



**HAL**  
open science

## **Low troposphere monitoring with TRAQ mission.**

T. Phulpin, B. Beghin, P. Hebert, Claude Camy-Peyret, Cathy Clerbaux,  
Juliette Hadji-Lazaro, Pierre-François Coheur, Jean-François Léon, L.  
Lavanant, P. F. Levelt

### ► To cite this version:

T. Phulpin, B. Beghin, P. Hebert, Claude Camy-Peyret, Cathy Clerbaux, et al.. Low troposphere monitoring with TRAQ mission.. Community Workshop on Air Quality Remote Sensing from Space : Defining an optimum observing strategy, Feb 2006, Boulder, United States. 2006. hal-00110656

**HAL Id: hal-00110656**

**<https://hal.science/hal-00110656v1>**

Submitted on 24 Apr 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Low troposphere monitoring with TRAQ Mission

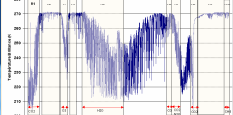
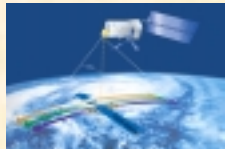
T. Phulpin, B. Beghin and P. Hebert  
 Centre National d'Etudes Spatiales (CNES),  
 C. Camy-Peyret (LPMAA), C. Clerbaux (SA), J. Hadji-Lazaro (SA), P.-F. Coheur (ULB), J.-F. Leon (LOA),  
 L. Lavanant (CMS), P. Levelt (KNMI)

## Air Quality Monitoring from space

- With state-of-the-art techniques some key species like NO<sub>2</sub> or SO<sub>2</sub> are well retrieved from UV-VIS sensors, but there is still some disagreement between products. The O<sub>3</sub> estimate is good in the stratosphere but not fully satisfactory in the troposphere. Some promising results have been obtained with TES. CO is retrieved with good precision by MOPITT. First encouraging results for CO and CH<sub>4</sub> over land have been presented by SCIAMACHY. Simulations indicate promising results from IASI. However trace gas retrieval are far from being operational in the troposphere.
- Studies to define proper tropospheric missions are slow to converge. There are noticeable differences between the requirements of CAPACITY, MTG and IGACO
- Techniques must be improved to provide parameters with adequate revisit and vertical resolution
- Access to low tropospheric trace gases and micro-particles has to be proved

### IASI FIRST LESSONS

IASI is a FTIR spectrometer devoted to operational atmospheric sounding to be flown on the MetOp series (European polar meteorological satellites) from 2006 to 2020. IASI will deliver atmospheric spectra from 655 cm<sup>-1</sup> to 2760 cm<sup>-1</sup> with 0.25 cm<sup>-1</sup> spectral sampling. The instrument was designed by CNES and manufactured by Alcatel, with co-funding from CNES and Eumetsat.



Major spectral regions for IASI sounding

Products which could be obtained from IASI are:

CLASSICAL VARIABLES	ACCURACY	RESOLUTION	RESOLUTION	RESOLUTION
Temperature profile	±0.5 K	1 km	1 km	1 km
Water vapor profile	±0.2 g/kg	1 km	1 km	1 km
Ozone profile	±0.5 DU	1 km	1 km	1 km
CO profile	±0.5 ppmv	1 km	1 km	1 km
CH4 profile	±0.5 ppmv	1 km	1 km	1 km
NO2 profile	±0.5 ppbv	1 km	1 km	1 km
SO2 profile	±0.5 ppbv	1 km	1 km	1 km
Cloud cover	±0.5 %	1 km	1 km	1 km
Cloud height	±0.5 km	1 km	1 km	1 km
Cloud optical thickness	±0.5	1 km	1 km	1 km
Surface SW	±0.5 W/m²	1 km	1 km	1 km
Surface LW	±0.5 W/m²	1 km	1 km	1 km
Pressure	±0.5 hPa	1 km	1 km	1 km
Pressure	±0.5 hPa	1 km	1 km	1 km
Pressure	±0.5 hPa	1 km	1 km	1 km
Pressure	±0.5 hPa	1 km	1 km	1 km

On this basis, CNES designed a new generation infrared instrument : SIFTI

## FOCUS

High revisit frequency : typically every two hours during daytime  
 Low troposphere profiles : Access to primary pollutants in the BL , specially NO<sub>x</sub>, SO<sub>x</sub>, CO, VOCs and O<sub>3</sub>  
 Micro-particles : PM10, PM2.5 or total burden

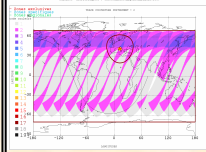
## LOW ORBITS WITH HIGH REVISIT OVER MID-LATITUDES

Several types of orbits were studied : GEO, MEO, Molnya, LEO  
 The ones offering the best trade-off to afford a revisit of 2 hours is a phased inclined orbit already studied at CNES for :  
 • JASON: The orbit is a 1200 km, inclined at 66°, 10-day phased orbit  
 • TROC: A dedicated orbit was studied for TROC (proposal to ESA Earth Explorer 2002).

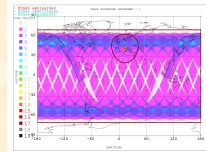
Technical issues are power availability and consistency with data acquisition cycles. Solutions like yaw steering or yaw flip are well-mastered by CNES

### Selection of orbit :

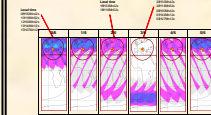
TROPOMI 1 day Coverage—Equinox day 15 of the local time cycle



SIFTI daily Coverage



Geographic/Local Time Cycle (76 days, 1.6x12 days)



Altitude : 720 km  
 Inclination : 57°  
 Phased orbit : 3 days

## TRAQ Mission objectives and Requirements

- TRAQ is a scientific mission devoted to :
  - Mapping of emission sources
  - Transport
  - Climate and air quality
- It is also
  - A gap filler (after Envisat, EOS, ...)
  - A GMES preparatory mission
  - A demonstration mission

## PARASOL

Parasol is a micro-satellite in the A-Train. The instrument is the follow-on of Polder on ADEOS 1 and 2. Its main characteristics are



The main results of Parasol are

- On the aerosols
- On the clouds and other parameters

	Consistency	Comparison to other products
Cloud cover	80 %/100%	AMS2 and MODIS No comparison, RMSE = 0.2
Water vapor		AMS2 and MODIS RMSE = 0.46 g/kg, RMSE = 4.034 kg/m²
Cloud Phase		AMS2 RMSE = 0.46 g/kg, RMSE = 4.034 kg/m²
Cloud Optical Thickness		AMS2 and MODIS RMSE = 0.46 g/kg, RMSE = 4.034 kg/m²
Surface SW	30 %/100 % Accuracy: 0.52 W	AMS2 RMSE = 0.2 %/100 %
Surface LW		AMS2 and MODIS RMSE = 0.2 %/100 %
Pressure		AMS2 and MODIS RMSE = 0.2 %/100 %
Pressure		AMS2 and MODIS RMSE = 0.2 %/100 %
Pressure		AMS2 and MODIS RMSE = 0.2 %/100 %
Pressure		AMS2 and MODIS RMSE = 0.2 %/100 %

## SIFTI

### Main requirements

SIFTI is designed to measure very precisely the infrared spectrum in the fundamental bands of O<sub>3</sub> and CO. The spectral resolution is chosen to resolve the profile of pressure broadened lines and to allow selection of the most uncontaminated ones. The noise figure is very low to reduce its impact on retrieval.

The spatial resolution is 10 km with a basic sampling every 50 km. The scan sampling can be optimized by pointing in the cloud holes as determined in real time by an integrated imager called CLIM (hole hunting or intelligent pointing).

SIFTI is a new and innovative interferometer design for high spectral resolution with expected very good radiometric performances. A breadboard, for testing this technical concept in the thermal infrared will be developed in 2006

### Design

Principles of radiometric performance



Preliminary design

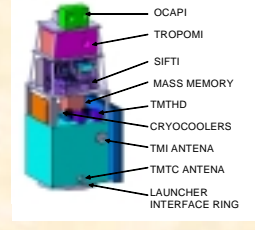


## TROPOMI

TROPOMI is the UV-VIS/SWIR sensor proposed by KNMI. With its 10 km resolution and its performances described in another paper by Levelt et al., it is a perfect complementary instrument to SIFTI and OCAP.

## TRAQ PAYLOAD

The accommodation of these various instruments on the same payload has been studied by CNES. Attention was paid to minimize the total weight and power in order to be compatible with a mini-satellite platform



## OCAPI

OCAPI is a multichannel imaging radiometer polarimeter. It inherits from Polder/Parasol but with higher spatial resolution and MODIS (SWR channels)

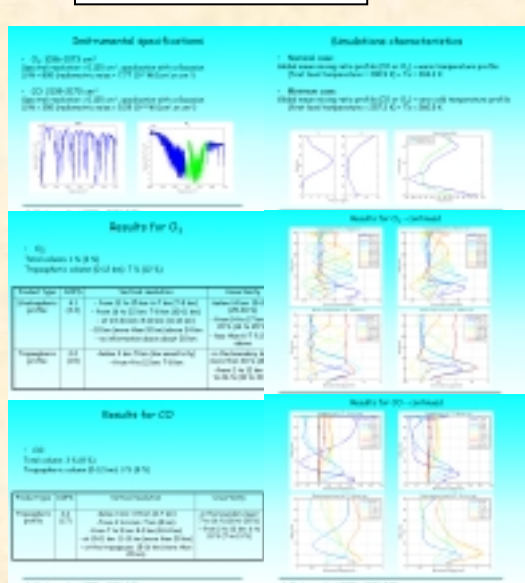


OCAPI (S) Specifications

OCAPI (S) Budget

## Simulations of performances:

### SIFTI stand alone



### SIFTI + TROPOMI



## Synergy

UV-VIS and IR provide complementary information and are both required for air quality studies. Besides the combined use for O<sub>3</sub> and CO retrieval, TRAQ will also take advantage of the synergy of the various instruments for:

- Surface albedo (OCAPI + TROPOMI)
- Aerosols properties (OCAPI + TROPOMI)
- Clouds parameters (cover, height, temperature, albedo) (CLIM, OCAP, TROPOMI, SIFTI)

## CONCLUSIONS

To get profiles of polluting species and specially low tropospheric contents, thermal infrared spectrometers are deemed necessary along with UV-VIS sensors. Shortwave infrared is also useful to get CO in the boundary layer. Multidirectional polarimetry is the only spaceborne technique available to detect aerosol micro-particles and should be included in a payload devoted to Air Quality monitoring.

TRAQ is a mission offering the opportunity of improving our knowledge on Air Quality but also allowing to define the characteristics of a future operational mission within the GMES framework.

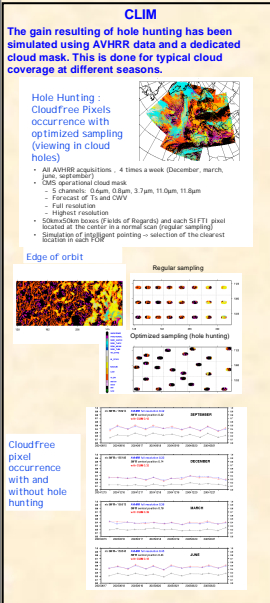
### CLIM

The gain resulting of hole hunting has been simulated using AVHRR data and a dedicated cloud mask. This is done for typical cloud coverage at different seasons.

Hole Hunting : CloudFree Pixels occurrence with optimized sampling (viewing in cloud holes)

- All AVHRR wavelengths, 4 times a week (December, March, June, September)
- Cloud operational cloud mask
- 5 channels: 0.6um, 0.8um, 1.2um, 1.6um, 2.1um
- Full resolution
- Cloud-free areas (if hole of 100m and each SIFTI pixel located at the center in a normal scan (regular sampling))
- Simulation of intelligent pointing = selection of the cloud-free location in each POC

Edge of orbit



CloudFree pixel occurrence with and without hole hunting