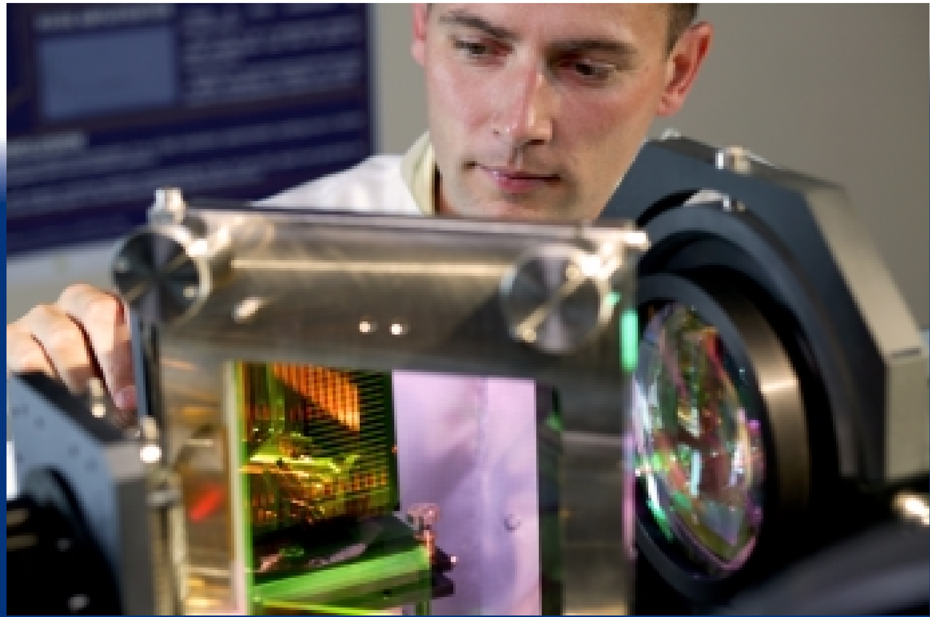
SIFTI : A new generation FTIR Spectrometer for the Tropospheric composition and Air Quality Mission (TRAQ)



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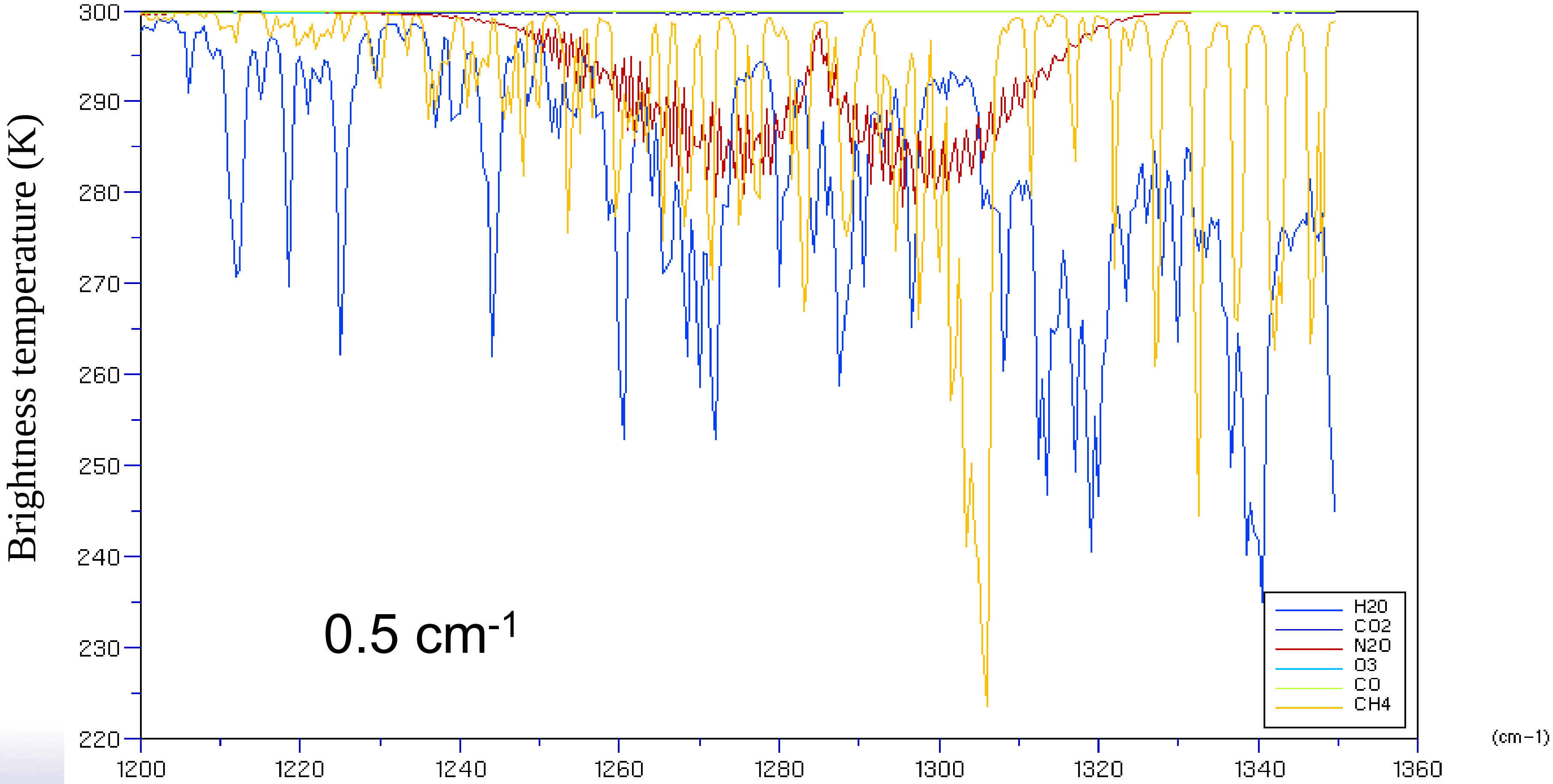
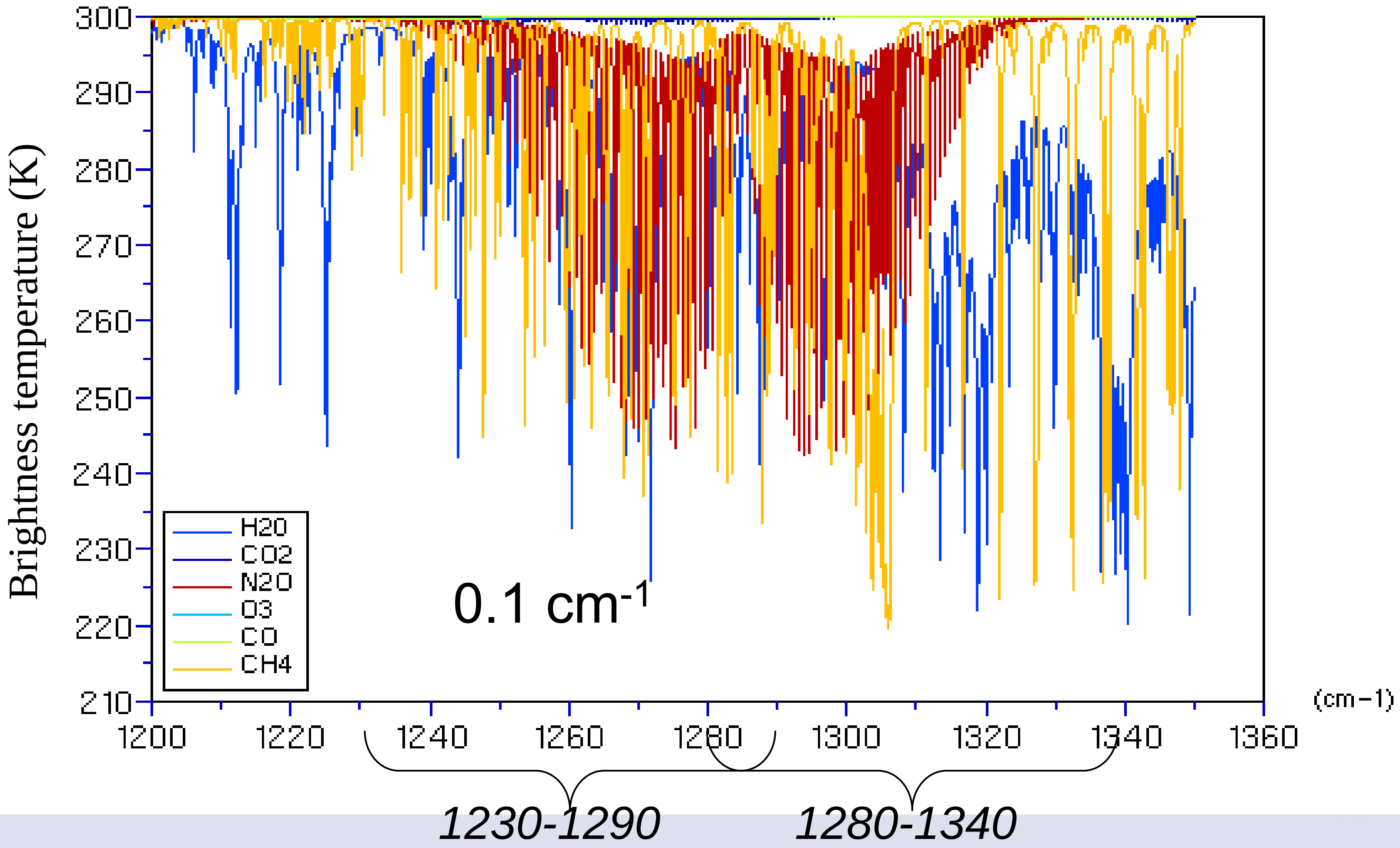
Temperature sounding in N_2O band (1)

1200 - 1350 cm-1



Temperature sounding in N_2O band (2)

1200 - 1350 cm-1



Temperature sounding in N_2O band (3)

	1230-1290	1280-1340	2160-2220	2220-2280	CO_2 longwave	CO_2 shortwave
DOFS	7.8	8.9	5.0	5.4	6.1	5.8

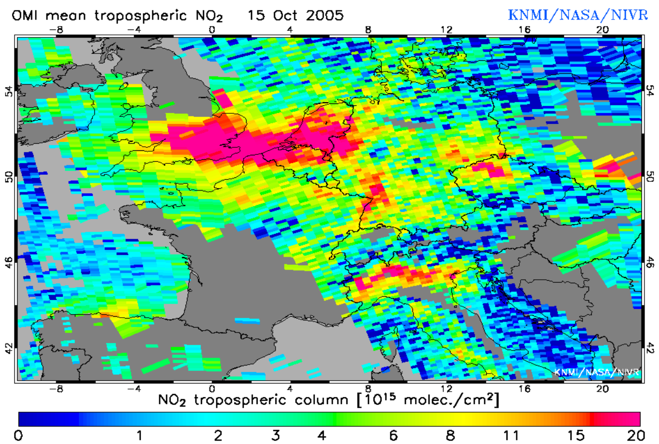
- **Better performances in N_2O band around 1300 cm-1 than in CO_2 at a resolution of 0.1 cm^{-1}**
- **However, performances for the CO_2 band are kept roughly constant requires a resolution of 0.1 cm^{-1}**

TRAQ Science Objectives

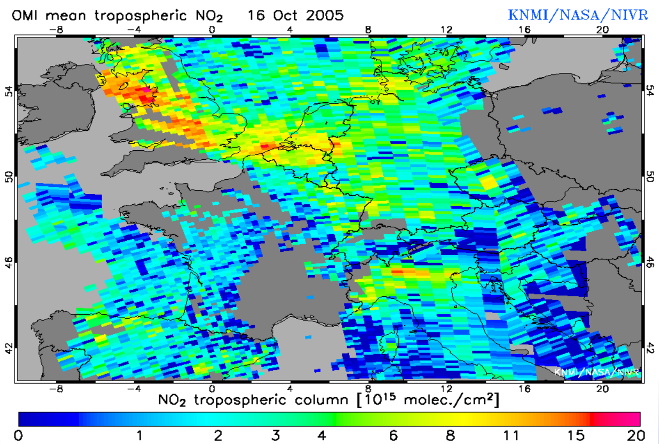
How fast is air quality changing on a global and regional scale?

What is the strength and distribution of the sources and sinks of trace gases and aerosols influencing air quality?

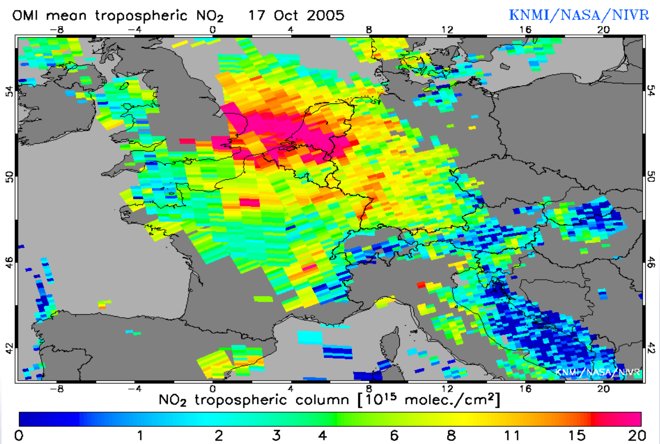
What is the role of tropospheric composition in global change?



Saturday 15 October 2005



Sunday 16 October 2005



Monday 17 October 2005

Mission Requirements

- Primary pollutants : NO_2, SO_2, H_2CO
- Ozone profile and specially good in the lowest tropo
- CO profile with good accuracy in the lowest tropo
- Aerosols and more specially PM2.5

Others : CH4, H2O, Temperature etc.

•At the highest spatial resolution (clouds) typically 10km

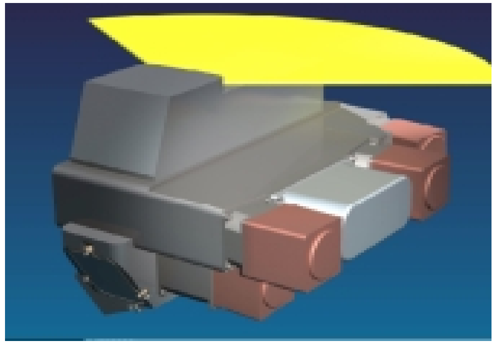
•As frequent as possible : every 2 hour

SIFTI associated with other instruments:

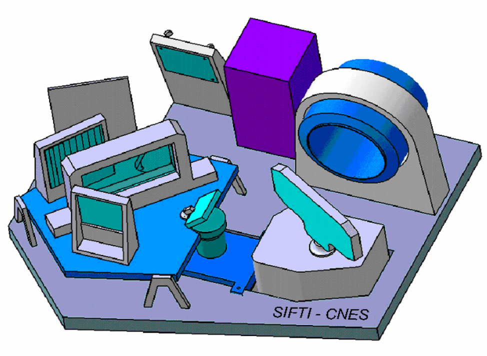
Species	spectral domain	Instrument
Aerosols	UV-VIS-SWIR	OCAPI
NO_2	UV-VIS	TROPOMI
H_2CO	UV-VIS	
SO_2	UV-VIS	
O_3	TIR	SIFTI
CO	SWIR+TIR	

Species	Product	Degrees of freedom	Absolute uncertainty
O_3	strato profile [12 – 50 km]	4	1 - 4 %
	tropo profile [0 – 12 km]	2.3	10 – 30 %
CO	tropo profile [0 – 12 km]	2.5	6 – 12 %
CH_4	tropo profile [0 – 12 km]	TBD	TBD

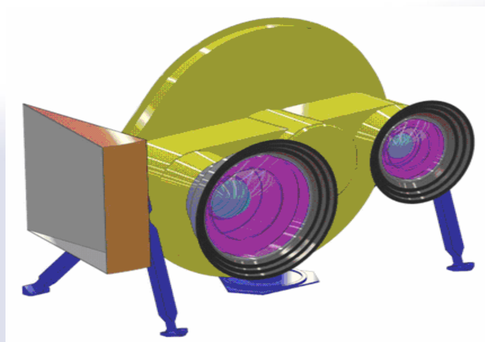
TRAQ Payload



TROPOMI: Backscatter instrument (trop) columns of O_3, NO_2, SO_2, HCHO, aerosols & CO and CH_4.
Heritage: Aura-OMI, Envisat-Sciamachy



SIFTI (FTIR): O_3, CO, CH_4: trop columns and profiles with intelligent pointing for cloud free pixels.
Heritage: IASI

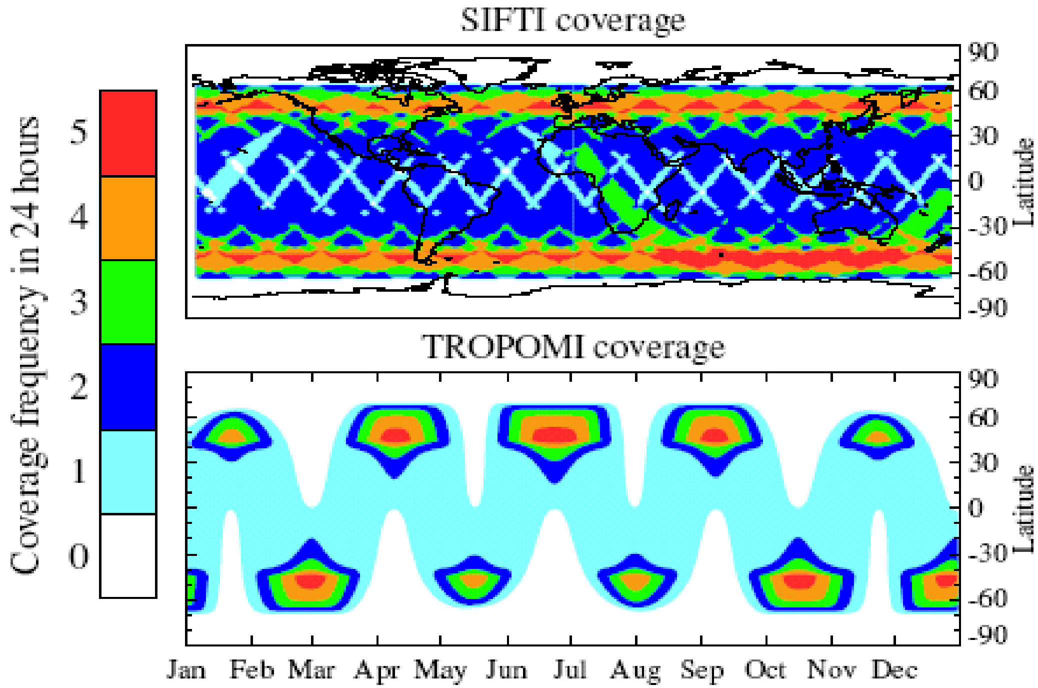


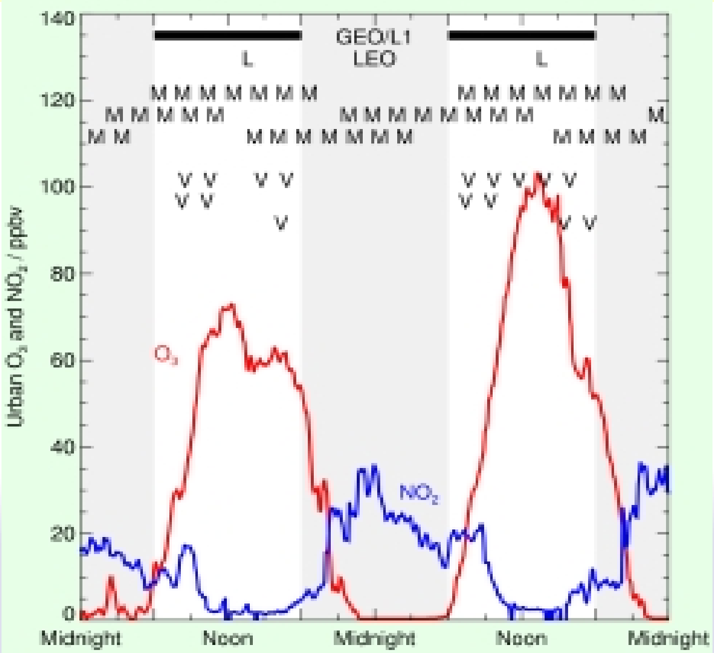
OCAPI: POLDER type of instrument:
AOD, single scattering albedo (Ω_0), Air quality index (AQI), aerosol sizes and aerosol type.
Heritage: POLDER, PARASOL

Orbit

Non-sun synchronous LEO orbit:
720 km, 57°

- Measures air pollution at mid-latitude up to 5 times a day with 90 minutes interval
- Retains most of global coverage, except for poles





Range:

- Swath: 2000 – 2600 km
- Pixel sizes: 5 km × 5 km to 10 km × 10 km

LEO versus GEO

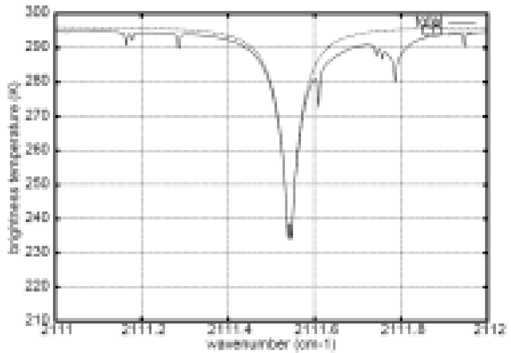
GEO does not provide global coverage and such detailed characteristics of aerosol

SIFTI : Instrument specification rationale

forward model (4AOP)

Retrieval performances:

concentration accuracy
vertical resolution
...



CO absorption line simulation

Instrument performances:

spectral resolution
noise
...

retrieval algorithm (optimal estimation theory)

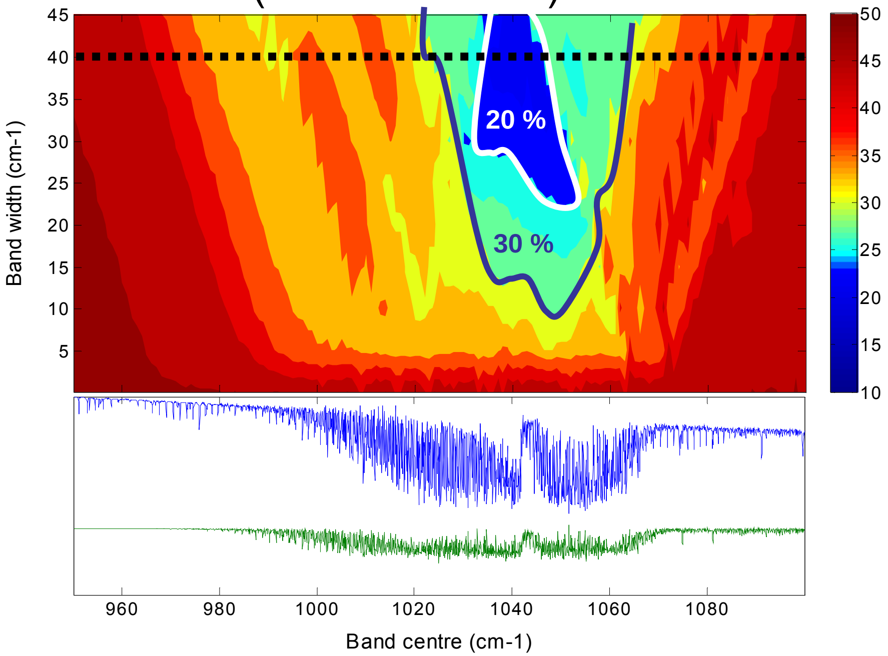
→ best compromise for spectral band selection, spectral resolution specification

→ impact of instrumental noise, compared to contribution of uncertainty on model parameters (SST, humidity, ...)

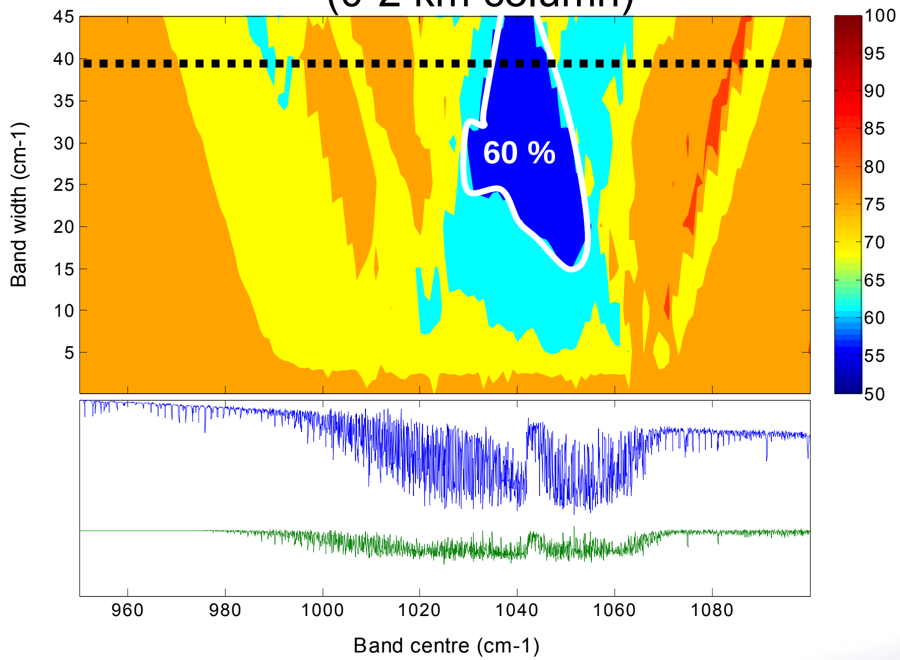
Ozone retrievals from Sifti / TRAQ

Optimizing spectral window for tropospheric sounding considering a 40 cm^{-1} wide interval

Lower troposphere
(0-6 km column)



Boundary layer
(0-2 km column)



Band centre between 1040 and 1055 cm^{-1} provides optimal results in terms of both vertical sensitivity (DOFS of 5) and errors (8 % on tropospheric column).

- **20 % for the lower troposphere**
- **60 % for the boundary layer**

cnes

SIFTI instrument specifications

- Objective performances:

Species	spectral band (cm^{-1})	Non apodized spectal resolution (cm^{-1})	NEDT / non apodized channel	
O_3 profile	[1030 – 1070] (9.71 µm – 9.35 µm)	0.0625 (R = 8500)	65 mK	
CO profile	[2140 – 2180] (4.67 µm – 4.59 µm)	0.0625 (R = 17000)	73 mK	
CO column	*[4270 – 4300]* *(2.34 µm - 2.32 µm)*	*0.1* *(R = 20000)*	*SNR = 100*	*Improves CO profiles retrieval*

➔ **very high SNR required in interferograms**

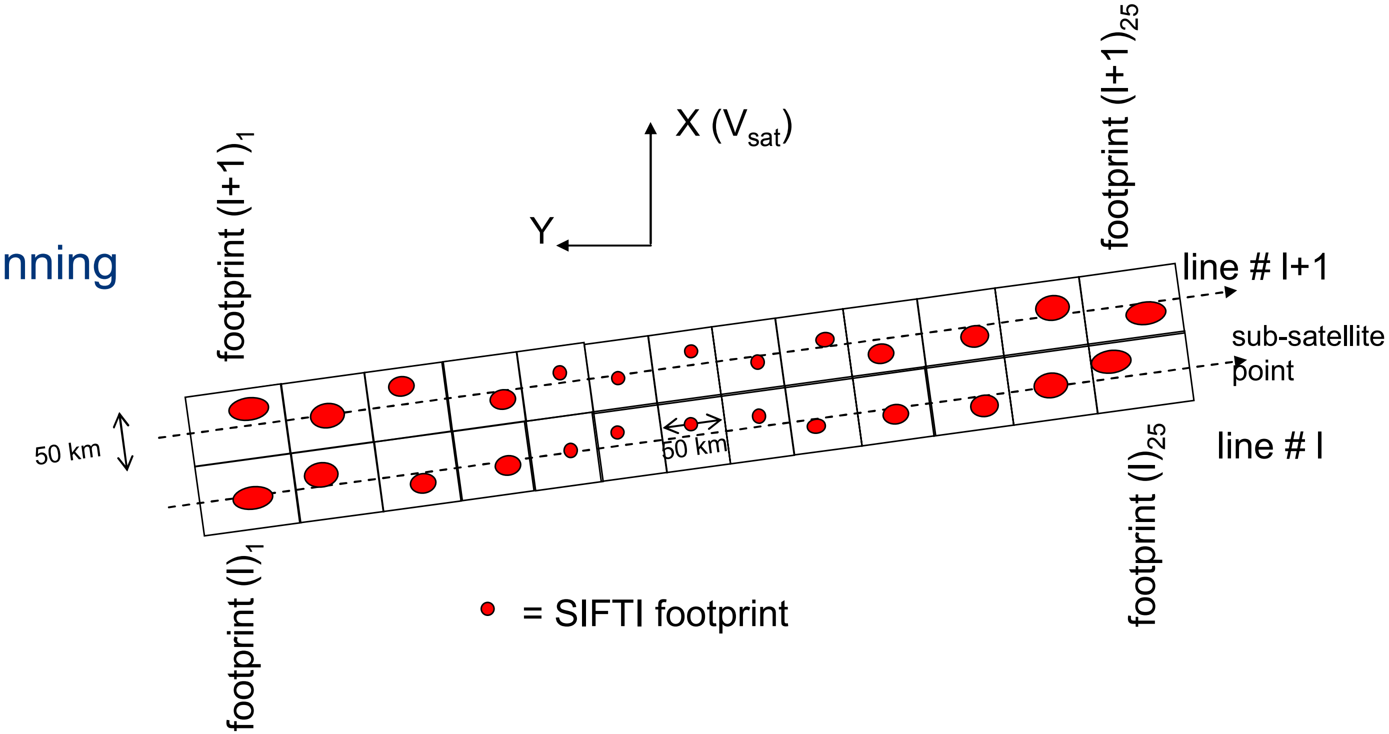
- Geometric requirements:
  resolution = 10 km, sampling = 50 x 50 km² at nadir
  > 25 footprints along the ± 50° swath

- System requirements: 2 hour revisit time
  5 fly by over Europe / 24h, by daytime 25 % of the year
  3 year lifetime

Instrument requirements

- Altitude = 720 km

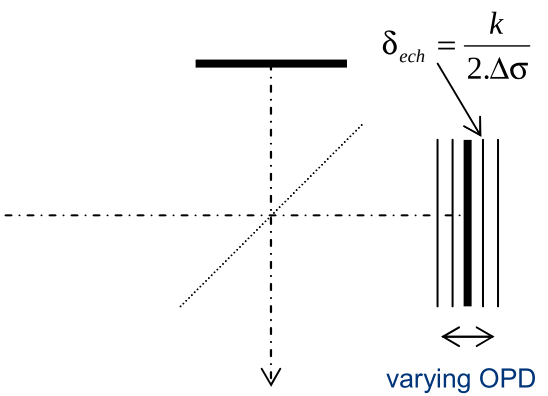
- 2 options:
  - agile earth scanning

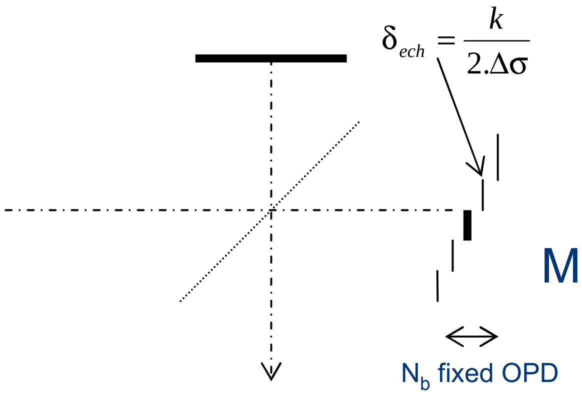


➔ cloud hole hunting either to view in cloud free areas or target cloudy homogeneous areas ➔ better mission efficiency

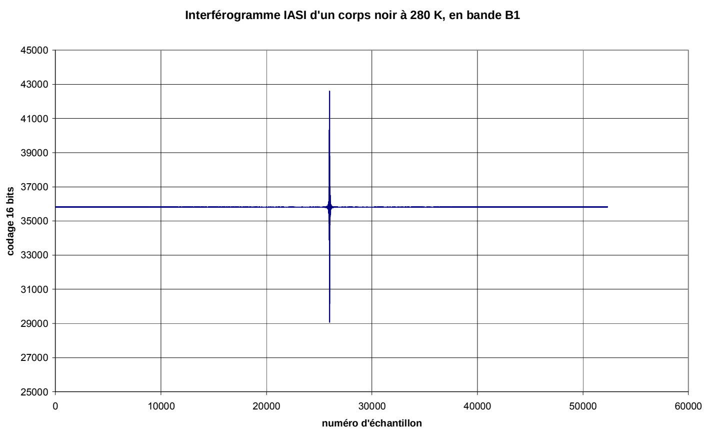
- SWIR spectral band : SIFTI / TROPOMI trade-off

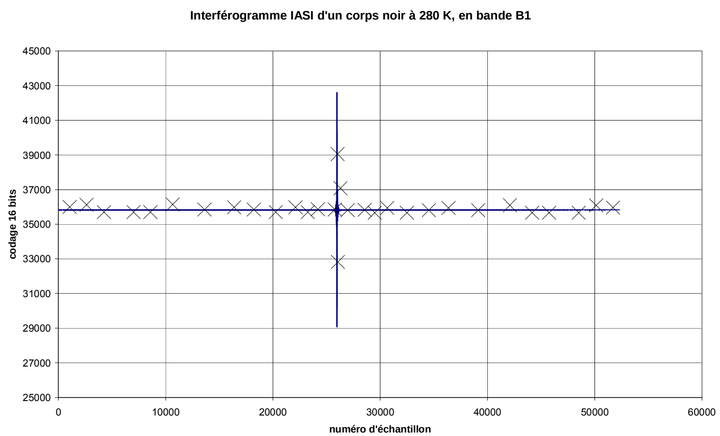
Principle of the "**S**tatic **I**nfrared **F**ourier **T**ransform **I**nterferometer"





$MOPD=1/d\sigma_{apod}$



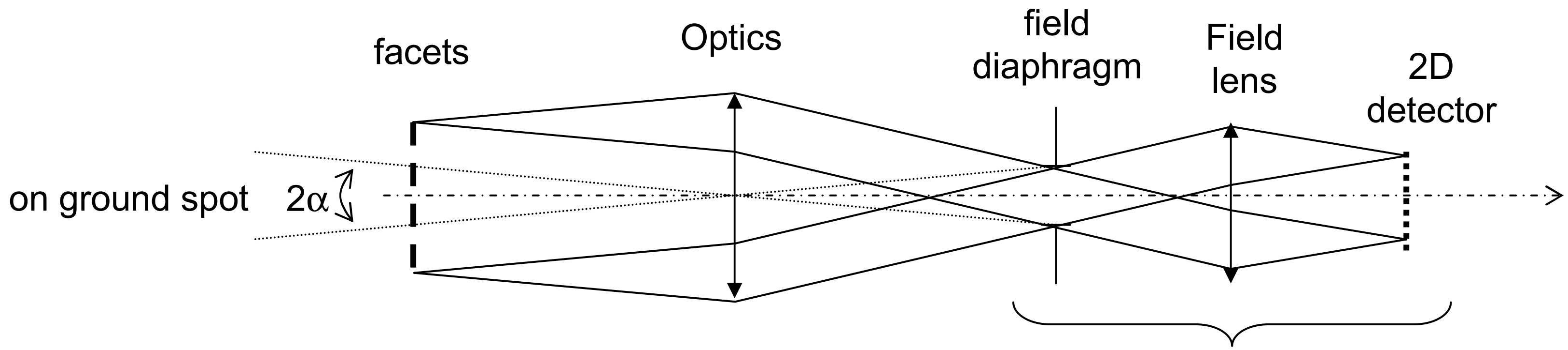


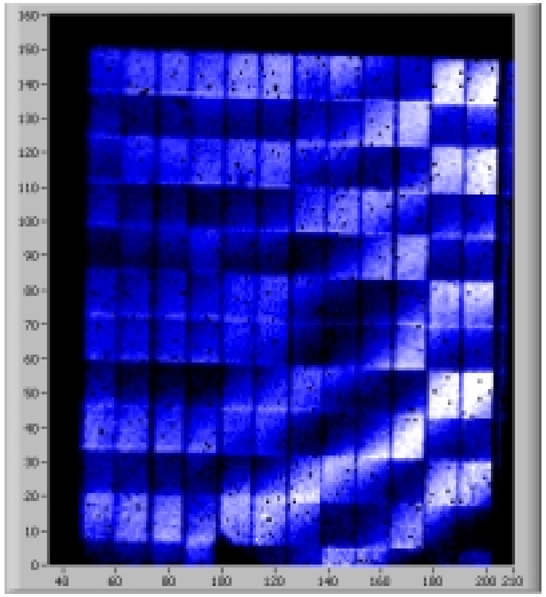
Under sampled interferogram
→ limited number of channels / narrow spectral band(s)

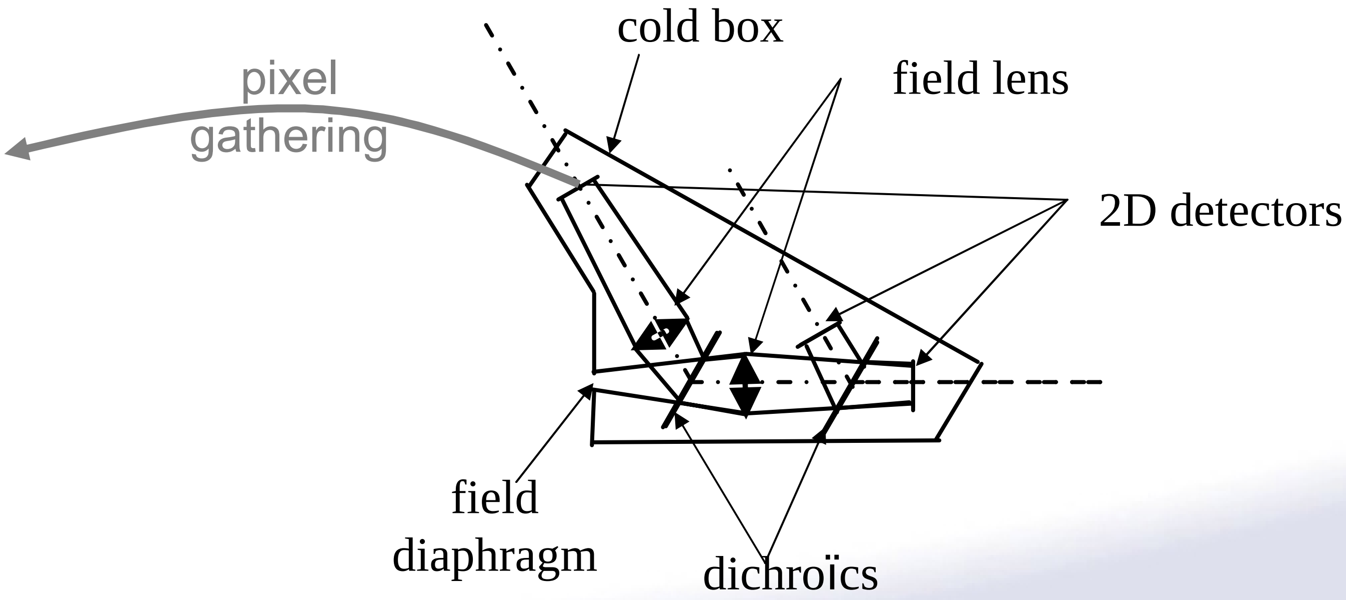
No translation mechanism

Knowledge of the position of each sample (OPDs)

Reading interferograms

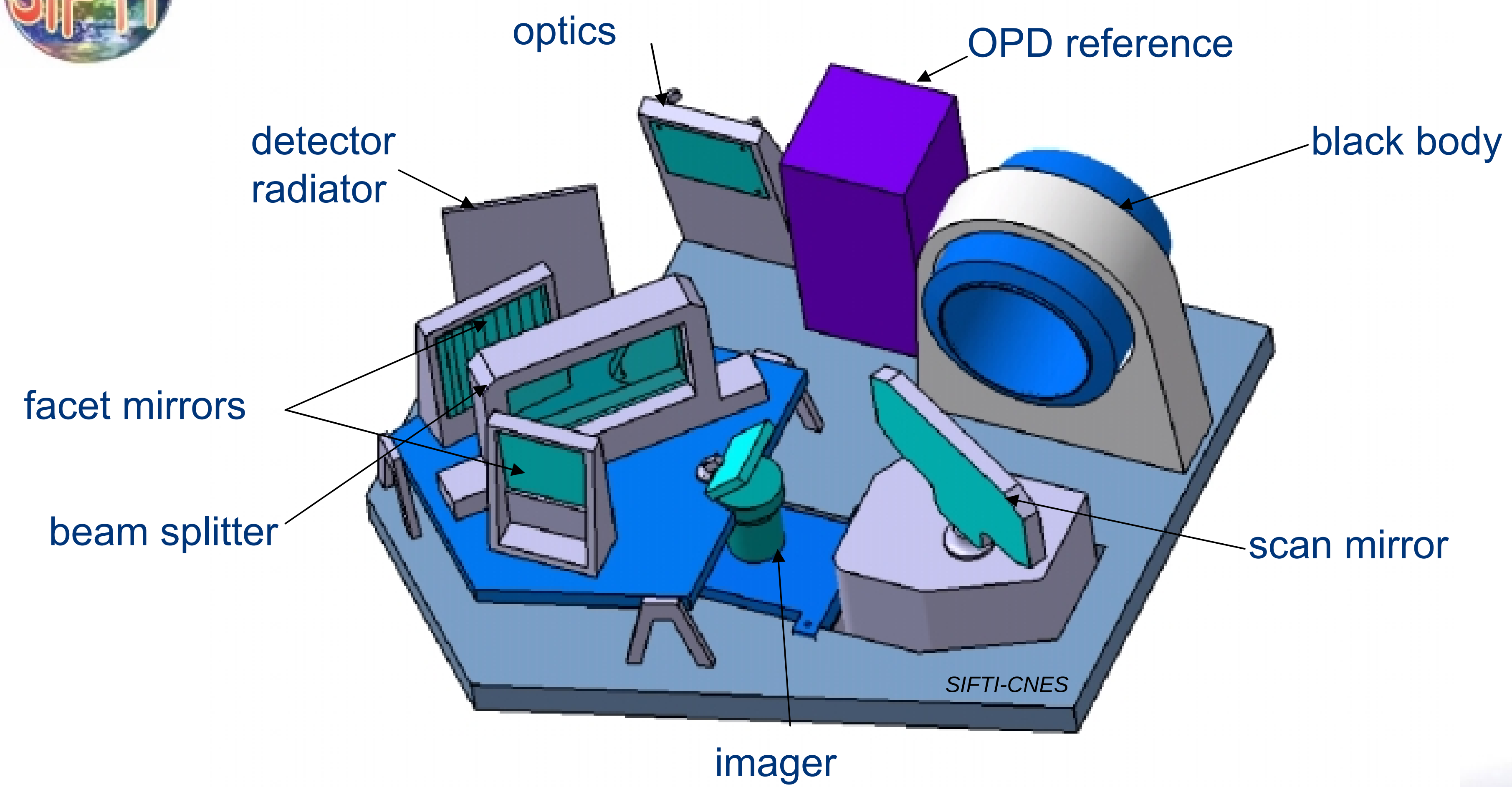






Effects of diffraction and optical quality
Narrow band optical filter

SIFTI preliminary layout



Phase 0 preliminary budget:

1 m × 0.6 m × 0.3 m
≈ 70 kg
100 – 150 W
24 Mbit/s

Radiometric budget: preliminary results

SNR at interferogram level	B1	B2
Goal requirement	11000	5300
Threshold requirement	5300	2700
Budget without phase modulation	8500	2200
Budget with phase modulation	11000	3000
Most important noise items	OPD knowledge + diffraction	Photon

Assumptions :

- Total integration time = 157 ms
- Aperture: 112 mm × 112 mm
- T instrument = 273 ± 0.1 K ; T cold box = 110 K ± 0.01 K
- T detector = 65 K (B1) and 90 K (B2) ± 1 mK
- Detector material = MCT
- Quantization: 14 bits (B1) and 11 bits (B2)
- Facet reading: 4 × 4 pixels surrounded by margin of 1+1 in B1, of 1 in B2
- Detection electronics noise: state of the art ++
- Knowledge on OPDs: better than ± 2 nm for the first ones
- Efficiency of deconvolution algorithm against diffraction better than 95 %

Conclusions

- An innovative technology
- The fruit of long term R&T activities
- Unpreceded instrumental performances
- New class atmospheric products
- A promising instrument that deserves further feasibility studies
- A CNES managed phase A, starting end 2006
- An InfraRed Performance Breadboard to be developed at CNES
- Possibly a pathfinder for future GMES air quality monitoring systems
- Paving the way to another concept of atmospheric sounder for new generation sounders based upon high spectral resolution in essential sub bands