Monitoring of atmospheric composition using the thermal infrared IASI/MetOp sounder

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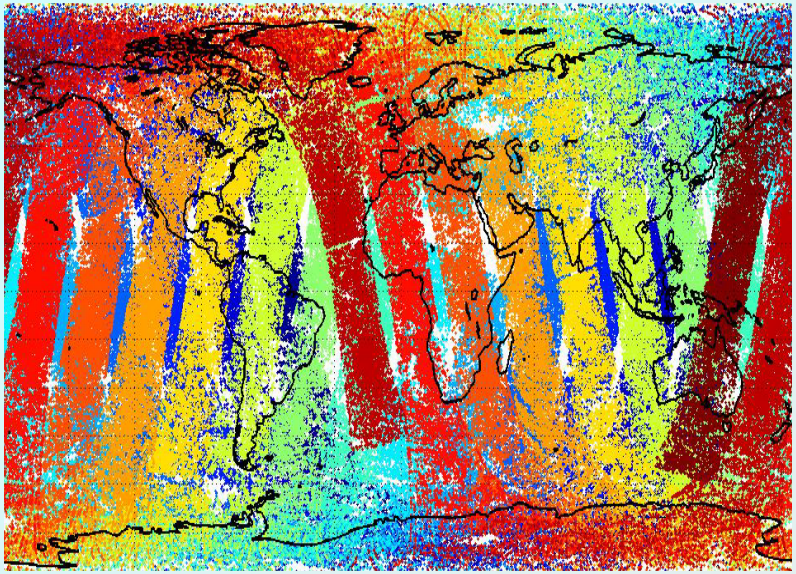
+ 2 oral presentations *+ 6 posters*

Outline

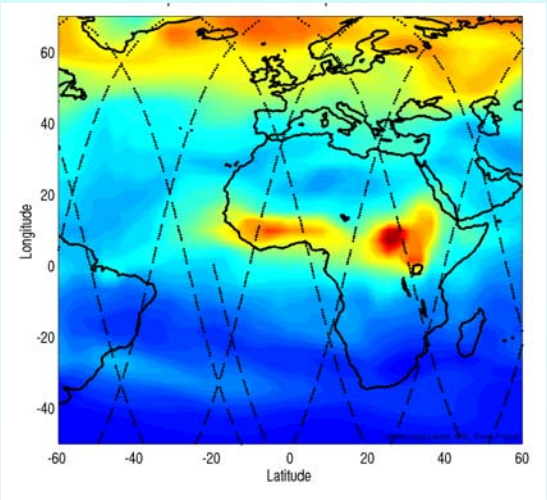
- What is the added value of IASI for tropospheric chemistry ?
- Trace gas retrievals from level 1C radiance spectra
  - Near-real time global distributions of O_3 and CO
  - Profile retrievals for chemistry species : O_3, CO, SO_2
- Conclusions and perspectives

What is the added value of IASI for tropospheric chemistry ? (1/3)

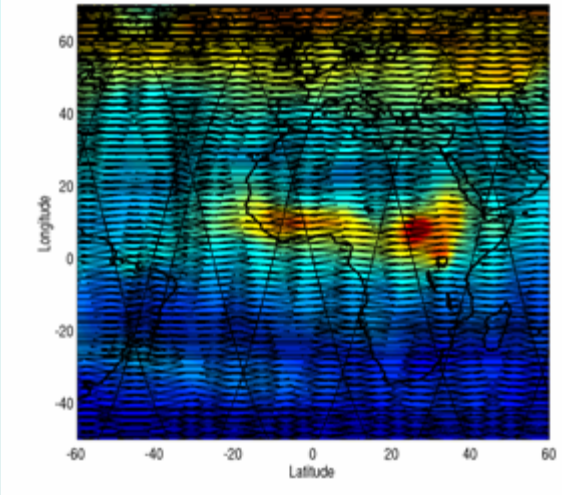
⊕ IASI provides global Earth coverage twice daily, day AND NIGHT

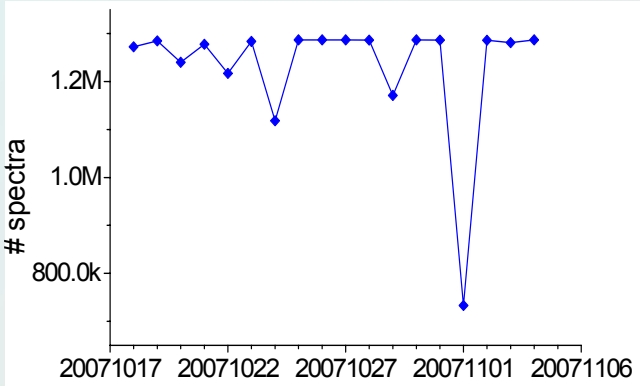


IMG/ADEOS *24h coverage*



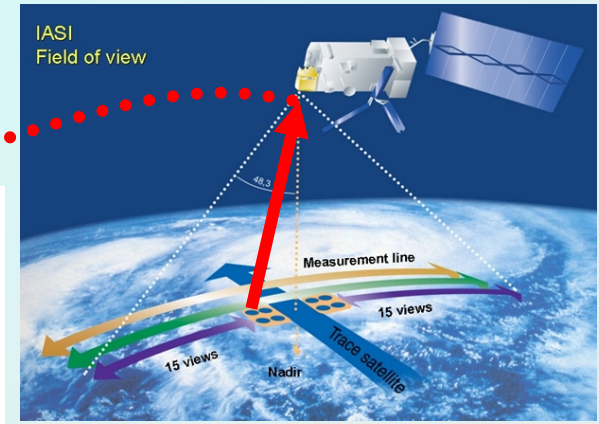
IASI/MetOp *24h coverage*

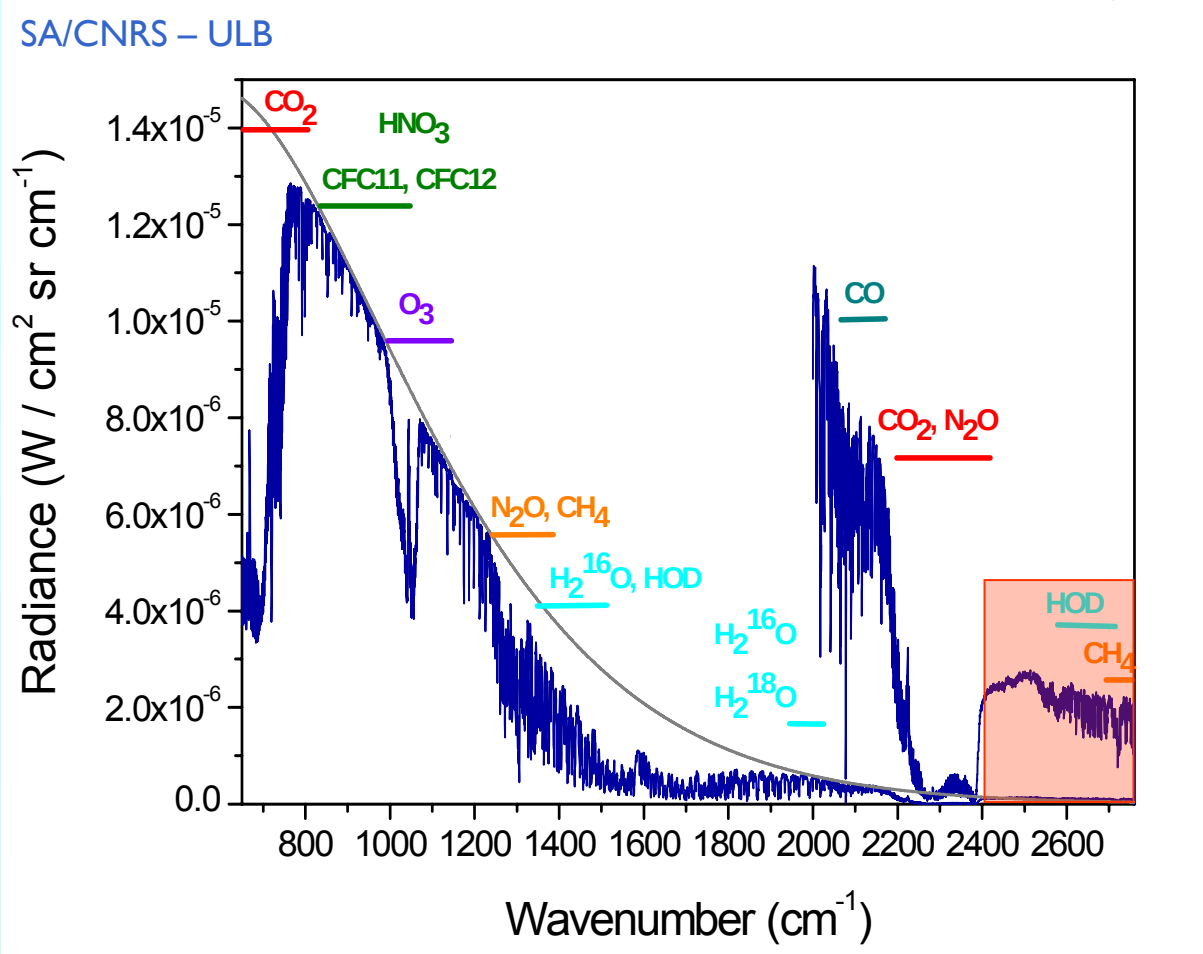




What is the added value of IASI for tropospheric chemistry ? (2/3)

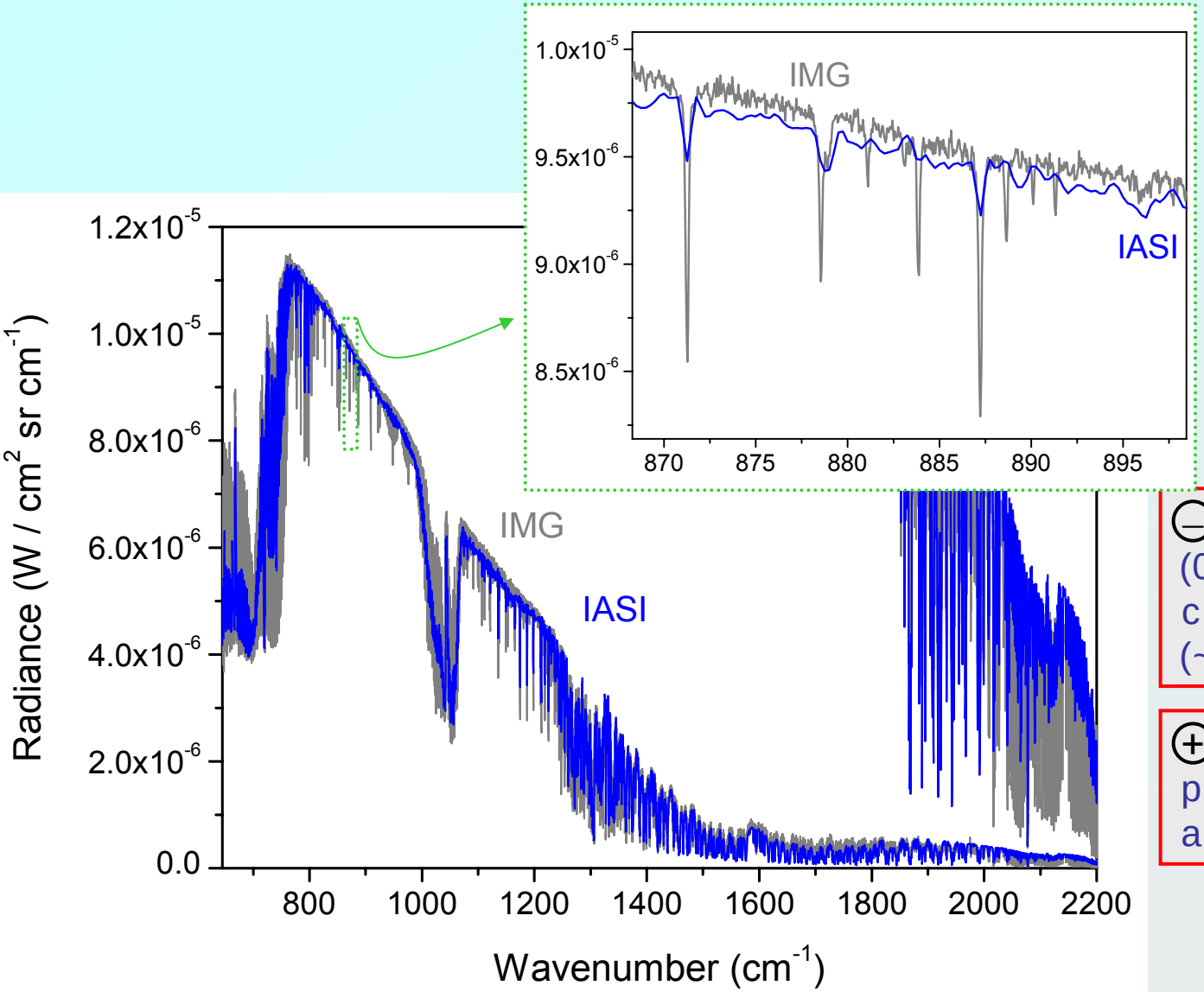
⊕ Broad spectral coverage (645-2760 cm^{-1} without gaps) → simultaneous sounding of many trace gases





⊕ Thermal + reflected solar radiation during daytime → possible improvements on the retrieval performances for CH_4 and HDO

What is the added value of IASI for tropospheric chemistry ? (3/3)



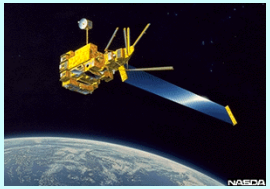
⊖ IASI spectral resolution (0.5 cm^{-1} apodised) is coarser than IMG or TES (~0.1cm^{-1})

⊕ IASI radiometric noise performances are above expectations

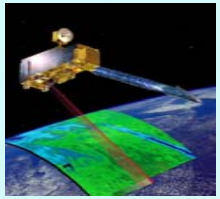
A long story…

1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006

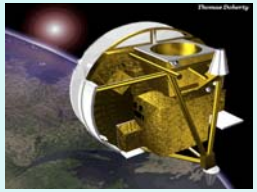
IMG/ADEOS



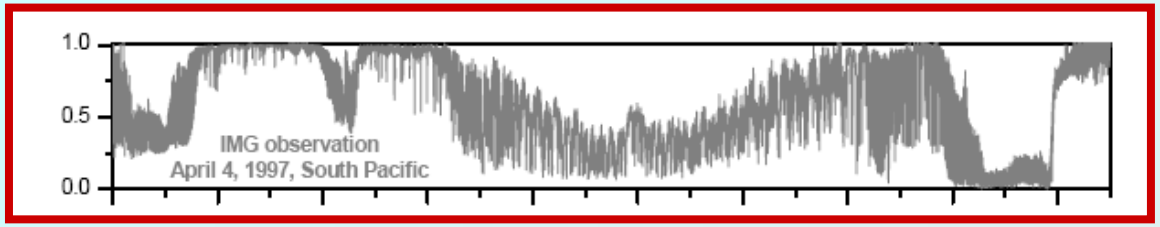
MOPITT/TERRA



ACE/SCISAT



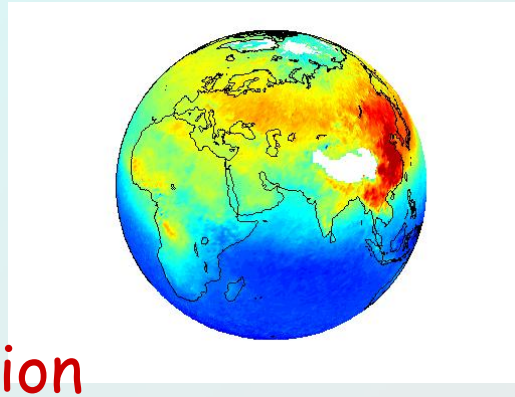
TES/AURA



IASI/MetOp

Retrieval algorithm

Data assimilation



Trace gas retrievals from level 1C radiance spectra

2 complementary tools

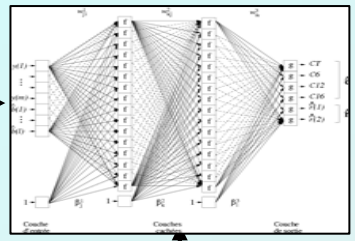
Near real-time (SA-NN)

→ **Columns** CO, CH_4, O_3

Neural network based techniques

inputs

$$\begin{pmatrix} \mathbf{y} \\ \hat{\mathbf{b}} \end{pmatrix}$$



outputs

$$\hat{\mathbf{x}} \Leftrightarrow \mathbf{x}$$

Parameters adjustment

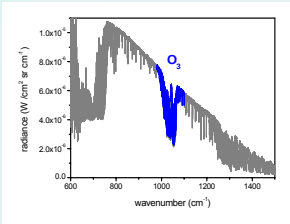
[Hadji-Lazaro et al., 1999; Clerbaux et al., 2001; Turquety et al., 2002, 2004]

Research (Atmosphit)

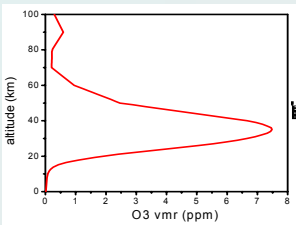
→ **profiles** of any (IR absorbing) species
→ errors
→ averaging kernels

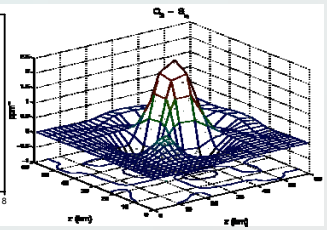
Constrained retrieval: Optimal Estimation theory

measurement



a priori information



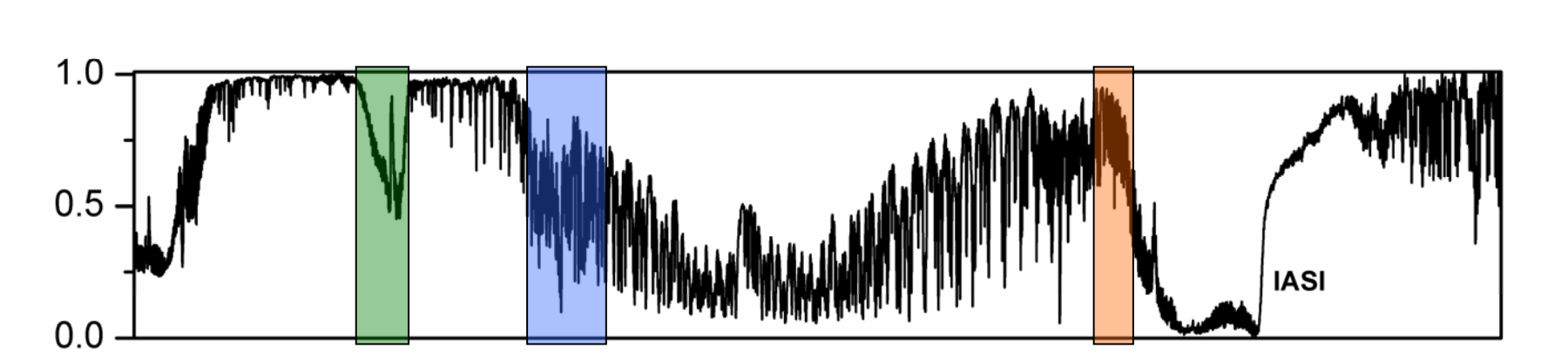


$$\hat{\mathbf{x}} = \mathbf{A}\mathbf{x} + (\mathbf{I} - \mathbf{A})\mathbf{x}_a + \mathbf{G}\boldsymbol{\varepsilon}$$

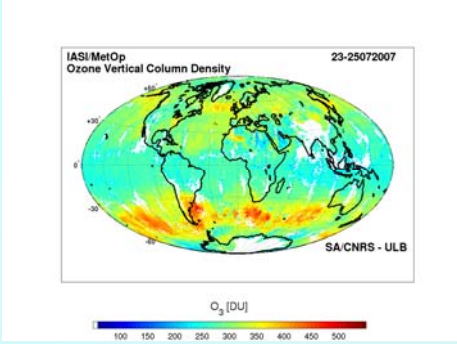
[Coheur et al., 2005; Barret et al., 2005; Wespes et al., 2007; Herbin et al., 2007]

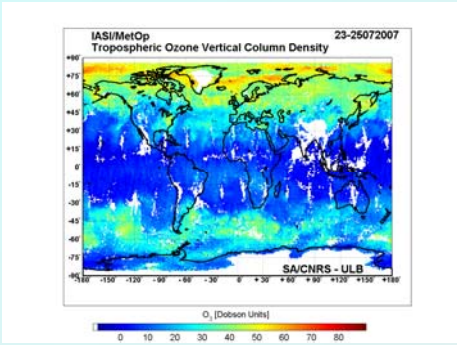
See poster

Trace gas retrievals from level 1C radiance spectra

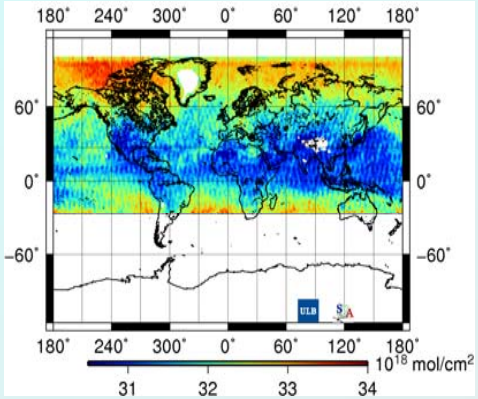


O_3

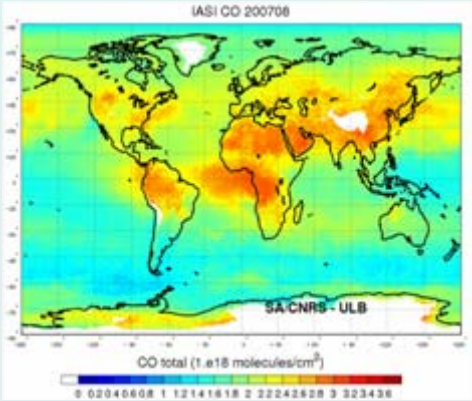




CH_4



CO



Implemented in the Eumetsat ground segment

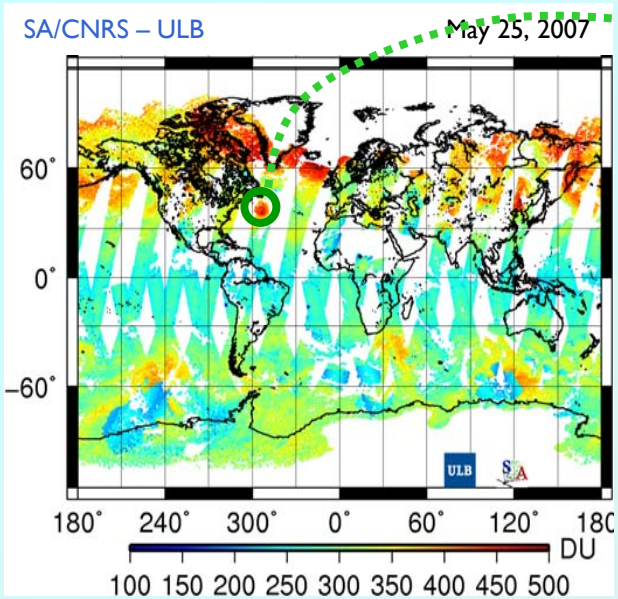
[Turquety et al, JGR 2004]

Trace gas retrievals from level 1C radiance spectra

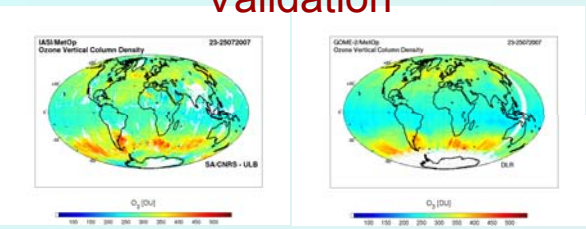
— OZONE —

Complementary information provided by the NRT and offline processing

total columns from SA-NN

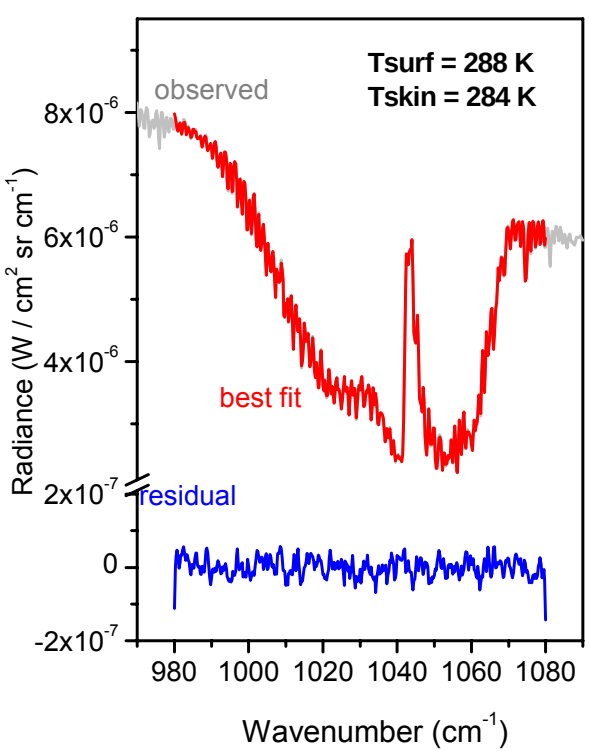


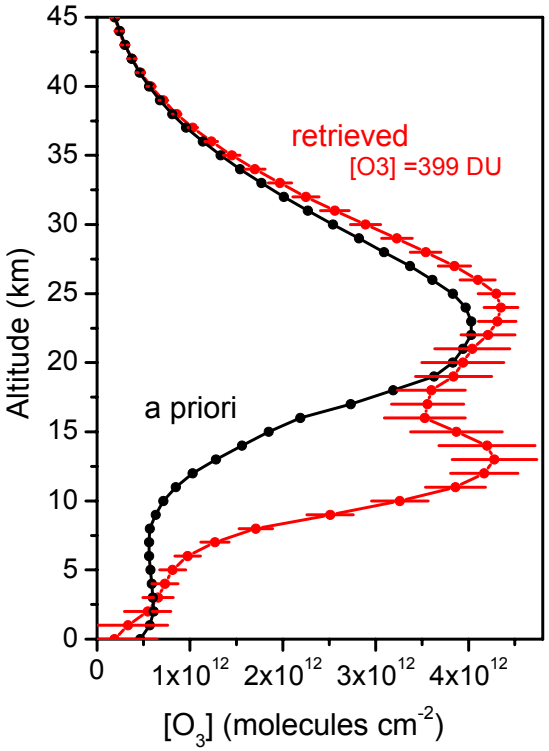
Validation



See poster

Vertical profiles from Atmosphit

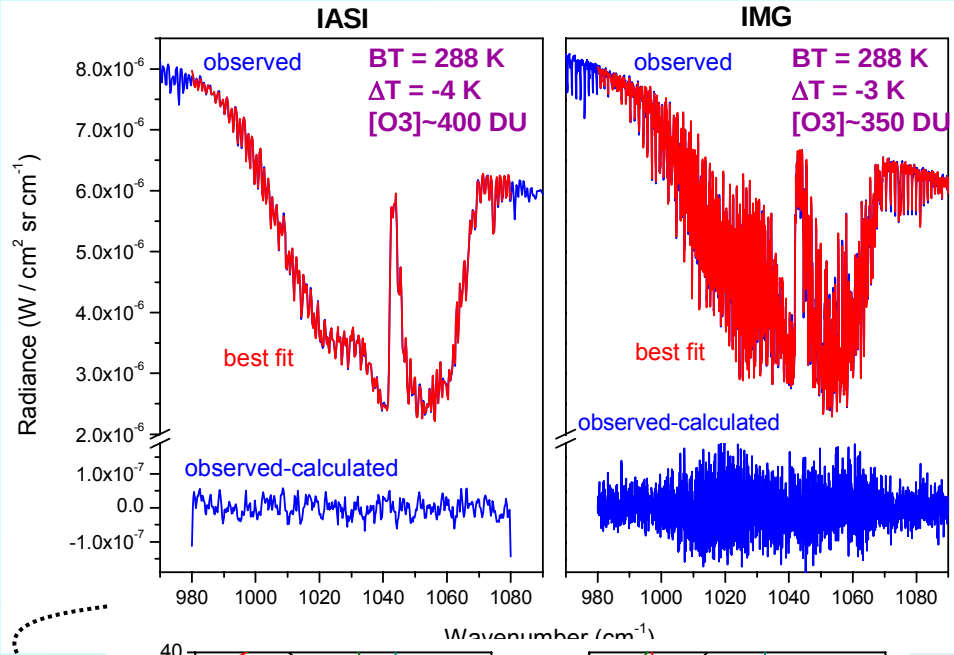


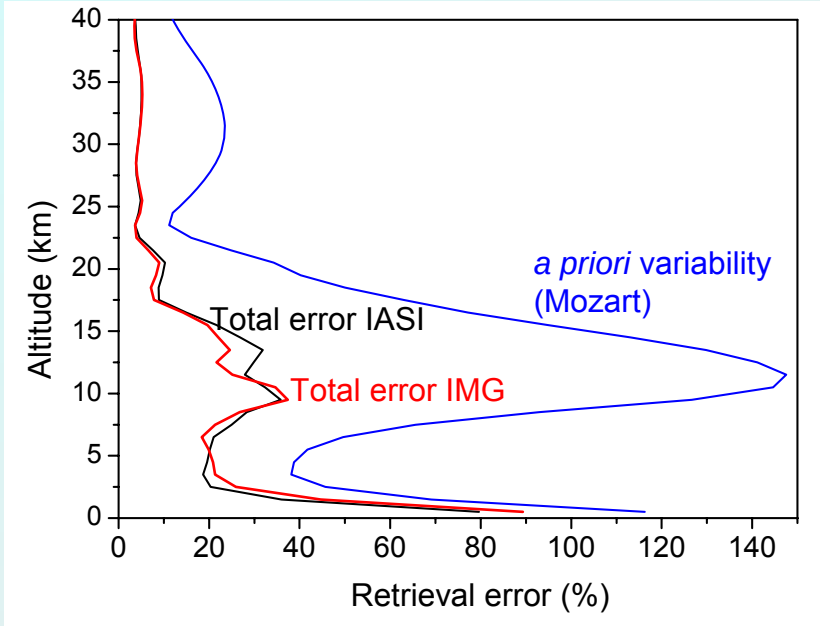


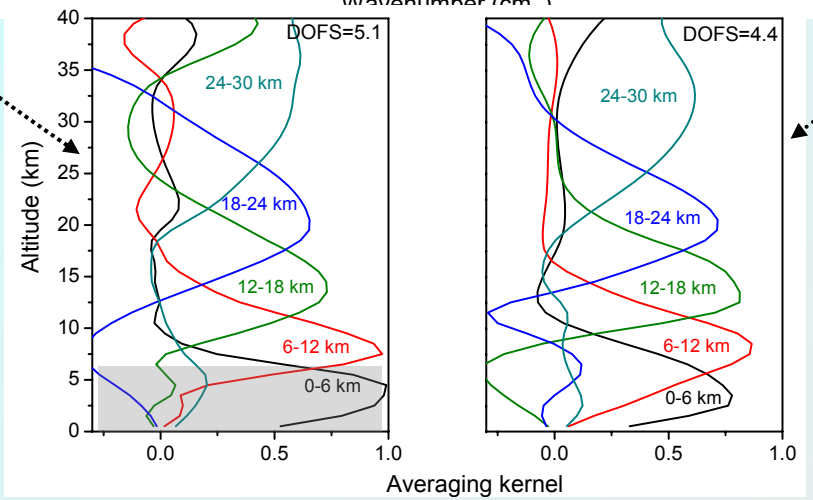
Trace gas retrievals from level 1C radiance spectra

— OZONE —

Retrieval characterization; comparison between IASI and IMG







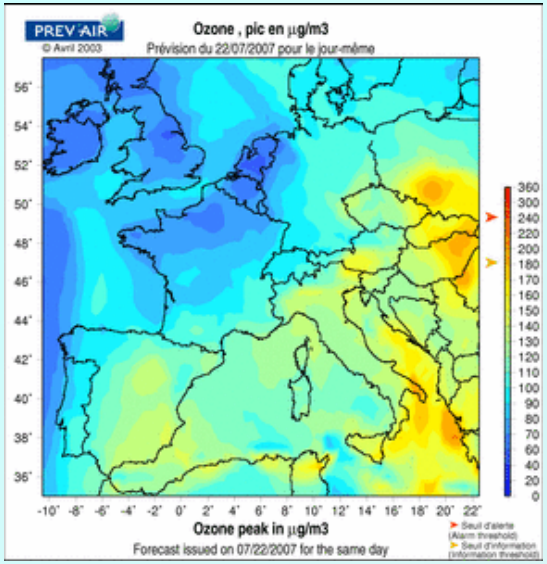
Layers	Total error	*A priori* variability
0 – 6 km	17	48
6 – 12 km	17	105
12 – 18 km	12	89
18 – 24 km	7	27
24 – 30 km	4	17

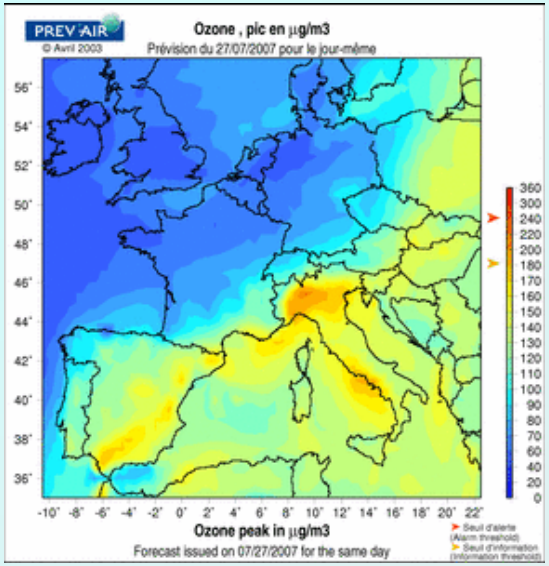
< 10 % error on the tropospheric column

similar performances IMG-IASI

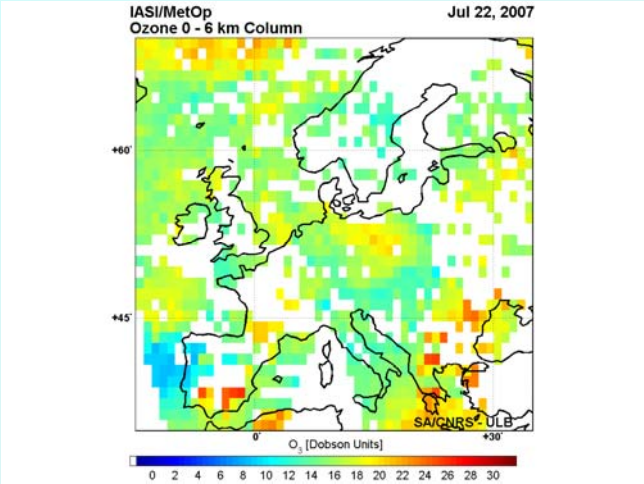
Trace gas retrievals from level 1C radiance spectra

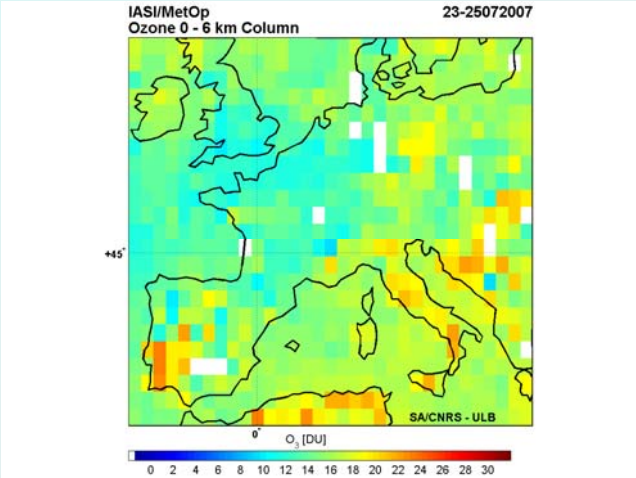
— TROPOSPHERIC OZONE —





See posters



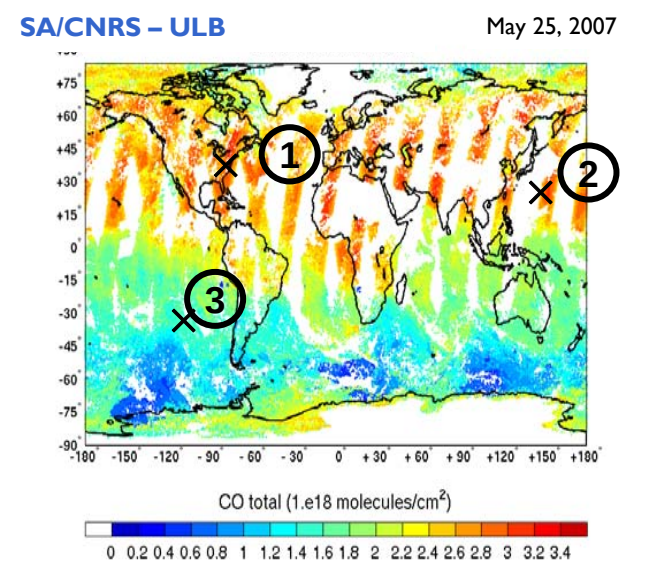


O3-SAF:

GOME2+IASI

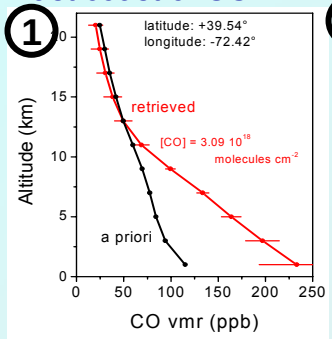
Trace gas retrievals from level 1C radiance spectra

— CARBON MONOXIDE —

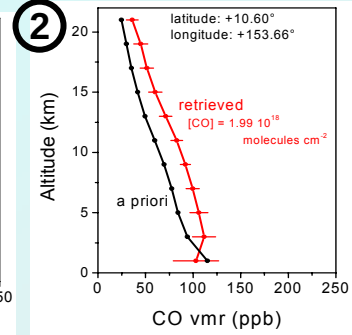


Complementary information provided by the NRT and offline processing

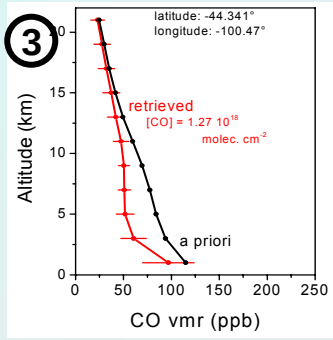
East coast of USA



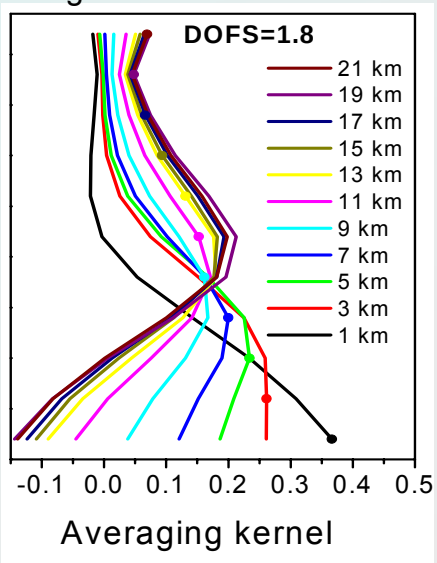
Northern Pacific



Southern Pacific

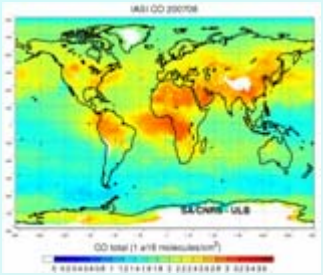


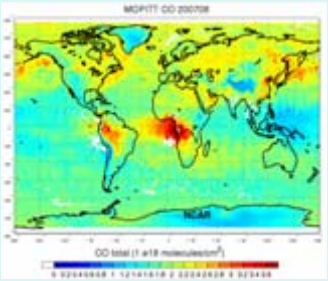
High thermal contrast case



DOFS: 1 to 2

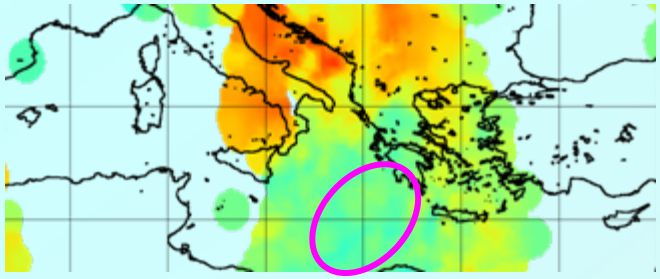
Validation



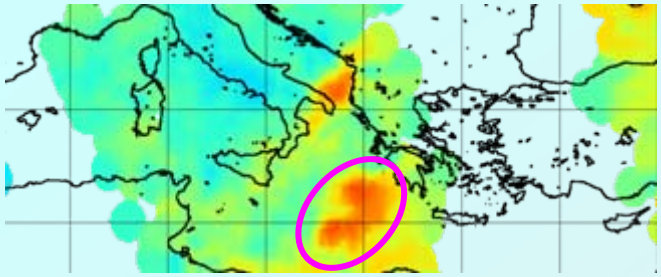


See poster

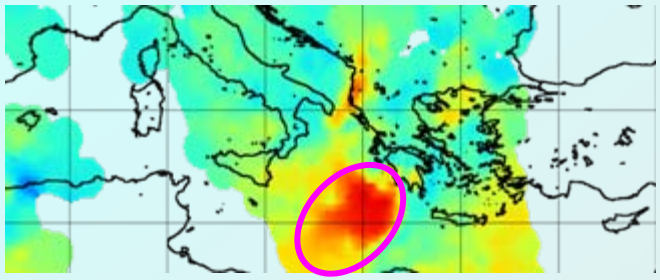
Trace gas retrievals from level 1C radiance spectra



20/08

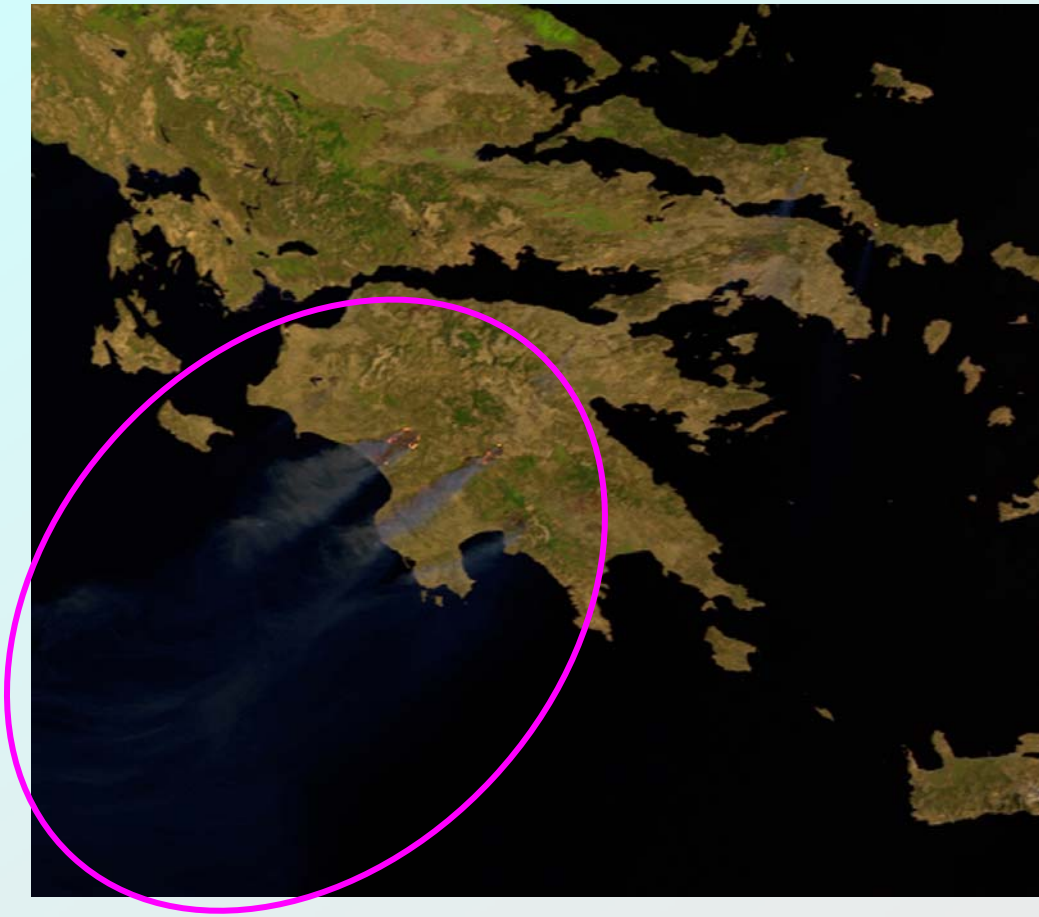


24/08



25/08

— CARBON MONOXIDE —

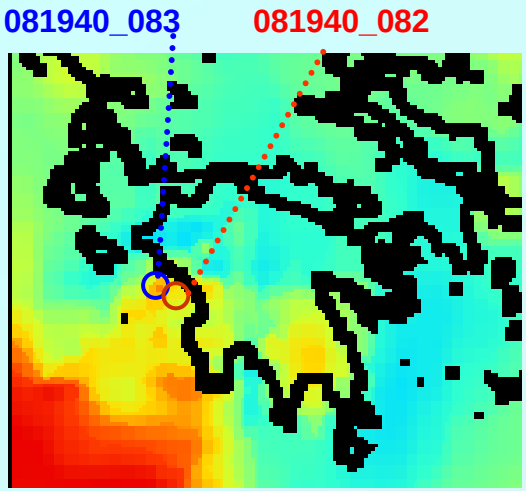


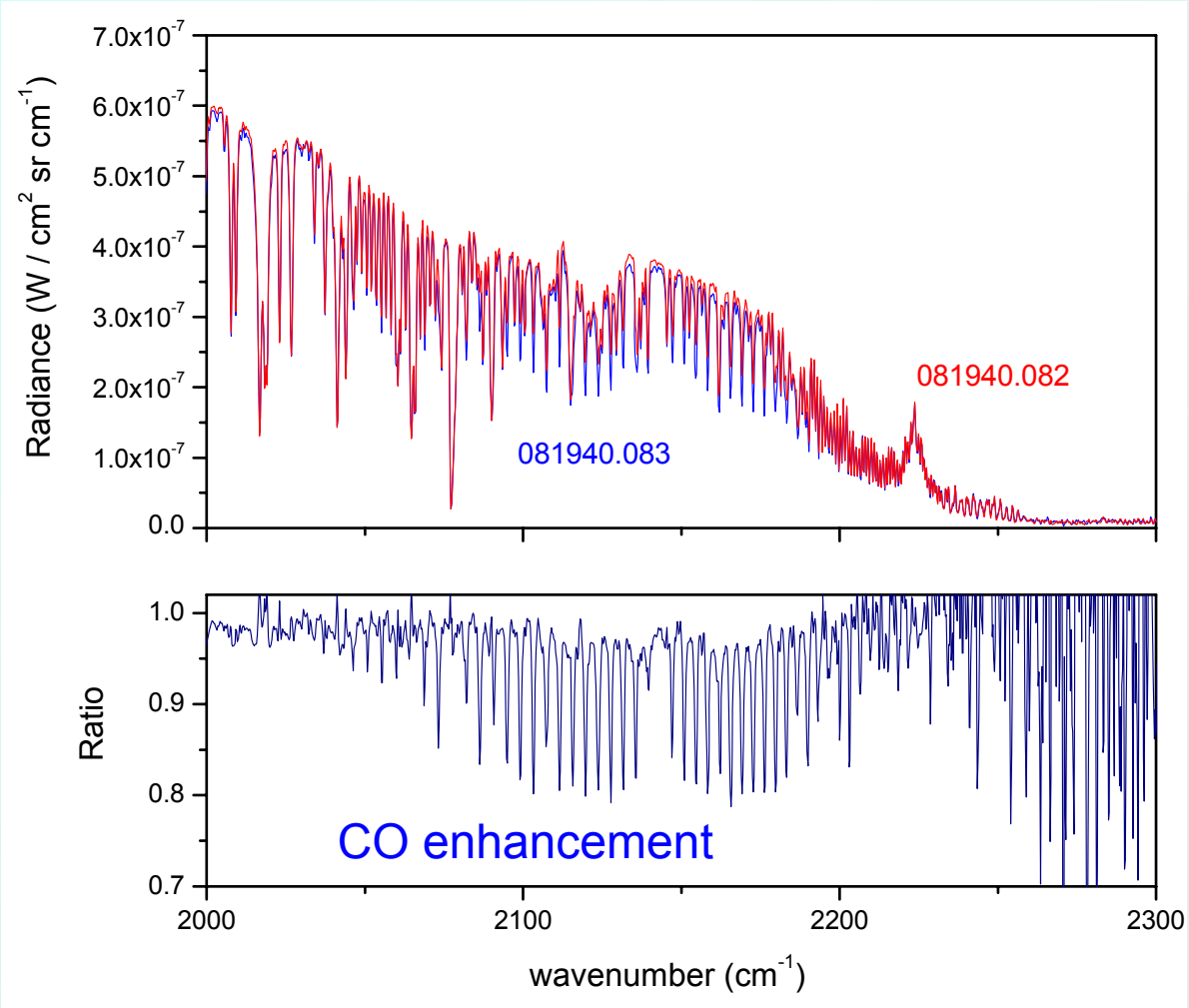
AVHRR 20070825.0955 UTC
(http://www.eumetsat.int/Home/Main/Media/News/030160?l=en)

Trace gas retrievals from level 1C radiance spectra

— CARBON MONOXIDE —

Example of fires in Greece, August 2007



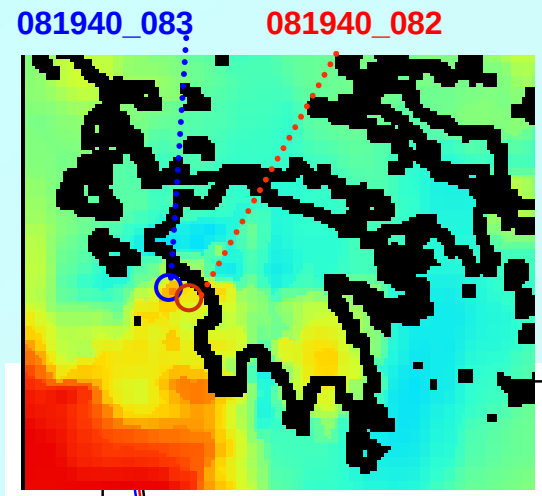


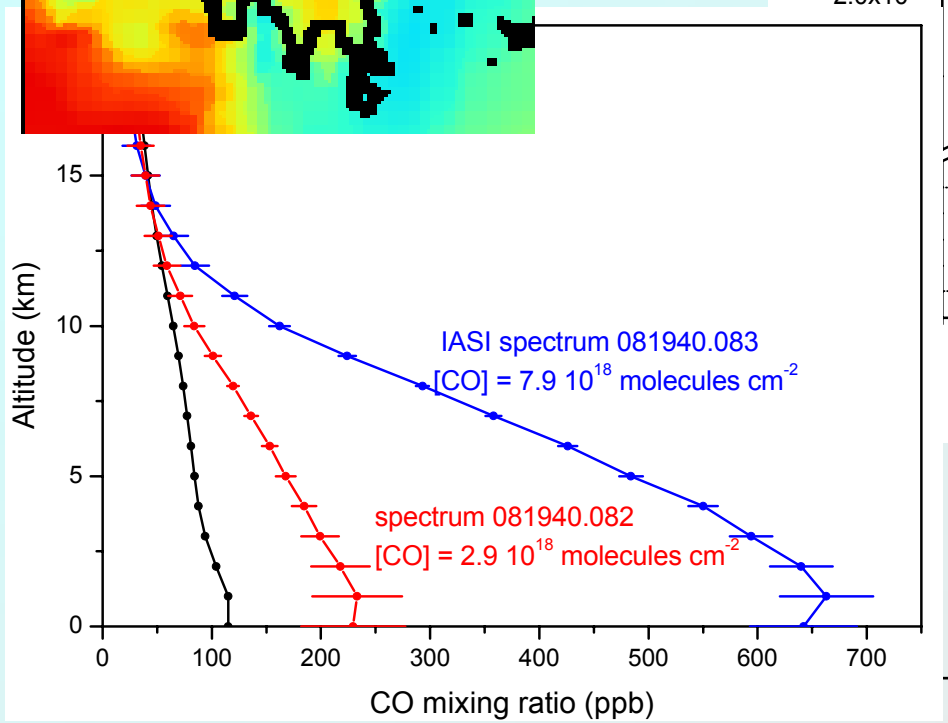
"Fine scale" composition variations within the plume are captured

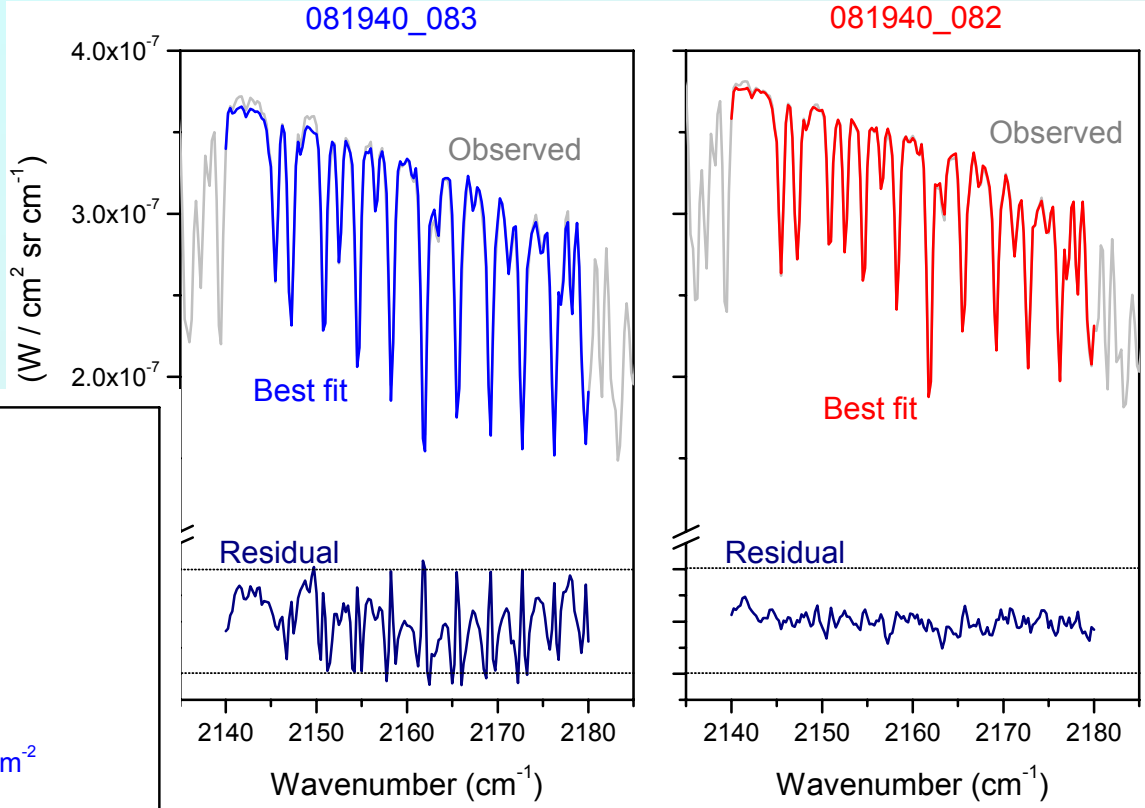
Trace gas retrievals from level 1C radiance spectra

— CARBON MONOXIDE —

Example of fires in Greece, August 2007



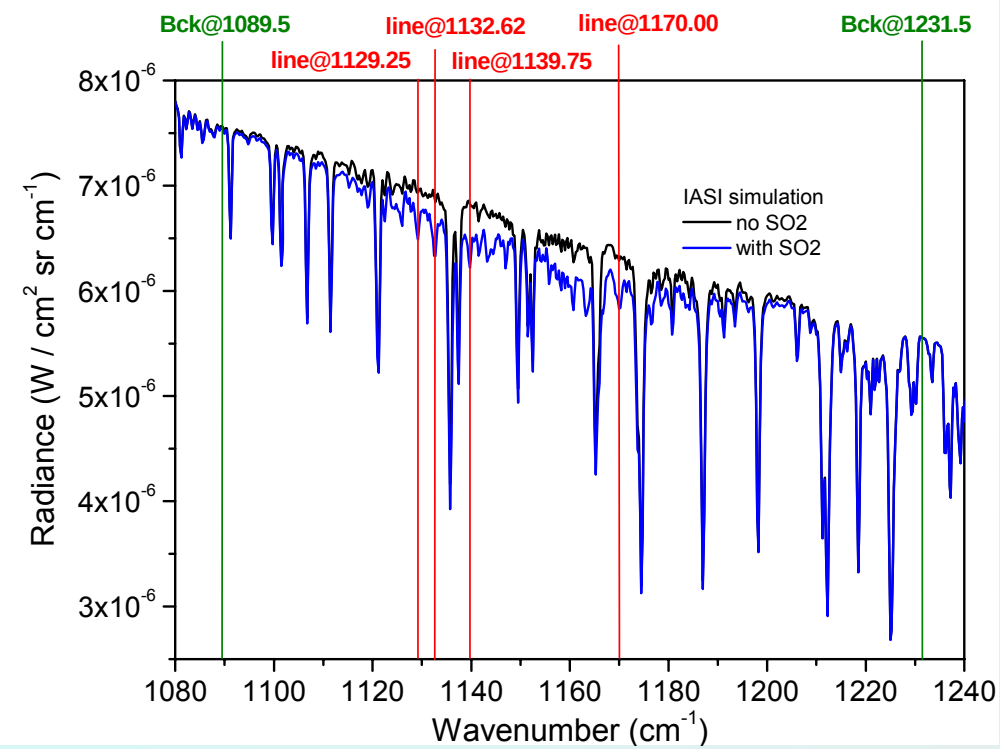




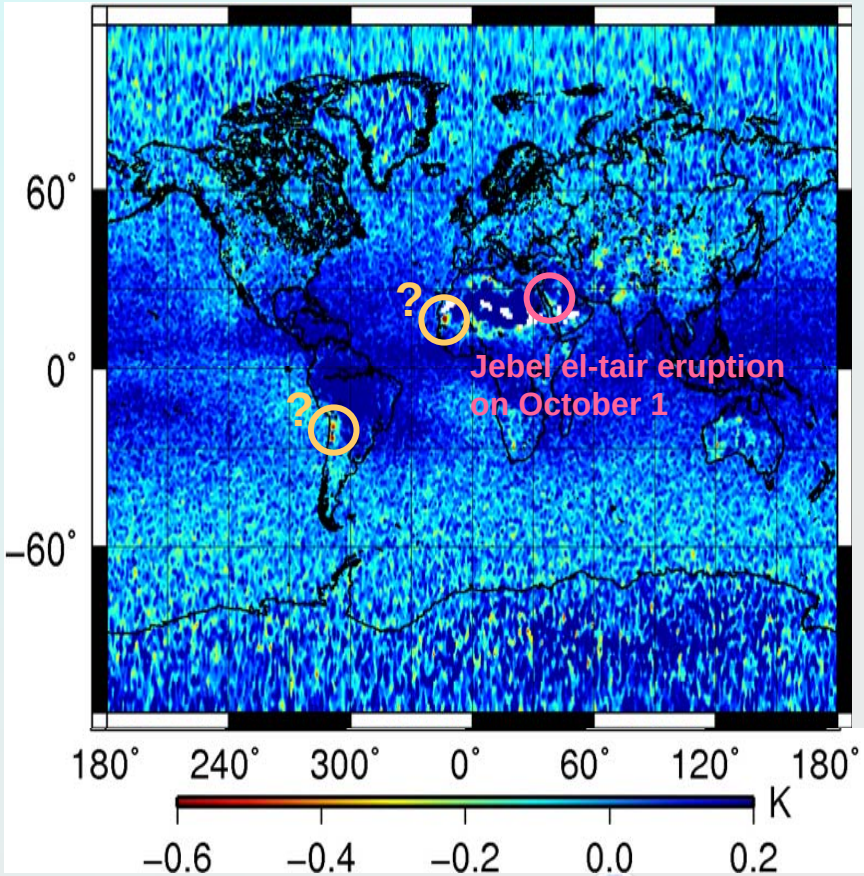
Trace gas retrievals from level 1C radiance spectra

— SULFUR DIOXIDE —

SO_2 NRT detection criteria based on brightness temperature difference (ΔT) in ν_1



ΔT averaged for October 2007

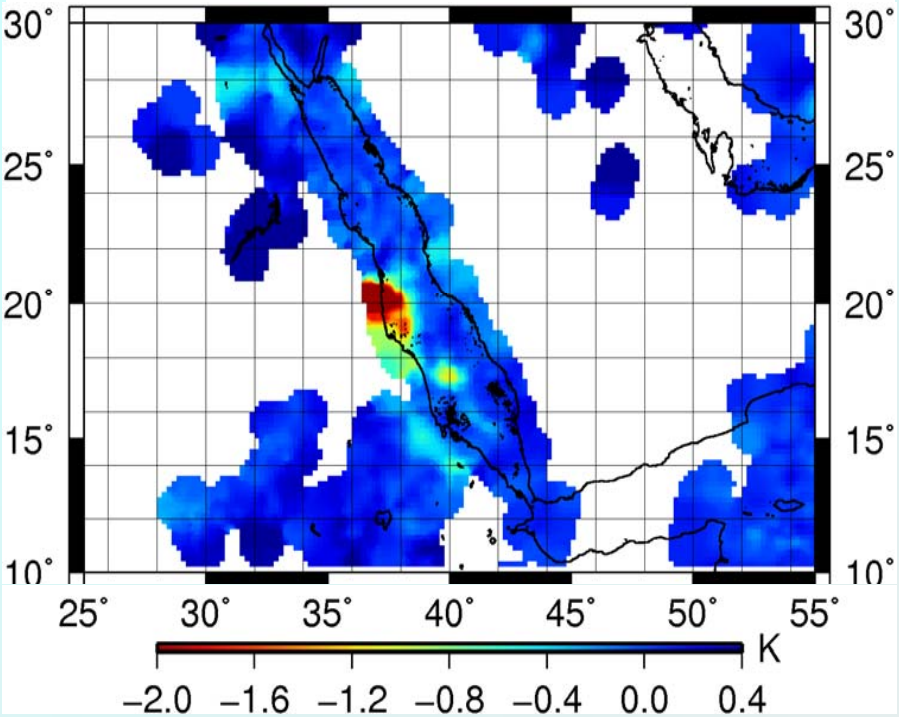


Trace gas retrievals from level 1C radiance spectra

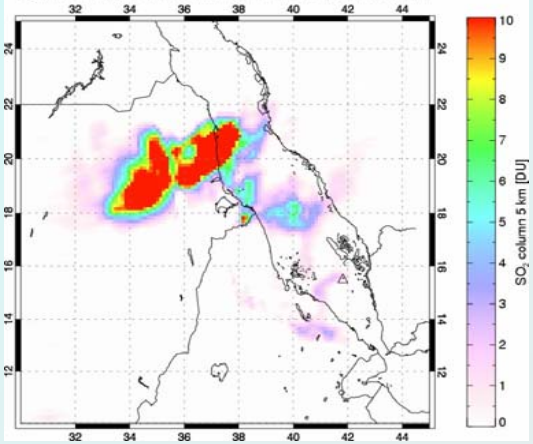
— SULFUR DIOXIDE —

Jebel at-Tair eruption, October 1, 2007

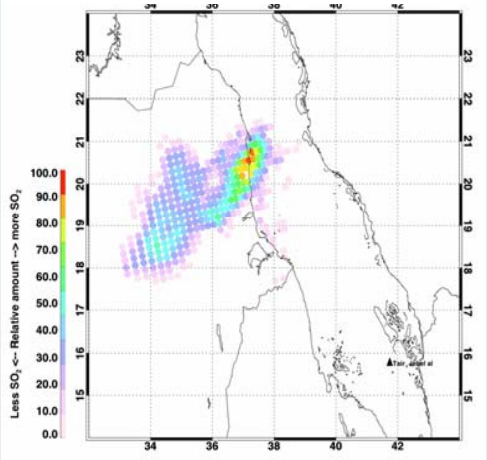
IASI ~7:18 UTC



OMI ~11:00 UTC



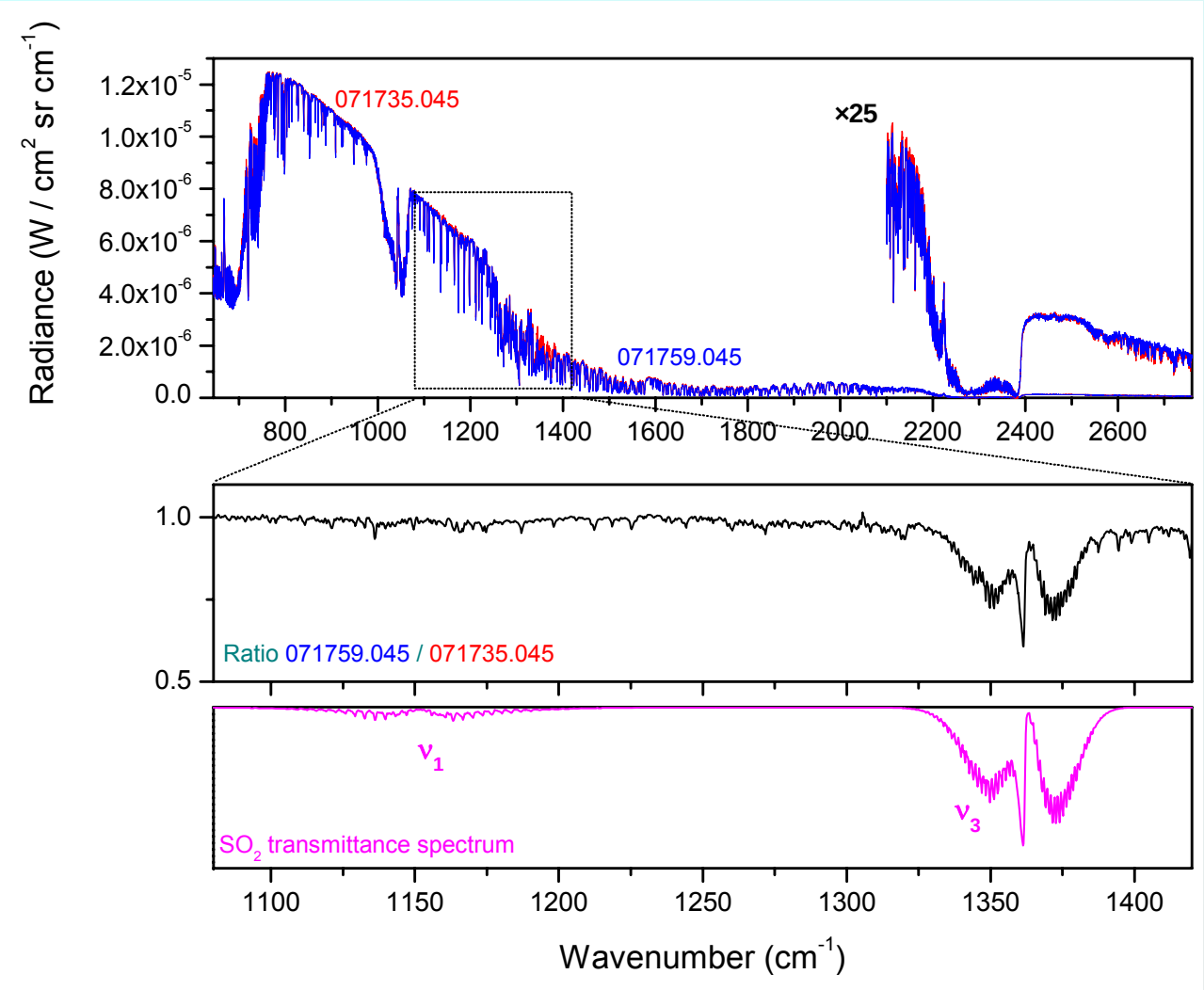
AIRS

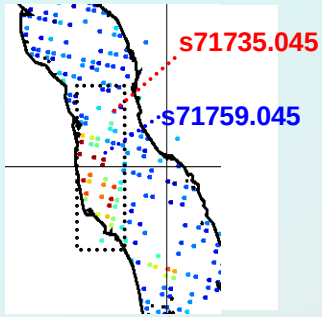


Trace gas retrievals from level 1C radiance spectra

— SULFUR DIOXIDE —

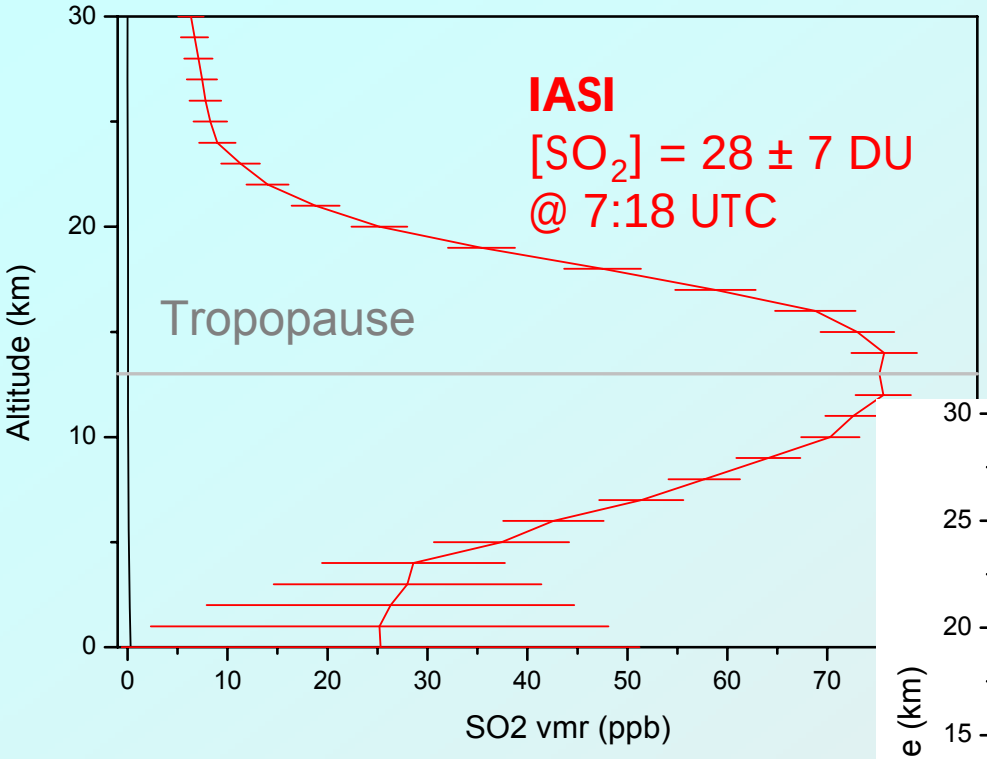
Jebel at-Tair eruption, October 1, 2007





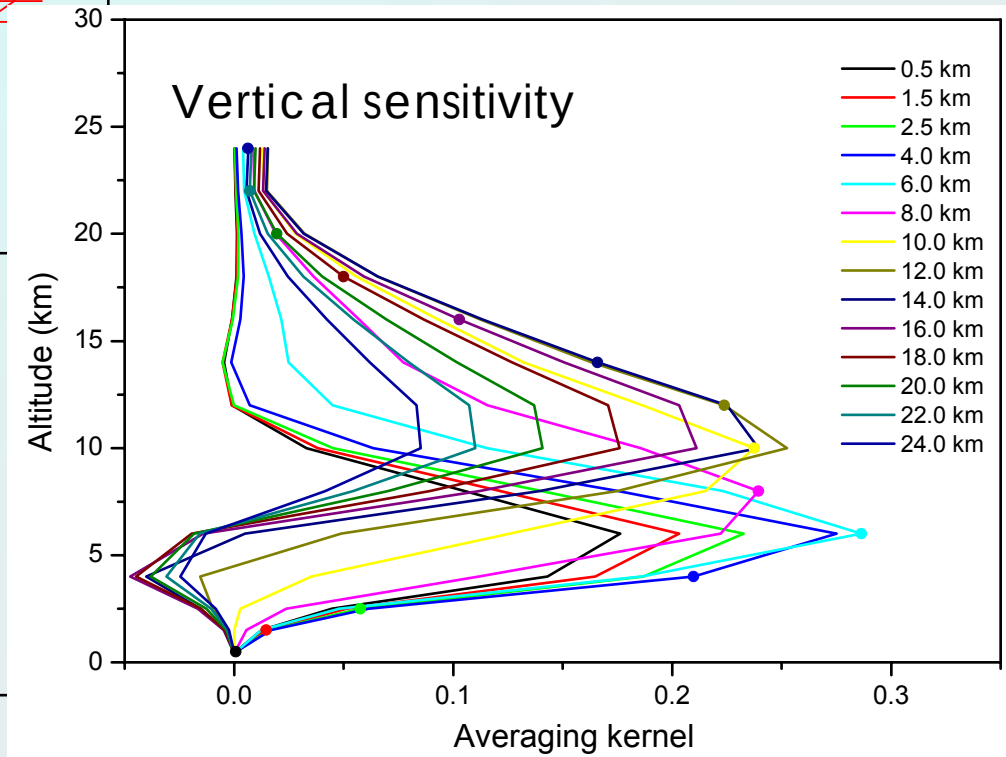
Trace gas retrievals from level 1C radiance spectra

— SULFUR DIOXIDE —



~SCIAMACHY
20 DU @ 12:30 UTC

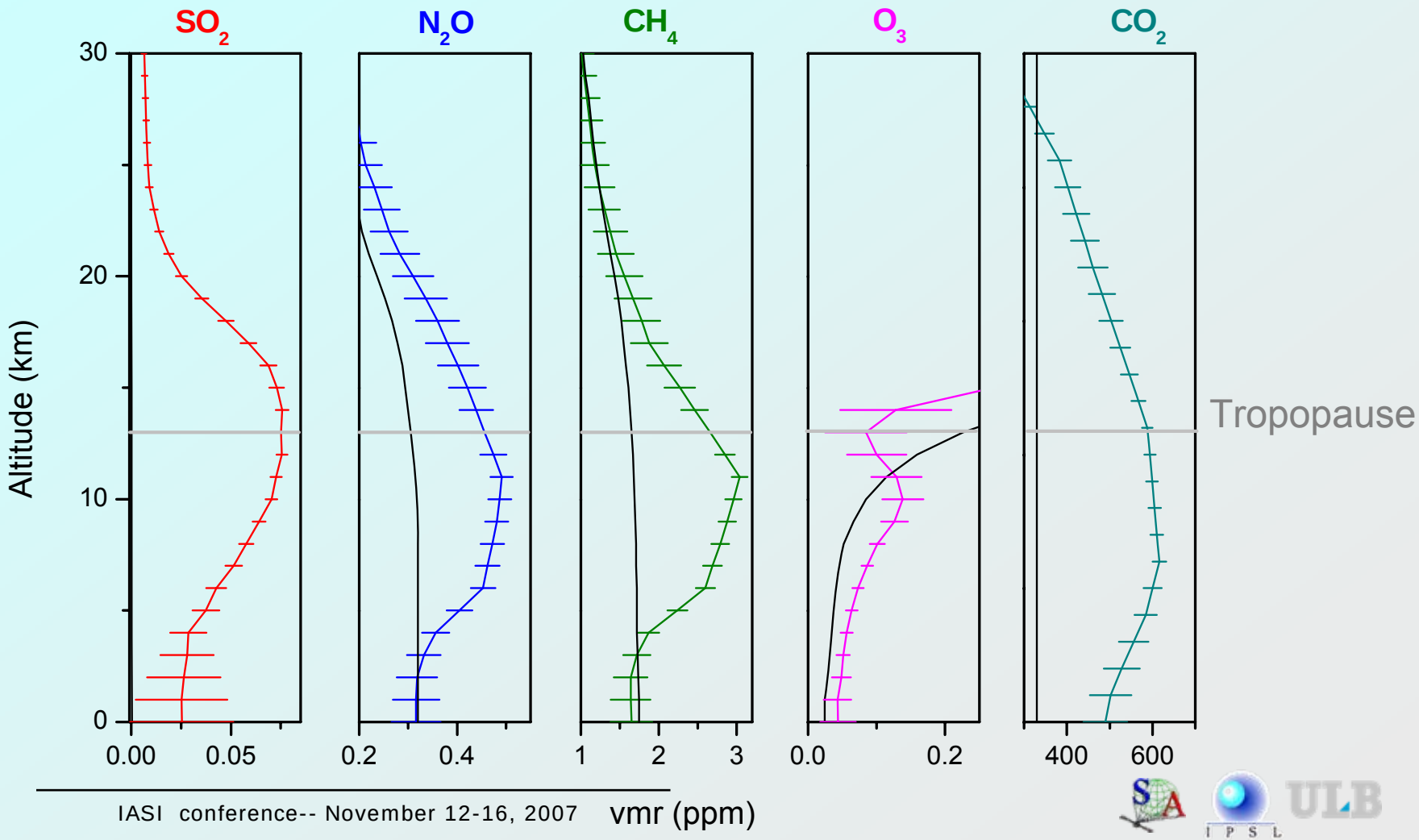
<OMI
35 DU @ 10:56 UTC



Trace gas retrievals from level 1C radiance spectra

— SULFUR DIOXIDE —

Correlation with other species



Conclusions and perspectives

IASI spectra seem of very high quality

- level 1C received operationally since May 2007 (> 1.0 10^6 spectra daily)
- level 2 (P, T, clouds) received operationally since September 2007

NRT processing

- O_3, CO columns and O_3 partial columns provided in NRT using the SA-Neural Network algorithm
- Preliminary comparisons with other space-based instruments show good agreement
- Some problems have been identified and need to be fixed (e.g. emissivity above desert)

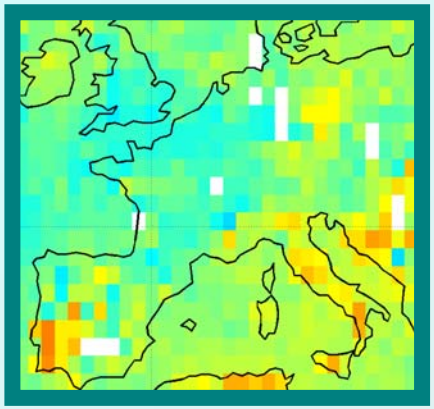
Current research processing

- O_3, CO profile with similar accuracy and vertical resolution than other sounders (to be confirmed on larger scale)
- CH_4 profiles using either ν_4 or ν_4 and ν_3 bands to increase sensitivity to the ground
- HNO_3 total columns
- Volcanic SO_2
- Water isotopologues
- Others (CFCs, OCS)

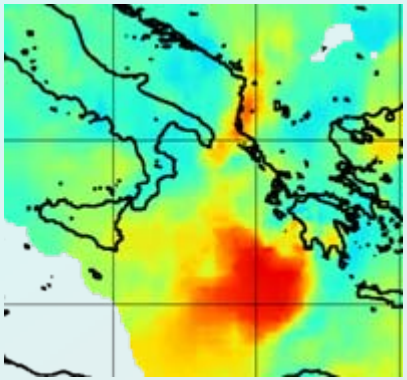
Conclusions and perspectives

Towards operational applications – GMES

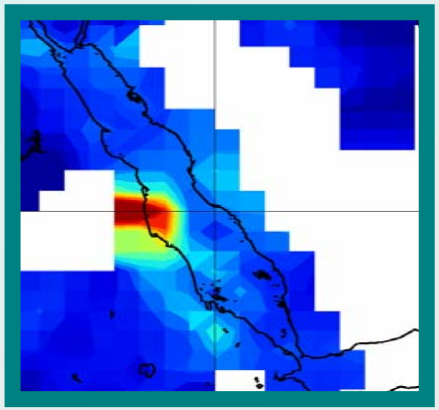
2006 MetOp (IASI/GOME) **2020**



Ozone SAF
EU FP7 CityZen



IPY - Polarcat



Volcanic threat