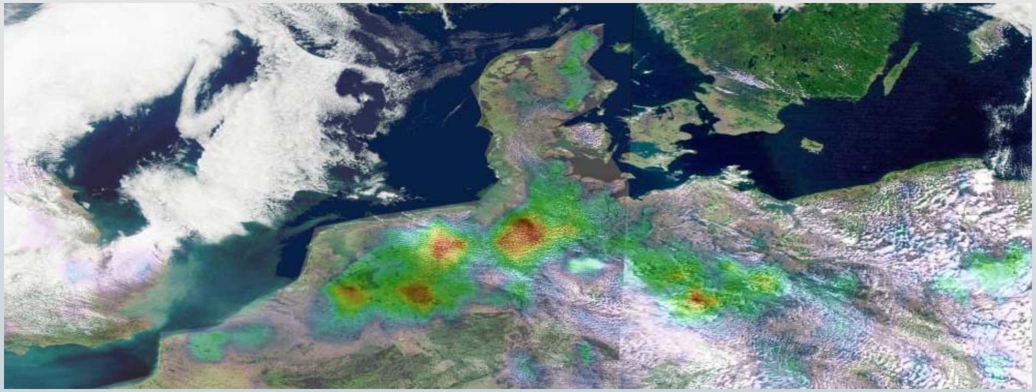
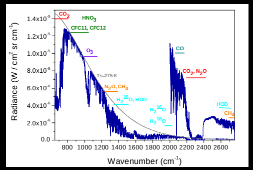
IASI contribution to chemistry(-climate)



MetOp

Polar orbiting satellite



Infrared
Atmospheric
Sounding
Interferometer

Thermal IR nadir sounder

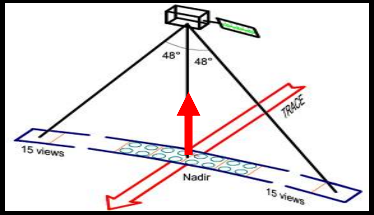
Key points for atmospheric composition:

Instrumental

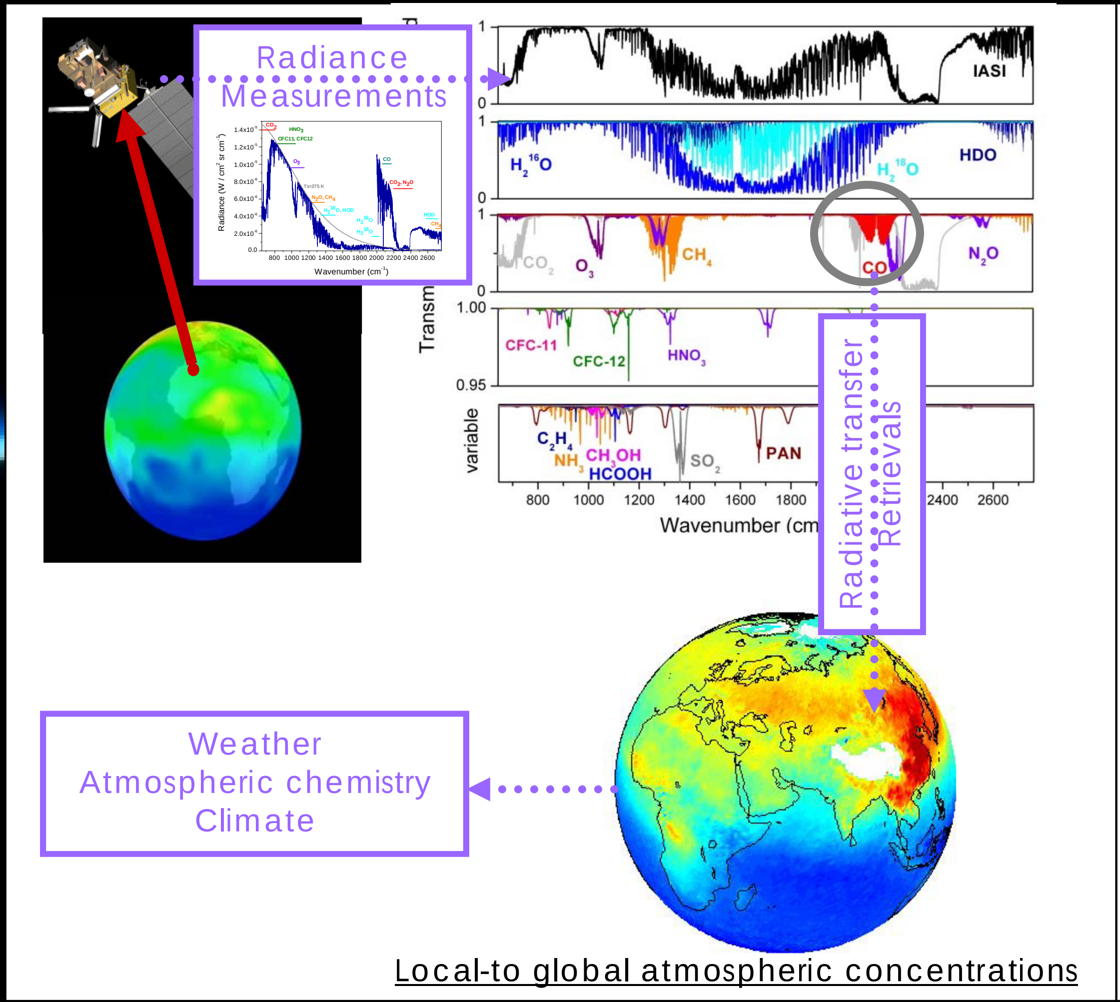
1. Broad spectral range (FTS!): 645-2760 cm^{-1} , without gaps
2. Relatively high spectral resolution: 0.5 cm^{-1} apodized
3. Low noise: 0.1 – 0.2 K in the regions of interest

Sampling

1. Relatively small pixel size: 12 km on-ground at nadir
2. Global coverage and high sampling: global measurements twice daily



IASI operational and science processing

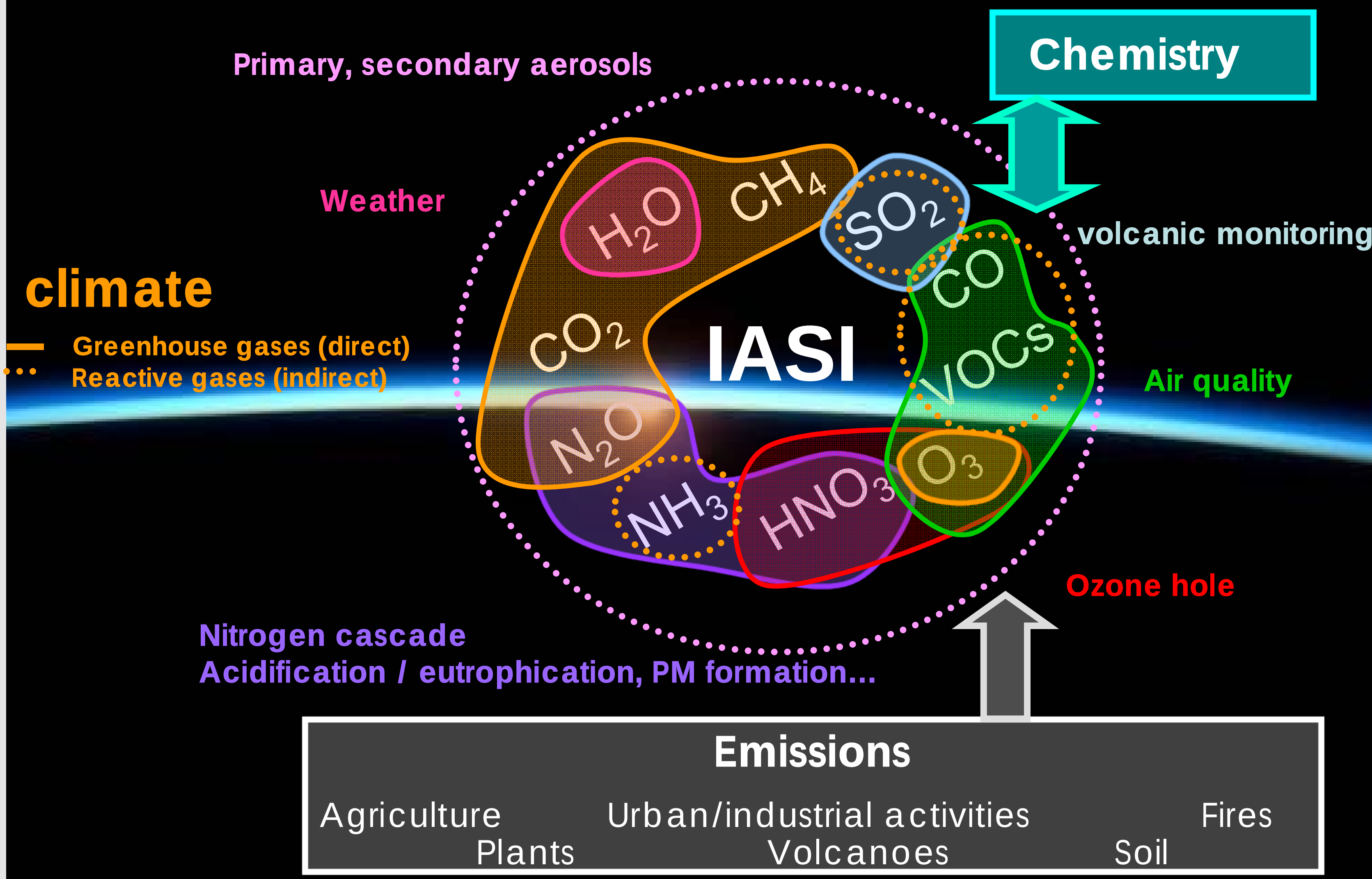


IASI species

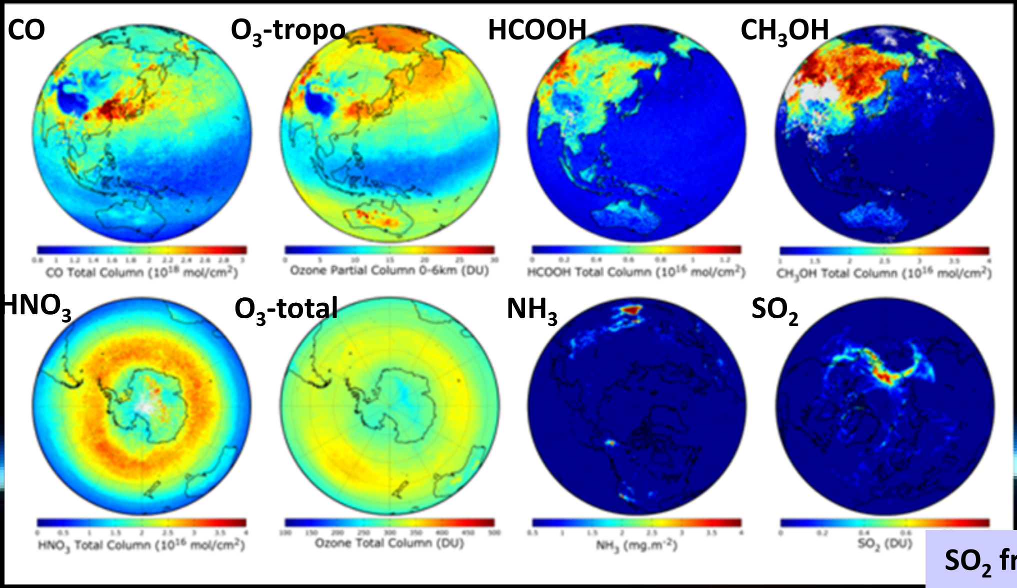
lifetime

	CFC12
years	CFC11 N_2O CO_2 CH_4 OCS
Weeks	CO O_3 HNO_3 SO_2
days	H_2O + Iso VOCs
hours	NH_3

Overview of species / processes

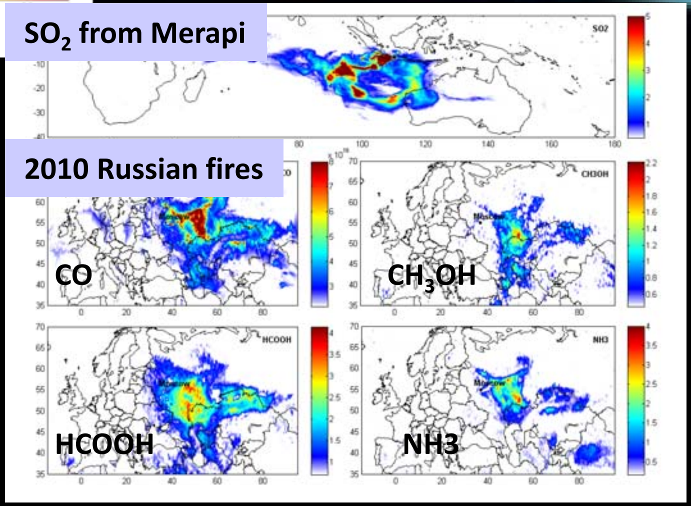


Overview of species / processes



→ **Global mapping**

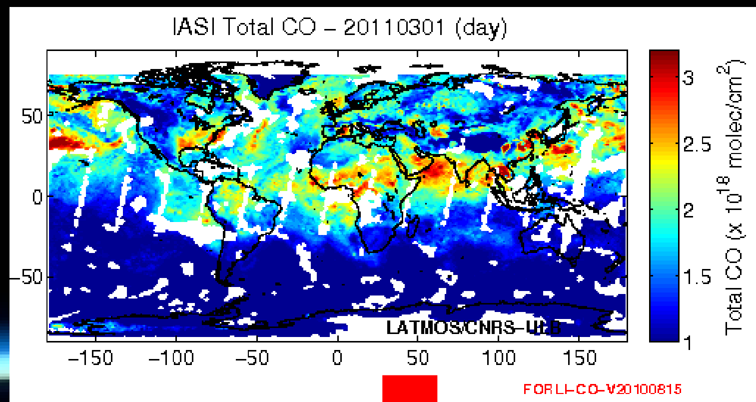
→ **Local plume chemistry**



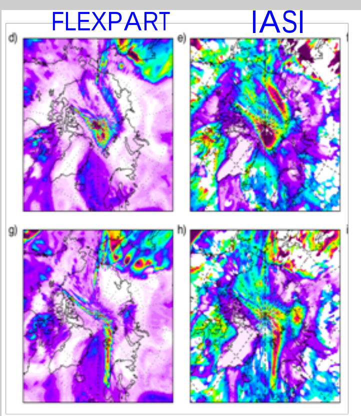
A range of applications: CO as an example

Global distributions twice per day

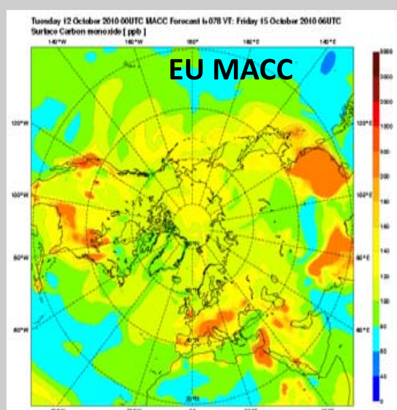
(ULB/LATMOS FORLI processing chains)



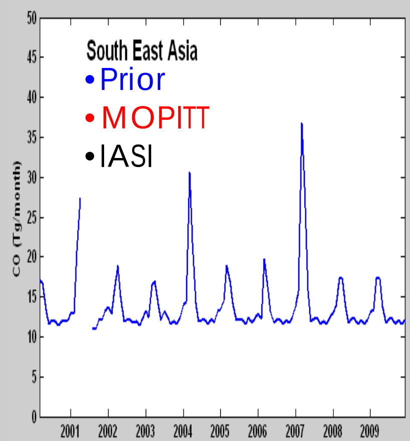
Long-range transport



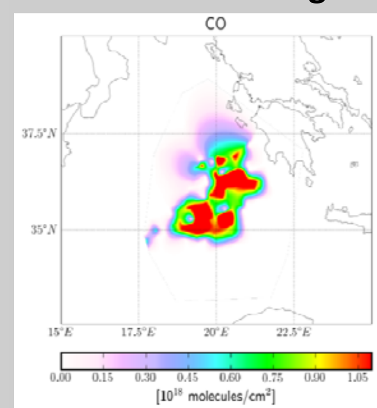
Air-quality forecast



Emission inventories

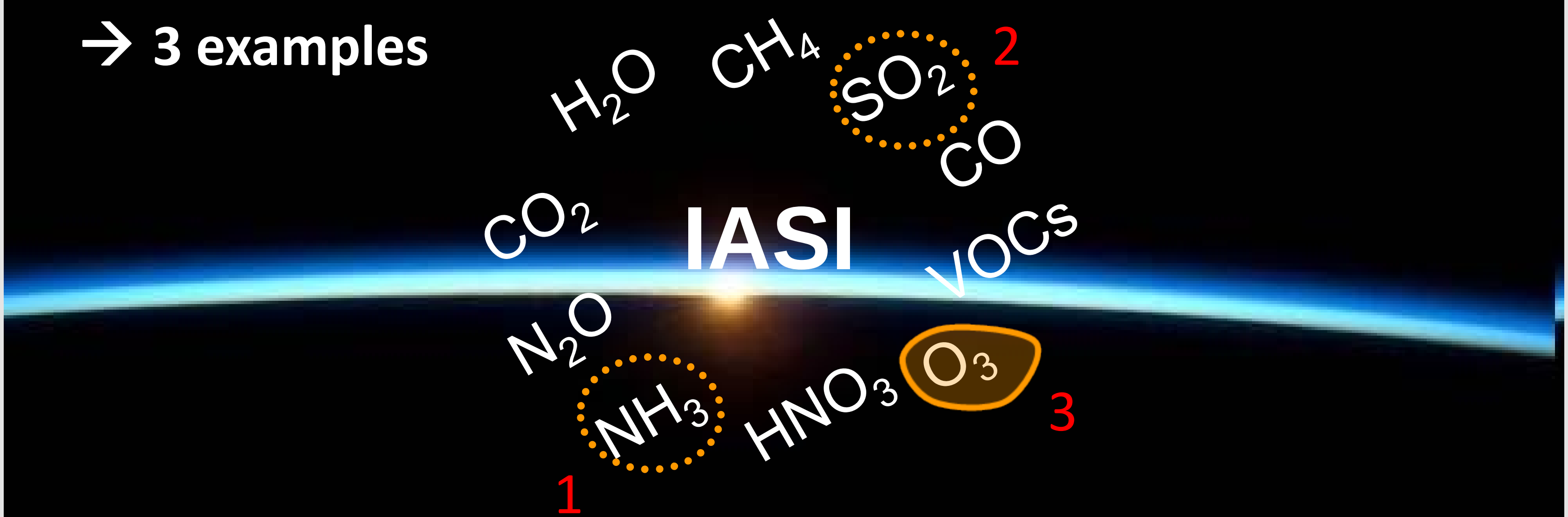


Fire monitoring



Contribution to climate: beyond CO_2 and CH_4

→ **3 examples**



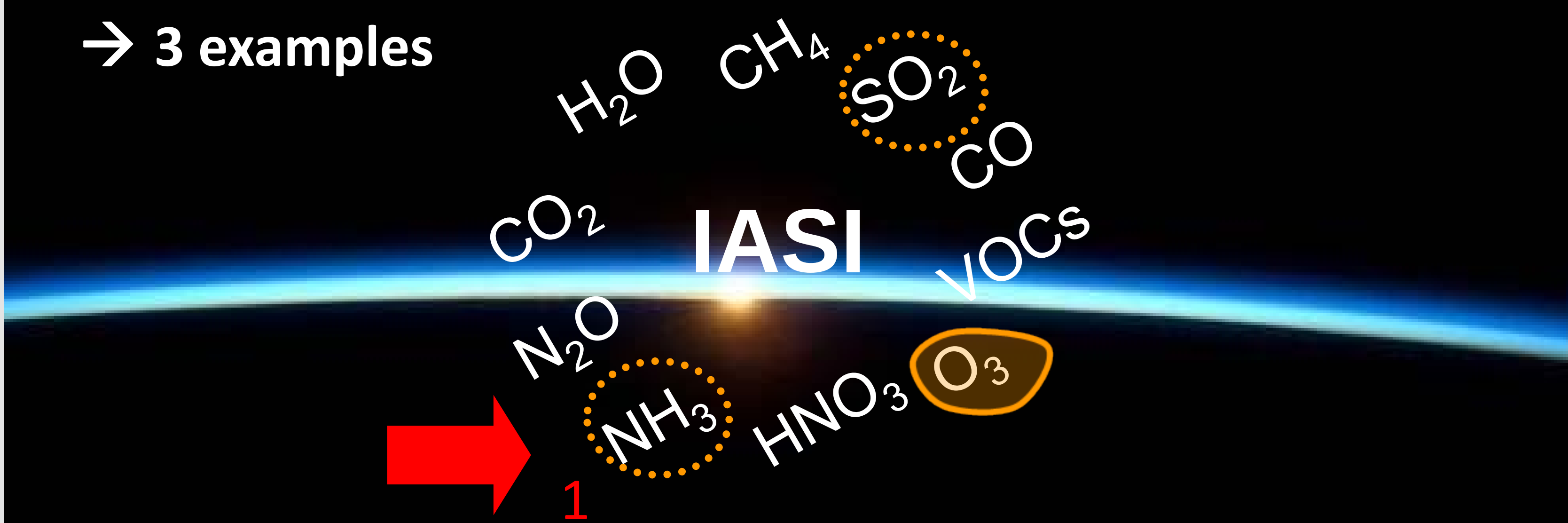
climate

— Greenhouse gases (direct)

··· Reactive gases (indirect)

Contribution to climate: beyond CO_2 and CH_4

→ **3 examples**

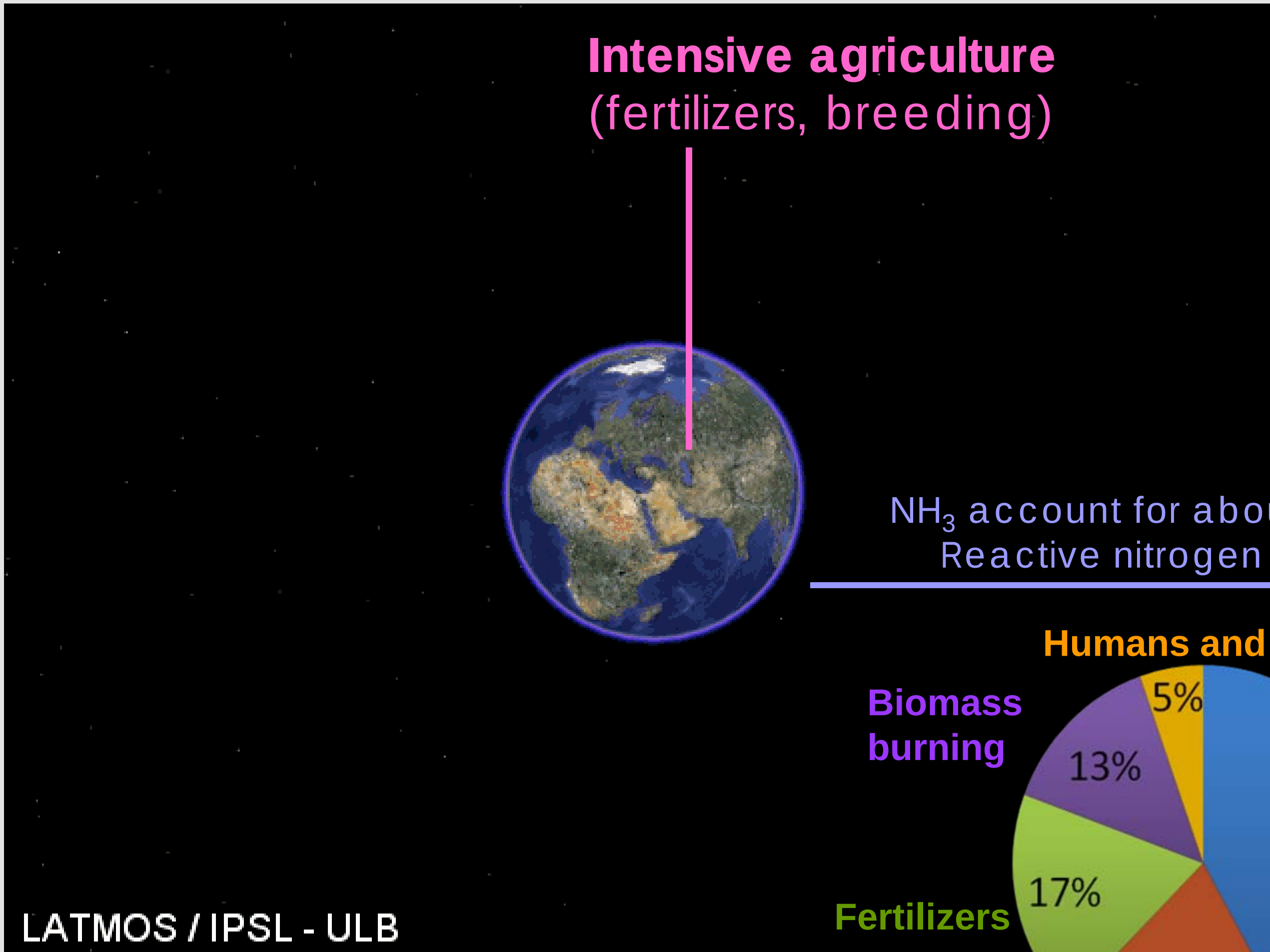


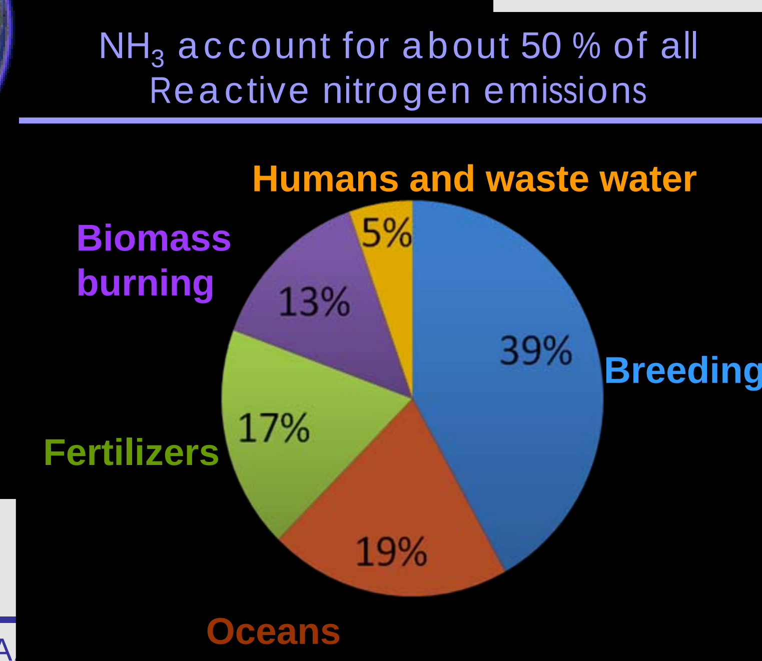
climate

— Greenhouse gases (direct)

··· Reactive gases (indirect)

Ammonia


Intensive agriculture
(fertilizers, breeding)
LATMOS / IPSL - ULB


NH_3 account for about 50 % of all
Reactive nitrogen emissions
Humans and waste water
Biomass burning
Breeding
Fertilizers
Oceans
5%
13%
39%
17%
19%

Contribution to chemistry-climate

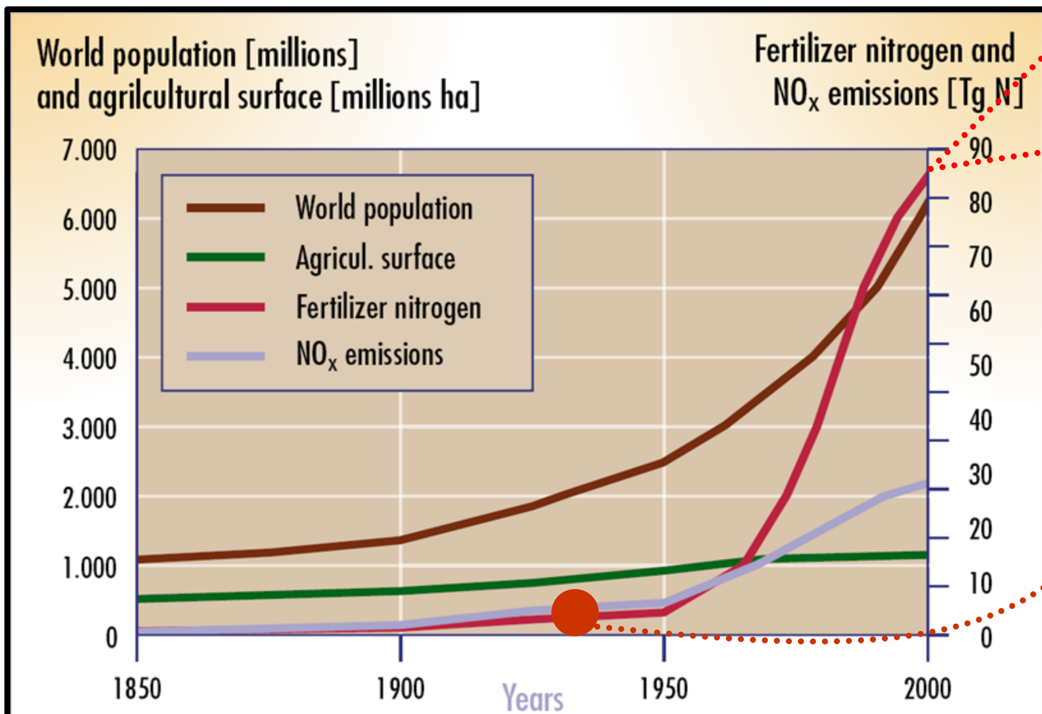
Ammonia

A word on reactive nitrogen emissions and the perturbed N cycle

Anthropogenic N-fixation

Energy
→ NO_x

Food
→ NH_3



Future trends highly uncertain

Haber-Bosch

$N_2 + 3H_2 \rightarrow 2NH_3$

Today ~40 % the world population depends on Haber Bosch process

Ammonia

Impacts of increased Nr emissions

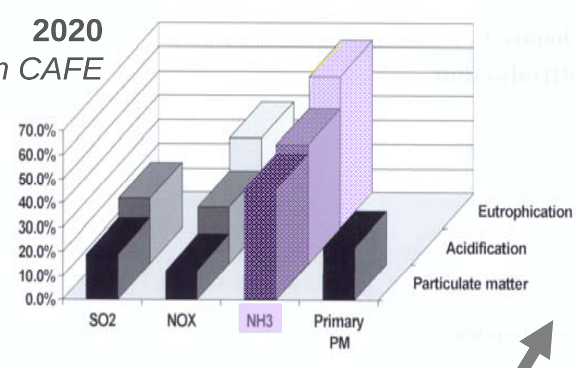
Reactive Nr emissions (NH_3 and NOx account for 90%) have increased fivefold since 1900, due to energy and food production. Future projections are highly uncertain.
→ All fluxes, including deposition have strongly been affected

Impacts are magnified through the **Nitrogen cascade** (Galloway 2003)
The same atom of Nr can cause multiple effects in the atmosphere, in terrestrial ecosystems, in freshwater and marine systems, and on human health

Form of Nr	*Ecosystem*	*Impacts*	*scale*
NO_x	Atmosphere	Acid precipitation / AQ (BL O_3, PM)	Regional
NH_3	Atmosphere	AQ (PM)	Regional / local
N_2O	Atmosphere	Climate / Stratospheric ozone	Global
NH_3 + other Nr	Aquatic	Eutrophication / acidification	Regional / local
NH_3 + other Nr	Terrestrial	Acid deposition / biodiversity loss	Local

Ammonia

Impacts of increased Nr emissions



1

Increased abundance of PM.

NH_3 is likely to become by 2020 the dominating primary anthropogenic source to particles in ambient air

Negative radiative forcing from nitrate aerosol would increase in importance with rising ammonia and NOx emissions and declining sulfur emissions (Shindell et al., 2009)

More NH_3-NO_x emissions

2

increased abundance of N_2O

N_2O contributes to a few percent in global warming only, but could, because it has a global warming potential 300 times superior to that of CO_2, have a more ***profound climate influence in the future if emissions continue to grow .***

3

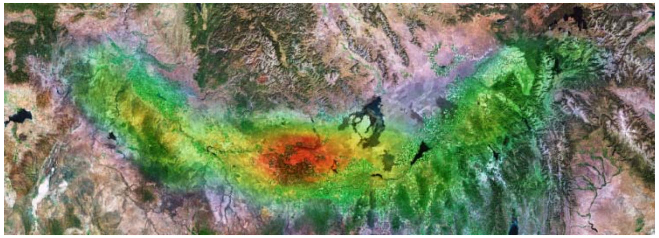
Perturbed N and C-cycles interactions

The increase in reactive nitrogen emissions, followed by long-range transport and deposition, stimulates the growth of continental biomass, in particular of forests. *Theoretically* ***enhances the uptake and storage of atmospheric CO2****. large uncertainties*

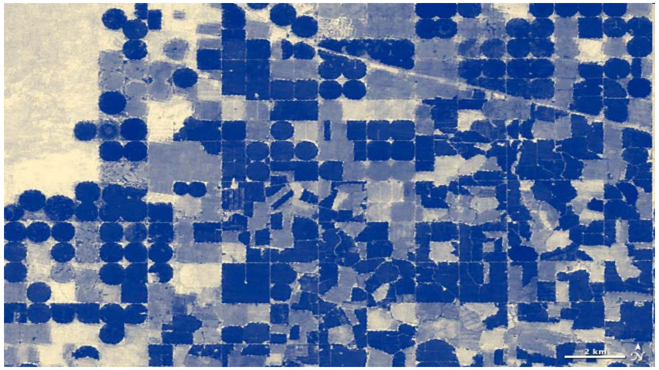
Ammonia

Mapping ammonia with IASI
Global view (1 year average)

Snake River Valley

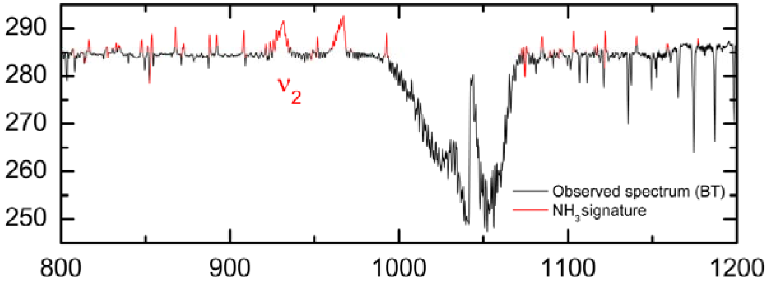


Ammonia On Idaho's Snake River Plain
IASI

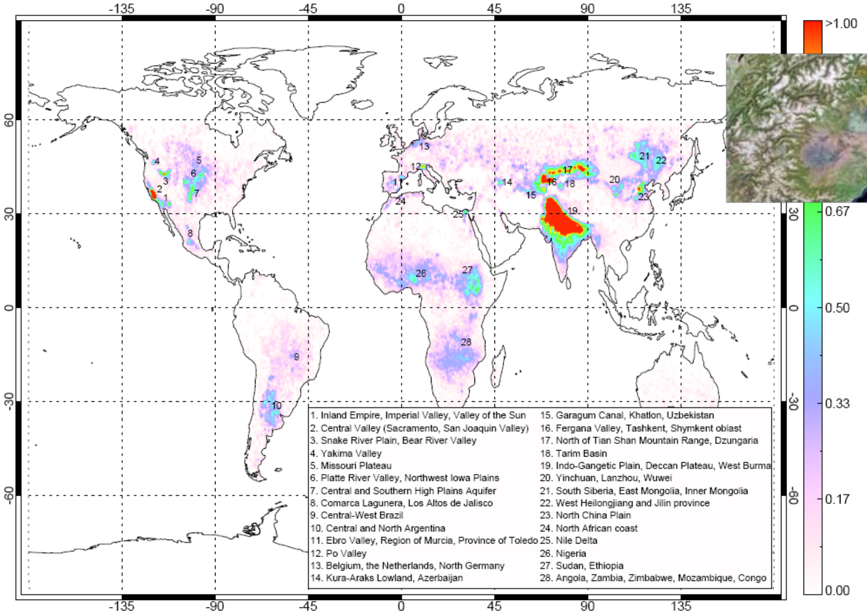


Water Use On Idaho's Snake River Plain
Landsat5 evapotranspiration

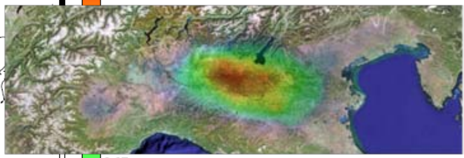
... dealing with a signal hardly detectable ...



→ 28 emission hotspots identified



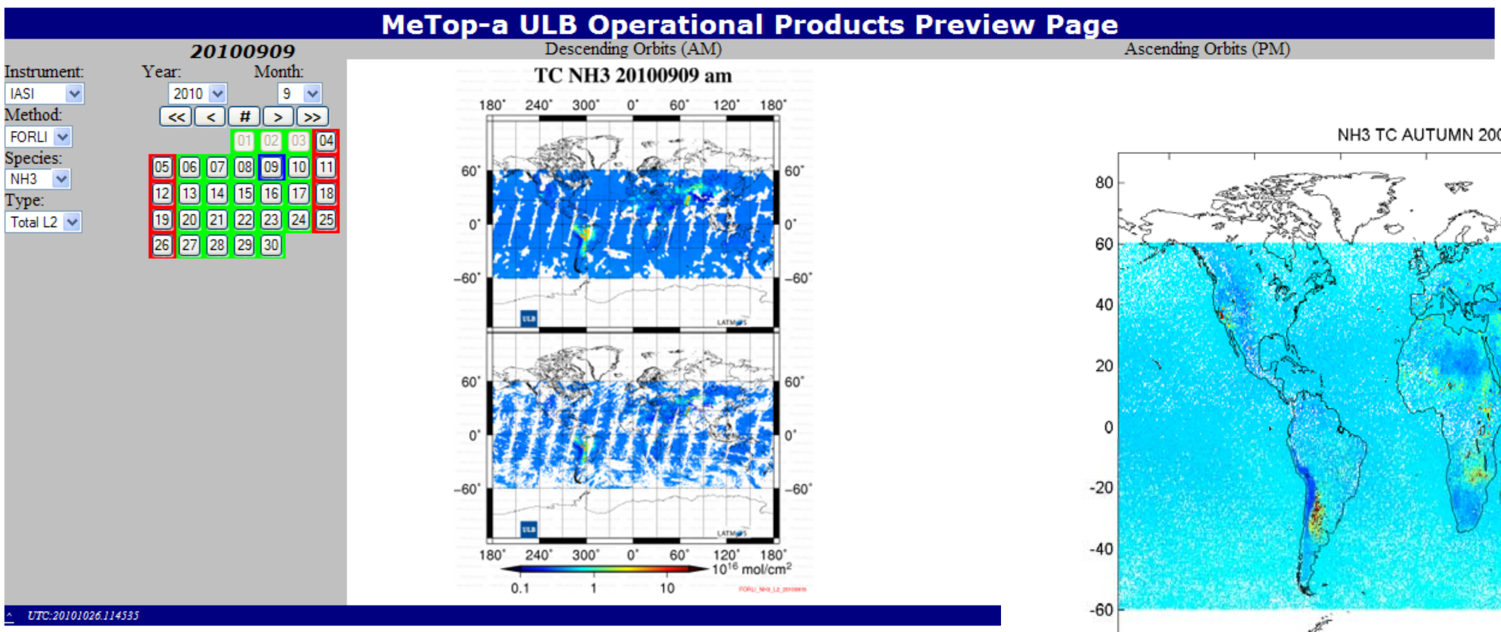
Po Valley



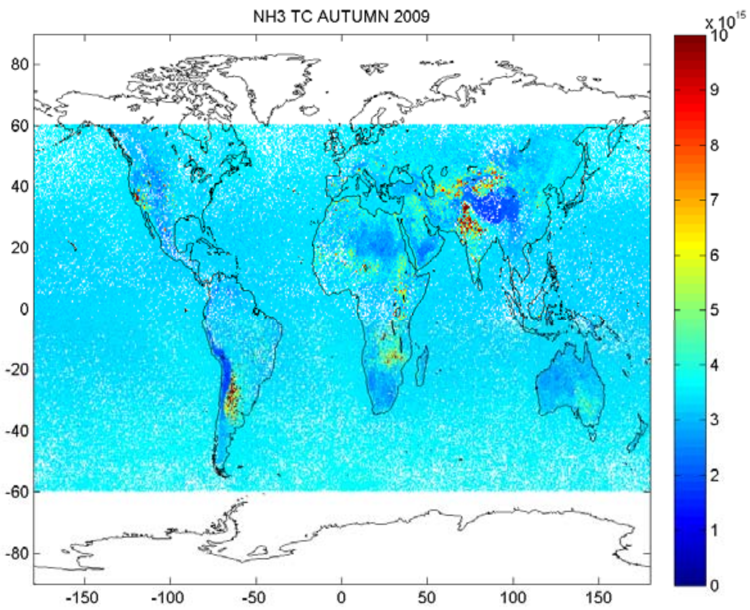
Ammonia

Mapping ammonia with IASI

Since 2010: NRT global distributions daily *(NH_3 total columns, morning orbit only)* available from ULB/LATMOS FORLI processing chain



Seasonal variations



Ammonia

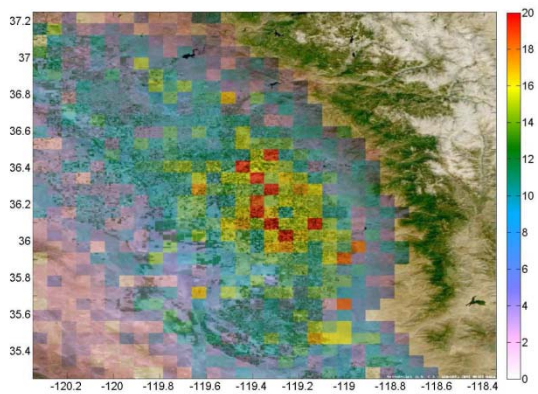
Mapping ammonia with IASI

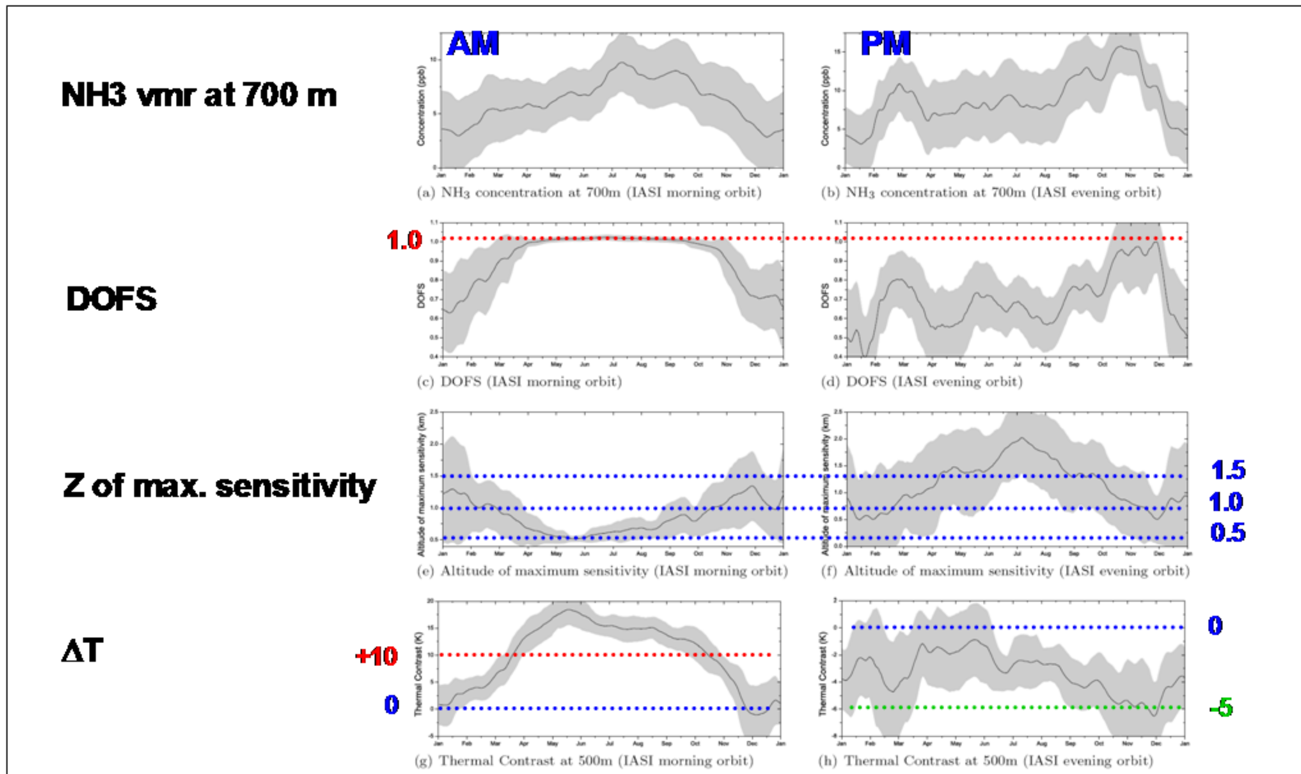
NH_3 is short-lived, confined in the boundary layer

→ **What do we / don't we see?**

The IASI sensitivity to NH_3 is strongly dependent on local thermal contrast

In most agricultural valleys, a monitoring year-round is possible

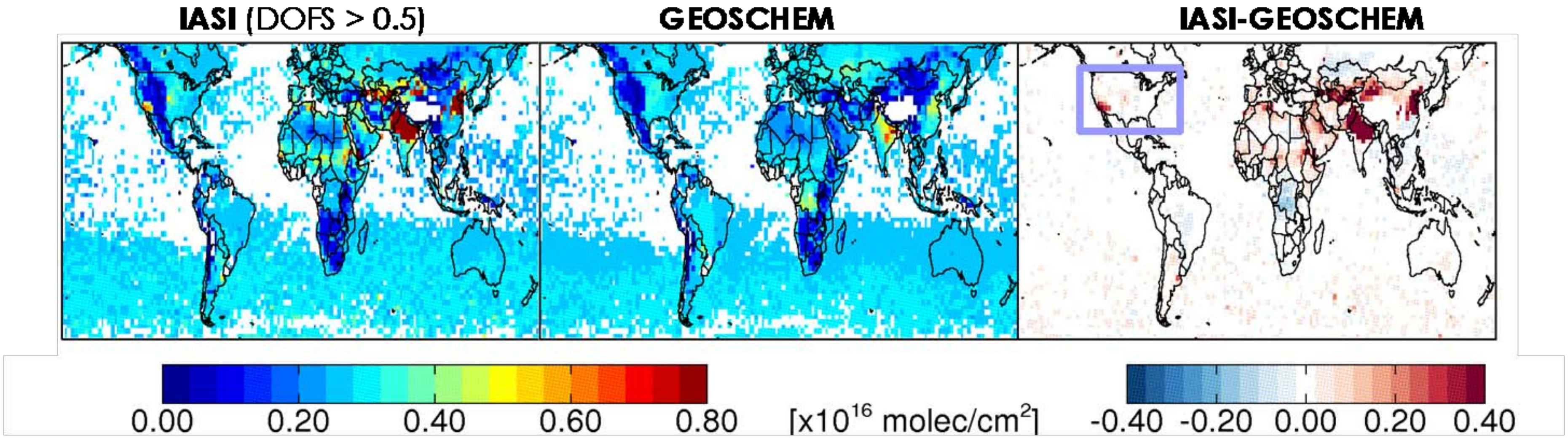




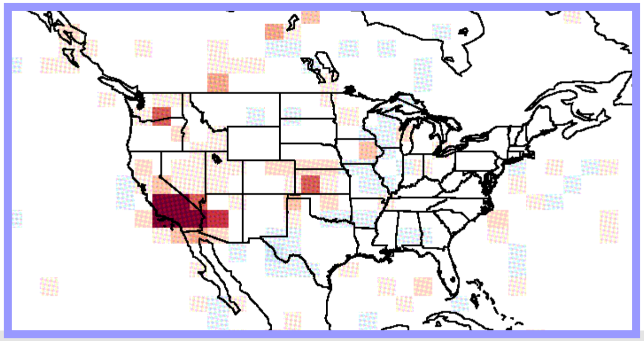
Ammonia

Mapping ammonia with IASI

→ **Improving on emission inventories?** (Courtesy C. Heald)



Models currently underestimate most emissions in Northern hemisphere (Factor of 2 or more)

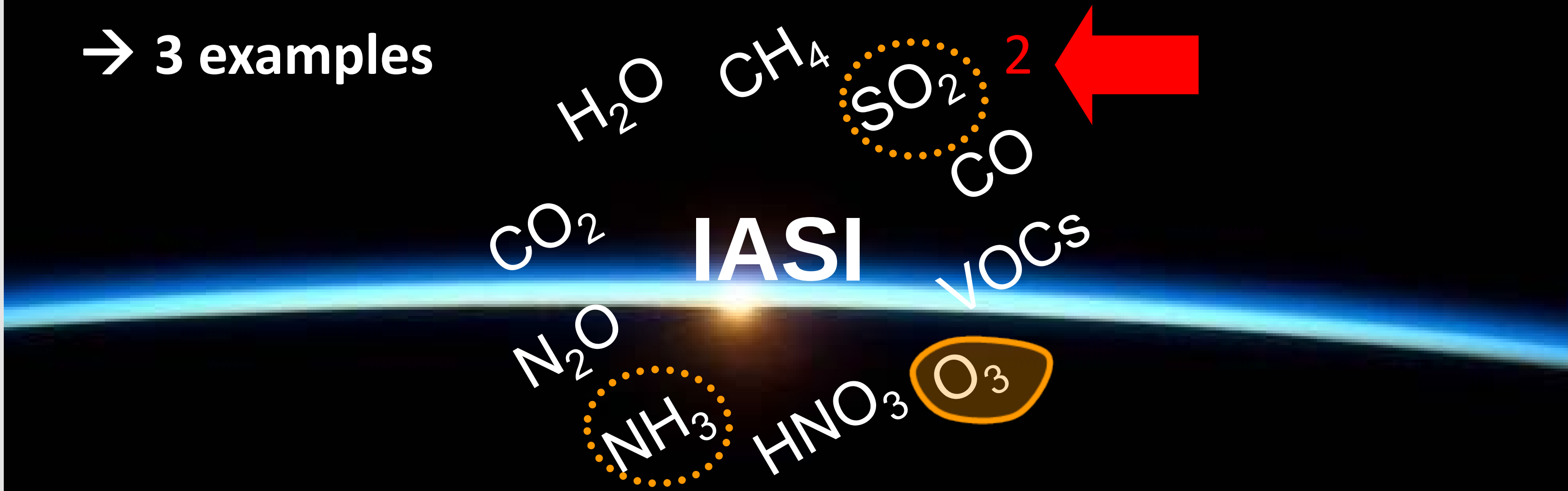


LATMOS ULB

Contribution to chemistry-climate

Contribution to climate: beyond CO_2 and CH_4

→ **3 examples**



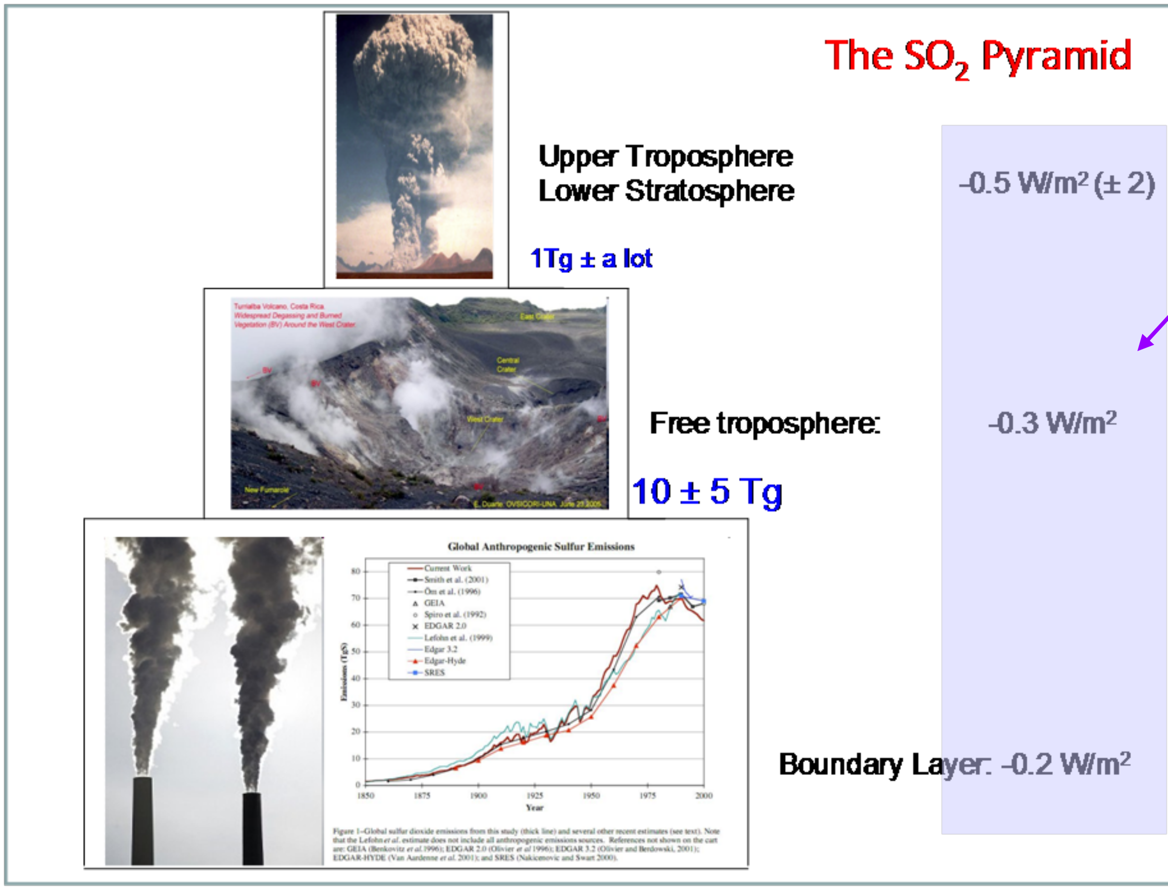
climate

— **Greenhouse gases (direct)**

··· **Reactive gases (indirect)**

Sulfur dioxide

Volcanic eruptions contribute only to 1% of total SO_2 emissions but have a significant forcing on climate



Sulfur dioxide

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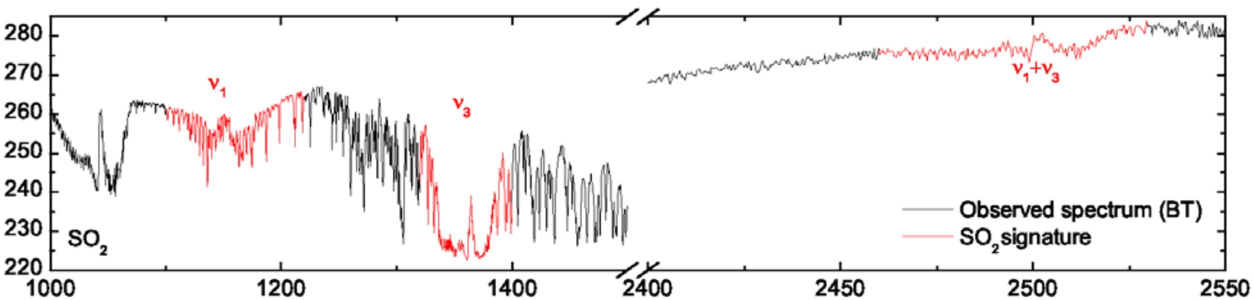
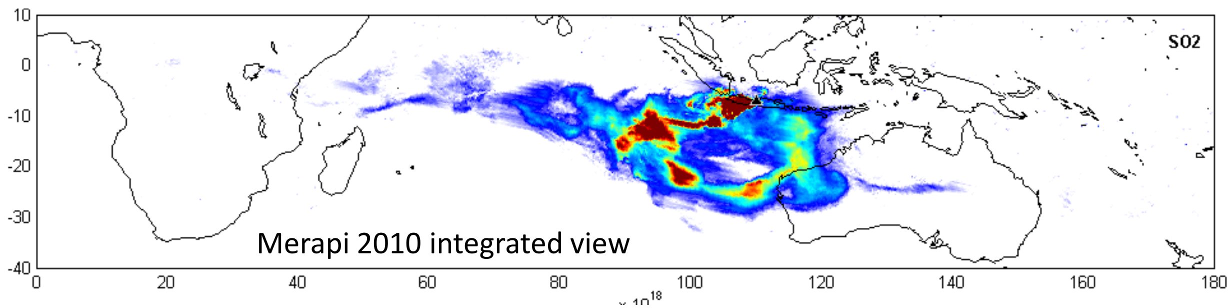
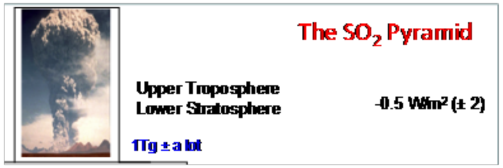
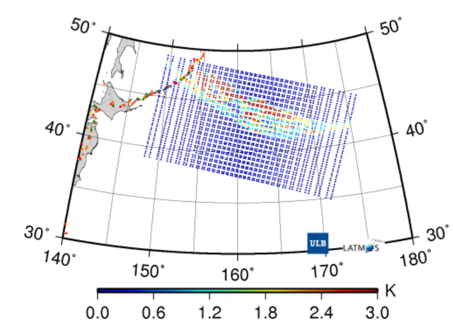






IASI is a good UTLS SO_2 sounder!



Operational alert system

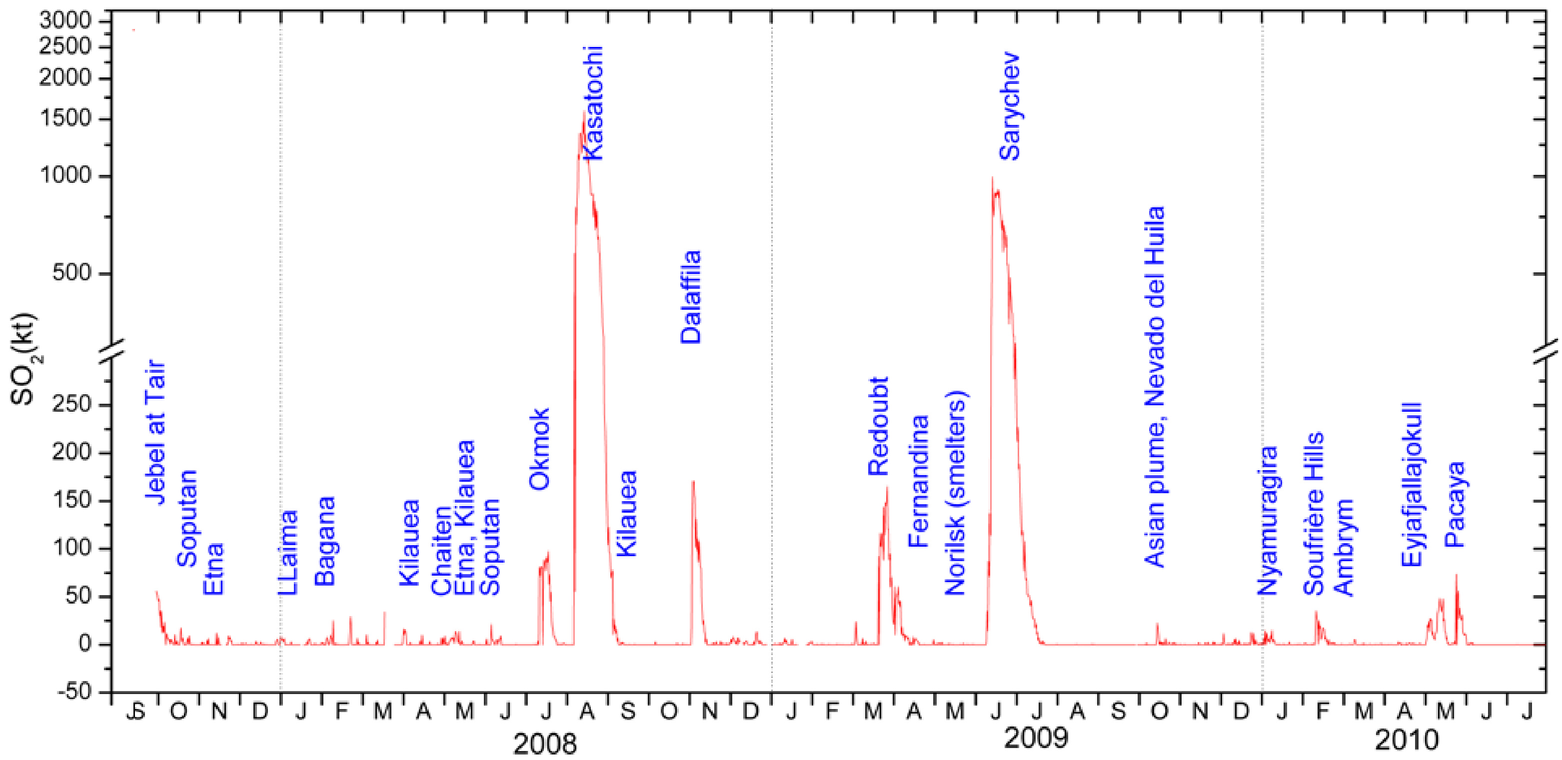
http://cpm-ws4.ulb.ac.be/Alerts/

http://sacs.aeronomie.be/

Sulfur dioxide

3 years of volcanic SO_2 monitoring

Time series



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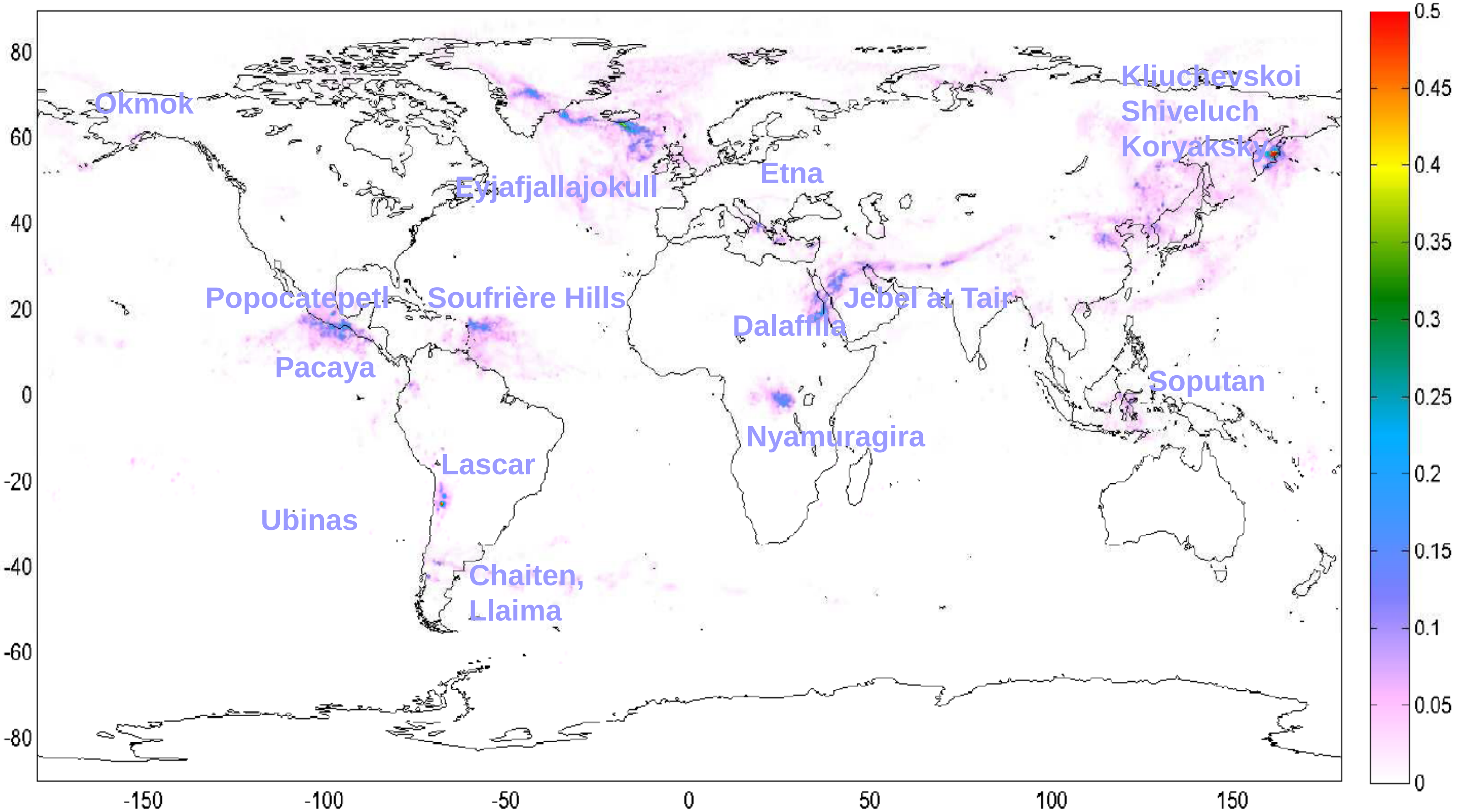
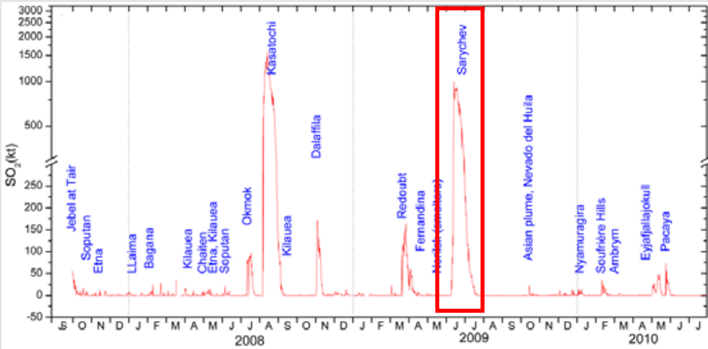
Sulfur dioxide

3 years of volcanic SO_2 monitoring

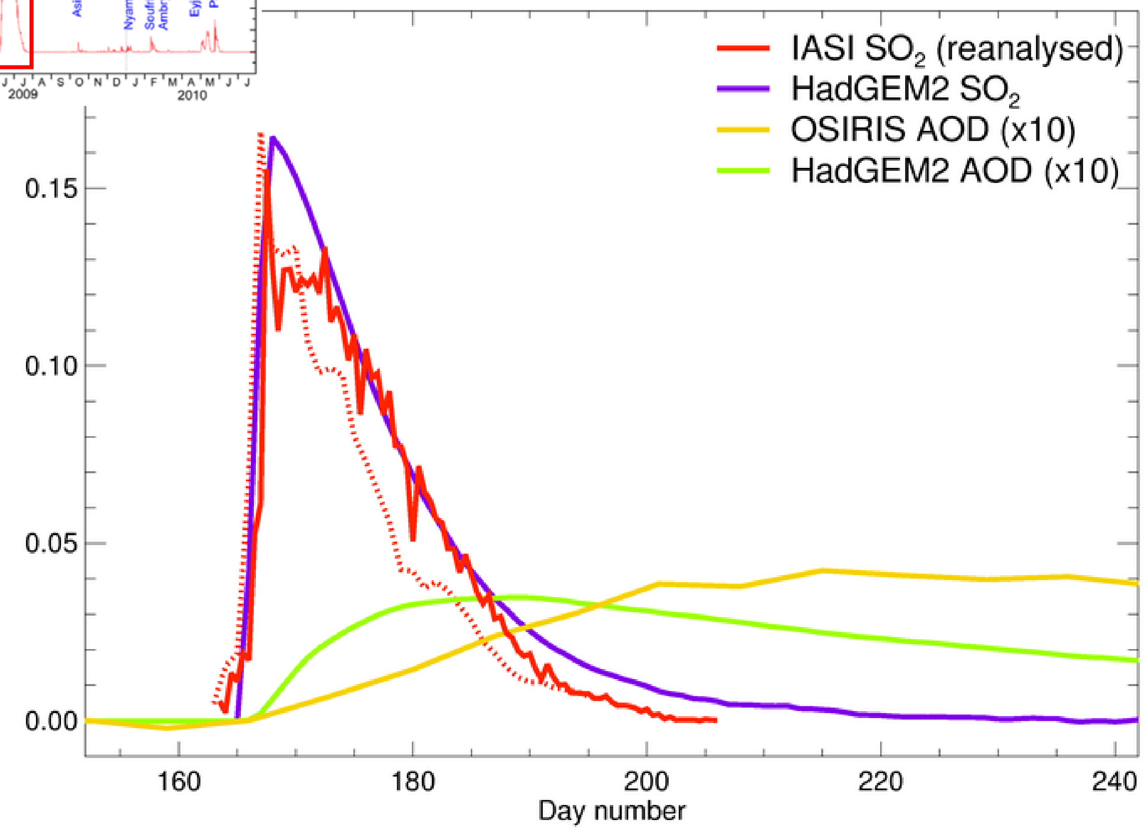
A global view



Sulfur dioxide



Sarychev peak eruption, June 2009



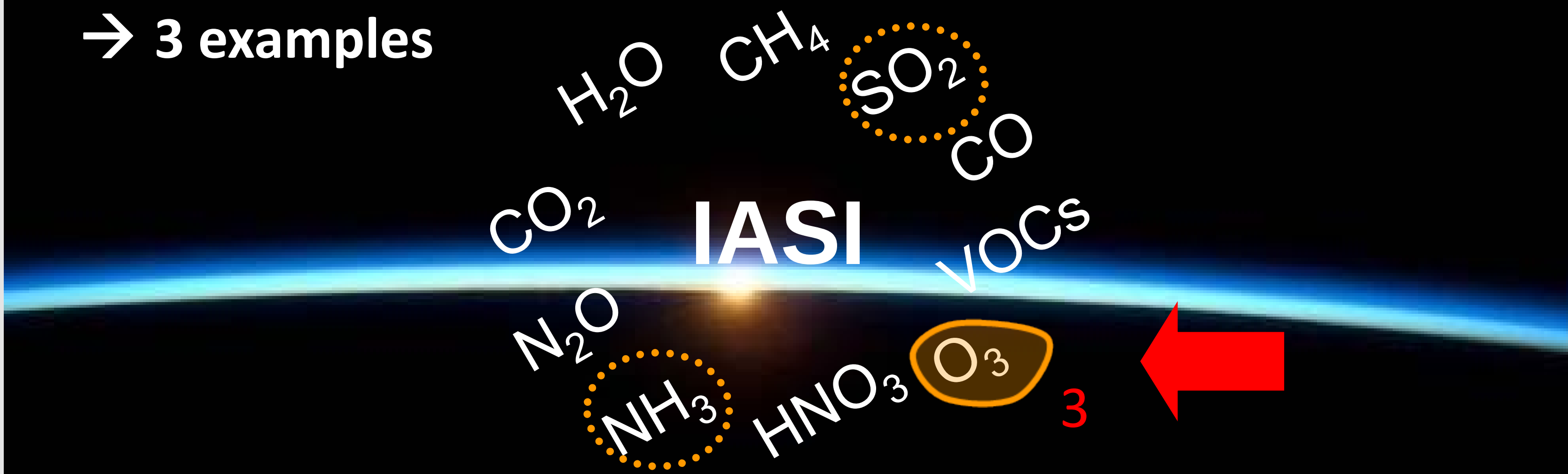
$SO_2 \rightarrow H_2SO_4$ depletion kinetics and climate impact

Haywood et al, JGR, 2010

LATMOS ULB

Contribution to climate: beyond CO_2 and CH_4

→ **3 examples**



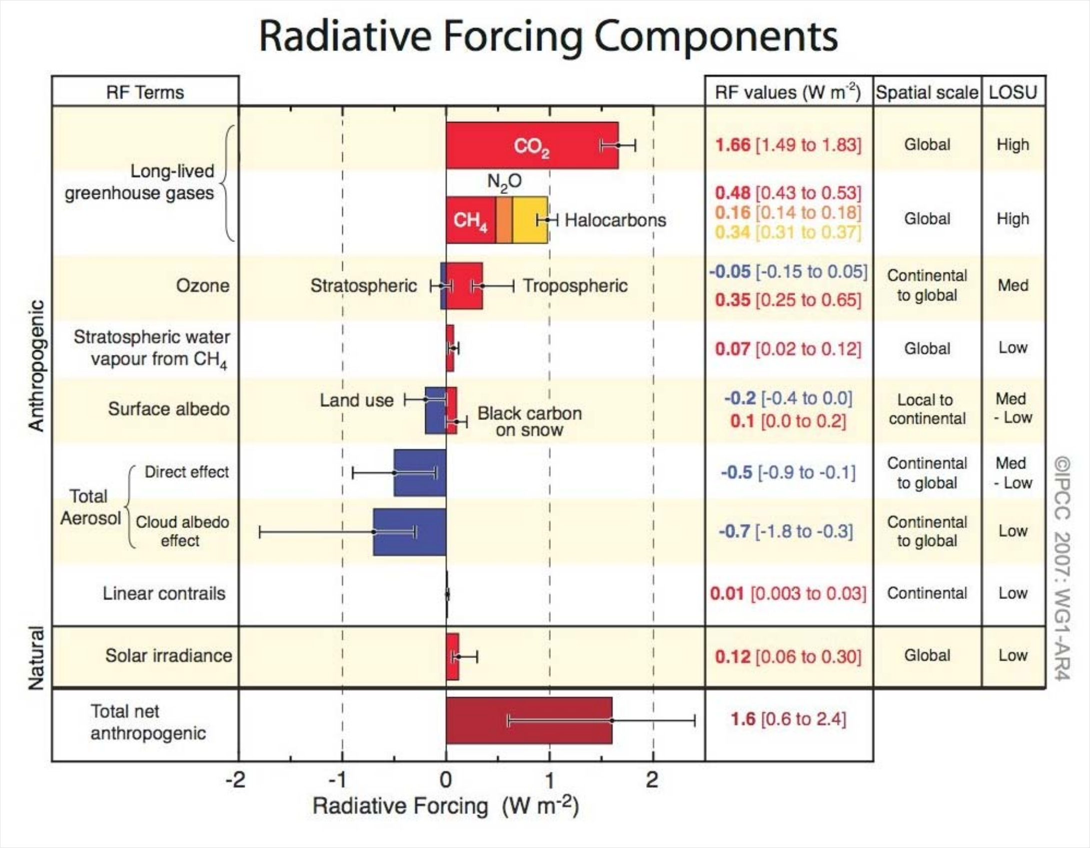
climate

— Greenhouse gases (direct)

··· Reactive gases (indirect)

Tropospheric ozone

Tropospheric ozone is the third most important greenhouse gas after carbon dioxide and methane

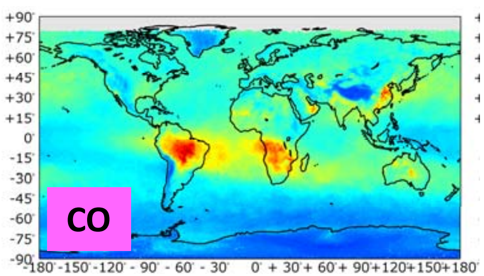


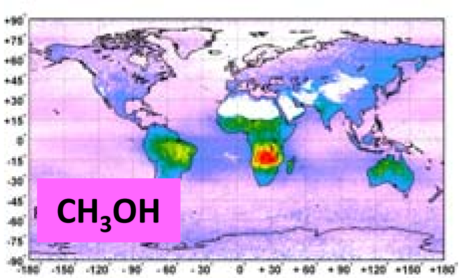
LATMOS ULB

Tropospheric ozone

Ozone vertical profiles retrieved from ULB/LATMOS processing chain in NRT

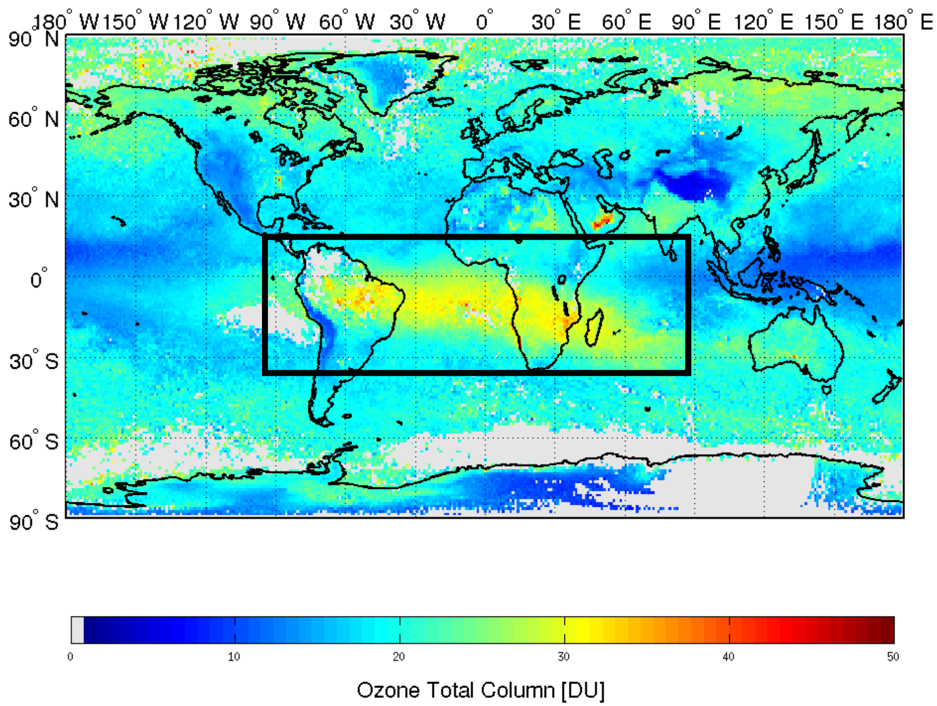
3-4 independent information → *tropospheric and stratospheric columns can be separated*





Ozone 0-8 km column (Preliminary)

Average for October 2010.

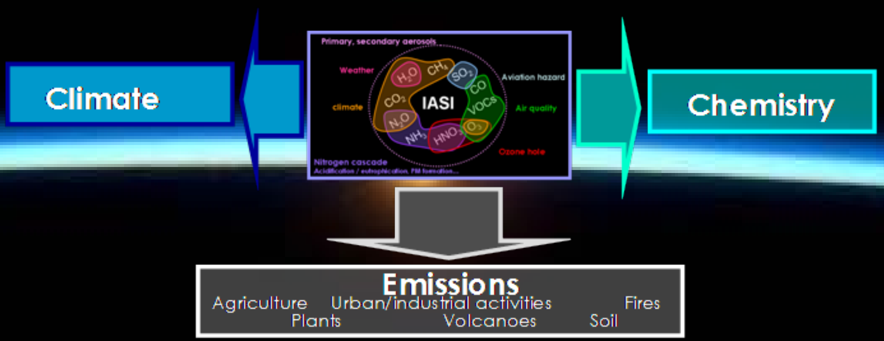


Large tropospheric ozone due to (fire) emissions of precursors from Africa and South-America) ?

Conclusions

• By measuring routinely and globally a suite of important atmospheric species, IASI contributes, in synergy with models, in quantifying emissions and in modelling atmospheric chemistry and transport. This, in turn, is essential to understand the processes driving climate and global change.

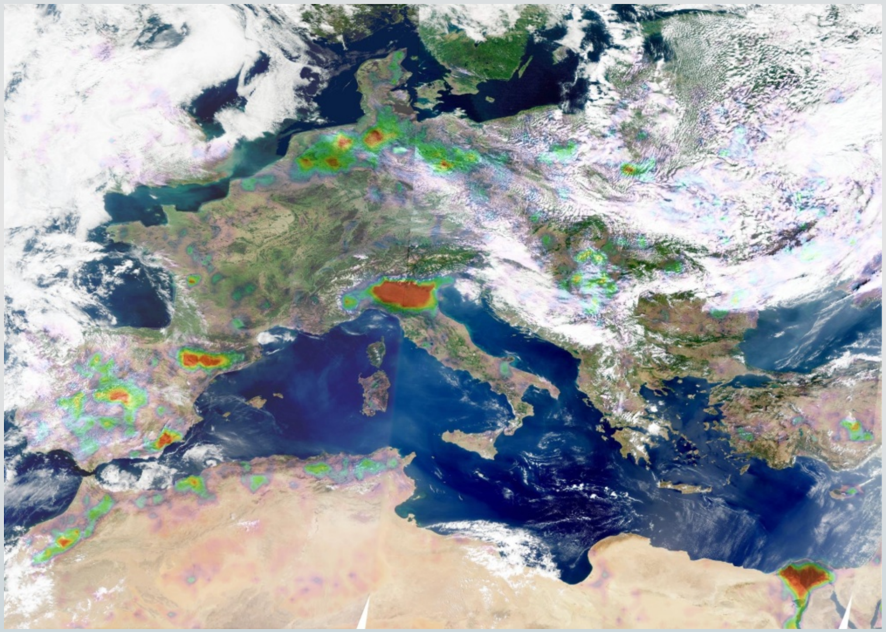
• Operational applications in air quality forecasting (MACC EU-GMES) and aviation safety (volcanic hazard; ESA-SACS and EU-EVOSS projects) have started.



• As one of the first advanced atmospheric infrared sounder, IASI helps to define a strategy for the long-term monitoring of the atmospheric composition. IASI and follow-on (IASI-NG with further improvements?) are expected to operate during decades. They are likely to become central in the Global Earth Observation System of Systems

Monitoring our changing atmosphere

Highlights from IASI mission



SPECAT/ULB

L. Clarisse
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A.Razavi
M. Theunissen
Y. Rhoni
M. Van Damme
C. Wespes

CNRS/LATMOS

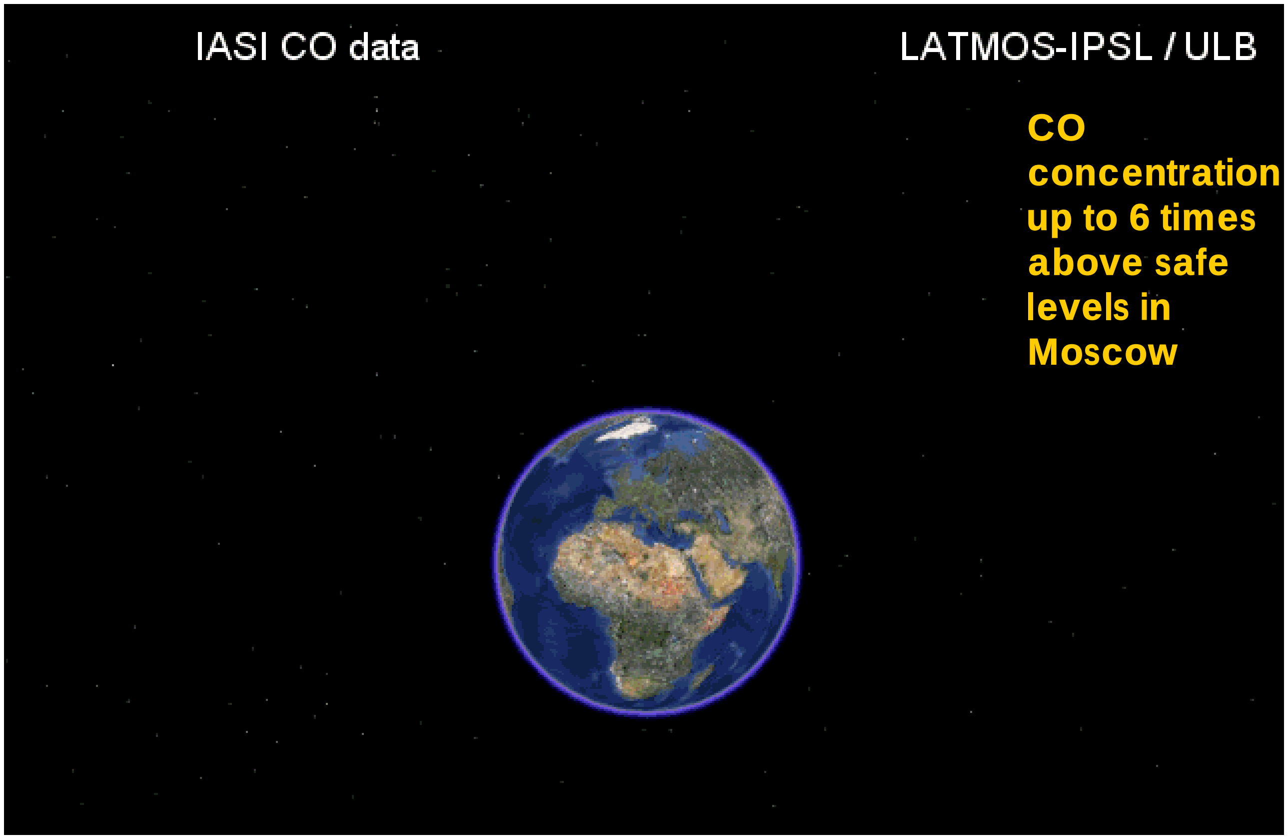
A. Boynard
C. Clerbaux
M. George
J. Hadji-Lazaro
M. Pommier
C. Scannell

Collaborators worldwide

S. Turquety (LMD), F. Dentener (JRC) C. Heald (CSU), R. Martin (DU), J. STavrakou and JF. Müller (BIRA-IASB), A. Fortems-Cheney, F. Chevallier (LMD), F. Prata (NILU)....

2010 Fires in Central Russia

IASI-CO
July 22 →
Aug. 22



CO total columns from the IASI/MetOp observations (FORLI-CO) from July 22 to August 22, 2010.
Data averaged over 3 days on a 0.5°x0.5° grid – only daytime with CO above 2.2 10^{18} molecules/cm^2
Animation by Maya George (LATMOS)

LATMOS ULB