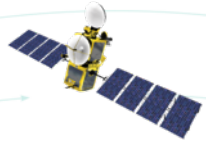
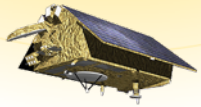
EUMETSAT's Contribution to the Copernicus CO_2 Mission



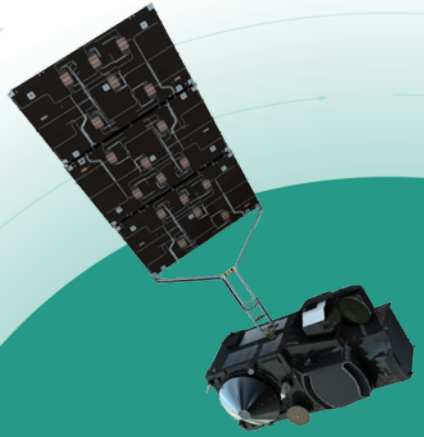
Continuous Operations, Processing, Monitoring, and Cal/Val

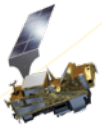


IWGGMS-15, Sapporo, Japan

R. Lang, C. Putignano, R. Perin, V. Santacesaria

and B. Bojkov





EUMETSAT operational mission planning

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

METEOSAT SECOND GENERATION
METEOSAT-8
METEOSAT-9
METEOSAT-10
METEOSAT-11
METEOSAT THIRD GENERATION
MTG-I-1 : IMAGERY
MTG-S-1: SOUNDING
MTG-I-2: IMAGERY
MTG-I-3: IMAGERY
MTG-S-2: SOUNDING
MTG-I-4: IMAGERY

EUMETSAT POLAR SYSTEM (EPS)
METOP-A
METOP-B
METOP-C

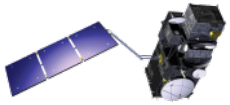
EUMETSAT POLAR SYSTEM SECOND GENERATION (EPS-SG)
METOP-SG A: SOUNDING AND IMAGERY
METOP-SG B: MICROWAVE IMAGERY

Mandatory Programmes

JASON (HIGH PRECISION OCEAN ALTIMETRY)
JASON-2
JASON-3

SENTINEL-6 (JASON-CS)

Optional Programmes



COPERNICUS
SENTINEL-3 A/B/C/D
SENTINEL-4 ON MTG-S
SENTINEL-5 ON METOP-SG A

Third Party Programmes

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

European GHG mission status and planning

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

TROPOMI / SENTINEL 5P

esa

IASI-NG ON METOP-SG A

SENTINEL-5 ON METOP-SG A

MicroCarb (CNES/UK Space)

Third Party Programme

SENTINEL CO_2

CO2M

CO2M

CO2M

Proposed Programme

Copernicus
Europe's eyes on Earth

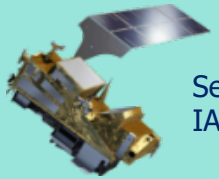
COPERNICUS
CO_2 SERVICE

CO2, CH4, (SIF)

Continuous calibration, validation, and monitoring needs for routine operations

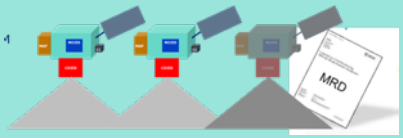
European GHG mission status and planning

Main product requirements



Sentinel-5p/5
IASI-NG

Species	Bias	Random
CH4	1.5%	1%
CO	15%	<10%



CO2M

Species	Accuracy	Random
CO_2	< 0.5 ppm	<0.7 ppm
CH_4	< 10 ppb	1%*

*Based on S5 requirement

18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

TROPOMI / SENTINEL 5P

esa

IASI-NG ON METOP-SG A

SENTINEL-5 ON METOP-SG A

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CO2M

CO2M

CO2M

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COPERNICUS
CO_2 SERVICE

CO2, CH4, (SIF)
Continuous calibration, validation, and monitoring needs for routine operations

What does EUMETSAT “operational” mission actually mean

An “operational” mission implies:

1. Very high availability and committed level of service toward end users (significantly better than 95%)
2. Well defined and committed timeliness
3. Continuously quality controlled and monitored production
4. Fully traceable specifications and configurations
5. Robust and quality (procedure) controlled implementations:
   - Long-term continuity of 1) to 5) over the full mission lifetime
   - Well characterised consistency between successive or tandem systems of the same mission and across missions (where required) ensuring operational sustainability.

➢ ***This does not exclude efficient evolutions (e.g. for adjustments, improvements, and continuous developments)! A successful “operational” mission implementation provides robustness and flexibility at the same time (and at the level needed by the mission objectives) !***

EUMETSAT's hyper-spectral "operational" missions dedicated to Atmospheric Composition and GHG.

Metop GOME-2 (Radiance, Irradiance, O_3 , NO_2 , SO_2 , HCHO, CHOCHO, BrO, UV products, H_2O, SIF, LER)

Metop IASI (Radiance, CO, SO_2 , O_3 , HNO_3 , NH_3 , CH_4)

MTG UVN (S4) (Radiance, Irradiance, O_3 , NO_2 , SO_2 , HCHO, CHOCHO, surface reflectance, H_2O, UV products)

MTG IRS (Radiance, CO, O_3)

EPS-SG UVNS (S5) (Radiance, Irradiance, O_3 , NO_2 , SO_2 , HCHO, CHOCHO, UV products, CO, **CH_4** , BrO, OClO, H_2O, surface reflectance, SIF)

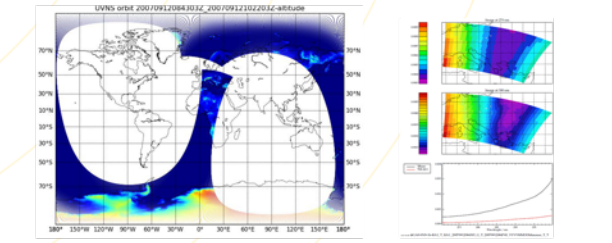
EPS-SG IASI-NG (Radiance, CO, SO_2 , O_3 , HNO_3 , NH_3 , CH_4)

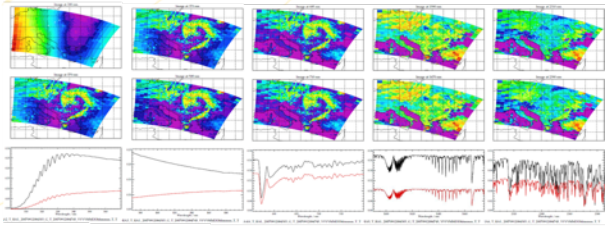
Copernicus CO_2M (Radiance, Irradiance, CO_2 , CH_4 , NO_2 , SIF)

EPS-SG S5/3MI/METimage – CH_4, aerosols and clouds

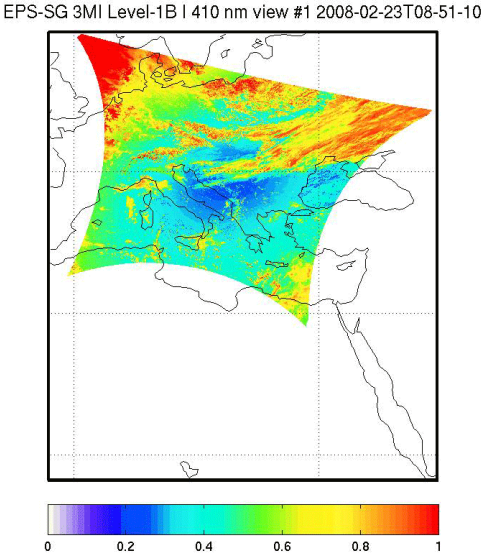
EPS-SG Sentinel 5

Parameter	
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

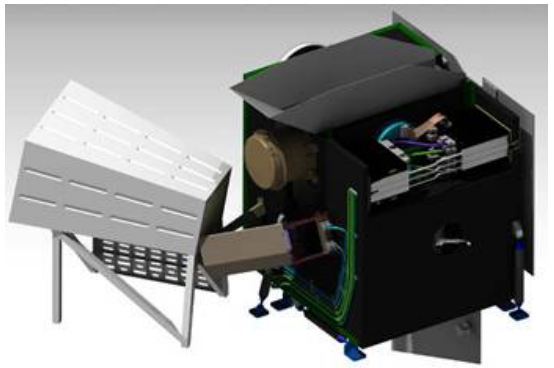


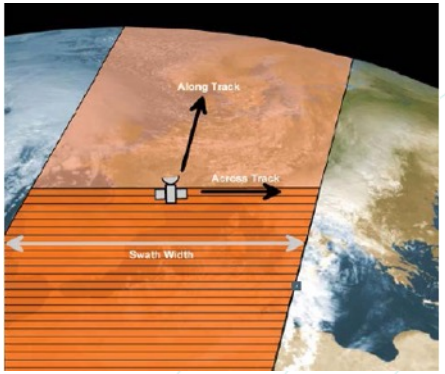


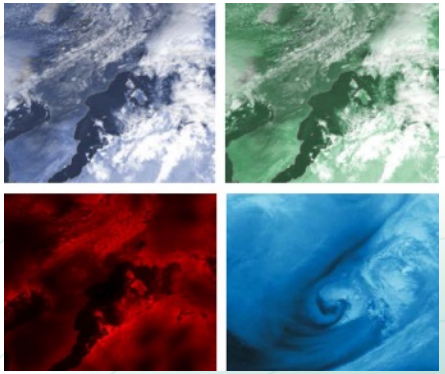
EPS-SG 3MI



EPS-SG METimage





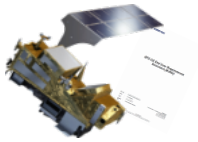


Spectral coverage: EPS-SG (S5, 3MI, METimage) vs. CO_2M

250 300 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 nm

S5

270 – 310 | 300 - 500 | 685 – 710 | 745 – 773 | 1590 – 1675 | 2305 – 2385



CO_2IS
NO_2IS

405 – 490 | 747 – 773 | 1590 – 1675 | 1990 – 2095

3MI

MAP

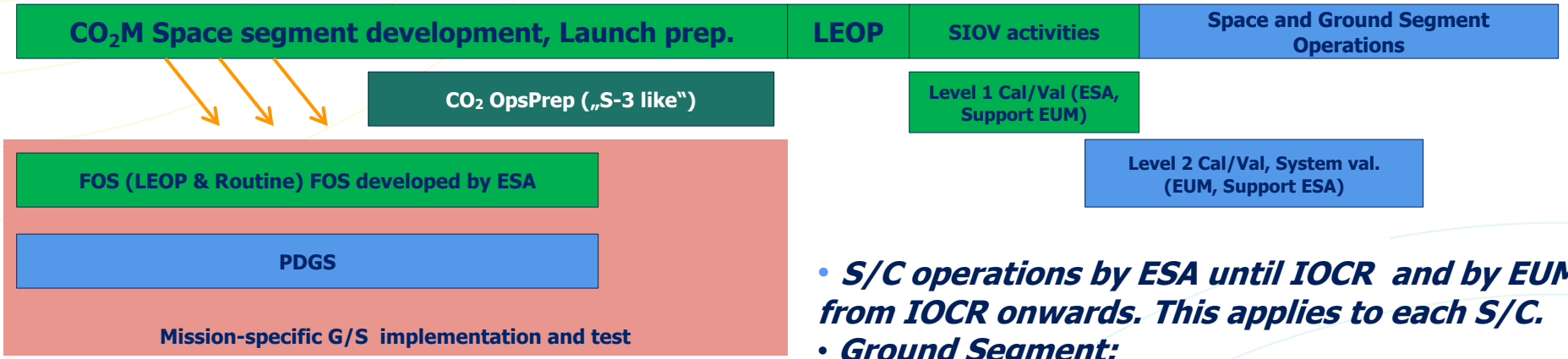
METimage

....

CI

EPS-SG
CO_2M

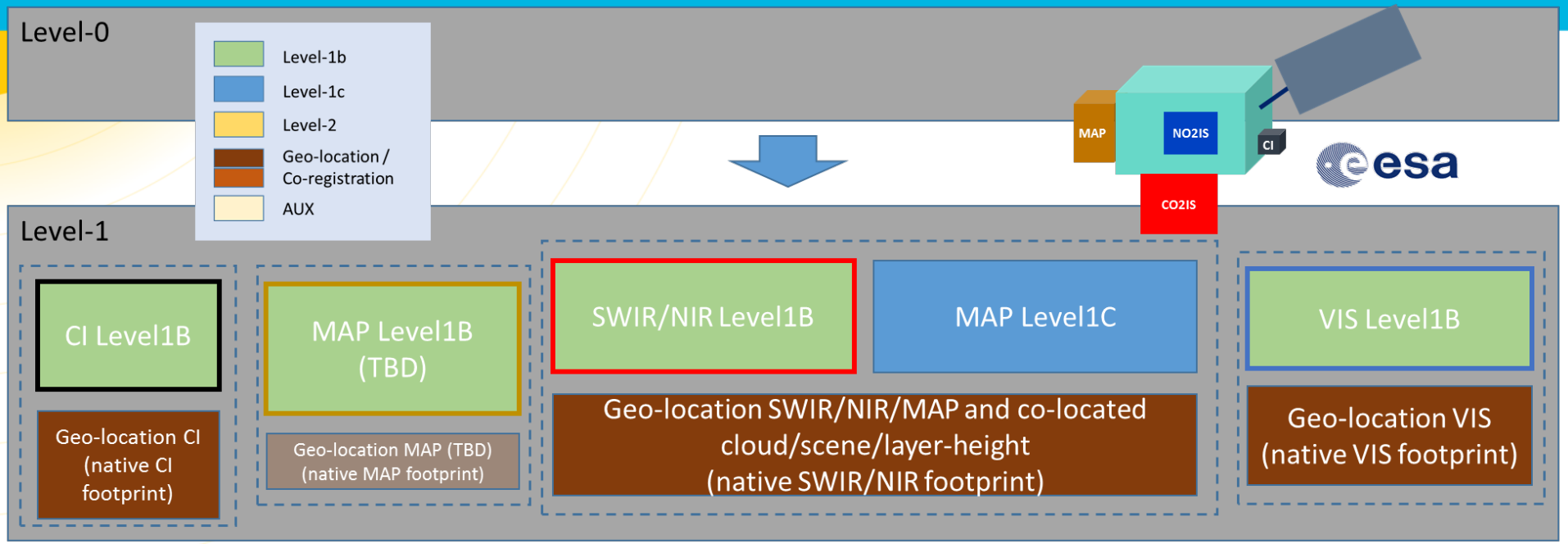
Planned ESA/EUM cooperation on Copernicus CO2M



- *ESA-provided*
- *EUM-provided*
- *ESA/EUM*

- ***S/C operations by ESA until IOCR and by EUM from IOCR onwards. This applies to each S/C.***
- ***Ground Segment:***
  - ***Single PDGS, operated by EUMETSAT.***
  - ***FOS H/O from ESA to EUMETSAT after IOCR***

CO_2M anticipated operational product level elements



EUMETSAT CO_2M Data Processing

EUMETSAT

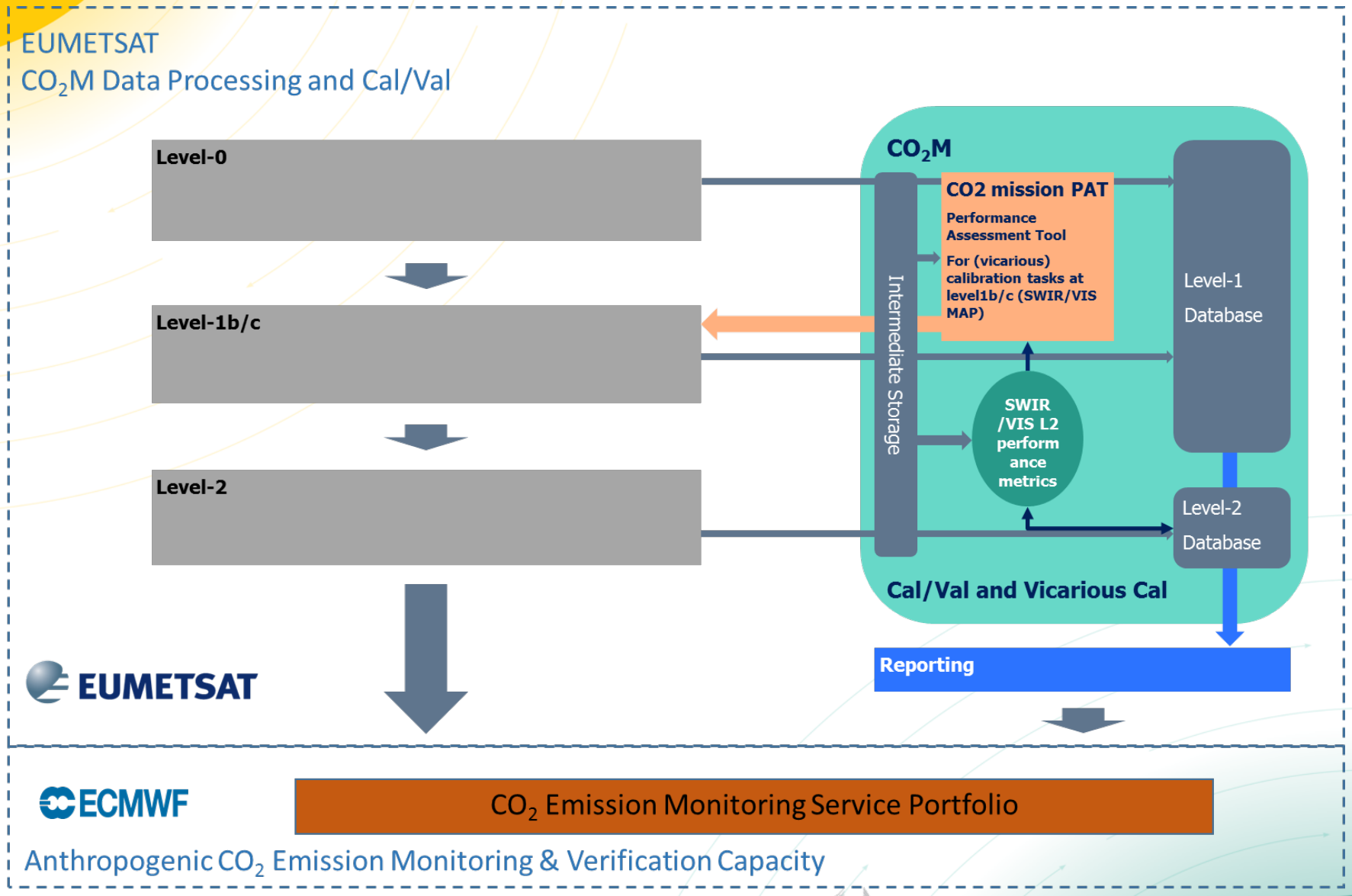
Anthropogenic CO_2 Emission Monitoring & Verification Capacity

CO_2 Emission Monitoring Service Portfolio

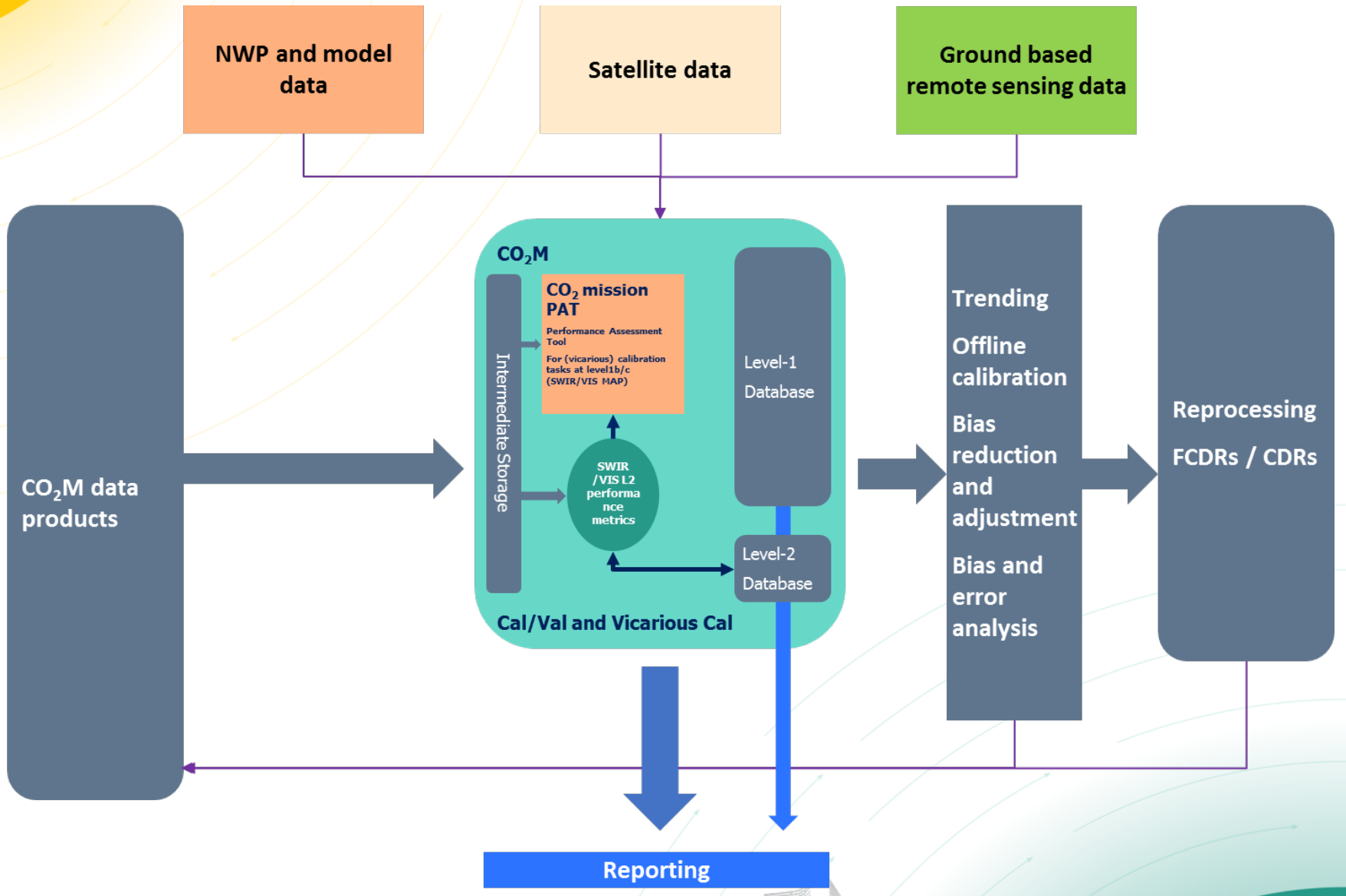
ECMWF

Copernicus EUMETSAT

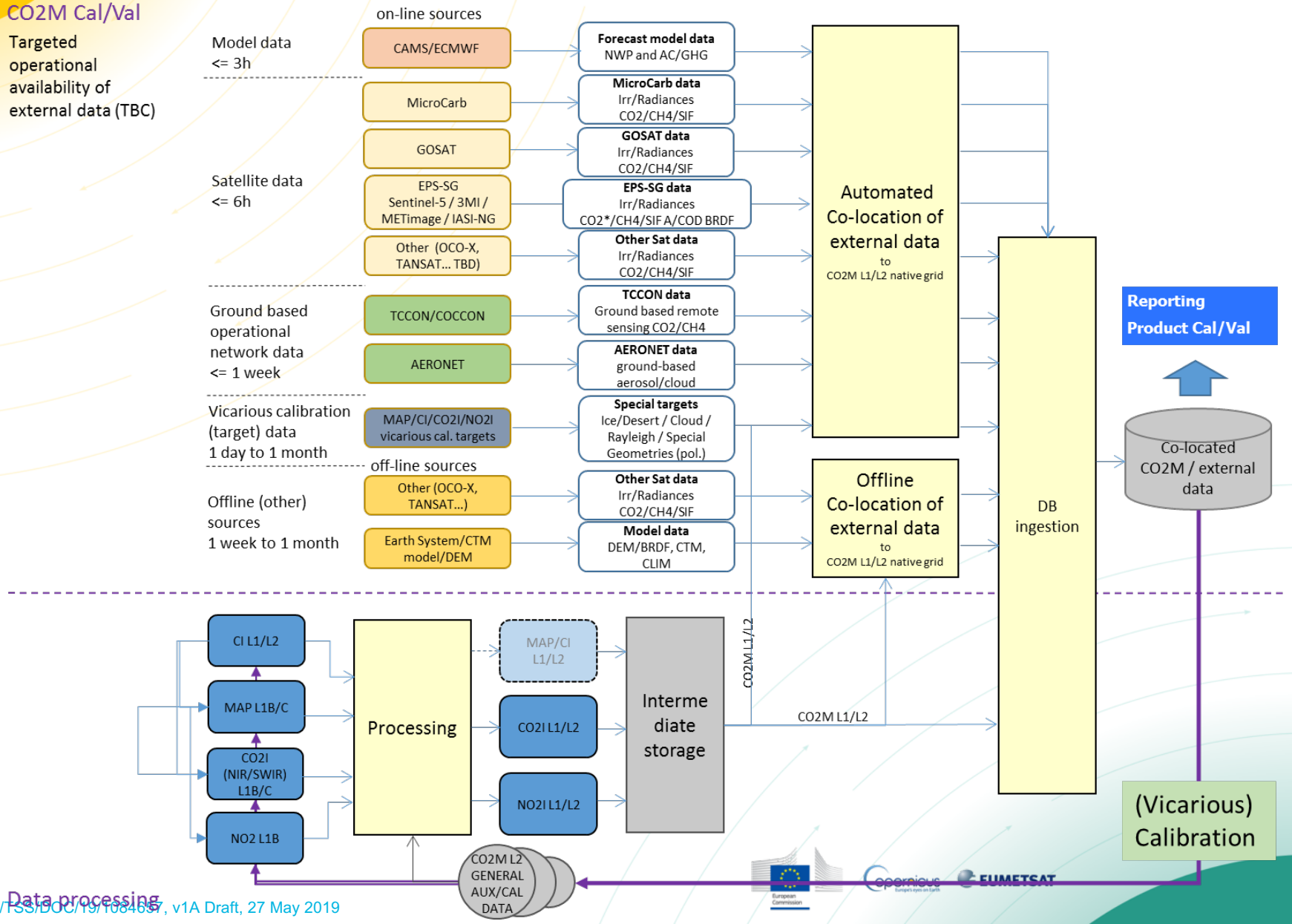
EUMETSAT CO_2M ground segment processing with Cal/Val and monitoring



EUMETSAT CO_2M processing continuous Cal/Val and monitoring

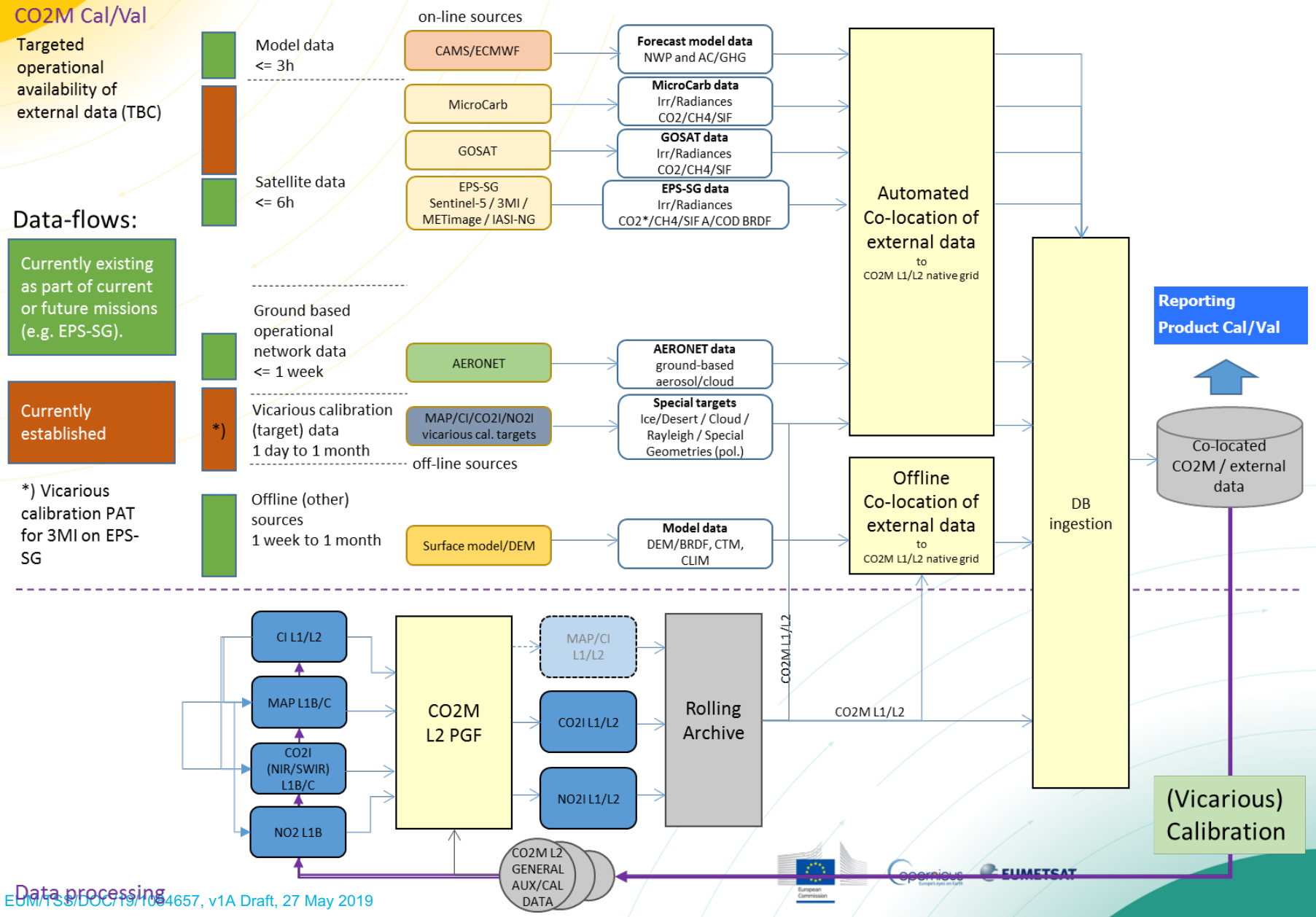


EUMETSAT CO_2M continuous Cal/Val and monitoring preliminary concept



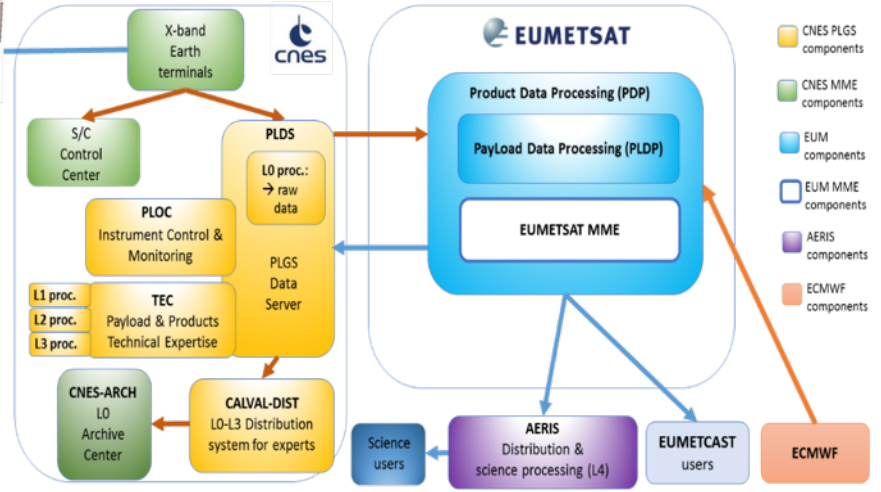
EUMETSAT CO_2M continuous Cal/Val and monitoring preliminary concept

Existent data-flows at EUMETSAT



EUMETSAT collaborations for GOSAT and MicroCarb

MicroCarb



EUMETSAT is working in collaboration with CNES on a H2020 In Orbit Demonstration / Validation project aiming at developing an NRT processing chain for Microcarb.

GOSAT

EUMETSAT has recently signed an agreement with JAXA to get NRT access to GOSAT and GOSAT-2 data.

Summary

- Challenging implementation schedule of very demanding end-user requirements (0.7 ppm -> ~0.2%)
- Demanding long-term accuracy, monitoring, continuous validation and (vicarious) calibration requirements during operations.
- Improved XCO_2 accuracy with accurate polarimeter (aerosol), cloud imager and NO_2 detection requires accurate operational co-location and co-registration scheme.
- Significant EUMETSAT experience in operating hyper-spectral missions (GOME-2/IASI/Sentinel-5) available, as well as for the oeprational co-location and co-registration of imager data (AVHRR/3MI/METimage).
- Significant CO_2M expansion of the existing robust operational ground-based validation and reference network infrastructure needed, based on existing external data-flows for Cal/Val and continuous monitoring. *MicroCarb and GOSAT collaborations on processing and data-exchange have been established with CNES and JAXA.*
- Need to establish a common infrastructure for the processing and provision of other relevant EUMETSAT and third-party mission data for continuous monitoring and level-2 bias assessment, as well as for input to the *Anthropogenic CO2 Emission Monitoring & Verification Capacity*.