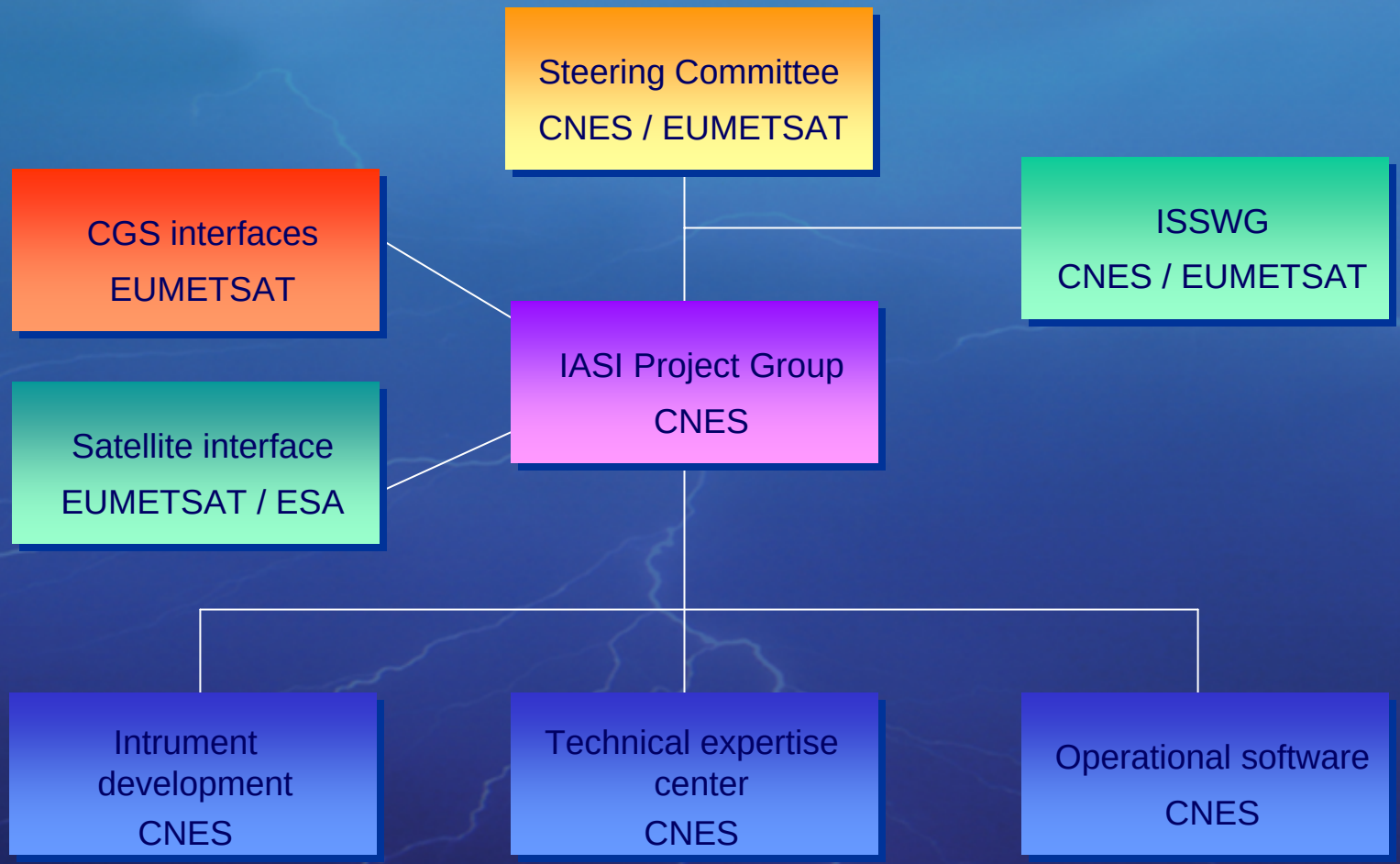
# Infrared Atmosphéric Sounding Interferometer

IASI

cnes

CENTRE NATIONAL D'ETUDES SPATIALES

# Partners


Steering Committee
CNES / EUMETSAT
ISSWG
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CGS interfaces
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Technical expertise center
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Operational software
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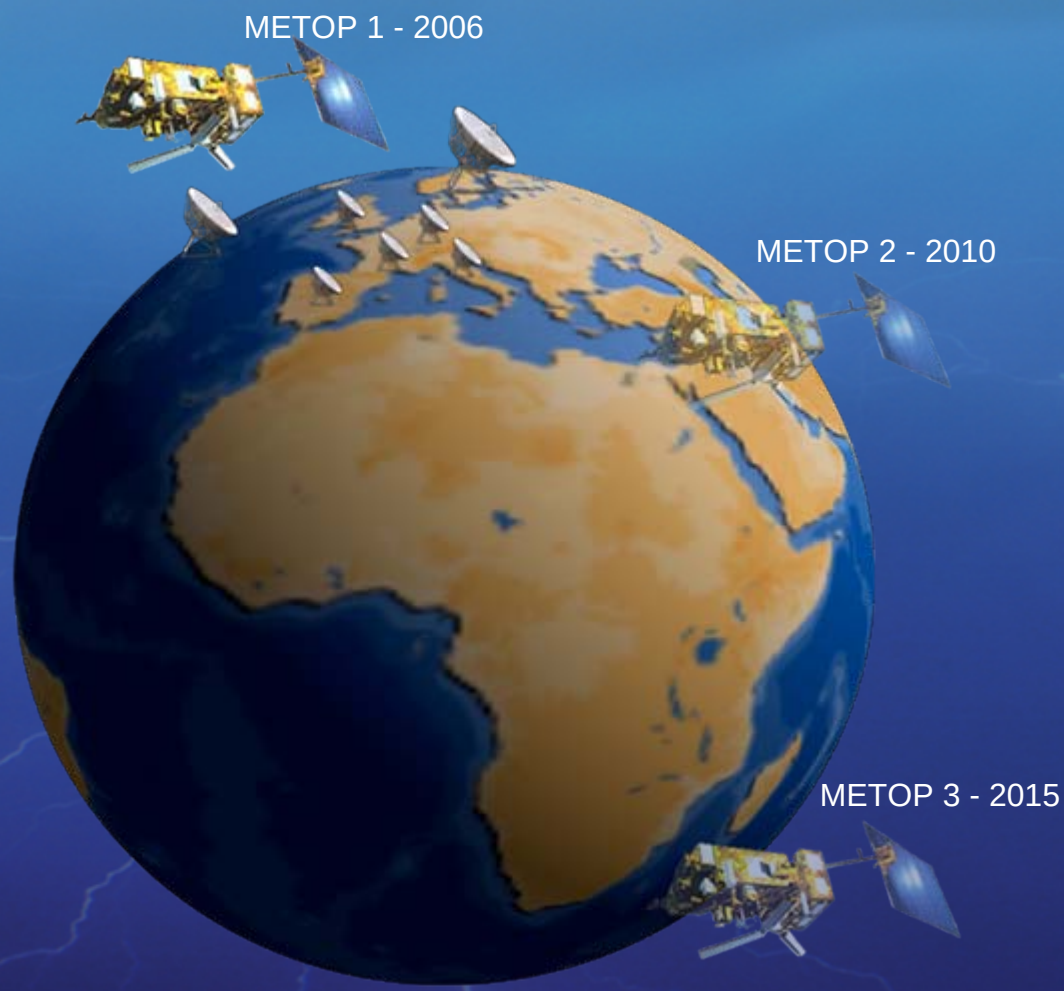
# Requirements

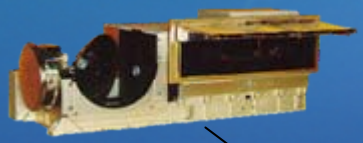
| GEOPHYSICAL VARIABLES | ACCURACY | VERTICAL RESOLUTION | HORIZONTAL SAMPLING |
|---|---|---|---|
| Temperature profile | 1K (cloudfree) | 1 km | 25 km (cloudfree) |
| Humidity profile | 10%(cloudfree) | 1-2 km troposphere (cloudfree) | 25 km (cloudfree) |
| Ozone total amount | 5%(cloudfree) | N/A | 25 km (cloudfree) |
| Ozone vertical distribution | 10%(cloudfree) | 2 or 3 pieces of independant information | 25 km |
| Fractional cloud cover | 10% | | |
| Cloud top temperature<br>Cloud emissivity | 2K | | |
| CO, $CH_4$, $N_2O$ column | 10% | N/A | 100 km |
| $SO_2$, CFCs | 10%-20% | | |
| Sea surface temperature | <0.5K (cloudfree) | | 25 km |
| Land surface temperature | 1K (cloudfree) | | 25 km |
| Land surface emissivity | 1% | | 25 km |

# METOP

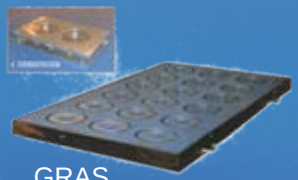
- Eumetsat Polar System Elements
- 14 years of operation
- >95% reliability on 5 years



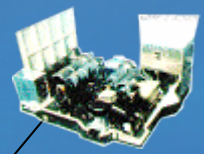
# Spacecraft and Instruments



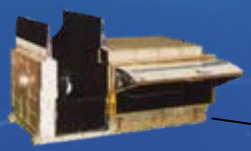
AVHRR-3



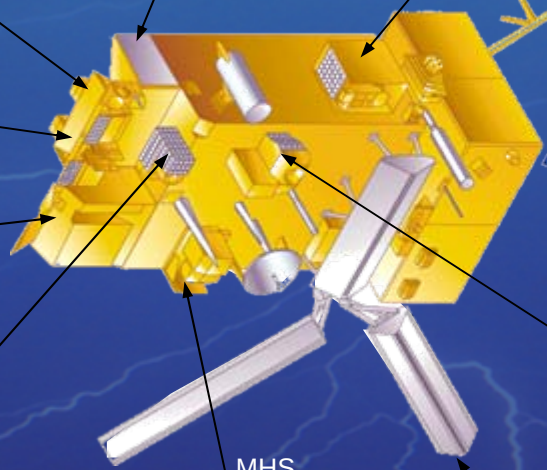
GRAS

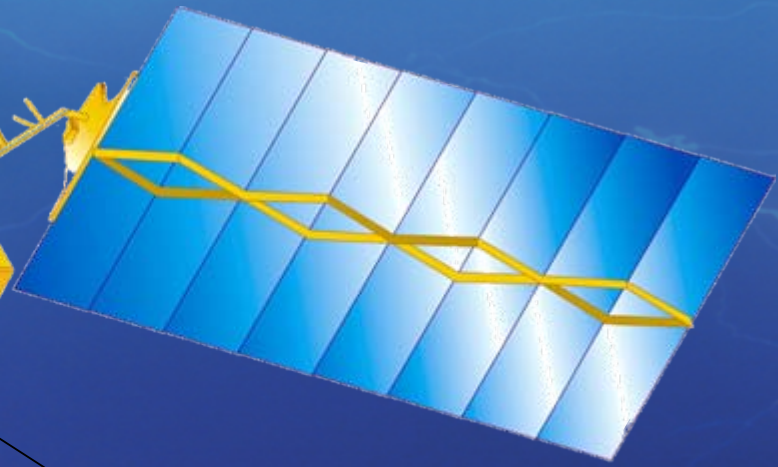


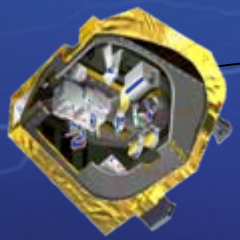
GOME-2



HIRS-4
METOP 1/2 only







IASI

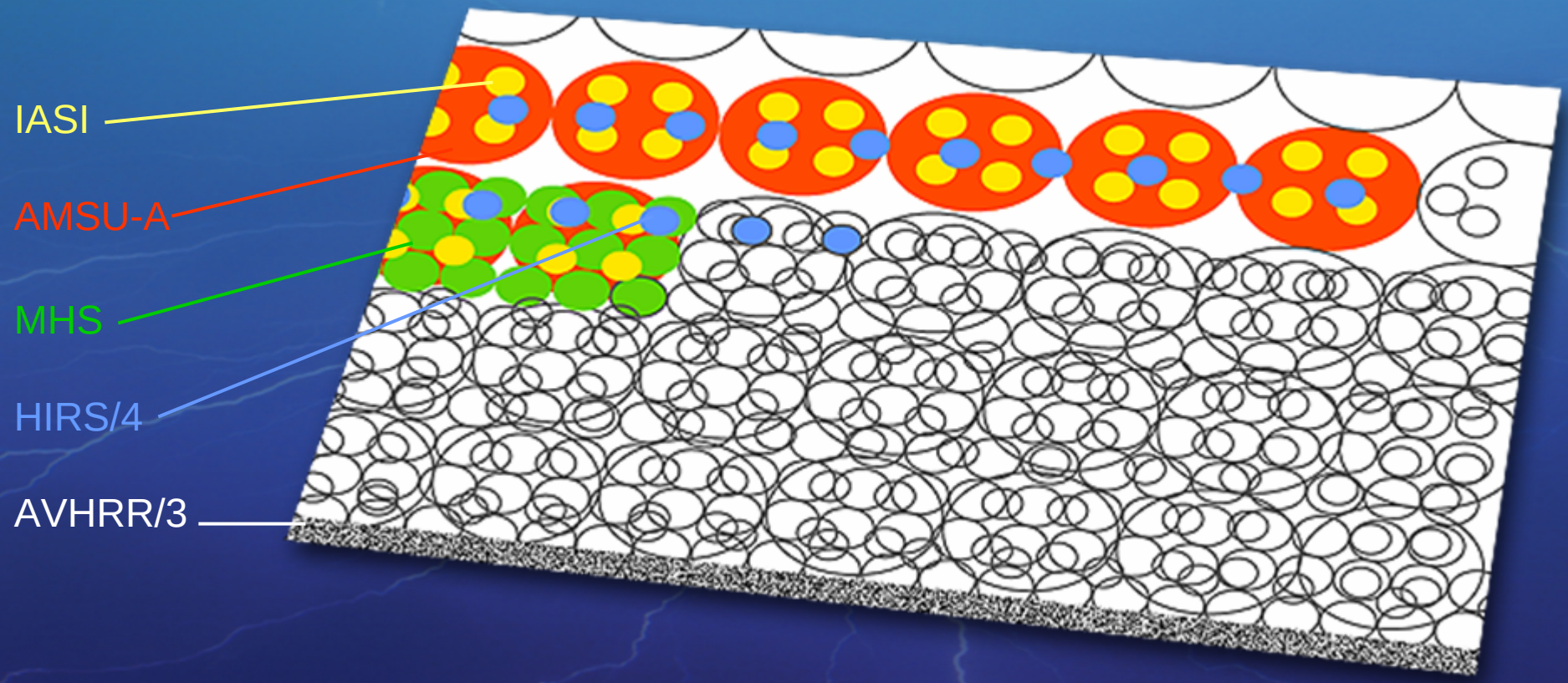
AMSU-A1

MHS

ASCAT

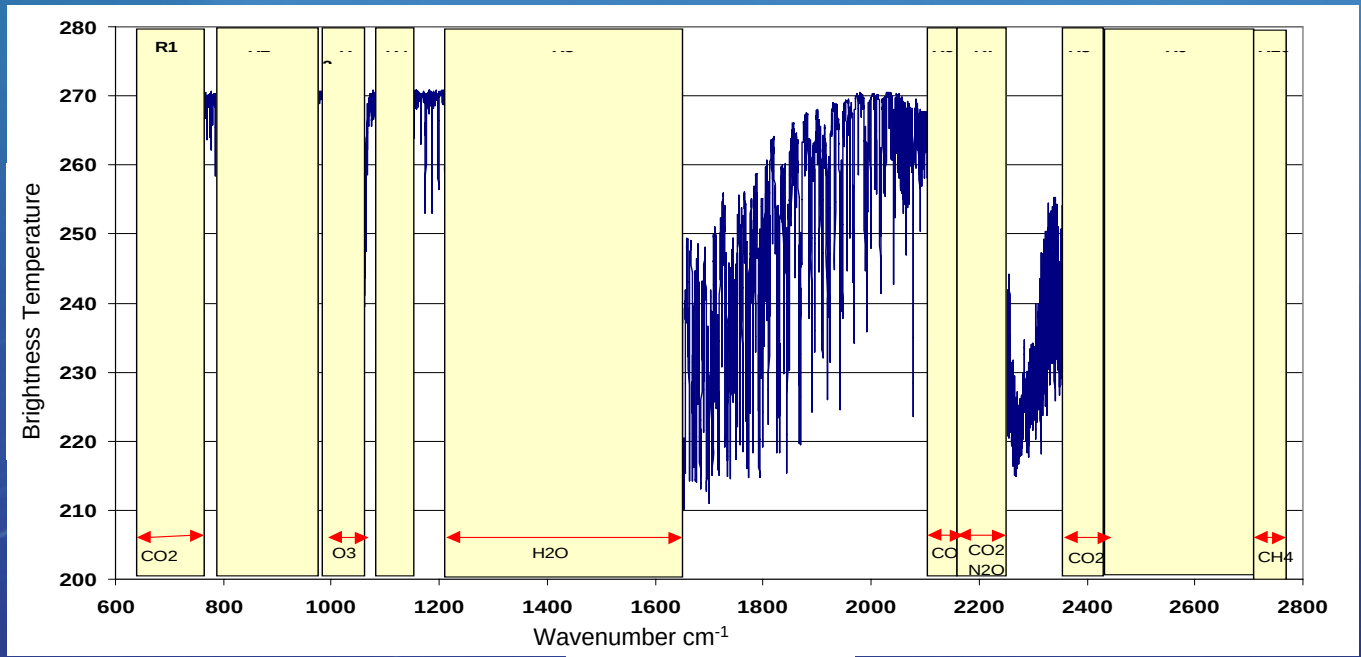
AMSU-A2

# Instrument Scan Patterns



# Spectral Range

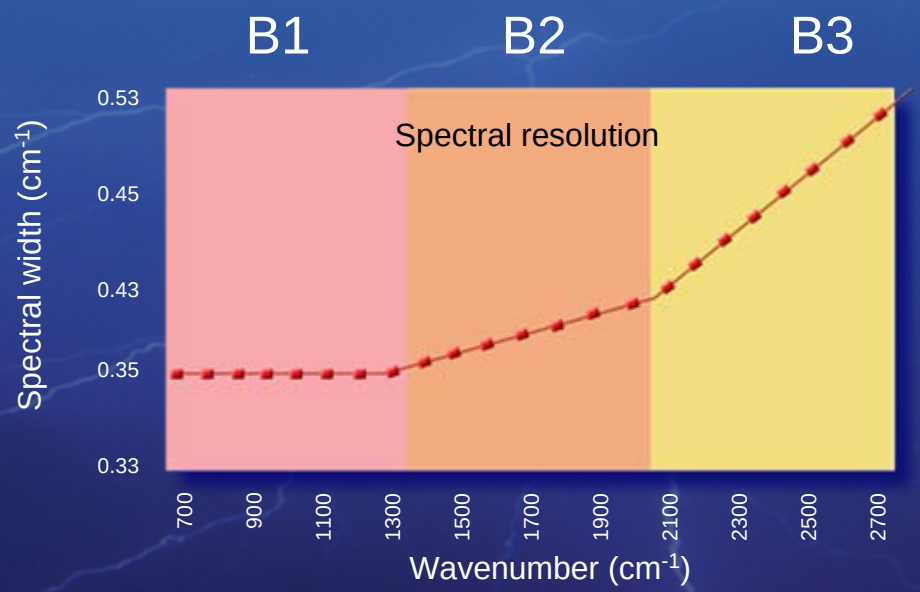
These products can be derived from high spectral resolution infrared sounder



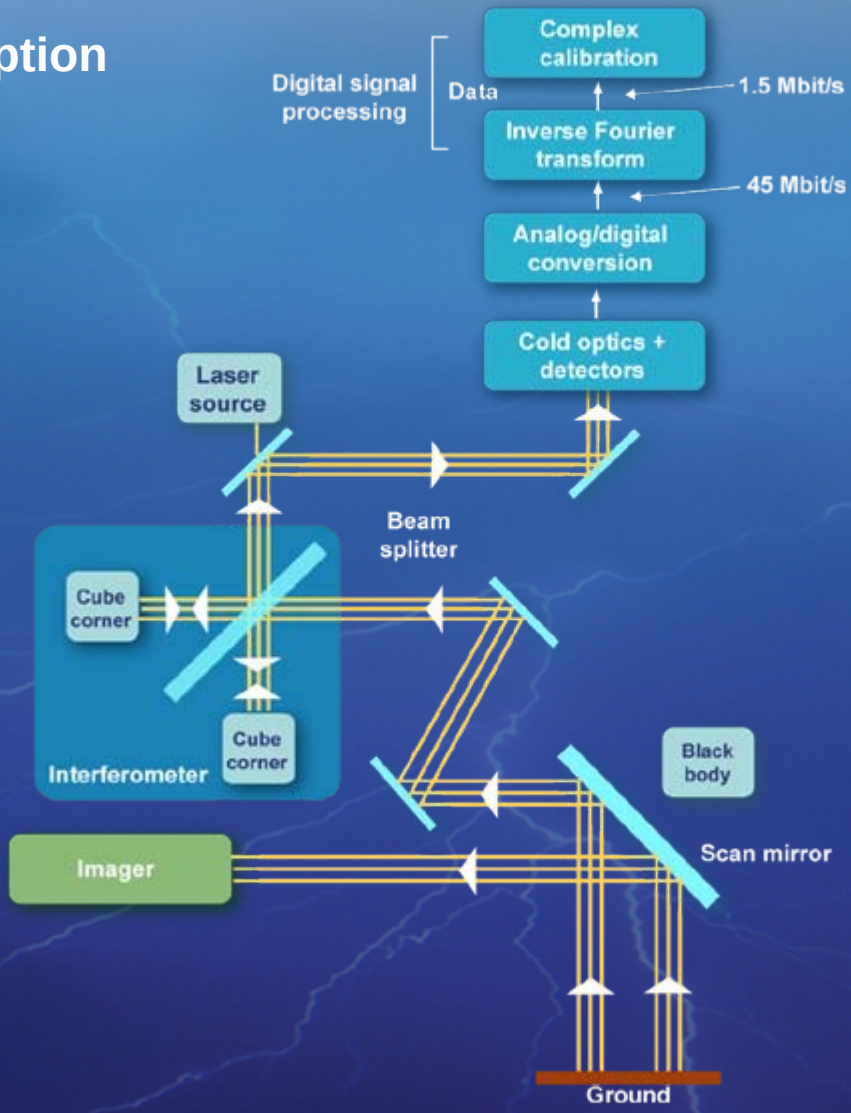

| Name | Spectral region | Absorption band | IASI application |
|---|---|---|---|
| R1 | 650 to 770 cm-1 | $CO_2$ | Temperature profile |
| R2 | 790 to 980 cm-1 | Atmospheric window | Surface and cloud properties |
| R3 | 1000 to 1070 cm-1 | $O_3$ | $O_3$ sounding |
| R4 | 1080 to 1150 cm-1 | Atmosphere window | Surface and cloud properties |
| R5 | 1210 to 1650 cm-1 | $H_2O$ | Humidity profile $CH_4$ and $N_2O$ column amount |
| R6 | 2100 to 2150 cm-1 | CO | CO column amount |
| R7 | 2150 to 2250 cm-1 | $N_2O$ and $CO_2$ | Temperature profile |
| R8 | 2350 to 2420 cm-1 | $CO_2$ | Temperature profile |
| R9 | 2420 to 2700 cm-1 | Atmosphere window | Surface and cloud properties |
| R10 | 2700 to 2760 cm-1 | $CH_4$ | $CH_4$ column amount |

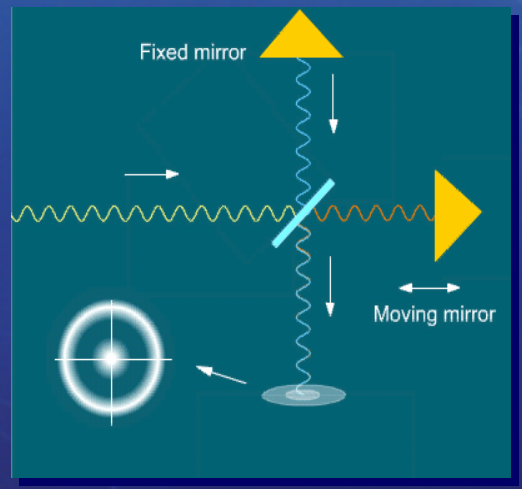
# Spectral : resolution (1/2)

- Spectral resolution (FWHM)
  - **The spectral resolution specification is based on the line spacing in the 650 $cm^{-1}$ $CO_2$ absorption band**
  - **This spacing is about 1.5 $cm^{-1}$**
- Spectral sampling interval = 0.25 $cm^{-1}$

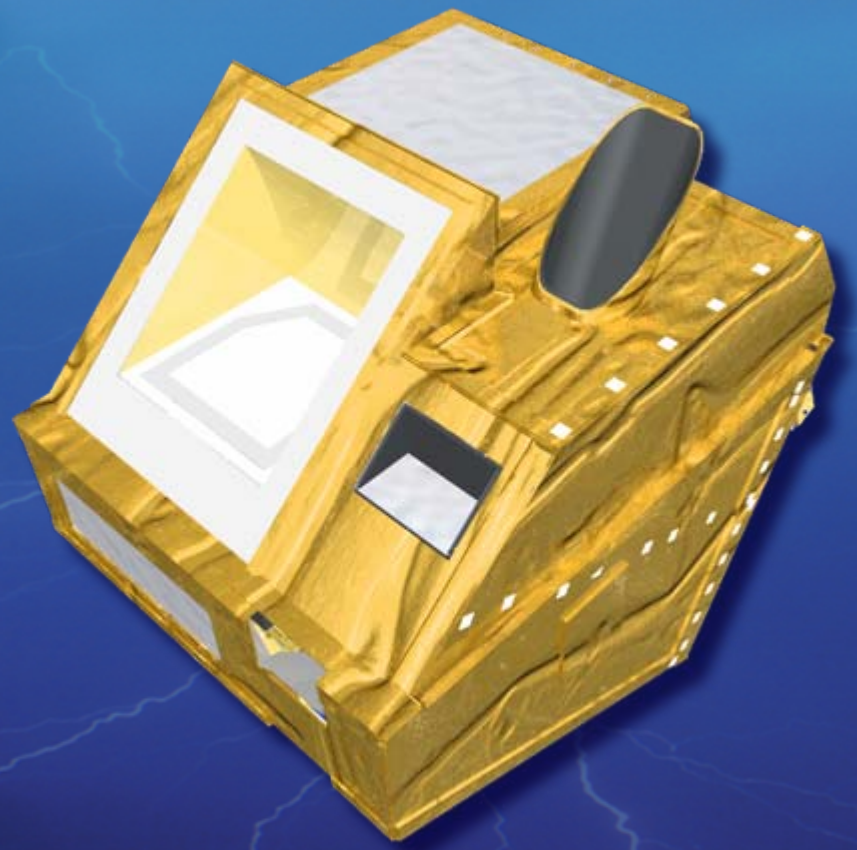


# Functional description



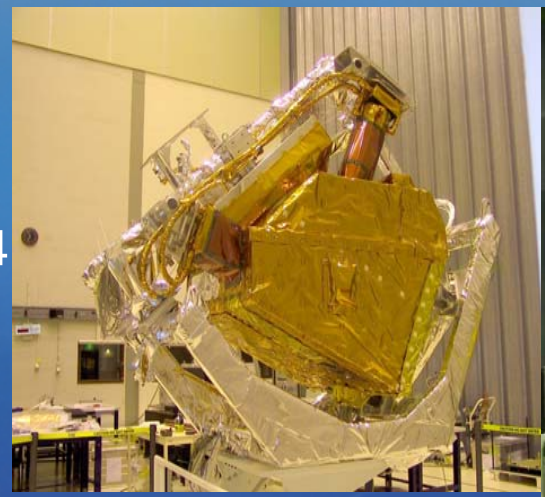
# Configuration



## Performances Tests

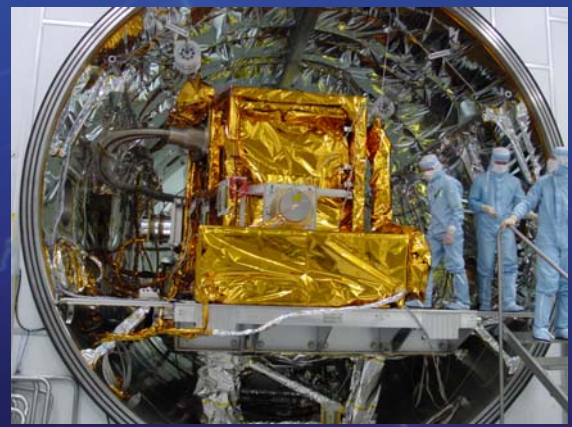
PFM Optical vacuum test : Oct 2003

PFM test on-board Metop: Feb 2004



Courtesy EADS

FM2 optical vacuum test : Sept. 2004

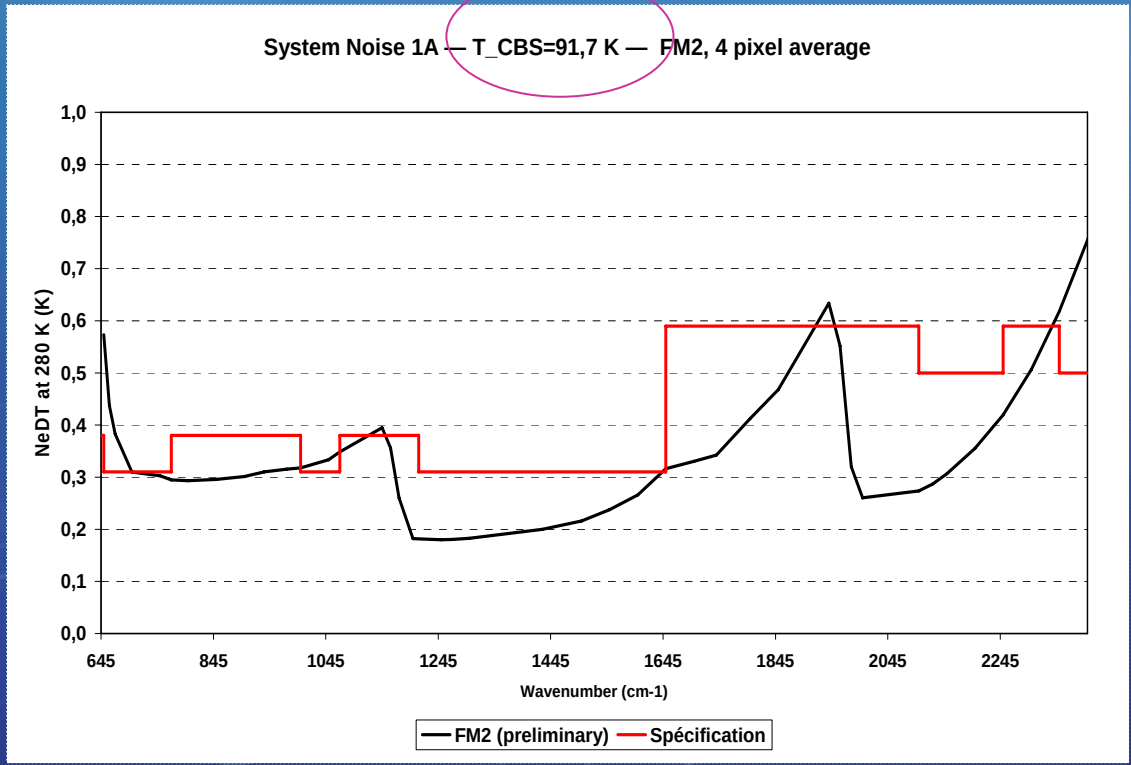


FM3 optical vacuum test : Oct. 2005

Courtesy Alcatel

## System radiometric noise for FM2 :

- Raw inteferograms processed with DPS
- Average of 4 pixel *27scan angle*40 lines
- Noise for each line and averaged on 40 lines




After cold box design modifications, ice contamination issue solved

## Radiometric calibration

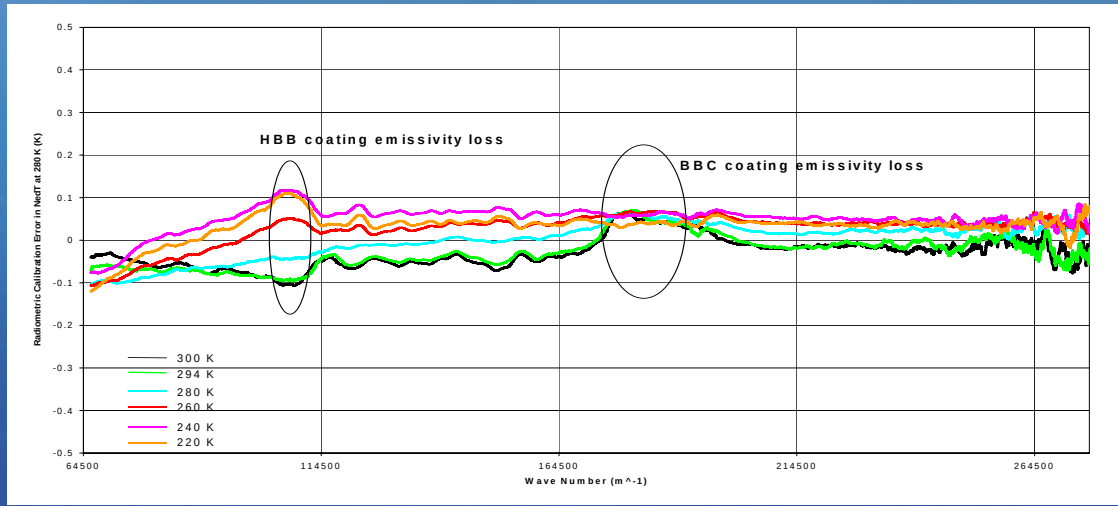
- Interpixel & interscan calibration
- Scan mirror characterization verified
  - **External HBB temperature : 85 K**
- Impact of the incidence on calibration error
  - **Measured for external HBB in SP= 1, 5, 10, 25 positions**
  - **Incidence : -56.67, -50, -41.67, -16.67 deg**
  - **External HBB temperature : 294 K & 240 K**
- Precautions
  - **Measurement repeated twice in order to detect potential thermal drift in the test setup**
  - **Effect of Earth Panel temperature verified**

# Radiometric Calibration : Sensitivity to incidence angle, scan mirror reflectivity, or thermal drifts

Raw results for Tscene=220-300k

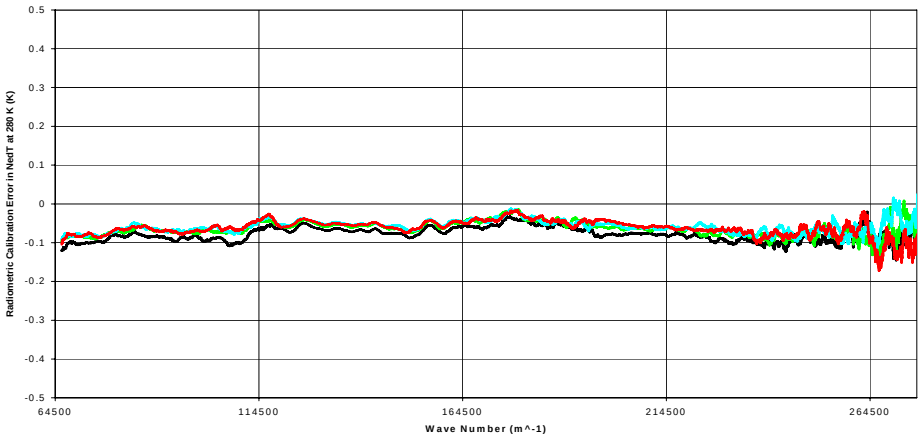
Pixel 1

Nominal configuration, Cold case



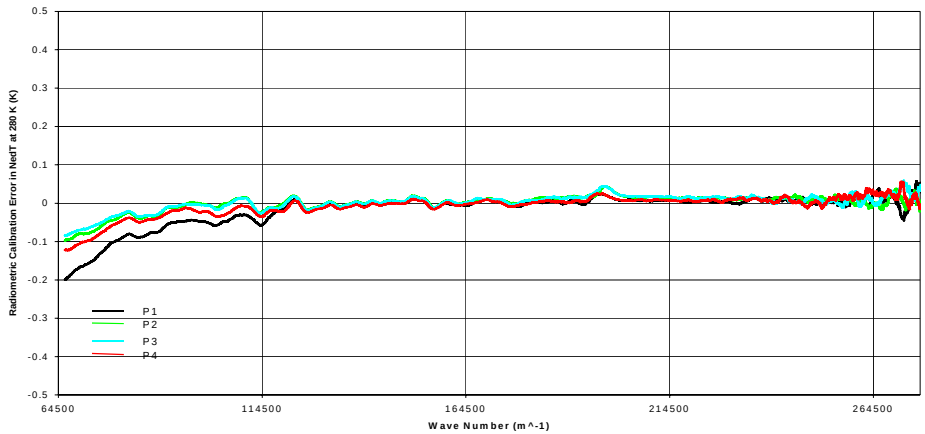

Interscan radiometric performance (Spec. 0.1 K)

HBB at 294 K, Pixel 1




Interpixel radiometric performance (Spec. 0.1 K)

HBB at 294 K, Pixel 1

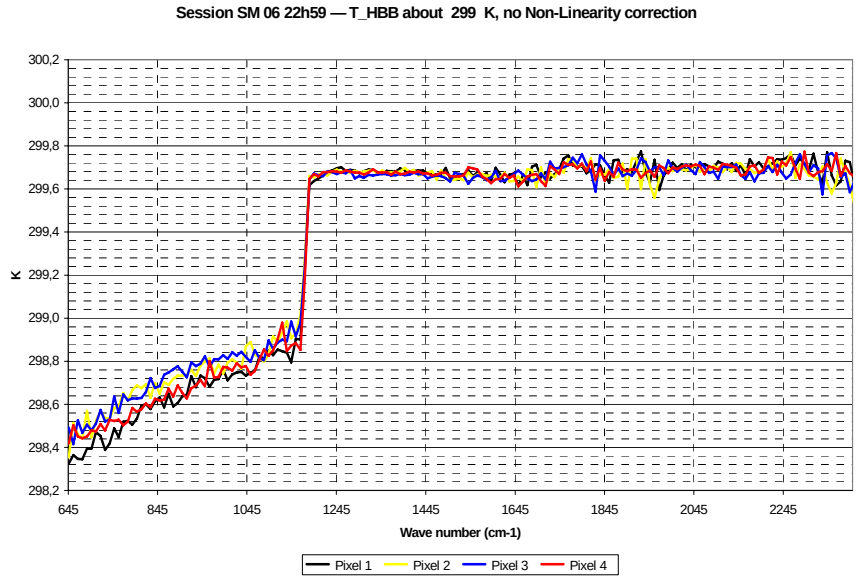


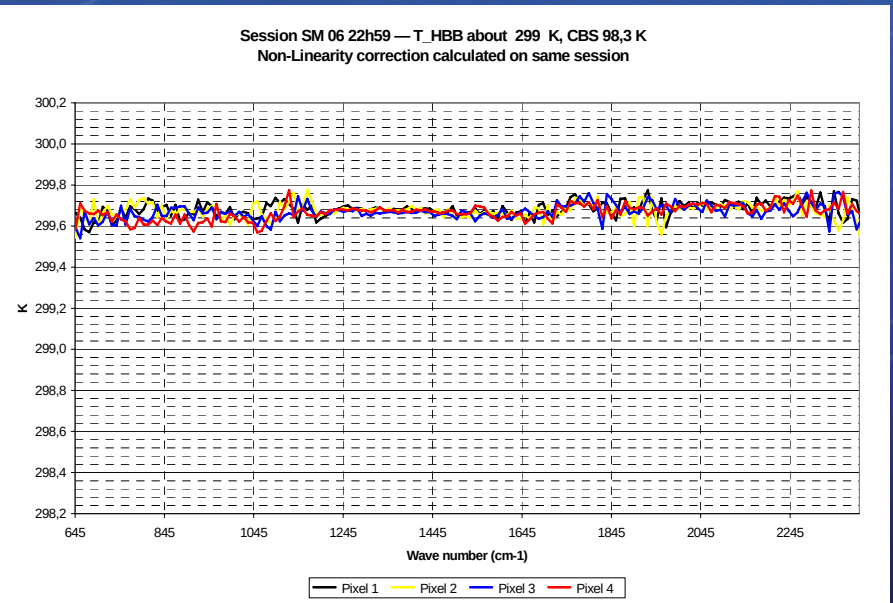
# Radiometric calibration

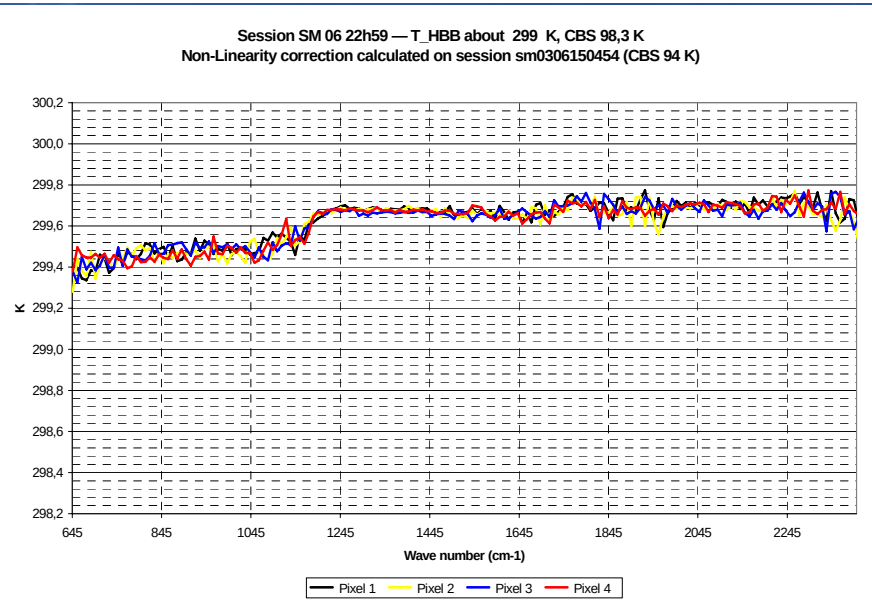
- Objectives of the Mission Specification on radiometric calibration are expected to be achiev
- Absolute Calibration error
  - **< 0.5 K**
- Intercalibration errors at a given time for all geophysical conditions
  - **< 0.2 K**
  - **4 pixels, all scan directions, all channels**
- Intercalibration errors over time
  - **< 0.3 K**
  - **Random variations (over orbit period)**
  - **Long term variations**

# Non-Linearity correction efficiency

- Measurements performed with CBS temperature = 98,3 K
  - **No NL correction : error = 1 K (B1)**
  - **NL correction : degree 2 polynom (B1)**
    - Computed from interf at 98,2 K
      → error < 0.2 K
    - Computed from interfs at 93,5 K
      → error < 0.4 K



# Spectral measurements during FM2 tests

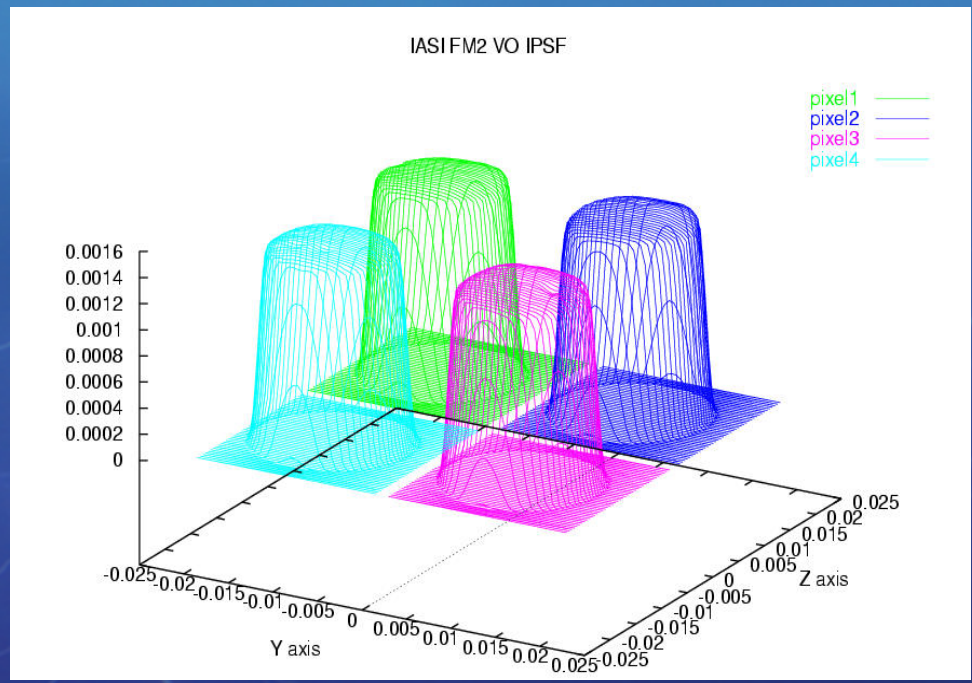
- An integrating sphere is put in front of the instrument with 2 laser beams injected simultaneously in it for direct measurement of the Instrument Spectral Response Function (ISRF)
  - **In B1 band : laser CO2 (10.59 µm)**
  - **In B3 band : laser HFDF (3.76 µm)**
  - **Laser beams are periodically occulted by a shutter for measurement of the sphere background emission**
  - **Gives also a direct measurement of the Cube Corner trajectory**
- Results are computed from raw interferograms processing
- Test performed with instrument either in
  - **External Calibration mode**
    - Allows to acquire a lot of data
    - Scan motion is limited to beta compensation law (biggest part of the dynamic disturbance)
  - **Normal Operation mode**
    - Nominal operation mode
    - But lower amount of data available
- Sounder IPSF measured with a dedicated OGSE (Geometric Collimator)

# IPSF

Non conformity % peak to valley measurement

Specification : ± 5%

| | B1 | B2 | B3 |
|---|---|---|---|
| Pixel 3 | 3,7 | 3,8 | 3,7 |
| Pixel 4 | 6,8 | 10,0 | 10,0 |
| Pixel 1 | 4,6 | 2,3 | 3,8 |
| Pixel 2 | 2,6 | 3,0 | 4,4 |




IPSF measurements close to predictions

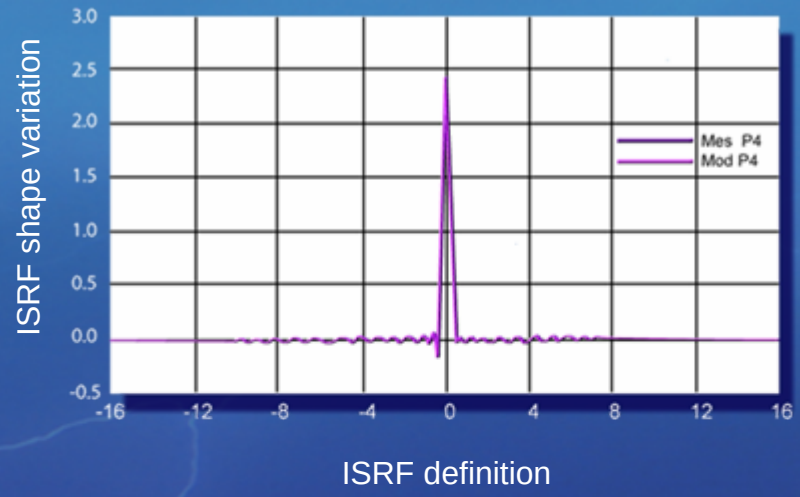
Alignment of the interferometer :

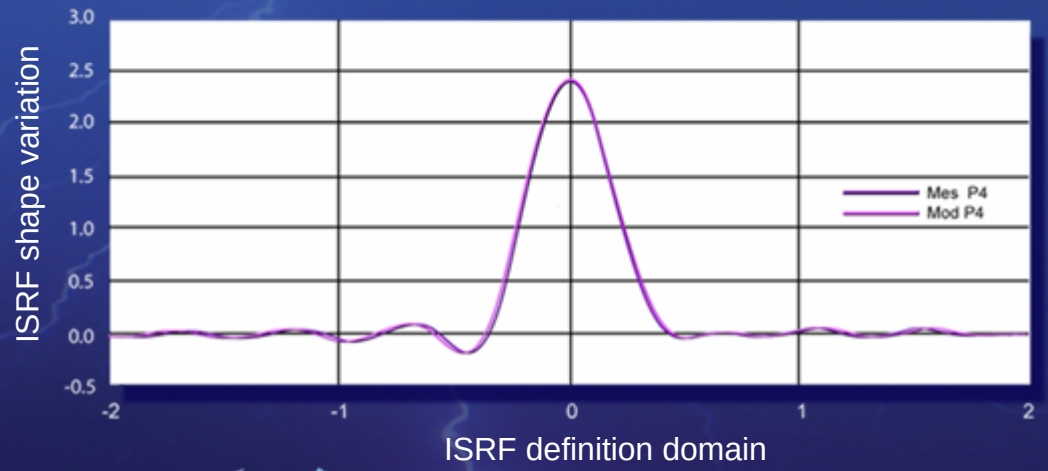
axis position < 200 µrad

Cube corner offset : 32 µm

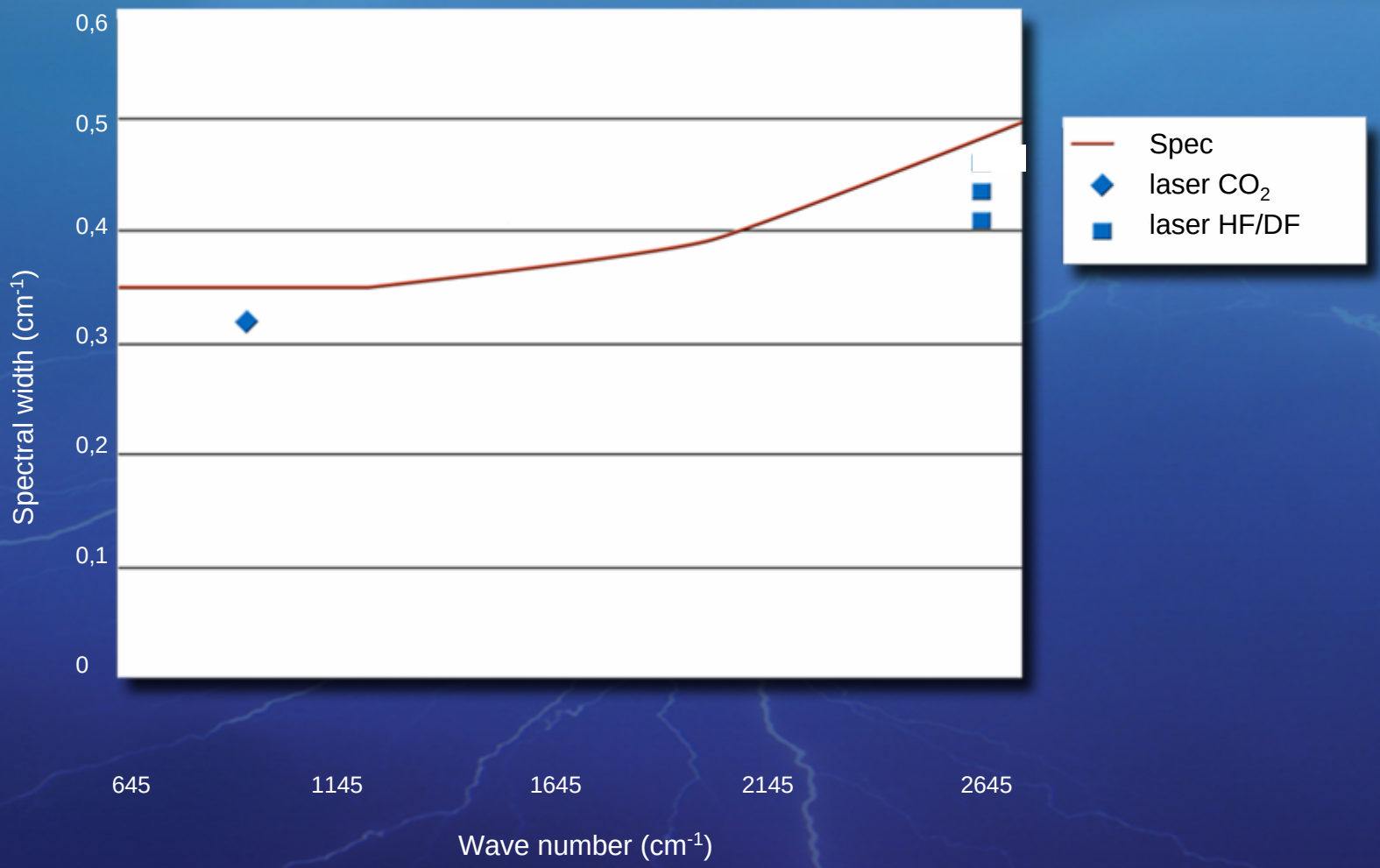
# Spectral

- The Instrument Spectral Resolution Function which was measured during the optical vacuum test is similar to the predicted one.



# Spectral resolution




***Spectral resolution within the specifications for the 4 pixels.***

## Spectral resolution

Maximum spectral shift = $10^{-5}$ < spec. ($2.10^{-4}$)

Spectral stability : < $8.3.10^{-8}$ in B1

< $2.5.10^{-8}$ in B3

***Spectral stability well in the spec. ($1.10^{-8}$)***

Shape error index $\varepsilon_2$: = quality index on the knowledge of the Instrument Line Shape = difference between modeled ILS and actual ILS

< 0.014 in B1 ~ spec. (0.026)

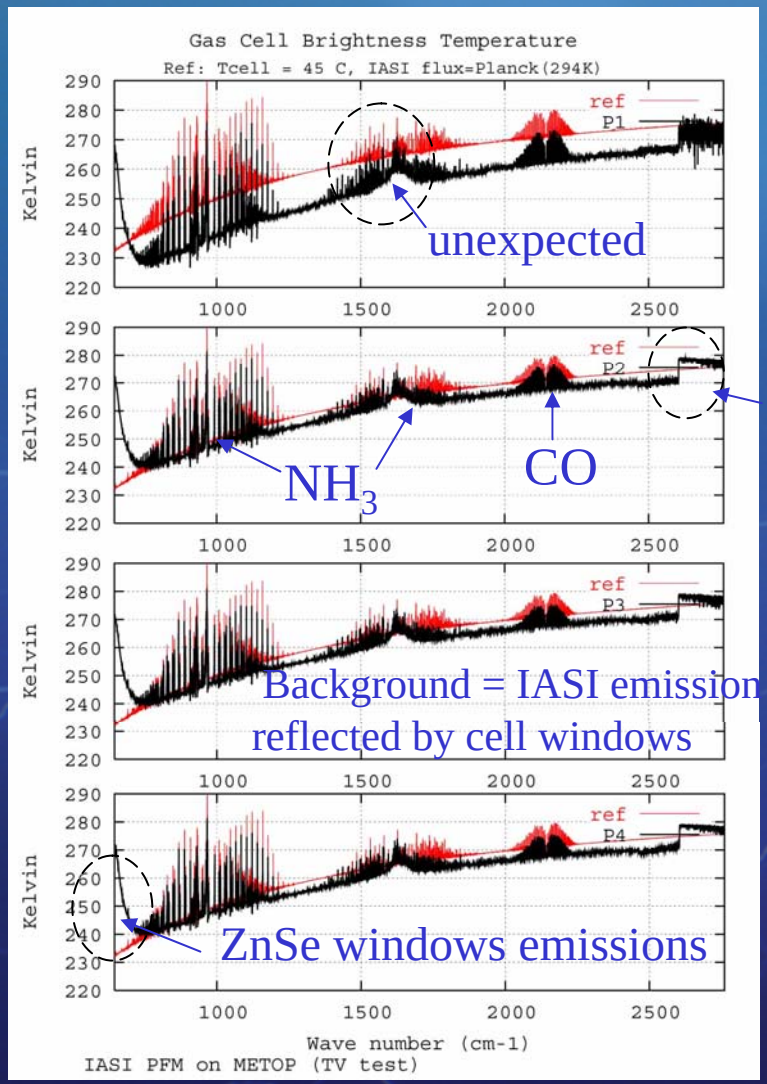
< 0.023 in B3 ~ spec. (0.042)

***Within the specifications***

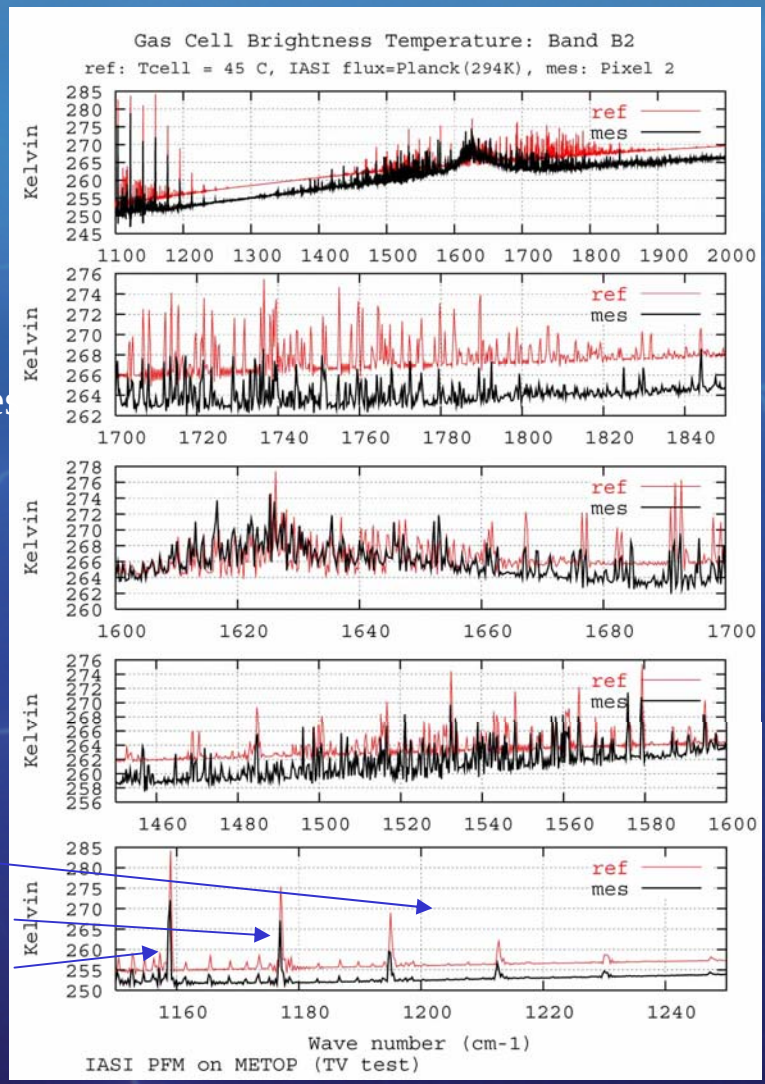
Shape error index $\varepsilon_1$ : = index on the knowledge of the ISRF

***ILS knowledge meets the spec. marginally***

# Gas Cell Measurements during TV test on Metop 2




"optimized" coding tables




Spectral lines in B1/B2 interband

## Geometry

- Pixels geometrical characterisation
- Pixel diameter : compliant with the expected values
- with less than 0.1 mrd difference
- Angular distance (in mrd) between pixel radiometric
- centers (nominal value is 21.63 mrd)

| | P1P2 | P2P3 | P3P4 | P4P1 |
|---|---|---|---|---|
| B1 | 21,65 | 21,61 | 21,67 | 21,61 |
| B2 | 21,52 | 21,68 | 21,57 | 21,55 |
| B3 | 21,55 | 21,66 | 21,57 | 21,57 |

- Effective pixel centres included within circles of less than 0.15 mrd in radius centered on the reference square corners (specification is 2 mrd)

***Geometric performances well within the spec.***

# Imager

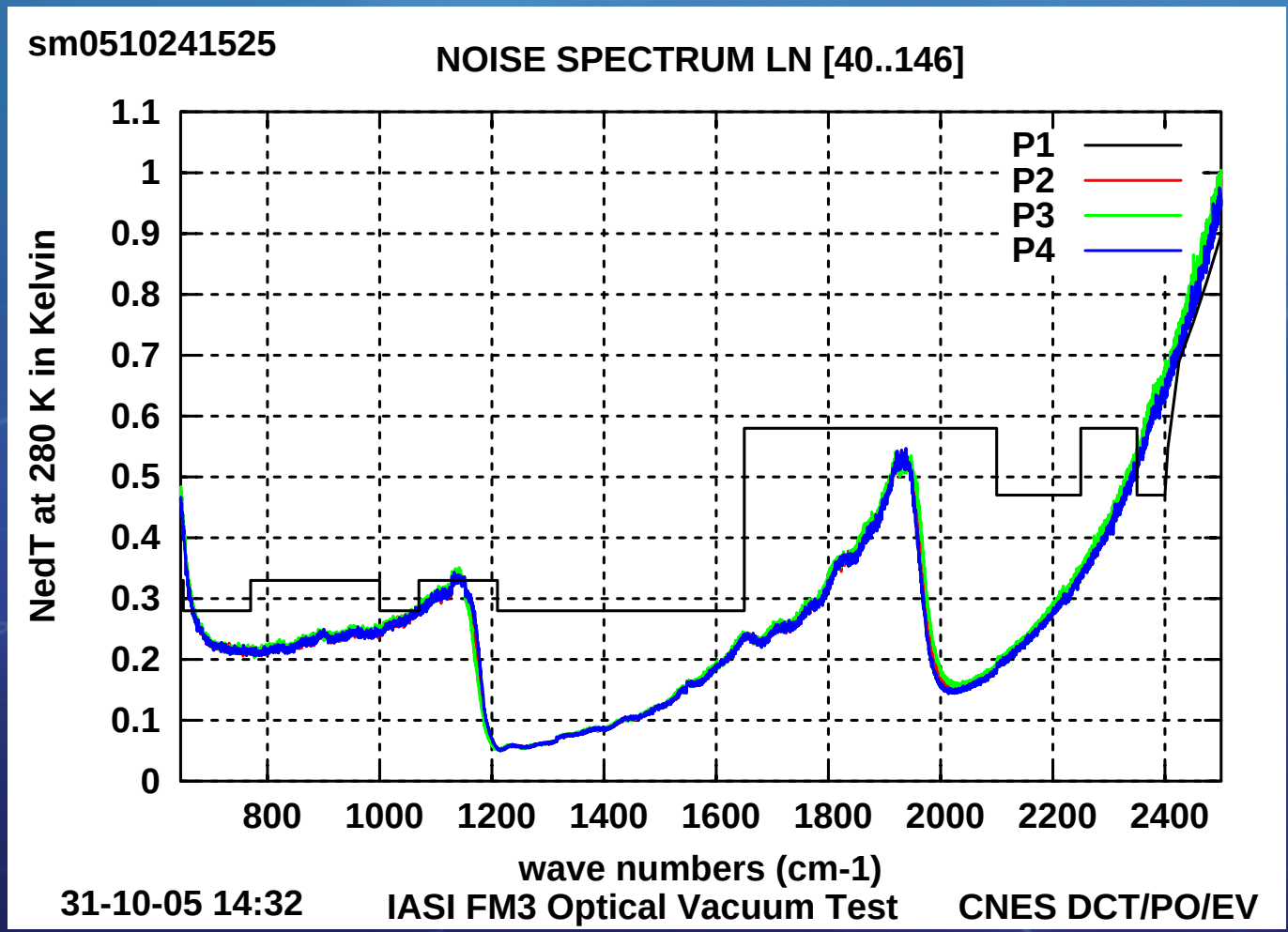
- Radiometric performances
  - **NEDT = 0.57 K (specified at 0.80 K).**
  - **Calibration accuracy < 1 K**
  - **Dynamic range : noise better than specification from 200 K to 300 K of scene temperature**

- Geometrical performance
  - **4 blind pixels (2 % specified)**

# FM3 Optical vacuum tests

- FM3 OVT tests were carried out successfully at Alcaltel in October 2005
- FM3 showed the same behavior than FM2
- Radiometric performances are slightly better (specially in B1) and confirm the validity of the models.
- Calibration is as good as for the FM2
- Water contamination is weak and could lead to a loss of about 0.2%/day
- Instrument was accepted by the Technical Review board
- It is now stored at Alcalel for integration on a next MetOp platform

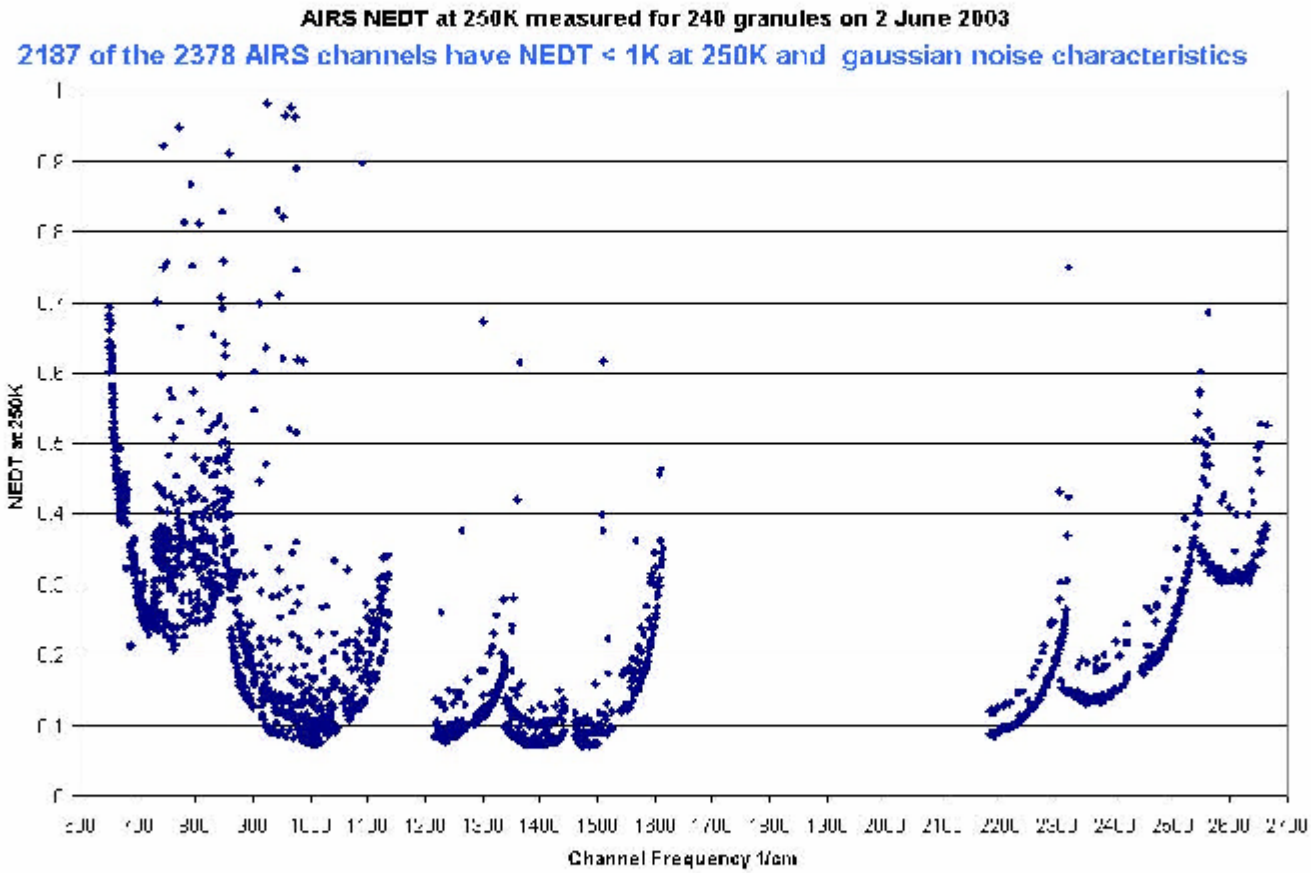
# IASI FM3 on ground radiometric performances

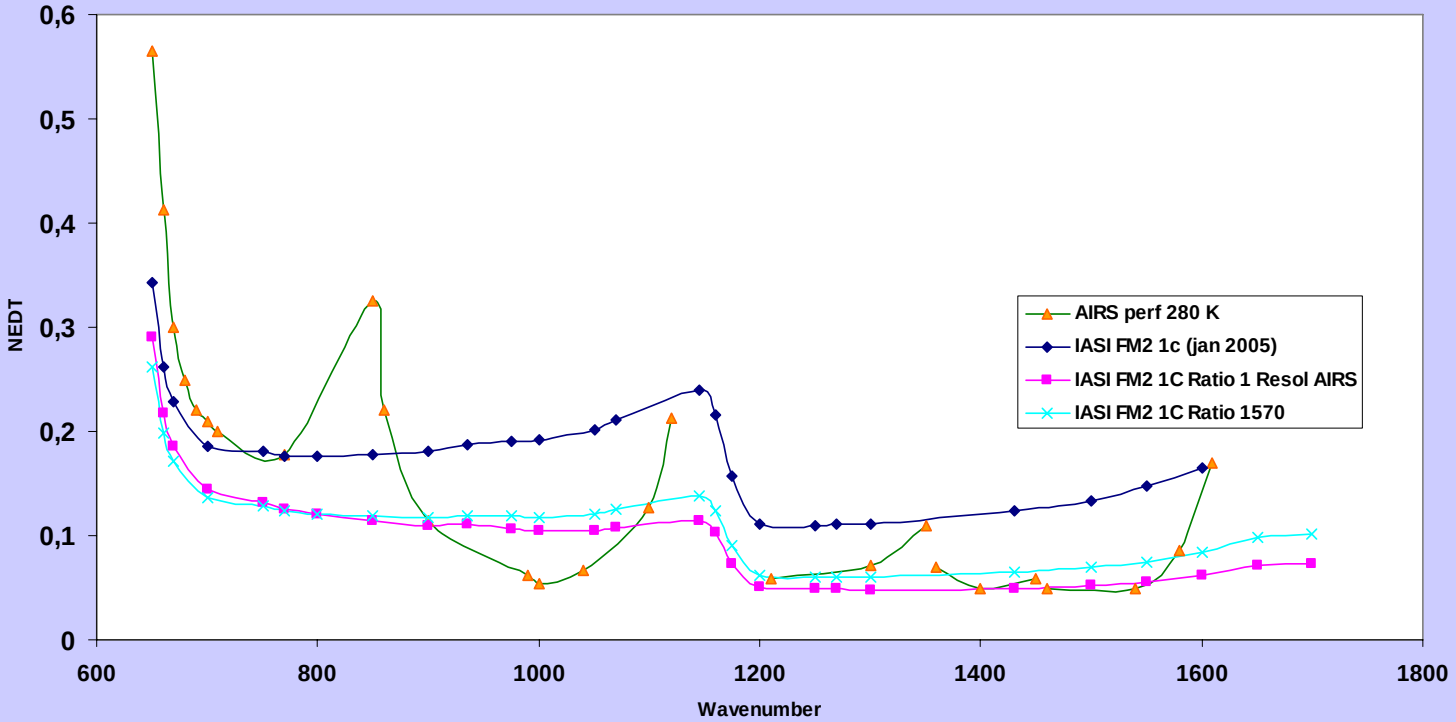


# Comparison IASI/AIRS

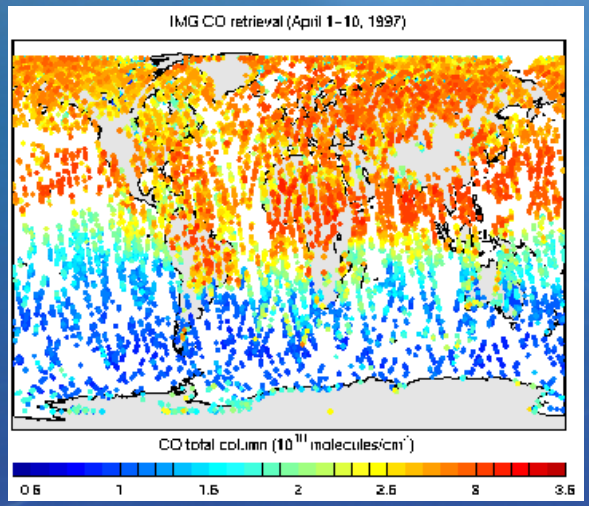
| | AIRS on AQUA | IASI on MetOp |
|---|---|---|
| Overpass time | 13:30 | 9:30 AM |
| Spectral coverage | 2378 channels<br>650 to 2670 $cm^{-1}$ with gaps<br>(1136-1216, 1614-2170) | 8461 channels<br>645 to 2760 $cm^{-1}$<br>continuous |
| Radiometric performances | See plot | See plot |
| Spectral Performances | From 0.4 to 2.5 $cm^{-1}$ | From 0.32 to 0.46 $cm^{-1}$ |
| Geometry | 3*3 pixels of 15*15 $km^2$ | 2*2 pixels of 12*12 $km^2$ |

# Measurement NEDT is excellent and stable



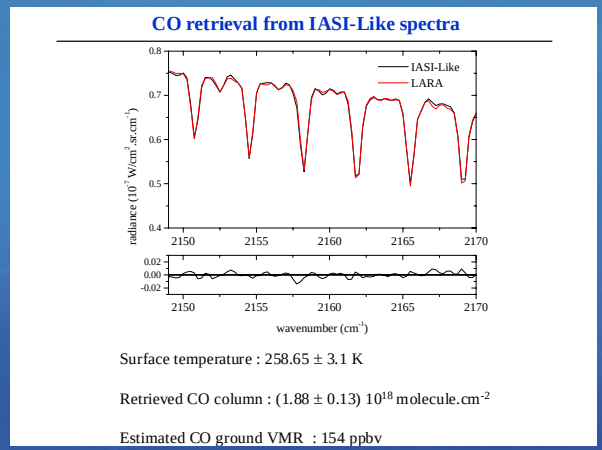

0,6
0,5
0,4
0,3
0,2
0,1
0
NEDT
600
800
1000
1200
1400
1600
1800
Wavenumber
AIRS perf 280 K
IASI FM2 1c (jan 2005)
IASI FM2 1C Ratio 1 Resol AIRS
IASI FM2 1C Ratio 1570

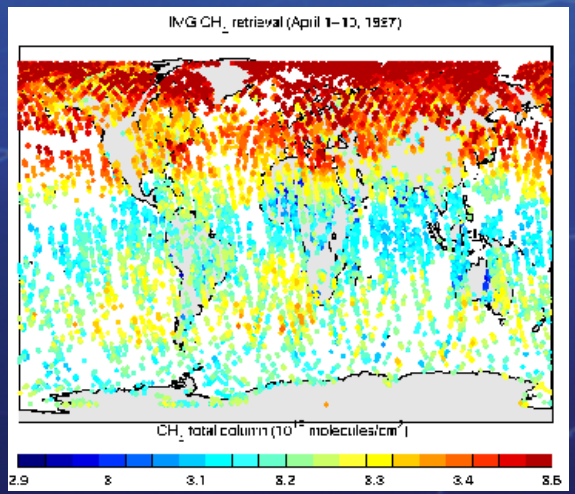
# CO and $CH_4$




CO column:

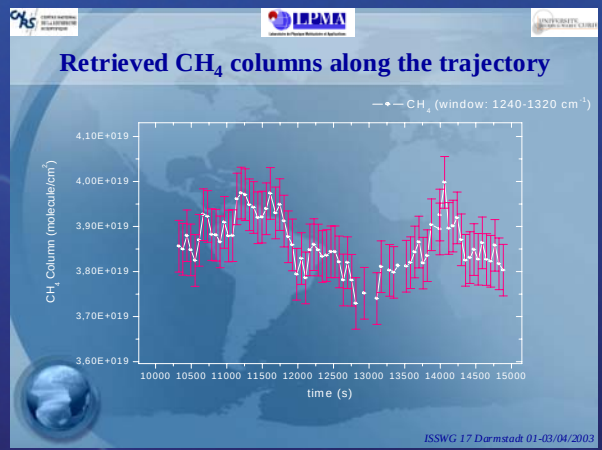
10-15%




CH4 column:

3%

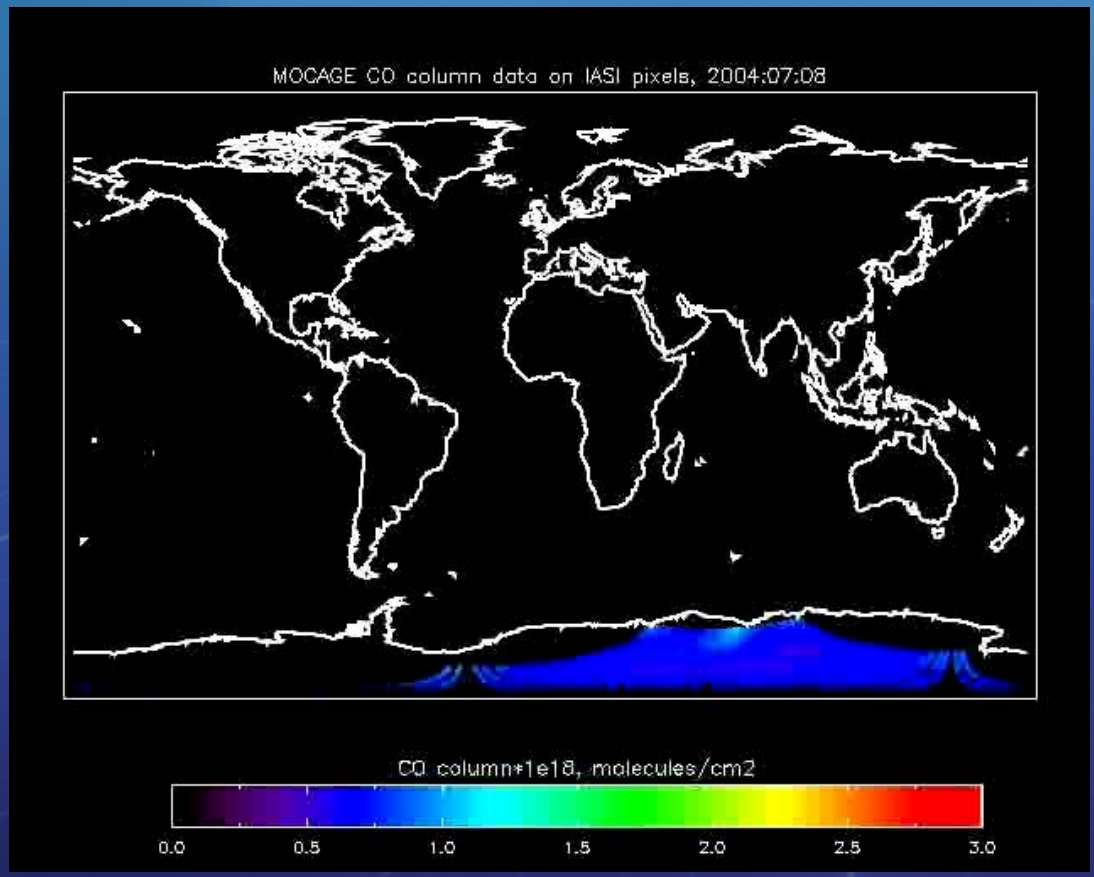



Clerbaux et al

Camy Peyret et al

# One day CO with IASI in cloud free conditions

(courtesy C. Clerbaux)



# Conclusions

- The last on the ground tests show that
  - **All performances meet their specifications (sounder and imager)**
  - **IASI proved an excellent behavior**
  - **The performance model is good and can be used in the analyses**
- IASI will be an tremendous step forward in meteorology and atmospheric research

# Infrared Atmospheric Sounding Interferometer


***THANK YOU FOR YOUR ATTENTION***

More information on
http://smsc.cnes.fr/Iasi