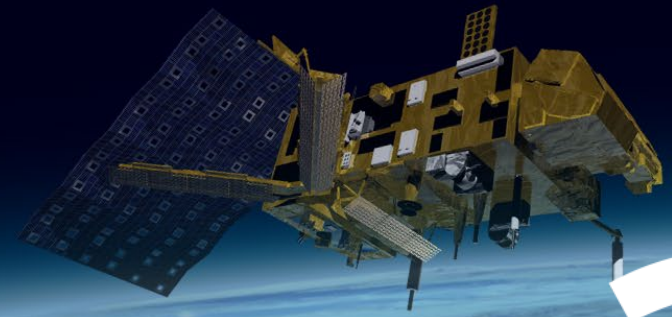


Operational observation of atmospheric chemistry at EUMETSAT

Rasmus Lindstrot, A. Cacciari, D. Czyzewska, S.
Gimeno Garcia, N. Hao, P. Köhler, R. Lang, R.
Munro, G. Poli, F. Rüthrich, M. Taberner, Y. Wang, B.
Bojkov

ESA Living Planet Symposium, 24/May/2022





Atmospheric Chemistry at EUMETSAT

Current missions

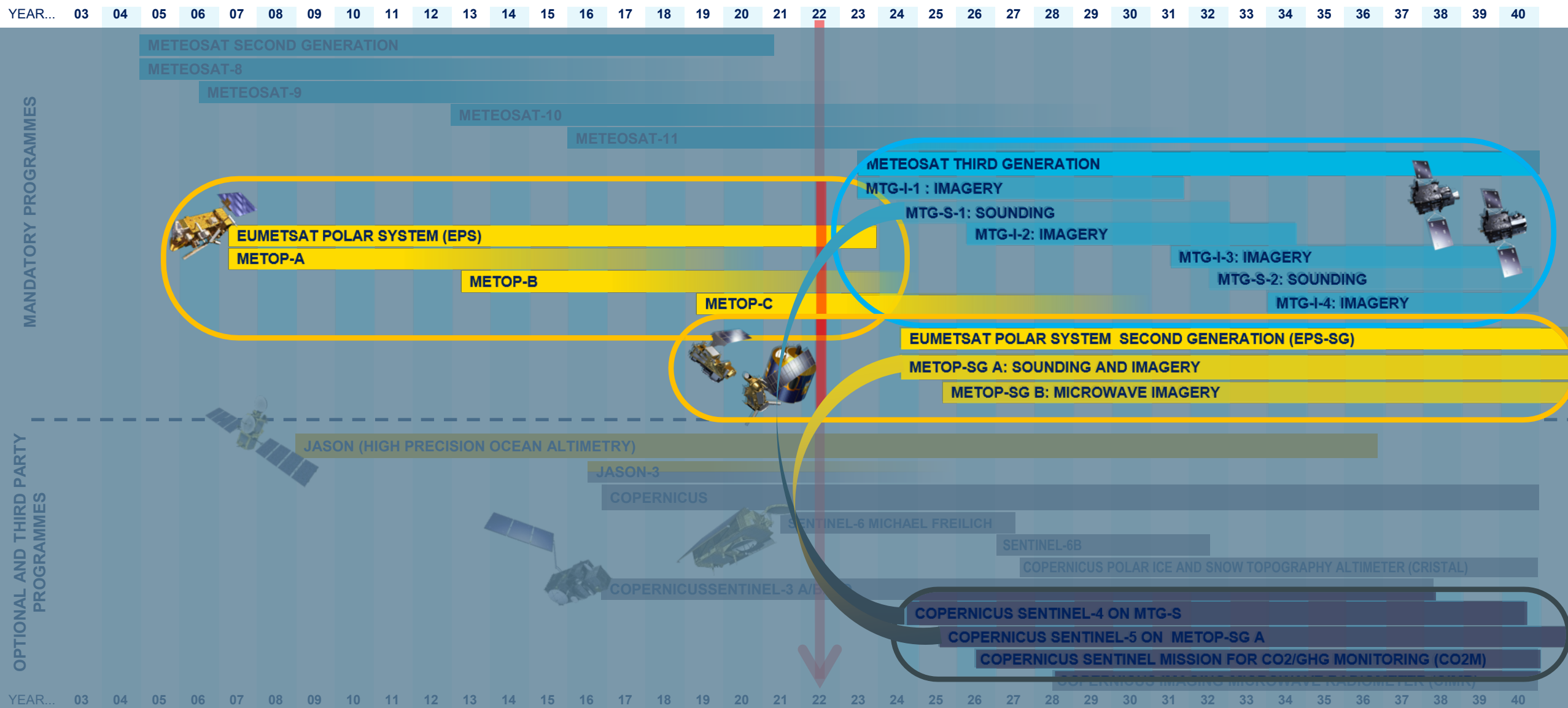
GOME-2 on Metop A/B/C

Future missions

Copernicus Sentinel-4 and Sentinel-5
CalVal planning



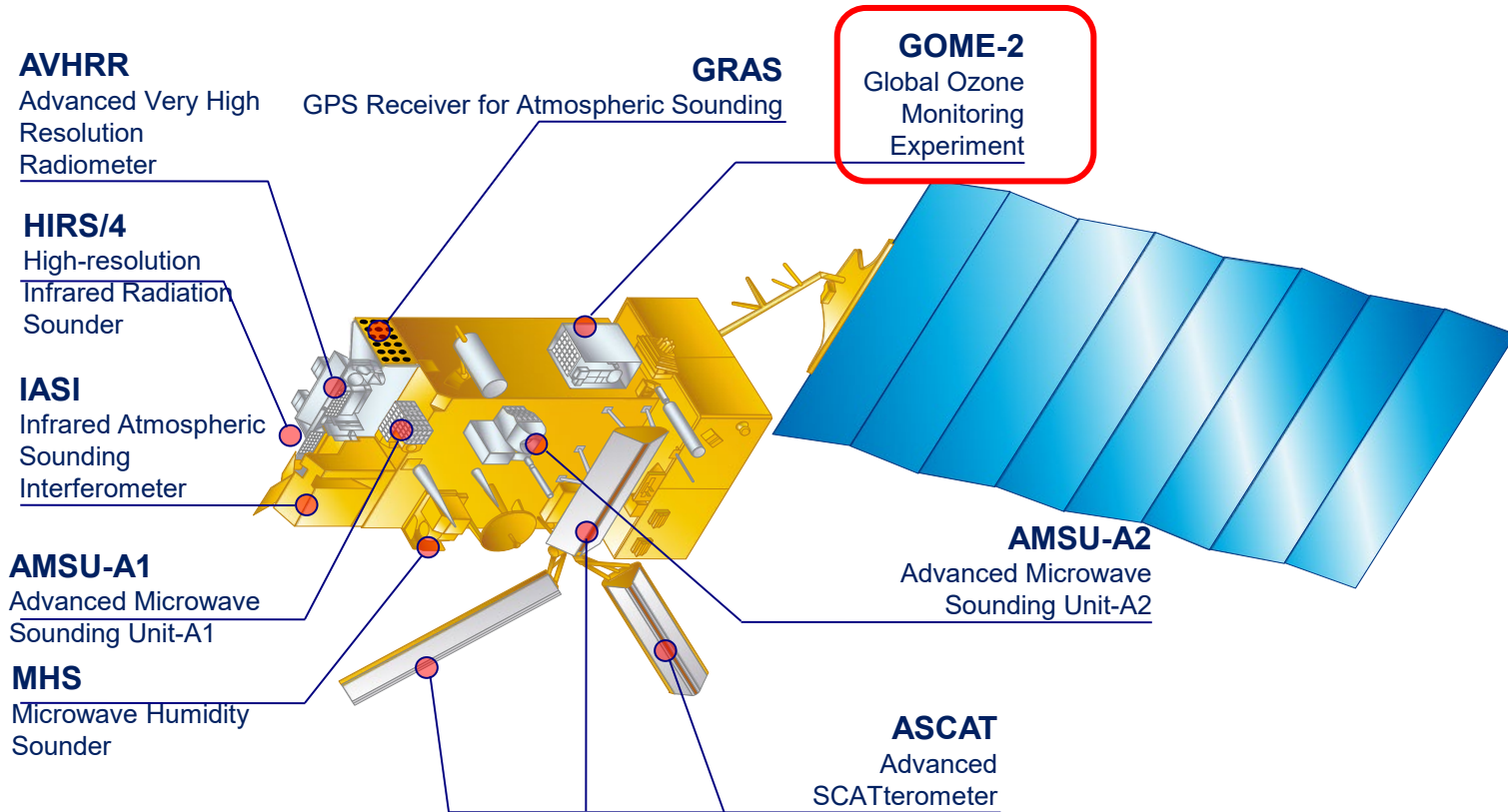
EUMETSAT mission planning - with focus on Atmospheric Chemistry





GOME-2 on Metop-A,B,C

Metop A **2006 - 2021**
Metop B **2012 -**
Metop C **2018 -**

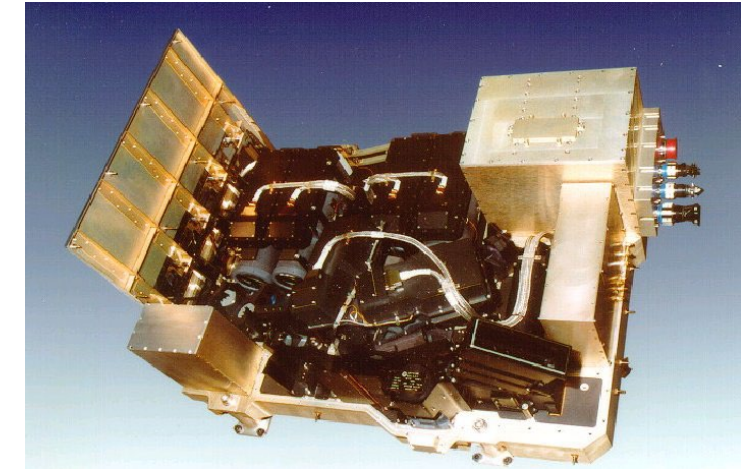


© 2018 ESA, CNES, AIRBUS SPACE OPERATIONS, Video 001_GSG_001

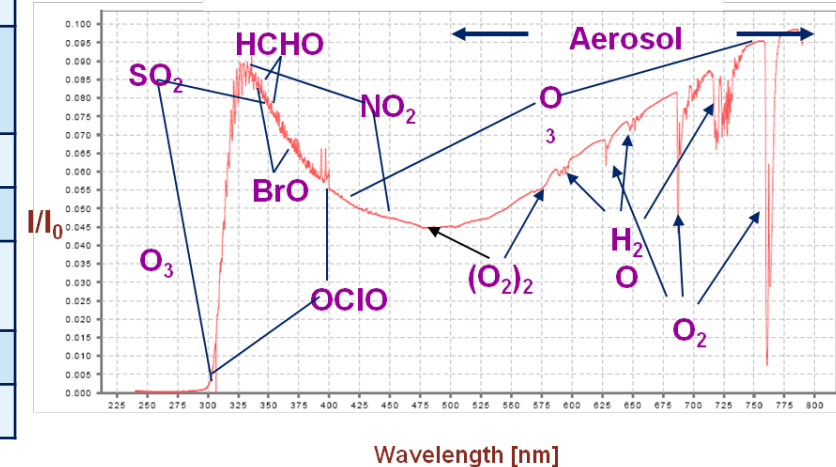


GOME-2 on Metop-A,B,C

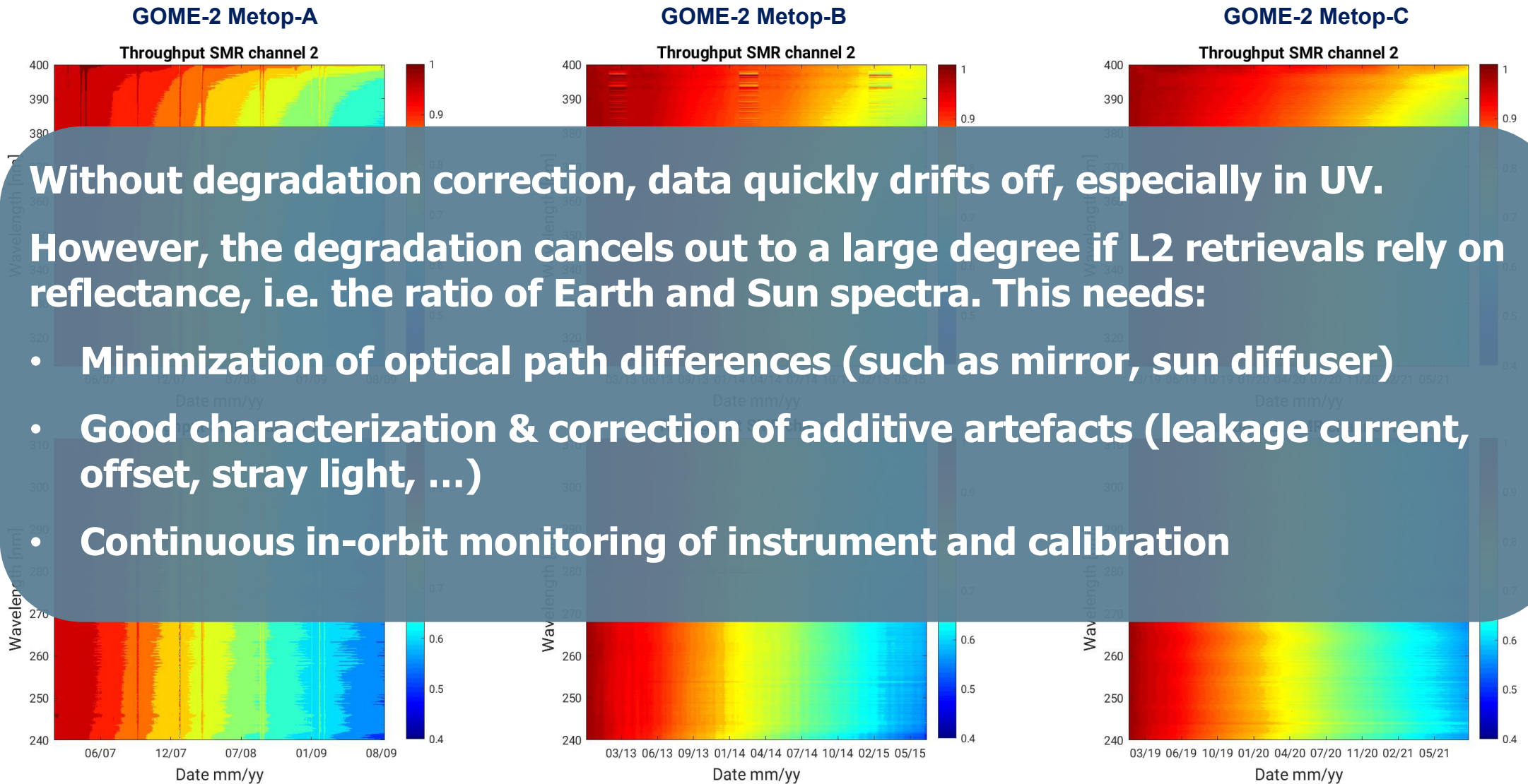
Item	Specification
Spectral range (nm)	240-790
Spectral resolution (nm)	0.26-0.51
Spatial resolution (km ²)	80 × 40 (main channels) 80 × 10 (PMD)
Swath width (km)	120-1920
Spectral channels	4096 (in four separated optical channels)
Polarization channels	30 (in two separated optical channels)
Calibration system	Spectral lamp, white lamp, solar diffuser LED
Dimensions	600 mm × 800 mm × 500 mm
Weight	68 kg
Main bus voltage	22-37 V
Power consumption	50 W
Data rate interface	400 kbit



GOME-2 main channel transmittance



- L1 products are being generated centrally at EUMETSAT
- AC SAF is generating the long list of L2 NRT, offline products and data records derived from these



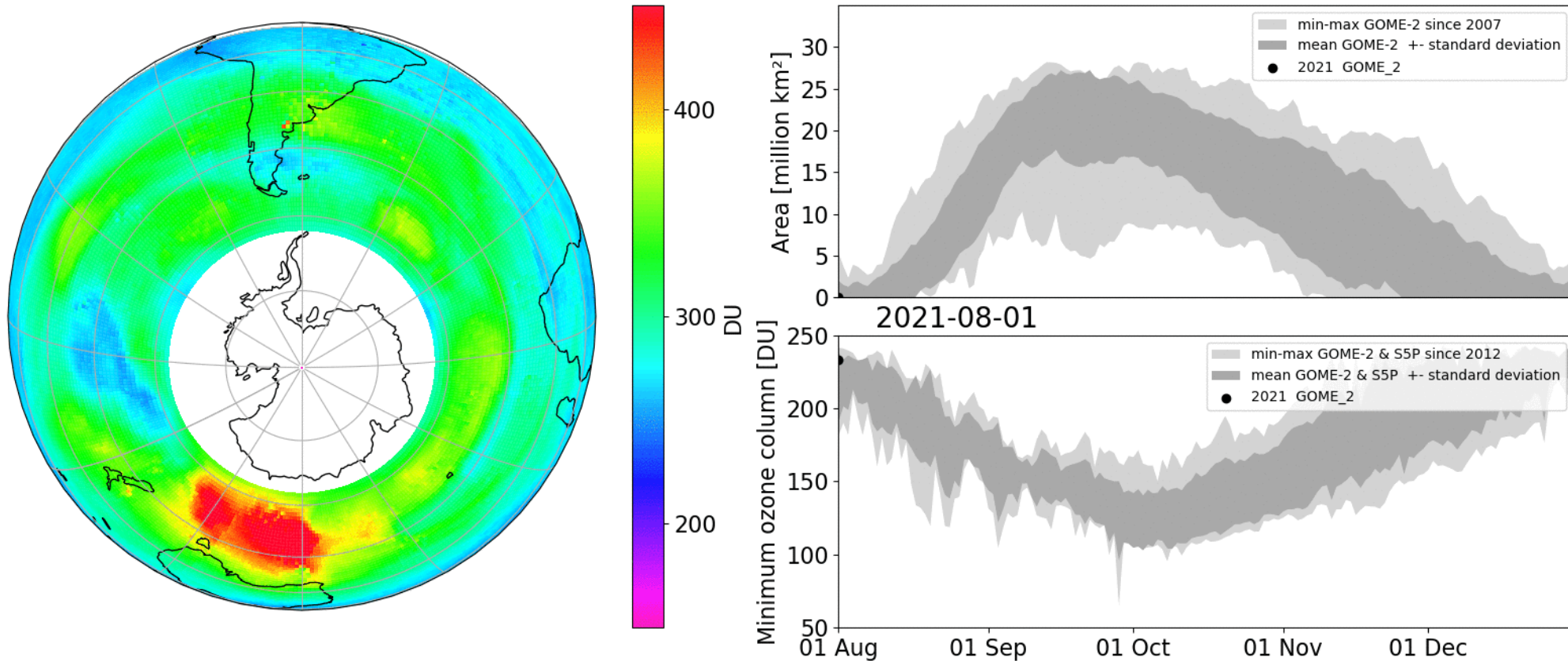
Without degradation correction, data quickly drifts off, especially in UV. However, the degradation cancels out to a large degree if L2 retrievals rely on reflectance, i.e. the ratio of Earth and Sun spectra. This needs:

- **Minimization of optical path differences (such as mirror, sun diffuser)**
- **Good characterization & correction of additive artefacts (leakage current, offset, stray light, ...)**
- **Continuous in-orbit monitoring of instrument and calibration**

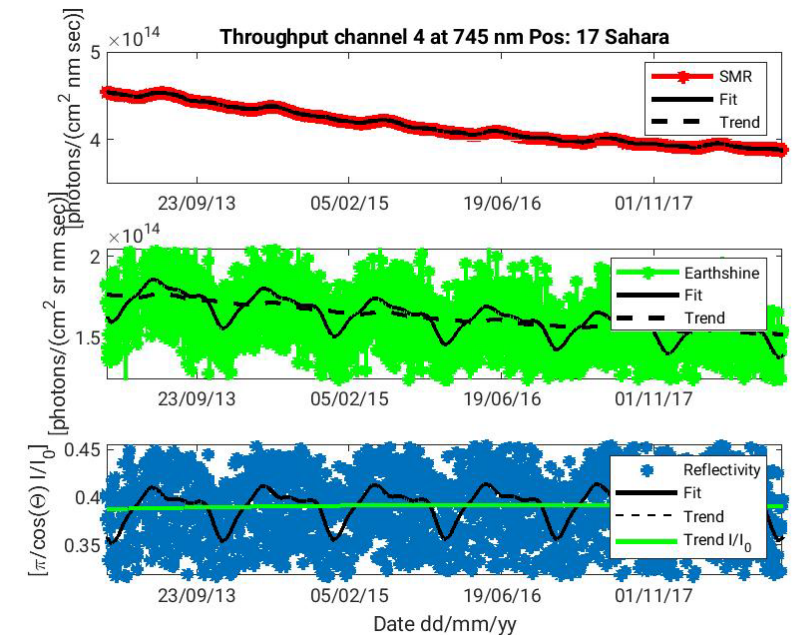
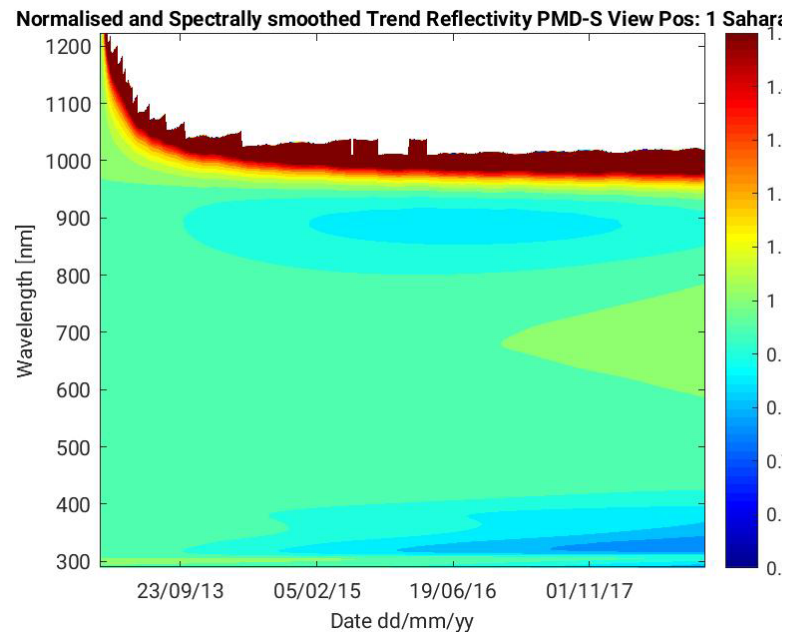
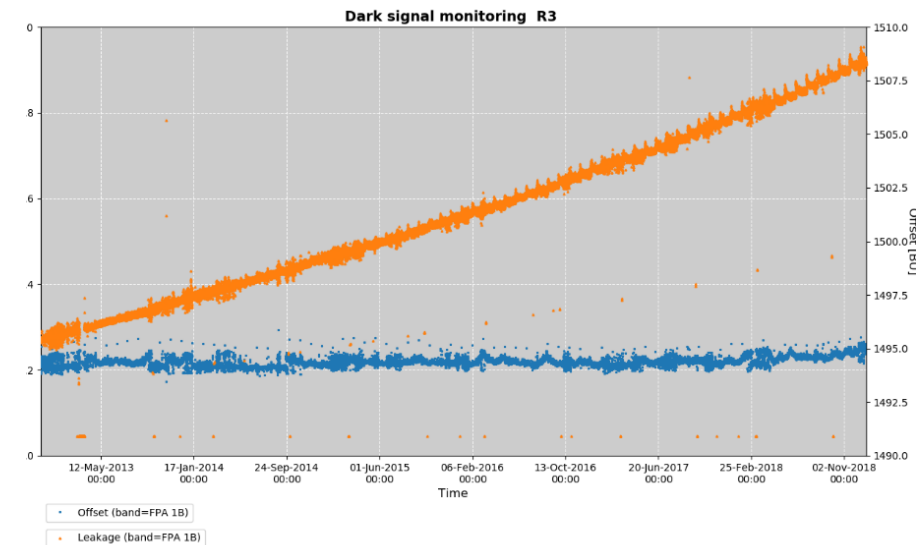
GOME-2 throughput for FM3, FM2, FM1 after similar time in orbit



GOME-2 L2 retrievals. Example: O3 monitoring



- 3rd reprocessing of GOME-2 L1 FDR available from next week, from the EUMETSAT Data Centre and/or User Service Helpdesk (ops@eumetsat.int)
- produced with the GOME-2 level 0-to-1b operational processor v6.3.3 and carefully validated
- covering 04.2007 - 12.2018 (Metop-A) 12.2012 – 12.2018 (Metop-B).
- doi:10.15770/EUM_SEC_CLM_0039



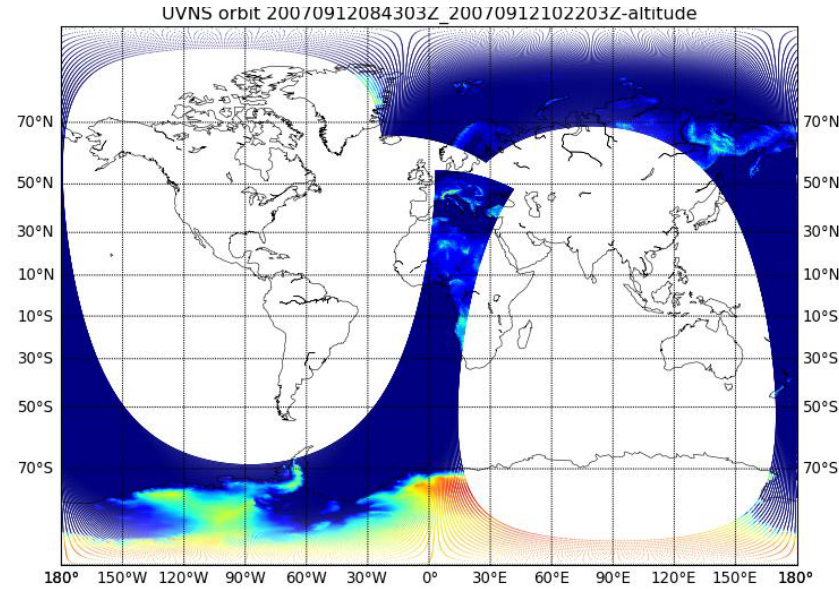


EUMETSAT Polar System – SG A / Copernicus Sentinel-5



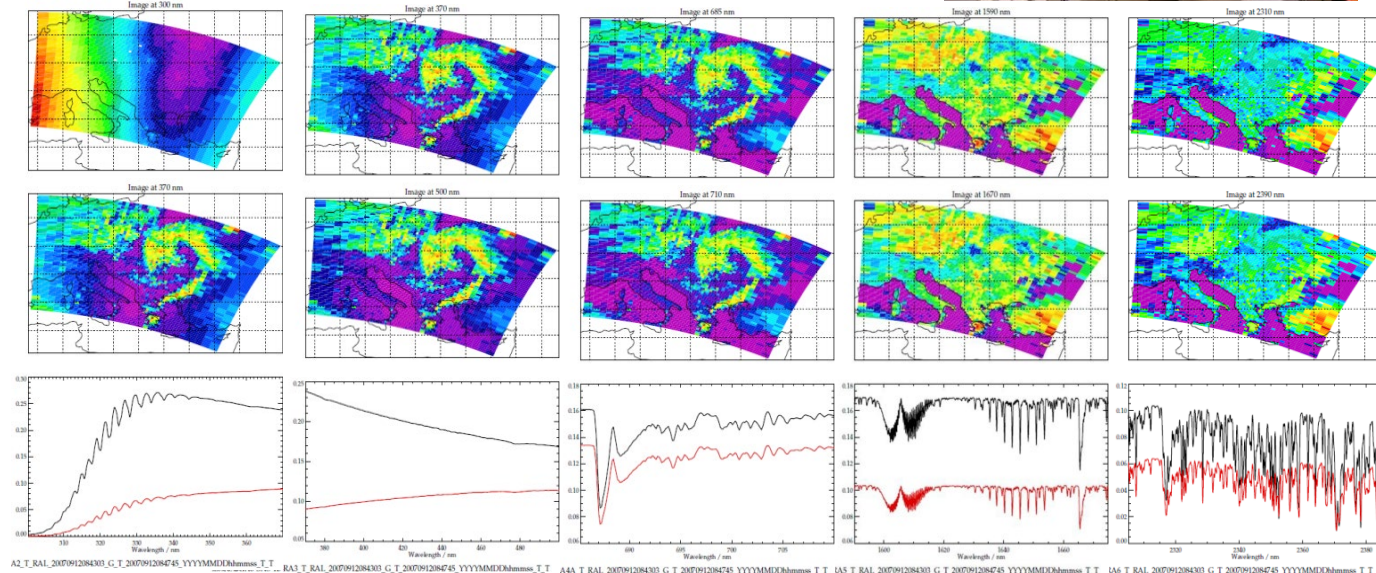
www.eumetsat.int

Parameters	
Clouds	Effective Optical Depth (cirrus only)
	Effective Height
	Fraction/Mask from VII
Aerosol	UV Absorbing Index
	Layer Height
Surface Albedo	Surface Albedo
Ozone O3	Stratospheric Vertical Profile
	Tropospheric Column
	Total Column
Nitrogen dioxide NO2	Total Column
	Tropospheric Column
Sulfur dioxide SO2	Total Column and Height
Formaldehyde HCHO	Total Column
Methane CH4	Total Column
Carbon monoxide CO	Total Column
UV	Spectrally Resolved Irradiance at Surface and UV Index
Glyoxal CHOCHO	Total Column
Scene heterogeneity from VII	Scene heterogeneity from VII



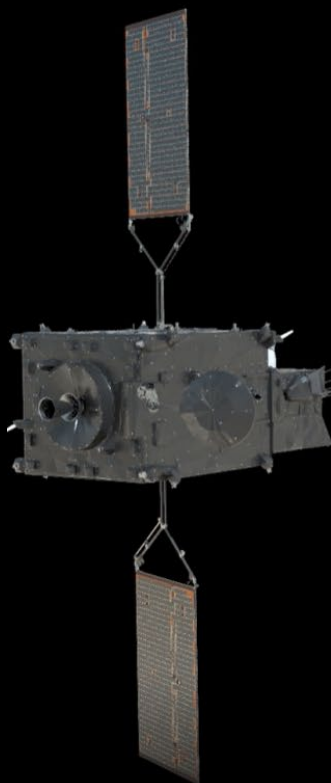
The Sentinel-5 instruments are CFI provided by ESA in the framework of the Copernicus Space Component to the ESA Metop-SG Programme.

Metop-SG A PFM
Credits: esa





- The Meteosat Third Generation – Sounder platform will carry the Copernicus Sentinel-4 payload.
- Currently scheduled for launch in Q2 2024
- First European Air Quality mission in a geostationary orbit



Copernicus Sentinel-4

UVN Sounder (Ultraviolet – Visible – Near-infrared)

1 scan every hour during daytime

1 sample every ~8 km

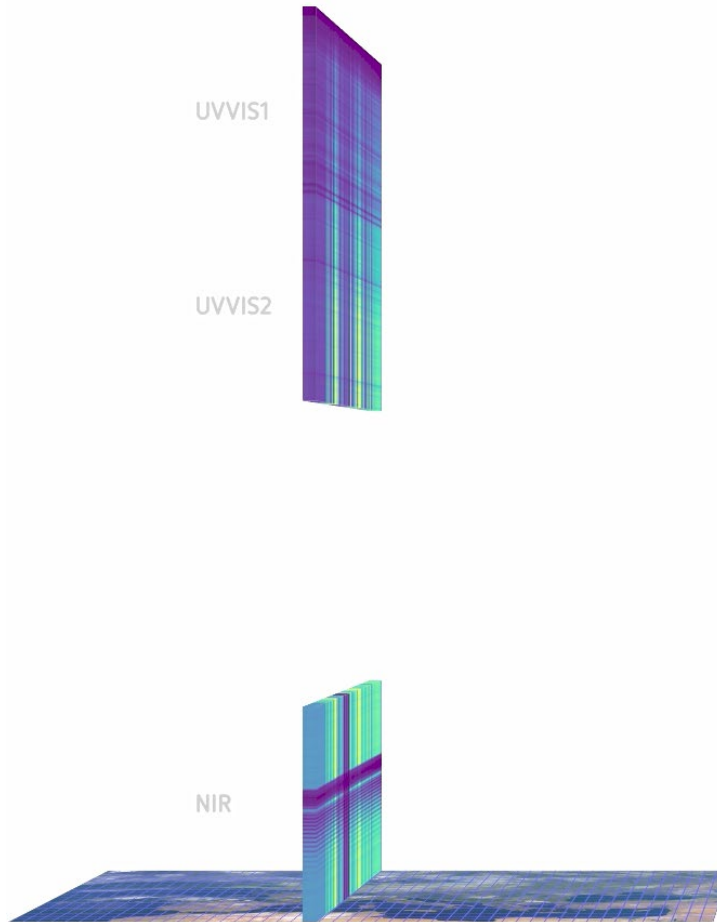
Meteosat Third Generation – Sounder



The Sentinel-4 instruments are CFI provided by ESA in the framework of the Copernicus Space Component.



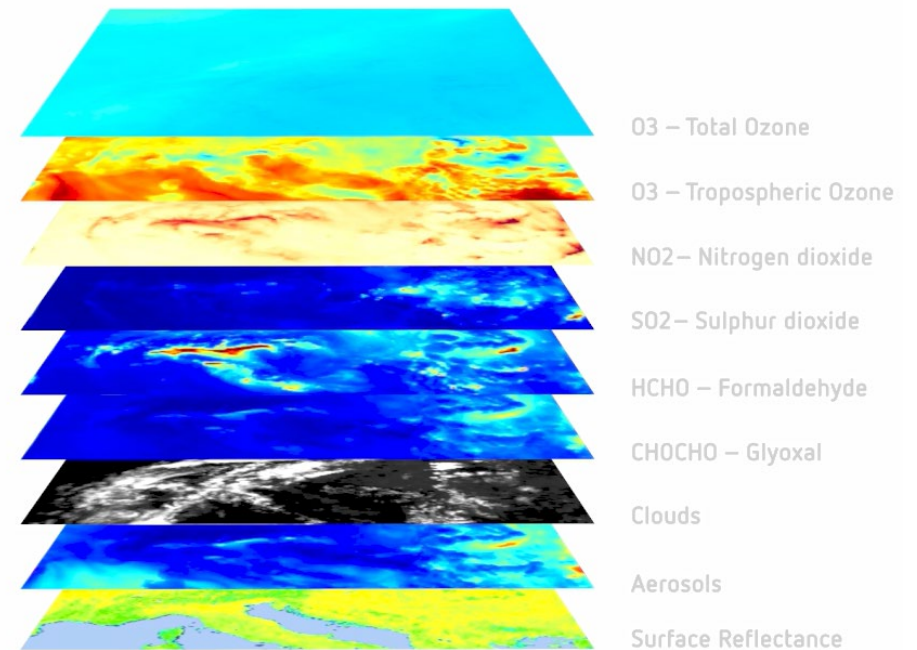
Parameter
Total O ₃ column
Tropospheric O ₃ sub-column
NO ₂ total column, tropospheric sub-column
SO ₂ total column
CH ₂ O total column
CHOCHO total column
Aerosol absorbing index
Aerosol layer height
Cloud optical thickness, fraction, altitude
Surface reflectance (Lambertian equivalent albedo and bi-directional reflectance factor), aerosol optical thickness
Cloud and scene characteristics from FCI re-sampled to S4 L1b spatial grid
Aerosol column optical thickness, type, layer height, absorbing index
Cloud optical thickness, fraction, altitude
O ₃ with enhanced separation of the lower troposphere



Meteosat Third Generation - Sounder

Copernicus Sentinel-4 UVN

Geophysical products (Level-2)

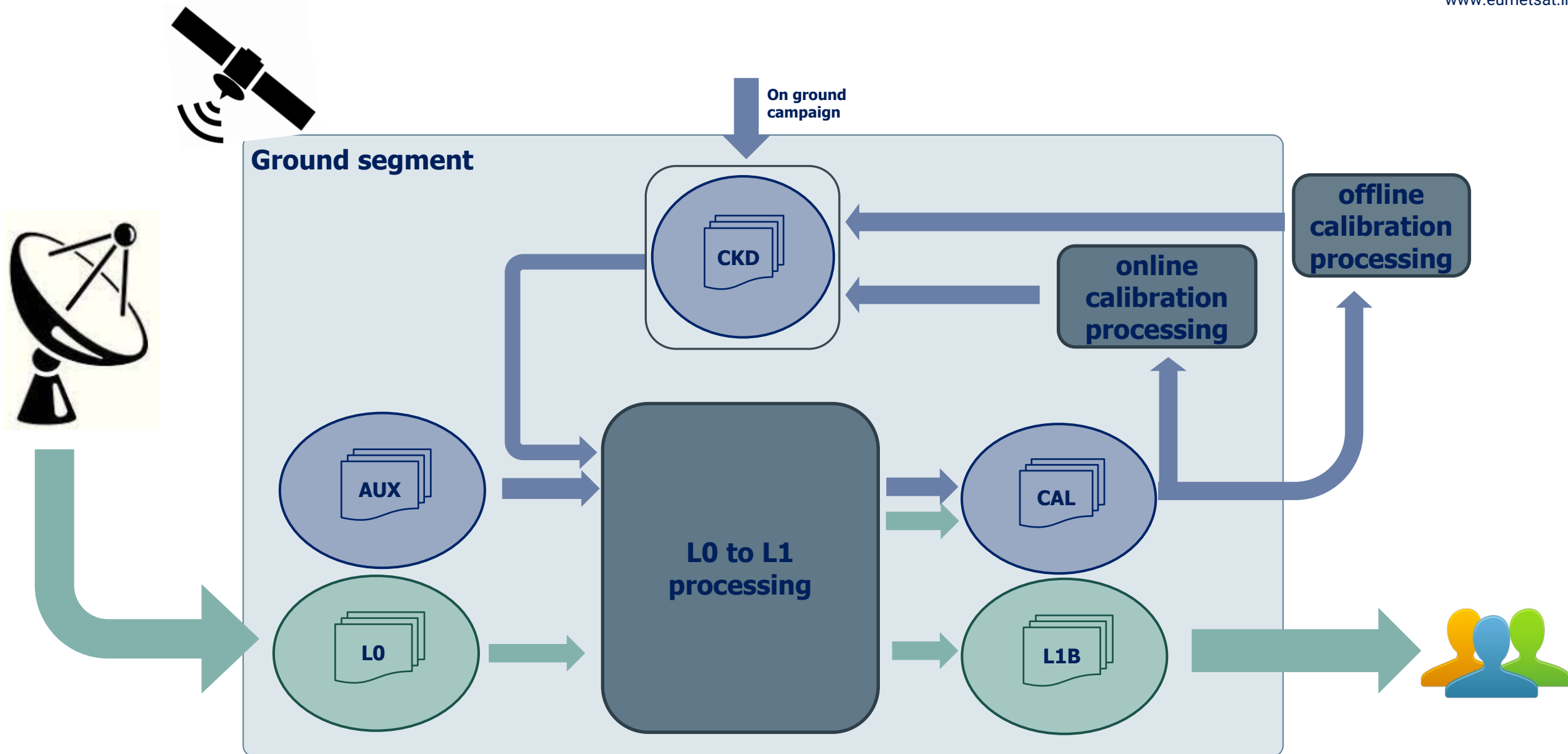




- High resolution spectrometer systems with very demanding radiometric/spectral/geometrical requirements.
- Throughout mission lifetime, L0-to-L1B processors need to have access to accurate Calibration Key Data (CKD) in order to generate compliant L1B products.
- Part of the CKD is dynamic, i.e., it is subject to temporal fluctuations and drifts at different time scales. Reasons: Launch/settling effects, Optics / detector / diffuser contamination & degradation, etc. **See GOME-2 example.**



- CKD life cycle:
 1. On-ground calibration campaign (-> CKD), complemented by
 2. Commissioning phase measurements (-> CKD completion & update)
 3. Routine operations (CKD update)
- On-board calibration sources (LED, WLS, SLS) are used in addition to Sun, Dark, Deep Space and Star measurements to monitor instrument calibration.
- Operational L0-L1 processors are designed to calculate updated CKD in an autonomous way, where possible
 - spectral calibration; dark current; electronics offset; system non-linearity; defective pixel maps; pixel response non-uniformity (PRNU), ...





- The **Sentinel-4 and Sentinel-5 Calibration and Validation Plan** captures the different tasks to be fulfilled during commissioning and routine phases.
- Level-1 calibration:
 - Solar, on-board, and vicarious calibration targets
 - Other satellite data (GOME-2, Sentinel-5p, TEMPO/GEMS, ...)
 - via international partner collaboration, partner agencies, GSICS, CEOS AC/VC.
- Level-2 trace gas (and ancillary) product validation and verification:
 - Ground-based observations (NDACC, Pandonia, WOUDC, Eubrewnet, TCCON, ...)
 - Other satellite data (GOME-2, Sentinel-5p, TEMPO/GEMS, ...)
 - Dedicated campaigns
 - Model-based validation (CAM5)
- These Fiducial Reference Measurements (FRM) will form the basis of the absolute validation
 - Timeliness requirement: < 48h (NTC)
 - Data access & format (Easy access, data format, consistent and traceable processing approach, traceability to standard and/or community recognised best practices, high product quality)
 - Documentation
 - Long-term availability in order to cover the time of the missions
- Announcement of Opportunity (AO) Call to be released 18-24 months prior to launch, whereby ESA and EUMETSAT invite interested groups to participate in carrying out the activities defined in the CalVal plan.

Preparation of CalVal tools & facilities is a primary focus now.



Thank you!

Questions are welcome.