Additional Bands for the improvement of MicroCarb performance

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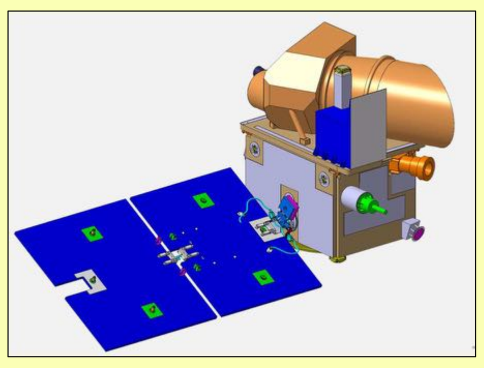
ABSTRACT

The objective of the CNES/MicroCarb mission is to retrieve the CO_2 dry air mass mole fraction (XCO_2) with a high accuracy, in order to better quantify the sources and sinks of CO_2 through assimilation into atmospheric transport models.

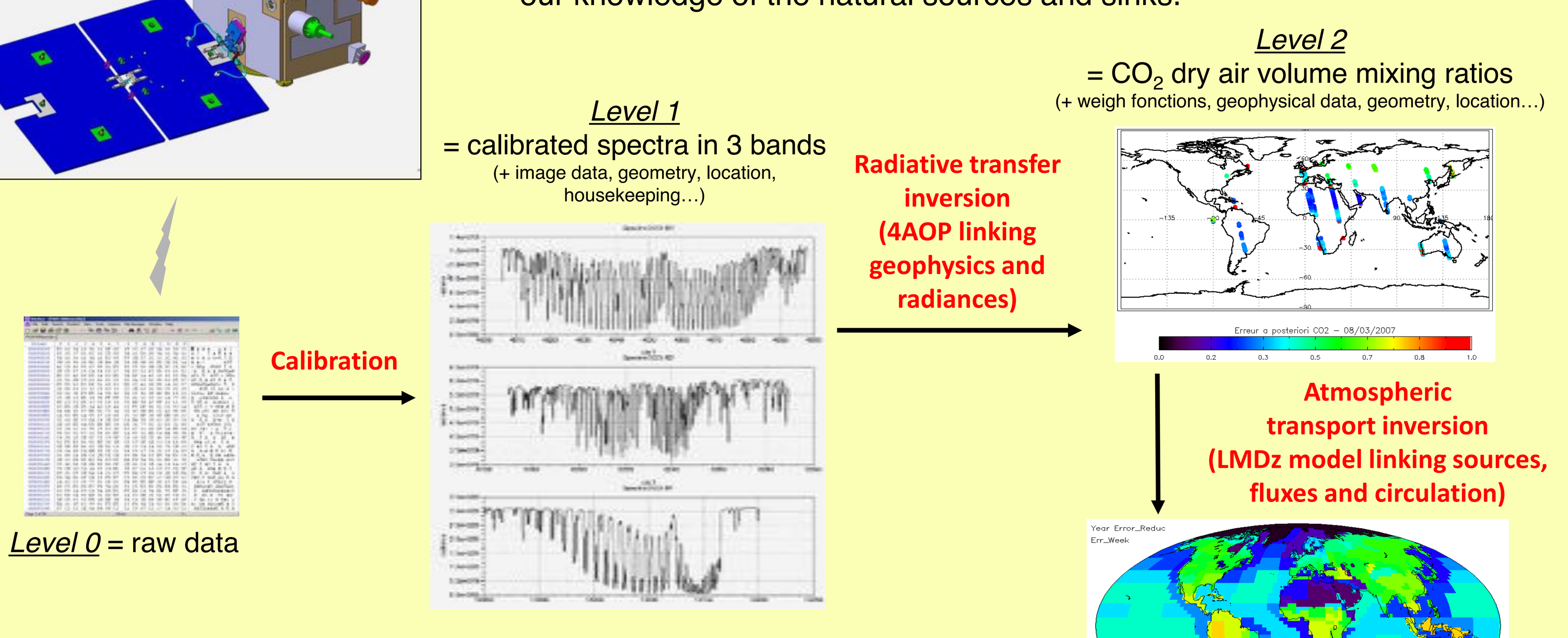
The MicroCarb instrument design has evolved to a more compact design, using a unique telescope, a unique grating and a unique detector on which all the spectral bands are acquired. This evolution gives the opportunity to easily acquire new bands, additionally to the 0.76 μm, 1.61 μm and 2.06 μm bands.

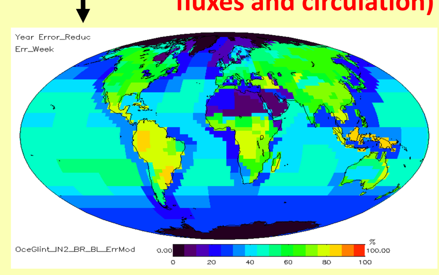
We discuss here the three new bands that have been studied for their scientific interest (especially for a better CO_2 measurement) and their instrumental feasibility: 1.67 μm, 1.27 μm and 2.35 μm. Final choice will be done very soon and any suggestion or comments are welcome.

1 – THE MICROCARB MISSION



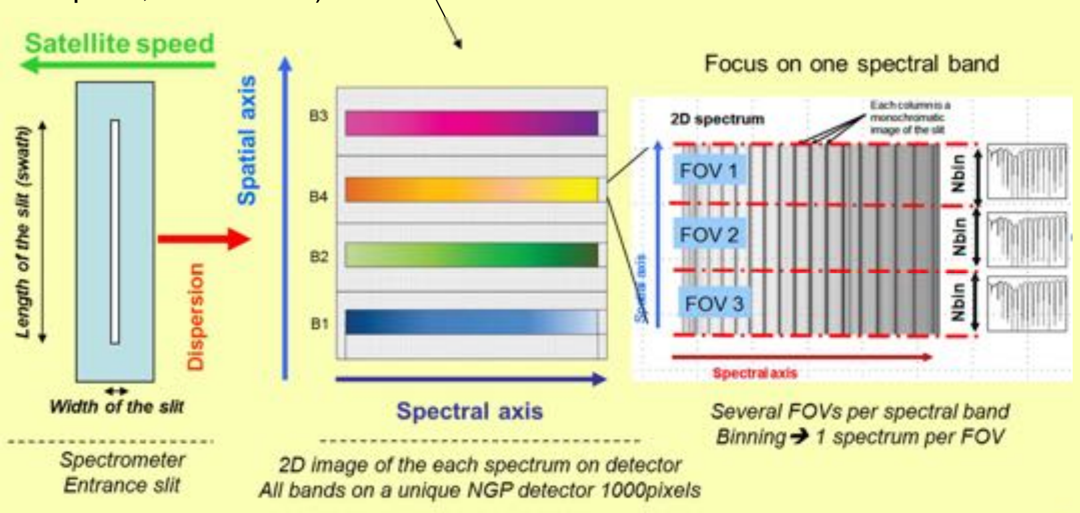
- Goal of the MicroCarb mission: monitor the global fluxes to better constrain our knowledge of the natural sources and sinks.





- MicroCarb started phase B (detailed definition) in Feb 2016
- CNES Myriade microsatellite
- 4 modes: Nadir, scan, glint and target (ex: TCCON stations)
- The instrument is a compact concept based on a single grating. The spectra are now acquired by a unique 2D detector.
  (See presentation Airbus Defence & Space, ICSO 2016)
- Mission main requirements:

Parameter	Value
Orbit	SSO - 649 km 10:30 LTAN (25 days cycle, 7 days sub-cycle)
Swath	15 km, 3 FOV
Elementary footprint	< 46 km² at nadir
CO_2 random error	< 1 ppm
CO_2 regional bias	< 0.1 ppm
Launch time	2020

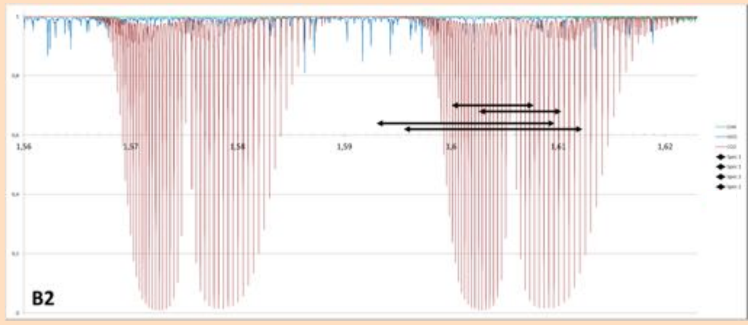


2 – MICROCARB NOMINAL BANDS

- L2 performances required by scientists: XCO_2 random error < 1ppm, regional bias < 0.1 ppm.

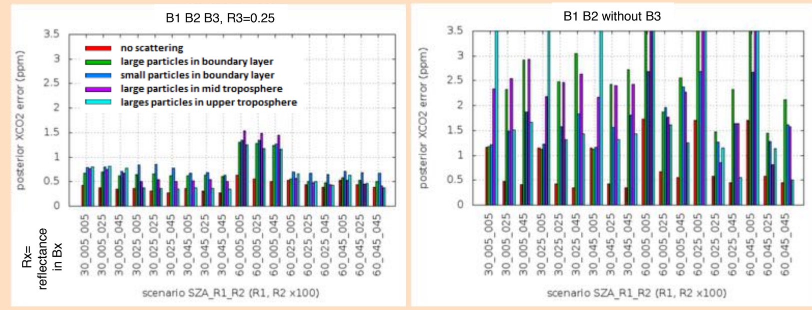
Parameter	Value
Wavelength	0.76 μm, 1.61 μm, 2.06 μm
Band widths	> 50 cm^{-1}
Resolution factor (λ/Δλ)	> 25 000
Signal to Noise Ratio	200 to 500 @ Lmoy

- **B2: weak CO_2 at 1.61 μm**
  - Purest area for CO_2
  - But: No information on the aerosol impact



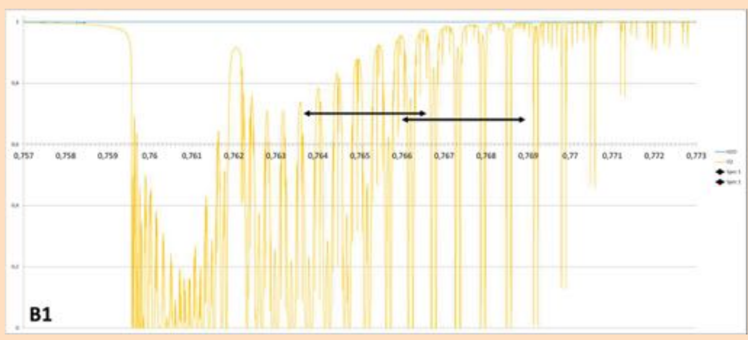
- **B3: strong CO_2 at 2.06 μm**
  - Most sensitive band to CO_2
  - Saturated lines provide information on aerosols
  - The aerosols spectral dependence creates a different impact on B2 and B3

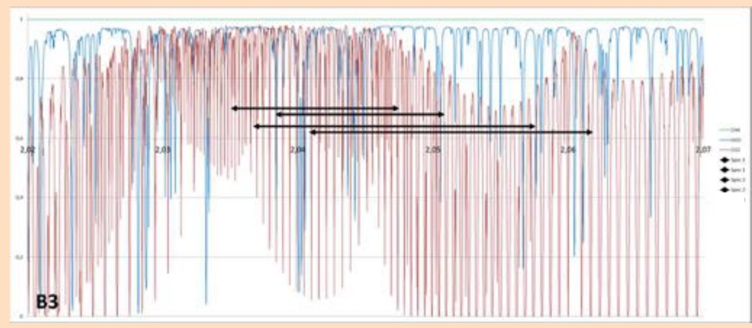
  ➔ The simultaneous measurement of B2 and B3 improve the CO_2 performance in aerosols contaminated scenes



- **B1: O_2 at 0.76μm**
  - Provides O_2 amount to compute XCO_2
  - Provides information on Psurf (with external information from ECMWF) and on the optical path (presence of aerosols).
  - Requires Fraunhofer lines to evaluate the photosynthesis fluorescence contamination
  - Spectroscopy not fully understood

- The strong contamination by H_2O increases the uncertainty on XCO_2, but provides information on the amount of dry air
- Spectroscopy is less known than in B2

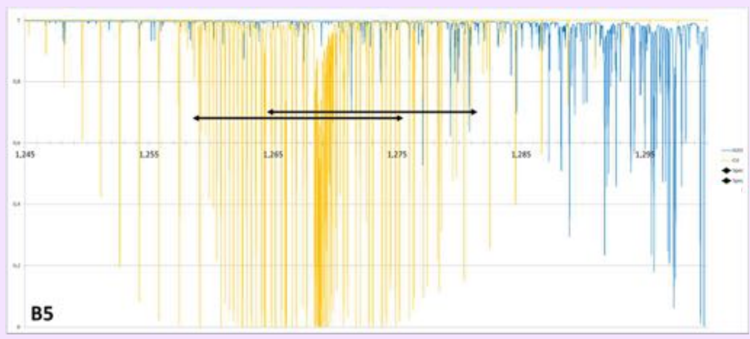




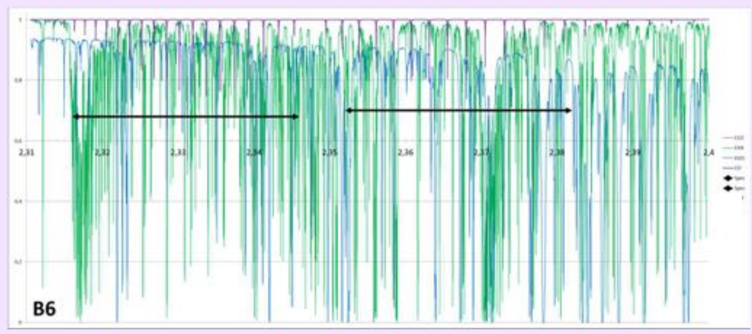
3 – MICROCARB POTENTIAL ADDITIONAL BANDS

- The enhanced instrumental concept gives the opportunity to acquire new spectral bands without decreasing the XCO_2 performances ➔ We may choose 1 or 2 additional bands
- It is a great opportunity to improve the CO_2 measurement with aerosols and to measure other species

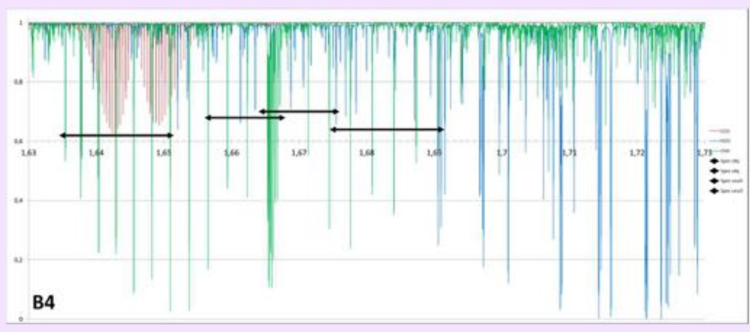
- **B5: O_2 at 1.27 μm**
  - Improve information on Psurf & aerosols in addition with B1 (O_2 at 0.76 μm)
  - Spectroscopy better known than at 0.76 μm
  - But contaminated by an airglow emission
    (see 4)



- **B6: CH_4, CO & H_2O at 2.35 μm**
  - The simultaneous measurement of CO_2 and CO gives access to the origin of CO_2 (incomplete combustions come from anthropogenic emissions and biomass burning)
  - Improves information on H_2O to reduce uncertainty on the amount of dry air and XCO_2



- **B4: CH_4 at 1.67 μm**
  - CH_4 is the second anthropogenic GHG and its emission processes have large uncertainties



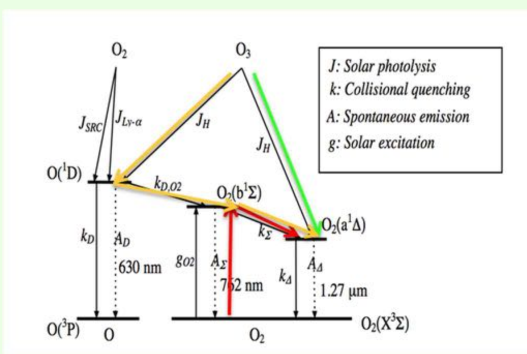
- **B4+B6: aerosols**
  - Measuring CH_4 simultaneously in two spectral windows gives the opportunity to better constrain aerosols (as measuring CO_2 in 2 bands)

- **First performances estimates without aerosols show compliance with common requirements**
- **Estimates with aerosols are on going**

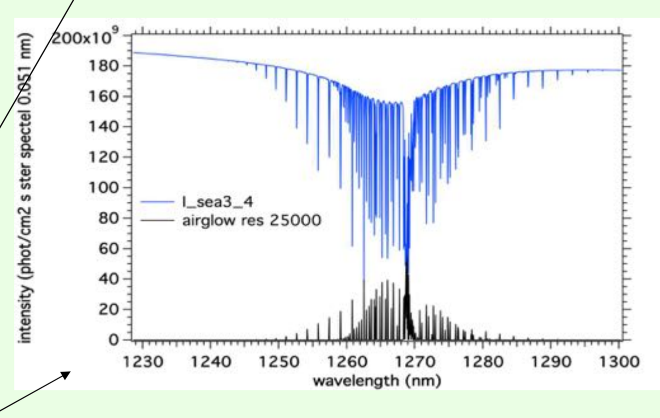
(ppmv)	A priori	Requirement	Perf @Lmin	Perf @Lmoy	Perf @Lmax
CO_2	16.79	1	1.18	0.44	0.16
H_2O	1835	NA	670	565	475
CH_4	0.085	0.017	0.025	0.013	0.010
CO	0.036	0.01	0.026	0.012	0.004

4 – SPECIFIC STUDY ON AIRGLOW AT 1.27 μm

- **The 1.27 μm O_2 band is known to exhibit strong emission of airglow due to the photodissociation of stratospheric and mesospheric O_3**
- **Ignoring airglow in the inversion leads to strong biases on Psurf (~80 hPa)**
- **Poor literature on this topic**

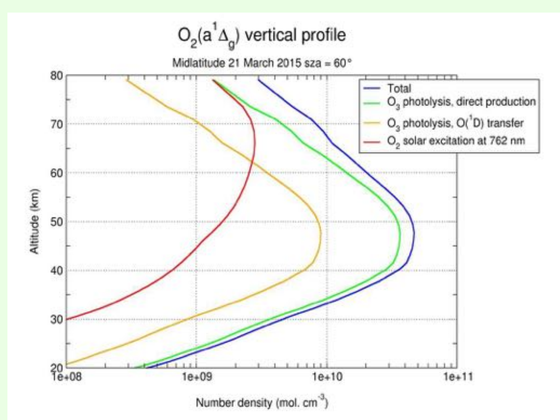


➔Dedicated study by LATMOS and ACRI, funded by CNES, to determine the possibility to use it with 0.76 μm band for an improved XCO2



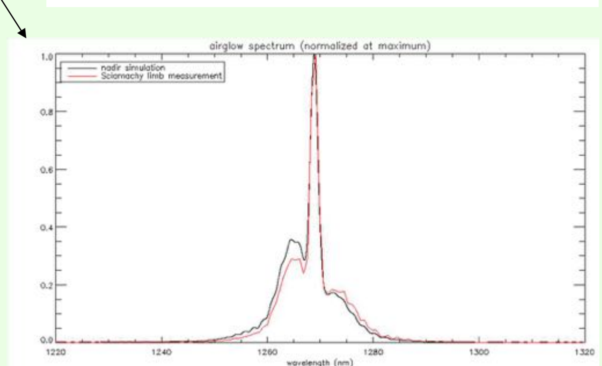
- **Modelling of the phenomenon:**
  - Spectroscopy and spectral shape of airglow (impacts centers of O_2 absorption lines)
  - Modelling of airglow emission w.r.t. VER (Volume Emission Ratio)
  - A Chemical Transport Model (REPROBUS by F. Lefevre) can provide estimates of VER
  - Preliminary comparisons to SCIAMACHY limb measurements

  ➔The study concludes in an accurate comprehension of the phenomenon



- **Decontamination of MicroCarb spectra**
  - Optimal estimation of airglow can efficiently be included in the MicroCarb inversion tool

  ➔ XO_2 residual biases are very low (0.01 hPa)
  - Possibility to remove the most contaminated channels if necessary



5 – OTHER CONSIDERED BANDS

Other spectral bands have also been considered but will not be selected

- **H_2O band (0.94 μm, 1.37 μm)**
  - Improves information on H_2O to reduce uncertainty on XCO_2
  - Saturated H_2O lines provide a very efficient tool to detect high cirrus
- **N_2O (2.1 μm, 2.25 μm)**
  - N_2O is the third anthropogenic GHG and its emission processes have large uncertainties