Major results of IASI in Atmospheric chemistry

Thierry PHULPIN, CNES DCT/SI/IM

Cathy Clerbaux (LATMOS), Pierre Coheur (ULB), Dave Edwards (NCAR)

CENTRE NATIONAL D'ÉTUDES SPATIALES

Outline

- **Context**
- **Why such excellent results**
- **Teams working with IASI**
- **Basic products CO and O3**
- **Detection of minor trace gases: ammonia, methanol, formic acid, nitric acid**
- **Applications**
  - Air quality monitoring
  - Emissions
  - Transport
  - Climate monitoring
- **Operational use**
- **Remaining issues**
- **Perspectives : from detection to quantisation**

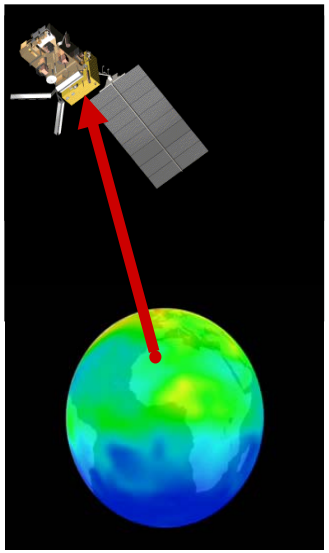
Context

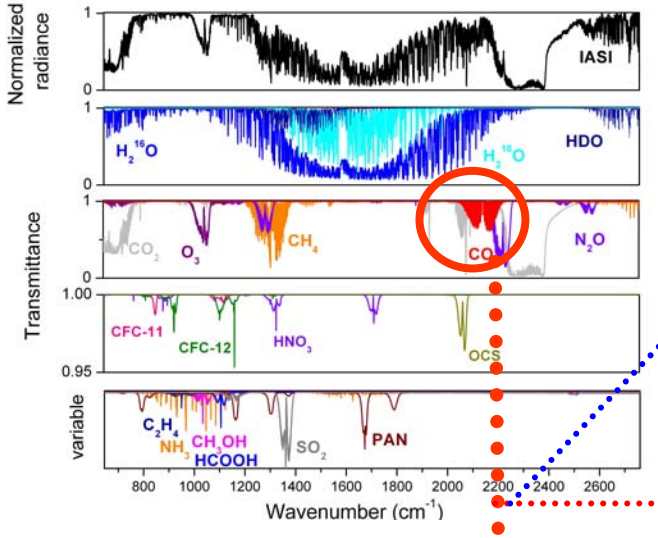
- 3 years after first IASI data dissemination, 2nd IASI international conference in Sevrier (25_29 January, 2010)
- The excellent performances of IASI were confirmed: very good accuracy, very stable.
- It allows many applications to be developed, among them Atmospheric chemistry, for which very convincing results have been obtained
- It paves the way to GMES Sentinel 5 and more applications from IASI-NG on post EPS

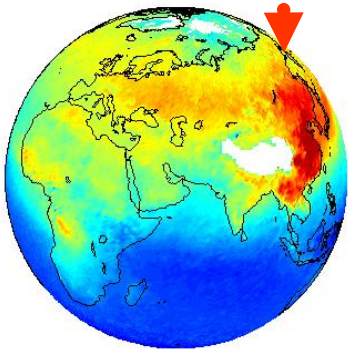
What are the resons of these good results?

- **AC is one of the IASI's target => the instrument was also designed for this purpose:**
  - Spectral coverage and resolution
- **AC applications was prepared by ISSWG to which several Pis contributed actively (Co chair and several scientists)**
- **Strongly supported by CNES**
- **AC products are in the list of level 2 products**
- **Spectroscopic information is good**
- **IASI characteristics allow development of applications :**
  - Swath
  - Availability
  - Stability
  - Accuracy
  - Combination with othe rmeasurements

Trace gases







Cloud free scenes

Atmospheric concentrations

Operational L2 products from Eumetsat processing

T and humidity profiles, cloud information

CO_2, CH_4, N_2O columns

O_3 total and partial columns

CO columns

Science L2 products from various processing chains

- NOAA (AIRS Team)

- France: LATMOS/ULB + LMD, LA, LISA, LPMAA, Cerfacs, Noveltis for CNES

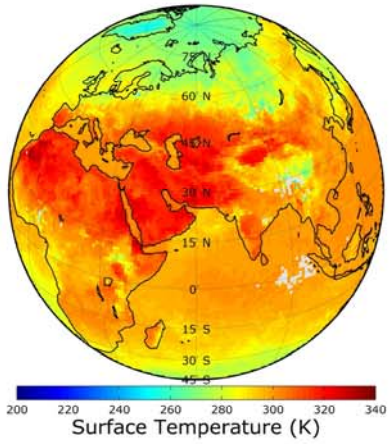
- Others: Leicester, University of Basilicata, SRON, RAL

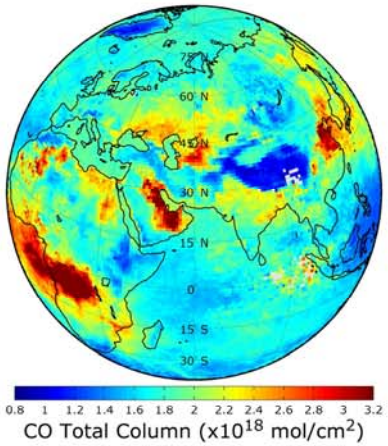
-ECMWF

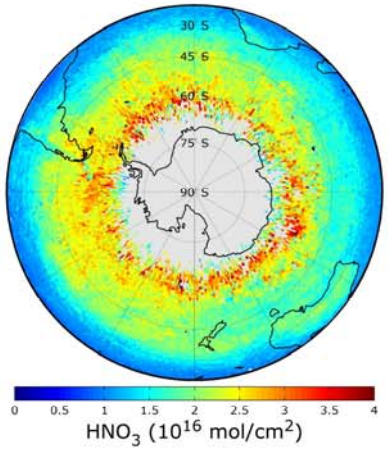
- A majority of users takes Eumetcast data for NRT processing
- Even if Eumetsat data are starting to be validated with a good quality, a large majority developed its own inversion

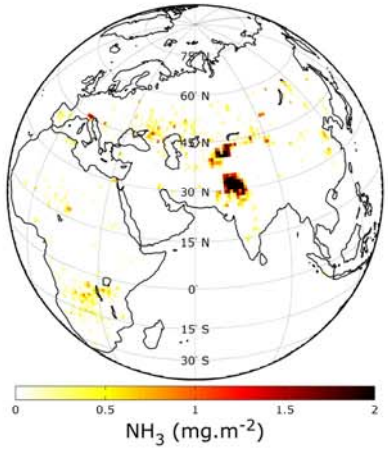
Trace gas products from IASI

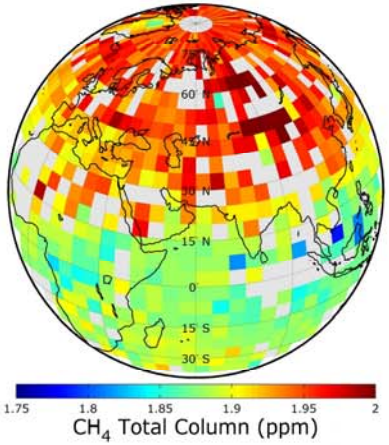
Average 1°x1°, 10 days, 18-28 August 2008

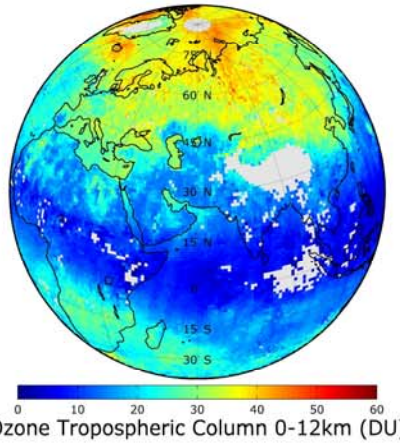


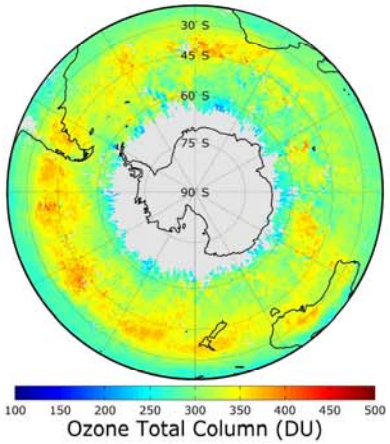


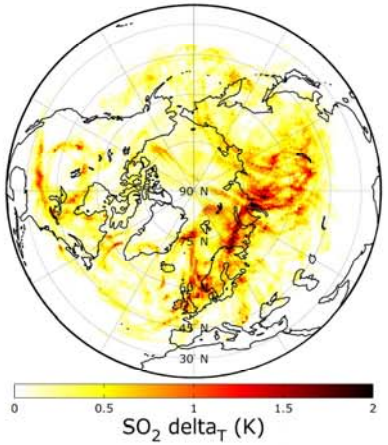






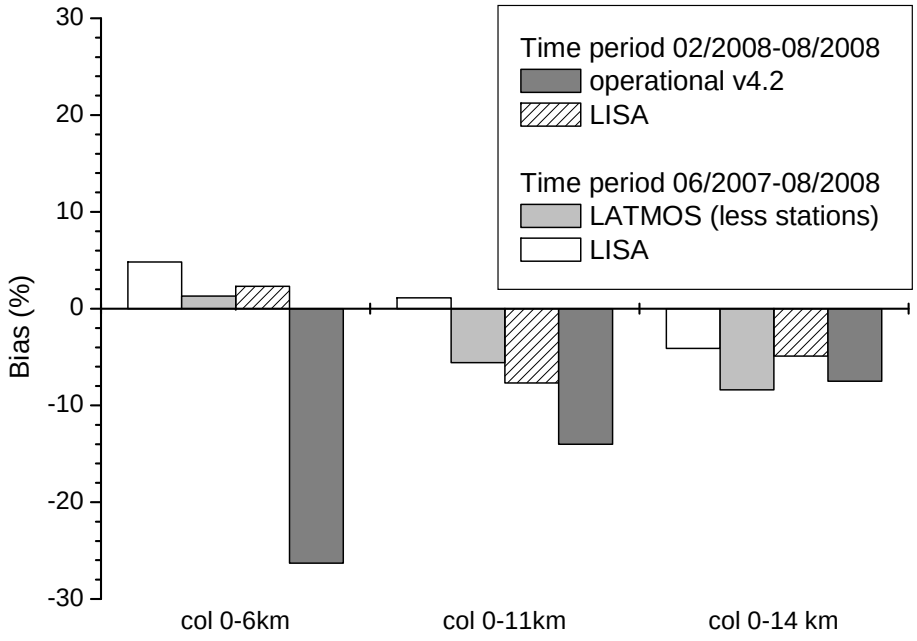






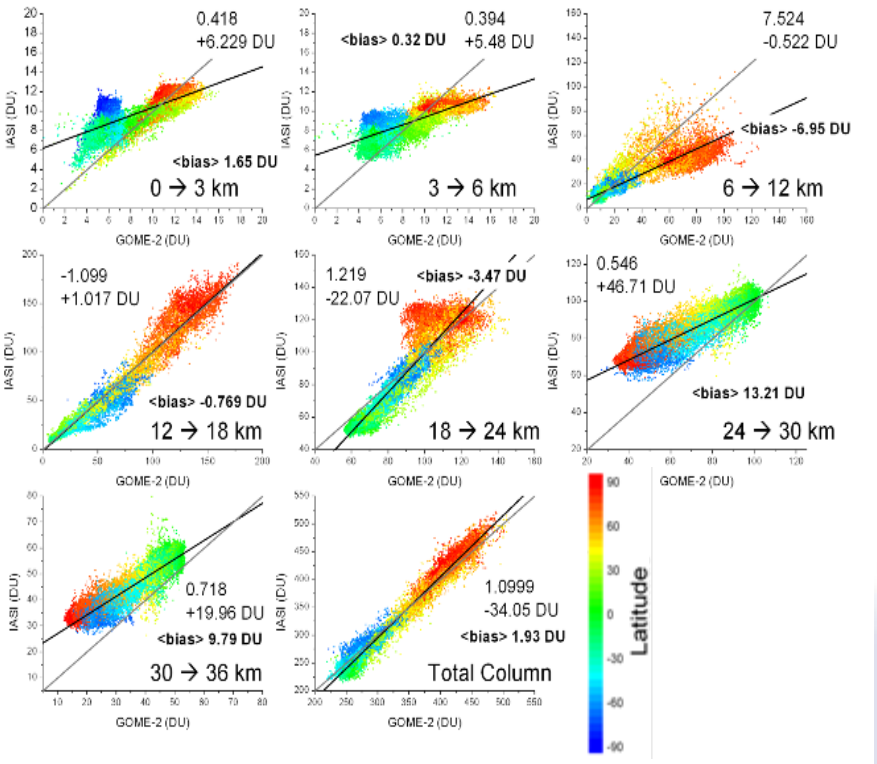
Clerbaux et al, ACP IASI Special Issue, 2009

VALIDATION – Ozone columns and profiles



LISA, C. Keim

Preliminary comparisons with GOME-2 partial columns (from operational profiles)

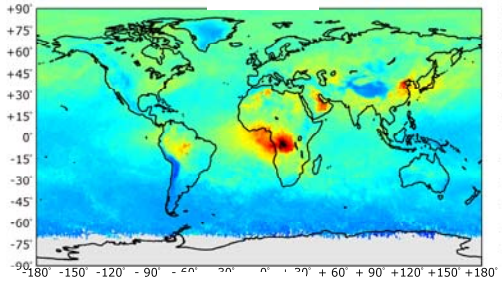


ULB, A. Boynard

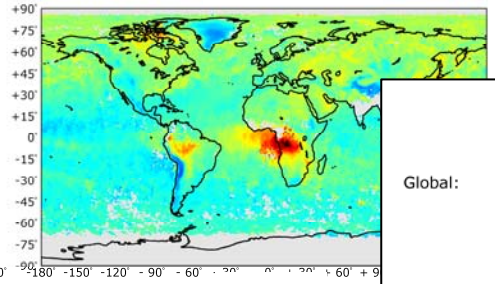
Carbon monoxide

Comparisons with other satellite data; Preliminary cross-validation

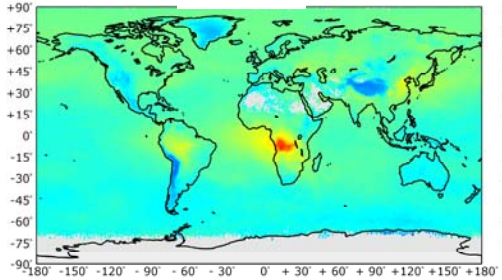
IASI



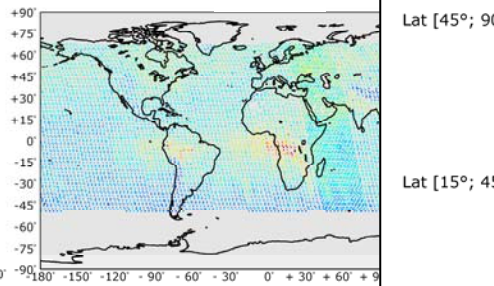
MOPITT



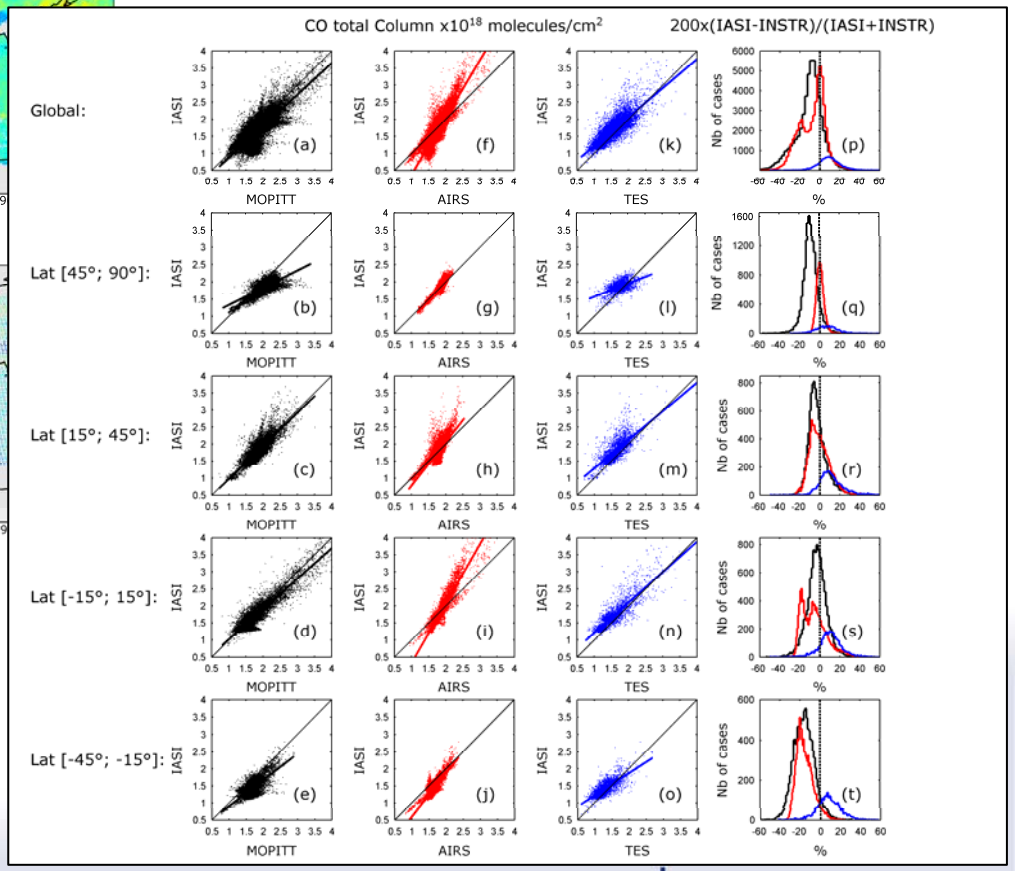
AIRS



TES



TES<IASI<MOPITT

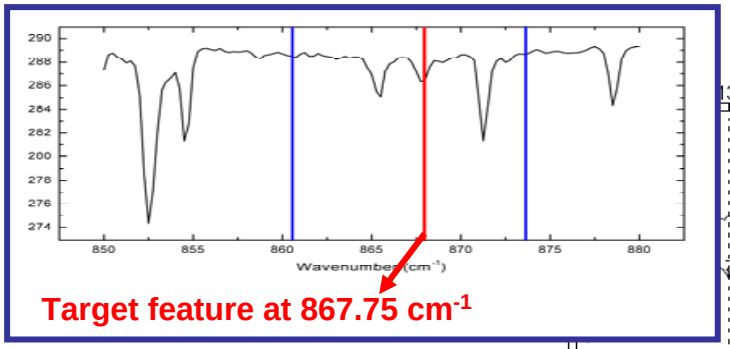


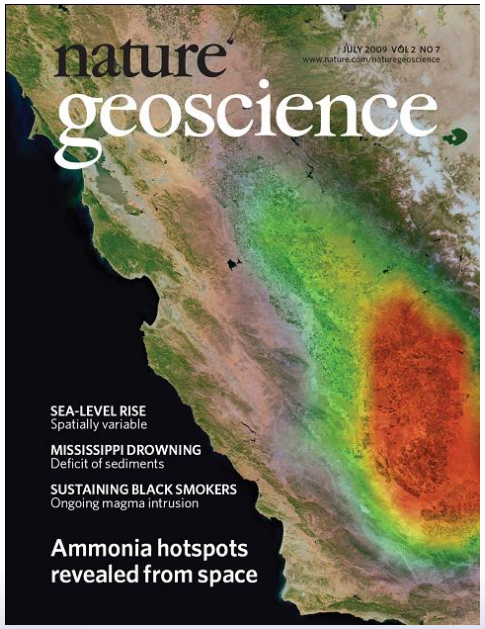
George et al., ACPD, 2009

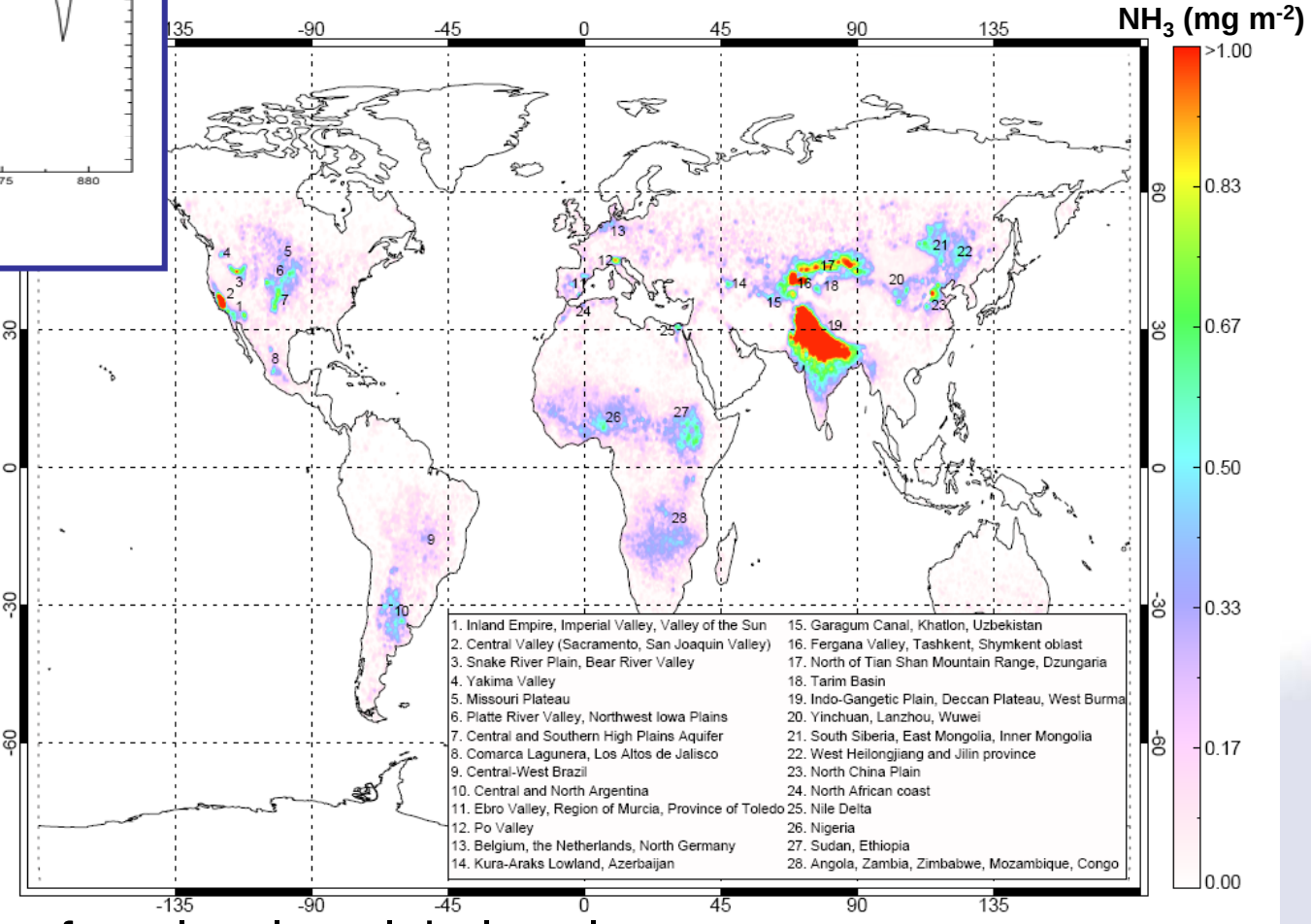
Tropospheric sources → Ammonia

2008 average

Clarisse et al., Nature Geo 2009







Mapping from local to global scale

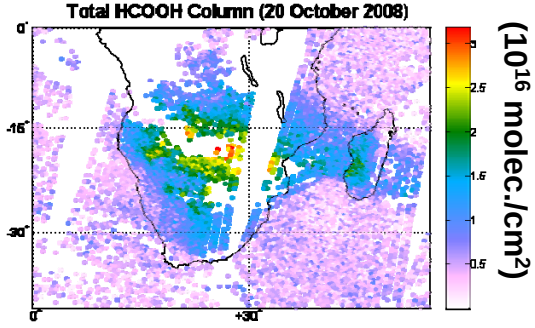
→ 28 emission hotspots identified

Tropospheric sources → VOCS HCOOH, CH_3OH

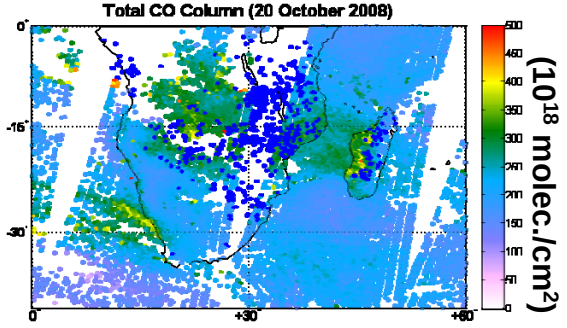
F. Karagulian, A. Razavi

October 2008

HCOOH



CO



High correlation HCOOH/CO/fire

→ **Biomass burning**

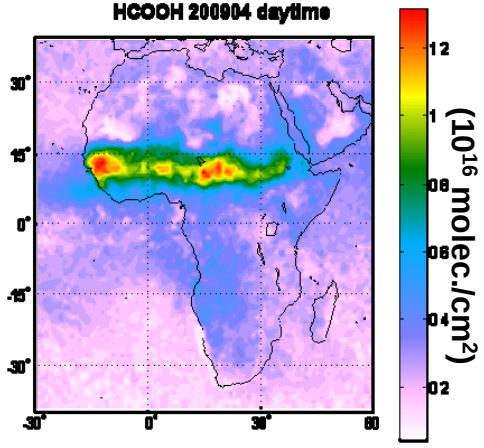
April 2009

High correlation HCOOH/CH_3OH

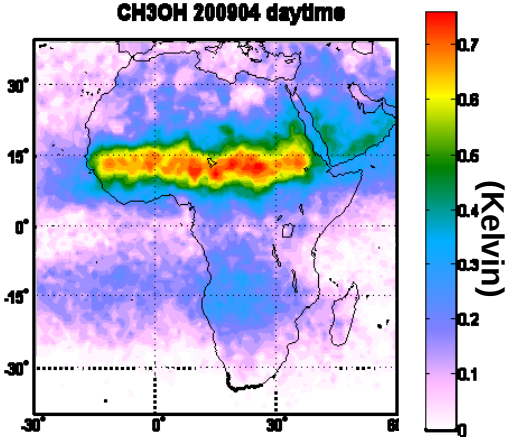
Weak correlation HCOOH/CO/fires

→ **Biogenic emissions?**

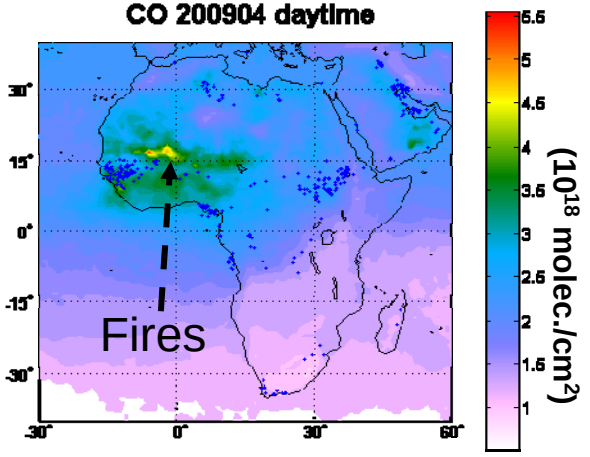
HCOOH



CH_3OH



CO



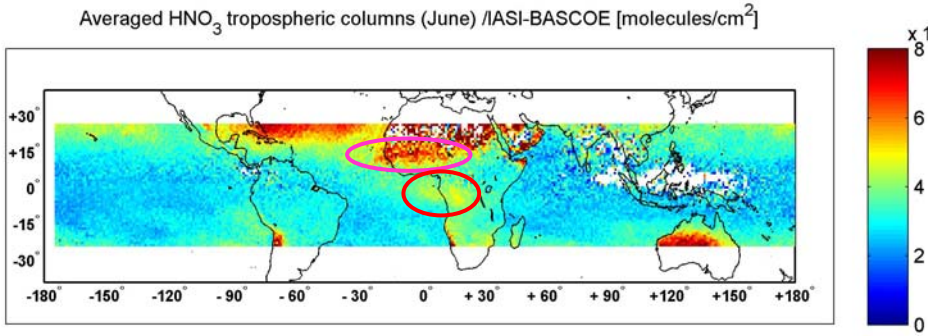
Chemistry/Transport

→ Nitric acid

No vertical information in the measurement → stratospheric column has to be subtracted

Using a stratospheric assimilated field (Bascoe)

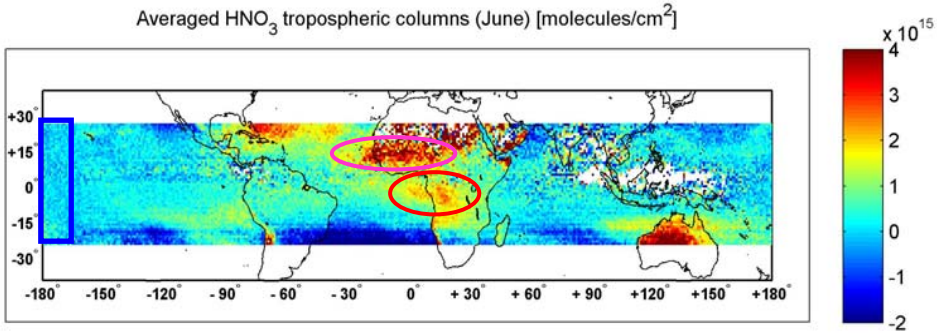
$[HNO_3]_{tropo} = [HNO_3]_{total/IASI} - [HNO_3]_{strato/BASCOE}$



Global but requires computational efforts
Stratospheric contamination remain

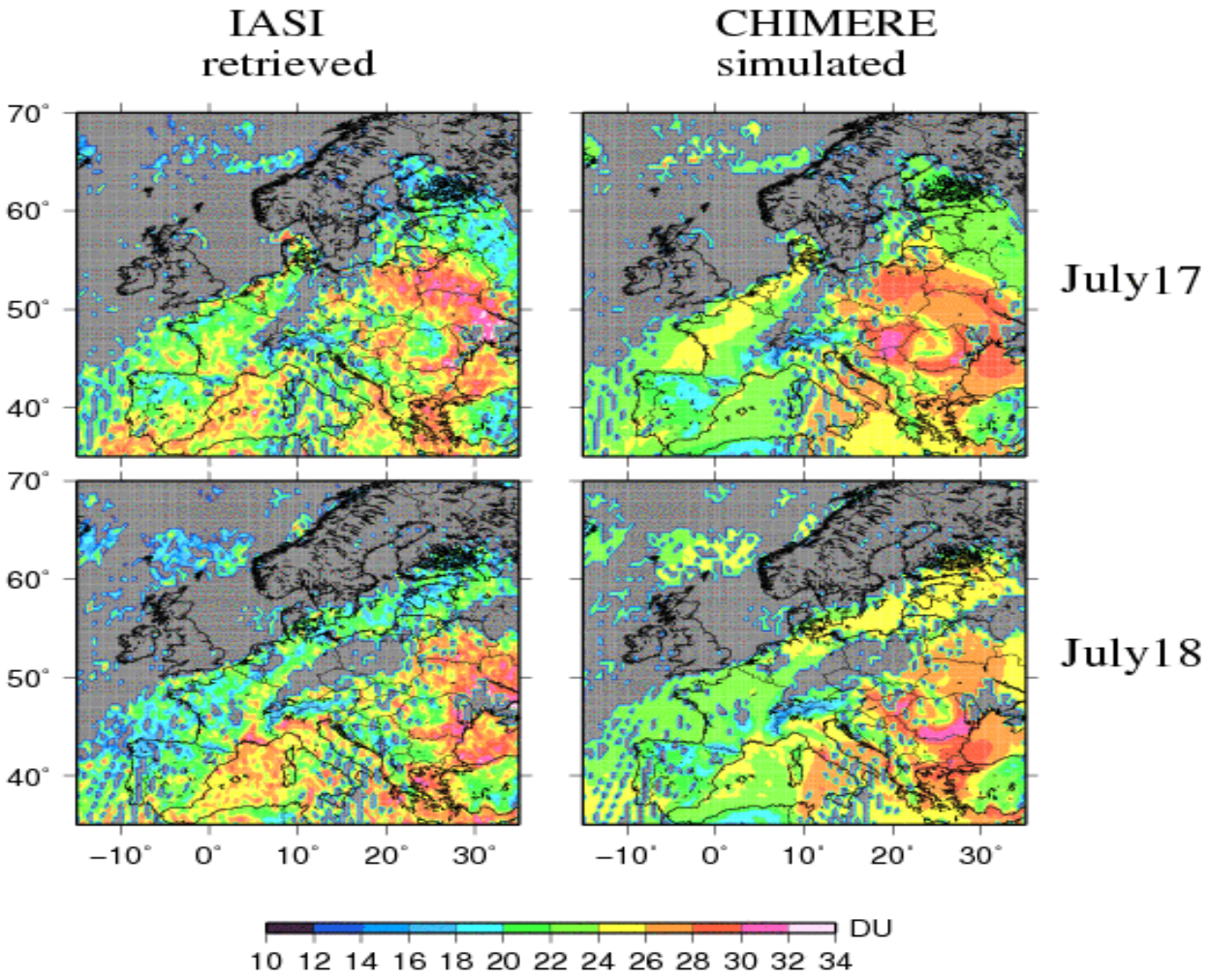
Using a background column

$d[HNO_3]_{tropo} = [HNO_3]_{total/IASI} - [HNO_3]_{background}$



Simple, robust but tropical regions mainly.
Provides a tropospheric “enhancement” rather than a column

Tropospheric O_3 over Europe during the heat wave in July 2007



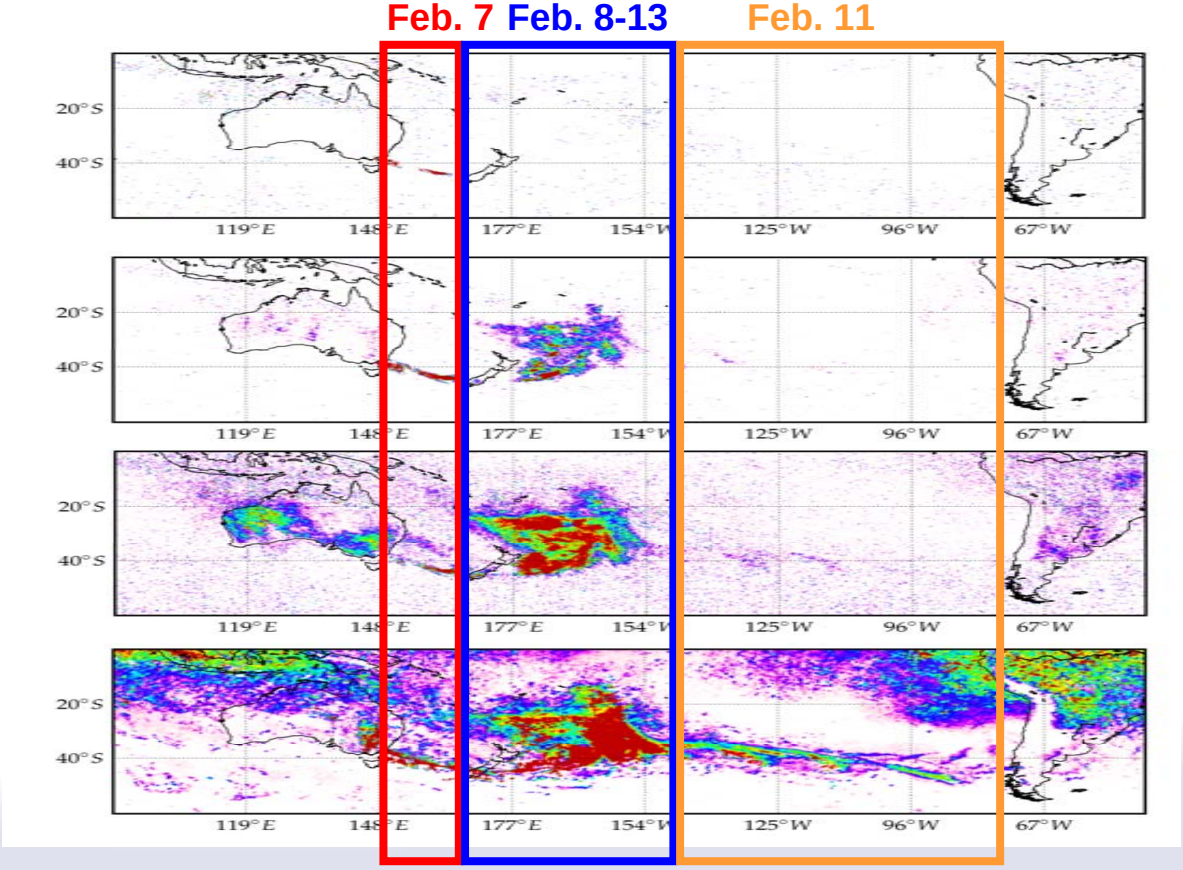
Eremenko et al, GRL, 2009

Chemistry/Transport

→ **Chemistry in fire plumes**

Australian fires (February 2009)

Integrated from 7 to 15 February 2009



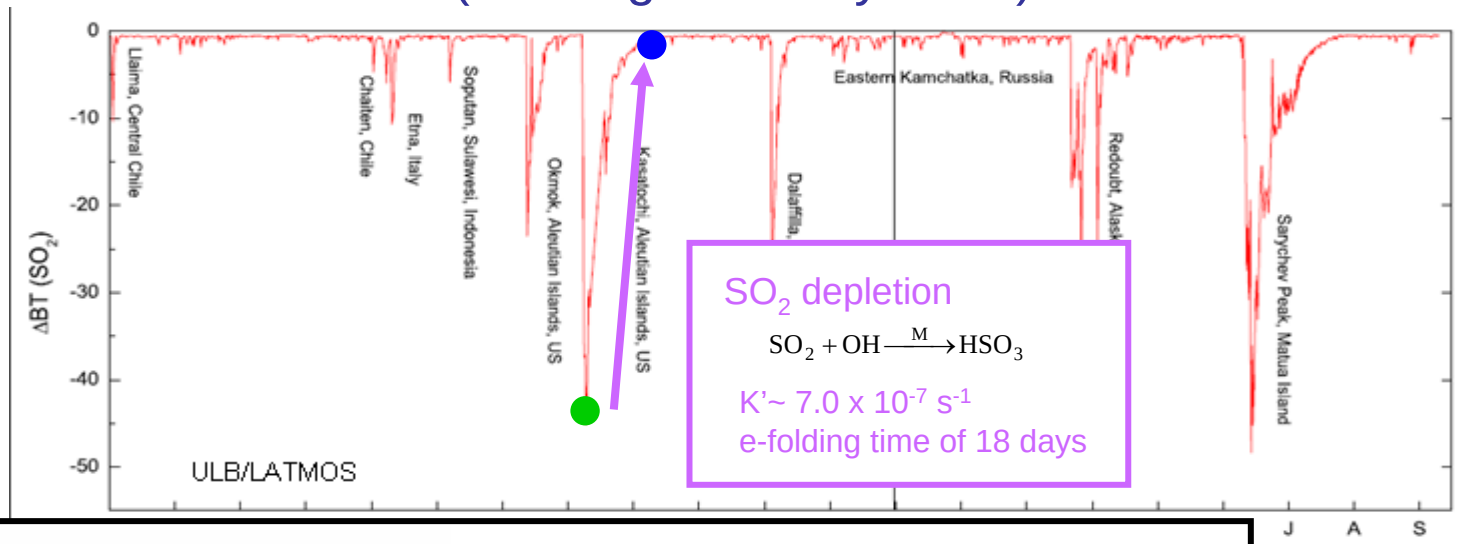
Enhancement ratios ΔX/ΔCO vs. time → chemistry in the fire plume

Coheur et al., ACP, 2009

Chemistry/Transport

→ SO_2 in volcanic plumes

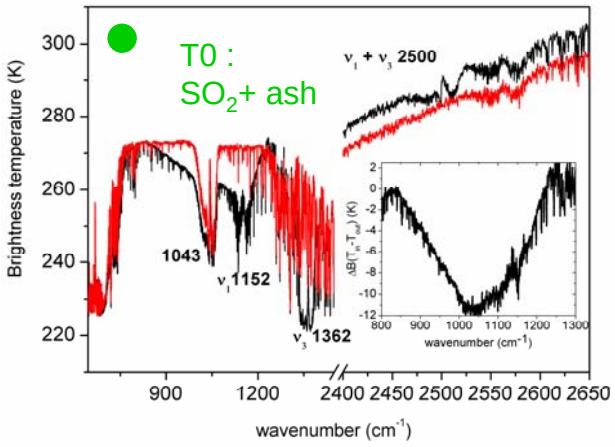
Volcanic plumes tracked by IASI
(starting January 2008)

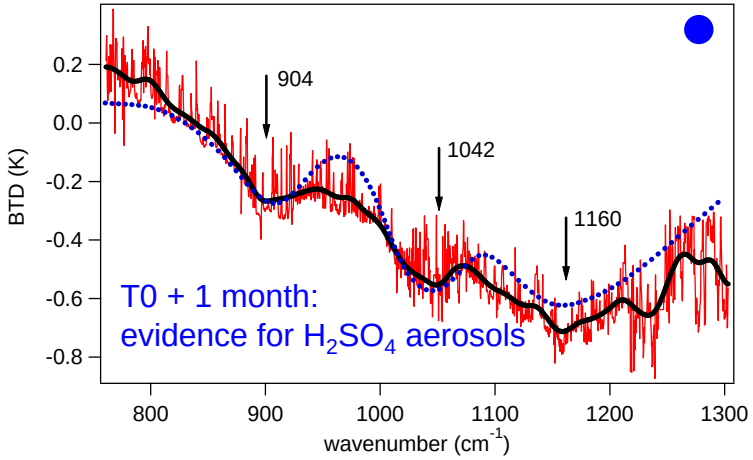


SO_2 depletion

$$SO_2 + OH \xrightarrow{M} HSO_3$$

K'~ 7.0 x 10^{-7} s^{-1}
e-folding time of 18 days



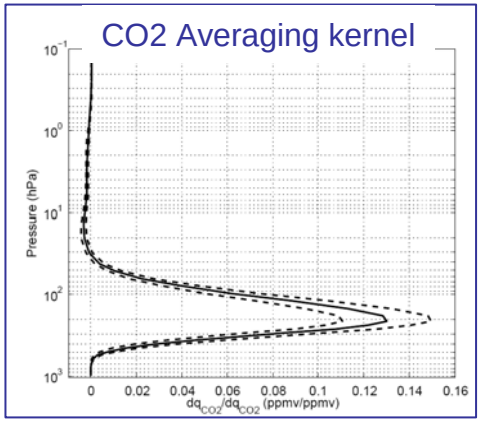


A word on climate: CO_2 / CH_4

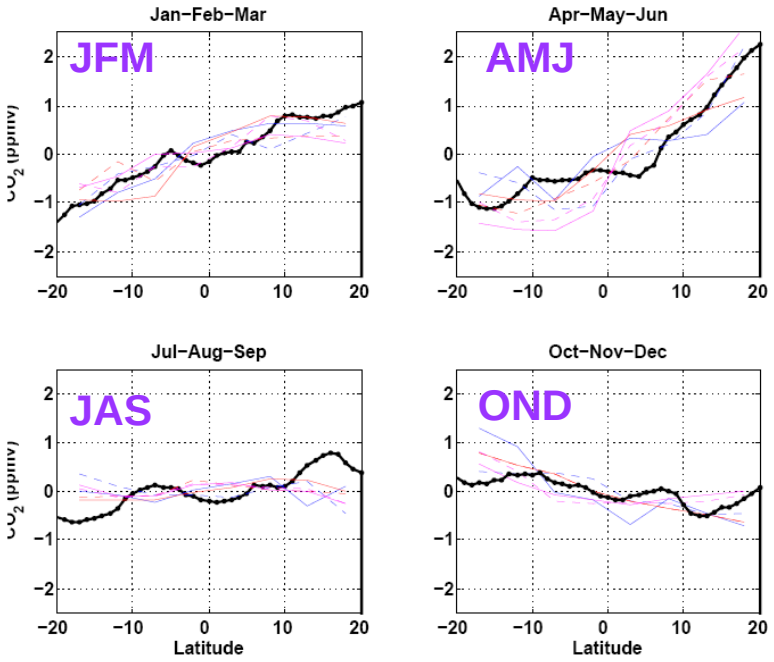
NN retrieval approach

retrieval of an UT integrated content **representative of the 11–15 km range**

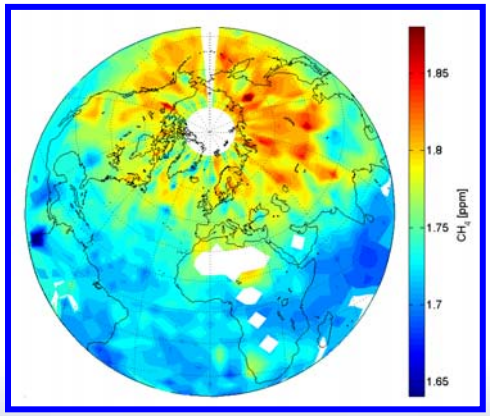
Retrieval @ 5°x5° resolution
Uncertainty ~2ppmv (0.5%)

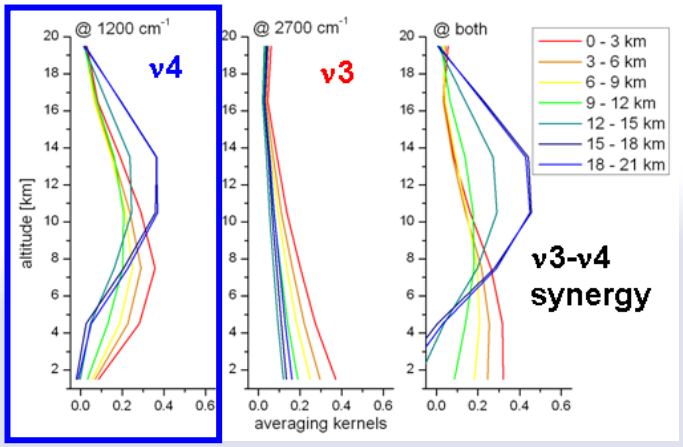


Crevoisier et al., ACP, 2009



CH_4: 4 days average (October 2008) on a 4x4° grid



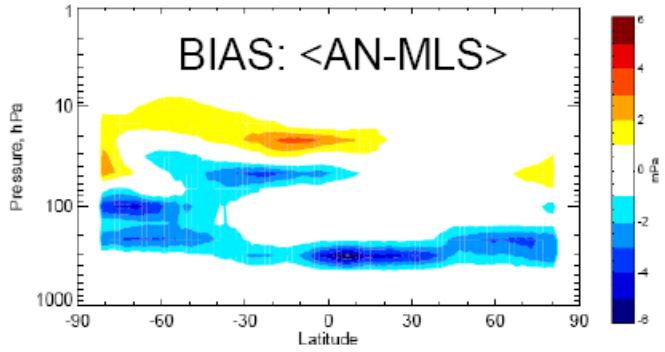


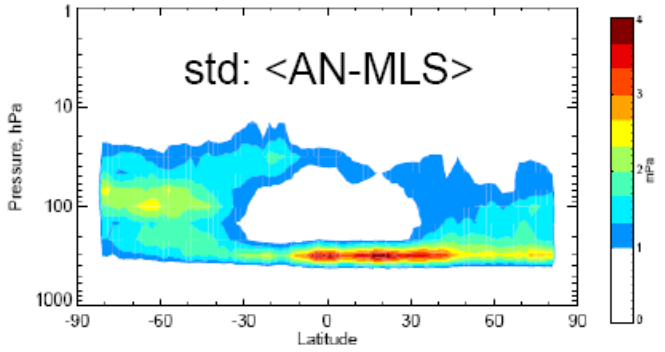
Razavi et al., ACPD, 2009

O3 (ECMWF)

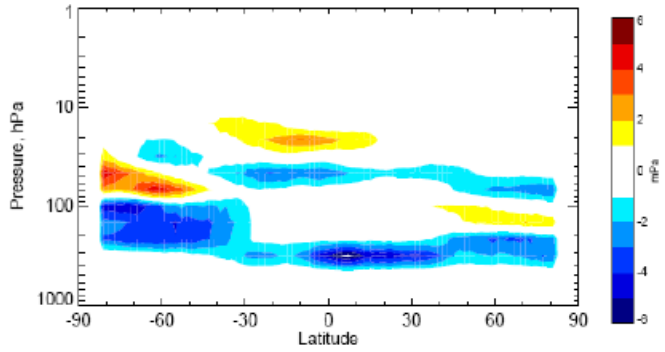
Verify against MLS (20090615-20090630)

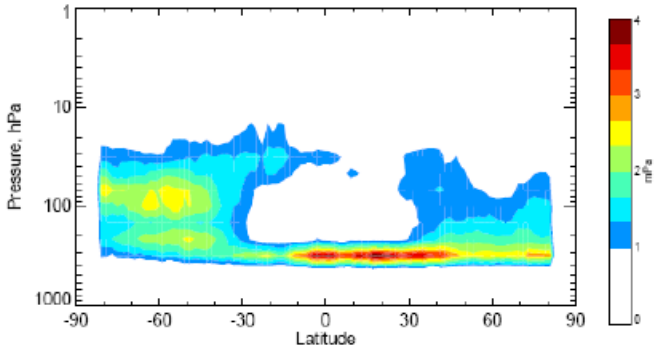
BASELINE
No O3 OBS



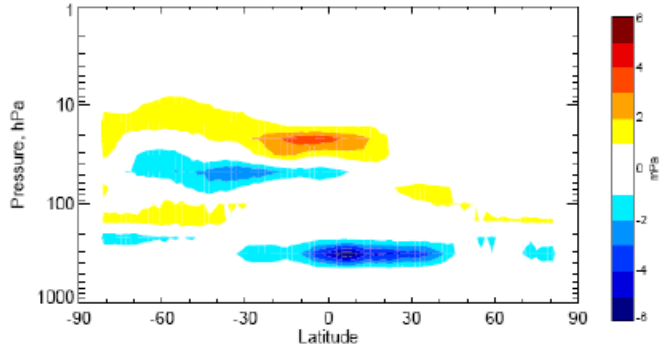


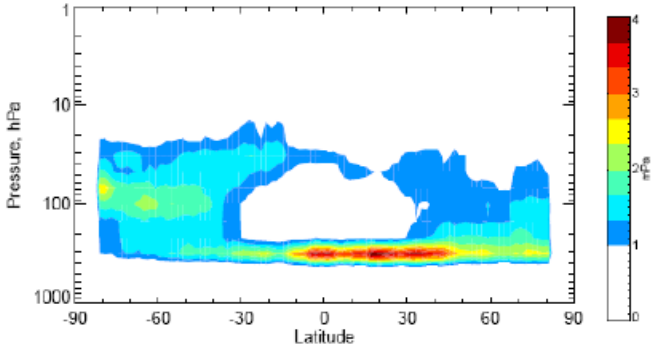
BASELINE
+SBUV+OMI





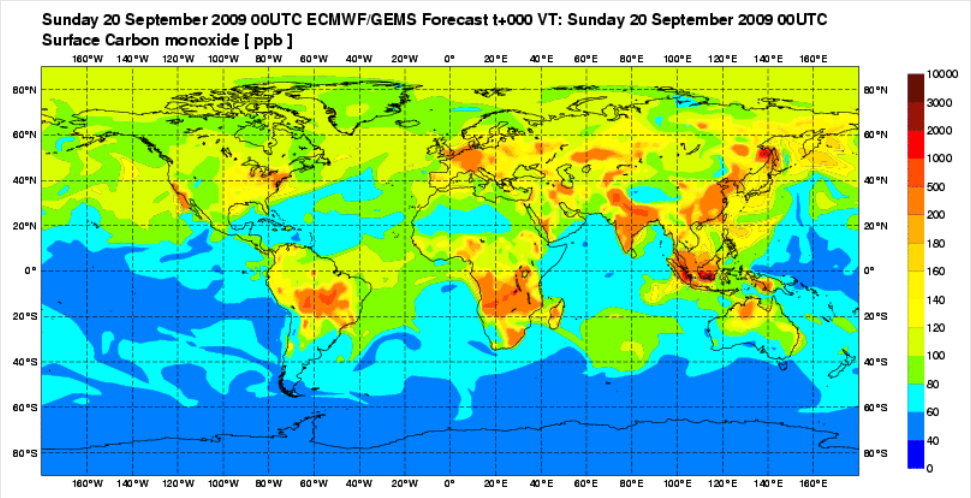
BASELINE
+IASI 16 O3 Channels





Assimilation of NRT CO total column data from IASI

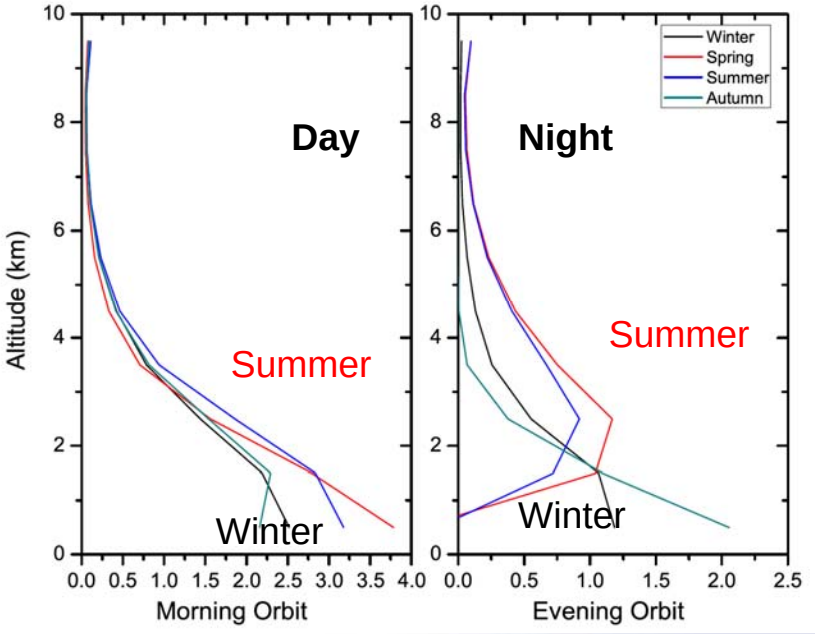
- Near-real time CO total column data from IASI produced by LATMOS-ULB have been assimilated in the GEMS/MACC near-real time analysis began on 12 February 2009, 0z
- Data look good. Departures and standard deviations are a considerably smaller than they were for the previously monitored (and assimilated) EUMETSAT CO product
- Analysis is drawing to the data. Bias and standard deviation of departures are reduced.



OPEN ISSUES

- **Thermal Contrast : Difference between surface TB and air temperature at maximum of Weighting function (highest concentration)**
- **Allows to access to Pollution in boundary layer**
- **But reduces the signal in the total column and induces differences between day and night**
- **Ground emissivity amplifies the effect**
- **Clouds (impact currently evaluated)**

Averaging kernels (San Joaquin)



Averaging kernels for NH3 (Clarisse)

Conclusions

IASI measures a dozen of species with a range of lifetimes, *routinely* and *globally* twice a day

Long-lived species (years)

→ ***Climate***

ESA-ECVs?

+ CO, O_3 (months)

→ ***Chemistry, AQ, Transport***

Air quality

CO (O3?) in ***FP7***-GEMS/MACC; ***FP7***-CITIZEN

Short-lived species + aerosols (days)

→ ***Sources, emission inventories***

Fire monitoring

(POLARCAT; ***ESA***-STSE/ALANIS?

Volcanic monitoring

IASI a demonstrated its capability in detecting minor species
Time is now to quantify the emissions
It is one goal of the GMES Sentinel 5

This will be obtained thanks to a higher spectral resolution and lower noise which will be present on the next generation of IASI IASI-NG which will fly on the Post EPS
It has been demonstrated that Humidity profiles and temperature profile will also benefit of increased performances of IASI-NG

cnes