

EUMETSAT role in the Copernicus space programme expansion: the contribution to CO2M, CRISTAL and CIMR missions.

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EUMETSAT role in Copernicus space programme expansion

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EUMETSAT is contributing to the upgrades of the Copernicus Space Infrastructure that are necessary to ensure continuity, enhanced continuity and expansion of the current observation scope:

Contributions to the development and deployment of the ground segment of the **Copernicus CO2M mission for routine operations**, including data processing infrastructure and operational processors. EUMETSAT will be in charge to perform routine operations.

Development and deployment of data processing chains for the provision of global ocean operational products from the **Copernicus CIMR mission**;

Development and deployment of data processing chains for the provision of global ocean operational products in synergy with Sentinel-3/-6, from the **Copernicus CRISTAL**.

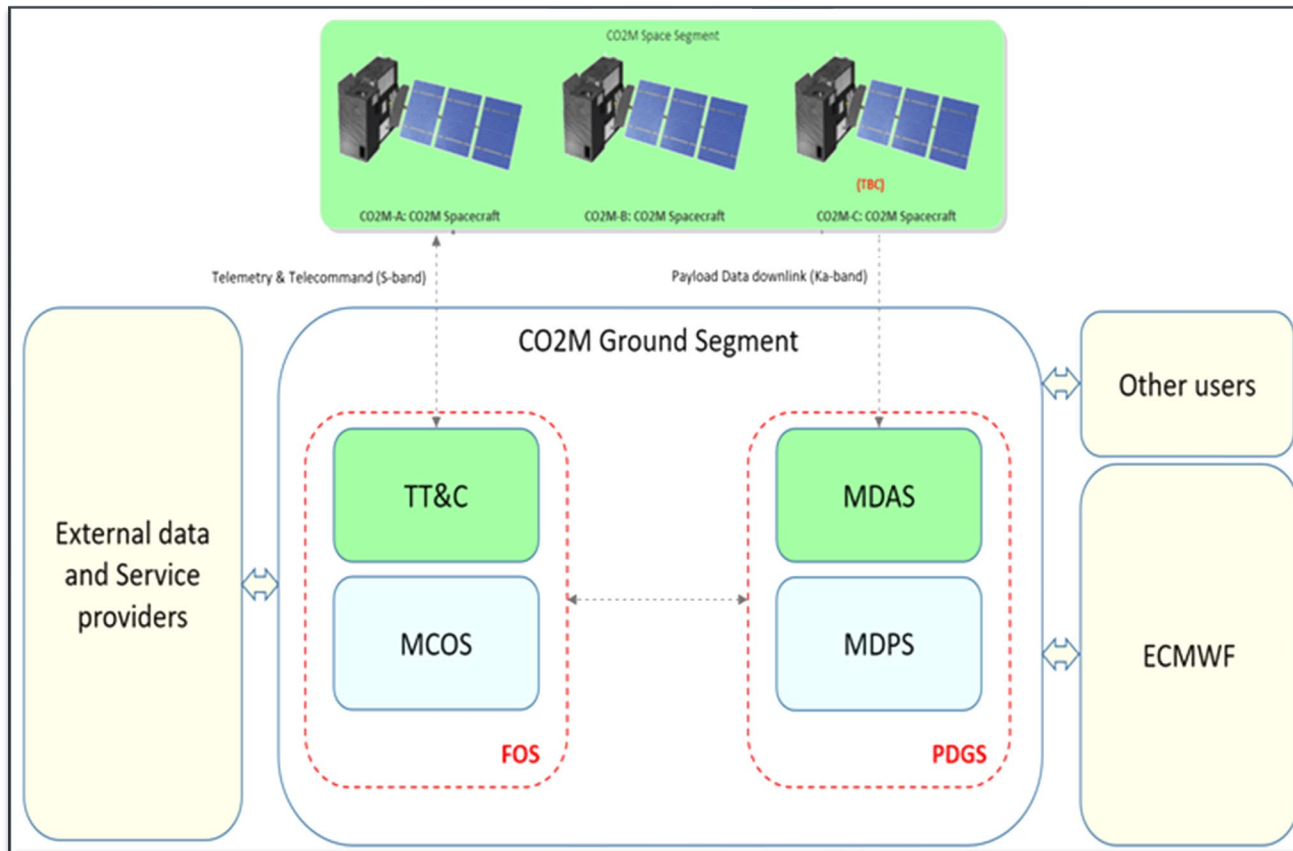




Copernicus CO2M System Development

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- **ESA is responsible** of the Space Segment development and its commissioning (ESA's presentation in Session B8.08.1 Copernicus Sentinel Expansion Missions)
- **EUMETSAT is responsible** of the development of the operational ground segment (with contributions from ESA) and the CO2M system operations in system commissioning and routine phase.
- **ESA and EUMETSAT are jointly performing** activities at System level, including the development and maintenance of the System Design, Technical Budget, Integration Verification Validation, Schedule, Risks, Science and Operation Preparation aspects, etc.



For payload data (PDGS):

- MDPS (Mission Data Processing Sub-Segment, including: L0/L1/L2 Operational Processors; Archival Dissemination) provided by EUMETSAT;
- MDAS (Mission Data Acquisition Sub-Segment) provided by ESA as a service.

For Flight Operations (FOS):

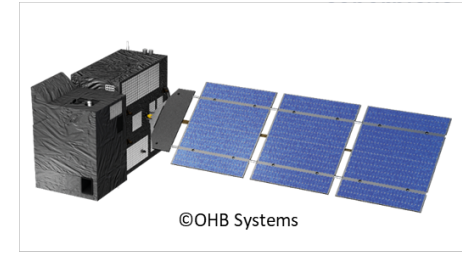
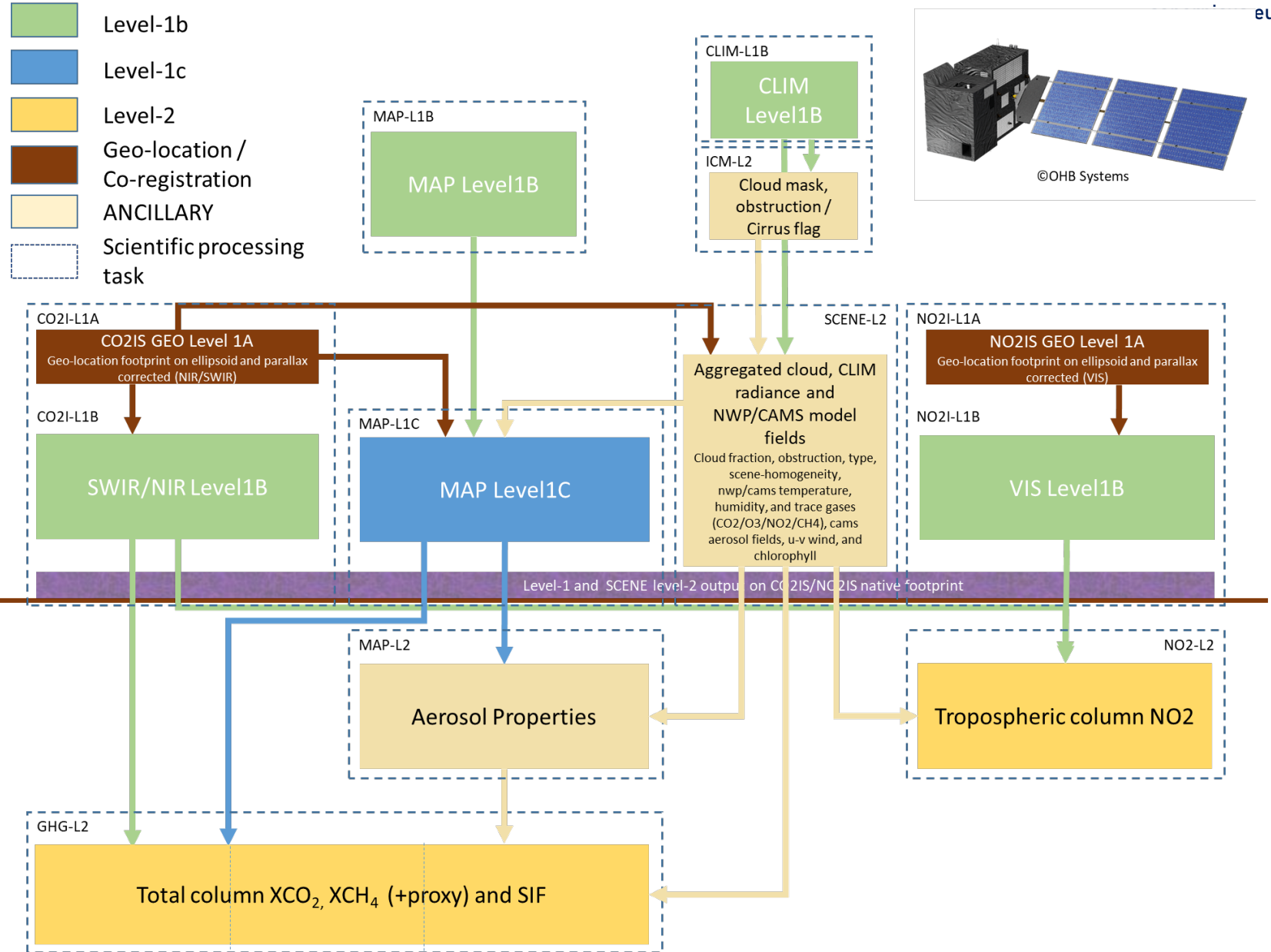
- MCOS (Mission Control and Operations sub-segment, including Mission Planning Facility) provided by EUMETSAT;
- TT&C (Telemetry, Tracking and Command) provided by ESA as a service.



EUMETSAT CO2M MDPS scientific processing tasks

CO2M
Mission Data
Processing System

Make one
"hyper-GHG/NO2-
instrument"
out of three!



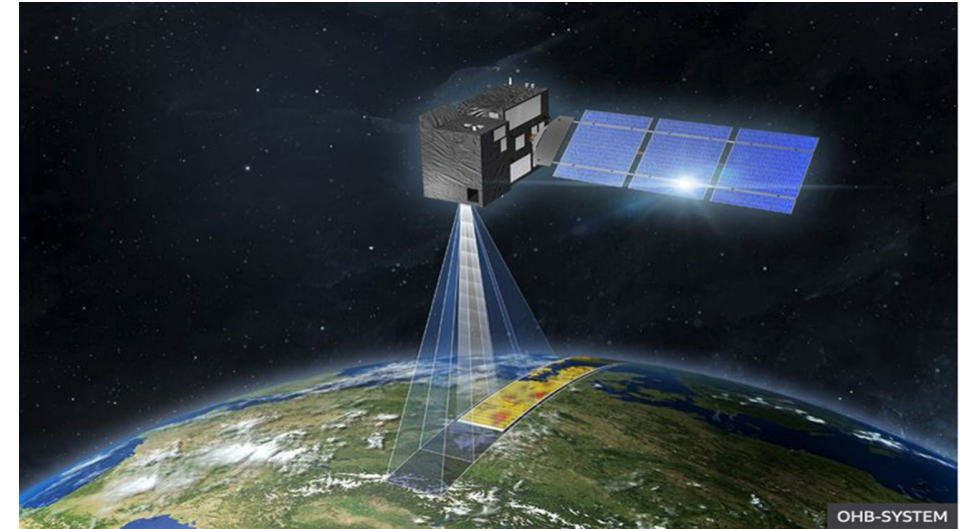
Below this level: everything is co-registered or provided at the CO2I/NO2I spectrometer footprint



Copernicus CO2M mission – processing and products

CO2M Products requirements (MRD v3):

Product	Spatial resolution	Precision	Bias
CO2	4 km ²	0.7 ppm	<0.5 ppm
CH4	4 km ²	10 ppb	<5 ppb
NO2	4 km ²	1.5x10 ¹⁵ molec/cm ²	<3.5x10 ¹⁵ molec/cm ²
SIF*	4 km ²	0.7 mW m ⁻² sr ⁻¹ nm ⁻¹	<0.2 mW m ⁻² sr ⁻¹ nm ⁻¹
Aerosols	16 km ²	0.05 AOD, 500 m LH	<0.05 AOD, 500 m LH
Clouds	4 km ²	<1% of FOV	

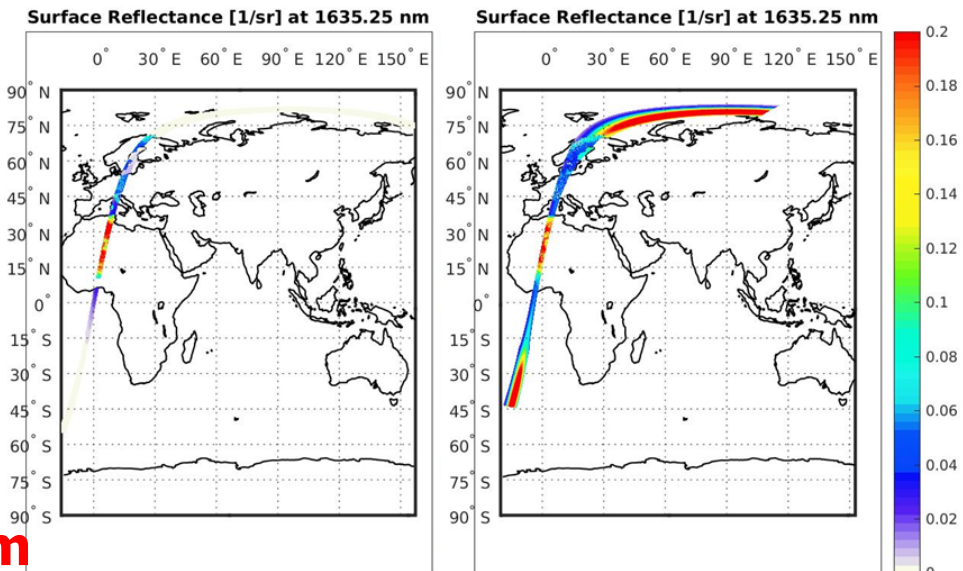


VIS band also covers CHOCHO (glyoxal)
 VIS & SWIR band also covers water vapour
 *Top-of-Atmosphere Solar Induced Fluorescence

Estimated amount of data (per orbit, per satellite) for CO2I:

Number of measurements: ~1.1 million
 Number of clear sky retrievals: ~200.000
 Level-1 product size: ~209 Gb
 Level-2 product size: ~5 Gb

Accuracy of 0.125 % @ 400 ppm needed!



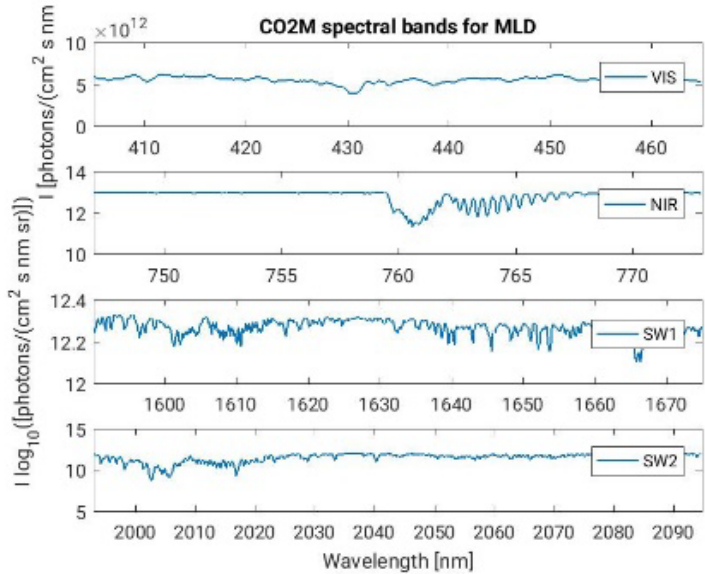


Copernicus CO2M mission – level-1 radiance and cloud products

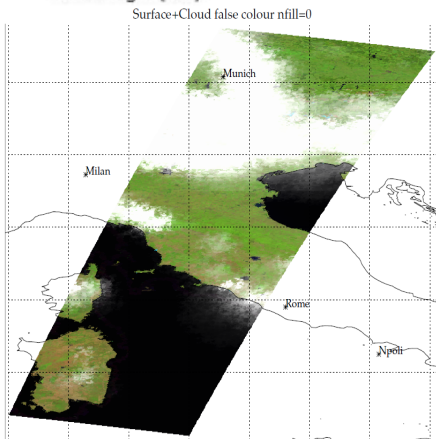
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Level-1b NO2-IS:
Calibrated radiances
VIS (405 – 490 nm)

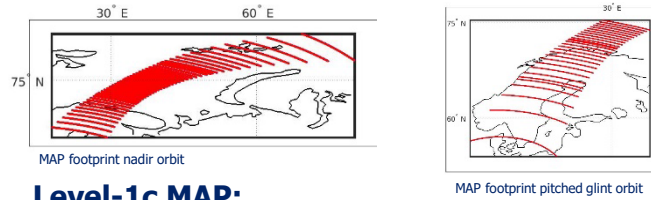
Level-1b CO2-IS:
Calibrated radiances
NIR (747 – 773 nm)
SWIR-1 (1590 -1675 nm)
SWIR-2 (1990 -2095 nm)



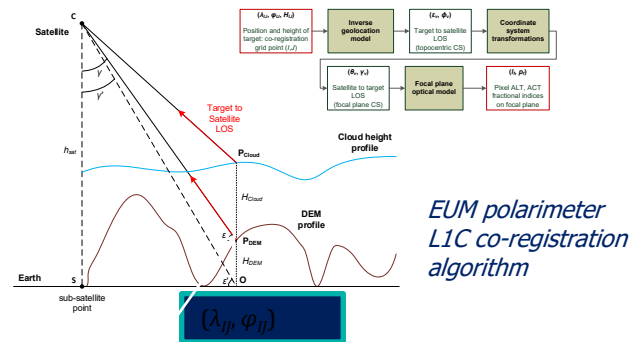
False-color image
VIS/NIR/SWIR-1
for modelled
CO2M radiances
from prelim. EUM
test-data-set
(From EUM test-
data study)



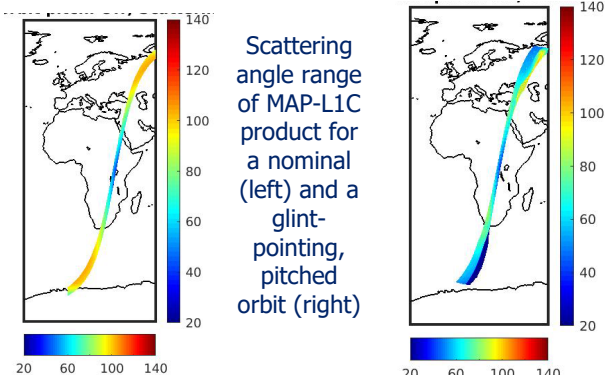
Level-1b MAP:
Calibrated pol. radiances
(410 443 490 555 670 (753) 865 nm)



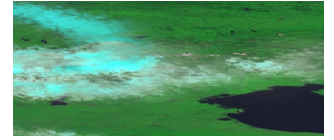
Level-1c MAP:
Multi-view I,Q,U radiances at CO2-IS footprint



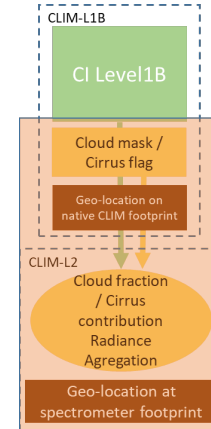
Pointing from P at CO2-IS lat/lon footprint point
 (λ, φ) , from terrain height H to MAP instrument
detector plane. (Cloud height parallax not considered for CO2M, TBC)



Level-1b CLIM:
Calibrated radiances
(670 753 1320 nm)



Cloud and cirrus flag /
cloud and cirrus obstruction at native resolution



EUM cloud CLIM L2 study (Syn-Cloud): Brockmann Consult

Level-2 CLIM:

Aggregated cloud and cirrus obstruction at CO2-IS resolution:

- Cloud fraction (geometric)
- Cloud top height (TBD)
- Cloud obstruction (radiometric)
- Scene inhomogeneity (std of imager radiances)

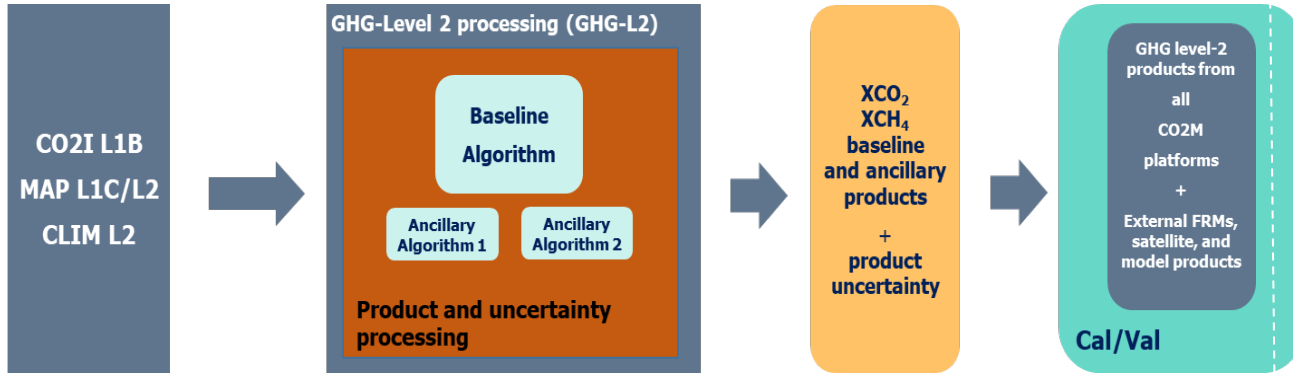
Additional cloud information:

- CO2-IS NIR: Oxygen A-Band
- NO2-IS: $(\text{O}_2)_2$ absorption
- MAP: I, Q, U (Rainbow, cloud type, ...)
- CO2-IS SWIR: cirrus



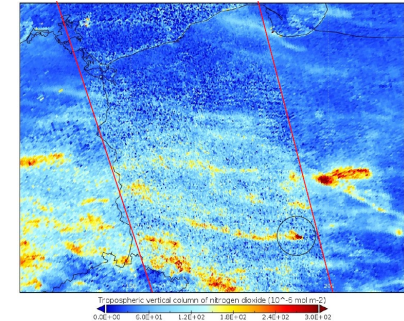
Copernicus CO2M mission – level-2 products

CO2M GHG level-2 product: XCO2 / XCH4



CO2M NO2 level-2 product (plume mapping)

EUM NO2 level-2 study algorithm: TriOpSys/KNMI



TropOMI/S5p zoom mode at ~2x2 km

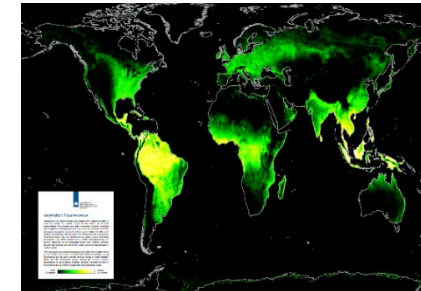
EUM GHG level-2 study algorithms:

*RemoTAP (SRON)
FOCAL (U. Bremen)
UoL-FP (U. Leicester)*

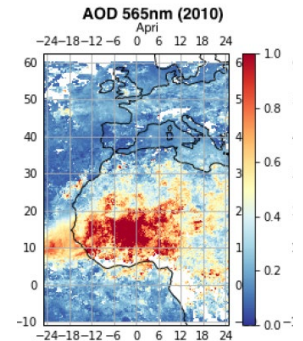
CO2M Products requirements:

Product	Spatial resolution	Precision
CO2	4 km ²	0.7 ppm
CH4	4 km ²	10 ppb (est.)
NO2	4 km ²	1.5x10 ¹⁵ molec/cm ²
SIF*	4 km ²	0.7 mW m ⁻² sr ⁻¹ nm ⁻¹
Aerosols	16 km ²	0.05 AOD, 500 m LH
Clouds	<5% of FOV	Water & cirrus clouds

CO2M SIF and Aerosol level-2 product



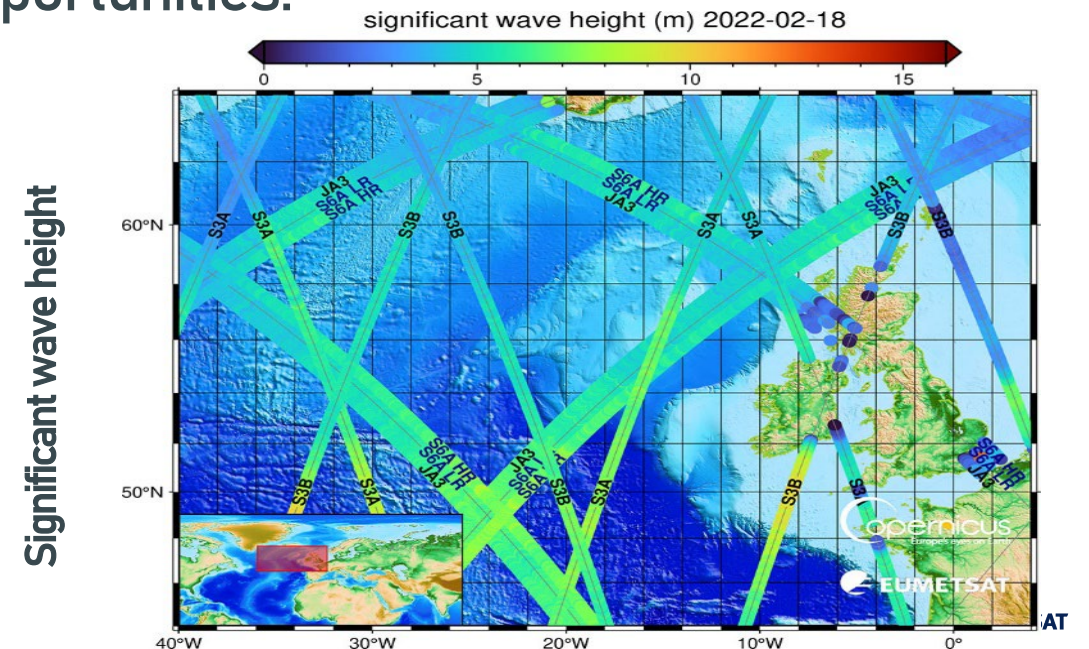
EUM SIF level-2 study algorithm: U. Leicester



EUM Aerosol level-2 study algorithms: GRASP (GRASP-SAS/U. Lille)

- The EUMETSAT Role in the Altimetry domain is:
 - provide data, products and support services to the Copernicus Marine information services and end users.
 - responsible for operating: Sentinel-3A/B/C/D and Sentinel-6A/B, EUMETSAT delivers products for Jason-3 Satellite.
- The involvement in CRISTAL(**B8.08.1 Copernicus Sentinel Expansion Missions**) is the operational generation of Global Ocean topography products including calibration and validation, in synergy with Sentinel-3/-6. Main opportunities:

- Dual Ku/Ka + Closed burst acquisition over open Ocean (as in S3) + Range Migration Correction (as in S6);
- Densify the existing tracks of the Copernicus altimeter missions (Jason-3, Sentinel-3A/B and Sentinel-6A/B soon)





Potential EUMETSAT Products Based on IRIS acquisition mode

Product	Latency	Format	Data Access		
			Dissemination	Online Access	Archive
ALT High Resolution (SAR) Including pseudo-LRM as is done in S3	NRT	BUFR	L2	L2	L2
		NetCDF	L2, L2P	L2	L2, L2P
	STC	NetCDF	L2P	L1A, L1B, L2	L1A, L1B, L2 (L2P, L3 archived TBD)
	NTC	NetCDF	–	L1A, L1B, L2	L1A, L1B, L2 (L2P, L3 archived TBD)
AMR-C	NRT	NetCDF	–	–	L2
	STC	NetCDF	–	–	L2
	NTC	NetCDF	–	–	L2

Applicable to this slide

Note 1: NetCDF groups to be adopted as in Sentinel-6.

Note 2: L1B-S little demand, at this early stage is out of the list and could be added if user community requests them.

Note 3: L1B NRT little demand, same as before; available for STC and NTC only as per S6.

Note 4: L2P include sea level, wave and wind; timeliness per product to be defined.

Note 5: MWR products left for similarity to S6 considering baseline AMR-C.

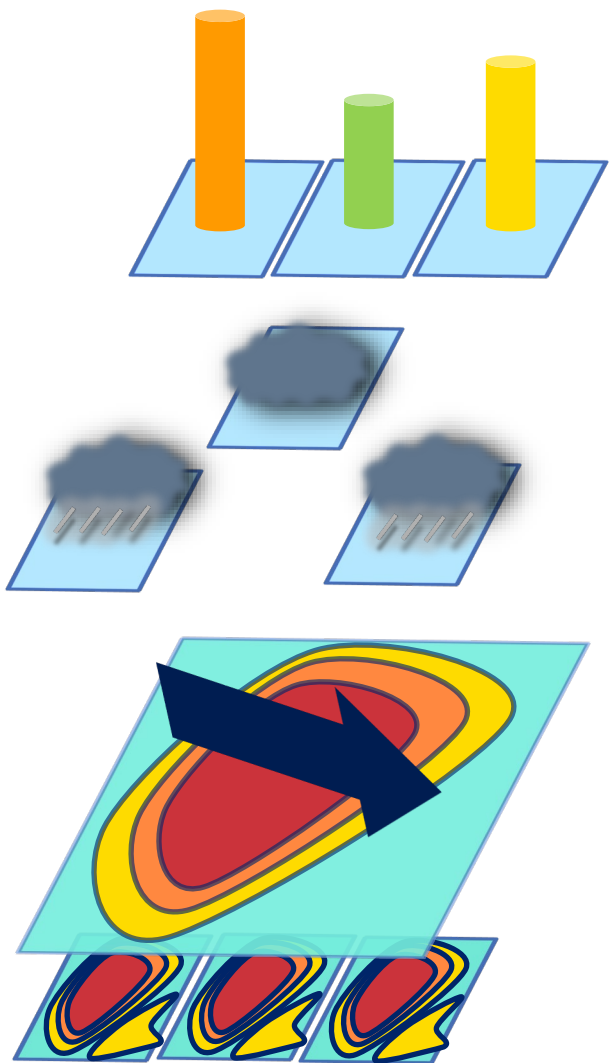


- The EUMETSAT Role in the MW domain is:
 - MW Sounding missions (EPS, EPS-SG);
 - MW/sub-mm Wave imaging missions (EPS-SG MWI & ICI)
 - Third party MW missions re-transmission
- Copernicus Microwave Imaging Radiometer (CIMR) will be a “game changer” in MW radiometry. For CIMR, EUMETSAT will assume responsibility for the global ocean products. The involvement in CIMR (**B8.08.1 Copernicus Sentinel Expansion Missions**) is the operational production of L2 global products over ocean. Main opportunities:
 - The CIMR orbit selection allows for the possibility of direct synergy at high latitudes with EPS-SG and other Copernicus missions. This needs to be explored to enhance the impact of EPS-SG and Copernicus data.
 - Elsewhere, complementarity is the word: global NWP/Ocean models taking benefit from assimilation of EPS-SG and Copernicus data.
 - Benefit of combined retrievals, inter-comparison/validation of geophysical parameters



CIMR L2 Products over global ocean

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Product ID	Description	Spatial resolution [km]	Total Standard Uncertainty	Timeliness	Revisit
TCWV-GO	Total Column Water Vapour	<15 km (g=5 km)	<10%	NRT3H	Daily
LWP-GO	Liquid Water Path	<15 km (g=5 km)	<50%		
PCP-GO	Precipitation rate	<15 km (g=5 km)	<80% at 1 mm h ⁻¹ or <50% above 10 mmh ⁻¹		
OWS-GO	Ocean Surface Wind Vector	< 40 km	2 ms ⁻¹ and <20° in direction at wind speeds ≥ 6 ms ⁻¹		
SSS-GO	Sea surface Salinity	<60 km	≤0.3 pss		
SST-GO	Sea Surface Temperature	<15 km	≤0.2 K		



Thank you!
Questions are welcome.