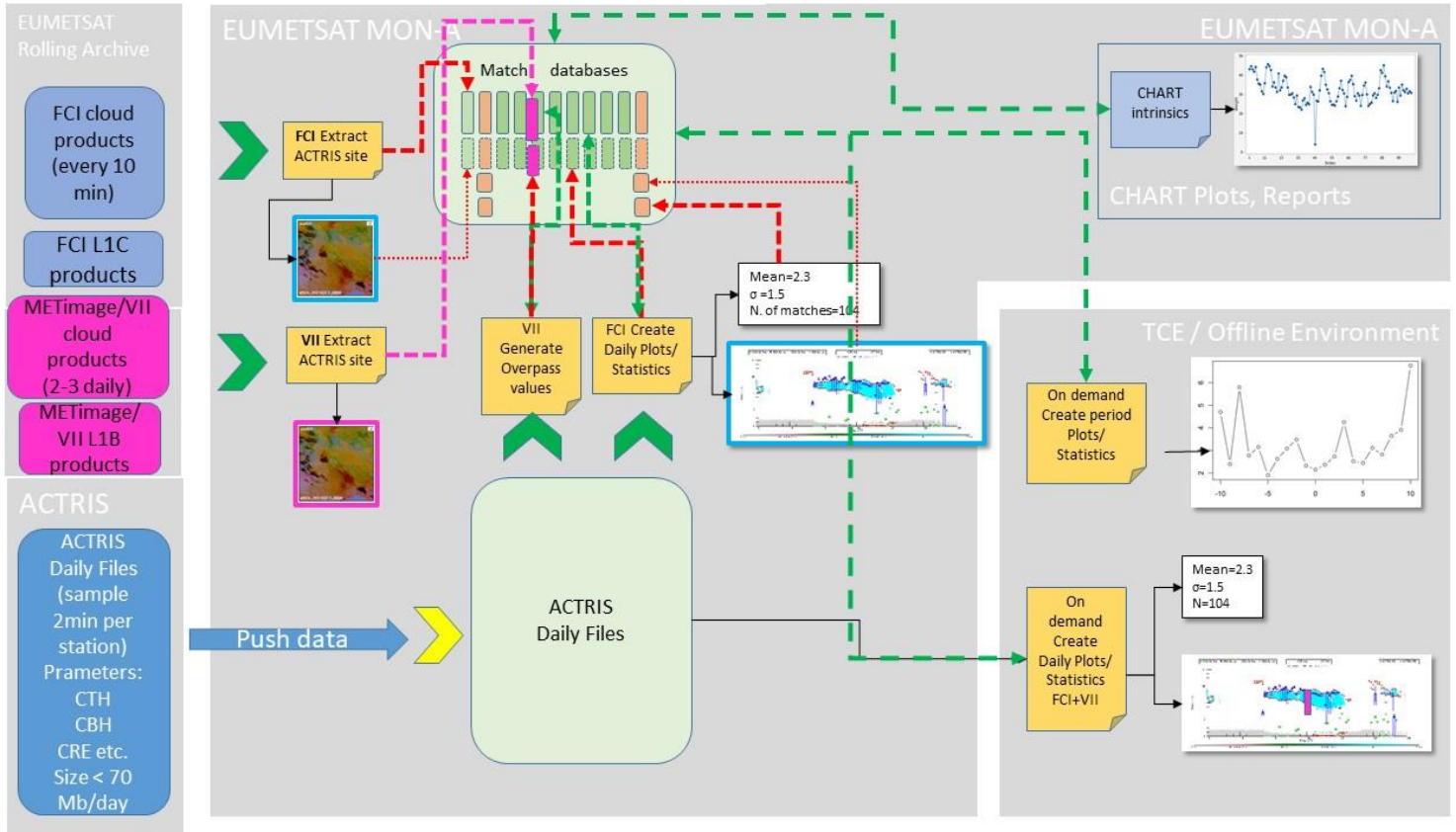
Operational | In development | Not yet committed (under study) | Not Applicable | Possible (not yet in plan)

Product/ Instrument	Metop	MSG	Sentinel 3			Metop-SG			MTG		CO2M	
	PMAP	SEVIRI	OLCI	SLSTR	SYN	3MI	S5 UVNS	MAP	FCI	S4 UVN	CLIM	MAP
Cloudy pixel identification												
Aerosol type												
Fine mode fraction												
Aerosol Optical Depth												
Aerosol Optical Depth (multi-band, i.e., Angstrom exponent)												
Single Scattering Albedo												
Refractive index – real												
Refractive index – imaginary												
Effective radius												
Aerosol height												
Aerosol Absorbing Index												
Side Product: BPDF												
Side Product: BRDF												

Validation strategy, facility and reference data

Essential steps in the validation framework:

- Daily/automated download of reference products;
- Matching/colocation with reference products;
- Generation and storage of daily match files;
- Generation of comparison plots, statistics/skill scores, and Cal/Val reports, both daily and (if requested) over longer periods (i.e., by accumulating data over selected time intervals and/or locations)



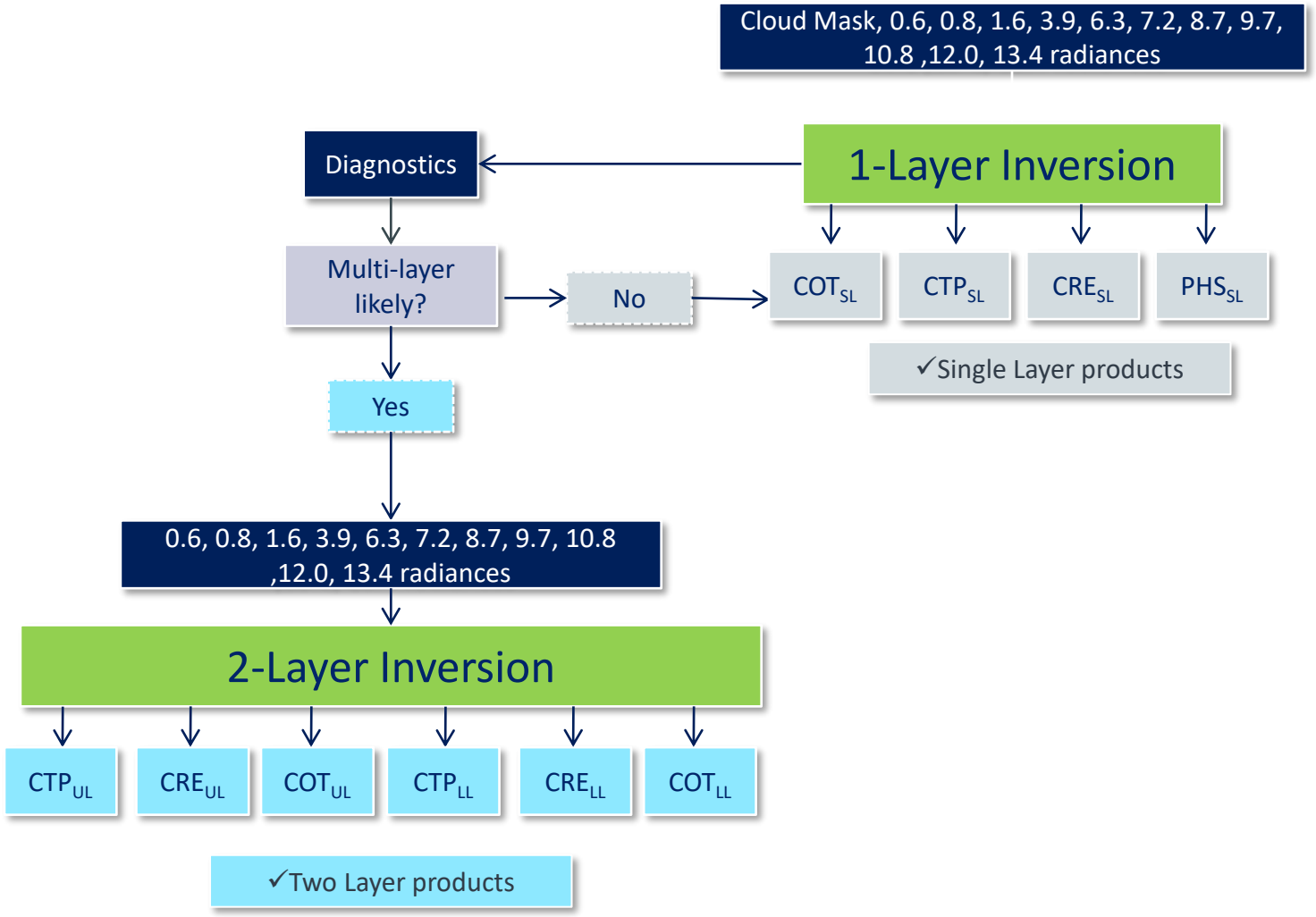
Reference data for the validation of cloud and aerosol products:

Ref. data source	Clouds	Aerosols
Space-born active instruments	~~A-Train~~ ~~Aeolus~~ EarthCARE	~~A-Train~~ ~~Aeolus~~ EarthCARE
Ground-based observations	ACTRIS-Cloudnet*	ACTRIS (Aeronet, Earlinet)*
Products from other space-based passive sensors/algorithms	~~MODIS~~ VIIRS ABI AHI	~~MODIS~~ VIIRS TROPOMI
Model-based measurements	/	CAMS EMAC ICAP/AEROSAT

***Framework of the European Project ATMO-ACCESS (talk H. Baars)**

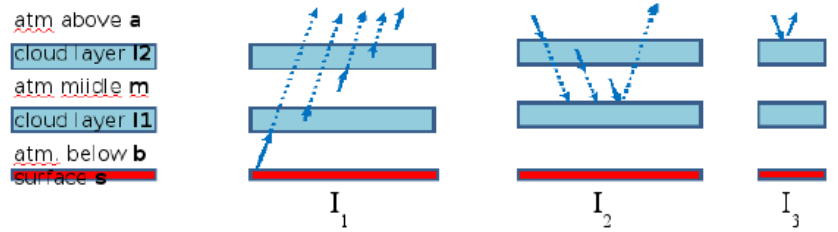
~~Past~~ | Present | Future

Optimal Cloud Analysis for Single/Multi-layer (OCA products)

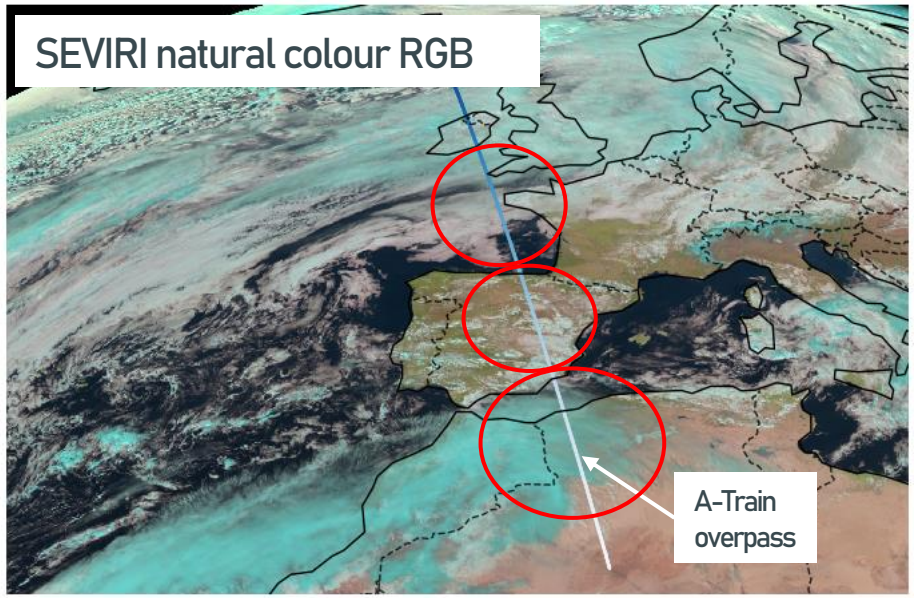


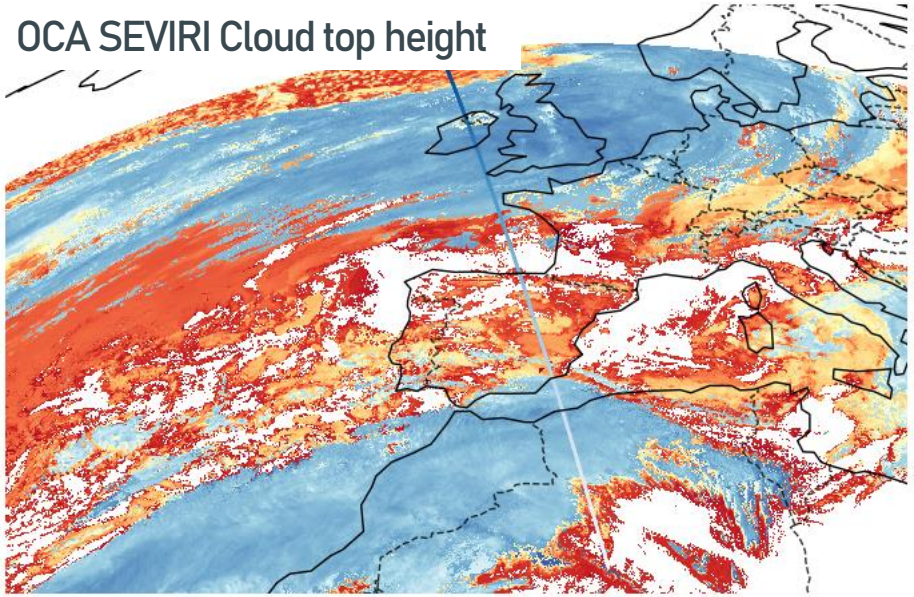
EUMETSAT cloud products based on optimal estimation framework (Watts et al. 2011) using radiances from imagers

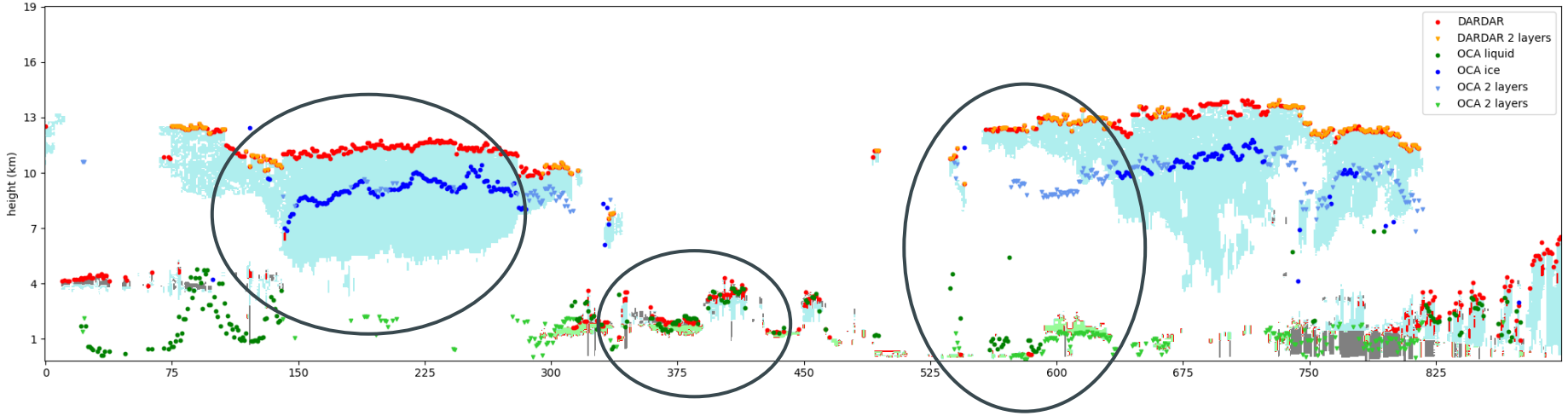
- Retrieved: cloud top pressure, optical thickness, particle size, cloud phase
- Flexibility to add new channels and instruments (e.g. MTG/FCI, EPS-SG/METimage)
- Simplified fast look-up table approach RT model
- Multi layer retrieval.
- Full uncertainty estimate
- CTP mostly depends on thermal IR channels and temperature profile
- COT,CRE: extra constraint from solar channels



Validation of OCA vs. A-Train/DARDAR







Combined radar/Lidar products are used for independent validation of cloud products from Imagers.

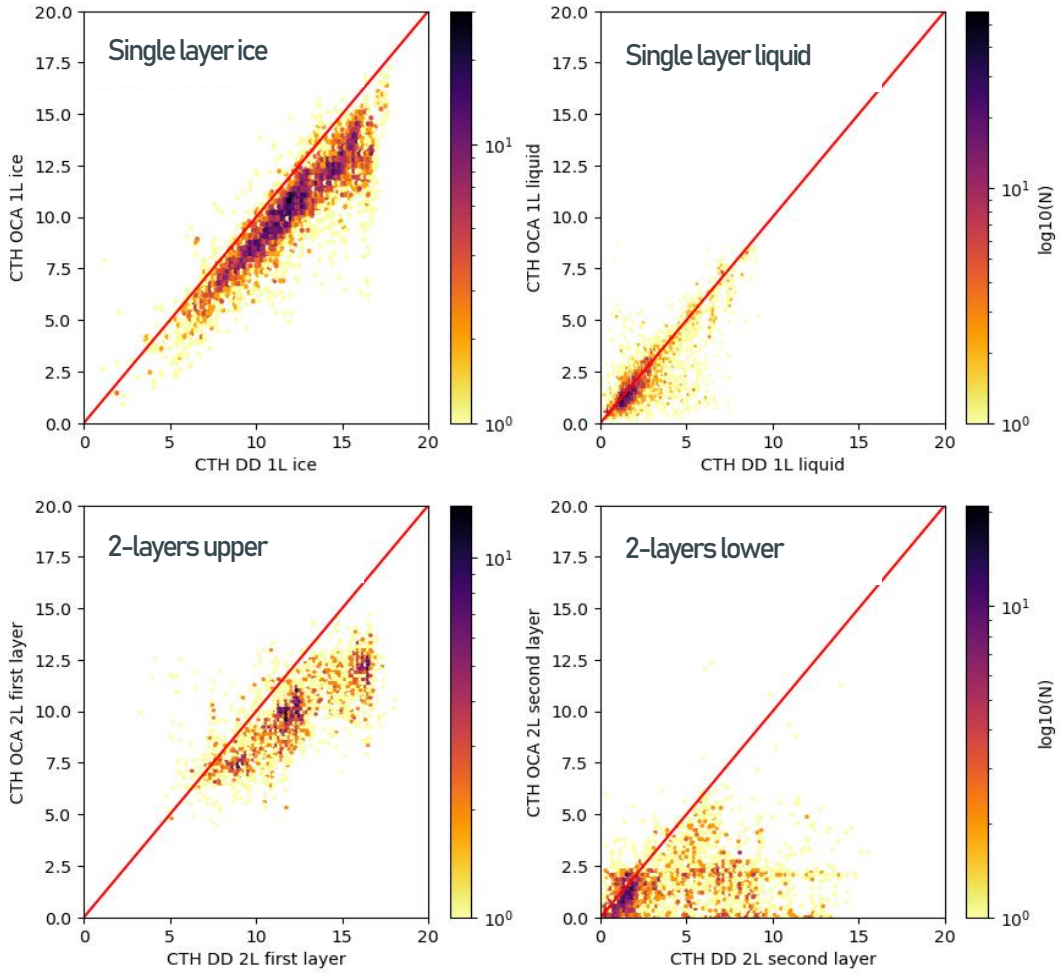
For example, estimating position, phase and overlap of cloud layers:

- Overlapping clouds: truth defined with combination of DARDAR target classification and CALIOP backscatter
- Thick ice clouds
- Low liquid/supercooled clouds

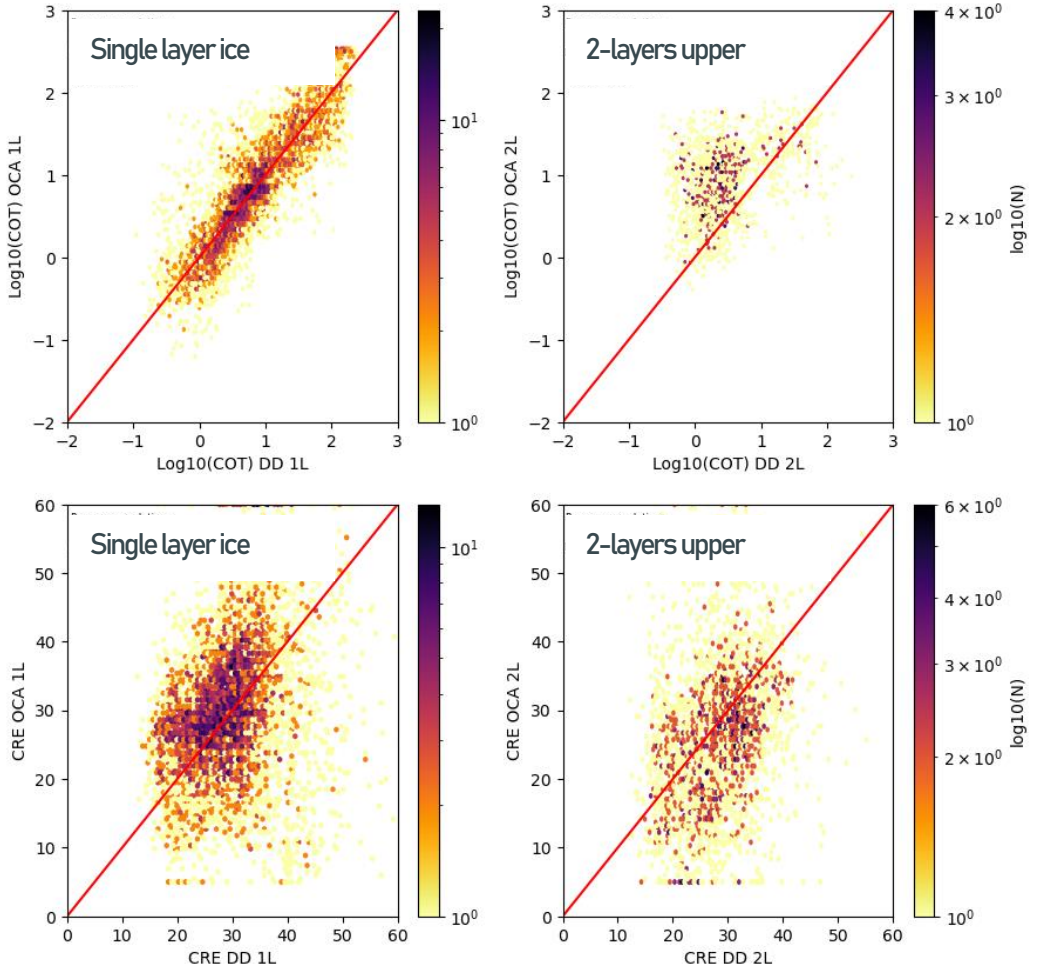
Statistics over multiple orbits

Quantitative estimates of retrieval errors with statistics collected over multiple collocated orbits: Cross comparison of cloud optical thickness and near-top effective radius for ice clouds.

Cloud top height validation



Ice cloud optical thickness and effective radius

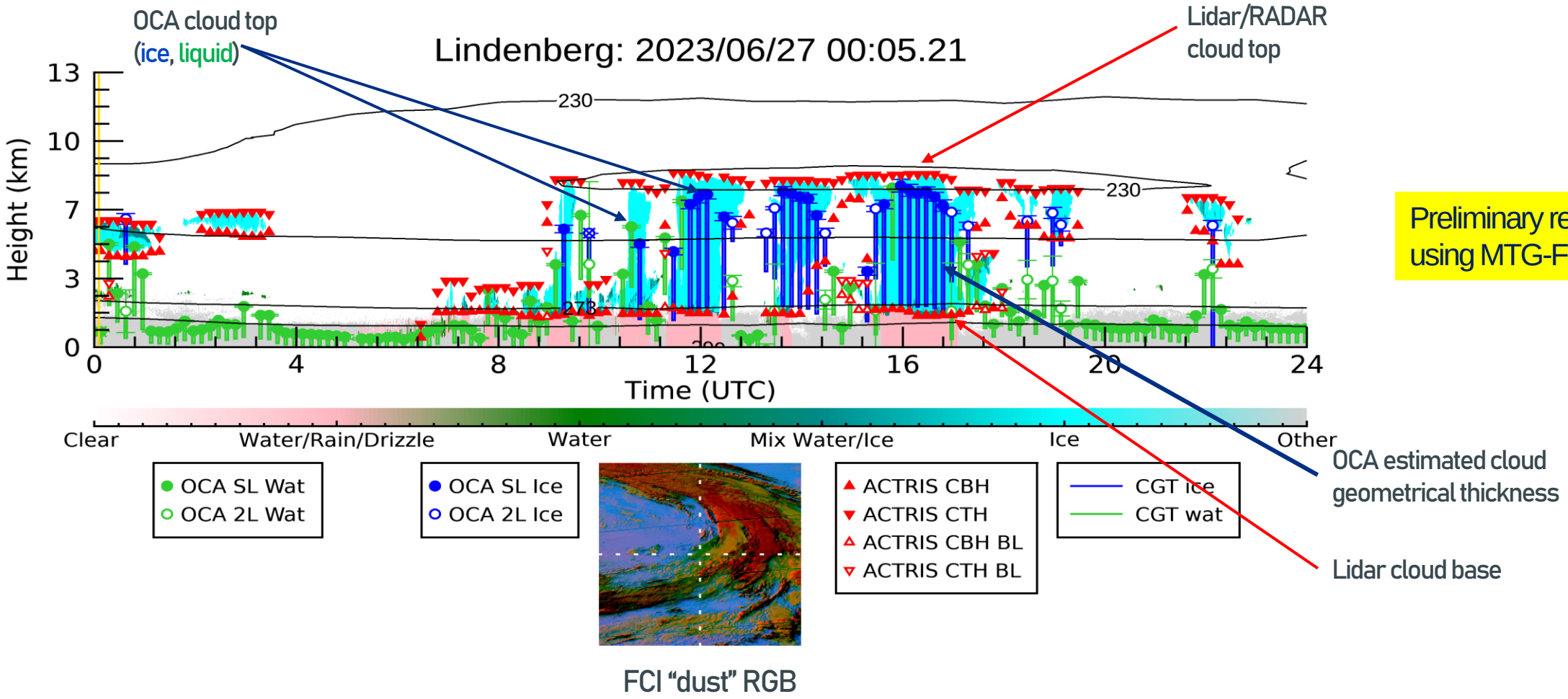


Validation OCA vs. ACTRIS-Cloudnet (high time resolution)

Compared parameters:

- Current: cloud detection (single and 2-layers), cloud phase, top/base pressure, optical thickness
- Can be added: Liquid/Ice Water Content, ice particle effective radius

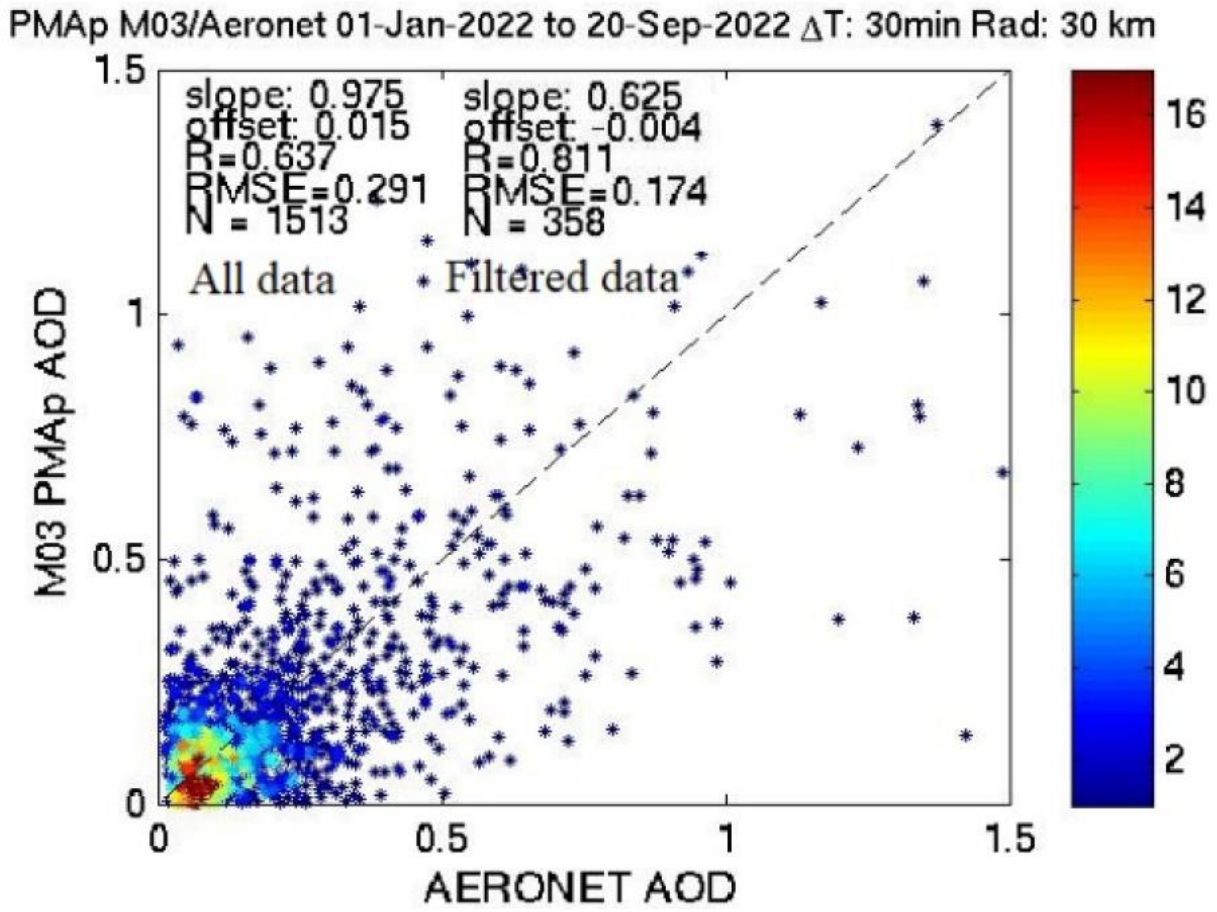
Statistics is accumulated over several orbits/repeat cycles (as for A-Train)



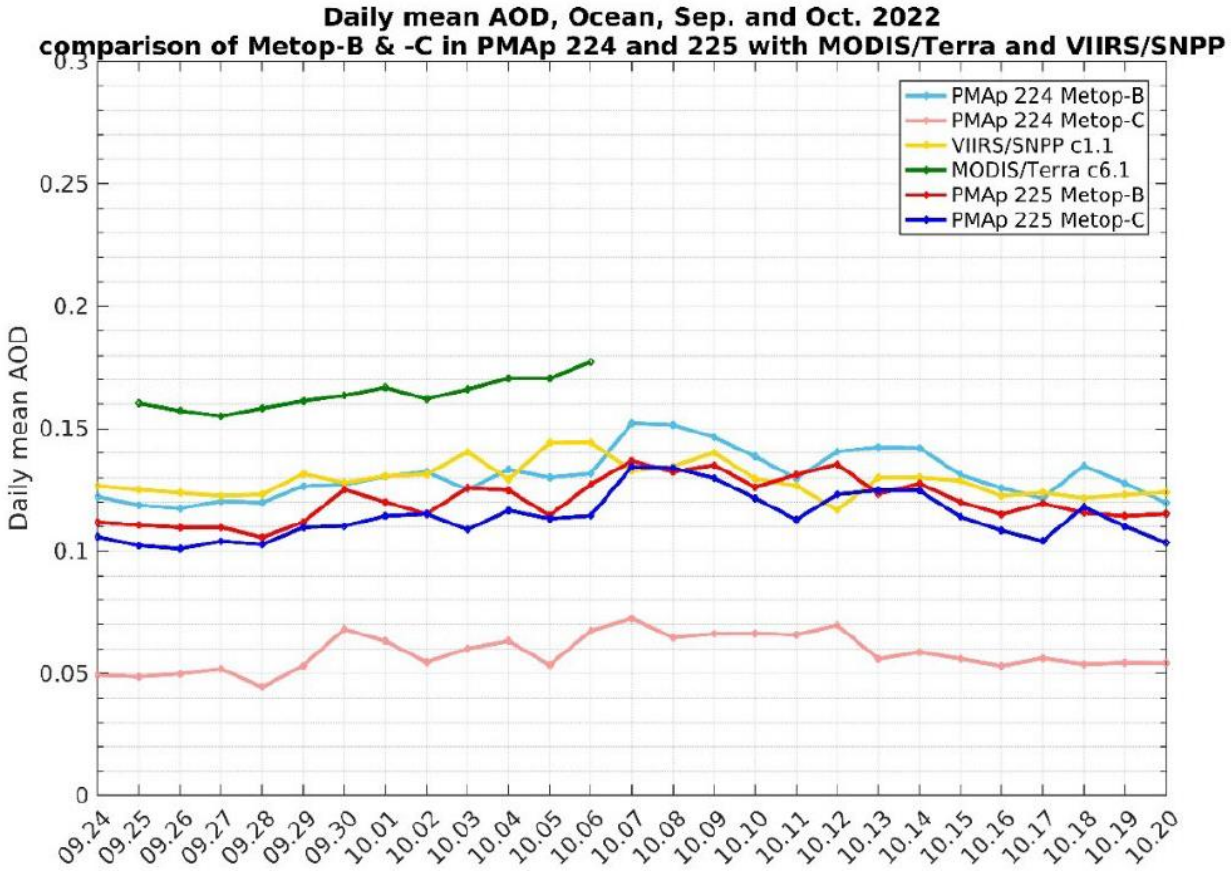
Preliminary results using MTG-FCI data!

Examples of monitoring and validation of Aerosol Optical Depth

Metop/PMAP vs. AERONET over land



Metop/PMAP vs. MODIS and VIIRS over ocean



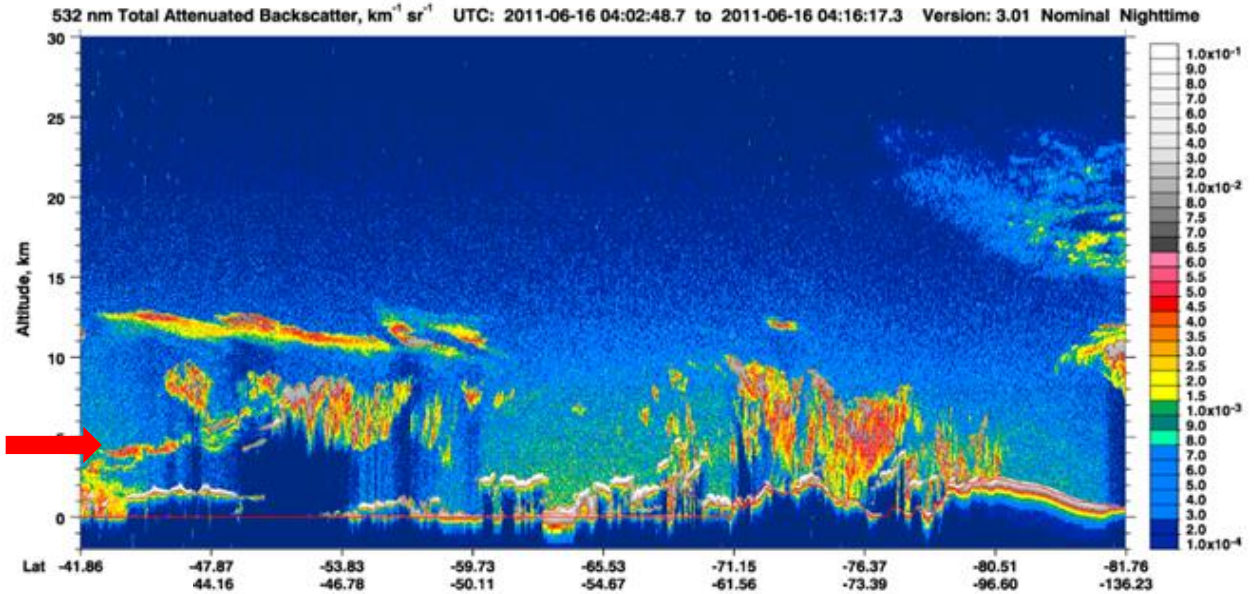
Adapted from "*Polar Multi-Sensor Aerosol Product (PMAP): Validation Re*port", EUMETSAT Doc. EUM/TSS/REP/14/745438 (Jan 2023)

Validation of Aerosol products with CALIOP

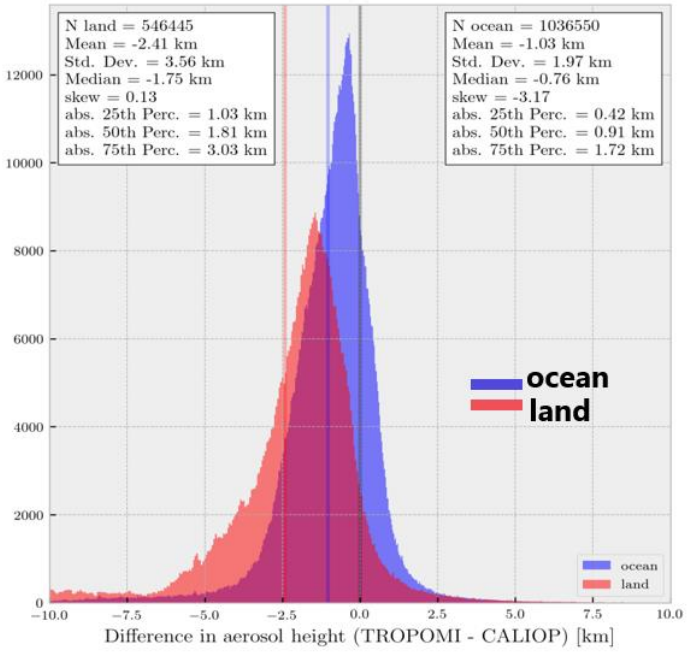
Support the analysis of problematic aerosol situations:

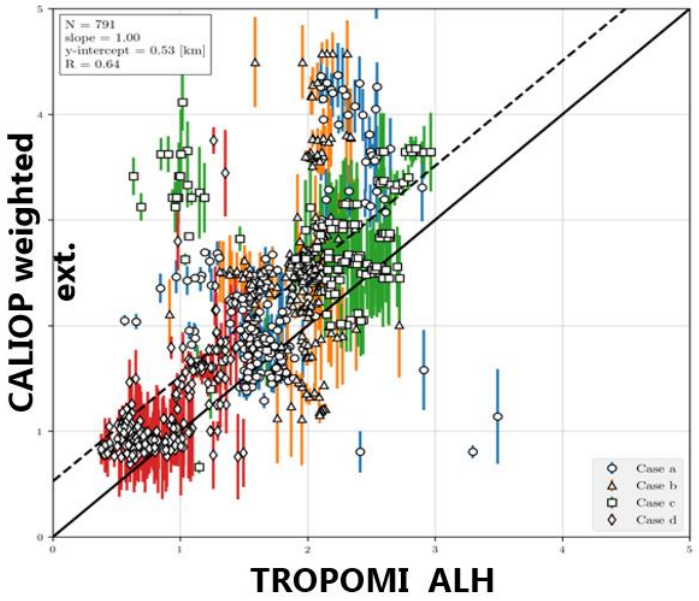
- A diagnosis can be provided about an specific altitude of the layer, its vertical distribution, a multi-layer situation, the identification of aerosol over clouds, residual cloud contamination, etc.

CALIOP Total Attenuated Backscatter @532nm (from Aeris web site)



Nanda *et al.*, AMT, 2019





Directly support the validation of aerosol layer height (ALH) from S3/OLCI (OLCOAH), 3MI, EPS-SG/MAP, etc.

- Provide a description of the vertical distribution – the definition of layer height usually remaining ambiguous
- Allow a quantitative evaluation of the performance

Plans for the use of EarthCARE products within EUMETSAT validation activities

Products

ATLID/CPR/MSI composite products selected for continuity with respect to A-Train/DARDAR products (see talk by S. Mason):

- ACM-CAP (liquid cloud/ice cloud/rain water content and effective radius, aerosol number concentration and extinction)
- ACM-COM (cloud water/ice content and particle size, aerosol type and optical depth at 355nm)

Use of the ACM-3D products (3D scene construction) is to be assessed.

Expected improvements with respect to A-Train we plan to exploit

- Fully synchronized observations form ATLID/CPR/MSI (lidar/radar/imager on the same platform)
- Higher accuracy of retrieved cloud/aerosol extinction profiles
- Better radar sensitivity to thin ice clouds and lower liquid cloud layers at higher spatial resolution
- Liquid cloud retrieval (although with higher uncertainty than ice clouds)
- Better discrimination and characterization of overlapping aerosol/cloud layers with HSRL ATLID. Aerosol/Cloud overlap is of particular interest for future EUMETSAT products.
- Improved synergic target classification

Remarks

Use of EarthCARE data in other EUMETSAT developments and activities:

- Assessment of the assumptions on aerosol vertical distribution (look-up tables) and layers in retrievals from instruments with no vertical capabilities (e.g., current Metop/PMAP product)
- Use of the Broadband Radiometer (BBR) for the validation of Outgoing Longwave Radiation (OLR) products
- Radiometric calibration of imagers (e.g., in plan for EPS-SG/METimage if temporal overlap allows)
- Comparison of atmospheric correction estimation from passive imagers (e.g., MAP and CLIM) and profile measurement from EarthCARE

All EUMETSAT products discussed here are available through the **EUMETSAT Product Navigator and Data Centre Download Tool**: https://navigator.eumetsat.int

Product monitoring and validation results available to users via **METIS** (**M**onitoring & **E**valuation of **T**hematic **I**nformation from **S**pace): https://metis.eumetsat.int

For **more information** about the EUMETSAT products discussed in this presentation, please contact:
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