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MicroCarb Operations Concepts

**D. Pradines (1), F. Buisson (1), D. Jouglet (1), A. Varinois (1),
V. Pascal (1), A. Lamy (1), I. Sebbag (1), François-Marie Bréon (2)**

(1) CNES, Toulouse, France (2) LSCE, Saclay, France

Contact: didier.pradines@cnes.fr

ABSTRACT

MicroCarb is a European initiative for the monitoring of CO2 fluxes and a better understanding of the mechanisms that control these fluxes. It will provide atmospheric CO2 concentrations data to the scientific community, in the continuation or in parallel to the on-going operational programs (GoSat, OCO-2, Tansat).

The MicroCarb instrument is a grating spectrometer that acquires high-resolution spectra in 4 bands between 0.76µm and 2µm. It will fly on board a micro satellite with a total mass under 200 kg with performances in line with the standards for CO2 measurements (i.e. 1ppm accuracy). Together with the requirement for a cost effective development, the compactness is made possible by an innovative optical design. Compared to previous mission with similar objectives, a specific innovation is the use of an additional spectral band at 1.27µm (O2 absorption) that may allow a better normalization of the CO2 column, provided the airglow can be accounted for.

The project is conducted by the CNES in partnership with the UK Space Agency, and involves the scientific community from both France and UK.

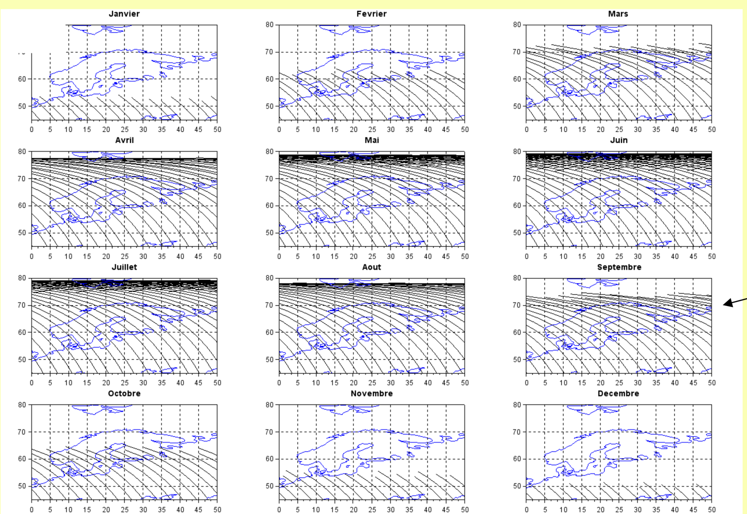
The MicroCarb project has now completed its preliminary design phase (phase B), is firmly decided, and is starting the realization phase.

This poster focuses on technical features: choice of the possible orbits, observation geometry and sampling, geometrical performances, acquisition modes (for CO2 measurements and calibration data) and mission plan optimization (according to lands/oceans mask, but also possibly to meteorological forecasts…).

1 – THE MICROCARB ORBIT

- MicroCarb will be launched as a co-passenger
- So it must comply with various constraints (orbit in particular) that could be imposed by the main passenger and the launcher
- A reference orbit is defined for engineering phase (thermal analysis, power analysis, downlink scenarios analysis…)

Reference Orbit	
Mean Altitude	649 km
Mean Local Time	10h30 (DN)
Inclination (sun-synchronous orbit)	98 deg
Eccentricity	Frozen (or so)
Orbit Cycle	25 days – 368 orbits (14+18/25) orbits / day 7-days sub-cycle



This reference altitude offers :

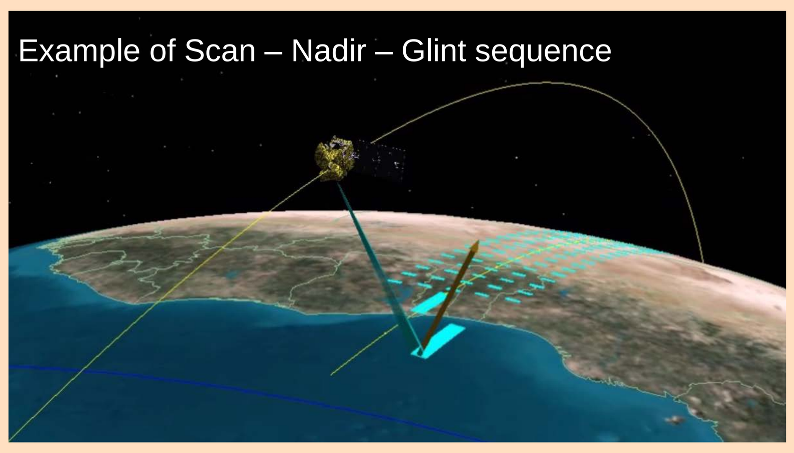
- a good global coverage (maximum inter-track distance = 109 km at the equator)
- a weekly homogeneous coverage (see example on Northern Europe)
- the possibility to achieve a reentry within 25 years (as required by the French Space Operations Act) despite a small ΔV total capacity (at this altitude, the need for reentry is < 9 m/s, wrt a total capacity of ~50 m/s)

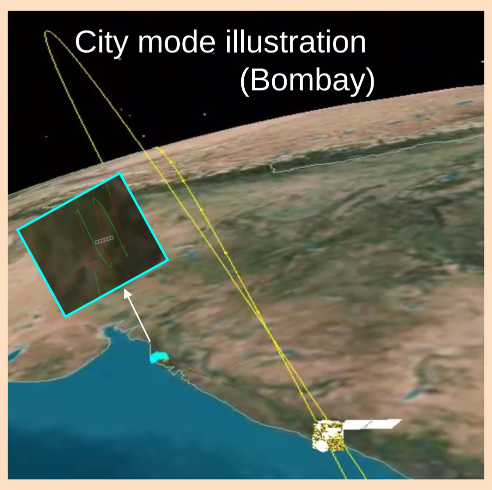
- MicroCarb is specified to be compatible with alternative orbits
- But it must handle some constraints on the altitude and on the β angle (between Sun direction and orbit plane):
  - for AOCS system (altitude range)
  - for the ability to reenter into the atmosphere within 25 years (maximum altitude)
  - for the detector passive cooling system (150K ± 100 mK): minimum altitude wrt Earth albedo, minimum β angle wrt Sun illumination)
  - …

Possible Orbits	
Mean Altitude	[600 km ; 700 km]
Mean Local Time	10h30 (DN) – 13h30 (AN)

2 – MICROCARB ACQUISITION MODES

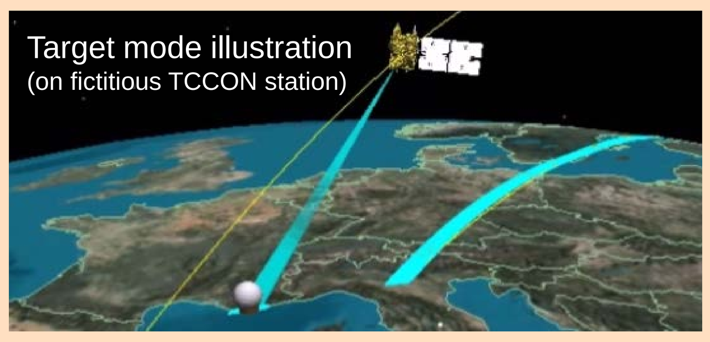
- **Baseline acquisition strategy:**
  - Over lands: Nadir, Off-Nadir (roll tilt wrt Nadir, adjusted so that the FOV passes over a selected validation site), or Scan mode
  - Over oceans: Glint mode
  - Scan mode:
    - Achieved by a one axis scan mirror (roll direction)
    - Adequate balance between scan mirror agility (up to 52°/sec) and accuracy/stability (0,03° / ±300µrad)
    - Homogeneous pattern: 100 km ALT – 100 km ACT between two acquisitions





- **Probationary modes:**
  - City mode (CO2 imagery):
    - 40 km x 40 km area (city, power plant)
    - On one single orbit
    - 3 km x 3km spatial resolution
    - VZA limited to 45° (TBC)
  - Regional mode (regional CO2 emissions):
    - 400 km x 400 km area
    - All the acquisitions are made during one single orbit
    - 50 km ALT x 50 km ACT sampling

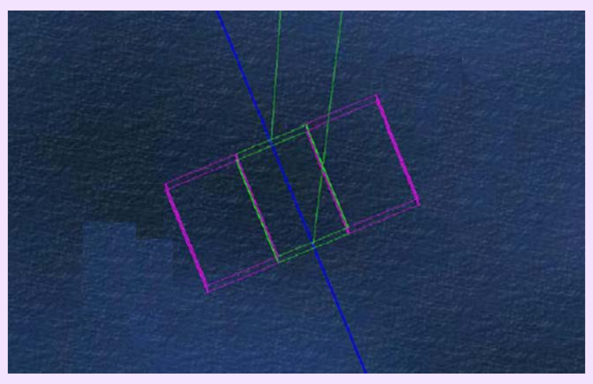
- **Miscellaneous calibration modes:**
  - L2 calibration target mode:
    - Either iFOV is moving forward with the same FOV/iFOV rate as in Nadir mode, in order to calibrate L2 products
    - Or iFOV is stopped above TCCON station, in order to observe potential biases induced by different VZA

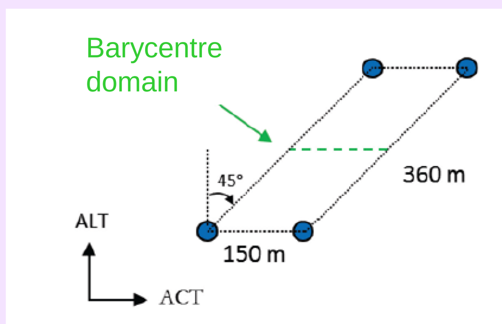


  - L1 calibration modes (some of them are TBC):
    - Oceans viewing on the night side of the orbit: useful for dark signal characterization
    - Cold sky: for the same purpose
    - White lamp: for detector pixels relative radiometry characterization (Gij) for Keystone partial model correction
    - Solar viewing through a diffuser: for absolute radiometry characterization, and evolution in time for spectral dispersive law characterization
    - Reference scenes on the Earth: for imager relative radiometry characterization
    - Geo-referenced sites on the Earth: for imager alignment characterization
    - Moon viewing: to assess the diffuser degradation
    - Earth limb viewing, or oceans viewing on the sunlit side of the orbit: for a validation of the airglow model used for the processing of the B4 band (1,27µm).

3 – MICROCARB FIELD OF VIEW

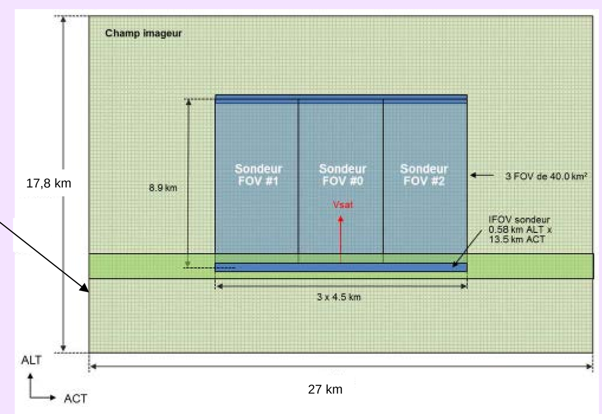
- MicroCarb instrument acquisition:
  - 3 simultaneous measurements
  - Dimension in Nadir mode: 3 x 4,5 km ACT x 9 km ALT
  - Nominal integration duration: 1,3 sec (this duration is widely configurable in flight by TC)
  - Instantaneous FOV dimension: 580m ALT





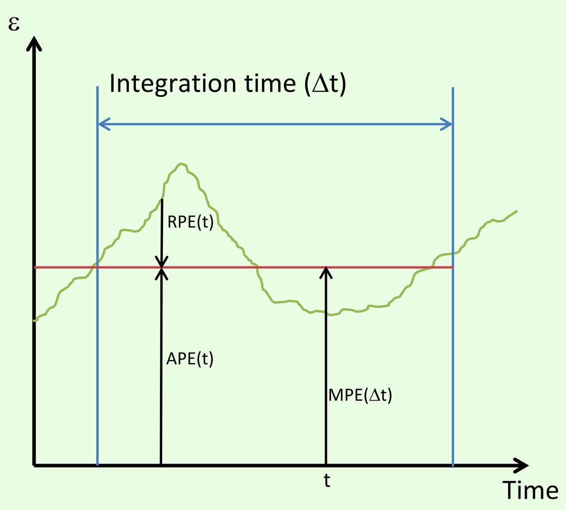
- MicroCarb has a polarization scrambler to limit the polarization rate to a maximum of 0,3% of the radiance (even for a 100% polarized scene)
- This scrambler is made of two couples of prisms which spread the FOV into 4 images on the Earth
- The barycentre of the 4 images can move in the ACT direction, by a maximum of 150m between extreme polarization cases

- The MicroCarb payload also includes an imager:
  - With one spectral band (red, centred on 625 nm)
  - IFOV dimensions (Nadir): 27 km ACT x 2,4 km ALT
  - SSD : 153 m ACT x 121 m ALT
  - Nominal sampling interval: 17 ms (configurable)
- This imager is used for:
  - Cloud detection (not the only source of information)
  - Spectrometer FOV geo-location



4 – MICROCARB GEOMETRICAL PERFORMANCES

- **Miscellaneous geometrical needs:**
  - MPE (Mean Knowledge Error, error averaged during spectrometer acquisition duration)
  - RPE (Relative Performance Error)
  - APE (Absolute Performance Error)
- **Depending on observation modes:**
  - Needs can be different above oceans / lands
  - Can be more or less difficult according to scan mirror position / displacement, LoS angle vs Nadir…



Need	Observ. Mode	Specified Values	Rationale
Geo-location knowledge (MPE)	Nadir	450 m (G), 900 m (T) (3σ)	For surface pressure assessment
Micro vibrations impact on ground (RPE)	Nadir (3σ)	225 m (G), 450 m (T) (3σ)	For surface pressure assessment
Absolute geo-location (APE)	Target (3σ)	4 km (G), 10 km (T) (3σ)	To be close enough to the TCCON station
Pointing knowledge (MPE)	Glint	0,01° (1σ)	For atmosphere thickness knowledge (this figure is challenging because of possible important LoS tilt in Glint mode (up to 60°)

Main geometrical needs

5 – OPTIMISATION OF THE MISSION PLAN

- The acquisition sequence is an automatic function of (manual planning also possible):
  - Oceans / lands mask
  - TCCON terminal visibility opportunities
  - Calibration needs
- A mission planning concept considering meteorological forecasts is currently analysed. In this example:
  - Yellow: nominal acquisition pattern
  - Red cross: measurement cancelled
  - Blue: additional measurements