

GHG PROGRAMME AT CNES:

MICROCARB, MERLIN, PROJECTS UPDATE





THE MICROCARB CO2 MISSION IS READY TO FLY !



MICROCARB : MISSION GOALS

- For the scientific community : Quantify the CO₂ fluxes at the Earth surface
- Improve our understanding of the mechanisms which control both sinks and sources (identification of the key parameters of these exchanges, of the processes controlling their seasonal variability)
 - ◆ Improvement of the models describing the carbon cycle
 - ◆ Assessment of the reaction of the exchange mechanisms to the climate change (See IPCC report **“Climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO₂ in the atmosphere “**)
- For international cooperation: contribute to the monitoring of the carbon cycle after GoSat 1 (2009), OCO-2 (2014), Tansat (2016)) and bring data in complement to Gosat-2 (2018) OCO-3 (2019-2022).
- For Space demonstration : propose a new technical solution in space for Europe to improve the understanding of the carbon cycle.
- Contribute to the preparation of future operational missions (CO2M)

THE MICROCARB CO2 MISSION AT A GLANCE

Objectives

- Natural CO2 fluxes at global scale
- Demonstrator for CO2 anthropogenic emissions

Main product: CO2 column integrated concentration

- Rqmt for random error < 0.5 ppm (G) , < 1.5ppm (T)
- Rqmt for regional bias < 0.1 ppm (G), < 0.2 ppm (T)

Instrument

- Passive grating spectrometer in NIR / SWIR 4 bands
 - CO2 : 1.61 μm & 2.35 μm , O2 : 0.76 μm & 1.27 μm
 - Resolving power 25000
- One embedded imager (red)
- Compact instrument (80 kg, 60W) on micro-satellite

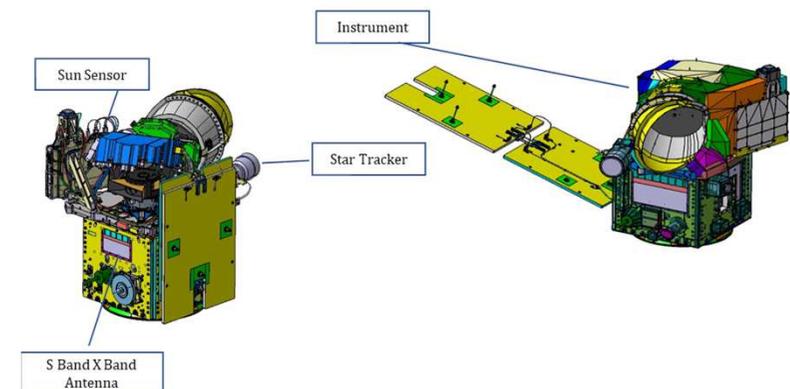
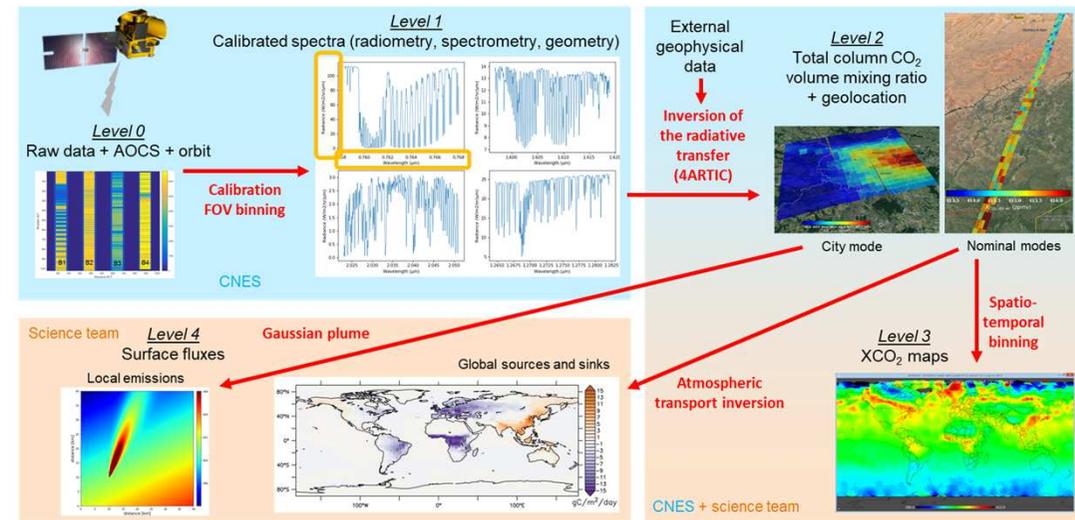
Orbit

- Polar sun-synchronous, alt 649 km, LTAN 22h30
- Cycle 25 days, sub-cycle 7 days, $\pm 200\text{km}$ across-track pointing mirror

→ Any target can be observed one a week (when weather OK)

Observations modes

- Science: nadir (3 ACT footprints 4.5x9 km²), scan, glint
- Probatory: City (2x2km² footprint, 40x40km² field), region
- L1 calibration: shutter, sun, moon, internal lamp, cold space
- L2 validation: fixed target mode (several minutes on same target), off-nadir target (quick ACT looking)



- ❖ **2022: Readiness of the Instrument (ADS) :** After a long detector characterization campaign, Instrument final assembly, functional & mechanical, EMC tests , The instrument was delivered to Toulouse in December 2022 and mated on platform
- ❖ **2023 Satellite Integration (TAS-UK) :** Final integration on the Myriade PF, early functional and performance tests, mechanical qualification, Satellite TVAC tests
- ➔ **2024 : Satellite qualification Review, MICROCARB is ready to fly (June 2024) and is stored and maintained in heatly condition in Toulouse.**
- ➔ **Q2 2025 : Launch planned on VEGA-C (with CO3D)**

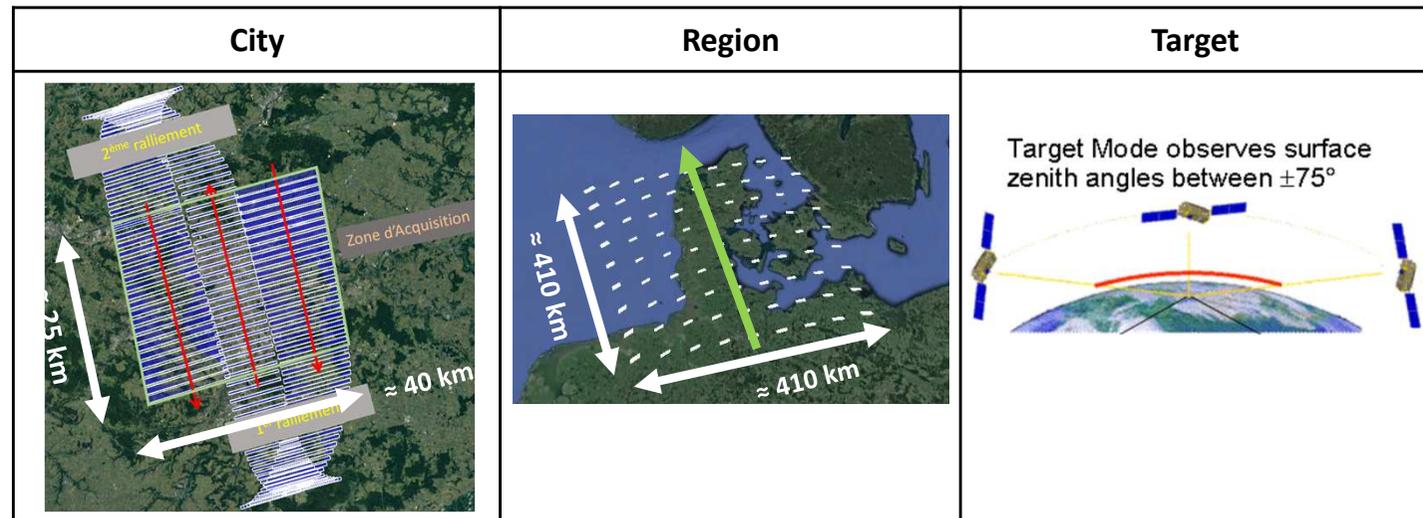
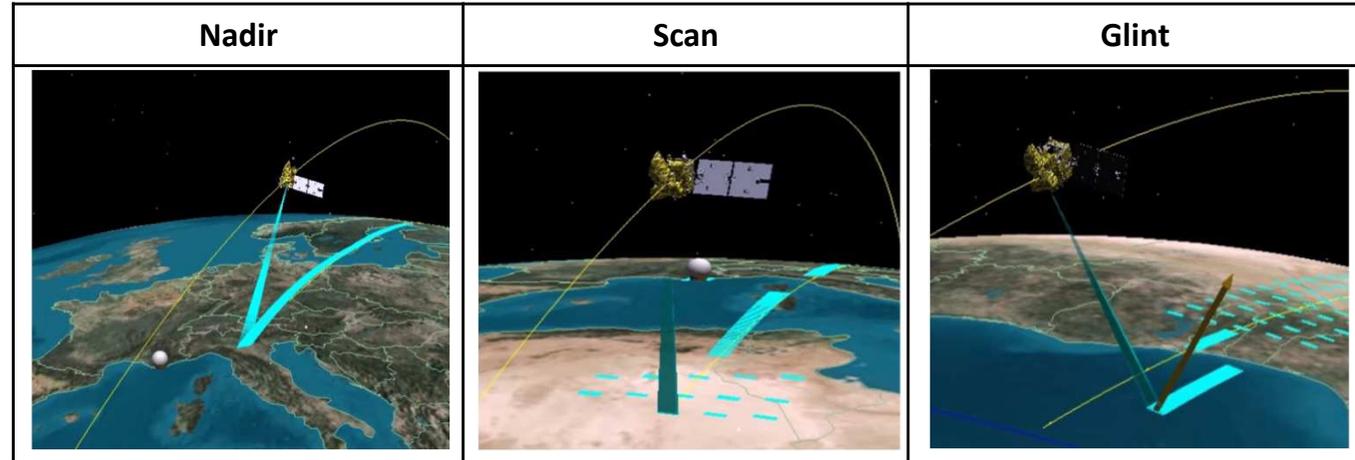


Pointing and Calibration System (PCS): 1-axis scanning capability in the ACT direction of $\pm 35^\circ$ and calibration lamps

- ❖ **Science nominal modes**
 - Nadir (lands)
 - Scan (lands to decorrelate footprints)
 - Glint (ocean)
 - Offnadir target

- ❖ **Probatory modes**
 - City
 - Region

- ❖ **Calibration modes**
 - Target (L2 validation)
 - Calibration : sun, lamp, shutter, cold space, moon, ground laser...
 - Limb for $1.27\mu\text{m}$ airglow



- **Phase 1 : 6 months => dedicated to degassing and calibration processes**
- **Phase 2 : 6 to 12 months after Launch => dedicated to validation of L2 with MAG members and dedicated cooperation partners.**
- **Phase 3: After 12 months, a CNES review will should decide if the data are ready to be open to the international community**
- **During these phases, various exercises are planned :**
 - **Massive operational comparisons: cal/val phase 1 & 2 & routine**
 - **To ground networks: TCCON, automated EM27, AERONETE. Each measurement (EM27, AirCore, aerosols) will be done under MicroCarb overpasses as often as possible**
 - **To models: CAMS analysis (NRT) and optimized-fluxes (delayed)**
 - **To other satellites : OCO-*, GOSAT-*, etc.**
 - **Dedicated Campaign will also be organised in 2025 by CNES & Labs and in 2026:
=> The MAGIC project (CNRS LMD) in Brasil in June 2026 ! & Link with COMET3.0 (DLR) & CarbonARA (ESA) : ABRACADABRA European initiative**



MICROCARB

Carbon Dioxide Monitoring Mission



Image of the day



Welcome to the Microcarb Portal!

The MicroCarb Portal provides scientists with free and open access to atmospheric composition Level 2 data products retrieved from the MicroCarb observations as well as CO2 flux estimates derived from the analysis of L2 products along with quicklook images for several products.

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ACCEPT



MERLIN STILL IN PROGRESS



WHY MERLIN ?



- Methane is mostly emitted in tropical regions where few surface observations are (can be) made
- Methane is also emitted at high latitudes where remote conditions (and geopolitical reasons) makes the surface observations difficult.
- Reconstructing methane emissions from regional to global scale requires low-biased data available at all latitude and at all seasons
- The Paris Agreement requires means of verification of GHG emissions reduction and Europe has to be independent on this matter.

and ...

- Current and planned passive satellite missions dedicated to methane :
 - Do not cover all latitudes all year round (ex: SWIR instruments)
 - Experience significant to large systematic errors which limit their ability to reduce uncertainties on methane fluxes (ex: SWIR).
 - Are not usually fully dedicated to methane or do not reach the required accuracy or a global coverage (ex: S5P, nanosats, ...)

MERLIN & THE NEW PLAYERS ON XCH4 OBSERVATIONS



MERLIN	GHGsat & Bluefield satellites
Global coverage: systematic measurements thanks to a LIDAR pencil of 100 m diameter at the surface	Local coverage: a few images a day at site scale (typically, 20 km window, with 20 m resolution)
No pointing mode	Pointing mode
Low random error: 1.0 %	Higher random error (e.g. 10% - 30% for GHGsat)
Low systematic error: 0.2 %	Higher systematic error: tens of %
Allows quantitative estimation of the diffuse methane sources with typical minimum value of 15 mg/m ² /day at 500000 km ² scale	Allows detection of strong site-scale industrial related methane emissions (15 kg/hour at 20 m × 20 m resolution ⇒ 1 kg/m ² /hour)
Active differential measurements with thin pencil less sensitive to clouds and aerosols. Specific treatment of reflective clouds.	Risk of fake detection due to clouds and aerosols
Automatic, exhaustive processing of LIDAR signals	Manual processing of images
Public data	Private data (industrial clients)



MERLIN LAST UPDATE



- Important progresses made as part of the payload development with ***Laser thermal and active laser beam pointing control finished with success in 2024***, the **Laser Transmit & receiver telescopes are finished.** => stabilized schedule on both LASO and instrument itself by the German teams. 2 models of payload are under tests and could be chosen to be in orbit for the same performance : the PFM or the EQM.,
- The Plateforme Myriade Evolution is ready and stored waiting the instrument integration planned today in end of 2027 or 2028 depending on the models of PL chosen.
- This allow the project to expect to be ready for launch in 2029.
- In the meantime, the laboratories prepare the software to process data and validate the data. The Scientific Group meet twice per year.

THANK YOU FOR YOUR ATTENTION