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

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Outline

- IASI instrument and status

- Monitoring of atmospheric composition and dynamics:

- H_2O and isotopes

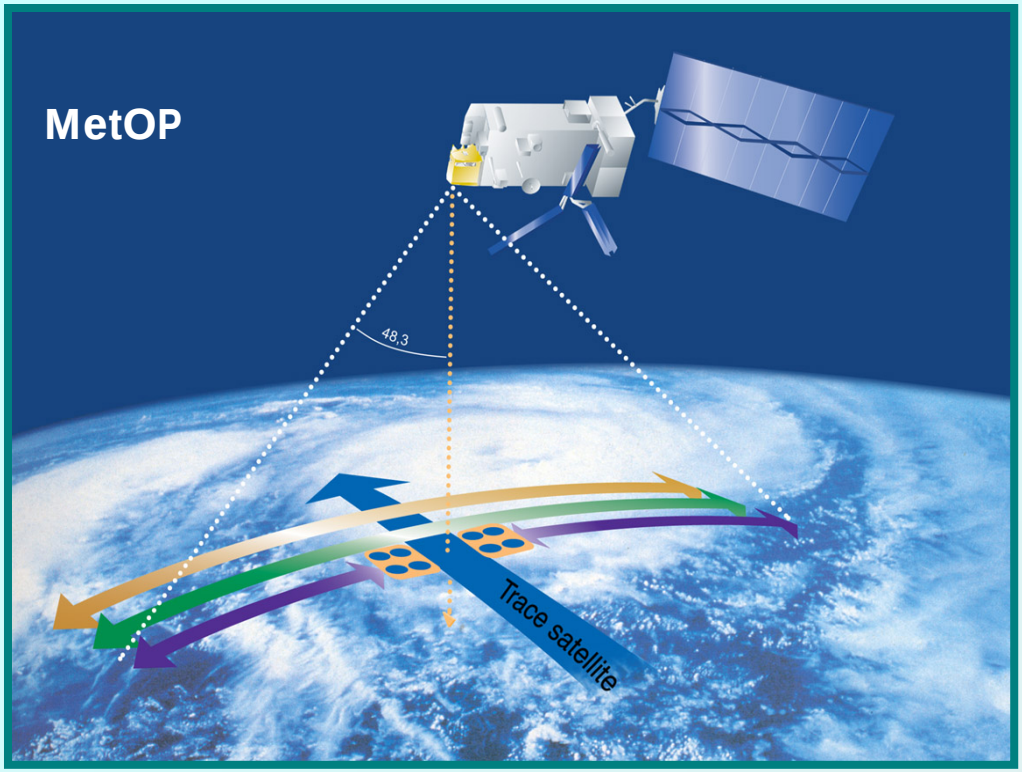
- Trace gases retrieval strato : O_3, HNO_3

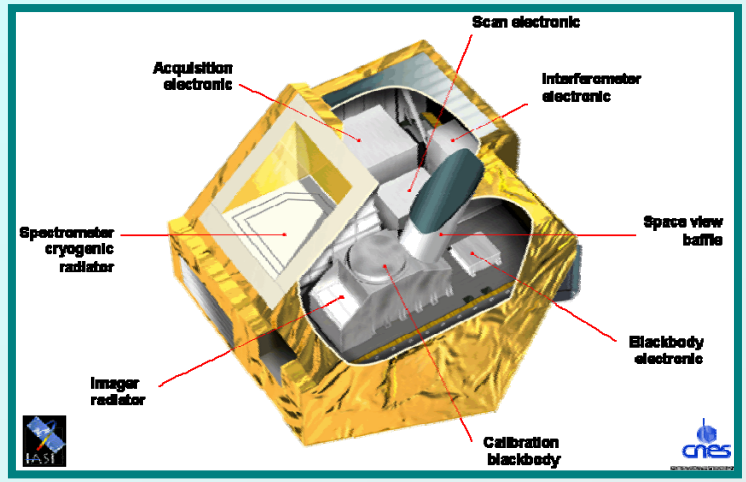
- Trace gases retrieval tropo : O_3, CH_4, CO

- Operational services (O_3 pollution peaks, fires: CO + other molecules, volcanoes: SO_2)

- Perspectives

IASI instrument





Nadir looking FTS

12 km pixel x 4 @ nadir
+ scanning = +/- 48.3°

Spectral coverage = 645-2760 cm^{-1}
Spectral resolution = 0.5 cm^{-1}
Radiometric noise ~ 0.25-0.5 K

Priorities:

Numerical Weather Predictions

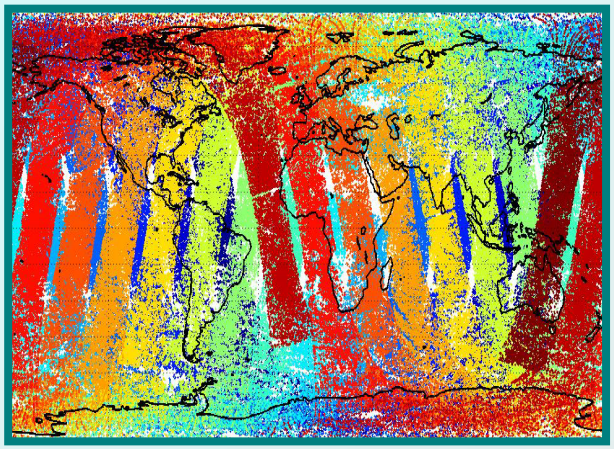
Temperature and humidity profiles each kilometer in the troposphere, (1 K, 10 % accuracy)

Tropospheric chemistry and climate

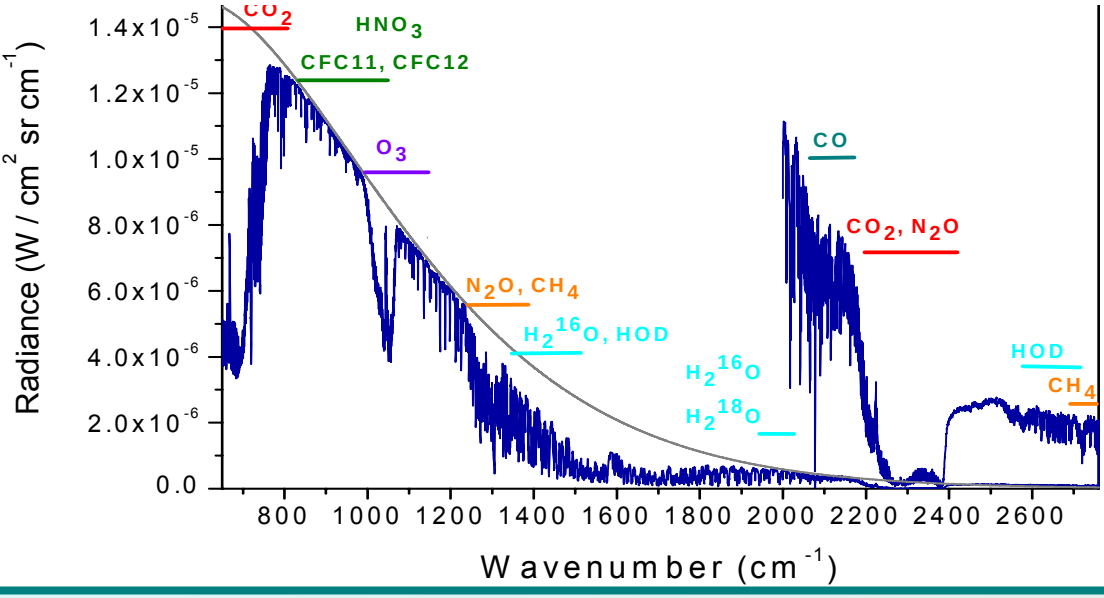
Integrated concentrations or vertical profiles for a series of target trace gases

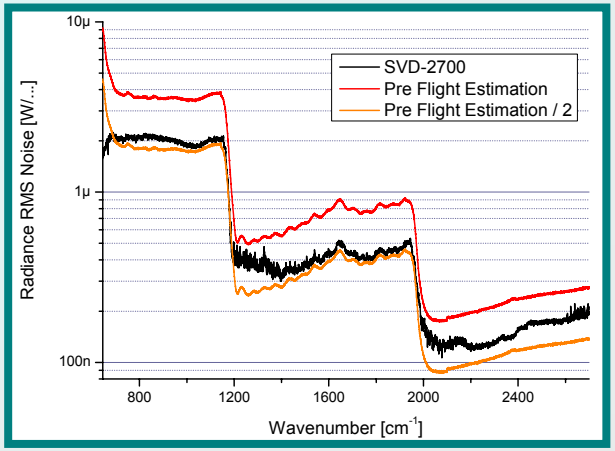
IASI timeline, data rate and performance

→ Oct. 19, 2006	MetOp-A launch
→ Nov. 29, 2006	First spectra
→ Jun. 4, 2007	L1C Operational dissemination (Eumetcast)
→ Sep. 27, 2007	L2 (P, T, clouds) operational dissimination
→ Mar. 1, 2008	L2 (trace gases) operational dissimination



SA/CNRS – ULB

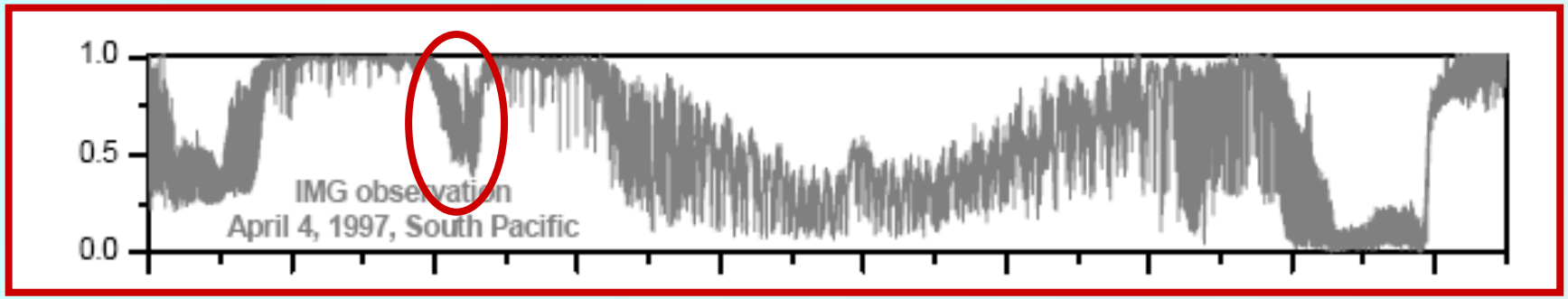




120 spectra along the swath (2400 km)
Each 50 km along the trace

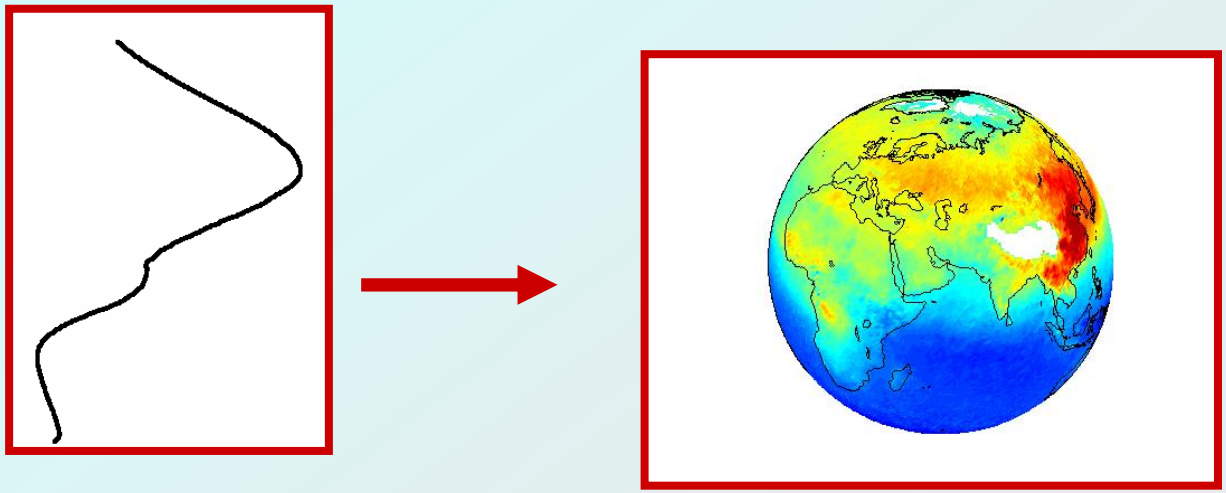
SNR: ~ 1000 in the O_3 9.7 µm band
~ 500 in the CO 1-0 band

> Up to 1.3 10^6 spectra/day (16Gb)



Retrieval algorithm

$$\hat{\mathbf{x}} = \mathrm{R}(\mathbf{y}, \hat{\mathbf{b}}, \mathbf{x}_a) = \mathrm{R}(\mathrm{f}(\mathbf{x}, \mathbf{b}) + \boldsymbol{\varepsilon}, \hat{\mathbf{b}}, \mathbf{x}_a)$$



Concentration + Averaging kernel + var-cov_error

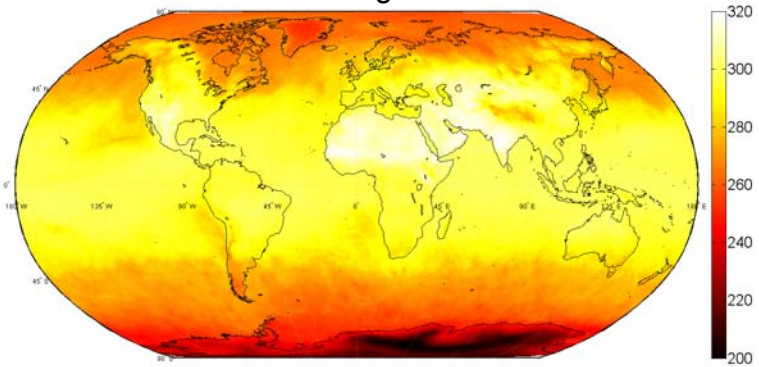
Operational Mode : **SA-NN, Fast-CO**

Research Mode : **Atmosphit**

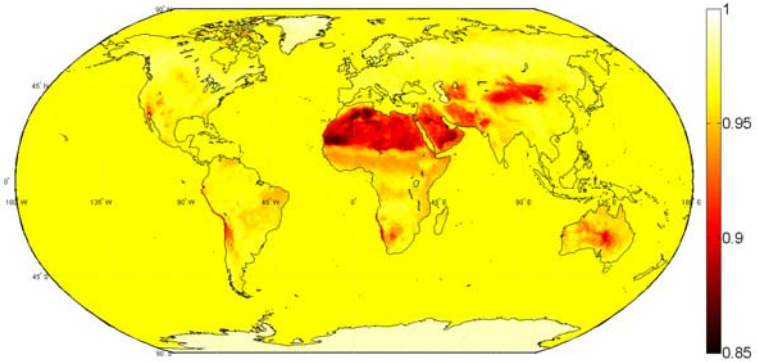
Thermal contrast with IASI

Monthly average, morning orbit

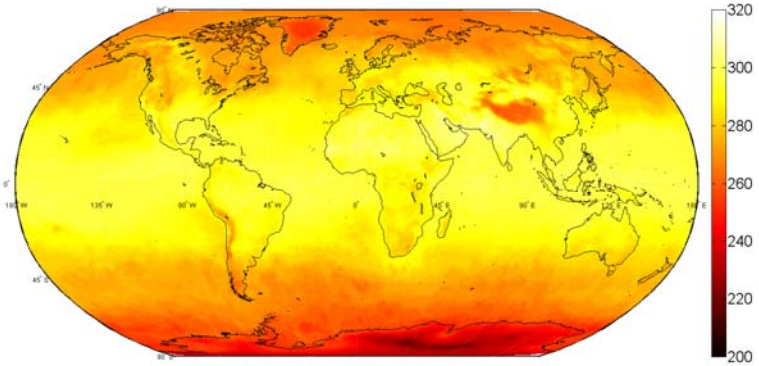
Skin Temperature T_s



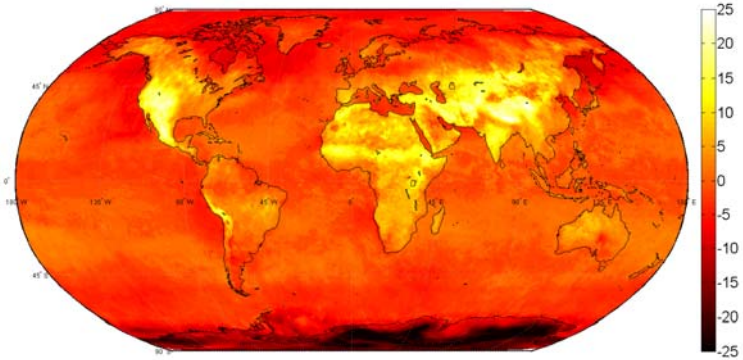
Emissivity (AURA data)



Atmospheric temperature L2 Eumetsat



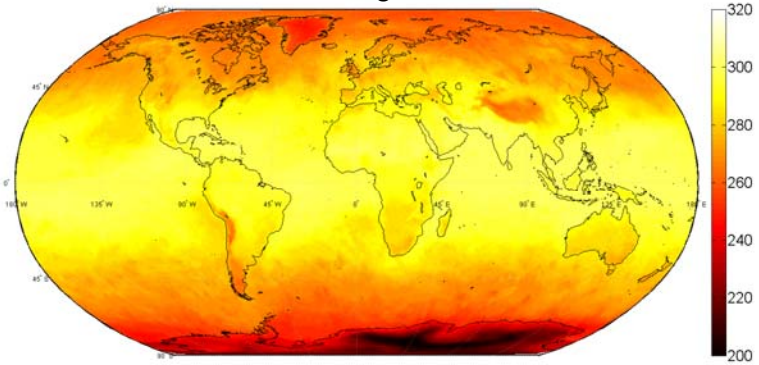
Thermal contrast



Thermal contrast with IASI

Monthly average, evening orbit

Skin Temperature T_s



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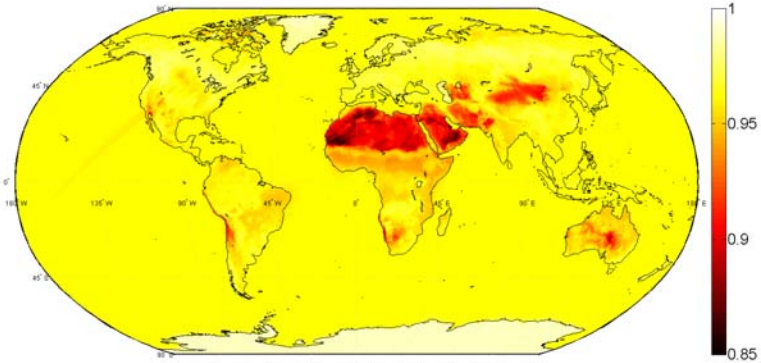
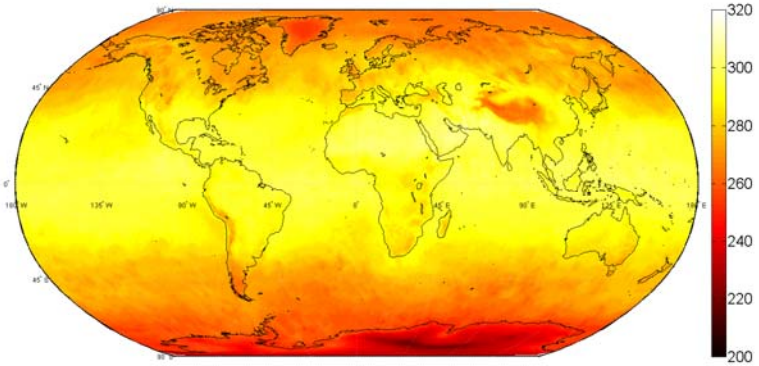
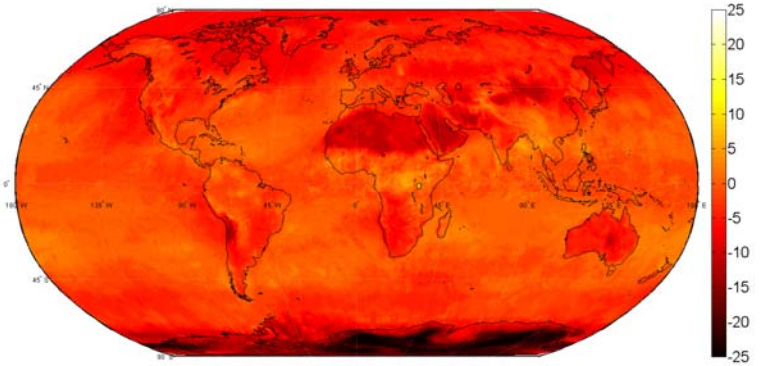


Atmospheric temperature L2 Eumetcat

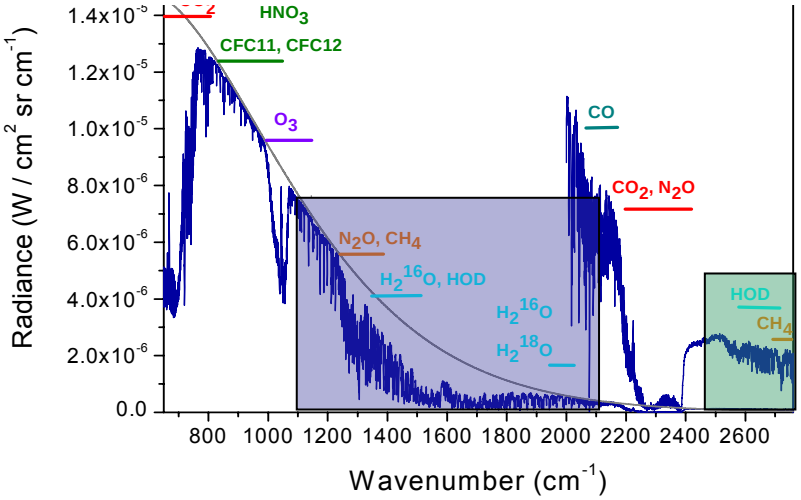


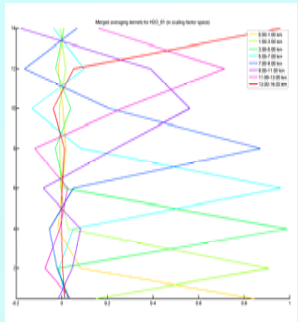
Thermal contrast



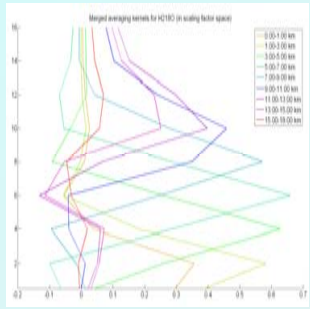
H_2O and isotopologues

SA/CNRS – ULB

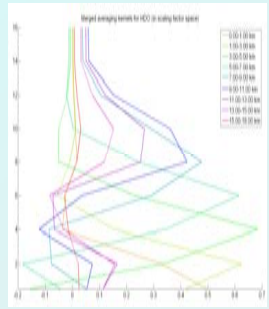




$H_2{}^{16}O$, DOFs > 6



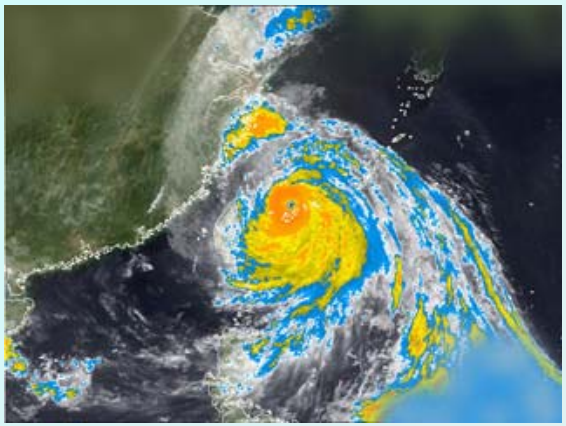
$H_2{}^{18}O$, DOFs > 3



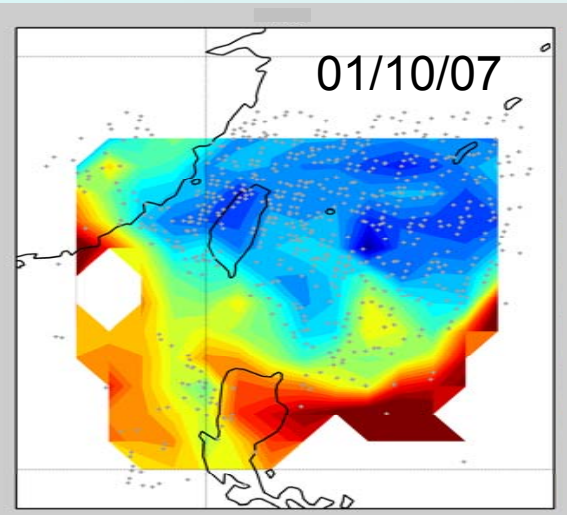
HDO, DOFs > 3

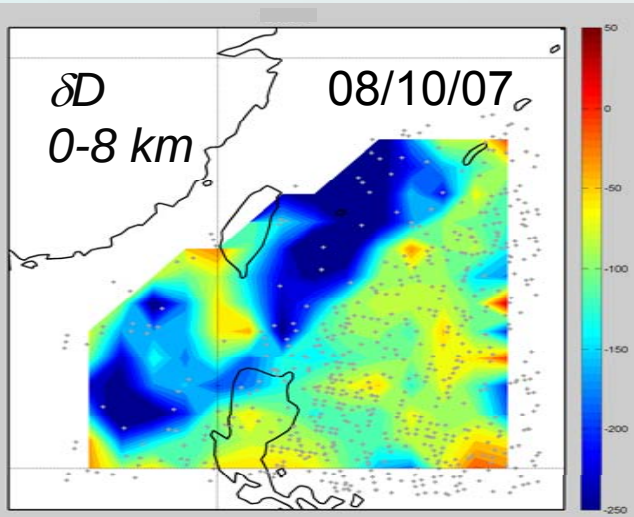
$$\delta = \left(\frac{R}{R_{SMOW}} - 1 \right) \times 1000$$

Super typhon Krosa (categorie 4)

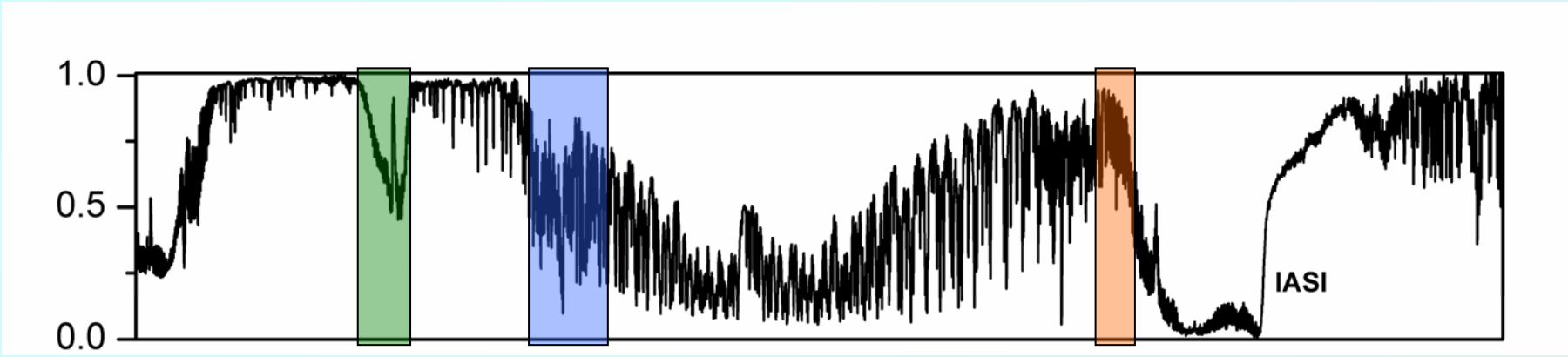


Credit H. Herbin, see poster

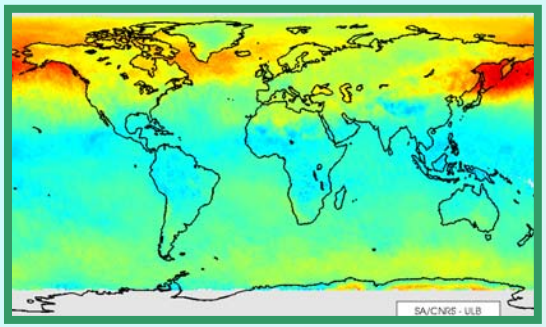


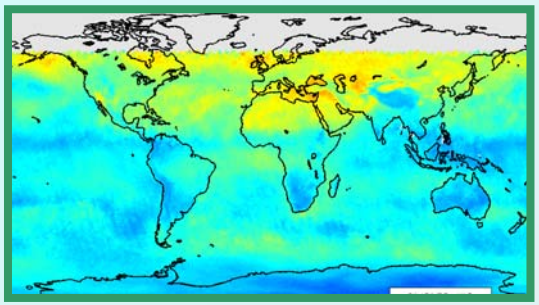


Trace gas retrieval from IASI: troposphere

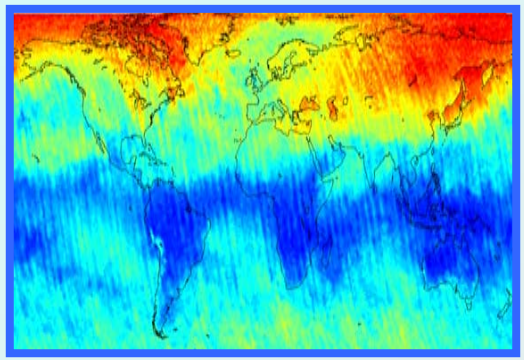


O_3

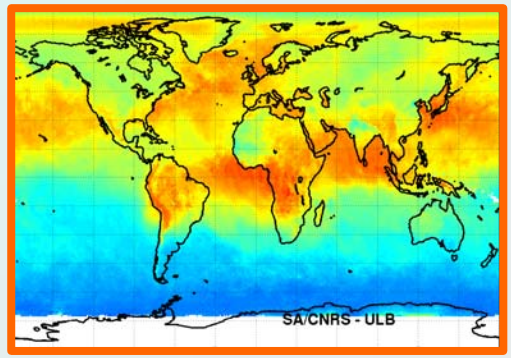




CH_4



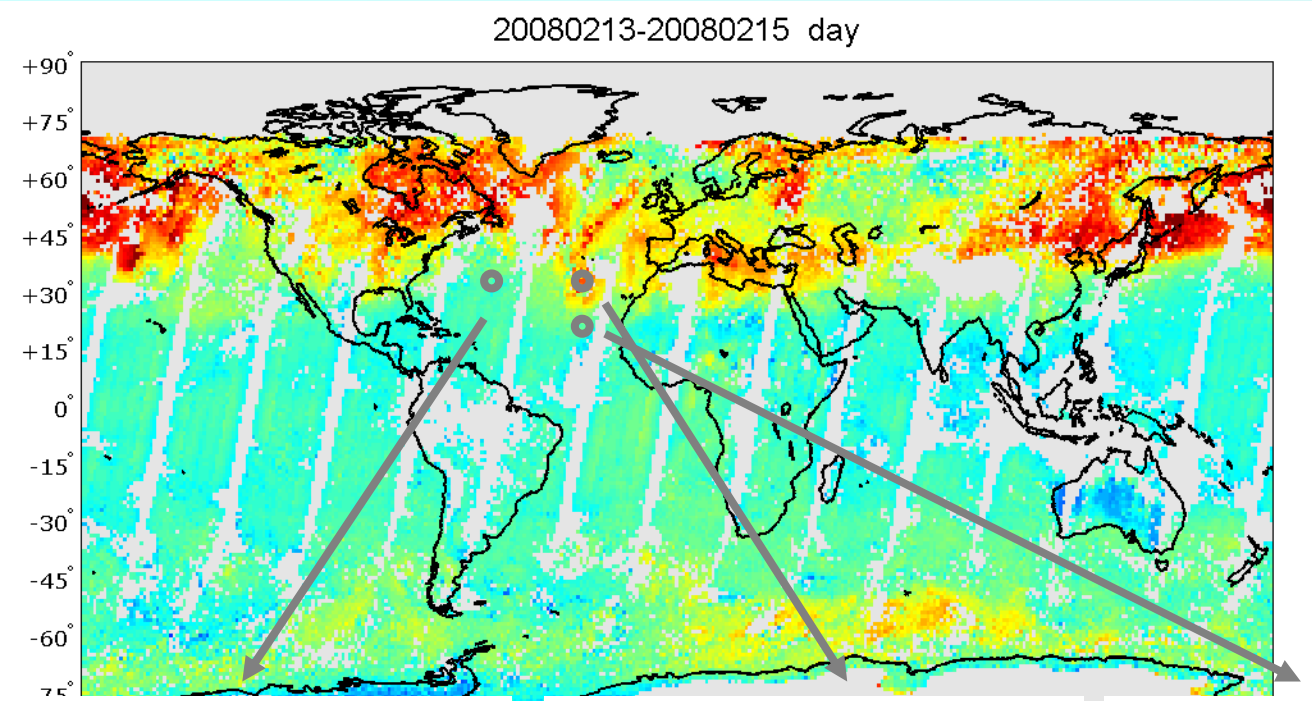
CO



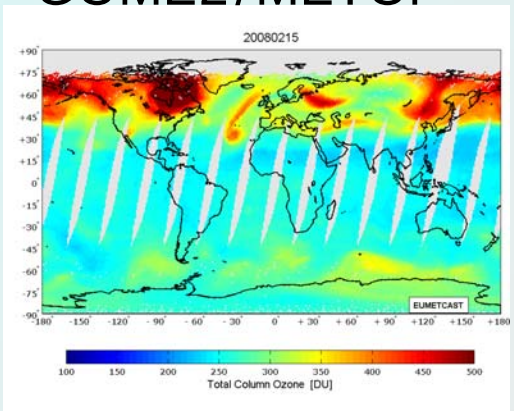
+ Research products :

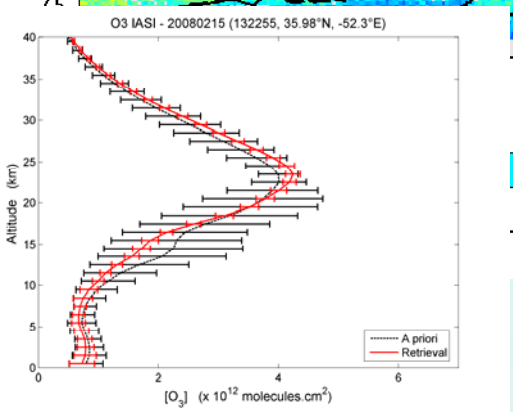
CO prof , O_3 prof , H_2O, HNO_3, SO_2, other

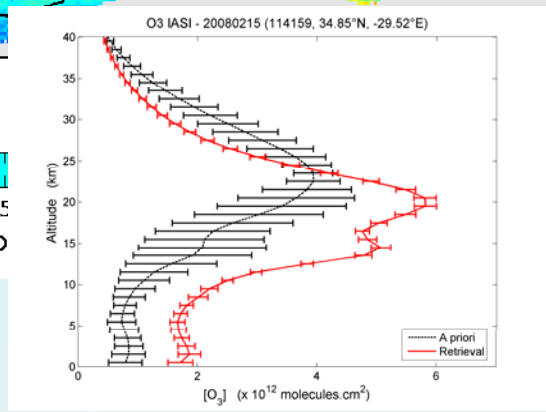
IASI / METOP – Ozone retrievals

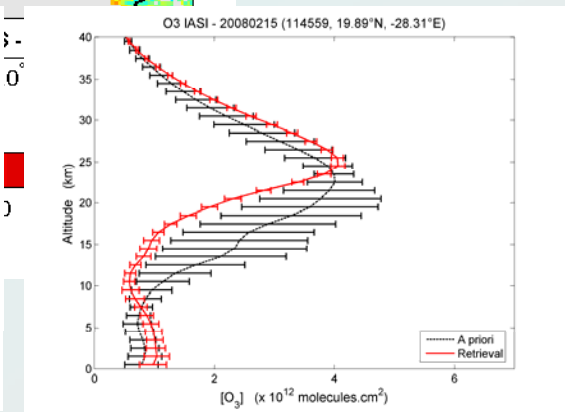


GOME2 / METOP



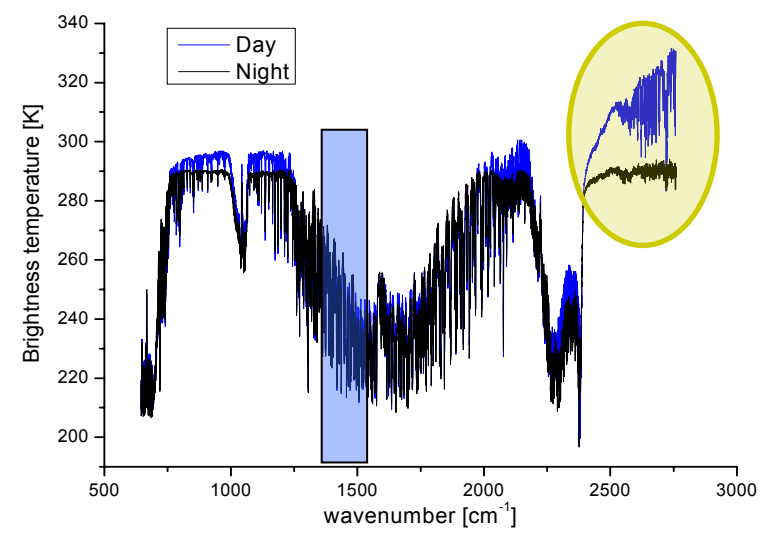


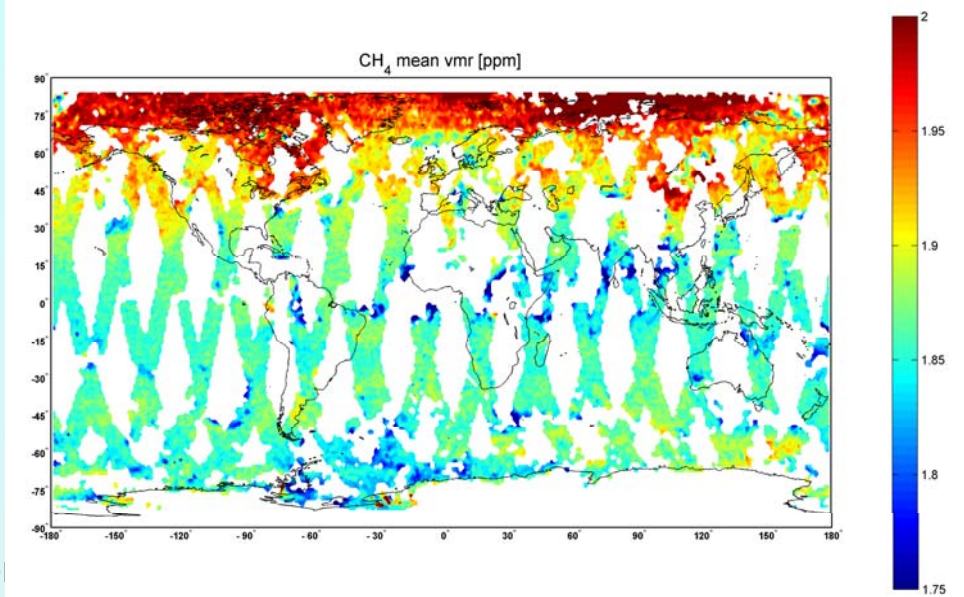




Courtesy A. Boynard / C. Clerbaux (CNRS)

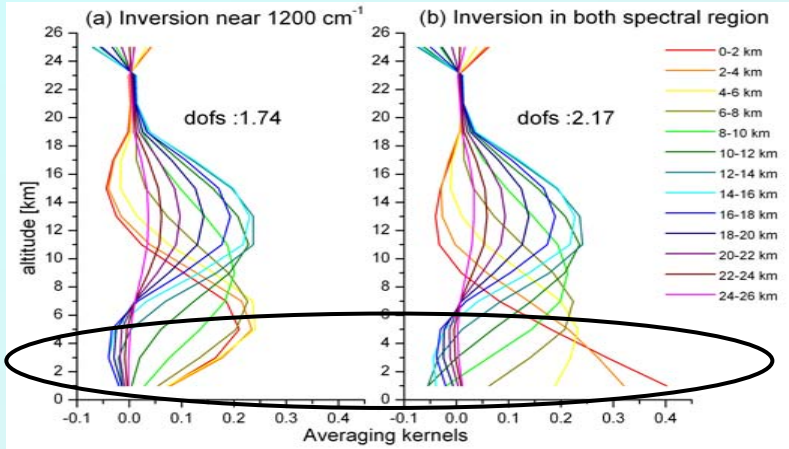
IASI / METOP – Methane retrievals





Two spectral bands to retrieve CH_4 (ν_3, ν_4)

Above 2500 cm-1 >> reflected solar radiatio

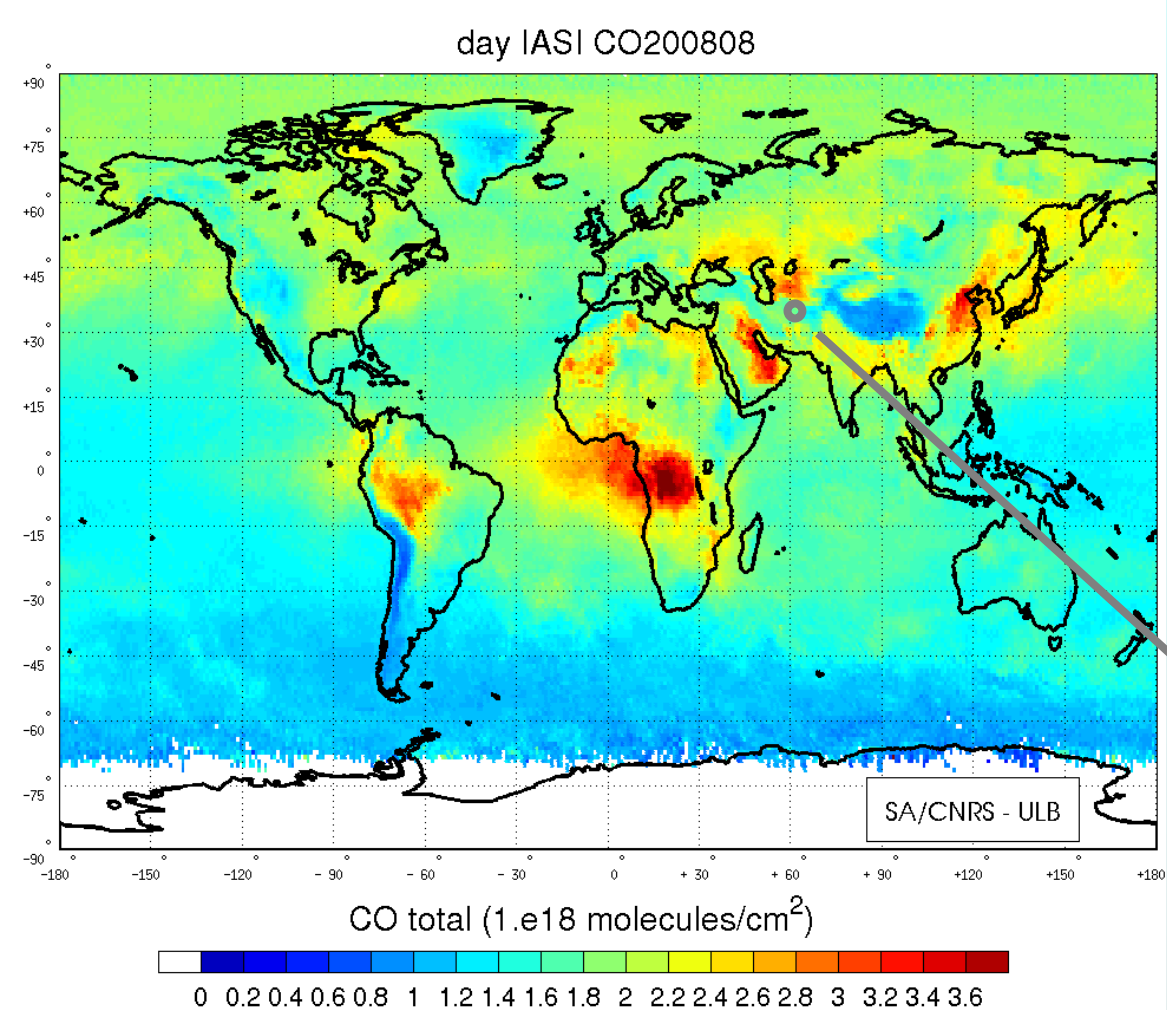


May 28, 2008

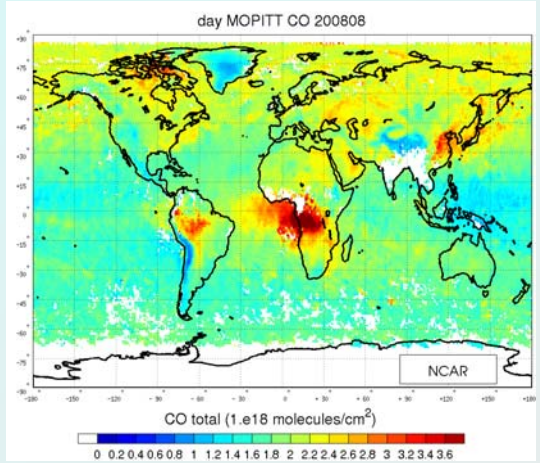
Credit A. Razavi

Improvement of the sensitivity in the boundary layer

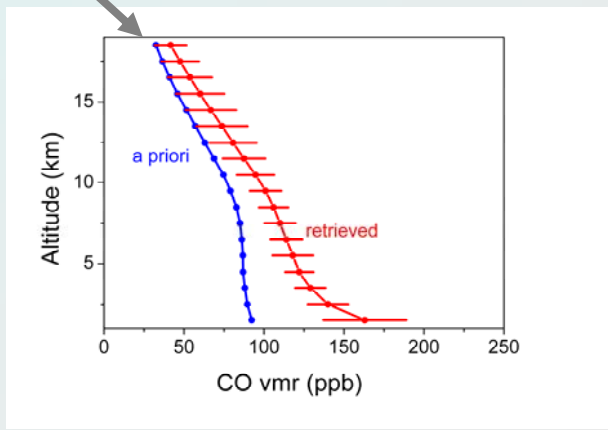
IASI / METOP – CO retrievals



MOPITT/AURA



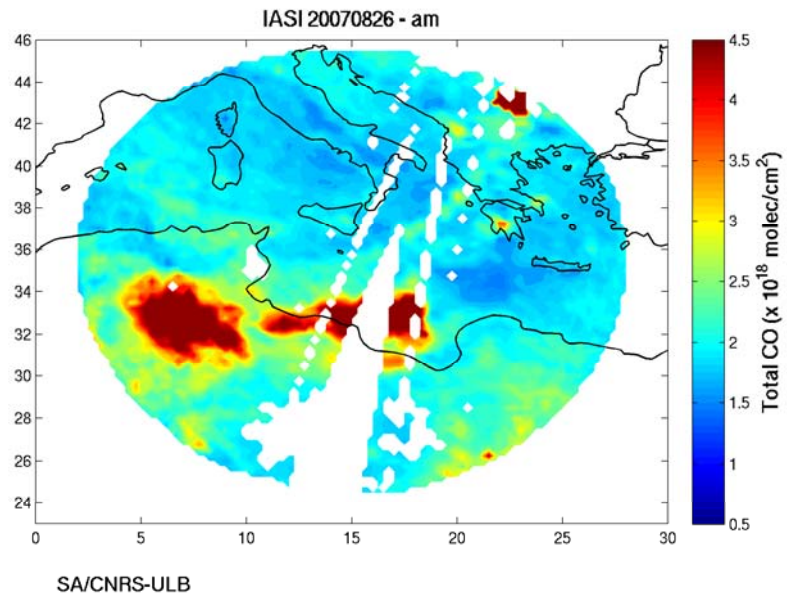
Teheran / Iran

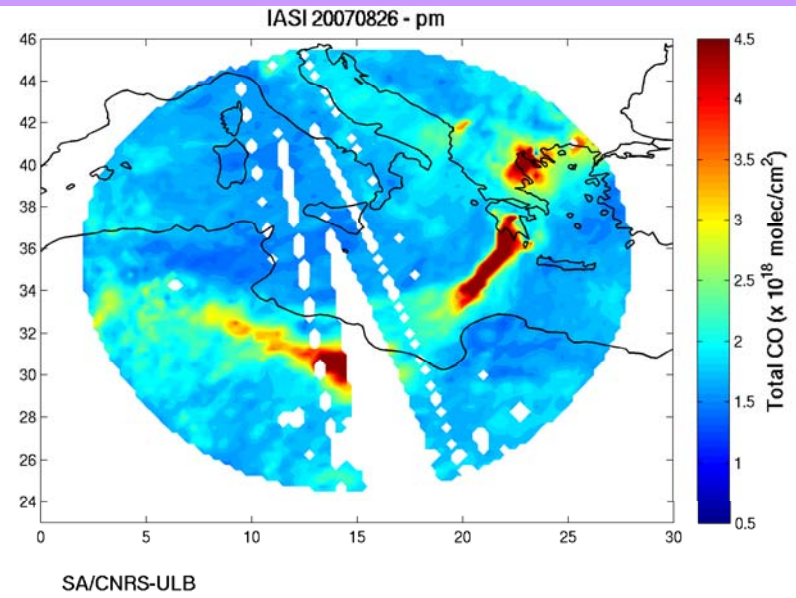


Credit M. Pommier / P. Coheur / D. Hurtmans

Fires in South of Europe in Summer 2007

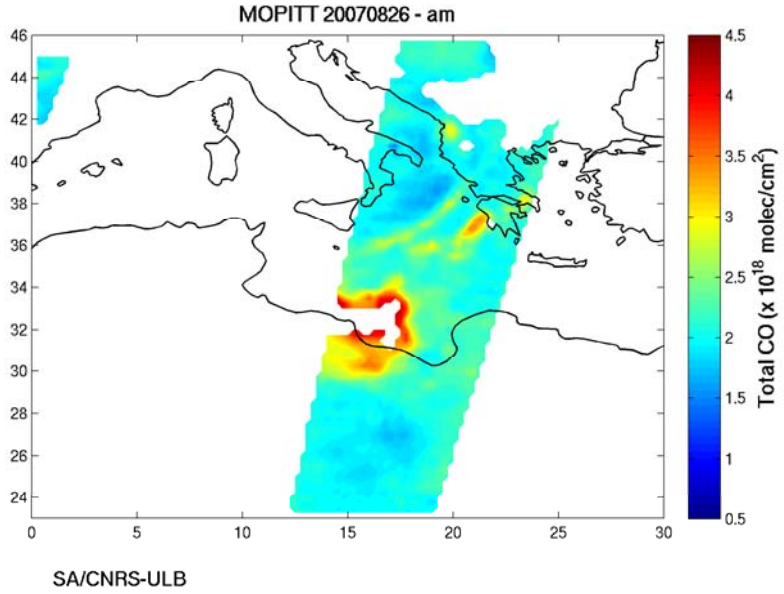
IASI

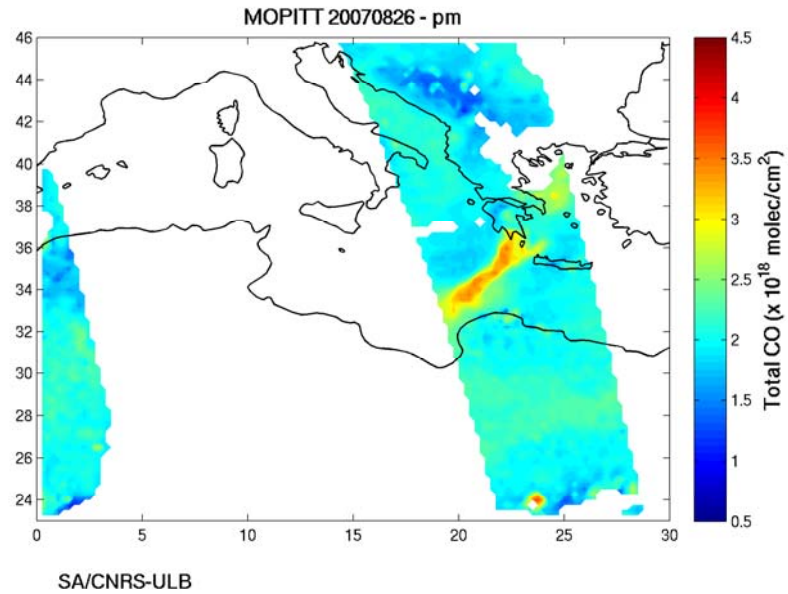




MOPITT

Credit S. Turquety / P. Coheur / D. Hurtmans

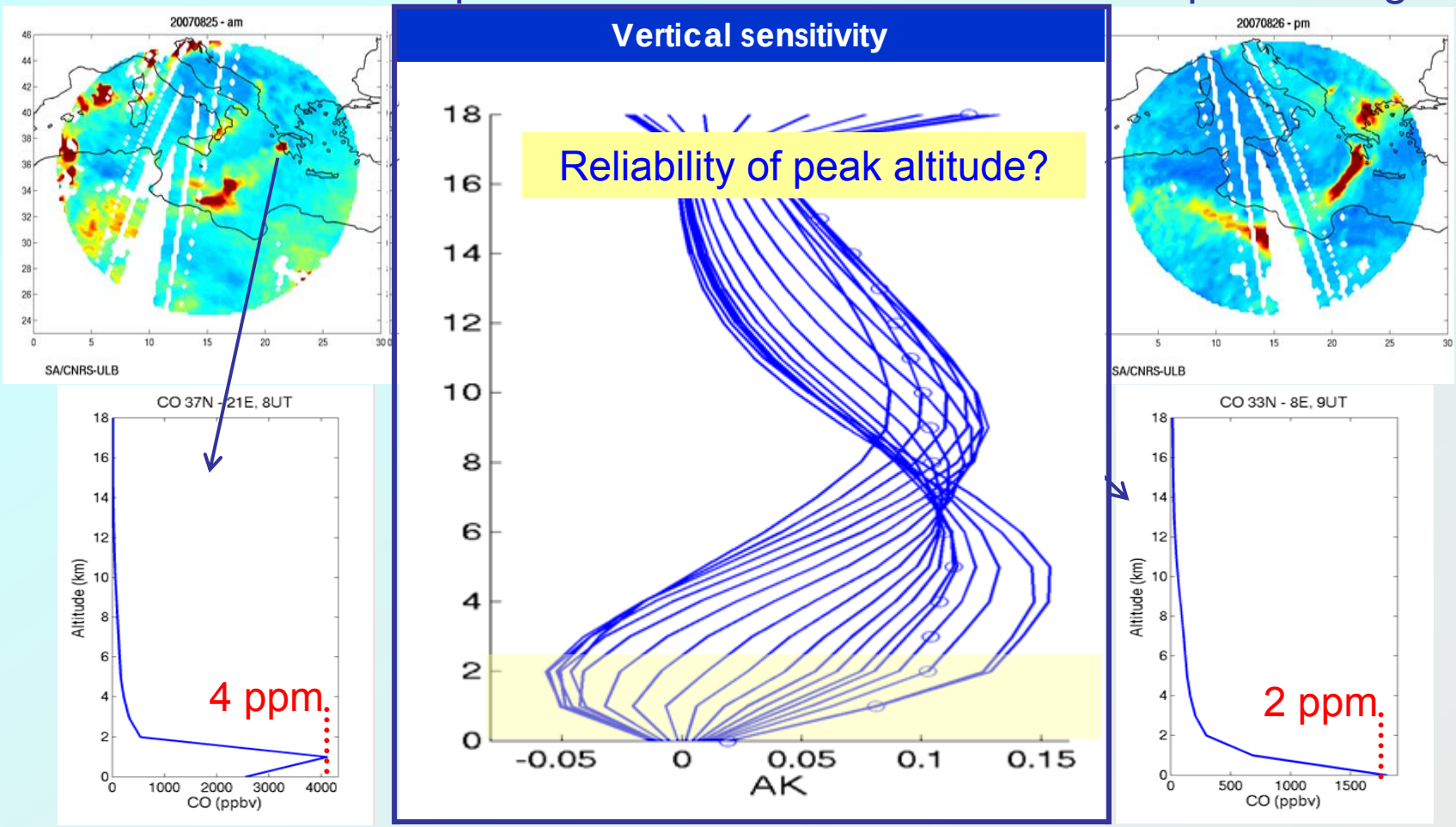




Fire plumes

Example of Southern Europe in Summer 2007

IASI NRT CO-profile measurements from ULB/SA processing

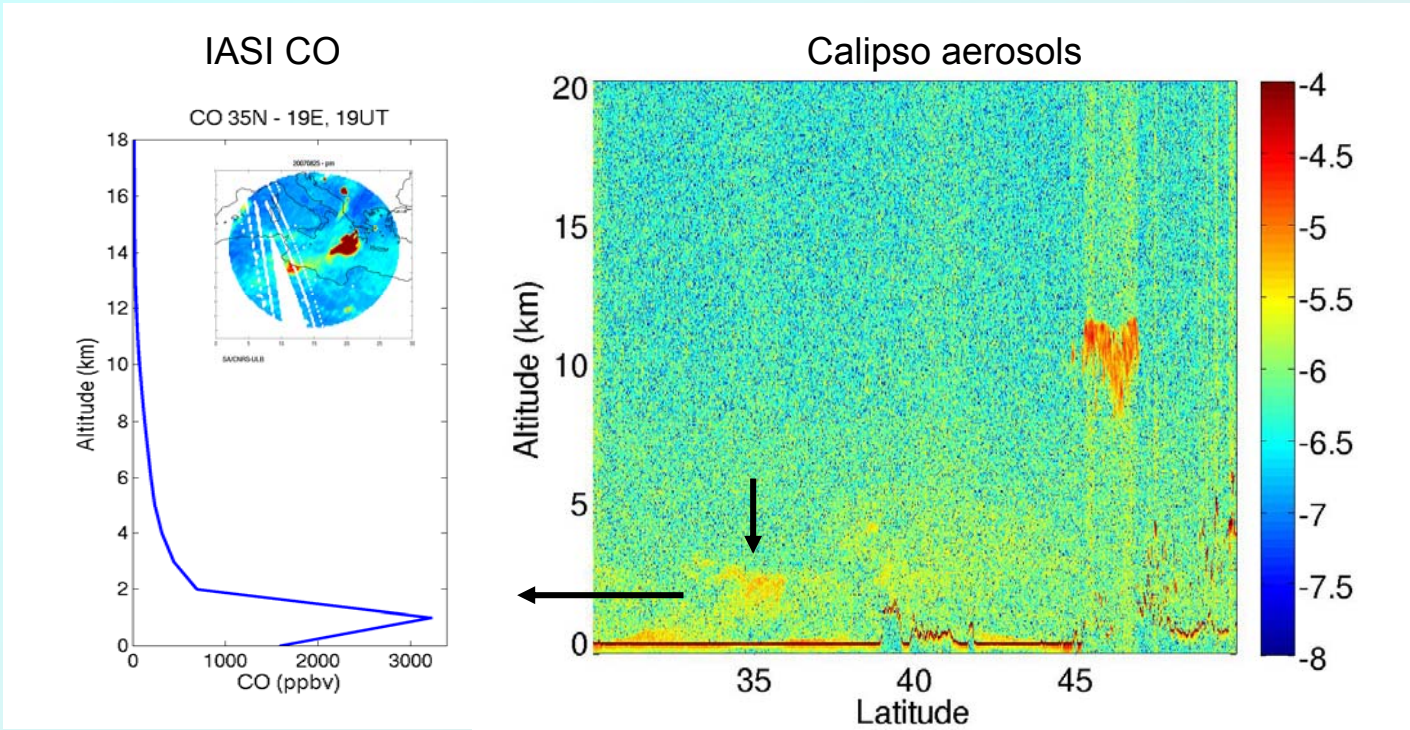


Remarkably high CO concentrations with peak at low altitude (< 2 km)

Fire plumes

Example of Southern Europe in Summer 2007

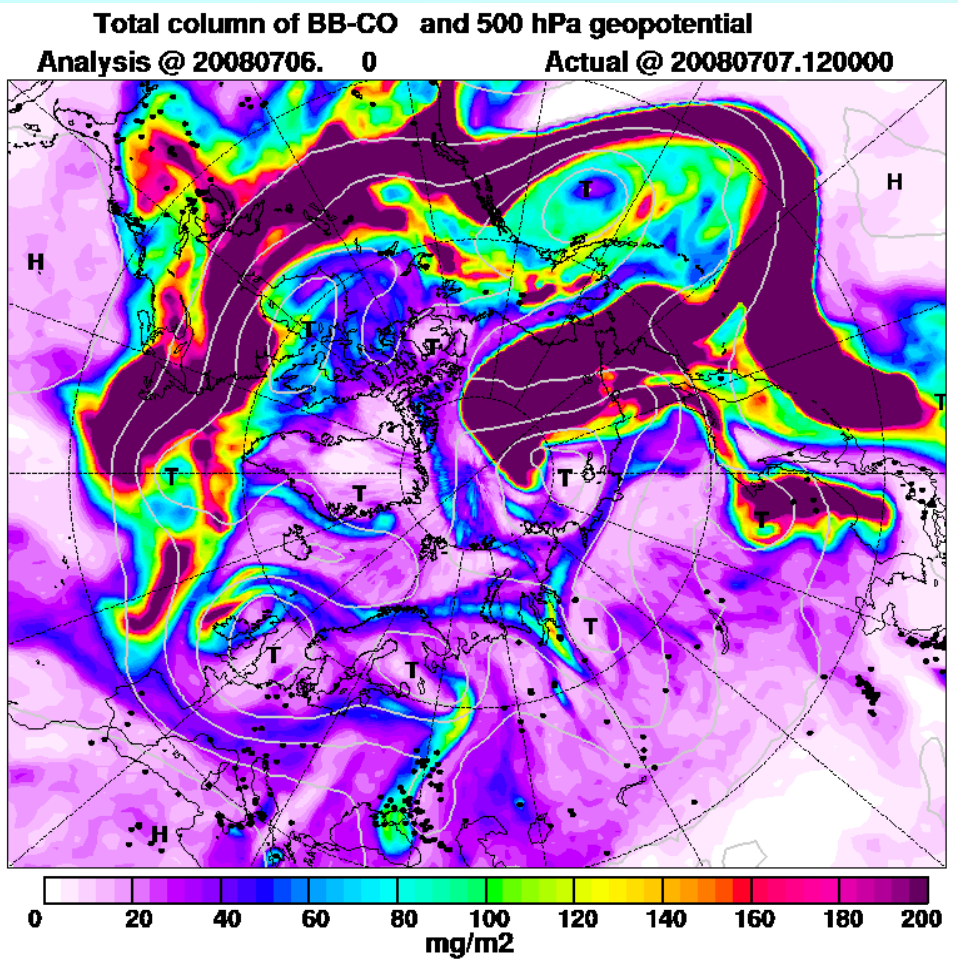
IASI NRT CO-profile measurements from ULB/SA processing



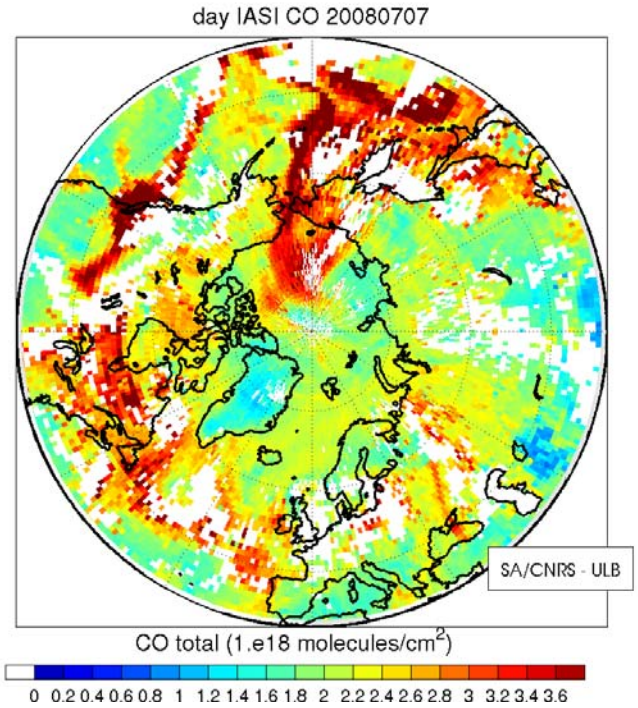
Reliability of peak altitude? Consistent with Calipso profiles

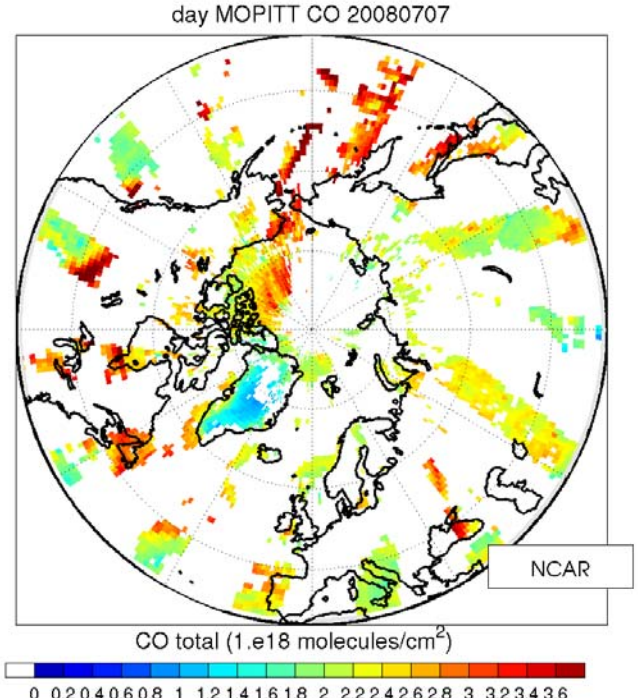
Remarkably high CO concentrations with peak at low altitude (< 2 km)

FLEXPART BB CO
20080707@ 120000UT



Credit M. Pommier





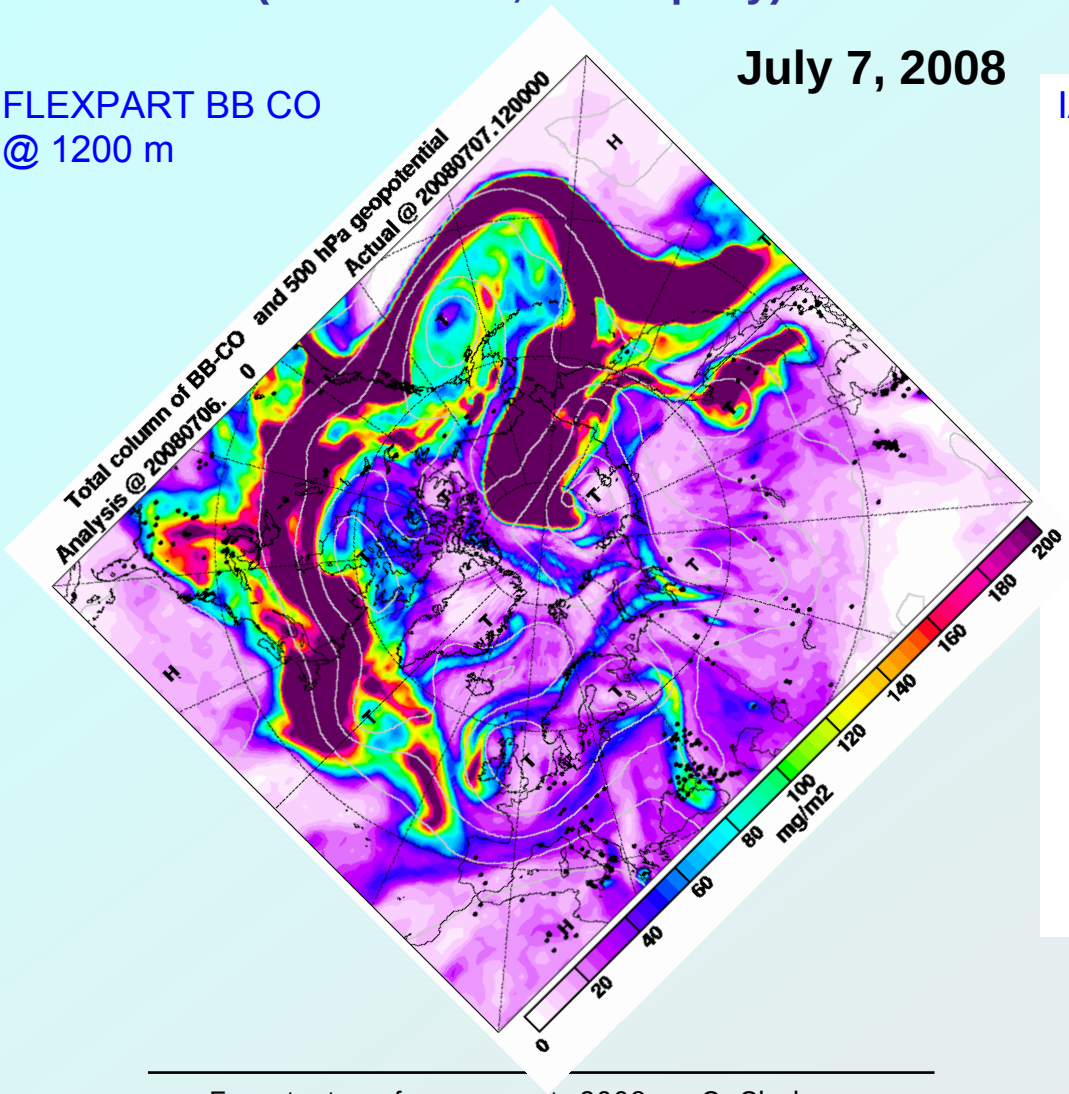
Fire plumes

Fires in Boreal regions in Spring/Summer 2008

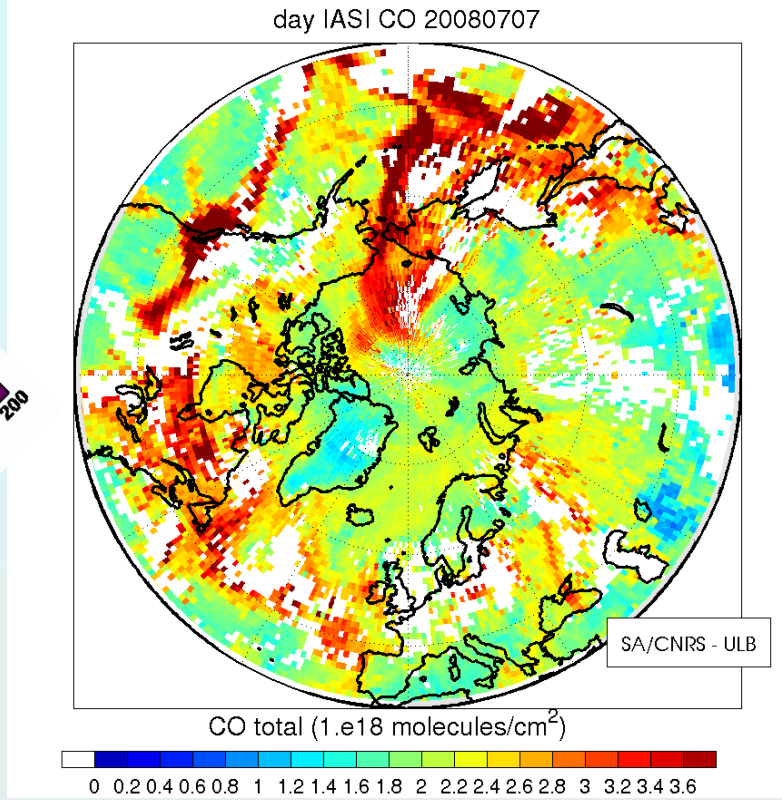
Tracking CO from boreal fires in the frame of IPY/Polarcat (M. Pommier, S. Turquety)

July 7, 2008

FLEXPART BB CO
@ 1200 m



IASI CO-NRT. Total column



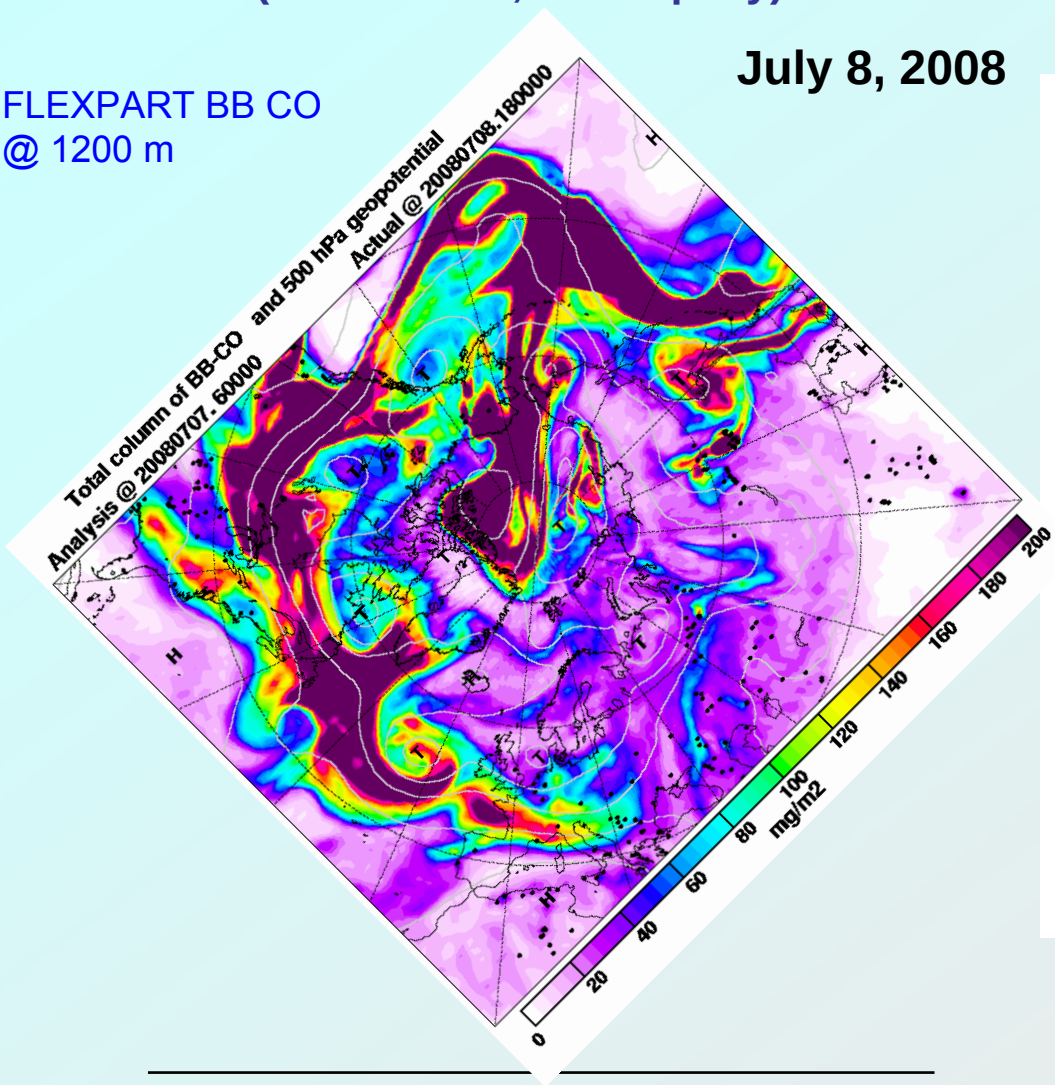
Fire plumes

Fires in Boreal regions in Spring/Summer 2008

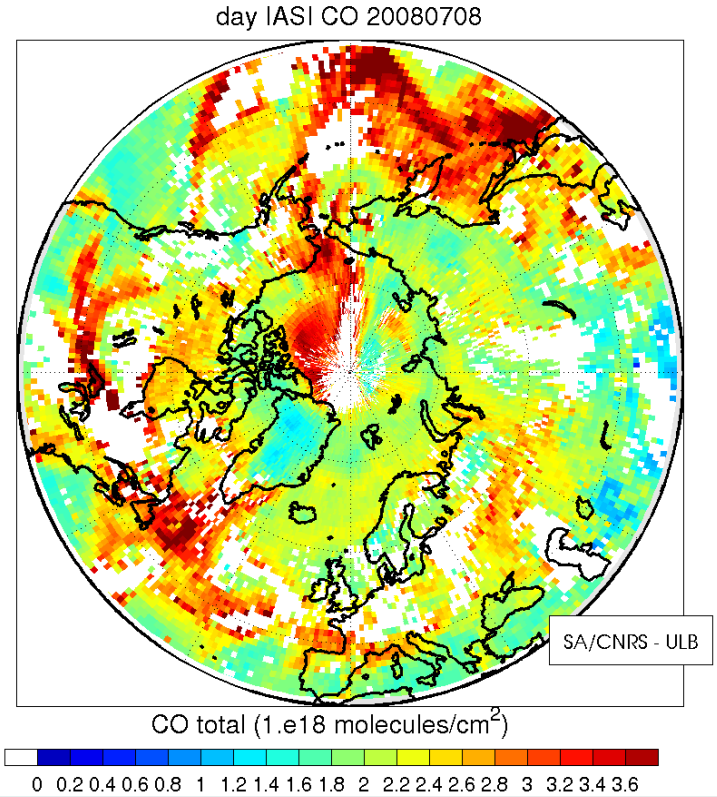
Tracking CO from boreal fires in the frame of IPY/Polarcat (M. Pommier, S. Turquety)

July 8, 2008

FLEXPART BB CO
@ 1200 m



IASI CO-NRT. Total column



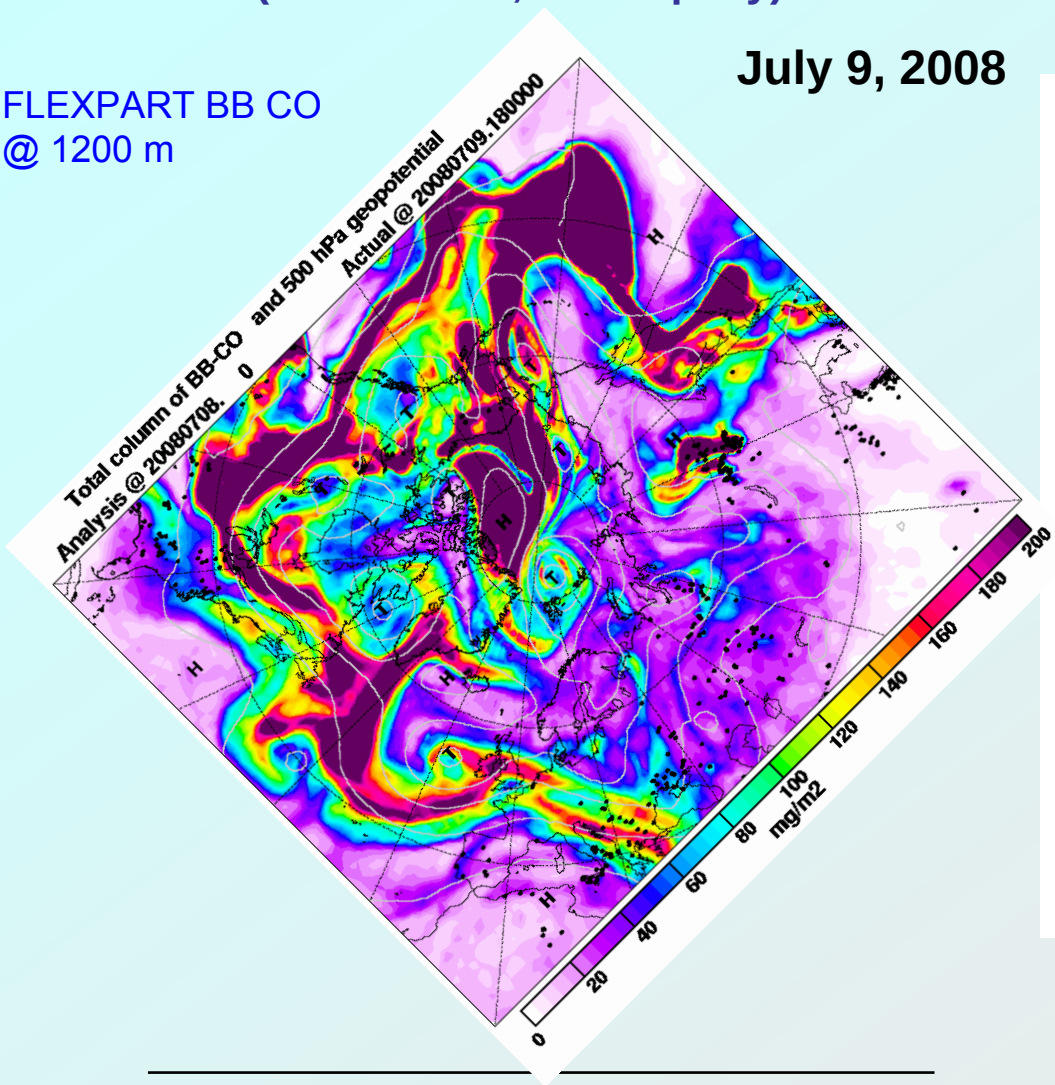
Fire plumes

Fires in Boreal regions in Spring/Summer 2008

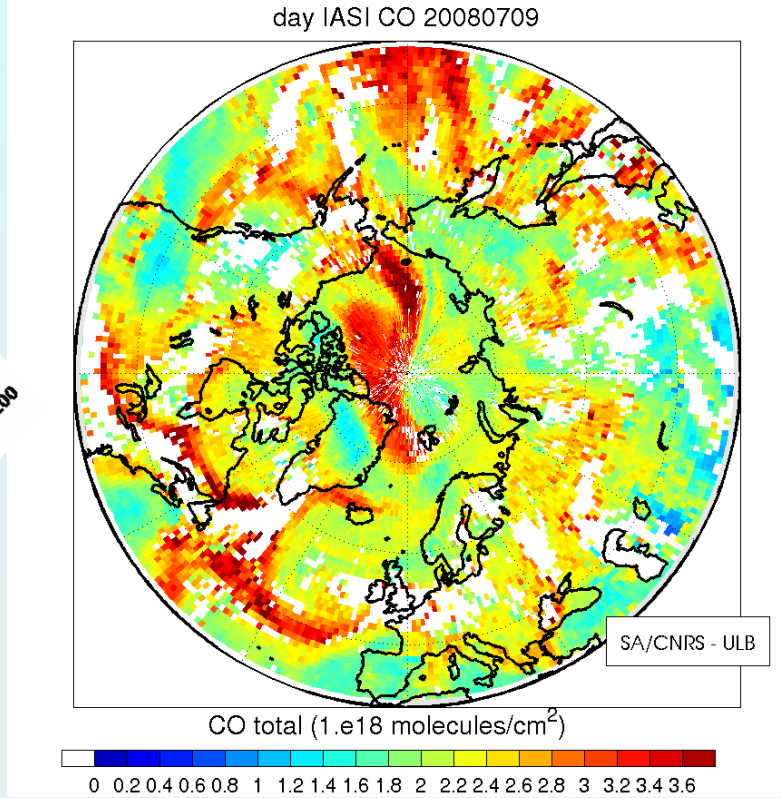
Tracking CO from boreal fires in the frame of IPY/Polarcat (M. Pommier, S. Turquety)

July 9, 2008

FLEXPART BB CO
@ 1200 m



IASI CO-NRT. Total column



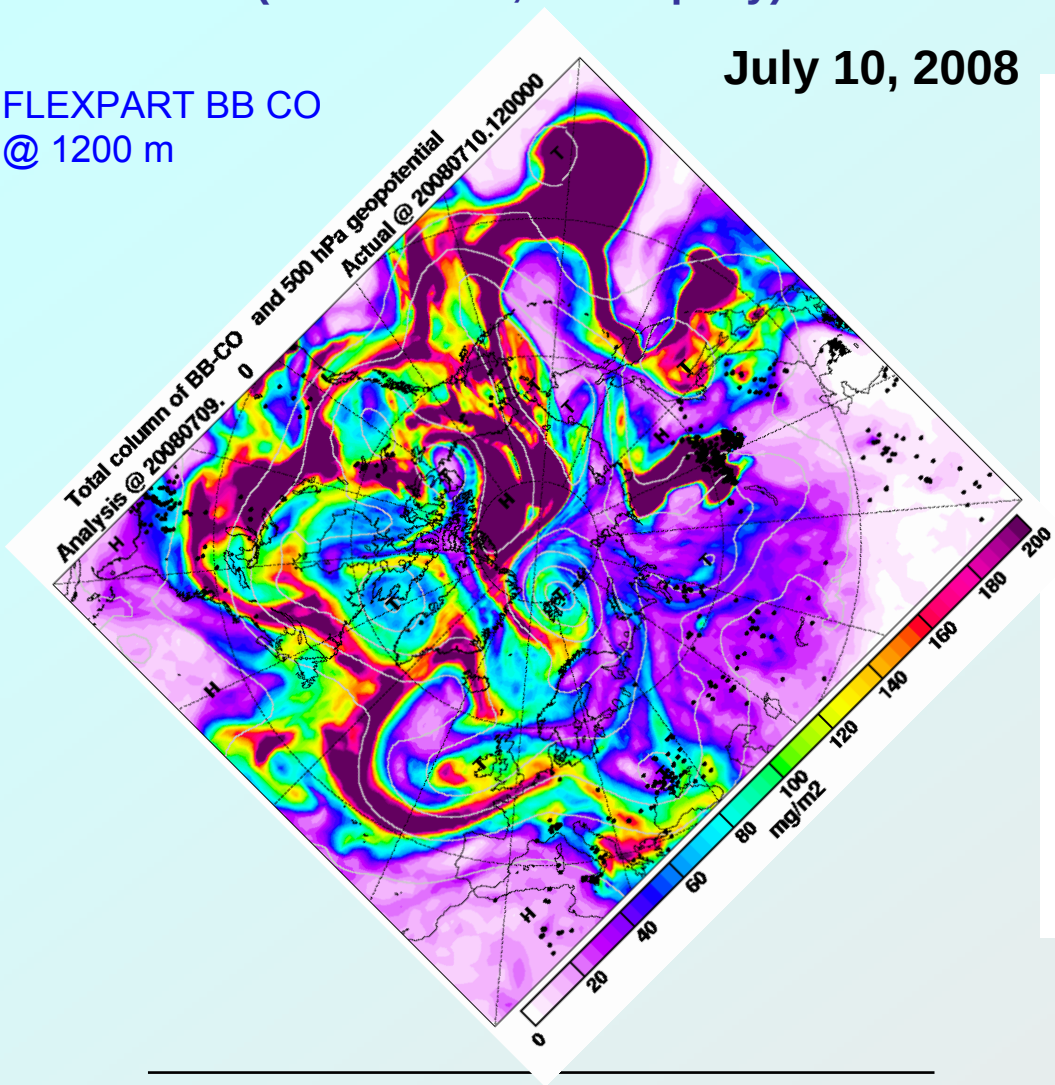
Fire plumes

Fires in Boreal regions in Spring/Summer 2008

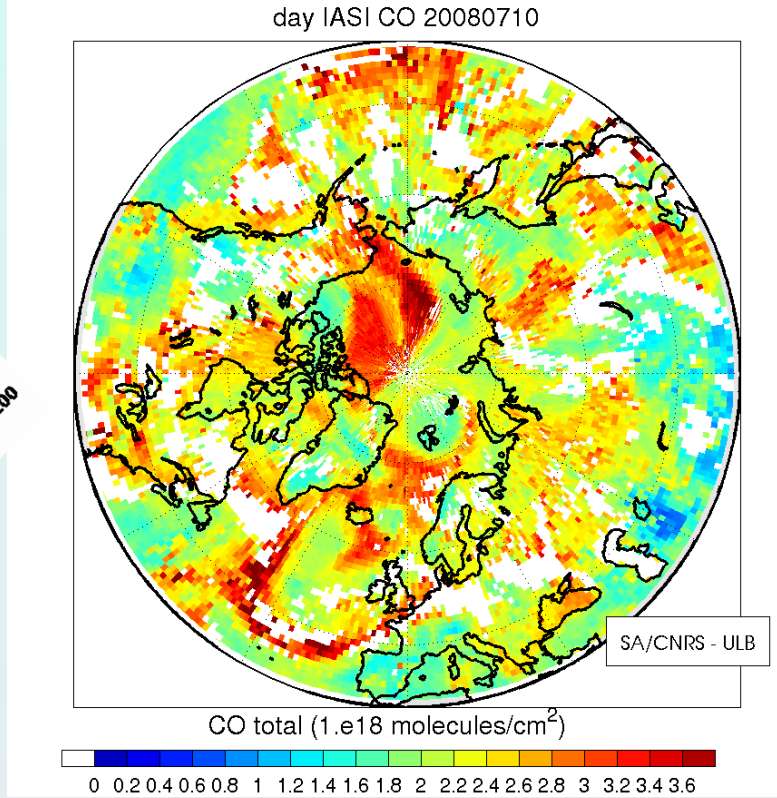
Tracking CO from boreal fires in the frame of IPY/Polarcat (M. Pommier, S. Turquety)

July 10, 2008

FLEXPART BB CO
@ 1200 m

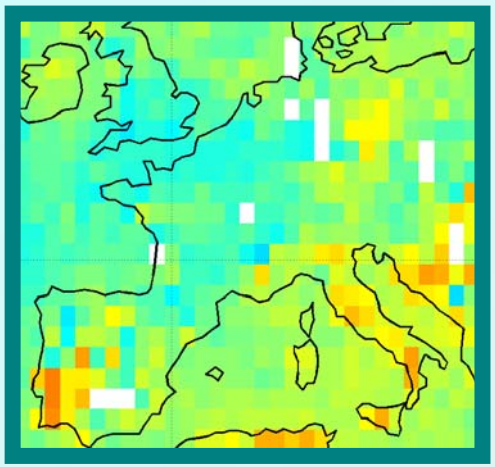


IASI CO-NRT. Total column



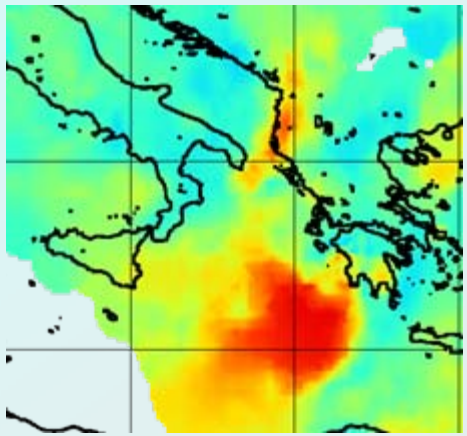
IASI/METOP – Operational applications (GMES)

Pollution forecast



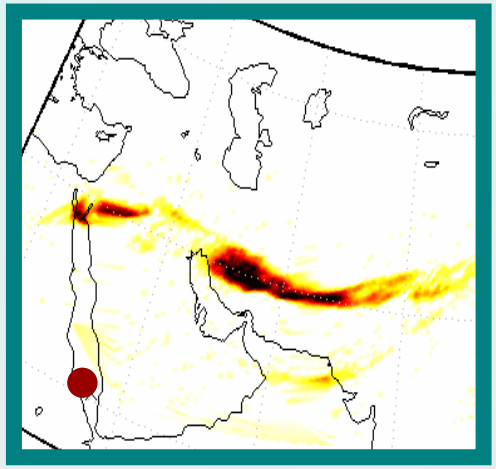
Ozone peaks

Fire detection



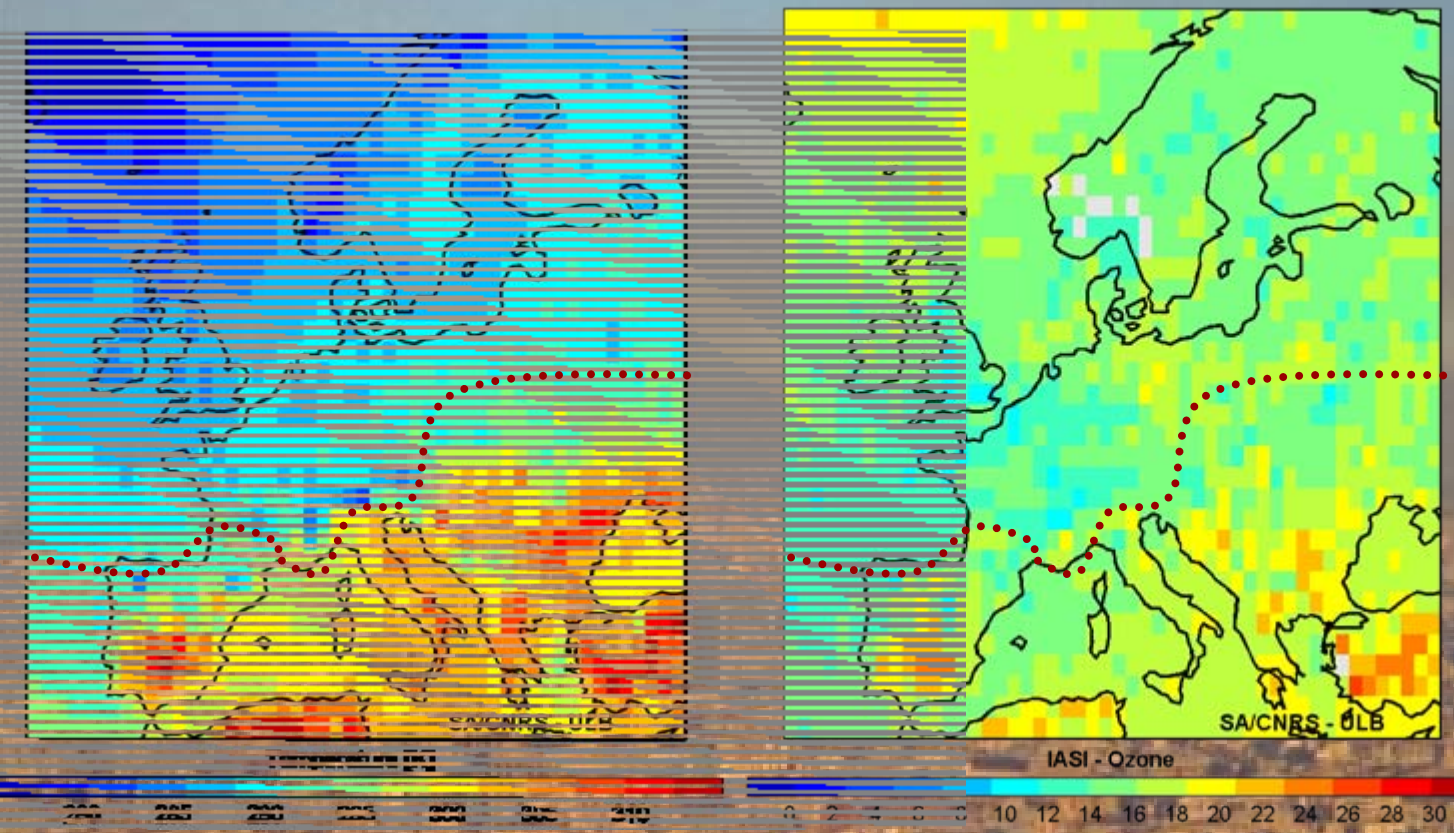
Long-range pollution

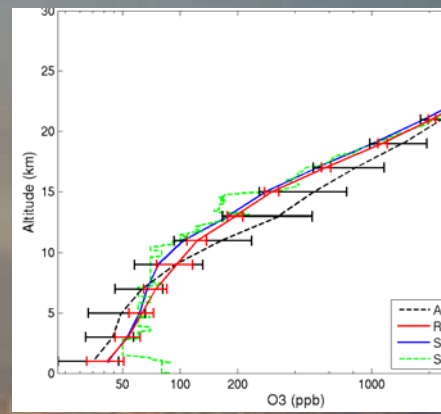
Volcanic plumes



Aviation threat

Ozone (O_3) - pollution peaks, South of Europe, 22-26 July 2007





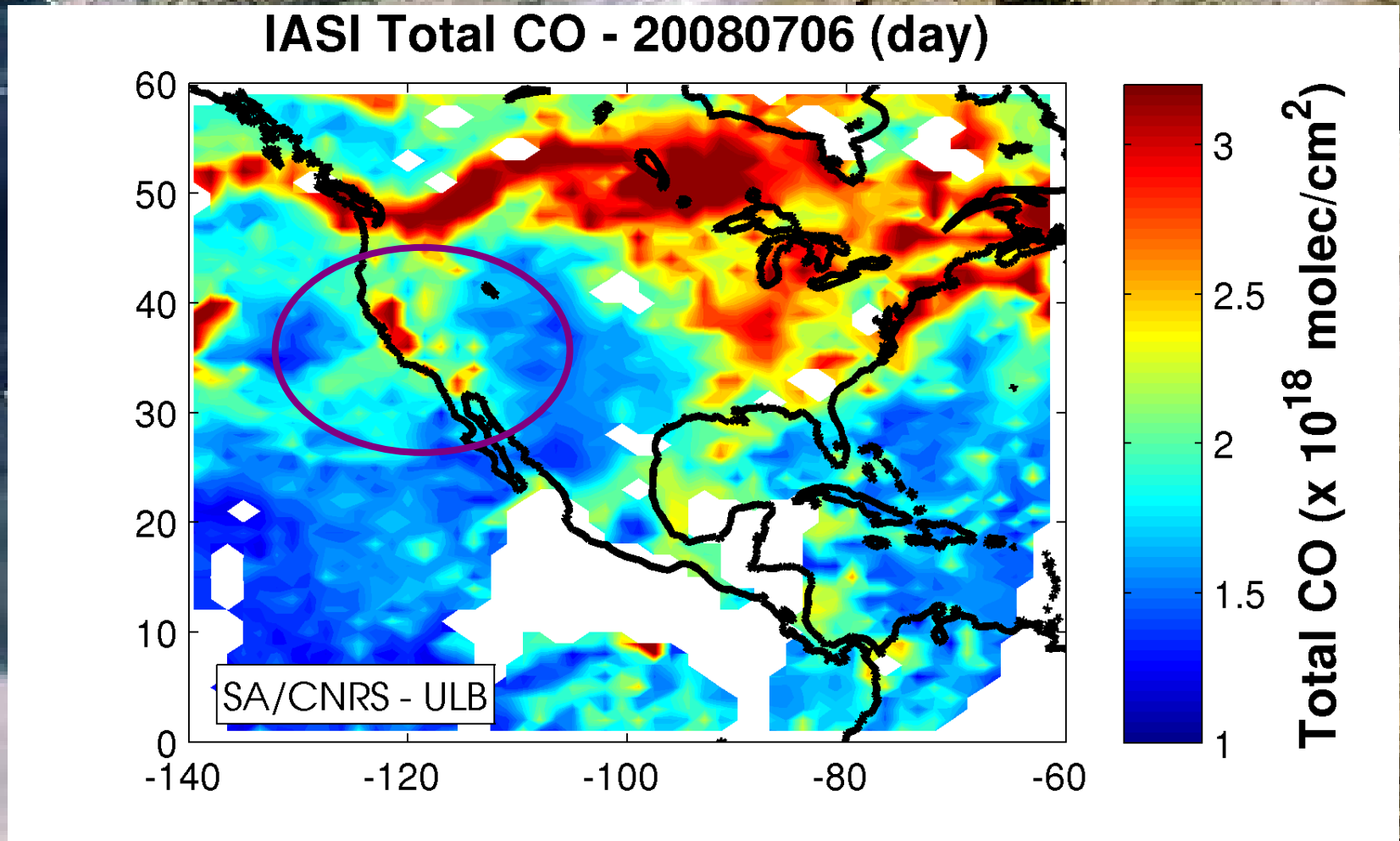
Temp, ECMWF data

IASI data: Ozone 0-6 km

Credit A. Boynard

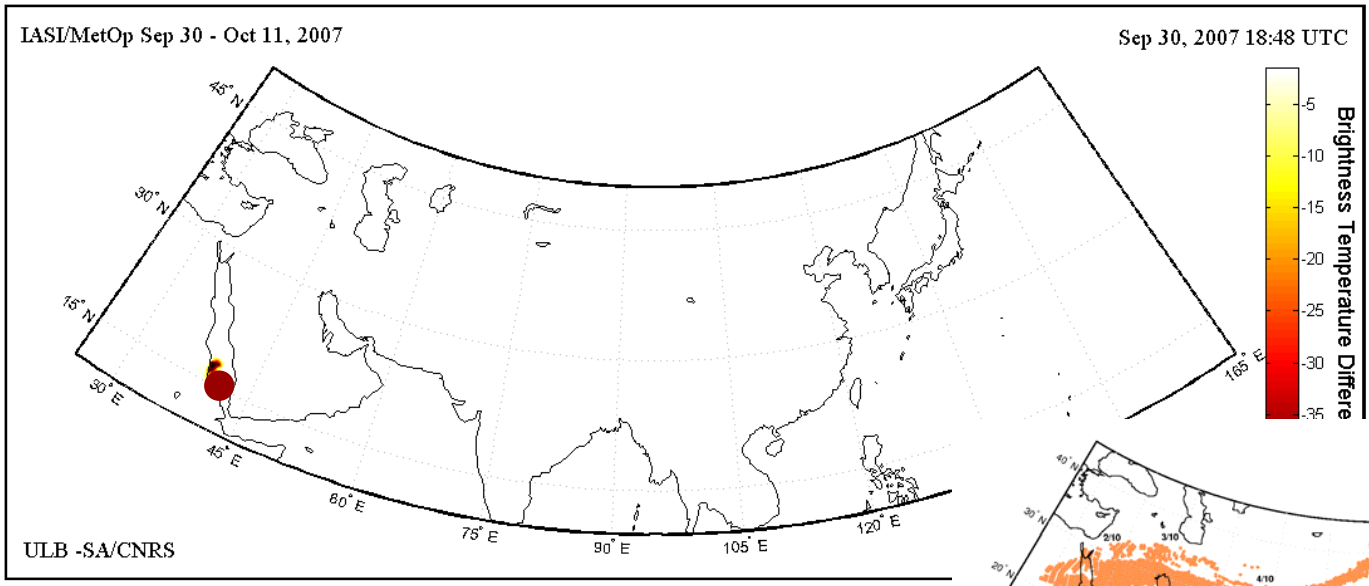
Carbon monoxide (CO) – Fires

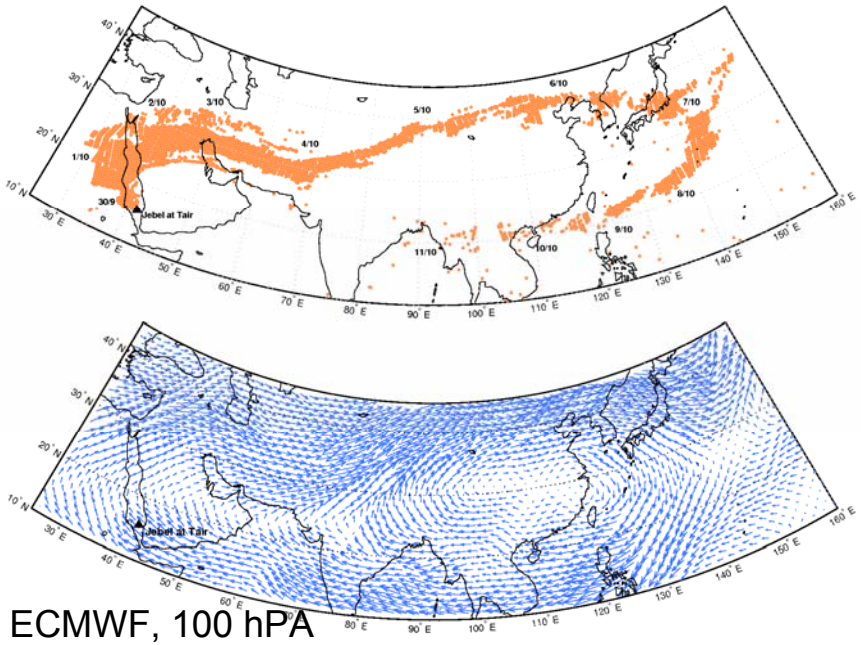
California, 6-14 July 2008



Sulfur dioxyde (SO_2) – volcano plumes

Jebel at-Tair (Red sea), 1 October 2007





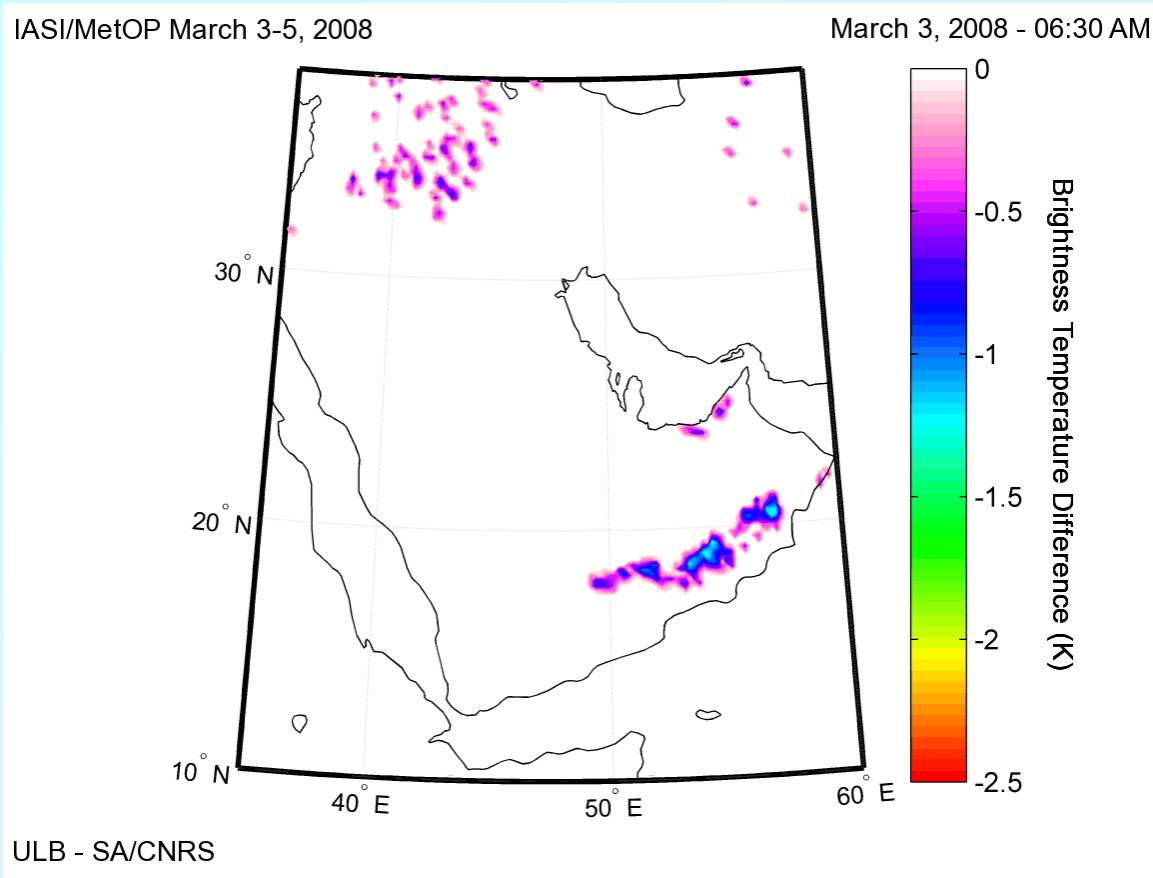
ECMWF, 100 hPA

Credit L. Clarisse, P. Coheur

Dust storm in Middle East, March 2008

MODIS, March 4

IASI



Credit P. Coheur

Conclusions and perspective

IASI is working great, thank you CNES and Eumetsat

Systematic treatment since about a year (~ 1.3 10^6 spectra daily).

Good spectral resultion, and excellent radiometric performances >> columns AND low resolution profiles during daytime.

10→15 species are monitored with applications in

- Climate (H_2O and isotopologues, CO_2, CH_4, N_2O)
- Ozone chemistry in the stratosphere (O_3, HNO_3) and troposphere (O_3, CO, CH_4, HNO_3, VOCs)
- Operational monitoring

Future work

Implement fast retrievals of H2O and isotopes, methane
Combine the 2 spectral ranges for methane
CO: Extensive validation with MOPITT, TES and AIRS
Combine O3 from IASI and GOME-2 (SAF-O3)