Information content of IASI for constituent estimation

C. Clerbaux, and the LATMOS IASI Team, Paris
P.-F. Coheur, and the ULB IASI Team, BXL

Outine

- Trace gas measurements with IASI
- Operational applications

EUMETSAT

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cnrs

Institut Pierre Simon Laplace
Sciences de l'environnement

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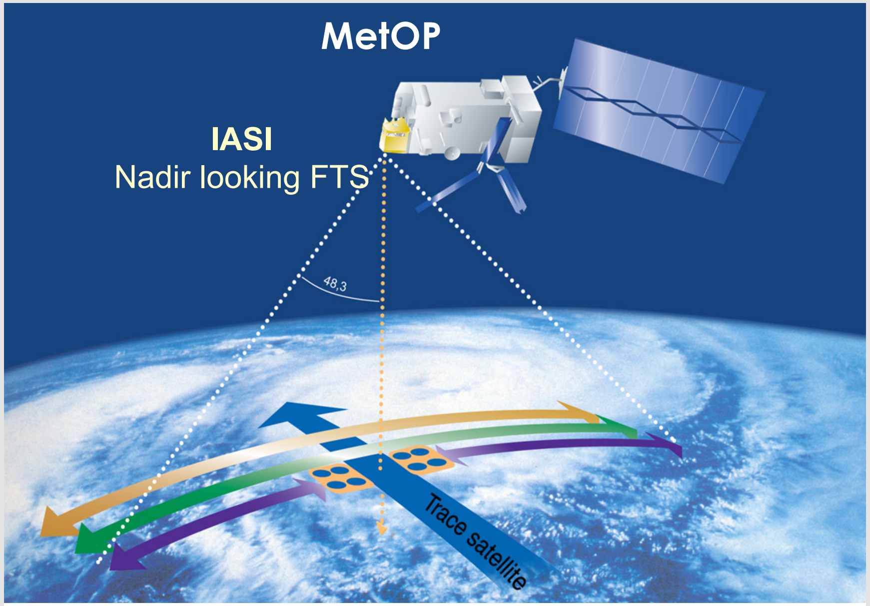
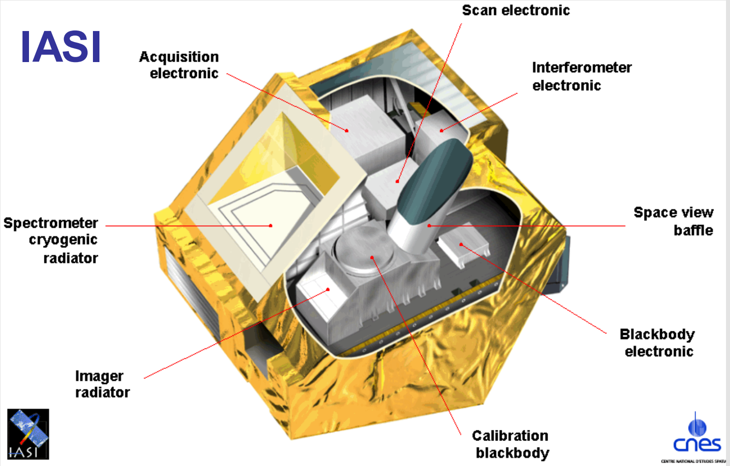
IASI advantages for monitoring trace gases



- 12 km pixel x 4 @ nadir
- 120 spectra along the swath (±48.3° Scan →2400 km), each 50 km along the trace



- Spectral coverage = 645-2760 cm^{-1}
- Spectral resolution = 0.5 cm^{-1}
- Radiometric noise ~ <0.1-0.2 K

Small ground pixel size

Global coverage twice daily (morning and evening orbits)

Broad spectral coverage without gaps

Medium spectral resolution

High radiometric performances

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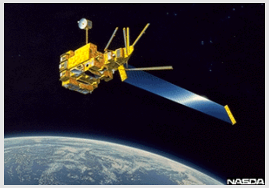
Atmospheric composition from infrared sounding instruments

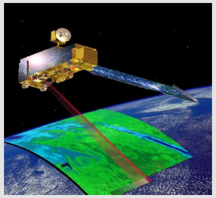
1995 — **2000** — **2005** — **2007**

IMG/ADEOS



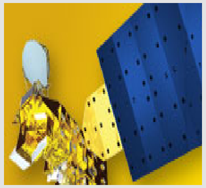
CO, O_3, HNO_3 profiles, HDO
Few days of measurements
High spectral resolution

MOPITT/TERRA



CO profiles (2 trop. Inf)
Global coverage 3 days
Atm. Chemistry

AIRS/AQUA



CO, O_3, CO_2, CH_4, H_2O, volcanic SO_2
Global coverage daily
Coarse spectral res.
NWP

TES/AURA

CO, O3 profiles (2 trop. Inf)
HDO, NH_3, CH_3OH
Global coverage 14 days
High Spectral resolution
Atm. Chemistry

IASI/METOP

Nadir TIR satellite sounding

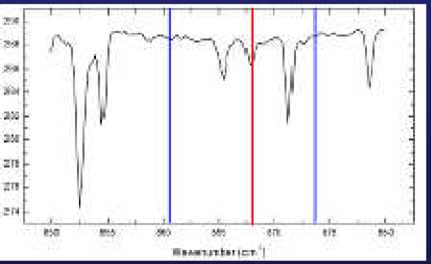
→ Tropospheric sensitivity with, in the best cases, *vertical profile information* for a series of species (mainly with *long to medium lifetimes*)

→ Surface sensitivity strongly dependent of thermal contrast → Can we monitor / quantify sources?

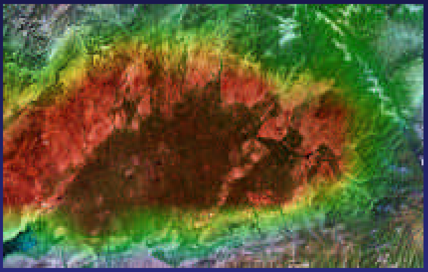
Reception and data processing set-up

BUFR
- **L1c**
- **L2** (T,cld)

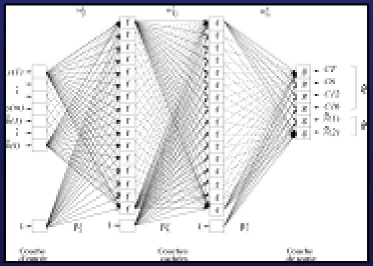
dBT (at L1c reception)



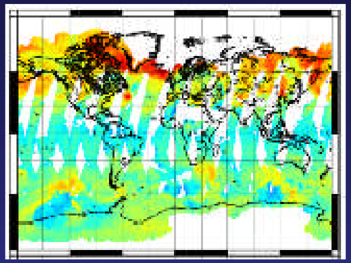
SO_2, NH_3, …



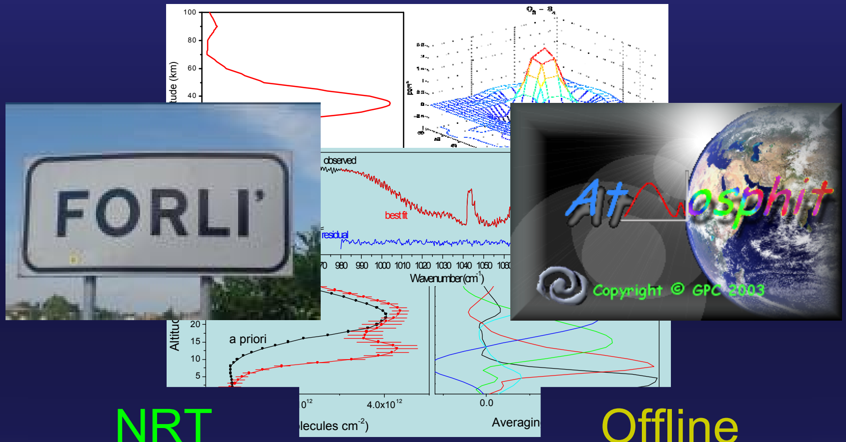
ANN (at L2 reception)



CO,O_3,CH_4



OEM

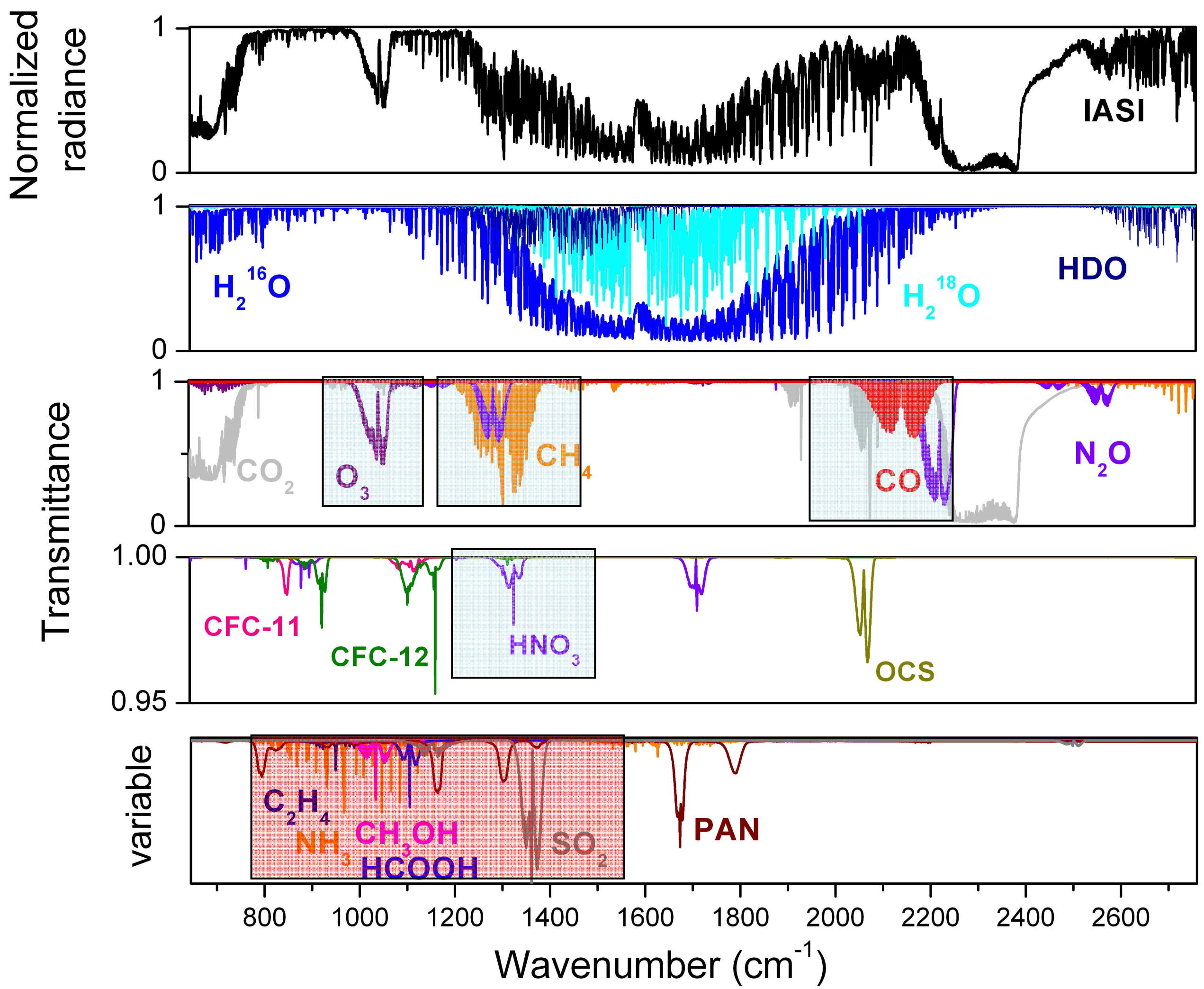


NRT processing

CO, HNO_3, O_3

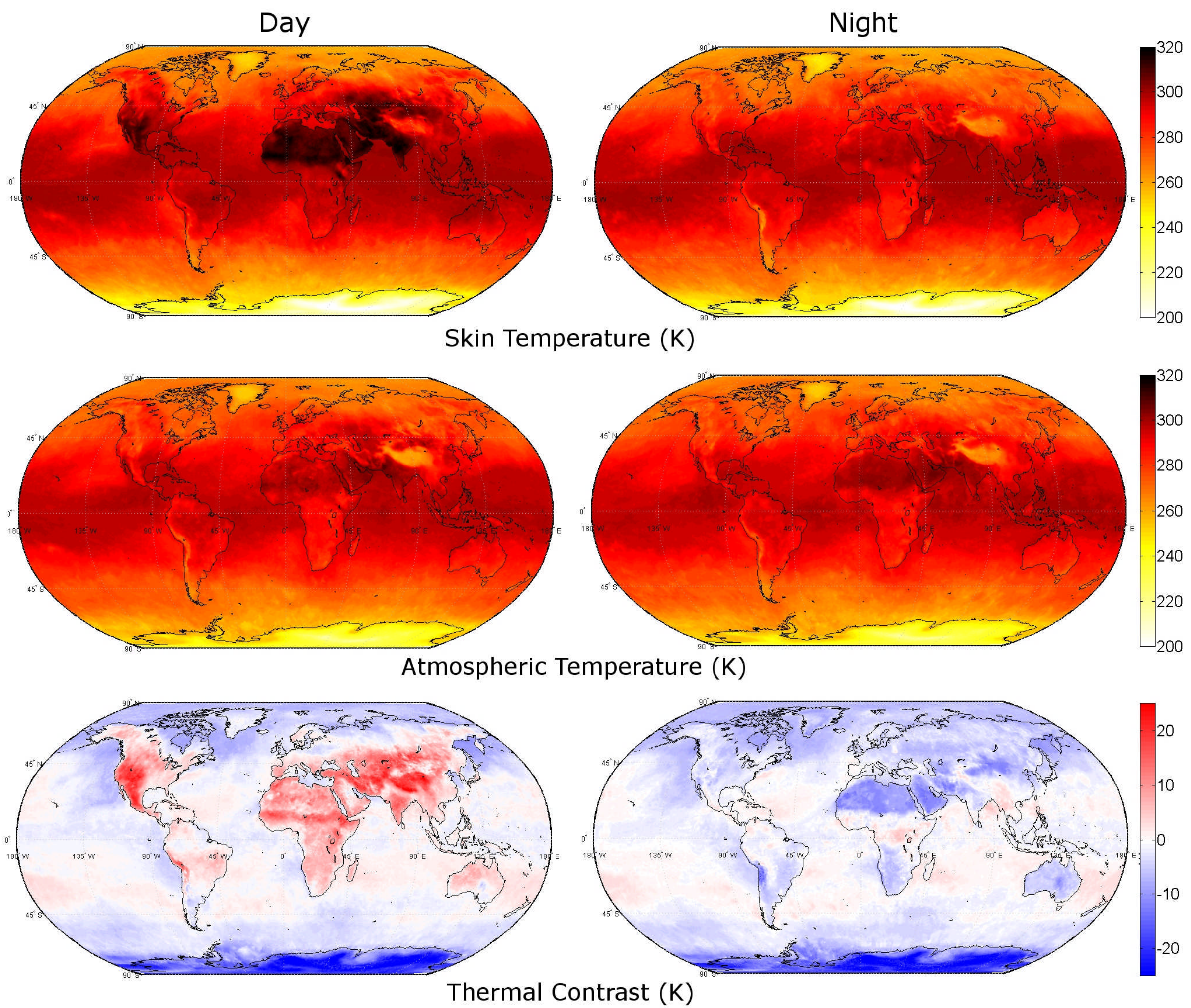
Offline (very) slow processing

IASI observations: radiances



Clerbaux et al, ACP IASI Special Issue, 2009

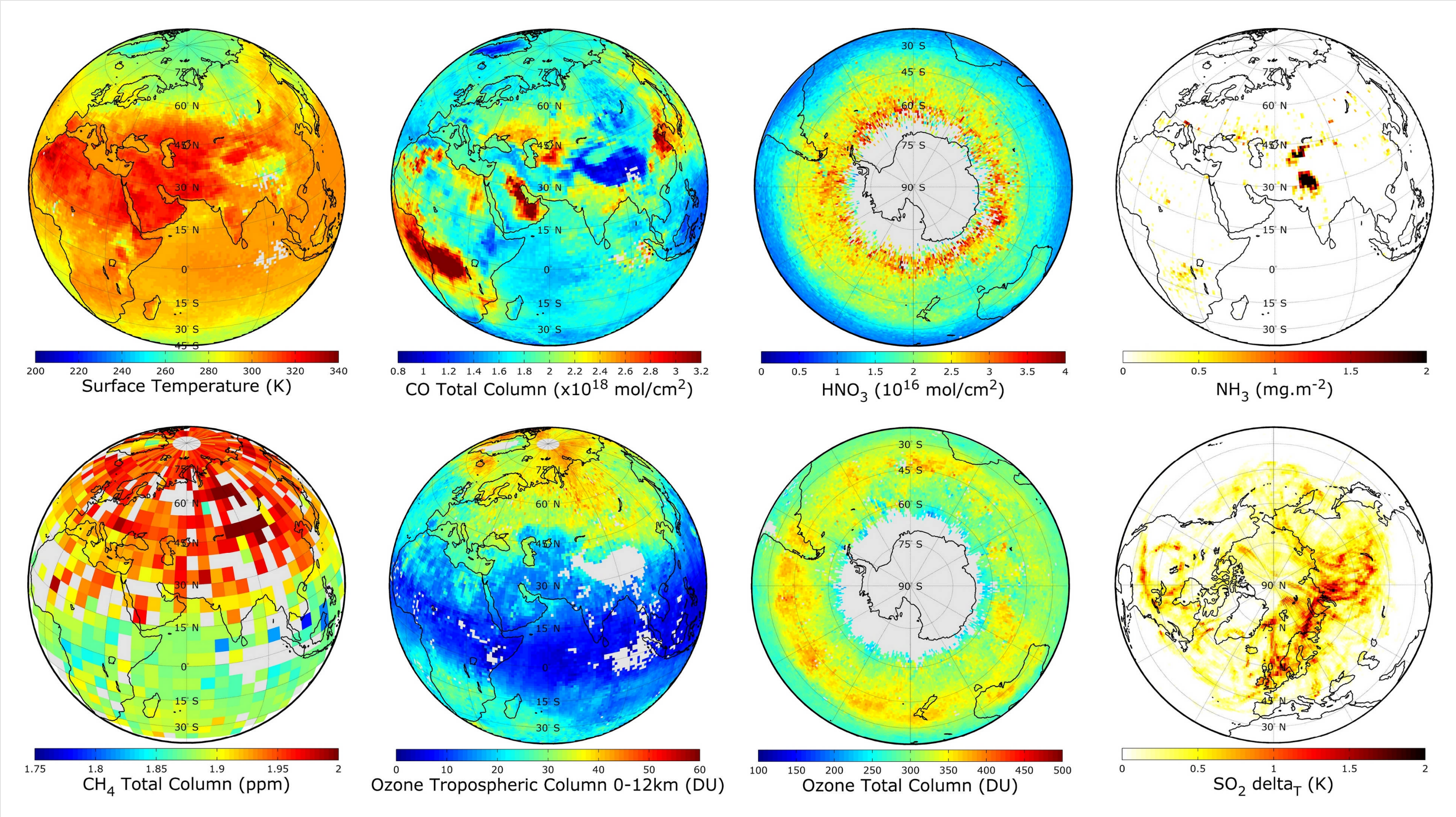
Thermal contrast – 1 month average (May 2008)



Clerbaux et al, ACP IASI Special Issue, 2009

Species	Vertical Res. (DOFS)	Error (%)	Comment	References
Long-lived species (lifetime > 10 years)				
CO_2	<1	*NA*	Strong absorber	Crevoisier et al., IASI ACP/ACPD
N_2O	<1	*NA*	Strong absorber	Ricaud et al., IASI ACP/ACPD
CFC-11	<1	*NA*	Weak absorber	
CFC-12	<1	*NA*	Weak absorber	
HCFC-22	*NA*	*NA*	Weak absorber	
OCS	<1	*NA*	Weak absorber	Shepard et al., IASI ACP/ACPD

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



Clerbaux et al, ACP IASI Special Issue, 2009

CO, O_3, HNO_3, SO_2 in near real time

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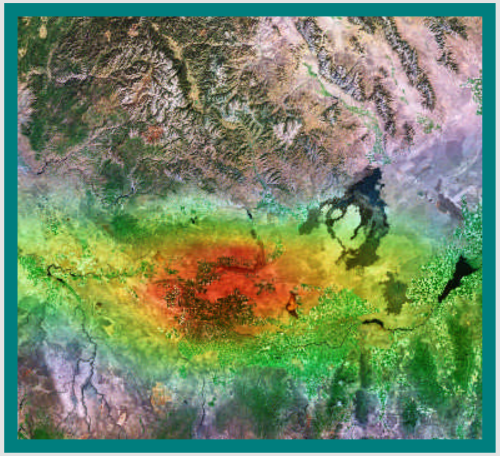
Species	Vertical Res. (DOFS)	Error (%)	Comment	References
Medium-lived species (lifetime a few weeks to a few years)				
H_2O	5-6	15% (0-20 km)	Dominant absorber	Herbin et al., IASI ACP/ACPD
HDO	3-4	30% (0-20 km)	Strong absorber + Absorption in the backscattered solar radiation	Herbin et al., IASI ACP/ACPD
$H_2{}^{18}O$	3-4	NA	Strong absorber	Herbin et al., IASI ACP/ACPD
CH_4	~1	<2% col. tot.	Strong absorber Absorption in the backscattered solar radiation	Razavi et al, IASI ACP/ACPD Crevoisier et al., IASI ACP/ACPD
O_3	3-4	30% (0-6 km) 3% col. tot.	Strong absorber with large stratospheric contamination	Eremenko et al., 2008 Boynard et al., IASI ACP/ACPD Keim et al., IASI ACP/ACPD Massart et al., IASI ACP/ACPD Feis et al., IASI ACP/ACPD
CO	1-2	10%		George et al., IASI ACP/ACPD Turquety et al., IASI ACP/ACPD
HNO_3	~1	15% Col. tot.	Weak absorber with large stratospheric contamination	Wespes et al., IASI ACP/ACPD

Species	Vertical Res. (DOFS)	Error (%)	Comment	References
Short-lived species (lifetime a few hours to a few days)				
NH_3		*NA*	Detected in fires and over agricultural regions	Coheur et al., IASI ACP/ACPD Clarisse et al., 2009
CH3COOH		*NA*	Detected in fires	Coheur et al., IASI ACP/ACPD
HCOOH		*NA*	Detected in fires	Coheur et al., IASI ACP/ACPD
C_2H_4		*NA*	Detected in fires	Coheur et al., IASI ACP/ACPD
SO_2 volcans		*NA*	Detected in volcanic plumes for concentrations above 2 DU	Clarisse et al., IASI ACP/ACPD
Aerosols				
Dust (sand), volcanic ash, ice clouds	~1	NA		

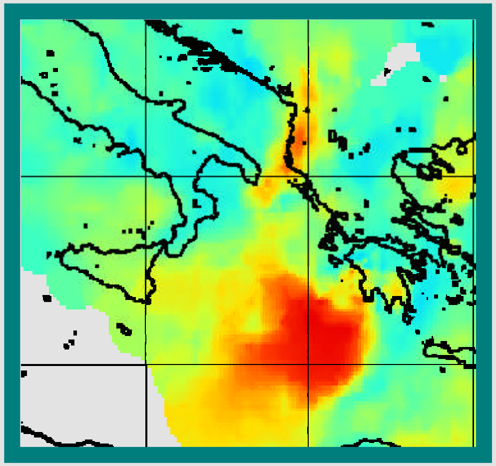
IASI/METOP – Operational applications (GMES)

Pollution forecast



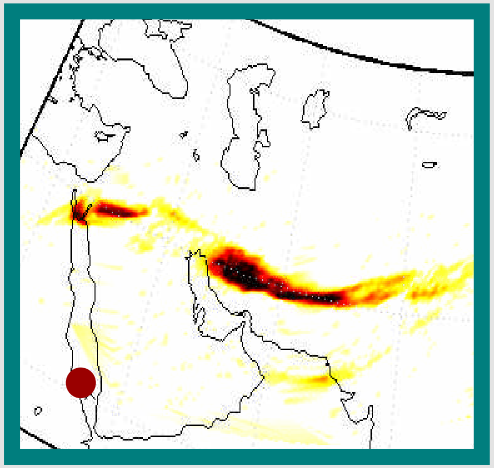
Ozone peaks
NH_3 sources

Fire detection



Long-range
pollution

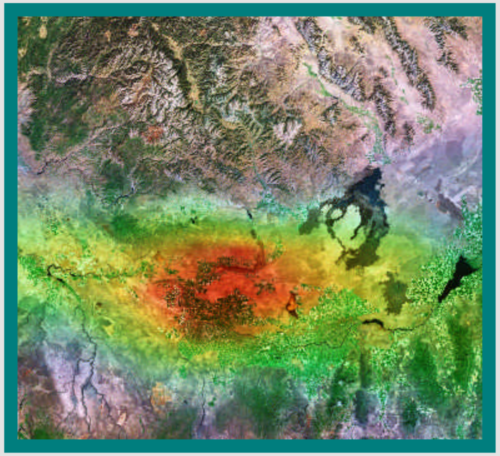
Volcanic plumes



Aviation threat

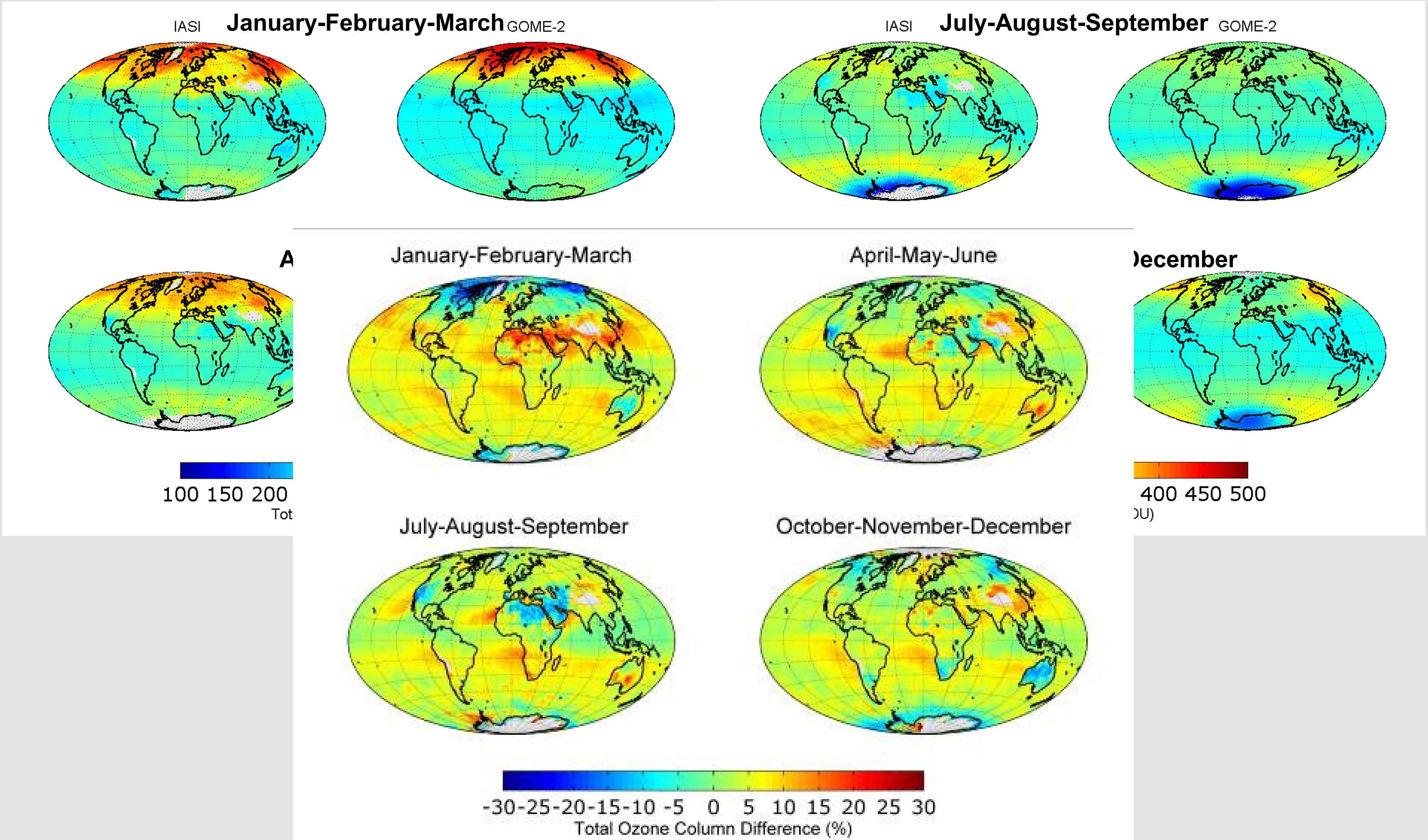
LATMOS ULB

Pollution forecast

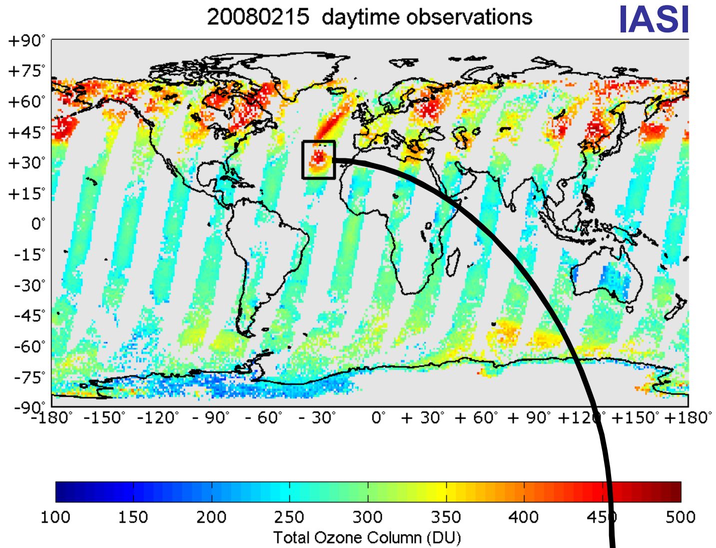


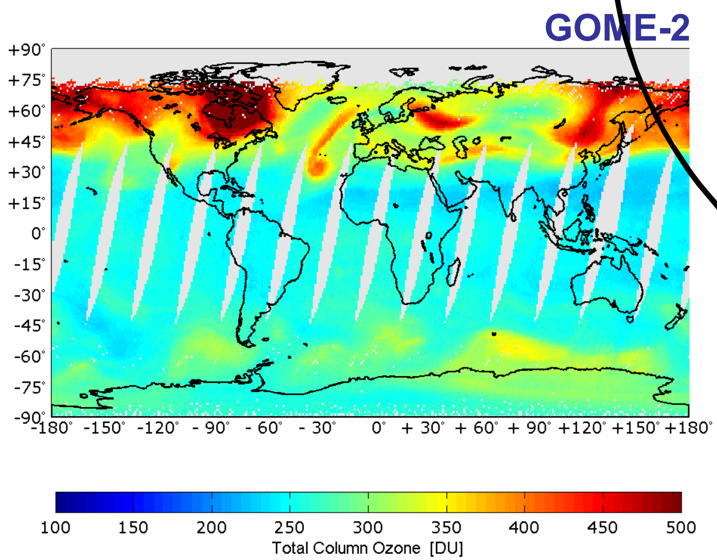
Ozone peaks
NH_3 sources

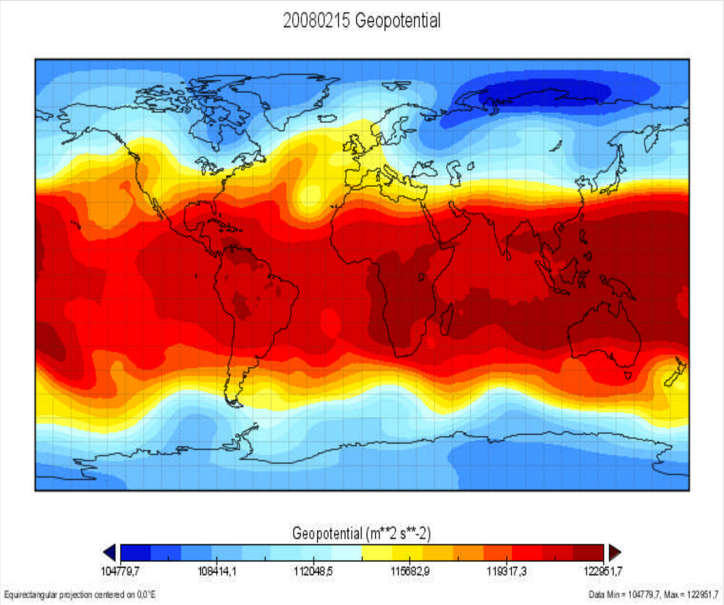
Ozone total column

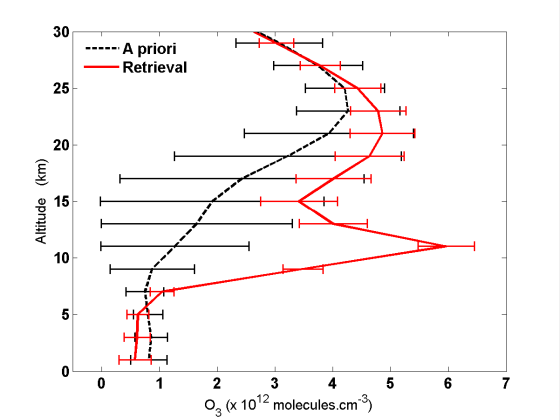


Ozone profile



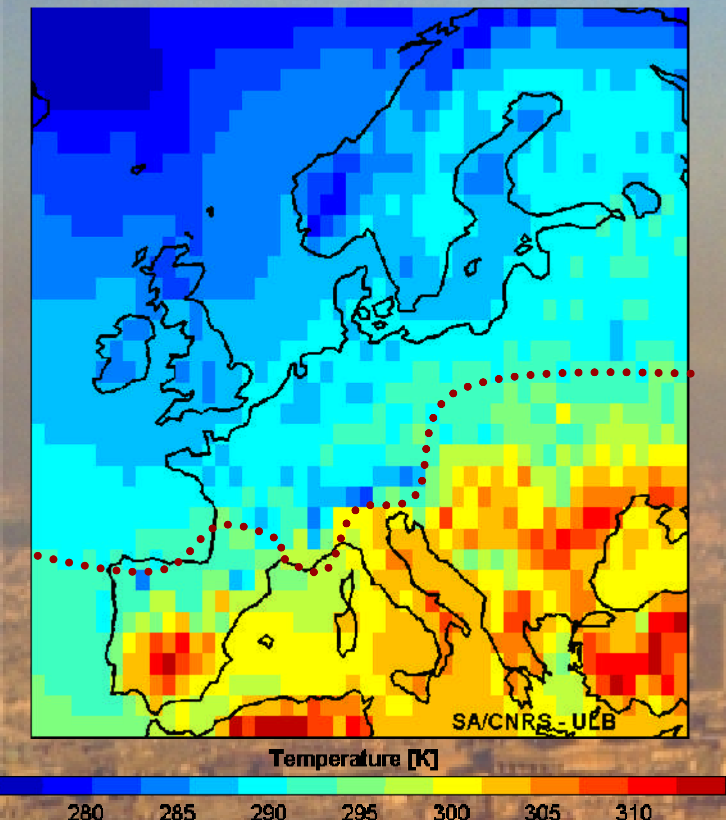




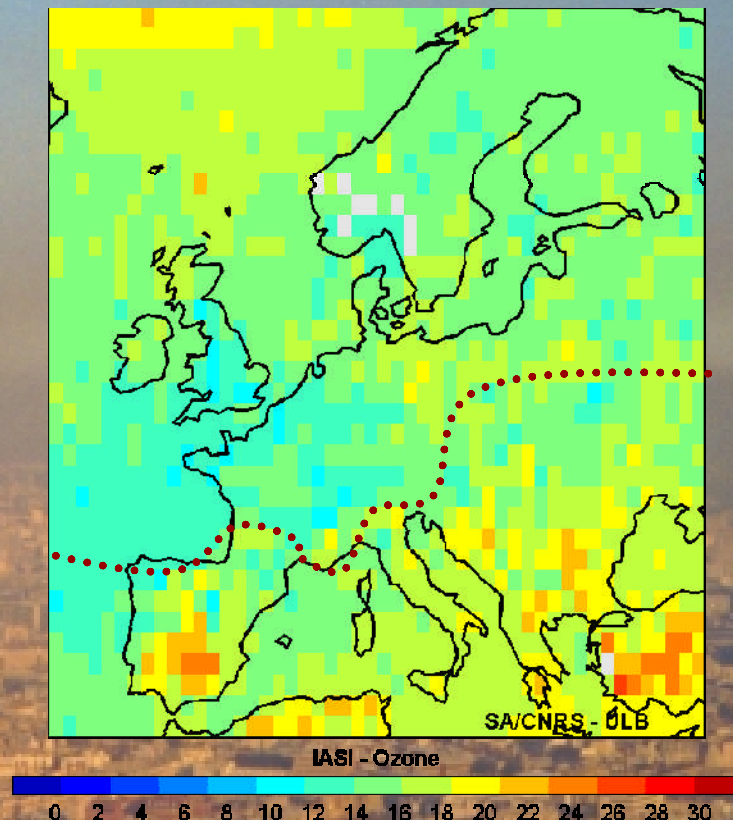


Boynard et al, ACP IASI Special Issue, 2009

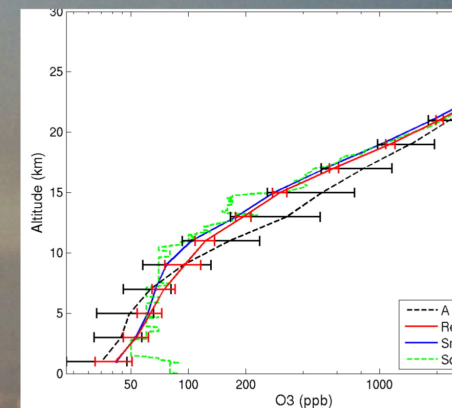
Ozone (O_3) - pollution peaks, South of Europe, 22-26 July 2007



Temp, ECMWF data



IASI data: Ozone 0-6 km



Credit A. Boynard

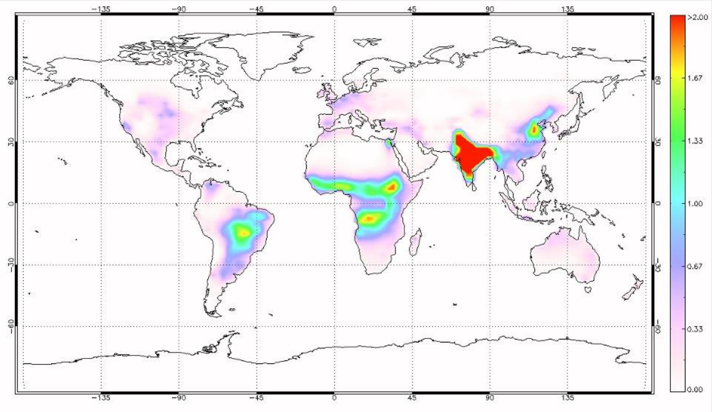
Relevance of atmospheric ammonia

- Dominant role in the nitrogen cycle (along with NOx)
- Formation of fine particulate matter (→ Air Quality)
- Acidification and eutrophication of the ecosystem

Sources

- Agriculture (66%): fertilizers, livestock waist, crops
- Natural sources (21%): oceans, soils, vegetation
- Biomass burning (13%)

Growing population goes together with an ever increasing demand of fertilizers, leading only to increasing ammonia emissions

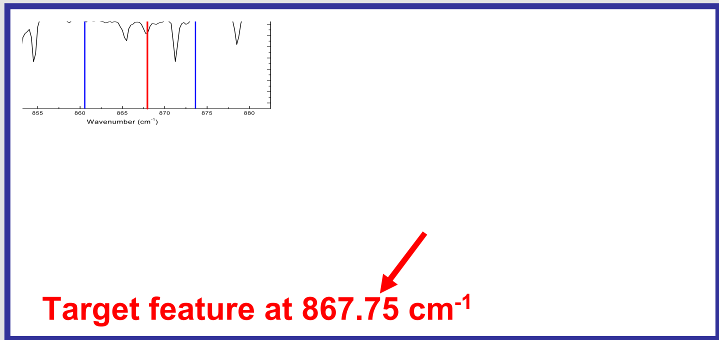


Lack of observations and inventories

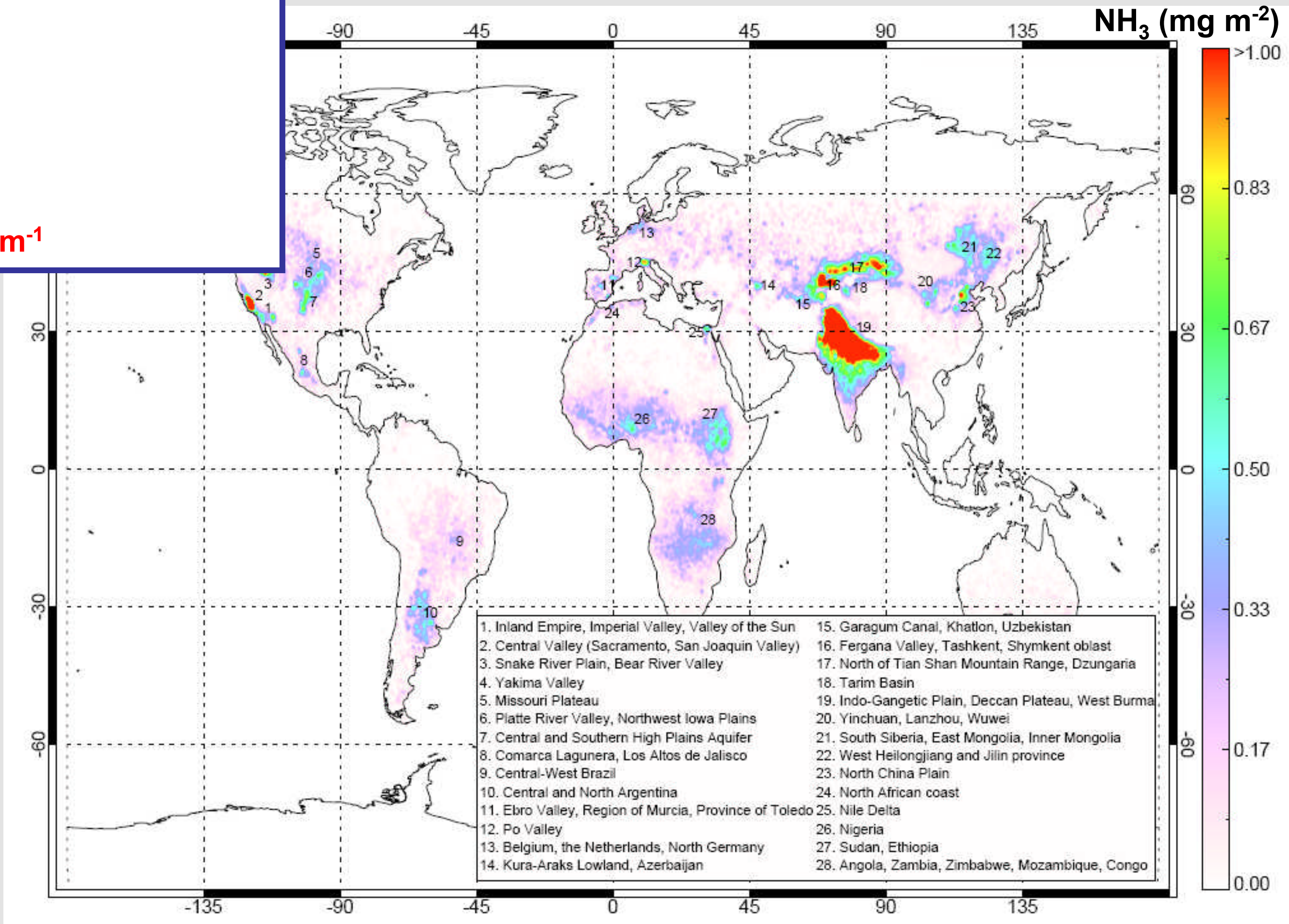
Estimates of global annual ammonia emissions have errors over 50%

2000 distribution from TM5

NH_3 from IASI: 2008 average



Clarisse et al, Nature Geosc., in revision

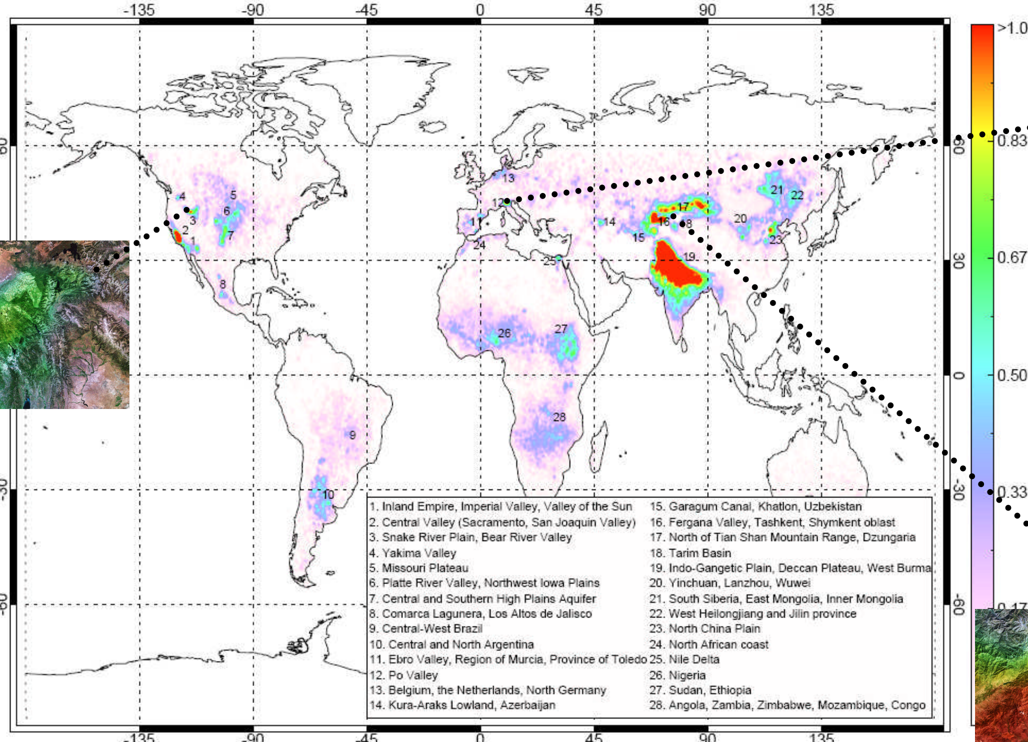


NH_3 from IASI: 2008 average

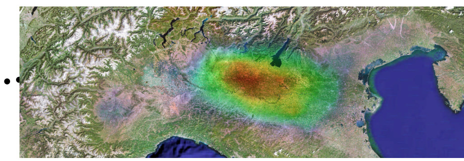
Mapping from local to global scale

→ 28 emission hotspots identified

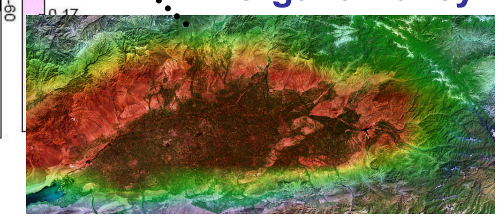
Snake river Valley



Po Valley



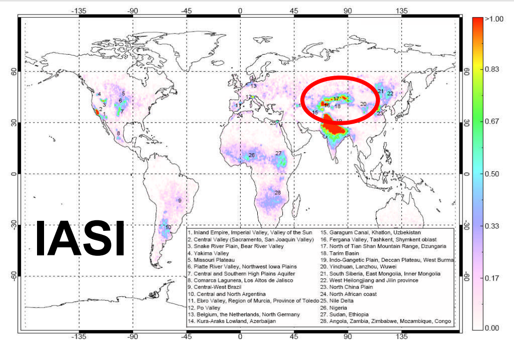
Fergana Valley

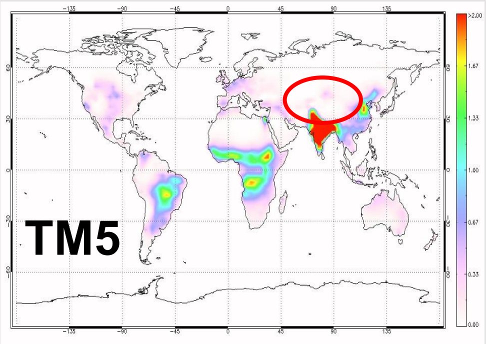


Clarisse et al, Nature Geosc., in revision

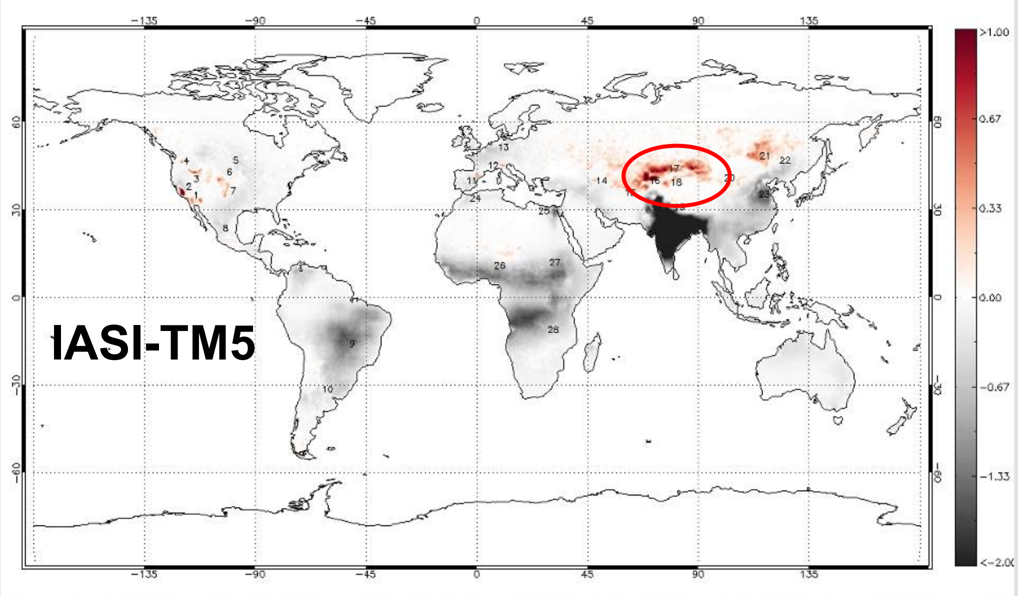
NH_3 from IASI: 2008 average

Comparison with models





Clarisse et al, Nature Geosc., in revision

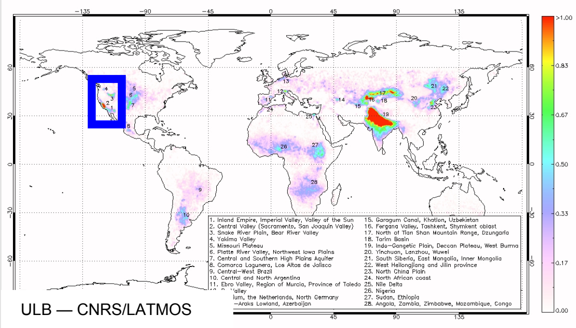


IASI > TM5 → Missing emissions

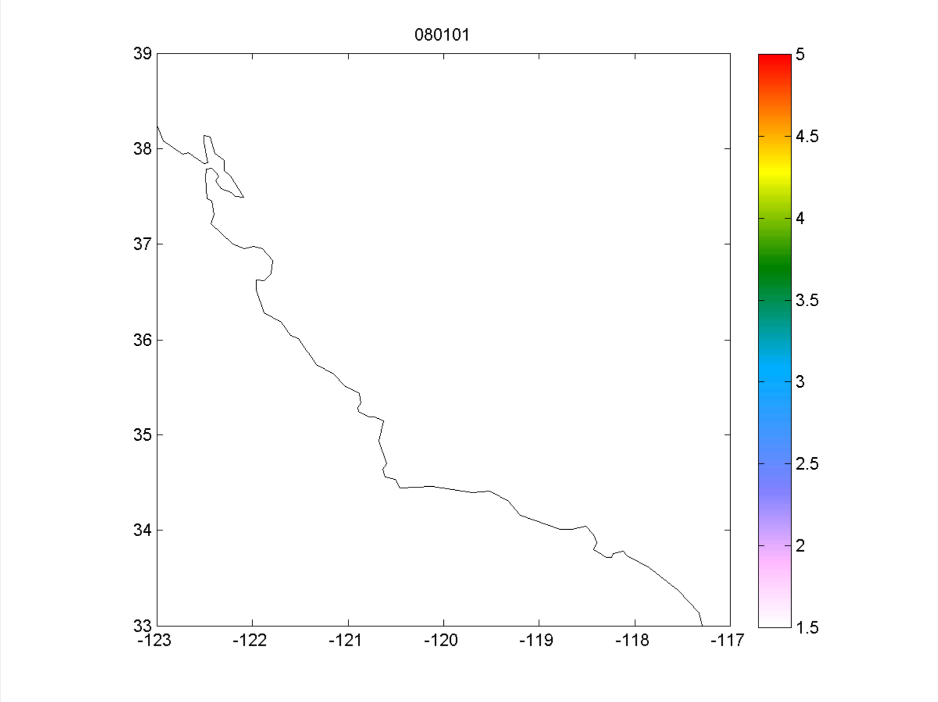
IASI < TM5 → Detection threshold (Thermal contrast!)

NH_3 from IASI (St Joaquin)
Spatial and temporal sampling

2008 yearly average

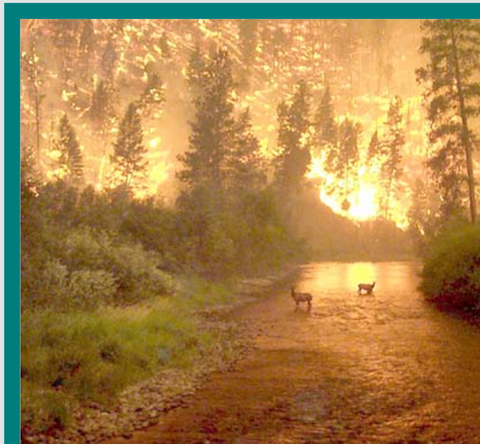


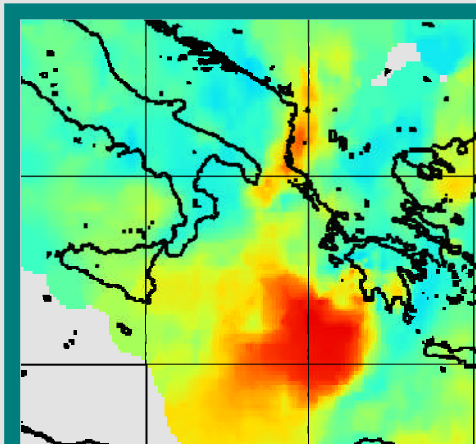
Clarisse et al., in preparation



Build up in early spring
Stays high throughout Spring-summer
Weakening in October

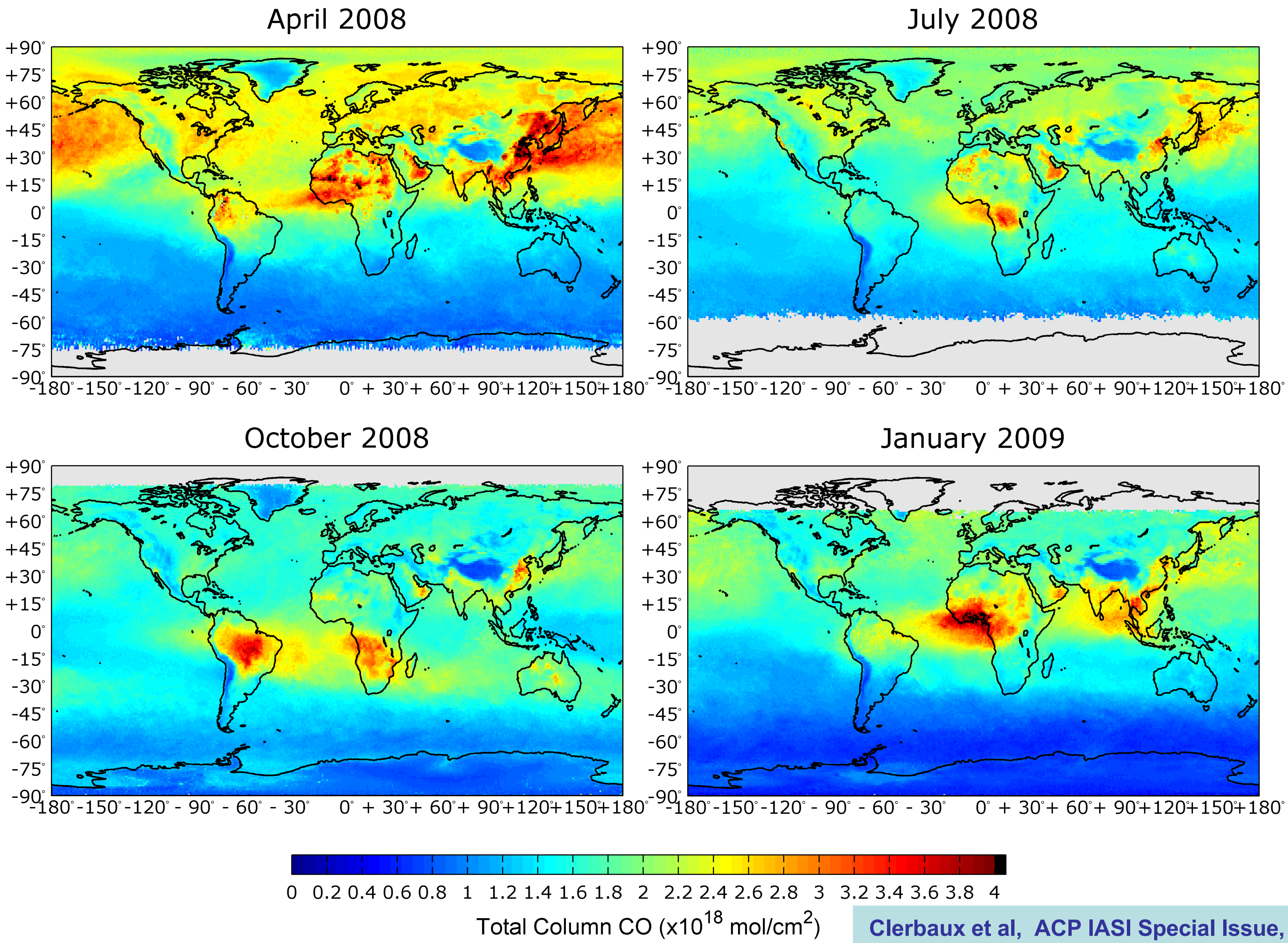
Fire detection





Long-range pollution

Carbon monoxide

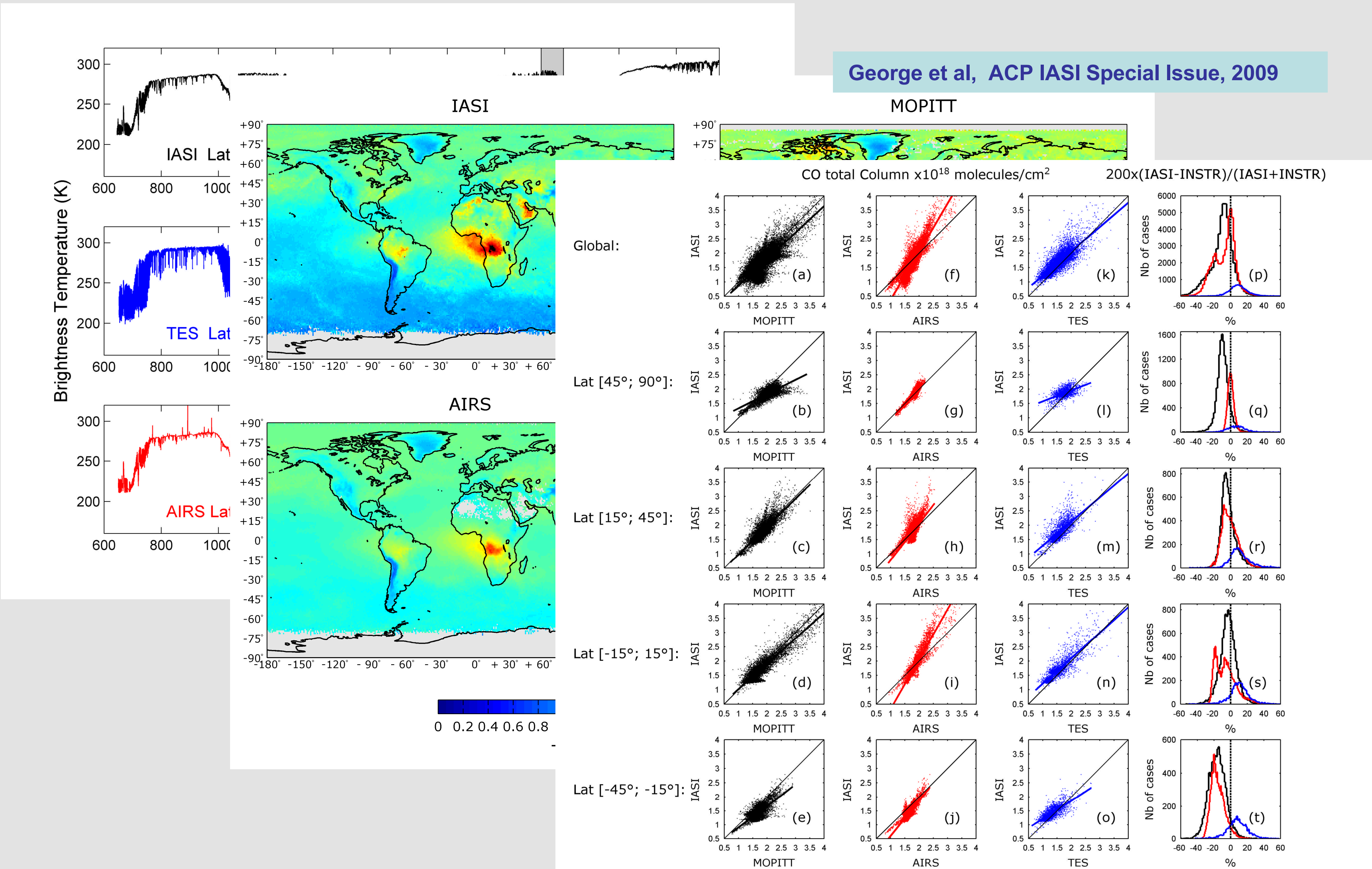


Clerbaux et al, ACP IASI Special Issue, 2009

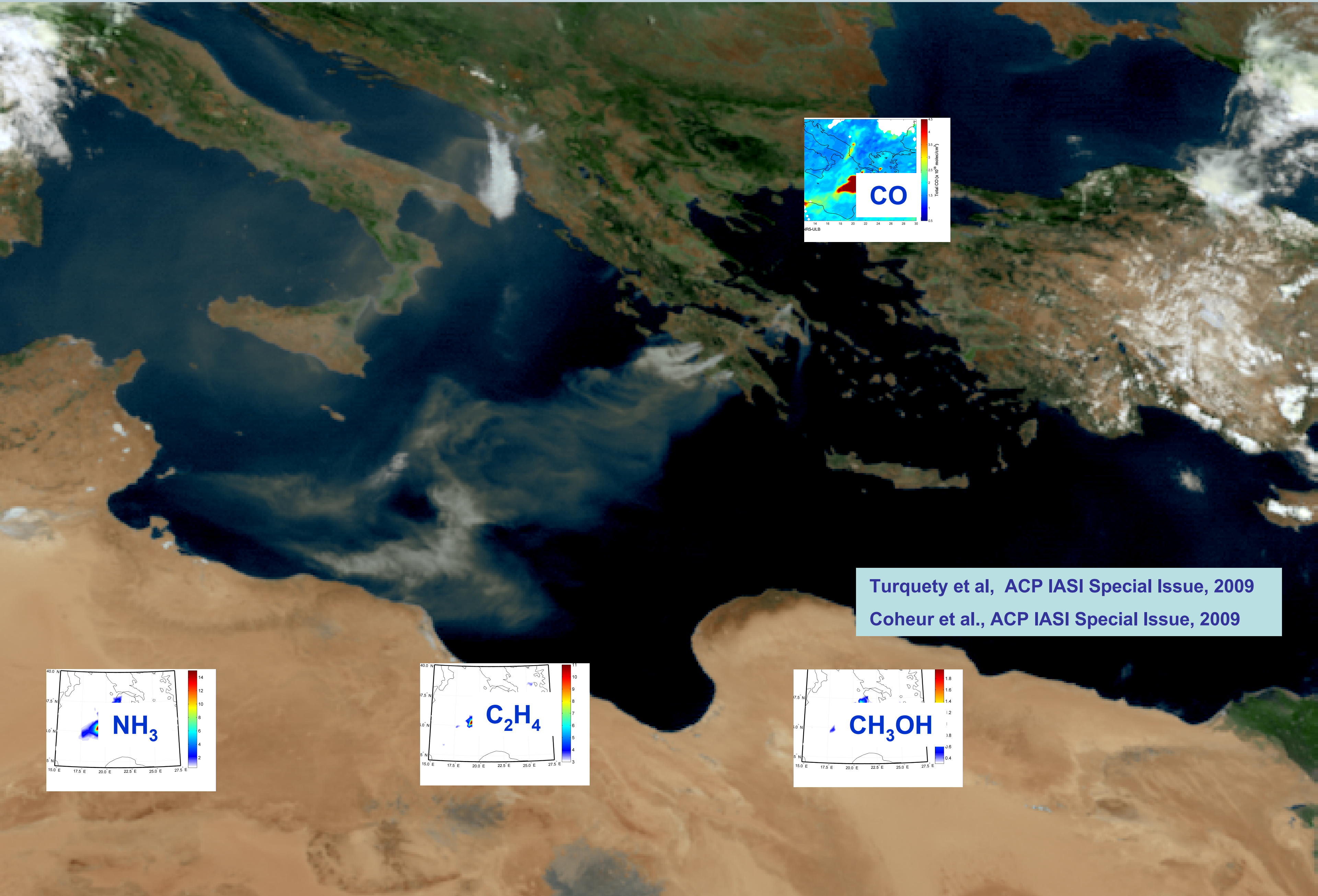
LATMOS ULB

CO, comparison with MOPITT, AIRS, TES, August 2008

George et al, ACP IASI Special Issue, 2009



Greek fires, August 2007

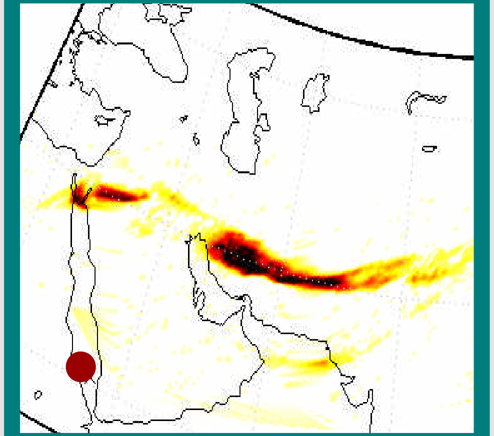


Turquety et al, ACP IASI Special Issue, 2009

Coheur et al., ACP IASI Special Issue, 2009

IASI/METOP – Operational applications (GMES)

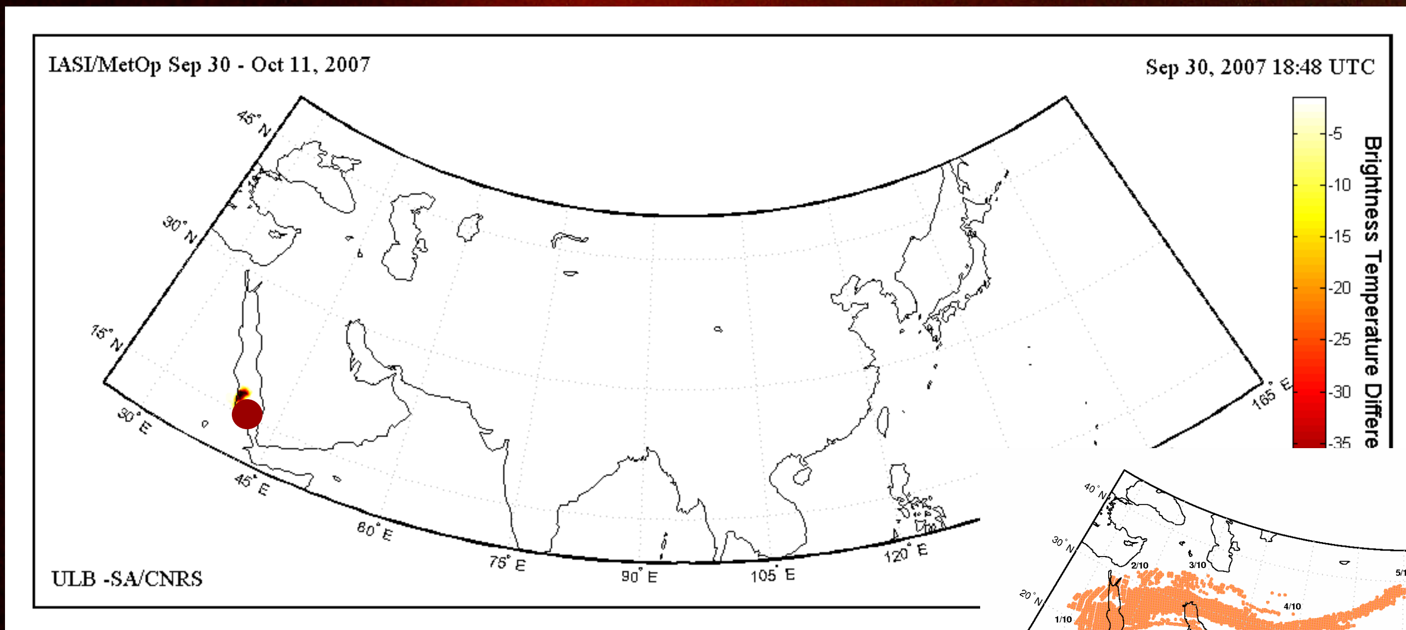
Volcanic plumes

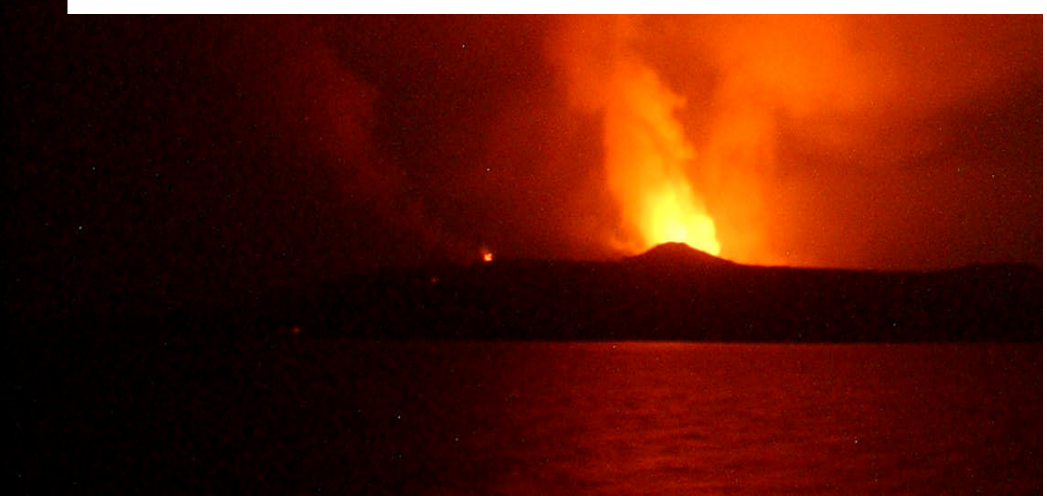


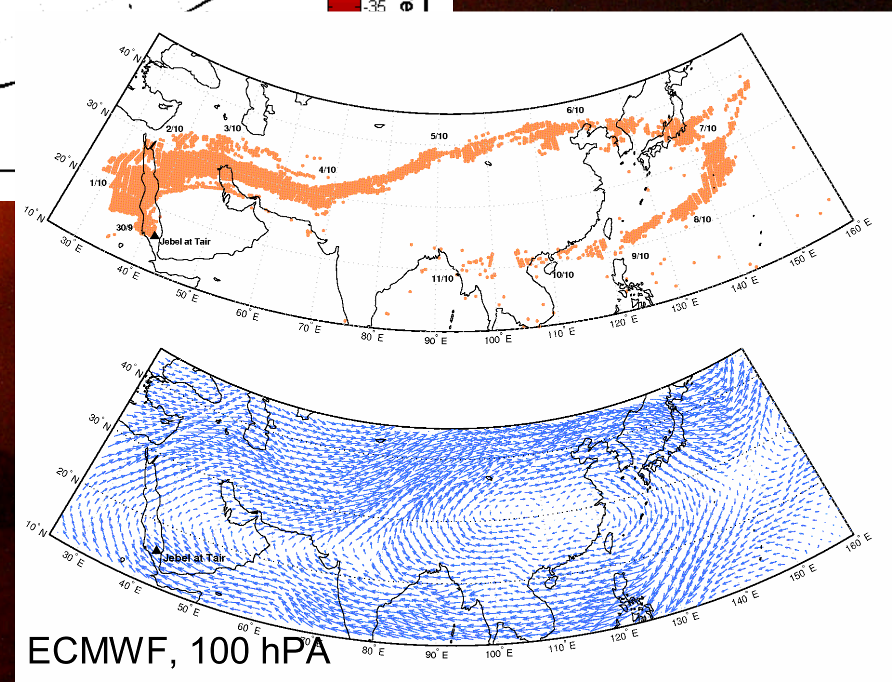
Aviation threat

Sulfur dioxyde (SO_2) – volcano plumes

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

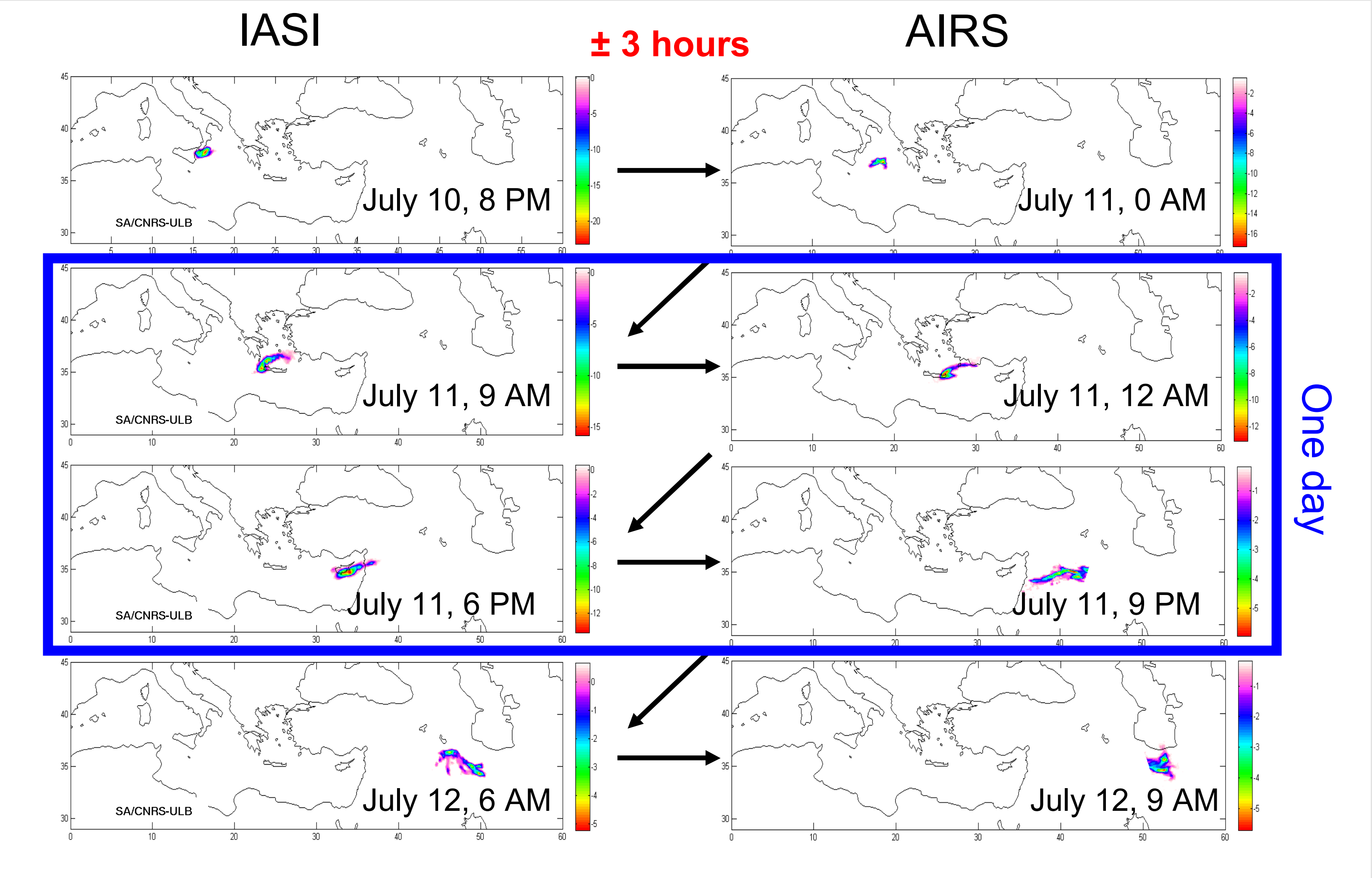






Applications Tracking transport and Chemistry

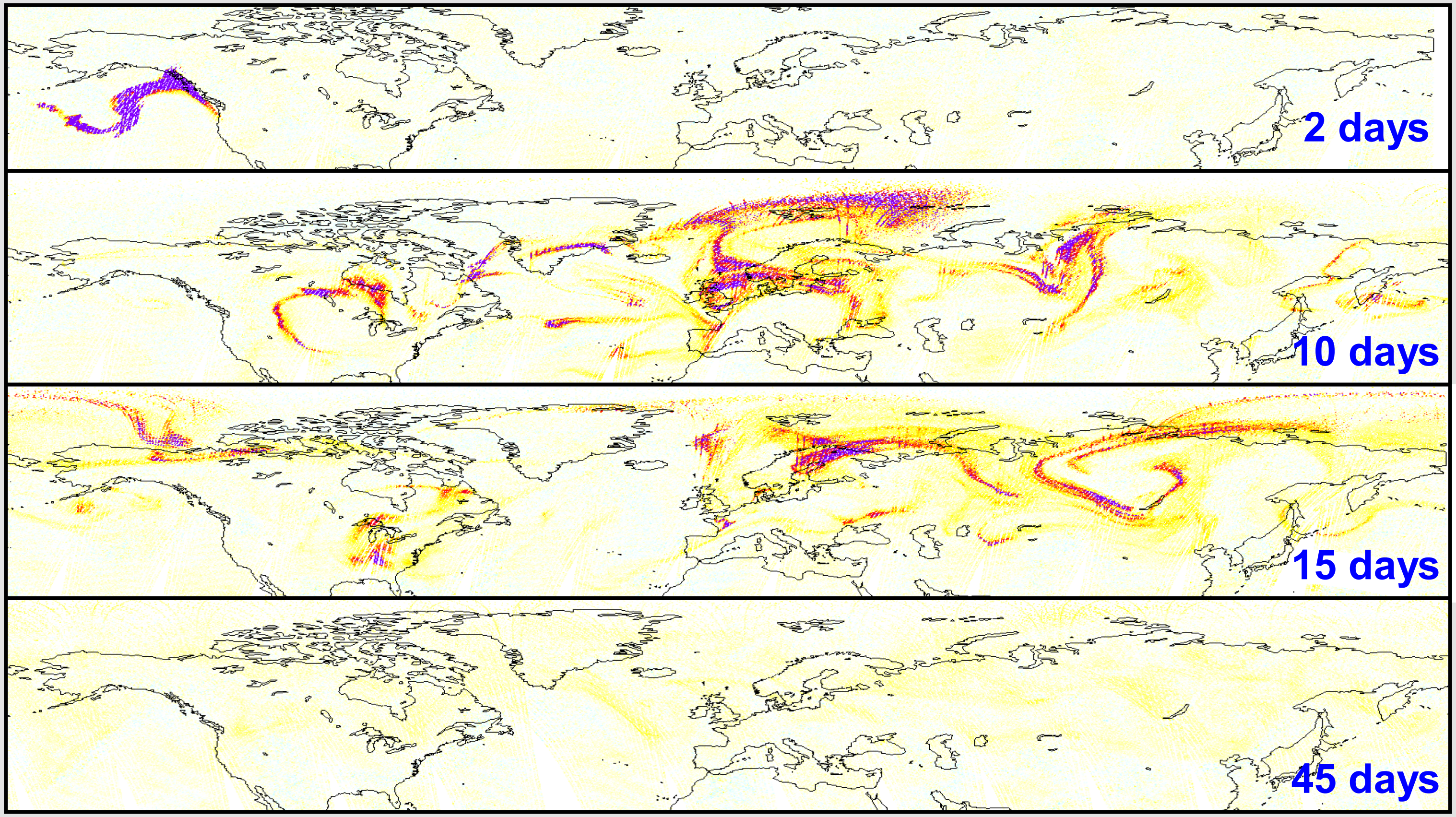
Etna *July 2008*



LATM

Applications Tracking transport and Chemistry

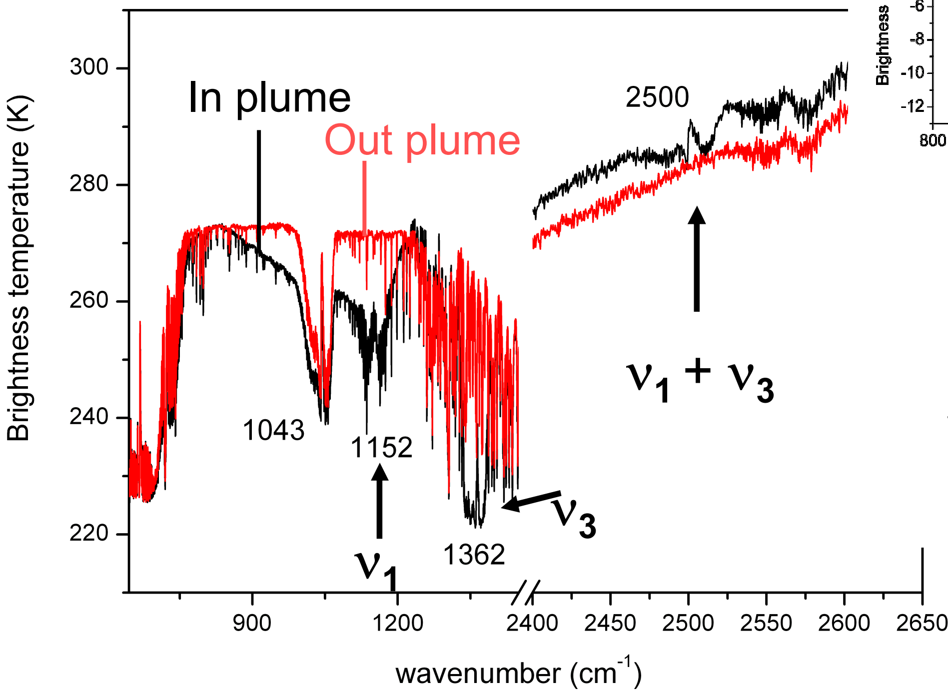
Kasatochi *August 2008* Plume's altitude ~12-16 km

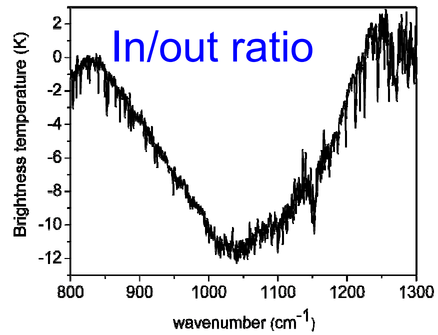


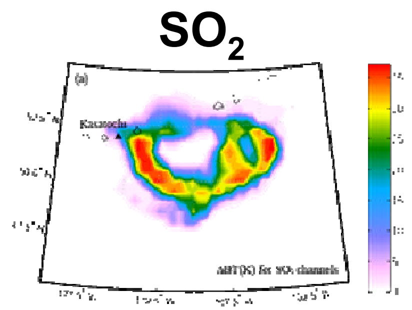
Spectral signatures

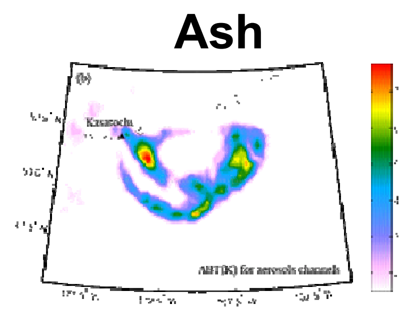
Aerosols: ***ASH***

Kasatochi. *August 2008*









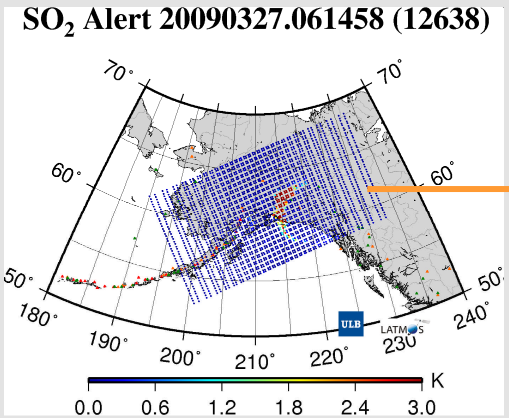
Applications

Operational alert systems:

Identification and tracking of volcanic plumes

http://cpm-ws4.ulb.ac.be/Alerts/

Provides alerts from BT differences in SO2-ν3 on BUFR basis (also e-mail system)
Useful for eruptions with emissions above the boundary layer
Extremely stable, without false alerts to now



Redoubt eruption from March 27

Location > 64.088950 -135.559800
Value > 14.005466 K
#Points > 57
File > iasi_20090324_192059_metopa_12603_eps_o.l1_bufr

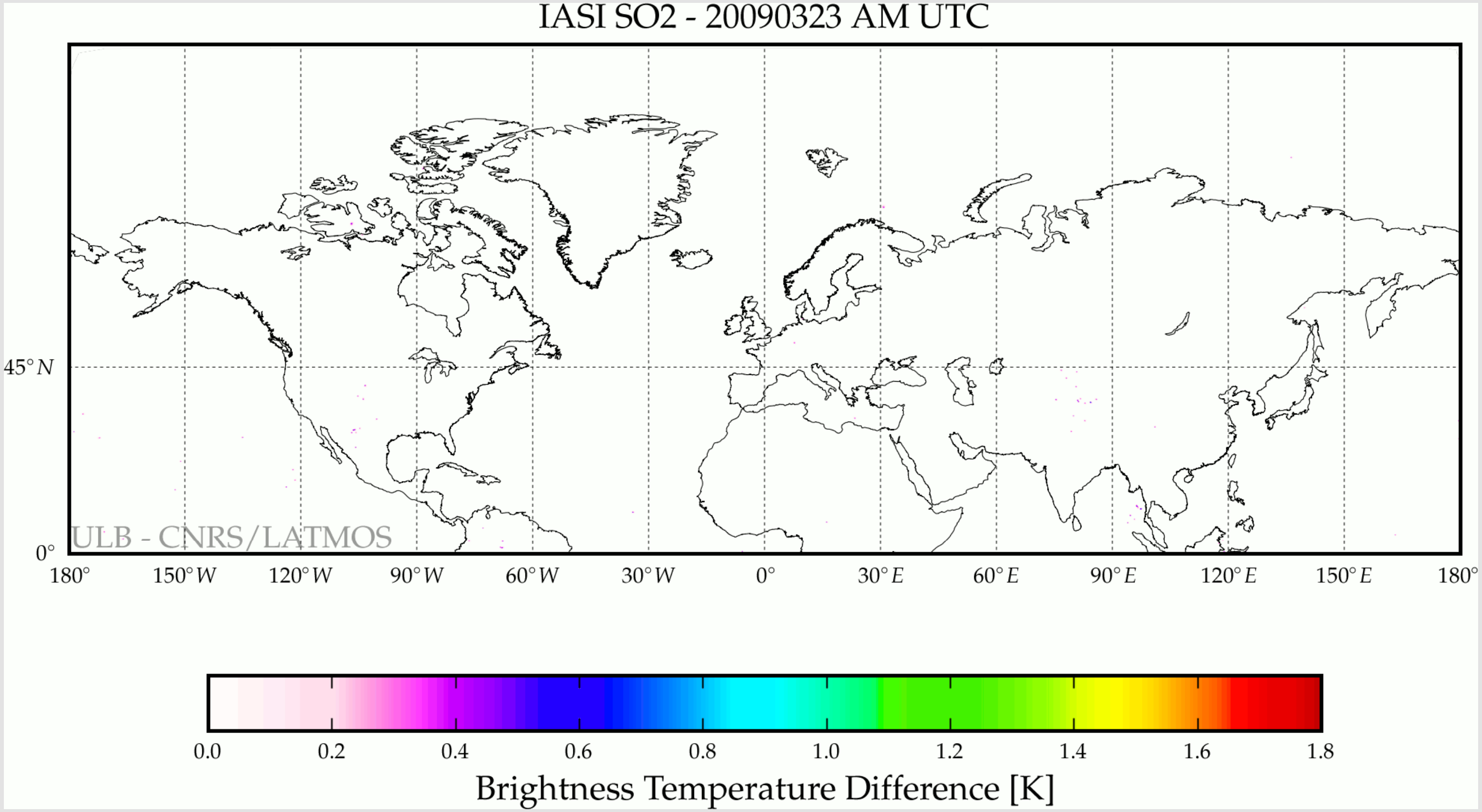
135 alerts sent for period of Redoubt (March-April 2008)

Further developments

- Include information on plume's altitude and aerosol content
- Implementing processing at Toulouse VAAC and at BIRA-IASB with ESA support (annex to SAVAA project)

Applications Tracking transport and Chemistry

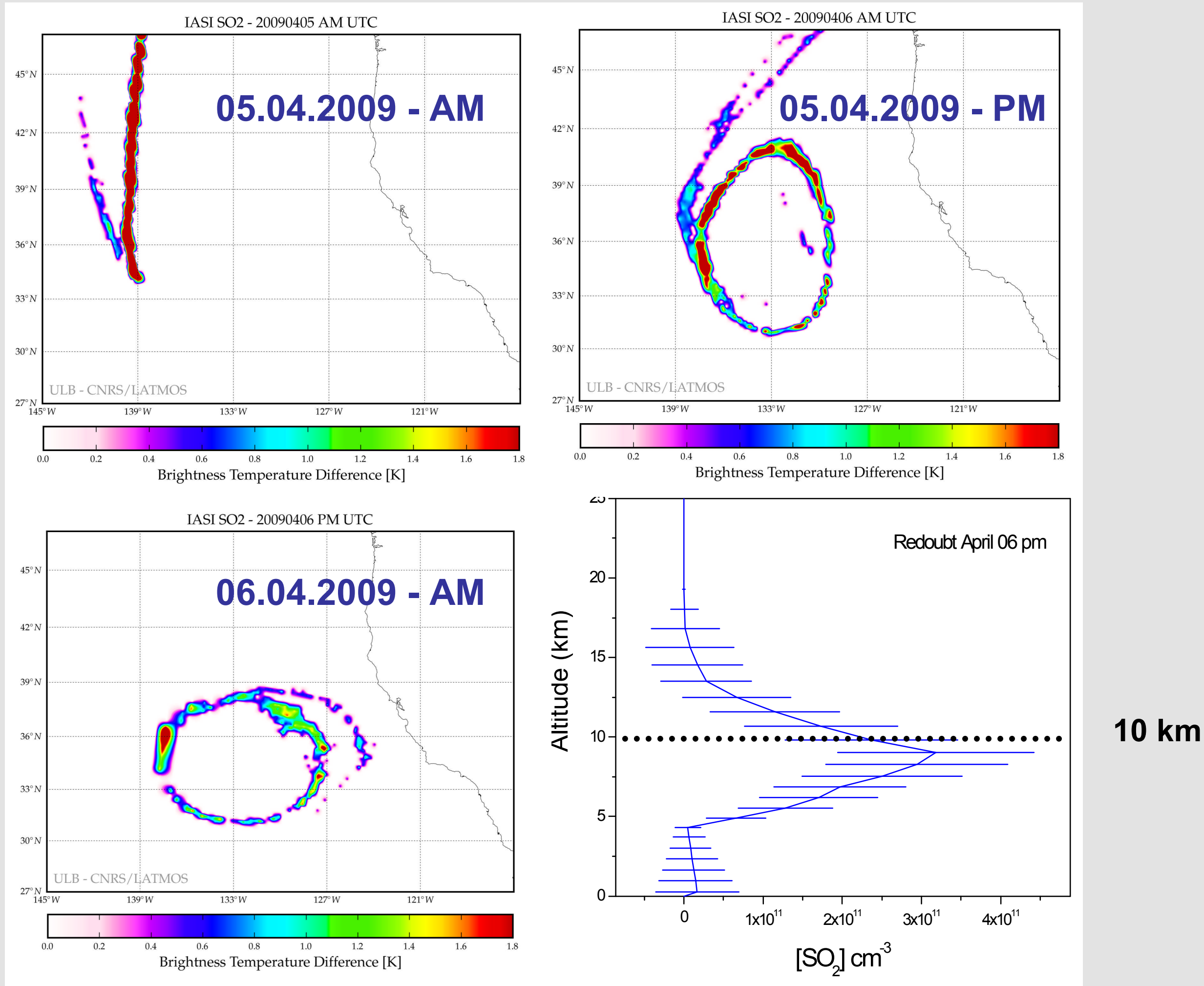
Redoubt *23.03-04.04 2009*



Applications

Tracking transport and Chemistry

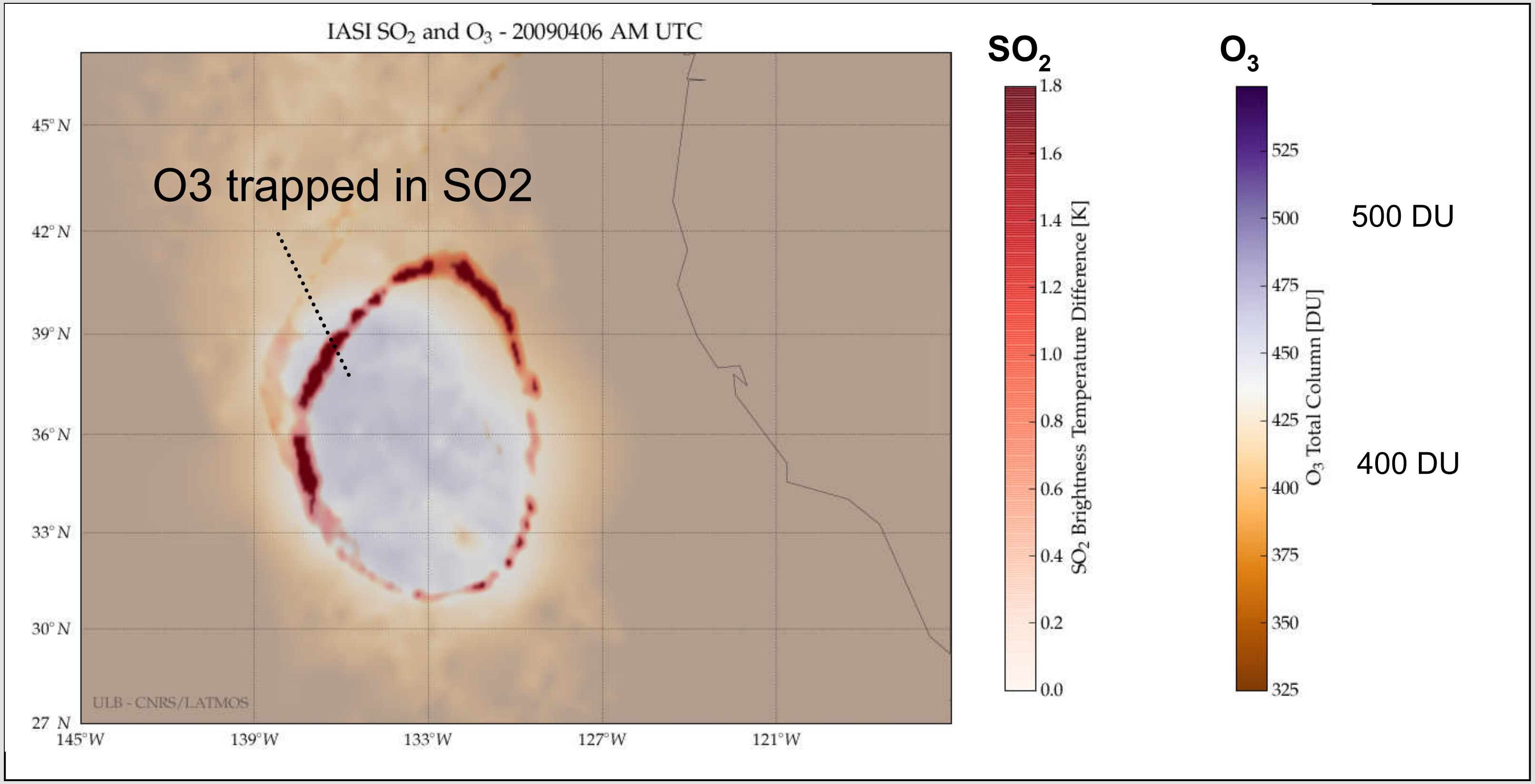
Redoubt *April 2009*



Applications

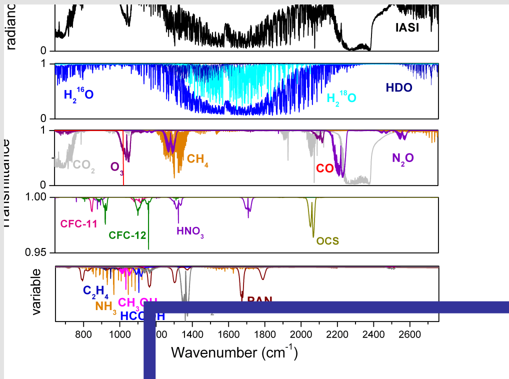
Tracking transport and Chemistry

Redoubt *April 2009*



Conclusions

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



+CH_3COOH, C_2H_2, HCN…

Long-lived species (years)
→ ***Climate***
+ CO, O_3 (months)
→ ***Chemistry, AQ, Transport***

Short-lived species + aerosols (days)
→ ***Chemistry, emission inventories***

- Operational applications starting (assimilation of CO; volcanic monitoring)
- New insights on emissions and chemistry (e.g. NH_3). Applicable to other species?

IASI ACP Special Issue

The IASI instrument onboard the METOP satellite: first results
Editor(s): A. Richter and T. Wagner
26 papers submitted, 23 on line (ACPD).

http://www.atmos-chem-phys-discuss.net/special_issue82.html