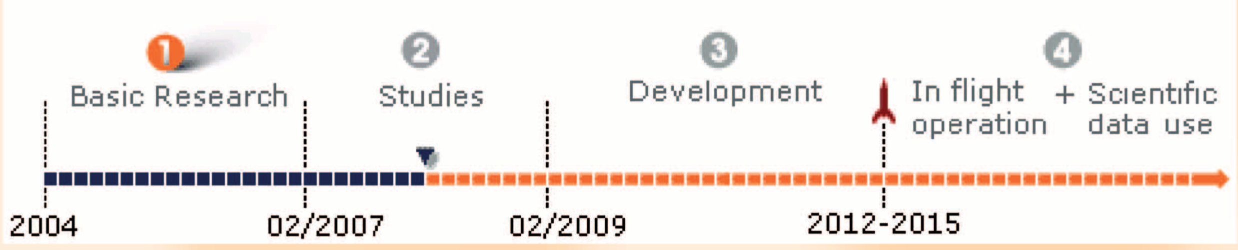
SIFTI a Static Infrared Fourier Transform Interferometer dedicated to ozone and CO pollution monitoring

C. Pierangelo[1], P. Hébert[1], C. Camy-Peyret[2], C. Clerbaux[3], P. Coheur[4], T. Phulpin[1], L. Lavanant[5], T. Tremas[1], P. Henry[1], A. Rosak[1]

Measuring pollutant concentrations in the boundary layer of the atmosphere is a major challenge for **air quality.** Infrared sounding, providing vertically resolved profiles for several trace gases in the troposphere, is a must for pollution observation. In this framework, CNES is currently leading a **phase-A study** for SIFTI, a Static Infrared Fourier Transform Interferometer devoted essentially to **ozone and carbon monoxide** (CO) measurements in the thermal (TIR) and short-wave infrared (SWIR).



1. Science objectives

Air quality and tropospheric composition on a global and regional scale

- Megacities ➡ air quality and human health: observe atmosphere *close to the surface*
- Diurnal cycle ➡ *day and night* observations (night for "background" level)
- Long-range transport of pollutants ➡ global and frequent observations

Sources and sinks of trace gases

- Emissions (still poor inventories)
  - ➡ distinguish boundary layer (0-3 km) from free troposphere
  - ➡ need for accurate quantification
  - ➡ CO as a tracer for combustion processes and biomass burning
- Oxidising capacity and sinks
  - ➡ oxidising capacities are controlled by ozone
  - ➡ importance of ozone precursors: CO et NO_2

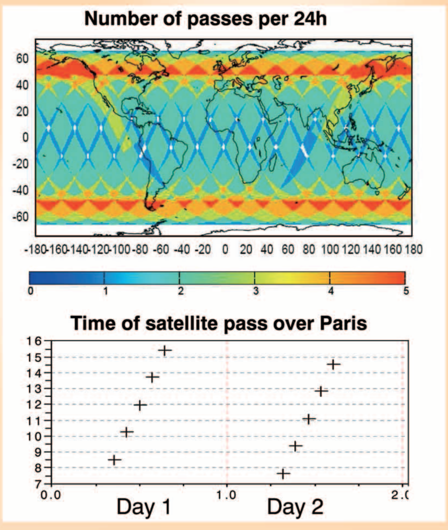
Tropospheric composition and global change

- Greenhouse gases and aerosols
  - ➡ CH_4 and *tropospheric ozone*: 30% of greenhouse effect
- Precursors of ozone and aerosols
  - ➡ *ozone role in climate*
  - ➡ CO and CH_4 oxidation: an important source of CO_2

2. Geometric requirements: when, where ?

High revisit frequency need:

- ➡ Original drifting orbit (720 km, 55°)
- ➡ Field of view ±40° to 50° (20 to 40 views per swath)
- ➡ Revisit: 5 times a day (temporal variability of pollution)
- ➡ Good regional covering (spatial variability of pollution)

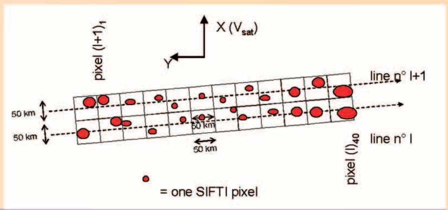


Geolocalisation need: 1 km

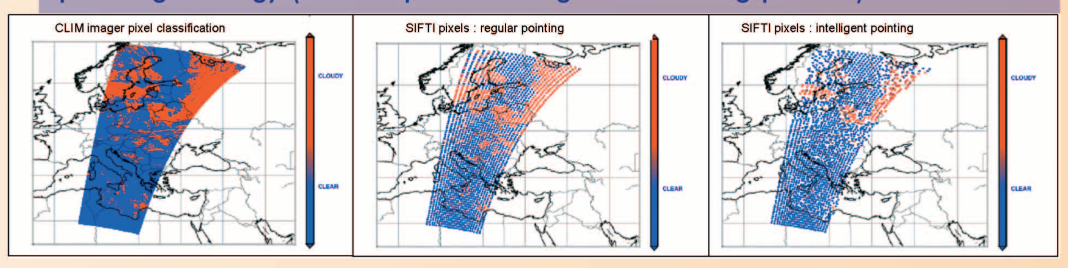
- ➡ Synergy with other measurements (e.g. a polarised spectrometer for aerosols and/or a UV-VIS spectrometer)
- ➡ Assimilation in atmospheric chemistry transport models

How to maximise the number of useful observations ?

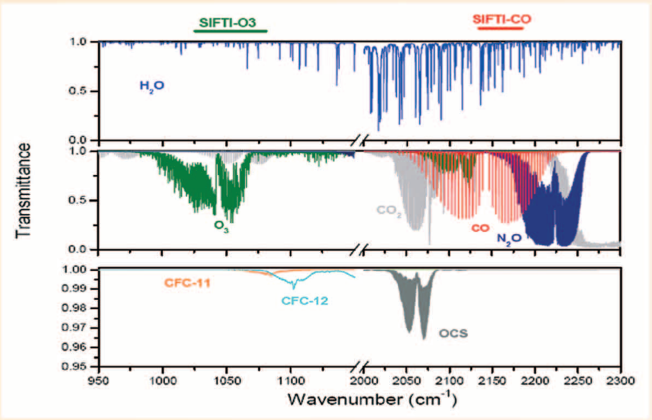
- ➡ Spatial sampling: 50 km * 50 km at nadir
- ➡ Wide swath
- ➡ Pixel < 10 km (small pixel to limit the cloud occurrence)
- ➡ Cloud clearing: calculating the clear radiance for partially cloudy pixels (research in progress)
- ➡ Intelligent pointing



An optional cloud imager, CLIM, with 2 bands in the infrared, will provide cloud cover information within the SIFTI instantaneous field of view. Real time cloud analysis, based on these CLIM measurements, will be used to anticipate the optimal viewing direction for SIFTI with respect to this cloud cover. The potential gain in cloud-free footprints using this intelligent pointing strategy (with respect to a regular scanning pattern) is around 2.



3. Instrument requirements



Band positions:

- CO and Ozone absorption bands
- Reduced contamination by variable gases (H_2O)
- B1: CO: 25 to 30 cm^{-1} in 2140-2180 cm^{-1} (4.6 μm)
- B2: O_3: 25 to 30 cm^{-1} in 1030-1070 cm^{-1} (9.5 μm)

  Option: B3: CO + CH_4: 4270-4300 cm^{-1} (2.3 μm)

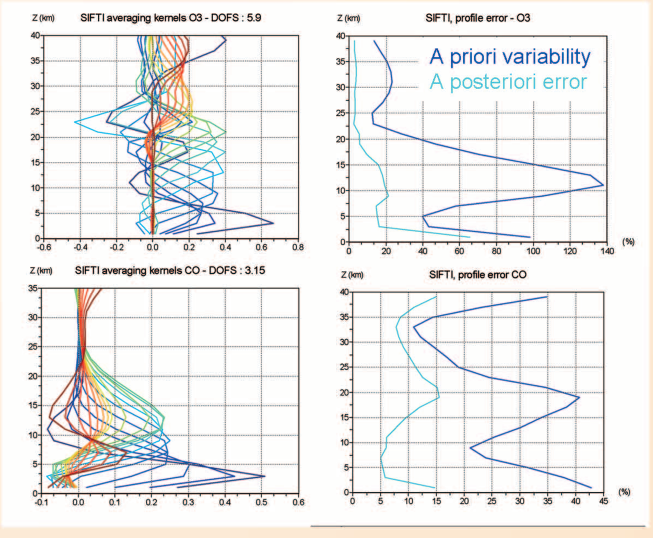
Spectral resolution: 0.125 cm-1 apodised (sampling: 0.0625 cm-1)

- ➡ Compatible with narrow CO lines
- ➡ Observe the line wings to probe the lower troposphere

High signal-to-noise ratio:

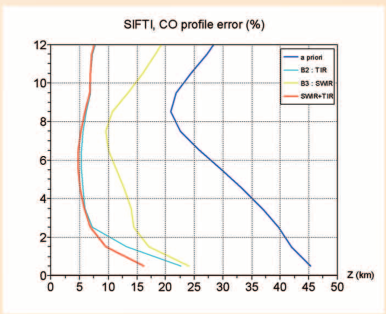
- B1: 0.08 to 0.1 K (NeDT @280 K)
- B2: 0.12 to 0.2 K (NeDT @280 K)

4. Expected product performances



High quality concentration profiles:

- Vertical resolution:
  - Ozone: 5 to 7 vertically independant pieces of information (DOFS)
  - CO: 2.5 to 4 with B2, 1.5 with B3
- Accuracy:
  - Tropospheric column: <10%

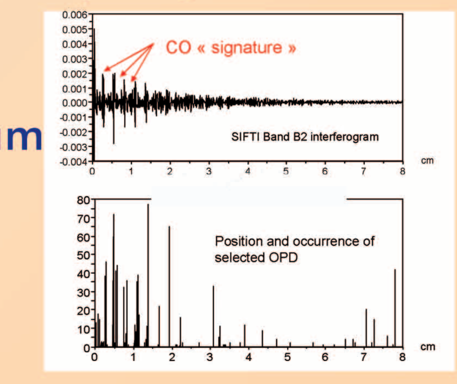


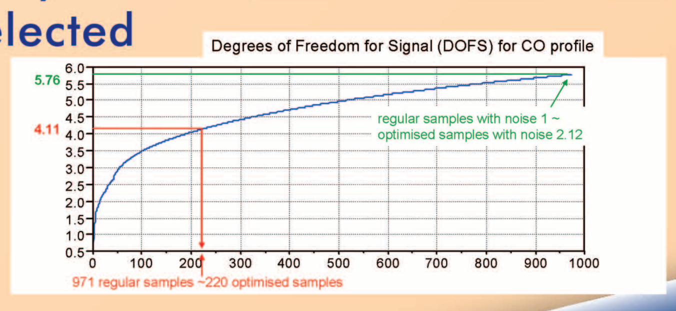
SWIR-TIR synergy:

- CO can be retrieved by combining the Short-Wave infrared and the thermal infrared spectral domains
- SWIR observations constrains the lower troposphere concentration

Interferometric retrieval with optimised sampling?

- CO periodic line comb produces a periodic fringe pattern in the interferogram => idea: acquiring and using only interesting OPD samples
- Optimal selection of samples for SIFTI B2, based on information content: only 87 different OPD samples are selected
- Direct retrieval of gas profiles from the interferogram
- Huge increase of performance ! (or more simple instrument)

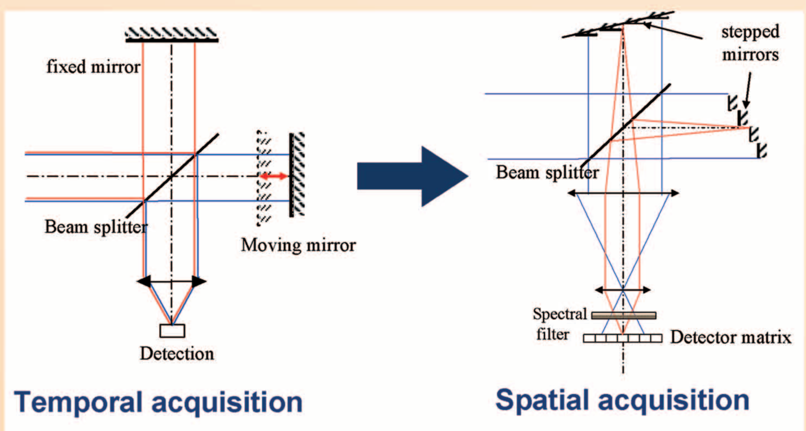




5. Static interferometry concept

Principle and advantages:

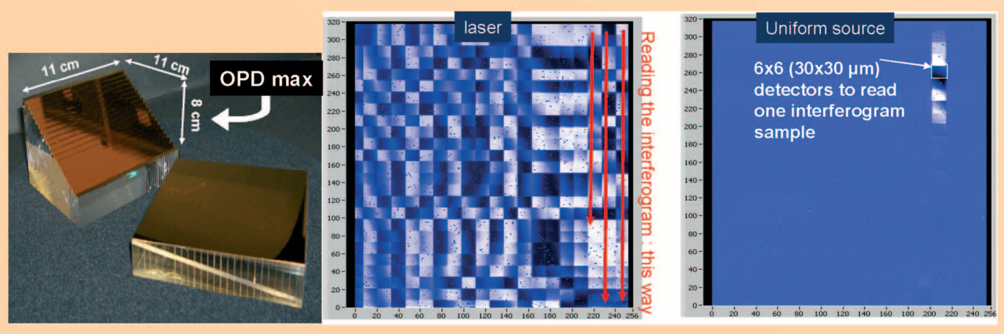
- Static sampling with facet scale mirrors: no mechanism, no dynamic perturbation => reliability
- High spectral resolution and sampling (1000 sampling per band)
- But: no interferogram over-sampling => narrow spectral band

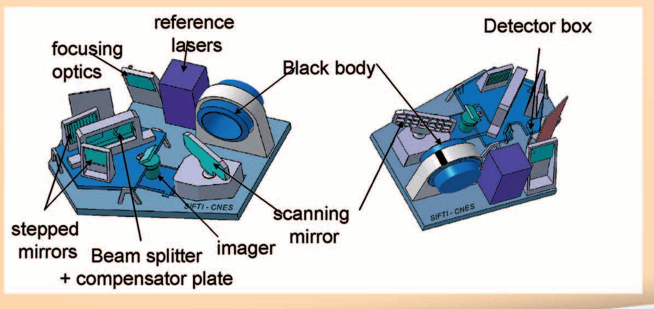


Difficulties:

- Need for a very good knowledge of Optical Path Differences (OPD): a few nm => on-board monitoring (laser or algorithm)
- Accurate radiometric inter-calibration of the matrix detectors

Facets are obtained by crossing the steps of two mirrors. In the manufacturing of the mirrors, the technology of molecular adherence allows as many facets as about one thousand in a 100 mm × 100 mm surface. The interferometric fringes are built on these facets, and are read by imaging them onto a 2D detector array.





(1) CNES, 18 Avenue Edouard Belin 31401 Toulouse Cedex 9, France - (2) LPMAA, 3 rue Galilée. 94200 Ivry sur Seine, France
(3) Université Pierre et Marie Curie, 4 place Jussieu, 75252 Paris Cedex 05, FRANCE – (4) ULB CP160/09, avenue F.D. Roosevelt 50, 1050 Bruxelles
(5) CMS Météo-France, avenue Lorraine, 22302 Lannion, FRANCE

To learn more about SIFTI: **http://sifti-mission.cnes.fr**
Author contact: clemence.pierangelo@cnes.fr

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