EUMETSAT

PROGRAMME OF THE EUROPEAN UNION

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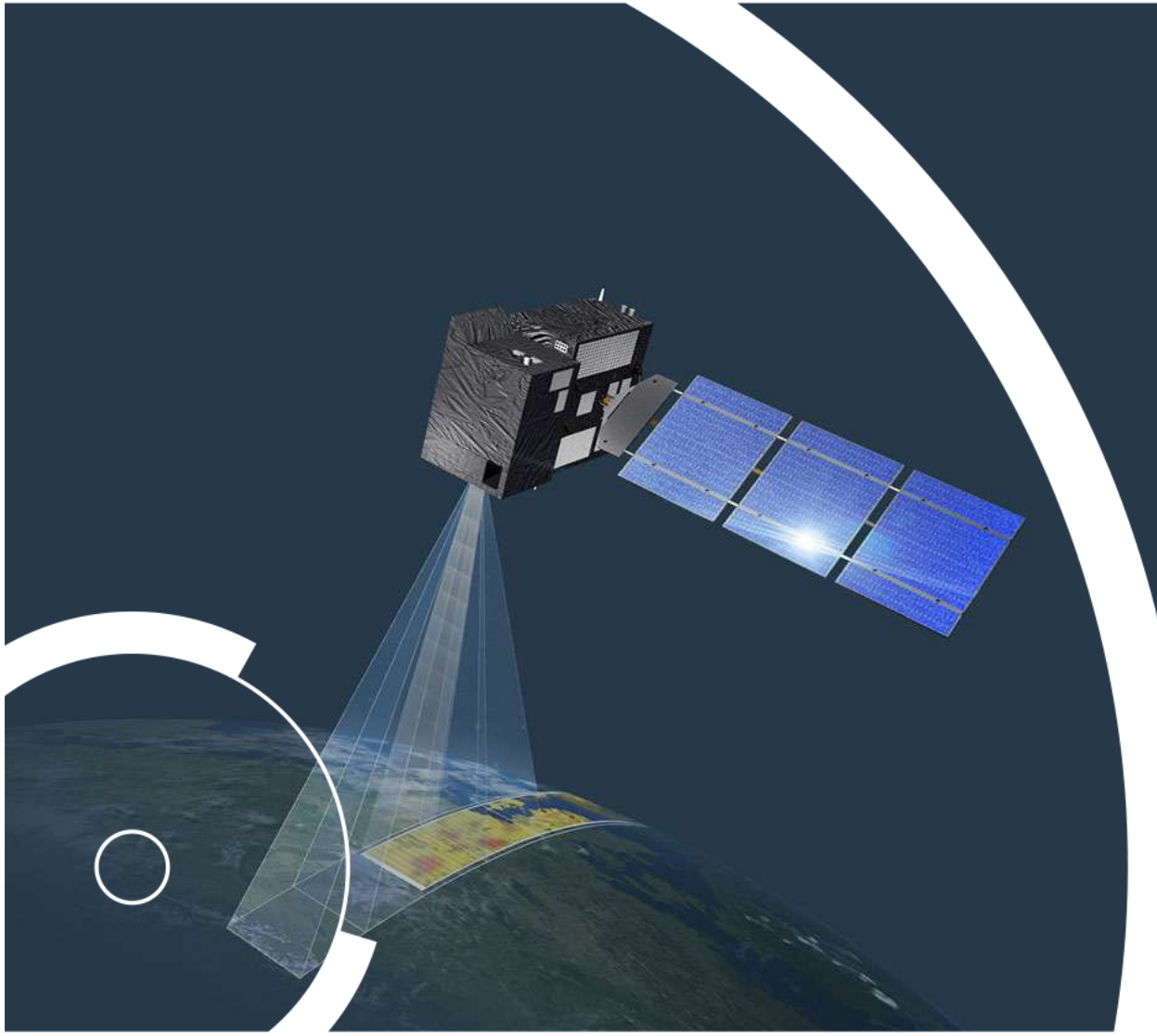

The Copernicus anthropogenic CO_2 Monitoring (CO2M) mission – operational product validation and monitoring

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IWGGMS-21, Japan, June 2025, Session 4: Cal/Val

1. CO2M overview

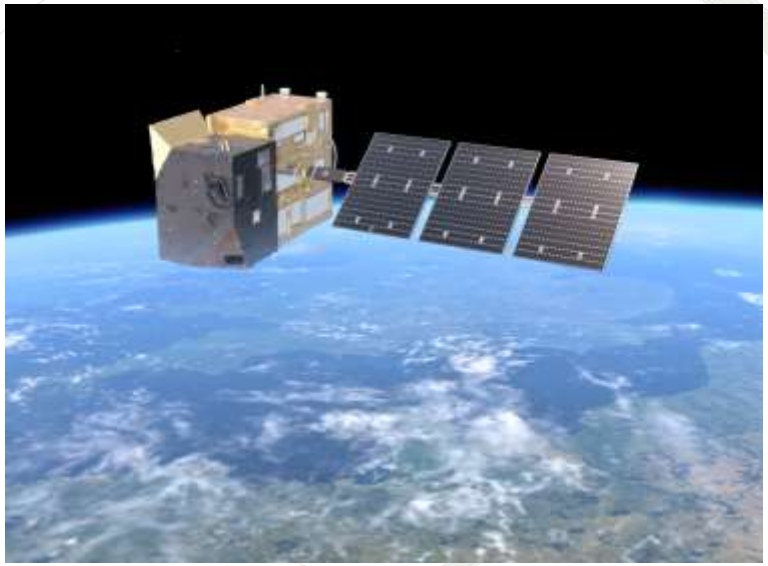
- CO2M made up of three instruments:
  - CO2I/NO2I (push-broom spectrometer) – measuring CO_2, CH_4, NO_2
  - MAP (Multi-Angle Polarimeter) – measuring aerosol properties
  - CLIM (CLoud IMager) – measuring thick and thin clouds
- 3 platforms (two launching within a few months, the third launching 18+ months later); all platforms on same orbital plane
- 11:30 LT overpass time
- 735 km altitude

1. CO2M overview

Product	Spatial resolution	Precision	Bias
CO_2	4 km^2	0.7 (0.5) ppm	<0.5 ppm
CH_4	4 km^2	10 (5) ppb	<5 ppb
NO_2	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	

2. Monitoring data

Calibration sources



Satellite-based data

Ground-based data

2. Monitoring data – Calibration sources

Calibration sources

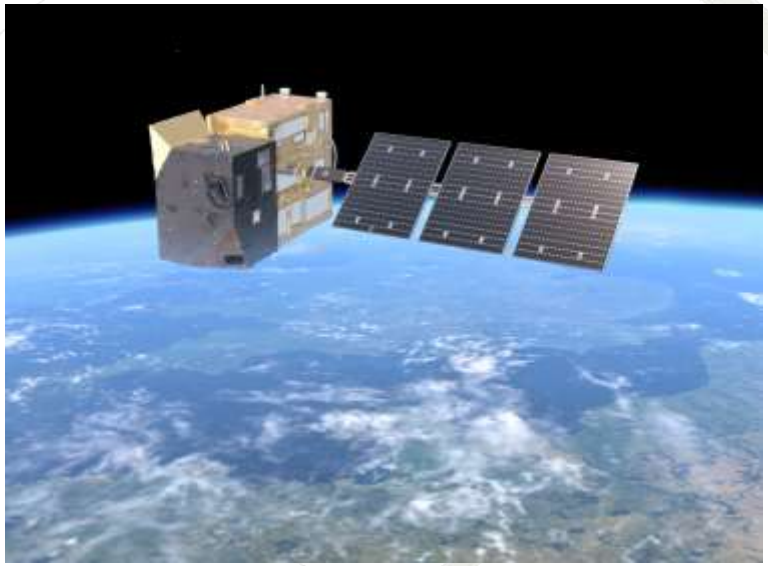
Source	CO2I	MAP	CLIM	Frequency
Sun	X	X		Day
Moon	X*	X*	X	Irregular
WLS	X			Week
Tuneable LED	X (ISRF)			Ad. Hoc.
Dark	X	X	X	Orbit

* Feasibility currently investigation

Common channel at 753 nm across all three instruments

2. Monitoring system

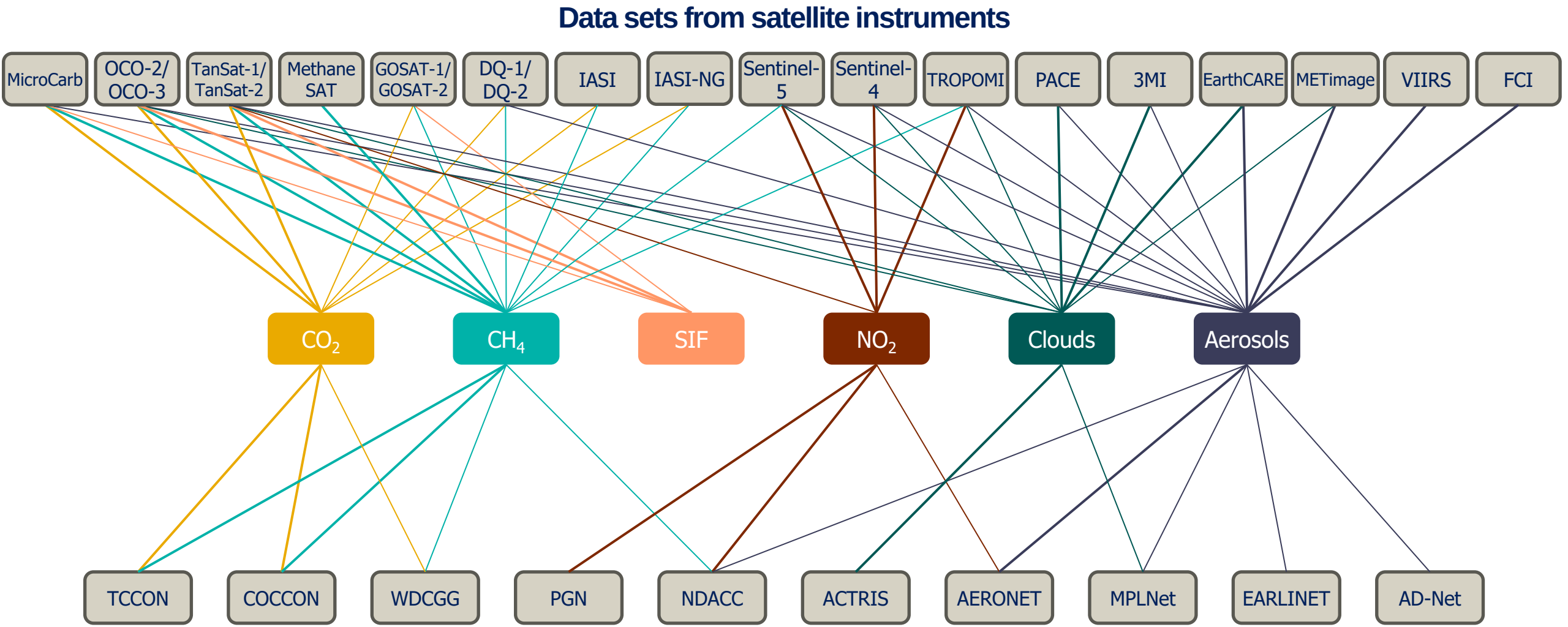
Calibration sources



Satellite-based data

Ground-based data

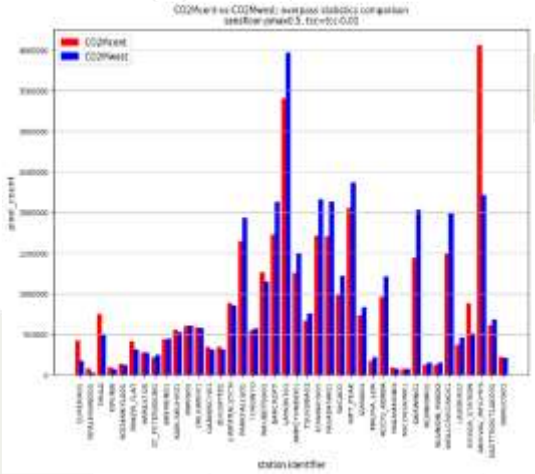
2. Monitoring System – Validation datasets



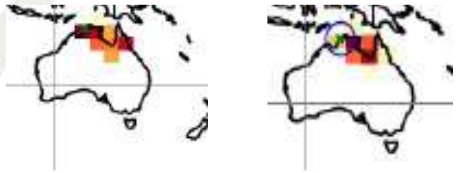
Ground-based data provision

- Phase 1 identified network requirements – led by LMU

CO2M overpass statistics per station:



Station footprint simulation:



Column sensitivity [ppm]

Emission sensitivity [ppm/kgC/m2/day]

iLab Kaminski et al., EUM CalVal study

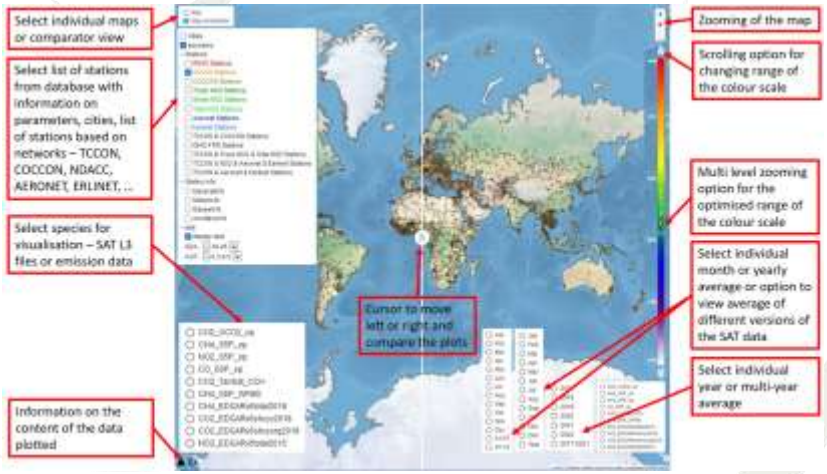
CO2M ground-station co-location criteria:

Dils et al, BIRA, EUM CalVal study

EUM Cal/Val Study

LMU iLab

CO2M validation resource and network-design:



Database: http://co2m.aeronomie.be

Sha et al, BIRA, EUM CalVal study

2. Monitoring system – Ground-based studies

Ground-based data provision

- Phase 1 identified network requirements – led by LMU
- Phase 2 (KO last week) will address commissioning preparation, evolution of validation methods, interface for provision of network/validation data, provision and processing of data – led by BIRA

2. Monitoring system – Ground-based studies

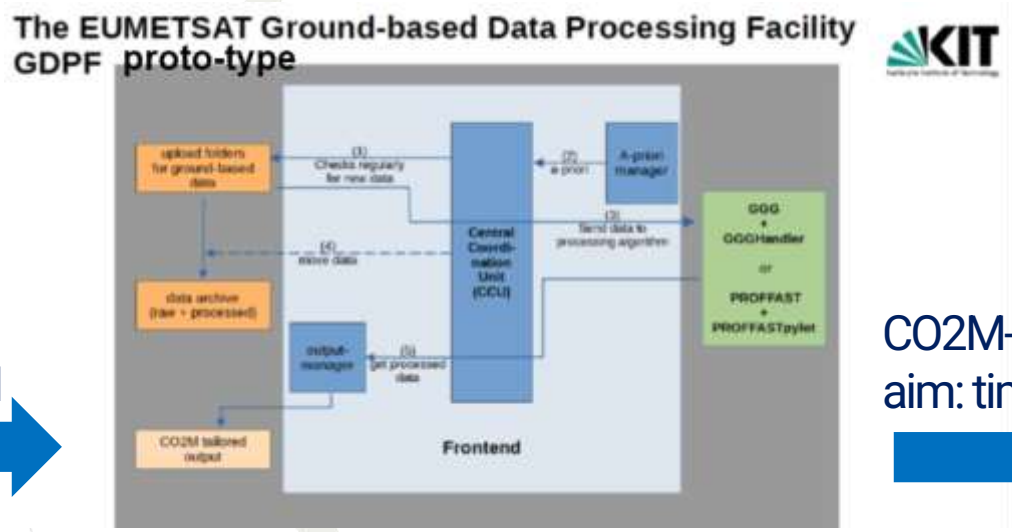
Ground-based Product (GBP) processing definition, led by KIT

- Data will come from TCCON and COCCON stations
  - Rapid delivery – required due to strict time constraints for commissioning timeline
  - This is NOT standard processing
  - Level 0 or Level 1 data from the stations, processed to produce a Level 2 product created for explicitly CO2M's needs (overpass times, etc)

2. Monitoring system – Ground-based studies

“SCENE for GDP” CO2M AUX product

CO2M a-priori and auxiliary data products



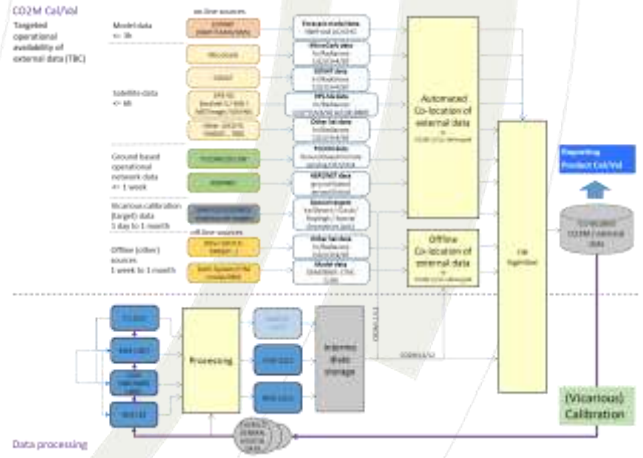
Level-1

TCCON
0.001 nm (@1.6 µm)

COCCON
0.14 nm (@1.6 µm)

CO2M-GDP Level-2
aim: timeliness <1 week

EUMETSAT Cal/Val Facility

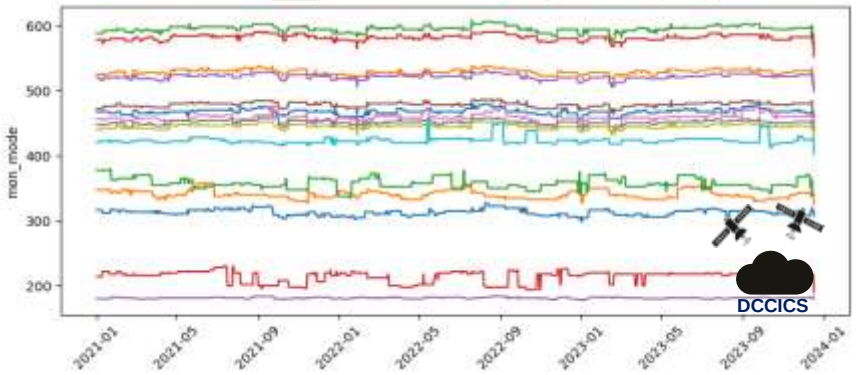


TCCON/COCCON Level-2 fiducial reference data (aim: timeliness < 2 month)

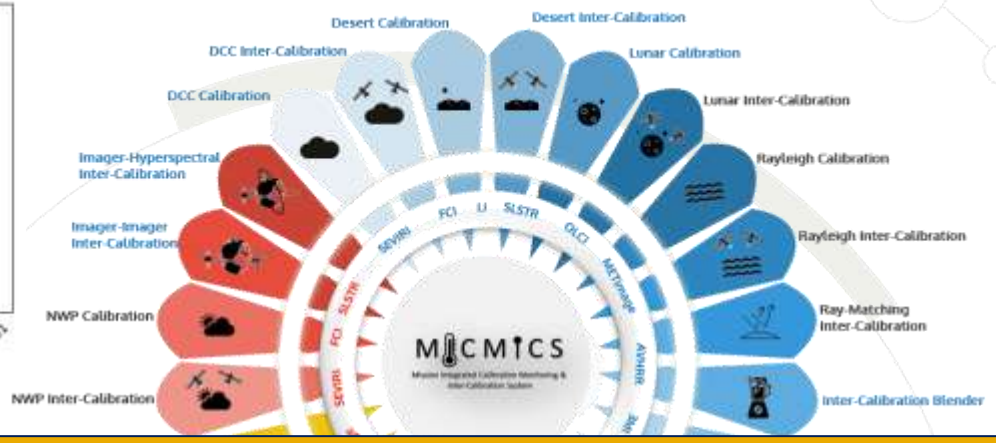
3. Cal/Val system

- Multiple systems already in place for current missions
- Variants on these systems will be used by CO2M

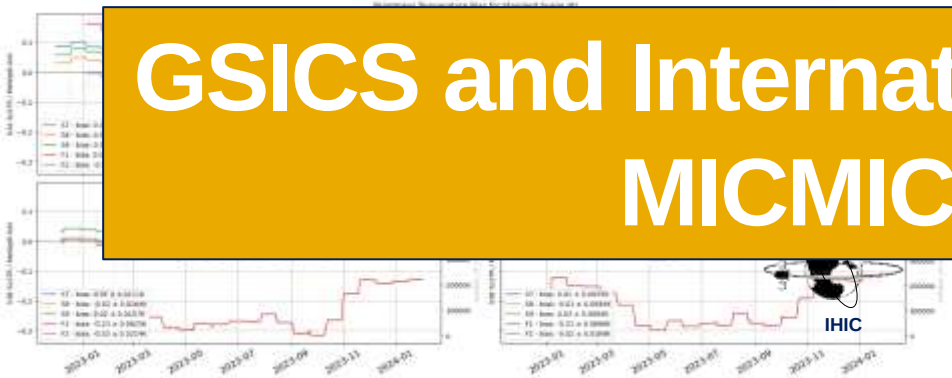
3. Cal/Val system – MICMICS (for Sentinel-3 OLCI/SLSTR)



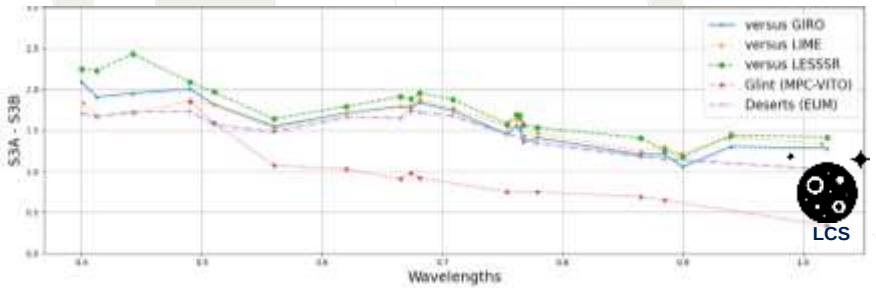
VNIR Drift monitoring



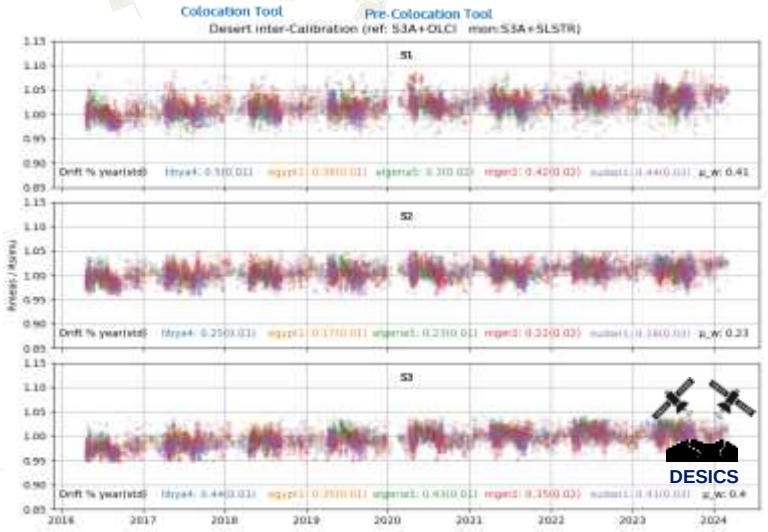
GSICS and International Cooperation key to building MICMICS over the last 6 years



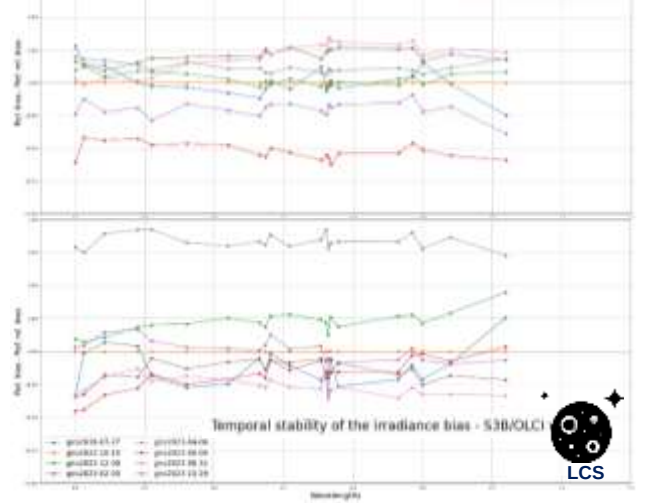
Monitoring IR channels



S3A-OLCI vs S3B-OLCI difference from various calibration and inter-calibration systems



VNIR Drift monitoring



VNIR Drift monitoring

3. Cal/Val system – STAR framework

The STAR (STatistical Analyses and Reports) Framework

Offline tool to support routine and ad-hoc monitoring of instrument and product performance during commissioning and operations

CHART-CORE

- common library for routine orchestration functions, e.g.
  - job triggering
  - database handling
  - report generation
- web-based frontend

STAR-CORE

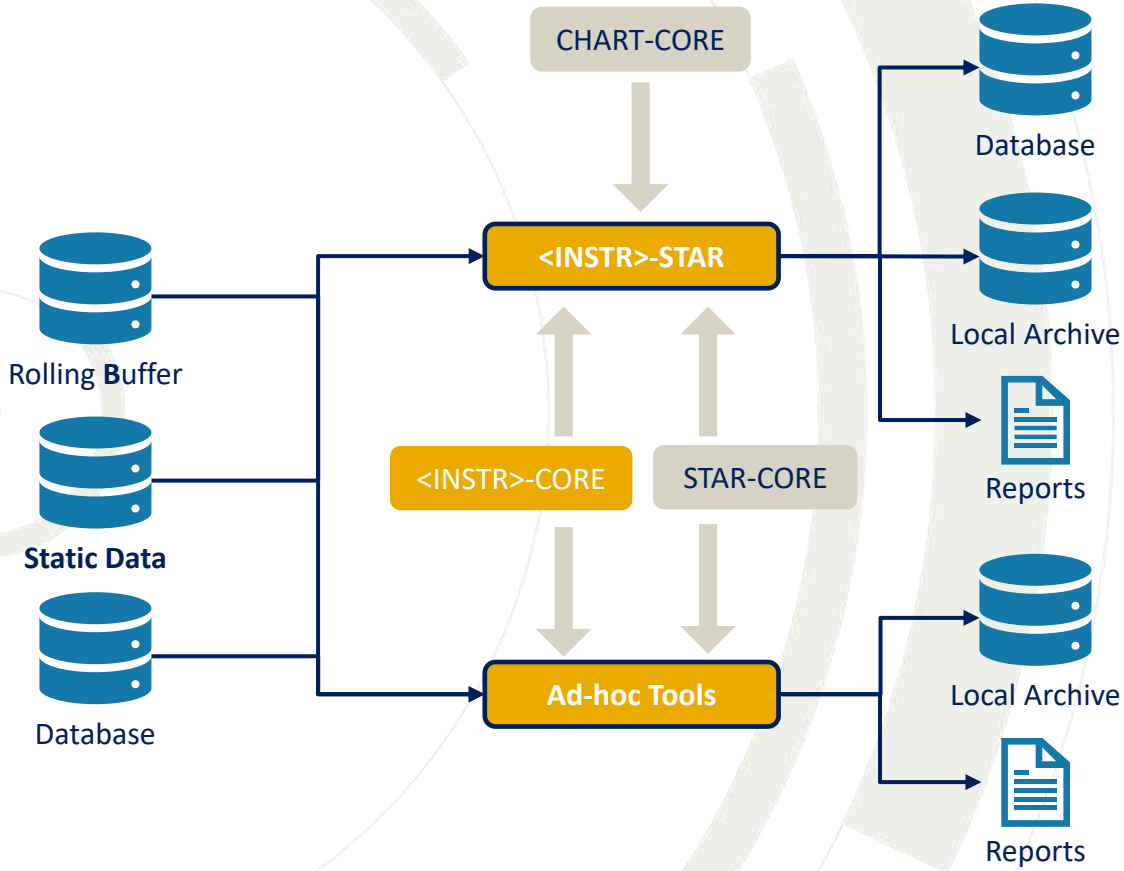
- common library for standard functions, e.g.
  - I/O
  - statistics
  - processing

<INSTR>-CORE

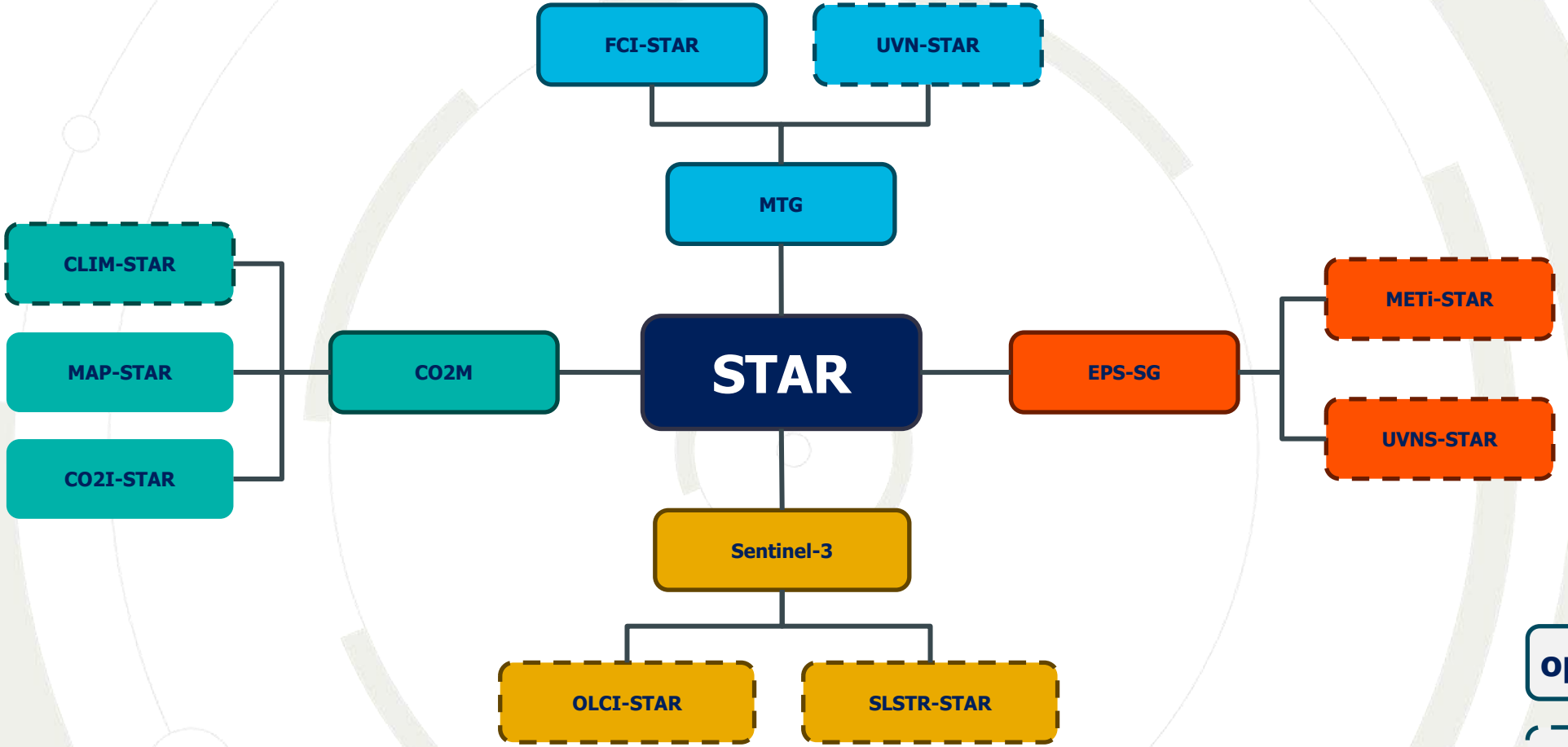
- common library for instrument-specific functions, e.g.
  - product readers
  - CCDB readers
  - instrument properties

<INSTR>-STAR

- centrally connects CORE libraries to run routine data processing, incl.
  - I/O handling
  - algorithm execution
  - report generation



3. Cal/Val system – STAR framework

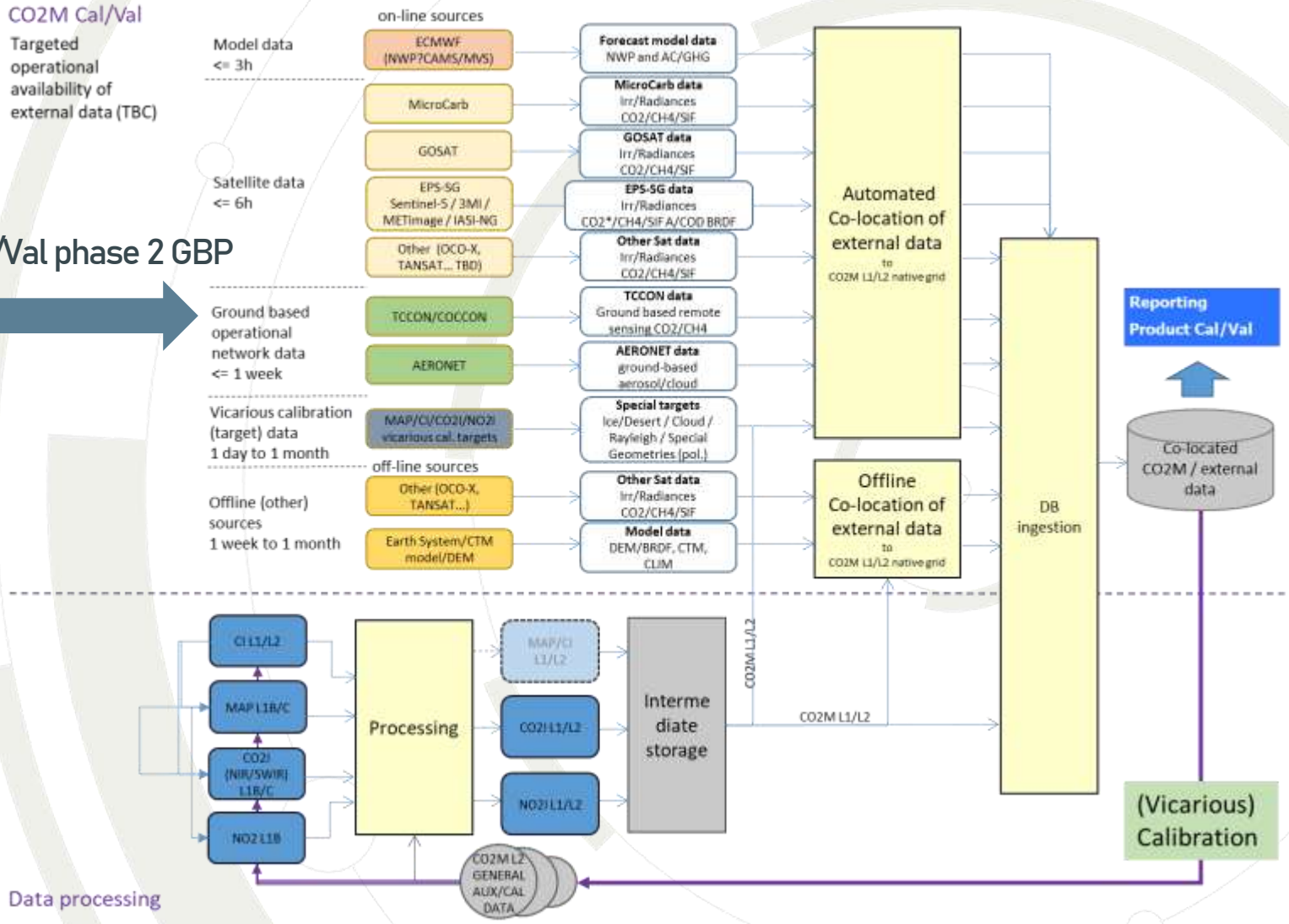


operational

in dev.

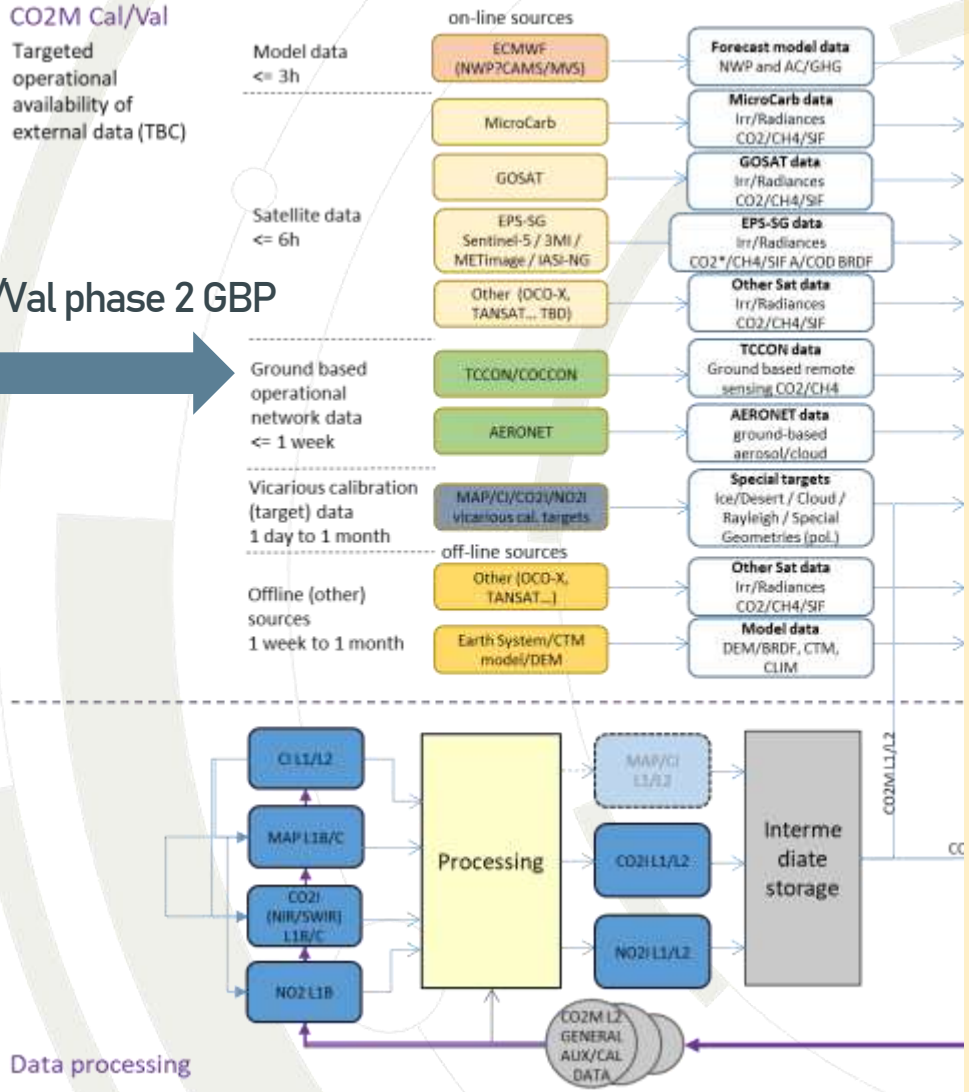
planned

4. CO2M Cal/Val facility

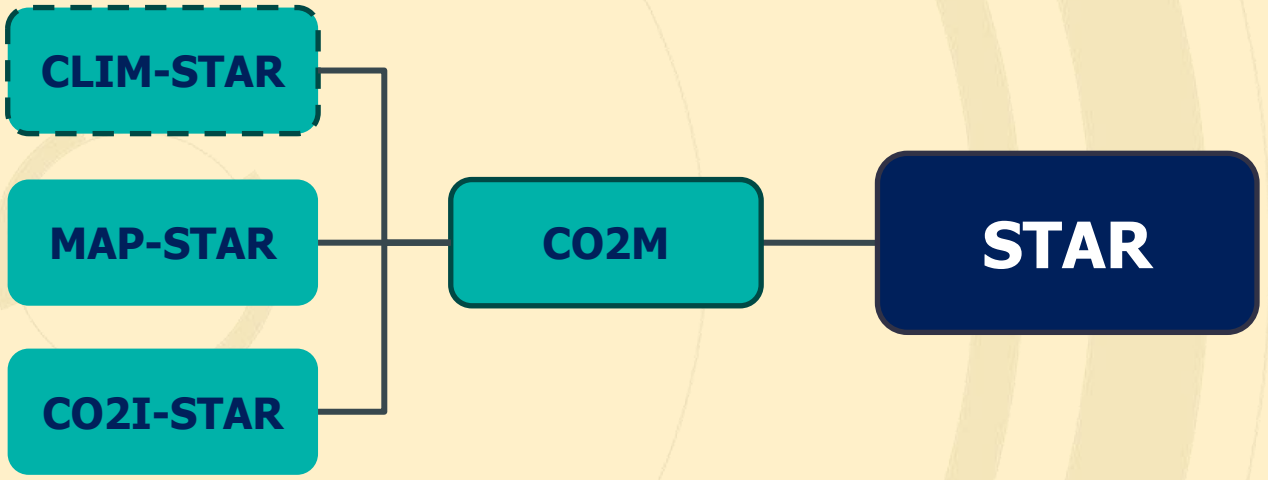


4. CO2M Cal/Val facility

Cal/Val phase 2 GBP



EUMETSAT STAR framework



Conclusions

- Two external projects supporting the Cal/Val system for CO2M
- Participation from the TCCON & COCCON networks will be key to the successful and timely commissioning of the satellite
- EUMETSAT Cal/Val facility will use operationally tested systems, adapted to the unique needs of each of the instruments within the mission
- Lessons learned from the upcoming launches of MTG-S and EPS-SG will be implemented in the commissioning of CO2M

Any questions?