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Preliminary results from in-situ measurements of CH_4, CO, CO_2 and N_2O by the SPIRIT instrument during the summer 2014 GLAM aircraft campaign

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SPIRIT Instrumentation:

SPIRIT (Spectromètre InfraRouge In situ Toute altitude) is an airborne infrared absorption spectrometer for the simultaneous measurements of several trace gases. It uses three continuous wave distributed-feedback room-temperature quantum cascade lasers (CW-DFB-RT-QCL) cooled by Peltier effect and exhibiting an excellent single-mode behaviour. In addition, CW operating mode lasers provide easy, high precision for concentration retrieval, large selectivity and sensitivity because of their reduced line width (< 3 MHz or 10^{-4} cm^{-1}) and enhanced line intensity. Thanks to the home-made QCL emission controller, the lasers work sequentially, triggered and synchronized by the data acquisition system, with sampling at 0.7 Hz. The optical system of SPIRIT consists of a patented non-resonant multipass cell (Robert, 2007). The path length can be varied from 20 to 200 m by the rotation of one half of the broad band spherical mirrors of the optical cell, providing high versatility as regard to the type and the concentration range of species to be measured. In the present study, SPIRIT has been used with *L*=83.88 m path length and with 3 QCLs emitting at 2179.772, 1249.627, 1249.668, and 2307.513 cm^{-1} for the detection of CO, CH_4, N_2O, and CO_2 ($^{12}C^{16}O^{18}O$ isotopomer), respectively. SPIRIT has been integrated in the Falcon-20 SAFIRE aircraft.

The experimental optical transmission *T* as a function of the wavenumber is retrieved by dividing the experimental signals by the associated baseline. The concentration retrieval is based on the Beer-Lambert law. The principle of the retrieval is to fit the natural logarithm of the transmission *ln[T]* with the simulated one, $C.S.g(\tilde{\nu}-\tilde{\nu}_0).L$, by adjusting the concentration *C* in molecule cm^{-3} (with $g(\tilde{\nu}-\tilde{\nu}_0)$ the absorption profile in cm, *S* the molecular line intensity in cm $molecule^{-1}$, and *L* the path length in cm). *S* includes the molecular partition functions and the lower-state energy of the transition *E"*, and is assumed to be a Voigt or a Galatry line profile including the air collisional broadening and the Doppler broadening half-widths and their temperature dependence coefficients, all calculated from the Hitran 2012 database (Rothman et al., 2013).

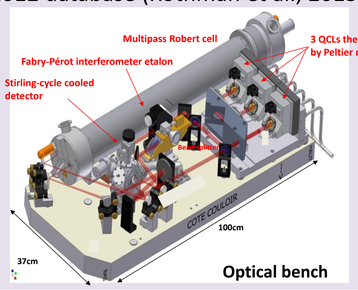




In left foreground, SPIRIT in the aircraft cabin, with the air sampling tube

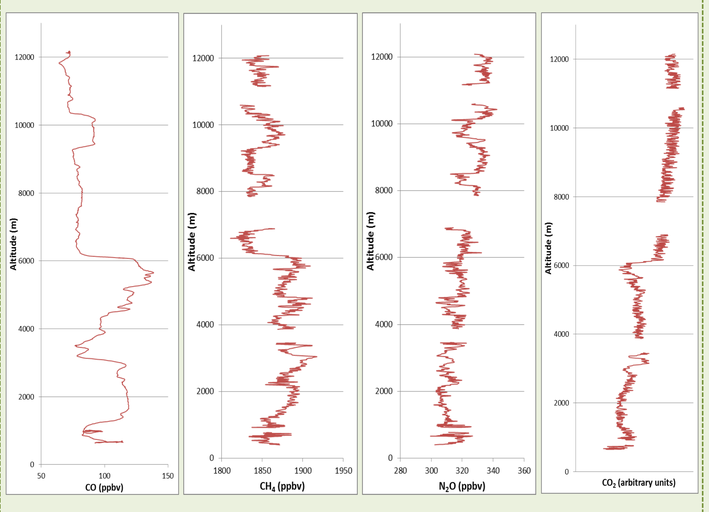
	N_2O	CH_4	CO_2	CO
Precision (ppbv)	3	9	2000	1
Precision (%)	1	0.5	0.5	0.5

Detection limit and precision in 1.5 s

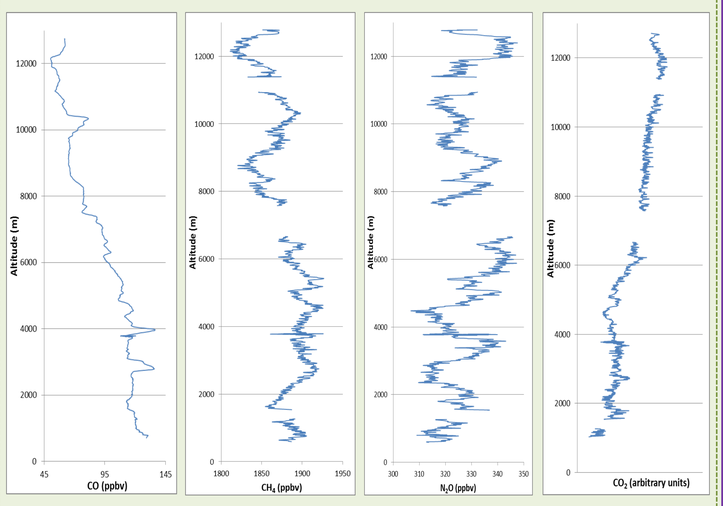


Optical bench

Examples of Vertical Profiles During two Descents:



Vertical profiles of CO, CH_4, N_2O and CO_2 during the descent above Lampedusa (6 August 2014).

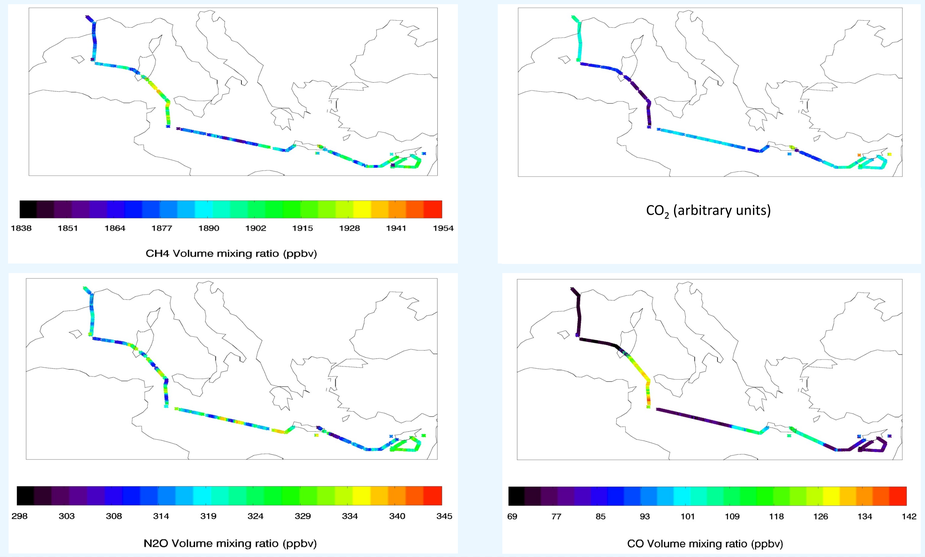


Vertical profiles of CO, CH_4, N_2O and CO_2 during the descent above Iraklion (7 August 2014).

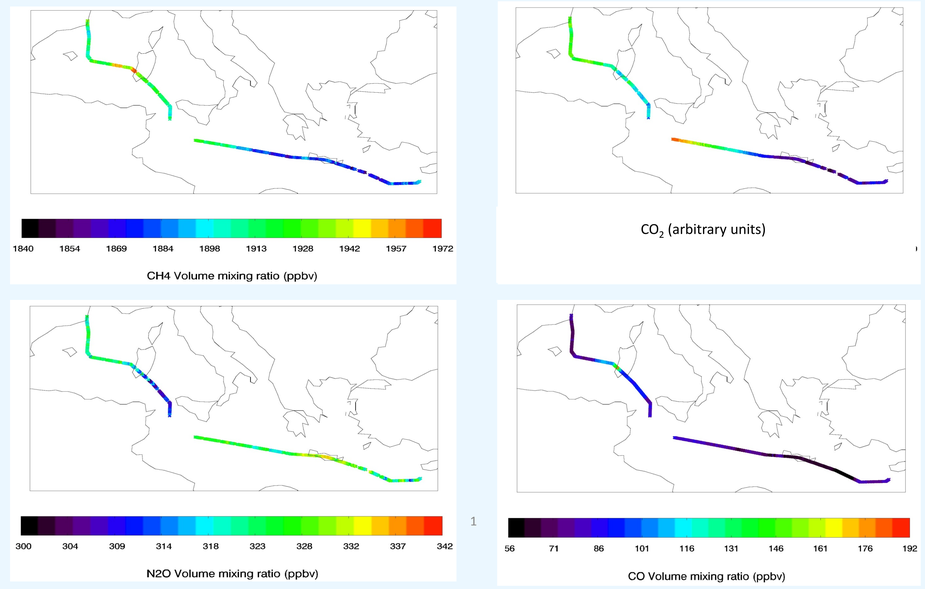
East-West Variations of Mixing Ratios at Constant Altitudes:

The SPIRIT instrument was deployed during the GLAM (Gradient in Longitude of Atmospheric constituents above the Mediterranean basin) campaign, as part of the CHARMEX project, in August 2014 from Toulouse to Larnaca onboard the Falcon-20 SAFIRE aircraft. The study presents in-situ measurements of CO, CO_2, CH_4 and N_2O during the **west-east transect at 5000-5500m altitude on 6-7 August (Fig. A)** and during **the east-west transect at 9000-9800m altitude for the flight back on 10 August (Fig. B).**

A



B



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