AN INTRODUCTION TO MICROCARB, FIRST EUROPEAN PROGRAM FOR CO2 MONITORING.

International Working Group on Green house Gazes Monitoring from Space IWGGMS-12

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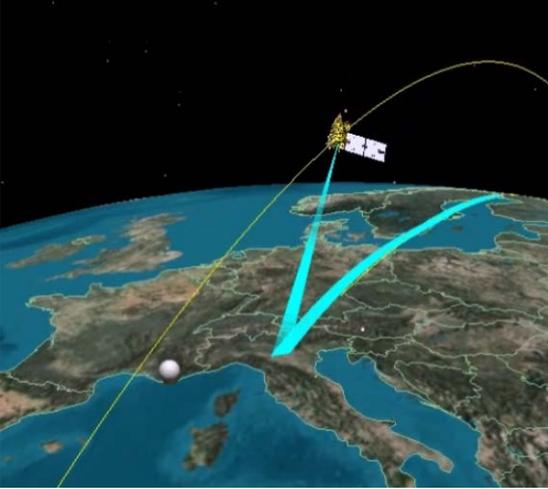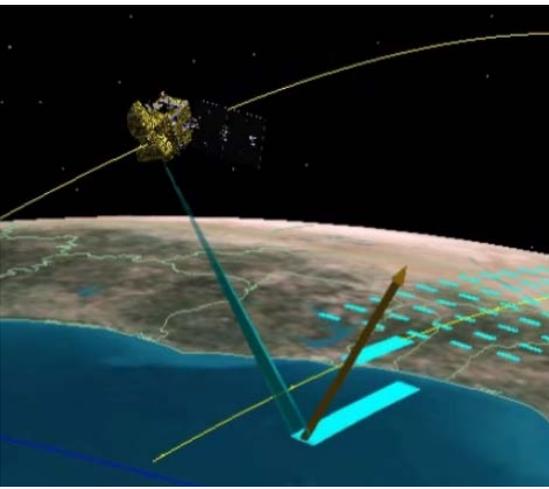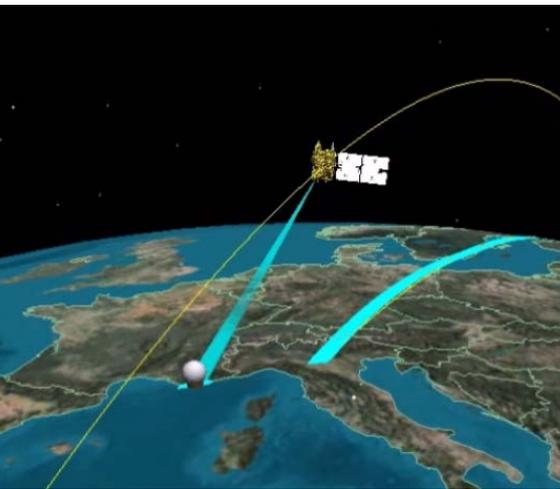
MISSION GOALS

- 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 "**)
- Ensure continuity of data and bring data in complement to Gosat-2 OCO-3 and Tansat.
- Prepare a possible family of instruments
- Bring a European contribution to the international efforts to improve the understanding of the carbon cycle.
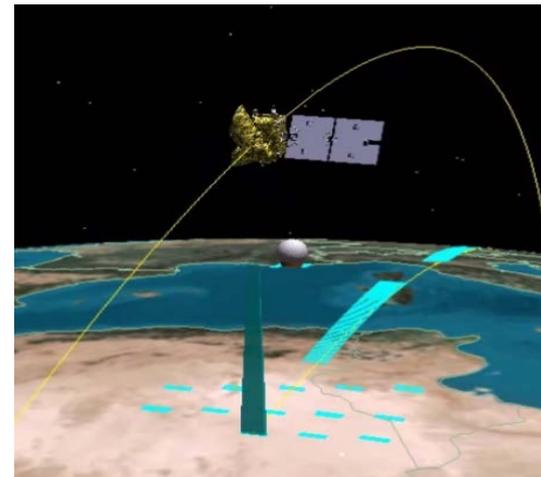
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MISSION DESCRIPTION

- Measurement of GHG atmospheric concentration (total column integrated content (CO_2 + CH_4) at global scale)
- Sampling mission (limited swath, sample size ~40 km²). Priority to the quality of the data.
- High precision (< 1 ppm) and low systematic error (bias < 0,1 ppm)
- Peak sensitivity (weighting function) near the surface
- Passive sounding instrument
- Compact and affordable instrument on board a microsatellite on LEO
- Launch date: 2020
- Life time: > 5 years
- Use the lessons learnt from projects in operation

- Orbit
  - ✦ Sun-synchronous – 649 km 10h30 LTDN
  - ✦ Period: 25 days (sub cycle 7 days)

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OBSERVATION MODES

Nadir	Glint	Target
Over lands	Over oceans	For calibration (TCCON)

Scan capacity

- Mechanism integrated in the instrument (rotating mirror. One axis)
- Across the track: $\pm$ 200 km
- Permits to acquire non correlated data
- Sampling distance: 100 km ALT and ACT

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SYSTEM ARCHITECTURE
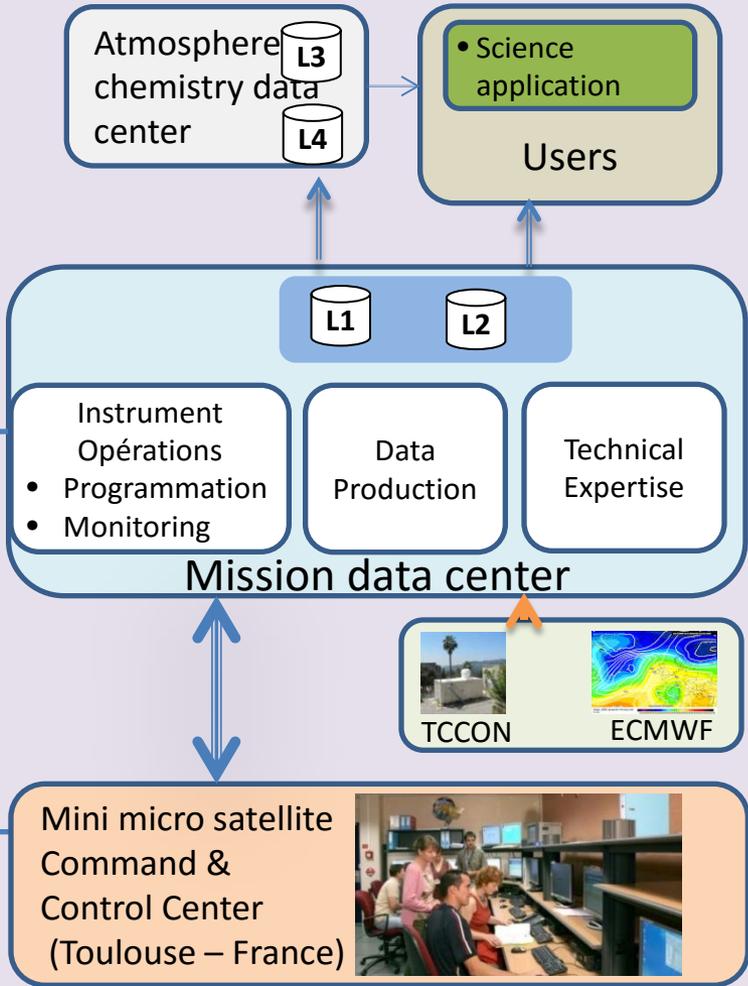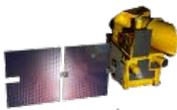
Architecture (based on Myriade)

X Band

S Band

Atmosphere chemistry data center | L3 | L4

• Science application

Users

L1   L2

Instrument Opérations
• Programmation
• Monitoring

Data Production

Technical Expertise

Mission data center

STATIONS NETWORK

Data transmission network

TCCON   ECMWF

Mini micro satellite Command & Control Center (Toulouse – France)

LAUNCHER
Soyuz Vega

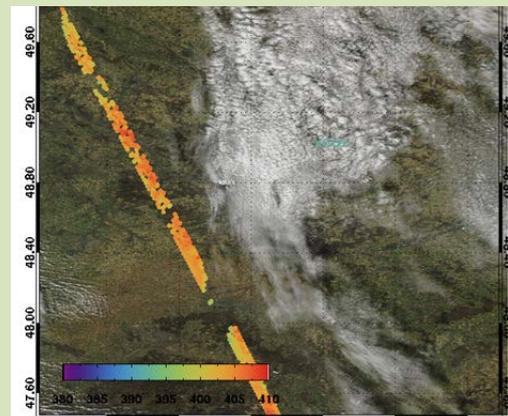cnes

PRODUCTS AND DATA PROCESSING

Processing, calibration
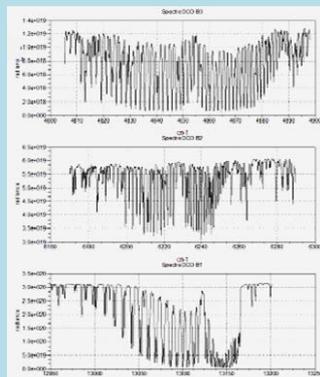
Level 0 =
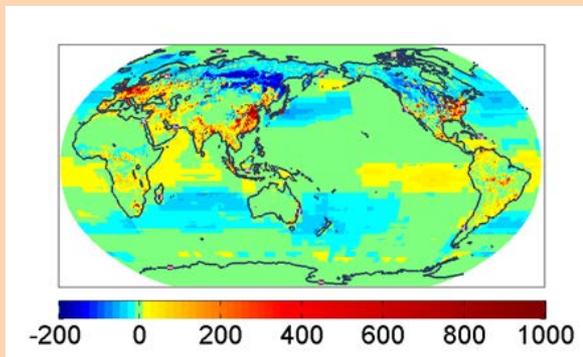Raw data

Level 1 = Calibrated
spectra in each band

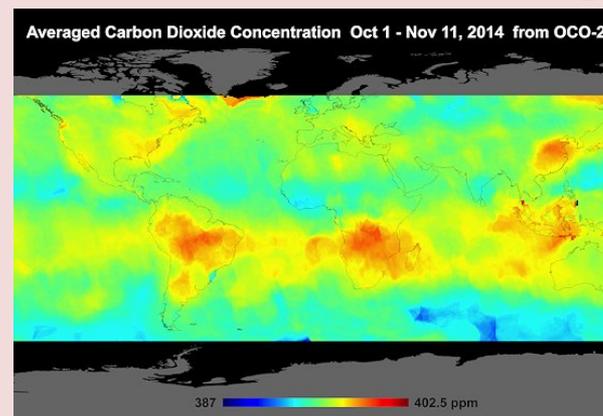**Inversion of radiative transfert**

Level 2 = CO_2
Concentrations (Credit NASA/JPL OCO-2)

Inversion of Global Circulation (transport model) LMDz

Level 4
= Flux CO_2
sources/sinks

Level 3
= monthly average maps XCO_2

Averaged Carbon Dioxide Concentration Oct 1 - Nov 11, 2014 from OCO-2

387   402.5 ppm
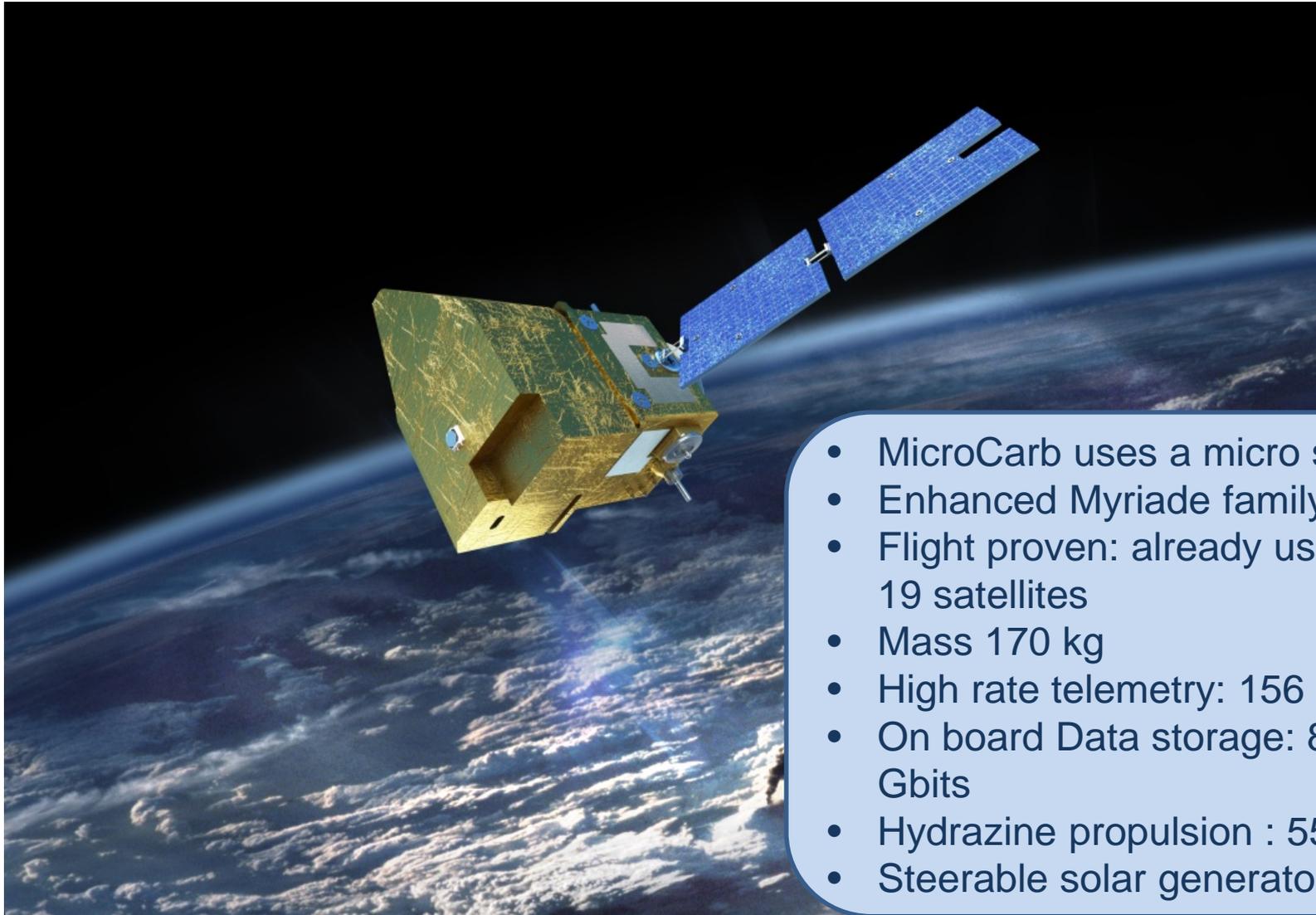
(Credit NASA/JPL OCO-2)

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SATELLITE DESCRIPTION

- MicroCarb uses a micro satellite
- Enhanced Myriade family
- Flight proven: already used for 19 satellites
- Mass 170 kg
- High rate telemetry: 156 Mbits/s
- On board Data storage: 800 Gbits
- Hydrazine propulsion : 55 m/s
- Steerable solar generator

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INSTRUMENT SPECIFICATIONS

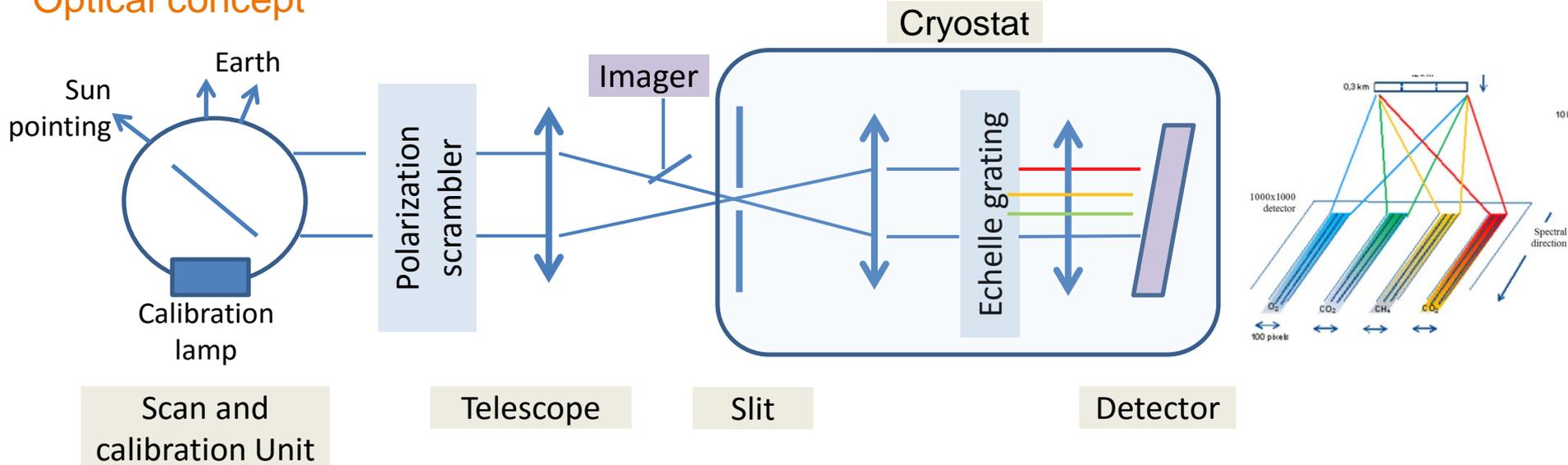|	
Type	Echelle grating spectrometer
Spectral bands	B1 (O_2): 767 nm BW : 10 nm B2 (CO_2): 1601 nm BW : 20 nm B3 (CO_2): 2046 nm BW: 26 nm *B4 (CH_4): 1674 nm BW: 22 nm* Still TBC. Fine tuning on going
Spectral resolution	R > 25 000
Field of views	3 FOV size 4,5 km (ACT) x 9 km (ALT) simultaneously acquired
Integrated Imager	Cloud detection. 0,625 μm Ground sampling: #100 m
Spectral sampling	> 2,8
Mass	< 60 kg
Power	< 55 W
Data rate	All data are downloaded. No processing on board => data rate 400 Gbits/day

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INSTRUMENT DESCRIPTION
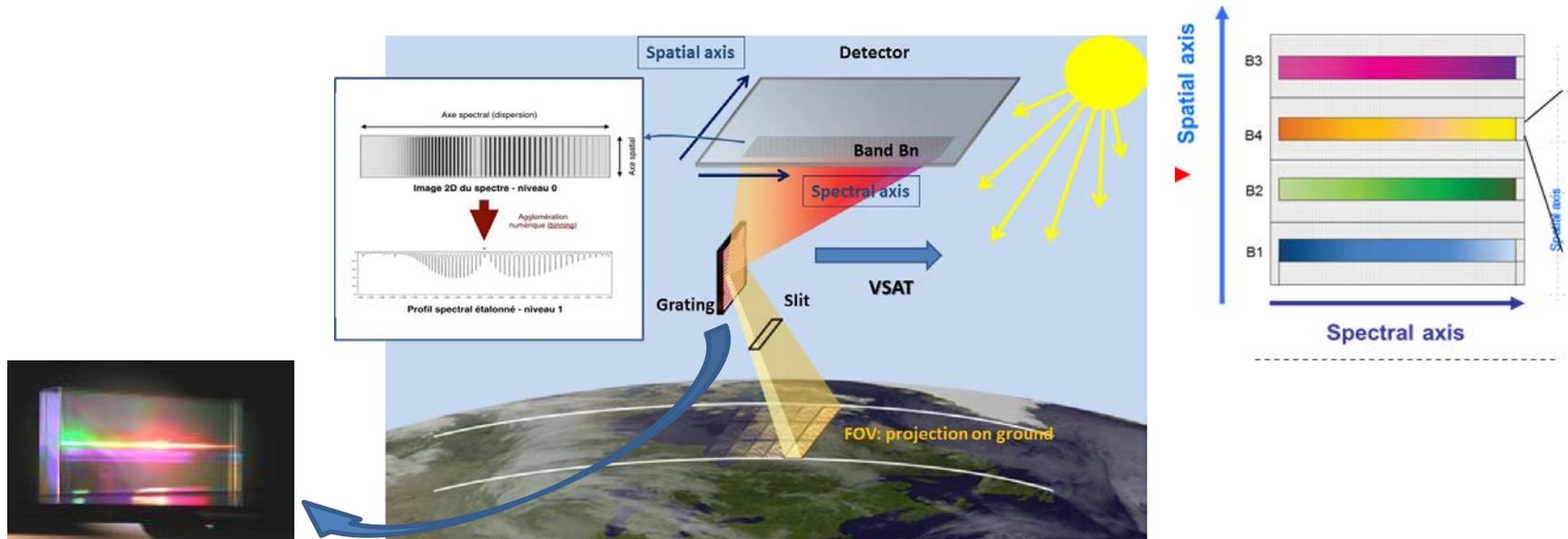
Instrument operating principle

- Echelle grating performs the diffraction
- In the detector, for each band:
  - ✦ Along X axis: spectrum
  - ✦ Along Y axis: projection of the slit on the ground
  - ✦ Each band uses ~100 pixels in the spatial direction
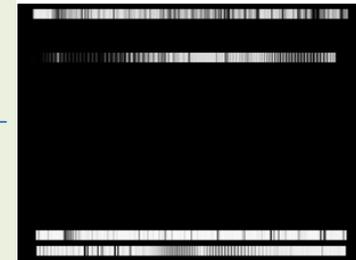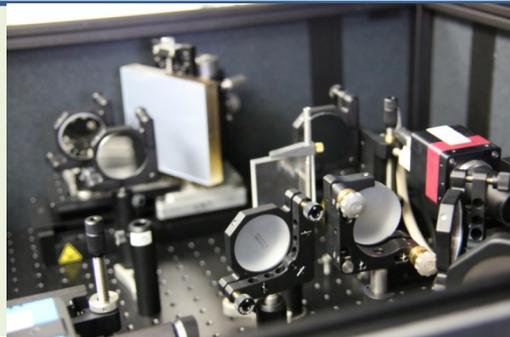
INSTRUMENT DESCRIPTION

Optical concept

Sun pointing — **Earth** — **Calibration lamp**

Polarization scrambler — **Imager** — **Cryostat** — **Echelle grating**

Scan and calibration Unit — Telescope — Slit — Detector

- Calibration
  - ✦ Internal calibration lamps
  - ✦ Direct illumination by sun

- Spectrometer/ Detector is unique for all the bands.
- New Generation Panchromatic HgCdTe 1kx1k

Concept was verified on an optical mock up

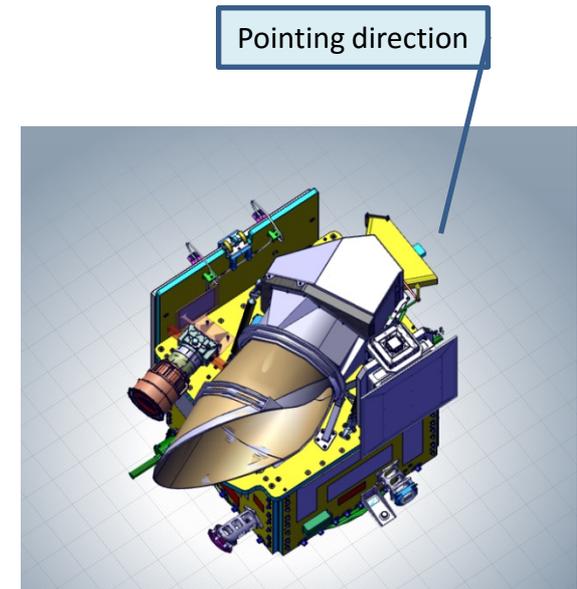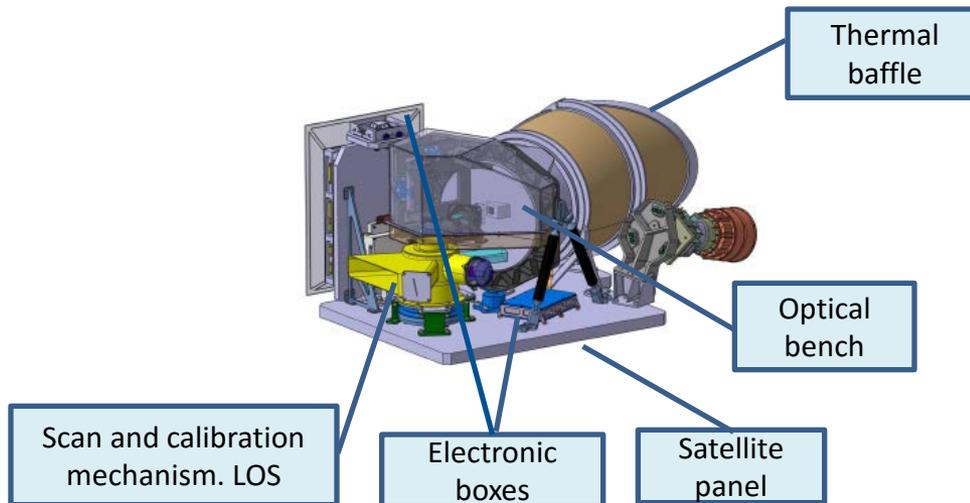Bands layout and width not representative of flight design

INSTRUMENT DESCRIPTION

Thermal concept

- Cooling is made passively: cryogenic radiator protected by earth and sun baffle
- Detector cooled down to 150K, Spectrometer cooled down to 225 K
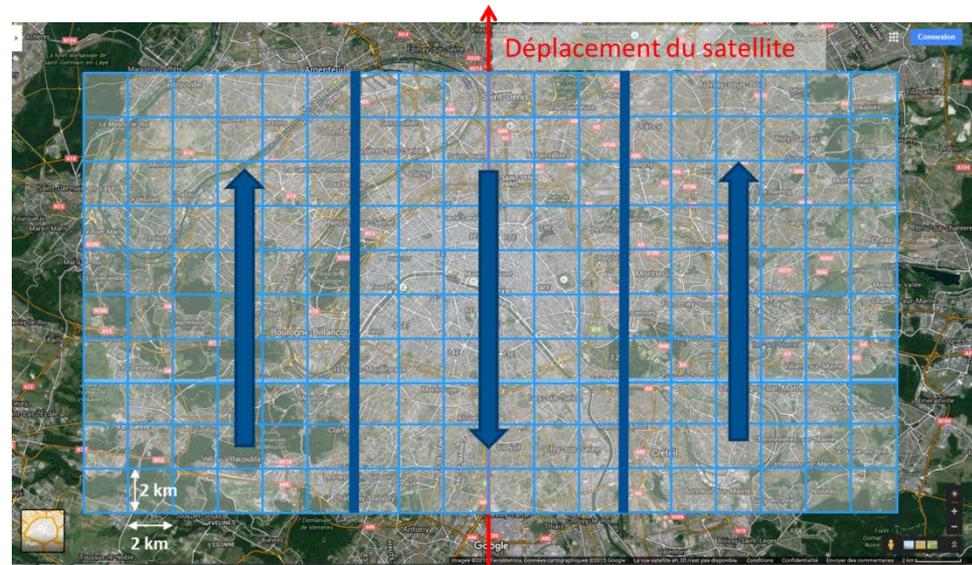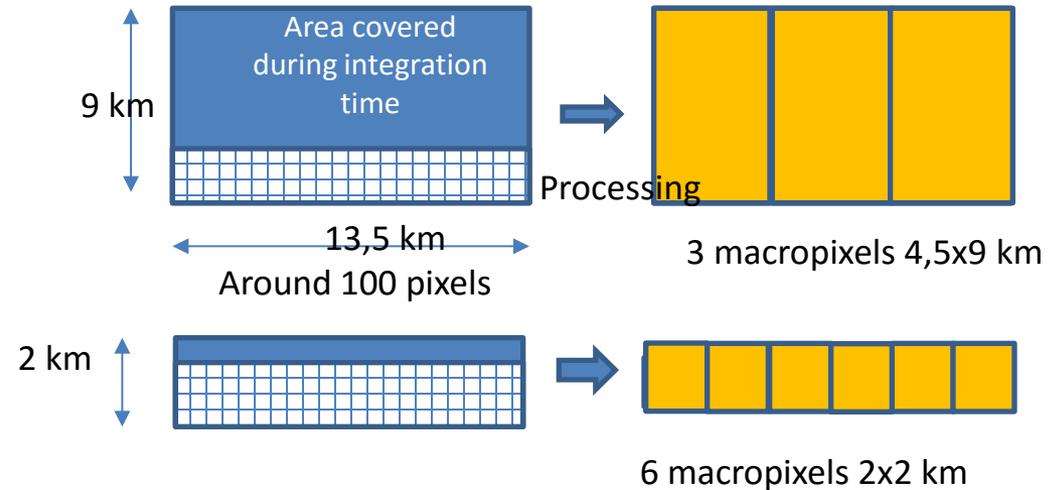
Mechanical

- Use of Si C for high stability.

Pointing direction

Thermal baffle

Optical bench

Scan and calibration mechanism. LOS

Electronic boxes

Satellite panel

Instrument lay out on Myriade platform

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Improved resolution or « City « mode

- Goal:
  - ✦ experiment capacity to characterize local emissions
  - ✦ Support for vicarious validation
  - ✦ locally improvement of the spatial resolution
- Obtained by slowing down the satellite scrolling + scan + binning tuning
- No data acquisition before / after (satellite maneuver)

- Typical footprint: 2x2 km
- Typical area surface: 40x25 km²

Area covered during integration time

9 km

13,5 km
Around 100 pixels

Processing

3 macropixels 4,5x9 km

2 km

6 macropixels 2x2 km

Déplacement du satellite

2 km

2 km

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STATUS - ORGANIZATION

Program decided

- Decision announced by French Government Dec 8th, 2015 (COP-21)
- Phase B is in progress

Organization. Actors)

- MicroCarb has been defined by CNES in collaboration with French research laboratories from CNRS and CEA
  - Laboratoire des Sciences du Climat et de l'Environnement (F.M.. Breon PI)
  - Laboratoire de Météorologie Dynamique
  - Institut Pierre Simon Laplace
  - Laboratoire Atmosphères, Milieux, Observations Spatiales, and others
- Funding is provided by French program "Investment for Future".
- CNES selected Airbus Defence and Space for the design and development of the instrument => design on going
- CNES proposes to other European agencies to join the project and share the efforts

LABORATOIRE DES SCIENCES DU CLIMAT & DE L'ENVIRONNEMENT