Ozone and CO with IRS on MTG

MTG Provides a Total of Five Missions Compliant to the User Needs

The Flexible Combined Imager (FCI) =

Full Disk High Spectral resolution Imagery (**FDHSI**), global scales (Full Disk) over a BRC = 10 min, with 16 channels at spatial resolution of 1 km (8 solar channels) and 2 km (8 thermal channels)

High spatial Resolution Fast Imagery (**HRFI**), local scales (1/4th of Full Disk) over a BRC = 2.5 min with 4 channels at high spatial resolution 0.5 km (2 solar channels), and 1.0 km (2 thermal channels)

InfraRed Sounding (**IRS**), global scales (Full Disk) over a BRC = 30 min at spatial resolution of 4 km, providing hyperspectral soundings at 0.625 cm^{-1} sampling in two bands.

Lightning Imagery (**LI**), global scales (80% of Full Disk) detecting and mapping continuously the optical emission of cloud-to-cloud and cloud-ground discharges. Detection efficiency between DE=90% (night) and DE=40% (overhead sun)

UVN Sounding, implemented as GMES Sentinel 4 Instruments provided by ESA

The Infrared Sounder

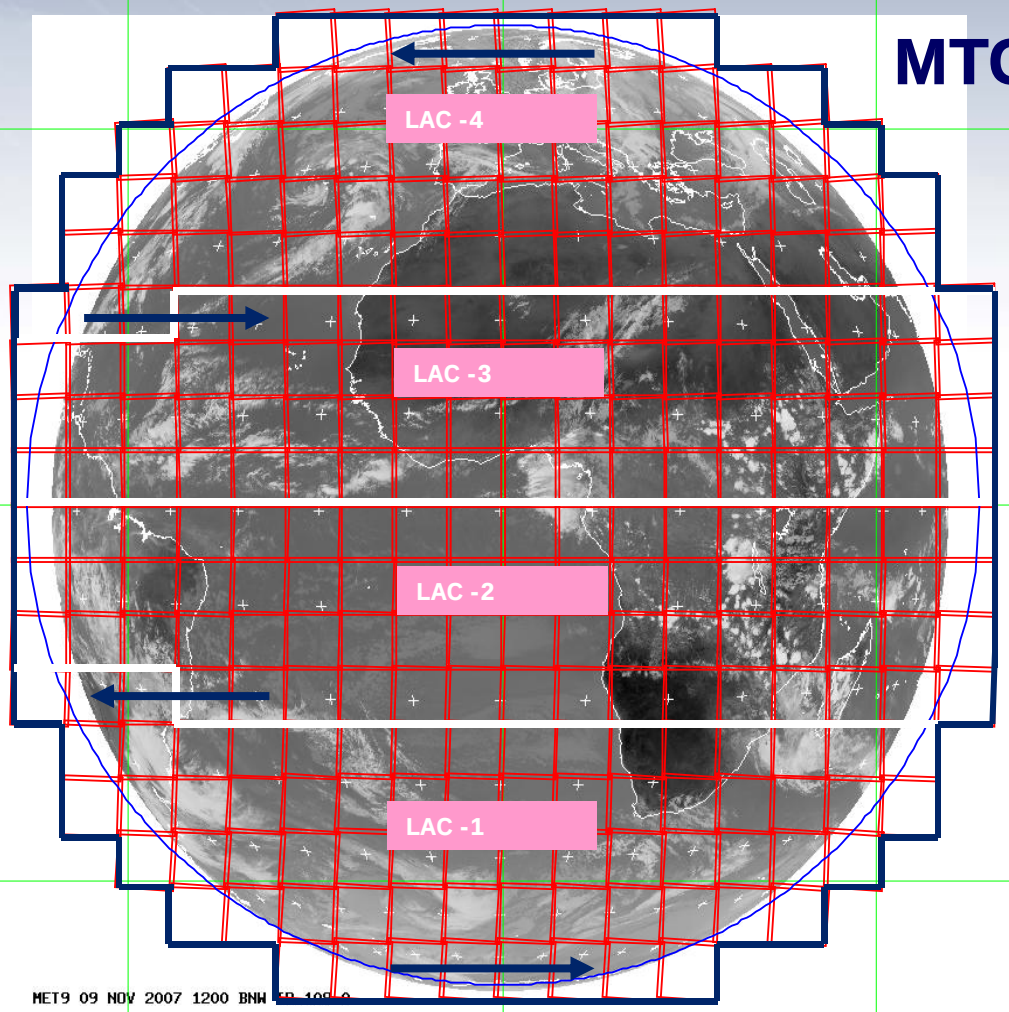
	Spectral	Spatial	Radiometric
Coverage	Two spectral ranges: LWIR: 700 -1210cm^{-1} MWIR: 1600 -2175cm^{-1} Extended range (reduced performance):	4 Local Area Coverage (LAC) zones 1 LAC every 15minutes	180 to 313K
Resolution	0.625cm^{-1}	4km at SSP	such to meet the NEDT spec
Accuracy and stability	such that the equivalent radiometric error is (roughly) below 50mK	Accuracy : ≈2Km Stability : ≈0.5Km (3 sigma)	Accuracy : 0.5K Long term stability : 0.3K Medium term stability : 0.1K NEDT : 0.2-0.5K

Heritage :

- A LEO IR sounder (IASI) is currently operated by Eumetsat
- Another LEO IR sounder (CrIS) is going to be launched by NASA as part of the NPP payload (launch in late 2011)
- The NASA/GIFTS concept

EUMETSAT

MTG-IRS Concept: Every 30 Minutes Europe



MTG-IRS Operations Scenario

~ 300 stares for Full Disc Coverage

~ 75 stares Local Area Coverage (LAC)

LAC-1/2/3/4 repeat cycle: 15 min
including 2-3 min for calibration

Basic Repeat Cycle Pattern over 6 hours:

5 times LAC-3 plus LAC-4

4 times LAC-2 plus LAC-4

3 times LAC-1 plus LAC-4

LAC-4 (Europe) covered every 30 min

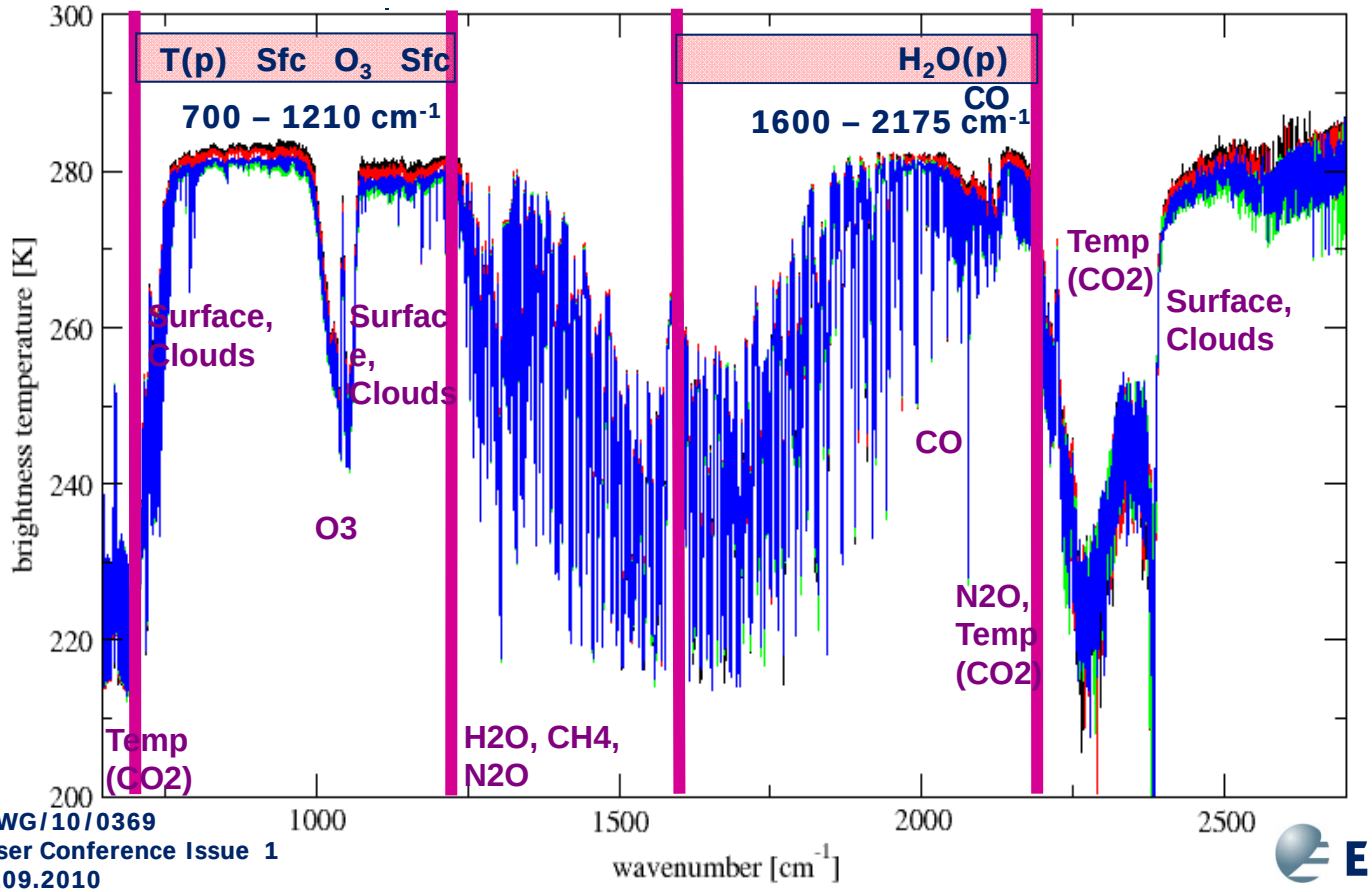
all LACs have at least 3 consecutive measurements with 30 min repeat cycle

Sli

EUMETSAT

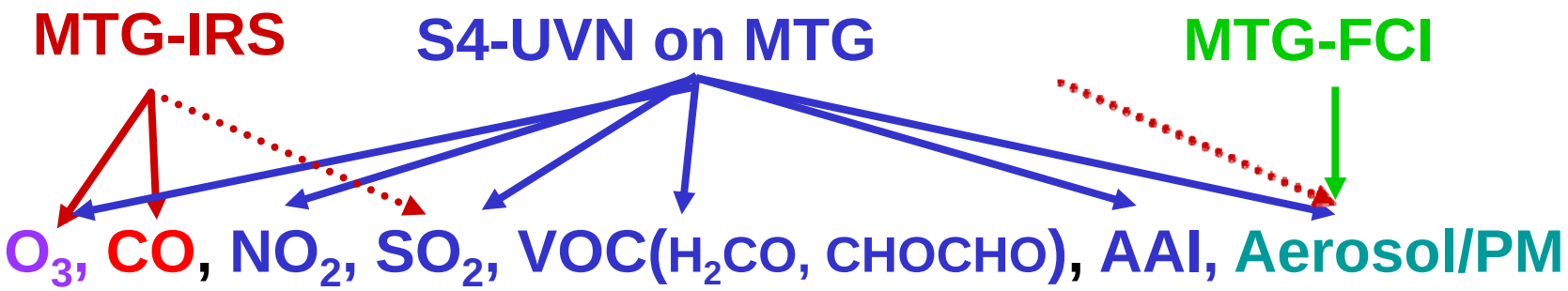
MTG-IRS Concept: High Spectral/Spatial sampling

MTG-IRS mission will deliver unprecedented information on horizontal and vertical gradients of moisture, wind and temperature between measurements of individual radiosondes and hyperspectral soundings from the polar orbiting satellites.



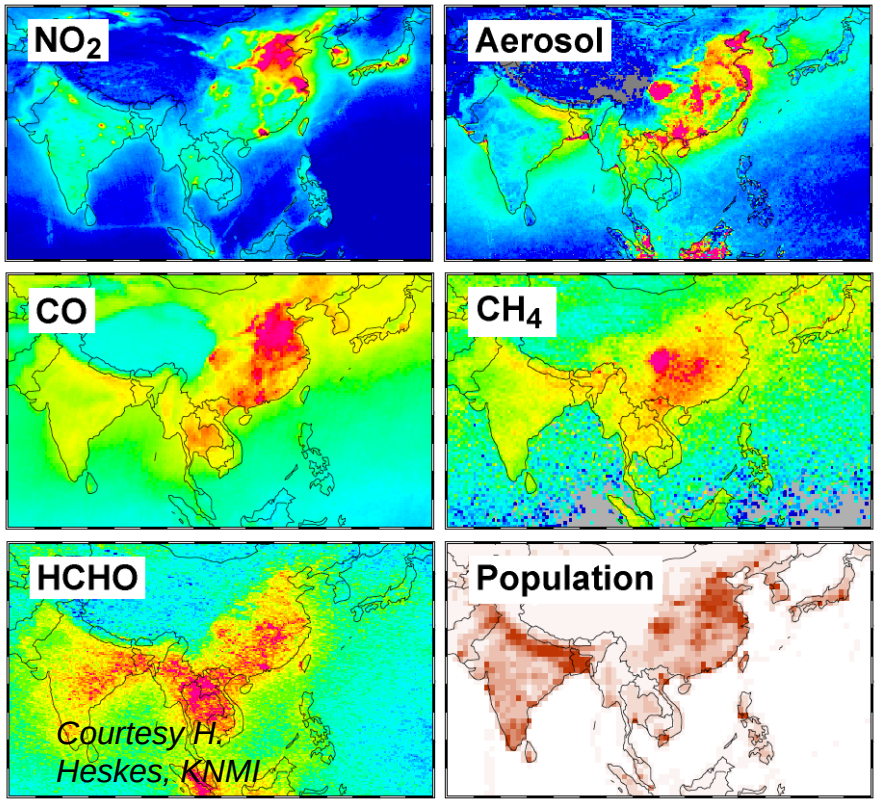
EUMETSAT

Synergies on MTG for Tropospheric Chemistry and Air Pollution Applications



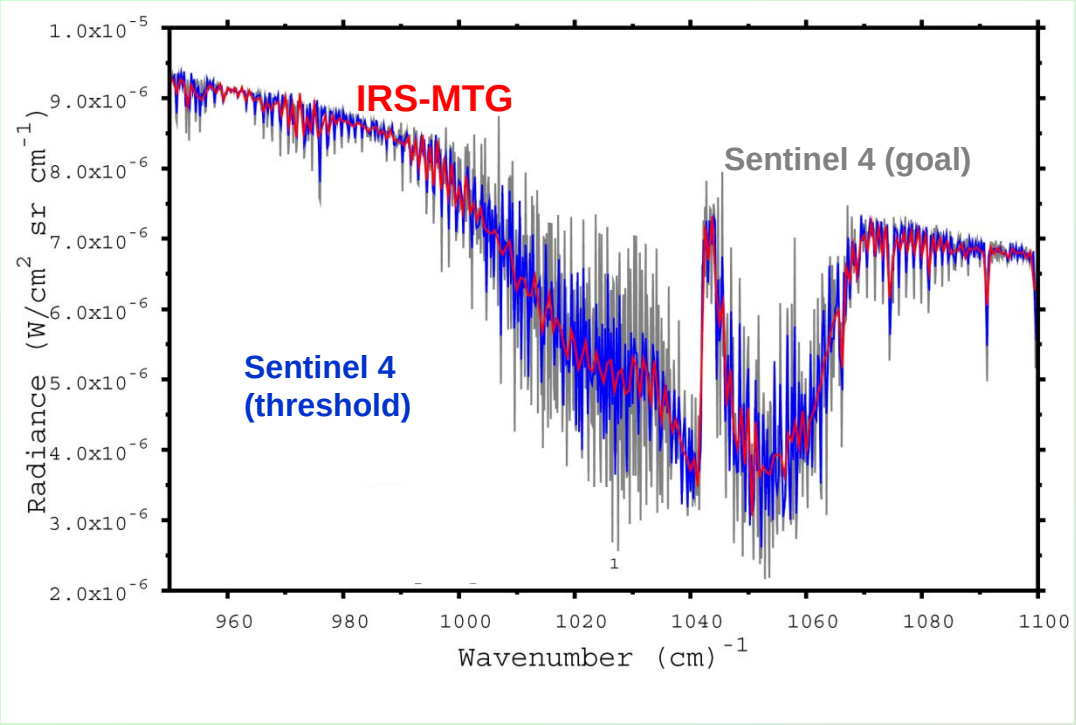
MTG-IRS, MTG-UVS/S4 UVN, and MTG-FCI and LI will provide unique and relevant data for tropospheric monitoring applications

!! L2 chemistry IRS products not planned for « Day 1 » operation



Ozone with IRS/MTG

IRS-MTG IRS3: OPD = 0.8 cm NEDT = 0.2K



Spectral resolution and sampling

•**MOPD** • **sampling** • FWHM of non-apodized ILS

- **0.8 cm • 0.625 cm^{-1}** • 0.75cm^{-1} → **IRS-MTG**
- **4.0 cm • 0.125 cm^{-1}** • 0.15cm^{-1} → **Sentinel 4 (goal)**
- **2.0 cm • 0.250 cm^{-1}** • 0.30cm^{-1} → **Sentinel 4 (Threshold)**

Radiometric noise

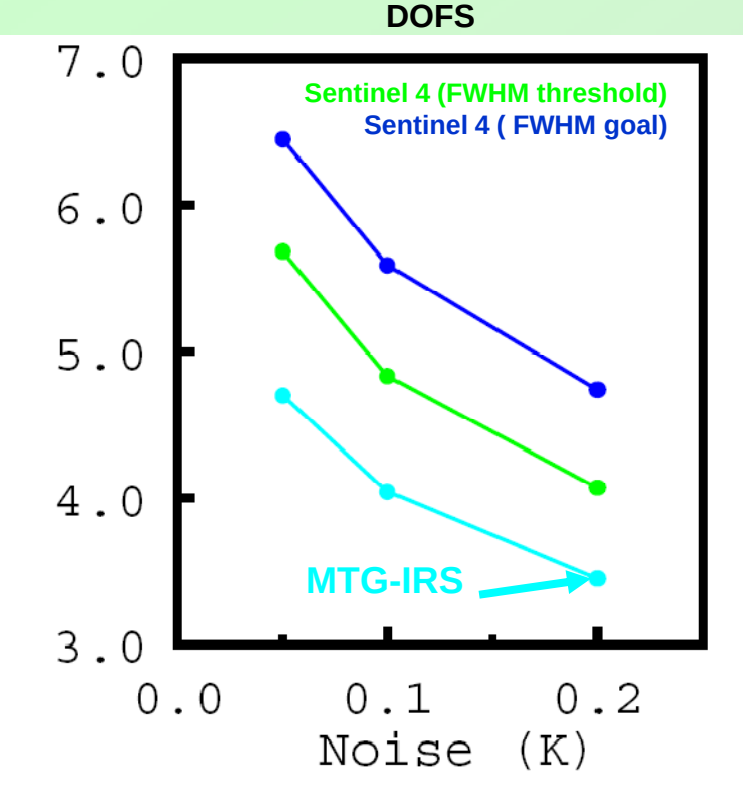
•**NEDT** (of 280K blackbody) • **NESR**

- **0.20 K • 2.45 10^{-8} W/cm^2 sr cm^{-1} → IRS-MTG**
- **0.05 K • 6.08 10^{-9} W/cm^2 sr cm^{-1} → Sentinel 4 (goal)**
- **0.10 K • 1.22 10^{-8} W/cm^2 sr cm^{-1}**

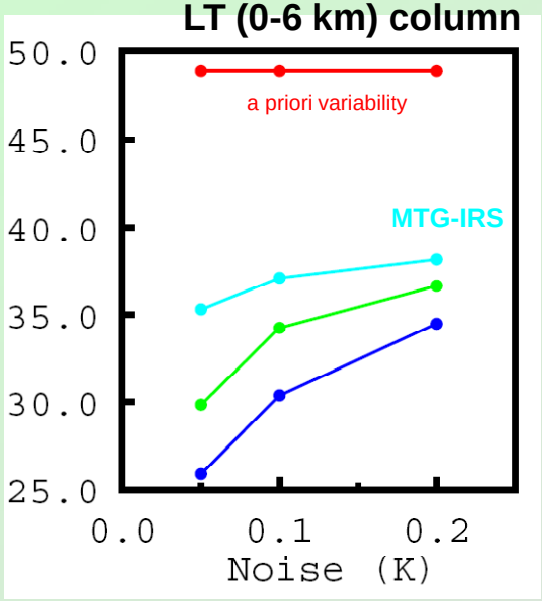
Results for ozone

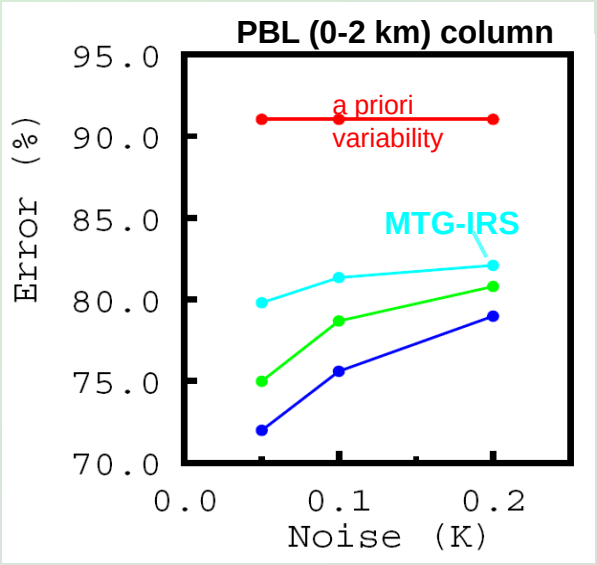
Summary

MOPD=0.8 cm (IRS-MTG)
MOPD = 2.0 cm (Sentinel 4 threshold)
MOPD = 4.0 cm (Sentinel 4 goal)

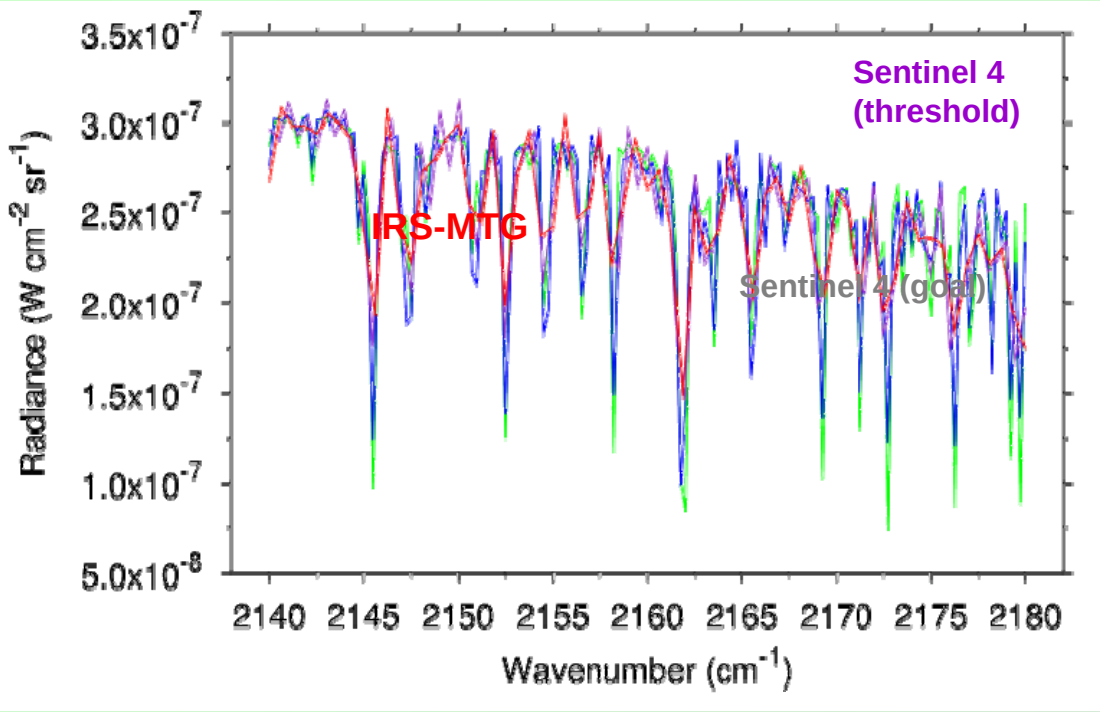


Varying spectral resolution and noise
ε = 0.96; ΔT = 0 K





Carbon monoxide with IRS/MTG



Spectral resolution and sampling

•**MOPD** • **sampling** • FWHM of non-apodized ILS

- **0.8 cm • 0.625 cm^{-1}** • 0.75cm^{-1} → **IRS-MTG**
- **4.0 cm • 0.125 cm^{-1}** • 0.15cm^{-1} → **Sentinel 4 (goal)**
- **2.0 cm • 0.250 cm^{-1}** • 0.30cm^{-1}
- **1.0 cm • 0.500 cm^{-1}** • 0.60cm^{-1} → **Sentinel 4 (Threshold)**

Radiometric noise

•**NEDT** (of 280K blackbody) • **NESR**

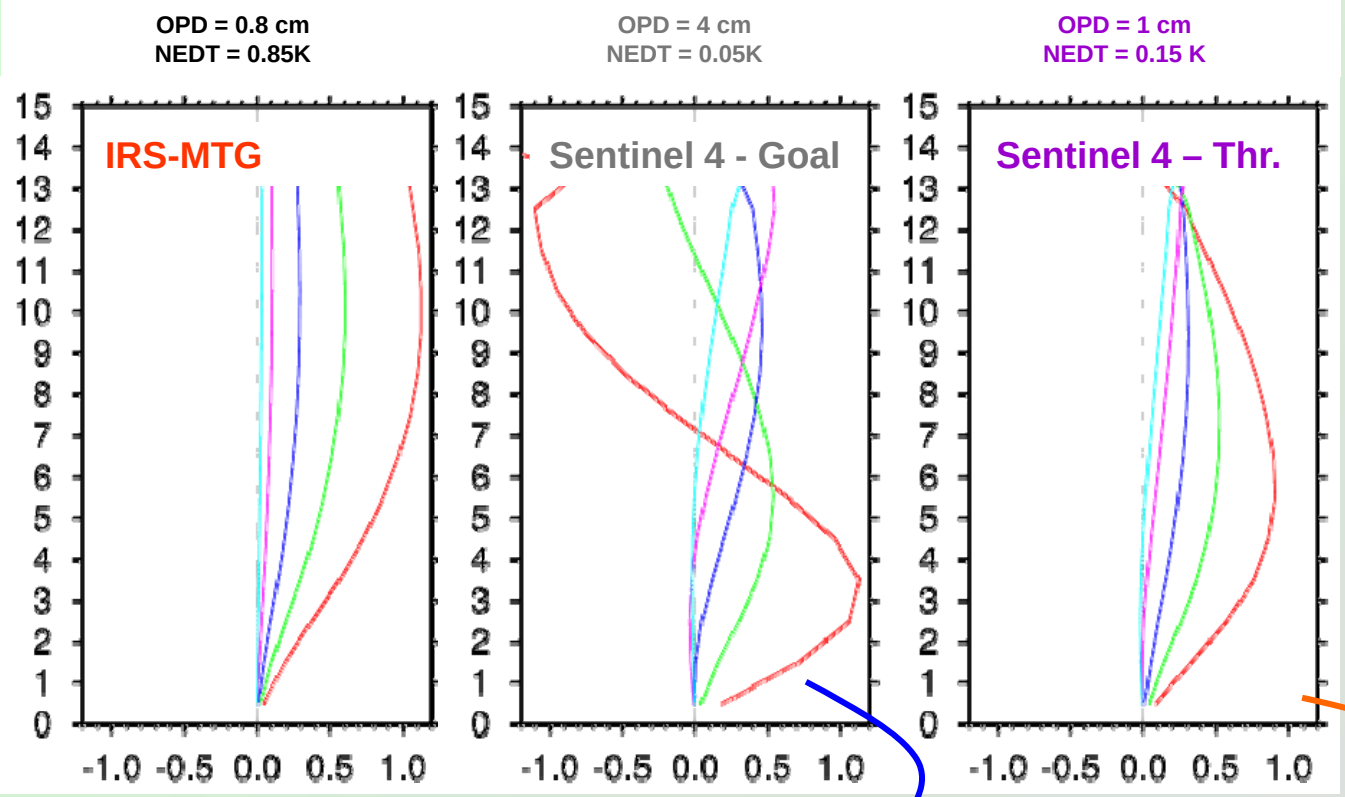
- **0.85 K • 6.12 10^{-9} W/cm^2 sr cm^{-1} → IRS-MTG**
- **0.05 K • 3.60 10^{-10} W/cm^2 sr cm^{-1} → Sentinel 4 (goal)**
- **0.15 K • 1.08 10^{-9} W/cm^2 sr cm^{-1}**

IRS-MTG IRS7: OPD = 0.8 cm NEDT = 0.85K

Results for carbon monoxide

Vertical sensitivity

Varying spectral resolution and noise
ε = 0.96; ΔT = 0 K



- Only Sentinel (goal) provides vertically resolved information in the troposphere
- Lowering the noise (IRS-MTG→Sentinel 4 Threshold increases sensitivity to the lower troposphere

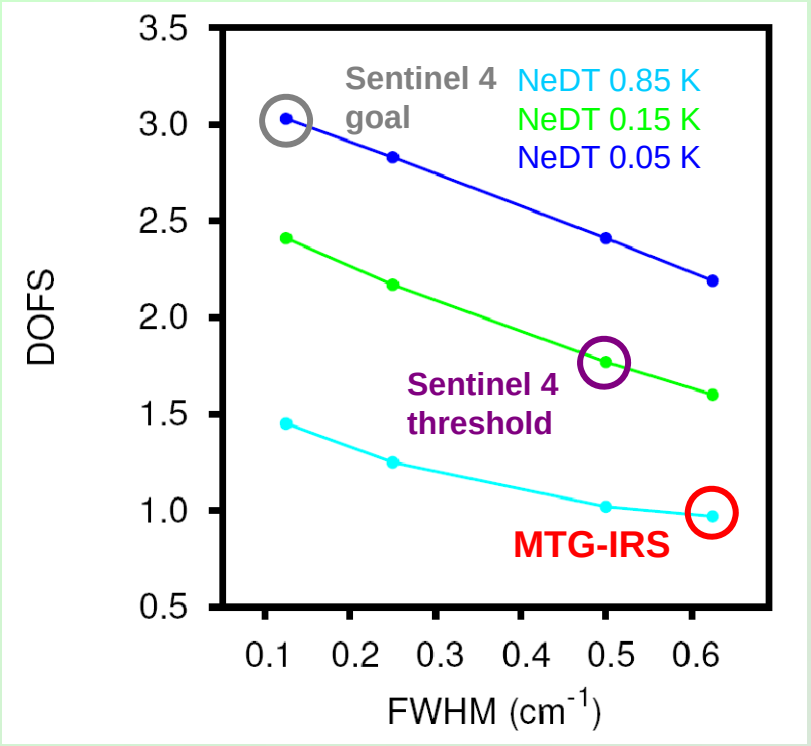
Results for carbon monoxide

A. Sensitivity analyses

Summary

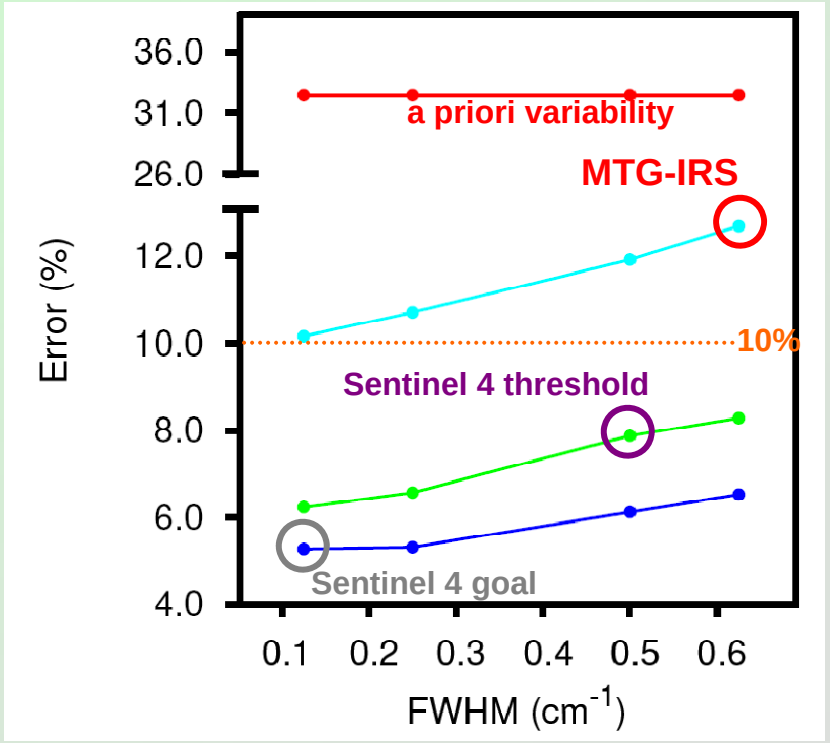
Varying spectral resolution and noise
ε = 0.96; ΔT = 0 K

DOFS



DOFS of 1 for MTG-IRS
Up to 3 for Sentinel 4 - goal

Total column error



13 % on total CO column for MTG-IRS
Down to 5 % for Sentinel 4 - goal

Conclusions

The levels of all controlled pollutants (NO_2, SO_2, CO, O_3, PM_{10} and $PM_{2.5}$) are continuously decreasing over Europe, except for O_3. The warning and alert levels of the latter are exceeded every year, and it will be worse in the future.
Ozone peaks occur between 12 and 15 pm.
Levels of pollution for CO are exceeded when fire events occur.

With the current MTG/IRS specifications:

Ozone DOFS around 3.5 → single information in the troposphere
CO DOFS around 1→ total column

Error on the tropospheric column is around 15 %
Impact of thermal contrast : Impact is in the lower troposphere. The error on the tropospheric column reaches ~ 10 % for positive values of thermal contrast.

Conclusions

Although the instrumental specifications for MTG-IRS are not optimized for chemistry, the instrument will provide tropospheric columns of O_3 and CO, with significant improvement on our prior knowledge, for high pollution events (photochemical pollution in the case of ozone; fires in the case of CO). The diurnal variability might be difficult to capture if thermal contrast remains low. However, as ozone pollution mainly occurs along with high temperatures, pollution peaks will likely be monitored.

One may expect to take benefit of the high sampling rate of the MTG sounder (0.5 hour over Europe) in order to set-up a specific retrieval strategy that would use the information at different times of the day (hence different thermal contrast) to extract the peak pollution events at the right time and place. Moreover the smaller MTG-IRS pixel size (4 km) would allow to average data in order to increase accuracy.

NH3 might also be measurable to some extent.

For volcano: main SO2 band missing but ashes detection OK