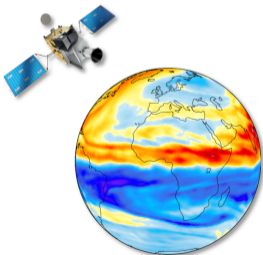


Contribution of the Meteosat Third Generation (MTG) / InfraRed Sounder (IRS) radiance assimilation in the characterization of the atmospheric chemical composition

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MTG - InfraRed Sounder (IRS)

The **Infrared Sounder (IRS)**, which will be launched in 2023 on board the Meteosat Third Generation (**MTG**) geostationary series, will be able to provide 4 km resolution data (over Europe), with a temporal sample of less than one hour.



Spectral samplings: $\sim 0.603 \text{ cm}^{-1}$ (LWIR)
 $\sim 0.604 \text{ cm}^{-1}$ (MWIR)

LWIR: $\sim 679.70 - 1210.44 \text{ cm}^{-1}$ (881 channels)

MWIR: $\sim 1600.00 - 2250.20 \text{ cm}^{-1}$ (1079 channels)

TOT: 1960 channels

Spectral sampling: 0.3251 cm^{-1}

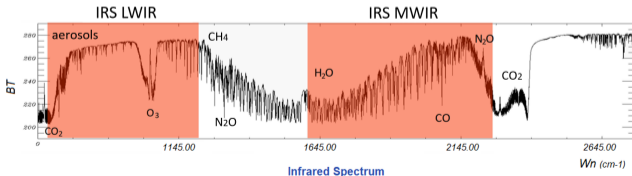
LWIR: $680.00 - 1210.24 \text{ cm}^{-1}$ (1632 channels)

MWIR: $1600.00 - 2250.20 \text{ cm}^{-1}$ (2001 channels)

TOT: 3633 channels



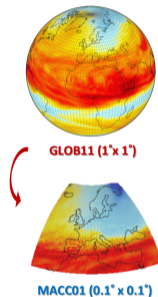
IRSx2



IRS characteristics can be essential in deducing information about atmospheric pollution.

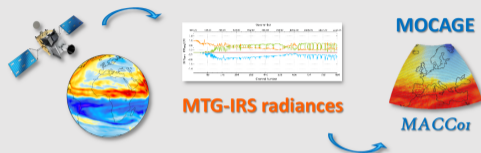
Modèle de Chimie Atmosphérique à Grande Echelle (MOCAGE)

- Météo-France takes part to the operational air quality forecasting system with the **MOCAGE** chemistry-transport model (developed since 2000).
- Three-dimensional model that covers (in operational) the global scale (GLOB11), down to a smaller scale (MACC01), using two-way **nested grids**. In research mode it can reach up to even smaller scales.
- Not uniform vertical resolution: 47 vertical altitude-pressure levels from the surface up to 5 hPa; denser levels near the surface, with a resolution of about 40 m in the lower troposphere and 800 m in the lower stratosphere. A 60 hybrid levels version is actually used in research mode: from surface, up to 0.1 hPa. Resolutions in upper stratosphere is around 2 km.
- It simulates gases, primary aerosols and secondary inorganic aerosols.
- Meteorological forecasts (wind, pressure, temperature, specific humidity, precipitation) are used as input (e.g ARPEGE or ECMWF meteorological forecast from IFS).
- Operational assimilation of AOD MODIS for aerosols. Research in progress for assimilation of IASI radiances for the Ozone.

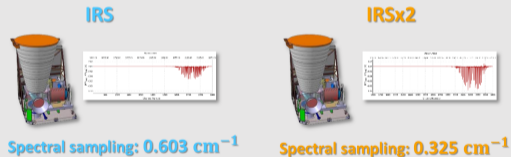


Main Goals

Evaluating the contribution of MTG/IRS radiance assimilation in a chemistry-transport model in order to characterize the atmospheric pollution over Europe



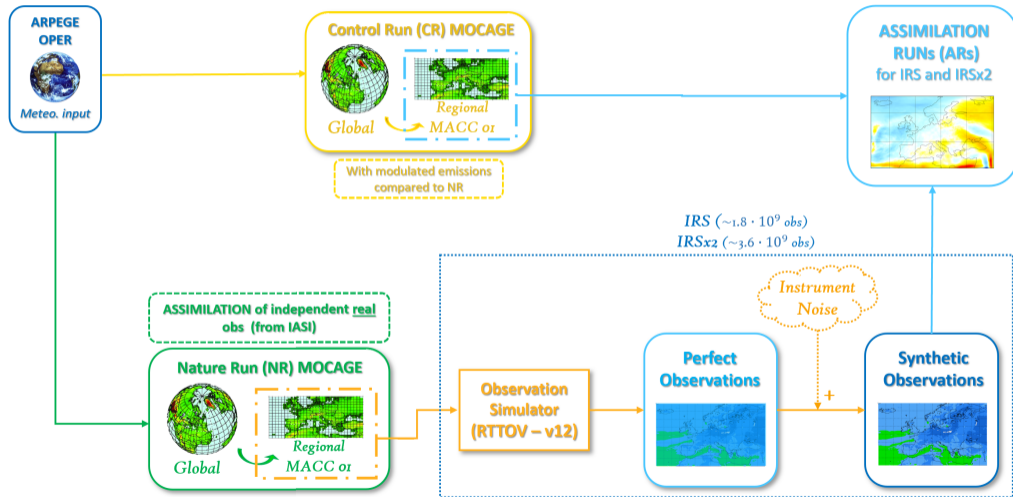
Studying the atmospheric pollution analysis quality as a function of the IRS spectral resolution: an IRS with increased resolution compared to the one at present under construction will be examined



Main focus on the Ozone



Observing System Simulation Experiments (OSSEs)



Experimental Setup

➤ Time period to cover

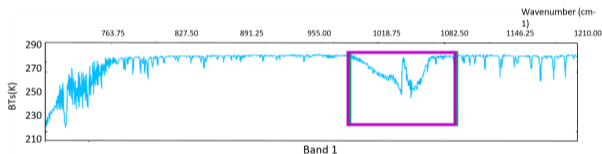


May-August 2019

} Documented cases
Ozone pollution

June 2019

➤ Spectral band and number of channels assimilated



IRS

982.464 – 1099.467 cm^{-1}
195 channels

IRSx2

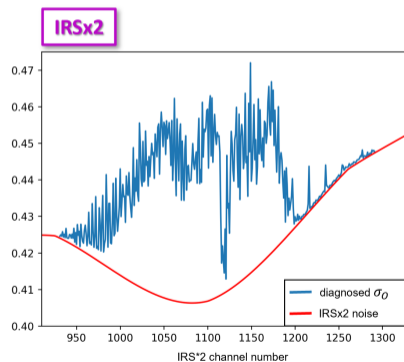
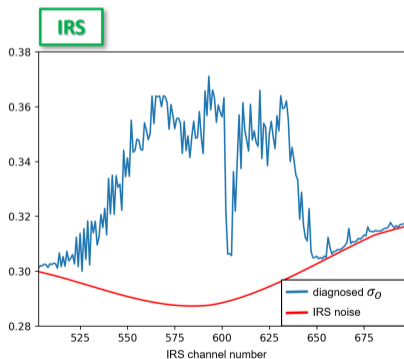
982.343 – 1099.379 cm^{-1}
361 channels

➤ Assimilation Algorithm

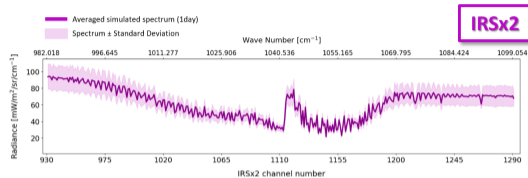
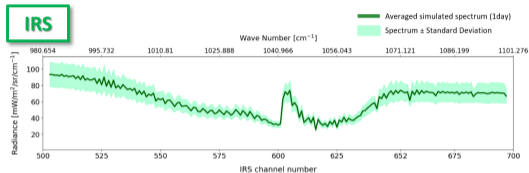
3D-Var with hourly assimilation window

Experimental Setup

- A first run of assimilation has been performed using a diagonal \mathbf{R} matrix (instrument noise) for both IRS and IRSx2. This was needed to perform a Desroziers diagnostic to compute a **full** \mathbf{R} matrix (see literature e.g. El Aabaribaoune, 2021)



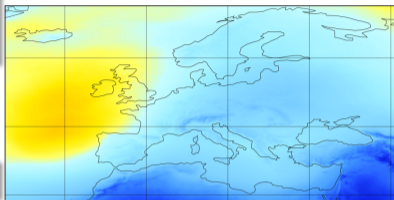
Simulated Observations



Simulated Observations

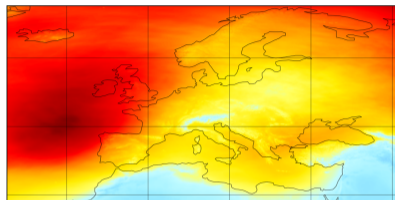
Ozone Total Columns

Average
over time
period
(June 2019)



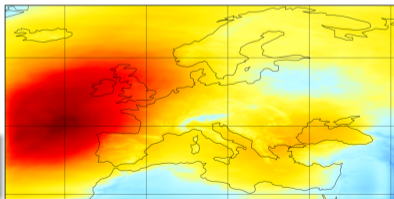
CR

O3 Total Column
283.0 300.8 318.6 336.4 354.2 372.0 (DU)
Data Min = 285.6, Max = 349.3 DU



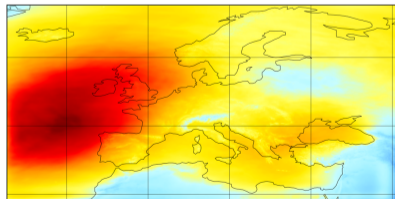
NR

O3 Total Column
283.0 300.8 318.6 336.4 354.2 372.0 (DU)
Data Min = 313.3, Max = 385.6 DU



AR
IRS

O3 Total Column
283.0 300.8 318.6 336.4 354.2 372.0 (DU)
Data Min = 293.0, Max = 386.2 DU



AR
IRSx2

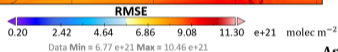
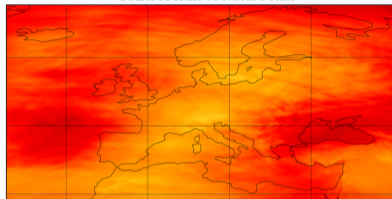
O3 Total Column
283.0 300.8 318.6 336.4 354.2 372.0 (DU)
Data Min = 292.8, Max = 386.2 DU

Scores

Average
over time
period

June 2019

Control Run vs Nature Run



Root Mean Square Error

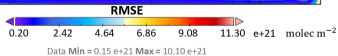
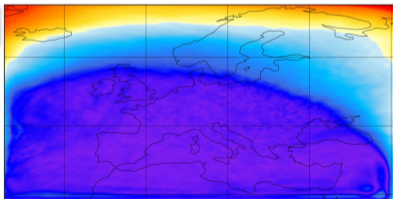
$$\text{RMSE} = \sqrt{\frac{1}{N_{\text{days}}} (x_i - y_i)^2}$$

x_i = reference

y_i = parameter to be scored

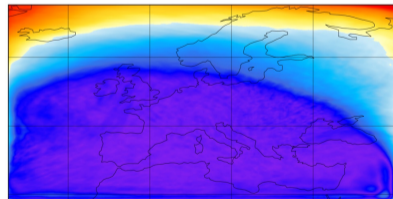
Assimilation Run vs Nature Run

IRS



Assimilation Run vs Nature Run

IRSx2

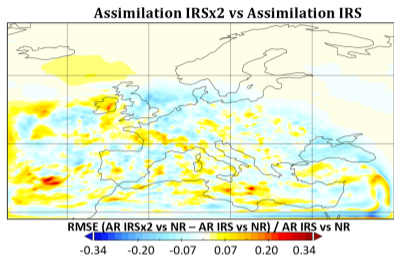


Scores

Average
over time
period

June 2019

Data Min = -0.30
Max = 0.37



Root Mean Square Error

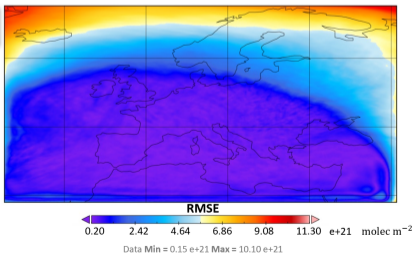
$$\text{RMSE} = \sqrt{\frac{1}{N_{\text{days}}} (x_i - y_i)^2}$$

x_i = reference

y_i = parameter to be scored

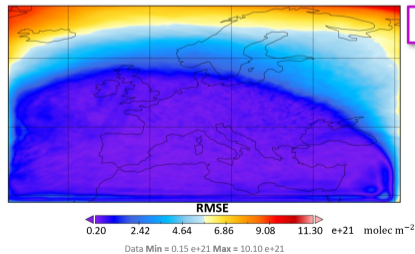
Assimilation Run vs Nature Run

IRS



Assimilation Run vs Nature Run

IRSx2



Conclusions

- **Assimilating radiances from the full ozone band in the MOCAGE model is beneficial in the case of both IRS and IRSx2**

RMSE average values of ozone total column over the domain and the time period

CR vs NR: **8.53 e+21 molec m⁻²** No Assim

AR vs NR: **2.51 e+21 molec m⁻²** Assim IRS

AR vs NR: **2.52 e+21 molec m⁻²** Assim IRSx2

- At this stage, ozone total column has been checked where IRS and IRSx2 show similar average scores. More significant differences are expected to be observed on the next steps

Next Steps

- Focus on specific cases and the specific days of ozone pollution to see if there are significant differences in using IRS or its version with increased resolution
- The study will be extended to other areas of the spectrum sensitive to other chemical species (e.g. CO and SO₂)

Thank you for your attention!

Questions?

Observing System Simulation Experiments (OSSEs)

