→ ATMOS 2015

Advances in Atmospheric Science and Applications

HCOOH distributions from IASI with updated retrieval parameters: comparison with ground-based FTIR measurements and IMAGESv2 model

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Tropospheric formic acid (HCOOH)

- HCOOH is **one among the most abundant volatile organic compounds** (VOCs) present in the atmosphere.

- With acetic acid it is a major **contributor to the acidity of precipitation**

- **Many sources:**

secondary product from other organic precursors + small direct emissions by vegetation, ants, biomass burning, soils, agriculture, motor vehicles.

- **Sinks:**

mainly removed through **wet and dry deposition** + (lesser extent) oxidation by the OH radical

HCOOH = short-lived species

lifetime is conditioned by the ratio of precipitation: in the boundary layer 2 days (rainy period) → 6 days (the dry season). **Global lifetime in the troposphere=3–4 days**

Photochemical loss is relatively slow ($\tau \sim 25$ days), so that any HCOOH formed or vented outside of the boundary layer **can be transported for long distances in the free troposphere**.

HCOOH: our knowledge is incomplete

Recent studies highlight:

A misrepresentation of emission from tropical and boreal forest in models (Stavrakou et al., Nature 2011)

A possible source of HCOOH over the Arctic Ocean (Jones et al., Atmos. Env 2014).

One or more large missing sources (Millet et al., ACPD 2015) → suggest a gap in our current understanding of hydrocarbon oxidation or the existence of an unknown direct flux

HCOOH: observations from space


Space missions allow getting global observations of the atmosphere


Their spatial coverage allows observing remote regions which are sparsely studied by field campaigns


Limited vertical sensitivity

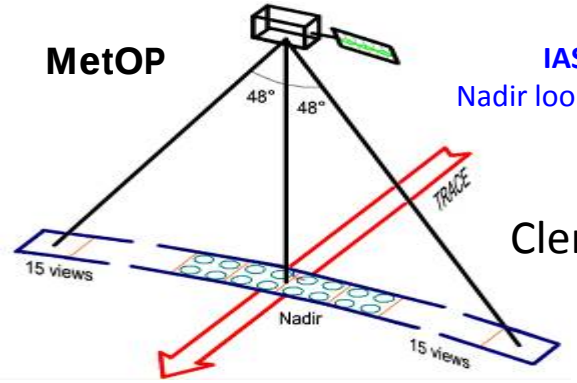
few satellites provide tropospheric HCOOH observations

nadir-viewing instruments: Infrared Atmospheric Sounding Interferometer (**IASI**) (e.g. Coheur et al., 2009), Tropospheric Emission Spectrometer (**TES**) (e.g. Cady-Pereira et al., 2014)

solar-occultation instrument: Atmospheric Chemistry Experiment (**ACE**) (e.g. González Abad, 2009)

limb instrument: Michelson Interferometer for Passive Atmospheric Sounding (**MIPAS**) → global distribution of HCOOH at 10 km (Grutter et al., 2010).

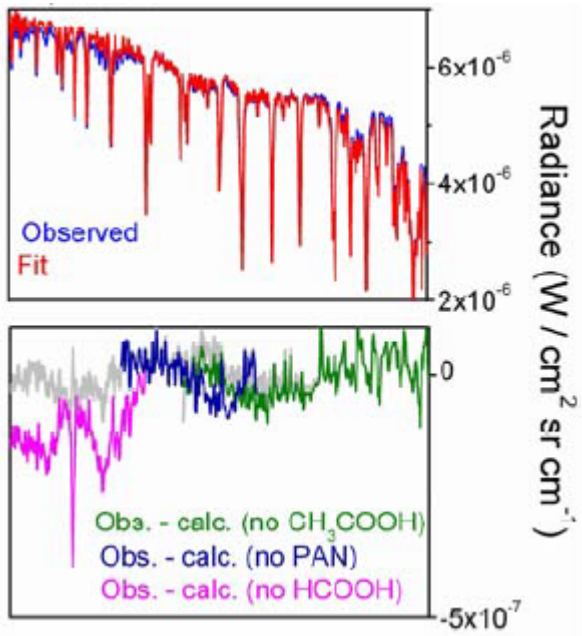
HCOOH: observations with IASI



IASI
Nadir looking FTS

Clerbaux et al. (2009)

MetOp: First European **meteorological** platform in **polar orbit** launched by EUMETSAT in 2006 (IASI-B launched in 2012)



Coheur et al. (2009)

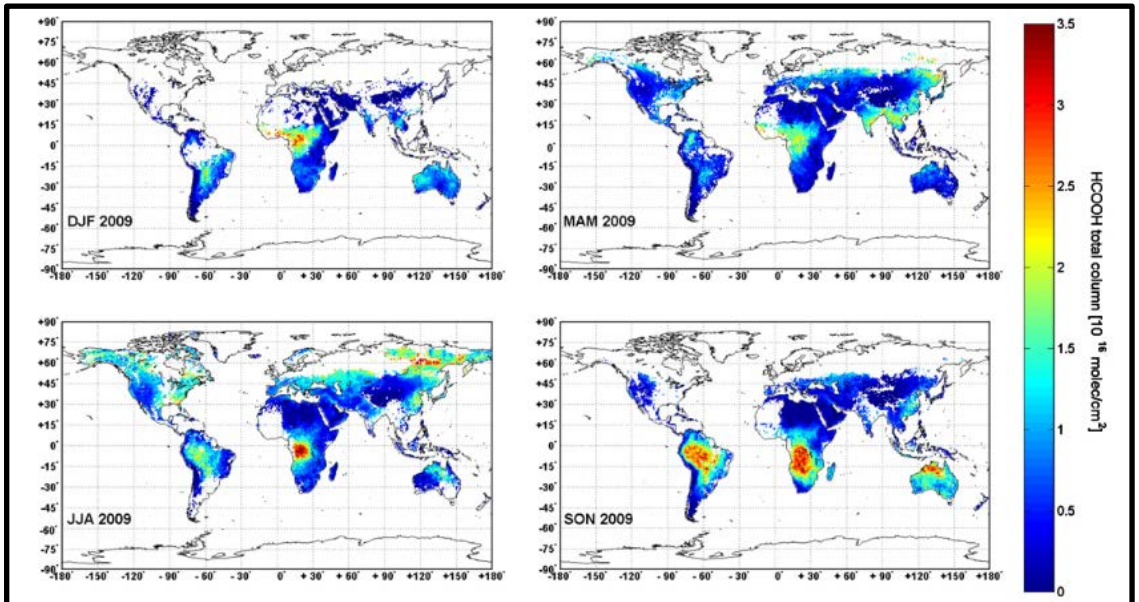
- 4 pixels (12 km at nadir)
- 120 spectra along the swath (±48.3° Scan →2400 km), each 50 km along the trace

Small ground pixel size

Global coverage twice daily (morning and evening orbits) – 14 revolutions/day

Spectra given in radiance or brightness temperature
→ signal from HCOOH expressed in ΔBT

HCOOH: observations with IASI



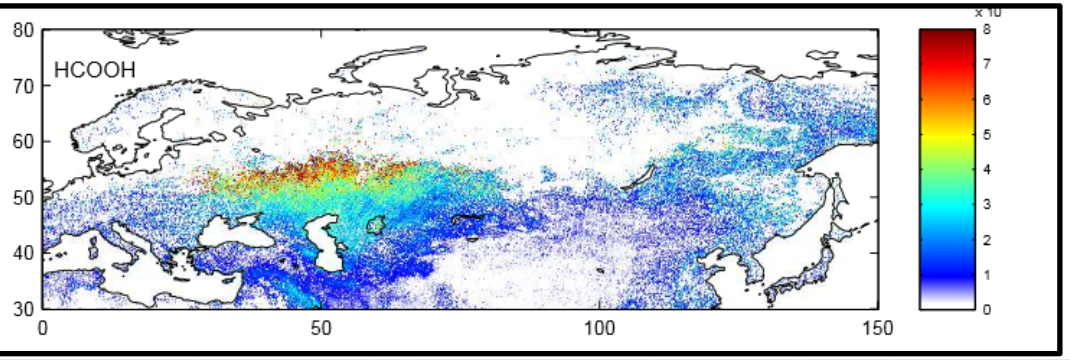
First global distribution by IASI (Razavi et al., ACP 2011)

Objective = find an accurate and fast technique to convert the ΔBT to total columns, avoiding a large computing time

→ **necessary to analyze 7 years of data**

Detection of extreme events: forest fires in Russia on 2010 (R'Honi et al., ACP 2013)

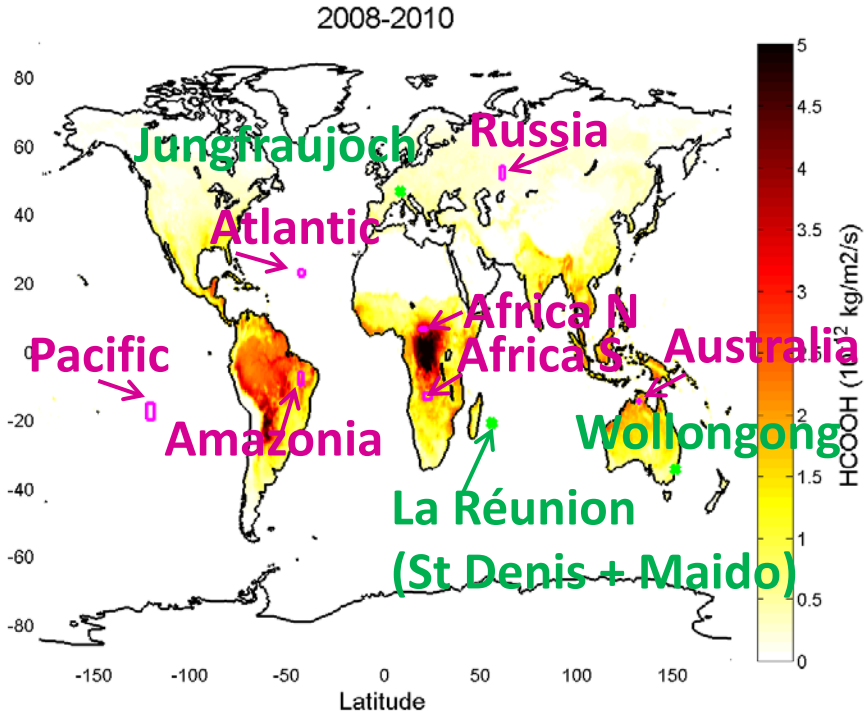
Retrieval relevant for huge amount of HCOOH



HCOOH: Retrieval approach (1/2)

MEGAN-MACC HCOOH emissions for the period between 2008 and 2010 on a 0.5°×0.5° grid. (Sindelarova, ACP 2014)

FTIR sites location



Region	Localization	Number of retrieved spectra
Africa N	6-7°N 18-22°E	265
Africa S	12-14°S 20-24°E	788
Amazonia	6-10°S 43-45°W	682
Atlantic	22-24°N 42-45°W	675
Australia	14-15°S 131-133°E	218
Pacific	20-22°S 140-142°E	472
Russia	50-54°N 60-62°E	538

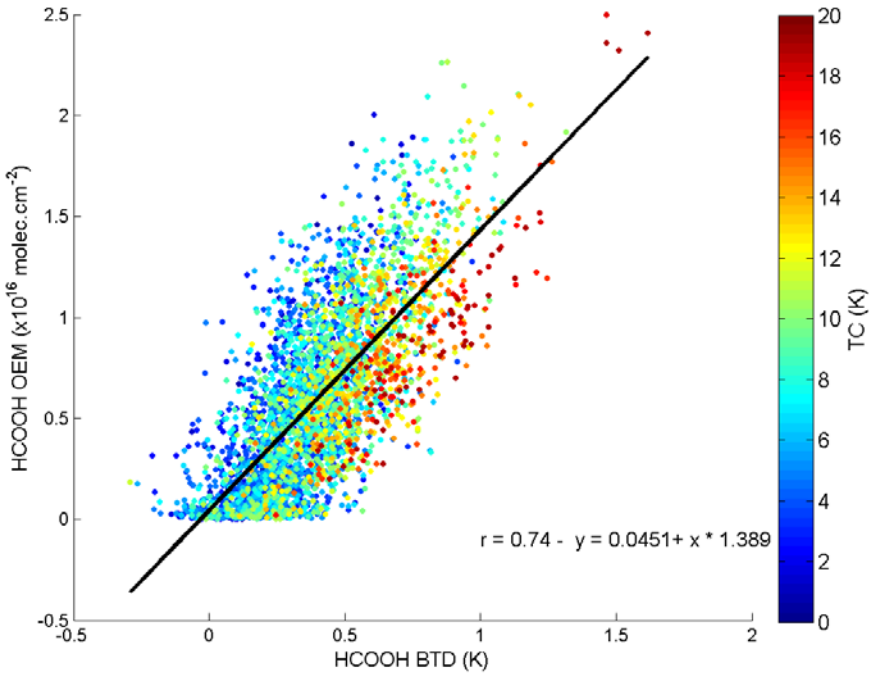
Data retrieved over 7 regions → emission sources, remote area, areas influenced by long-range transport + land and sea scenes

Seasonal variation is taken account: 5 first days of each month on 2009 are retrieved

HCOOH: Retrieval approach (2/2)

Parameters:

- 1095-1114 cm^{-1}
- Cloud fraction < 2%
- Same a priori than Razavi et al. (2011)
- Thermal contrast > 0 K ($T_{surf} - T_{atm\ 1st\ layer}$) *(Razavi et al. used TC >5K)*
- day-time and night-time data used

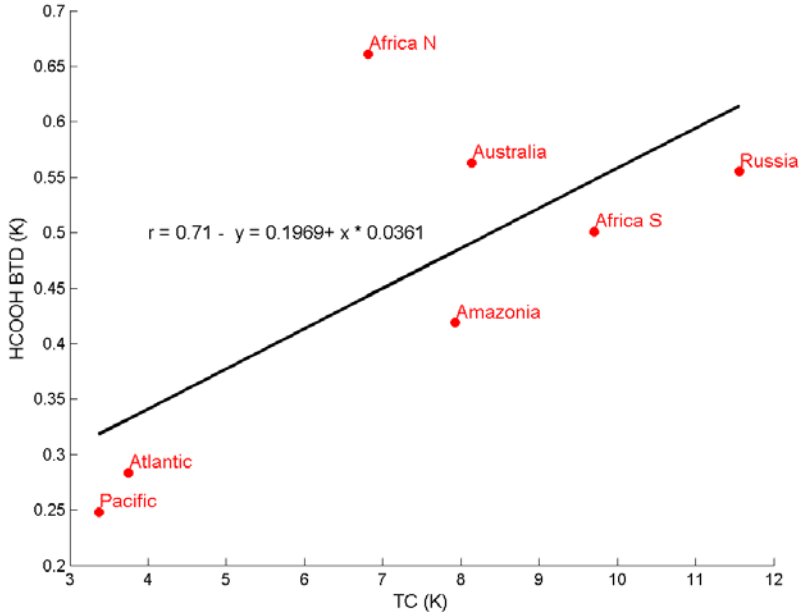


Good correlation between retrieved columns and ΔBT

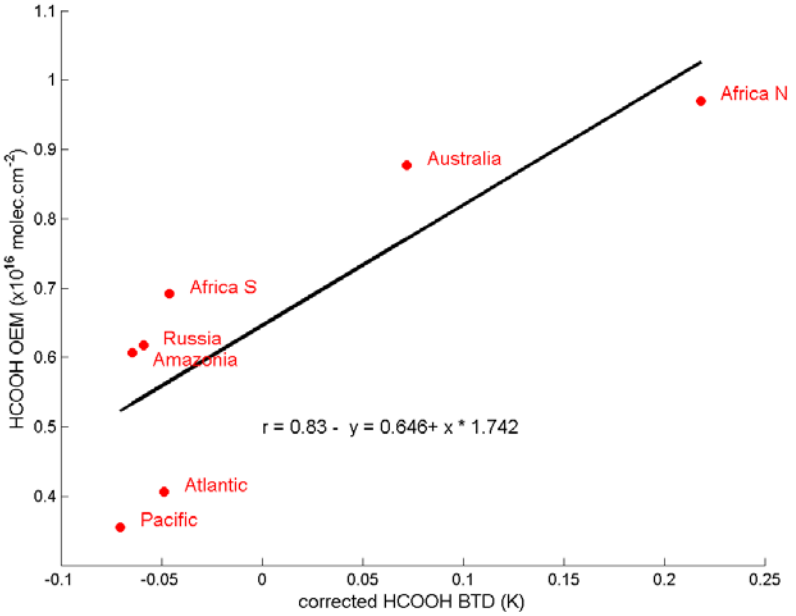
But conversion is dependent on the TC

Establishment of a new dataset

Reduction of the thermal contrast dependence:
Mean over 7 regions



correlation between ΔBT and TC



correlation between retrieved columns and corrected ΔBT (TC)

Conversion using both relationships:
Column = 1.742 × (ΔBT – TC × 0.0361 - 0.1969) + 0.646

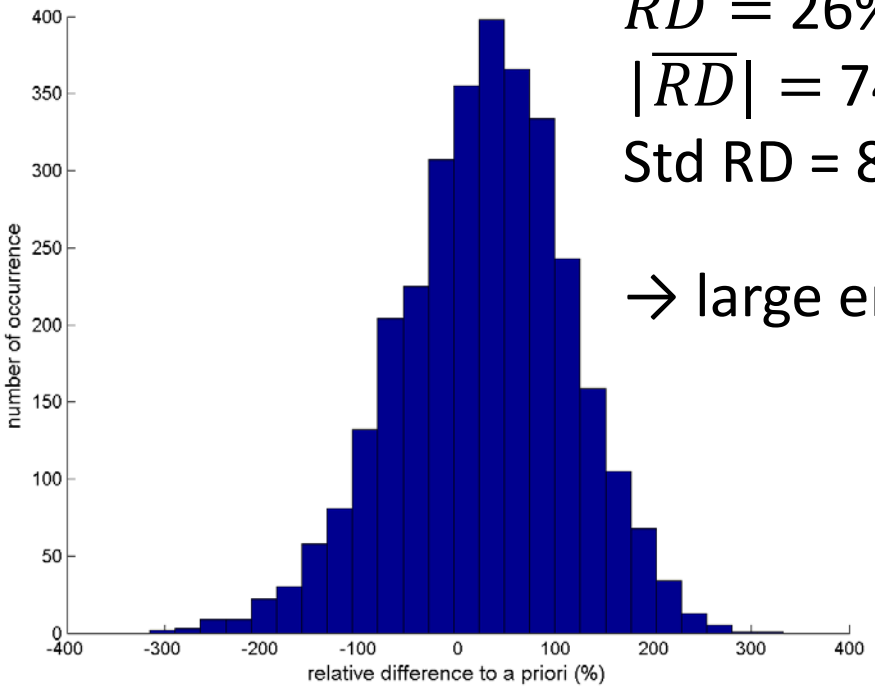
Error estimation

3 terms:

1) the instrumental error
2) the error caused by the conversion between the ΔBT and the total column
3) the error from the retrievals.

total error by forward simulation (>3000 spectra):

- Gaussian distributed random noise (σ = 0.15K) added to the BT channels
- the conversion formula is applied on the calculated ΔBT.



$\overline{RD} = 26\%$

$|\overline{RD}| = 74\%$

Std RD = 88%

→ large errors

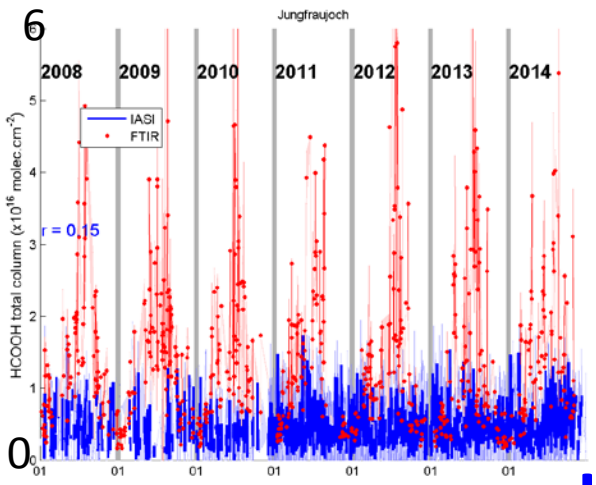
Comparison with FTIR (± 0.5°, daily mean)

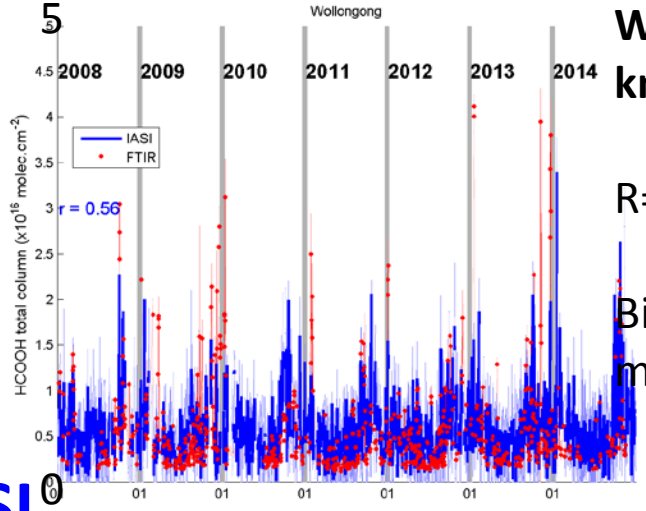
Simple altitude correction of total columns: C'= C × exp(Alt/7.4)

Jungfraujoch (3.6 km alt)

R=0.15

Bias=1.19×10^{16} molec/cm^2





Wollongong (0 km alt)

R=0.56

Bias=0.01×10^{16} molec/cm^2

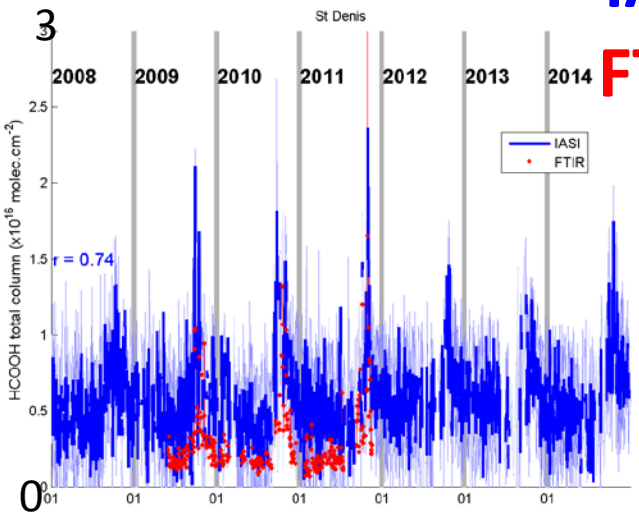
IASI

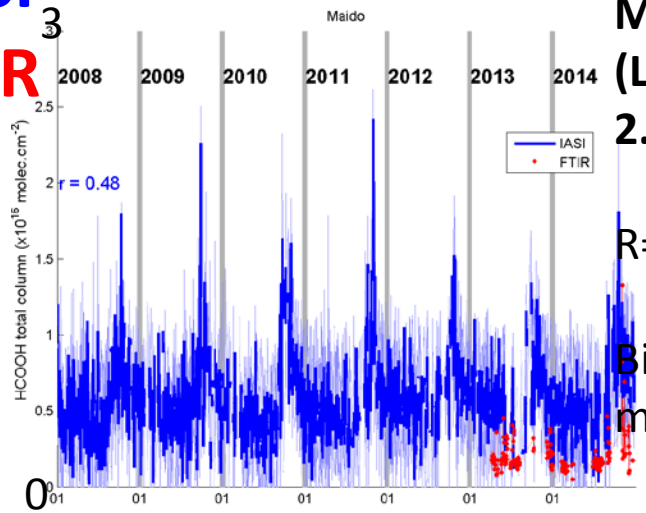
FTIR

Saint Denis (La Réunion – 0.26 km alt)

R=0.74

Bias=0.30×10^{16} molec/cm^2





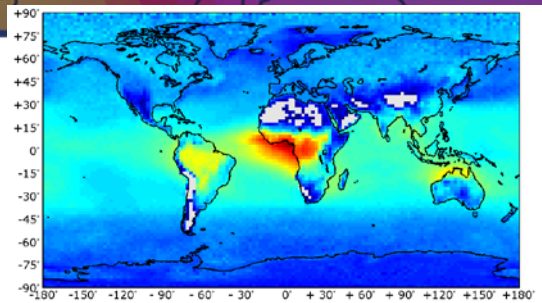
Maido (La Réunion – 2.5 km alt)

R=0.48

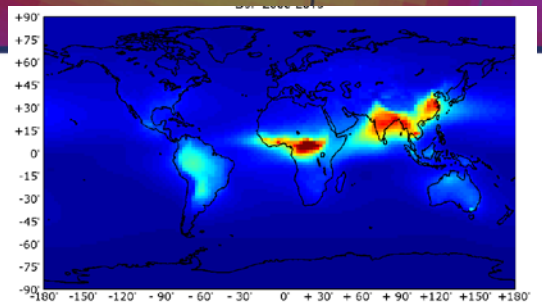
Bias=0.32×10^{16} molec/cm^2

Seasonal Variation (global distribution)

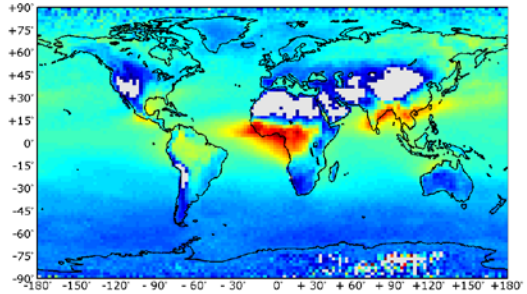
IASI (gridded IMAGESv2 =2°x2.5°)



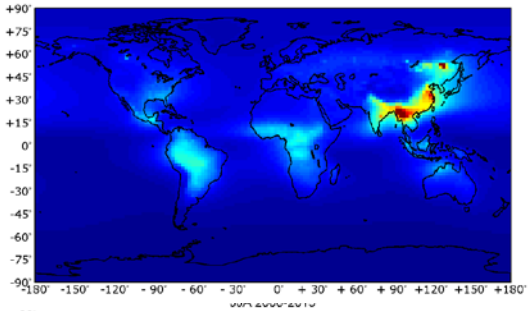
2008-2013 DJF

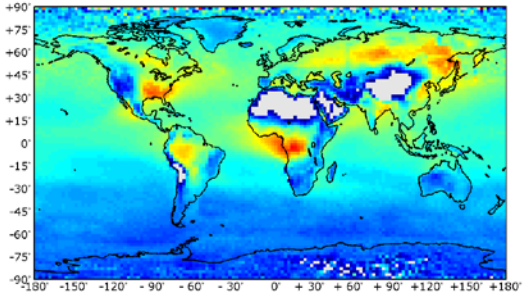


IMAGESv2

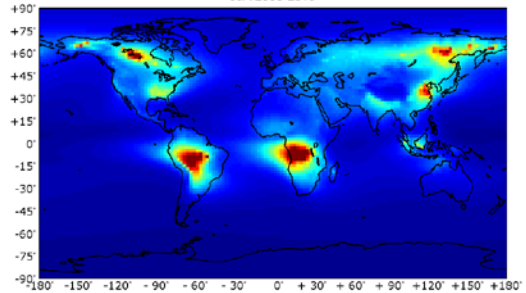


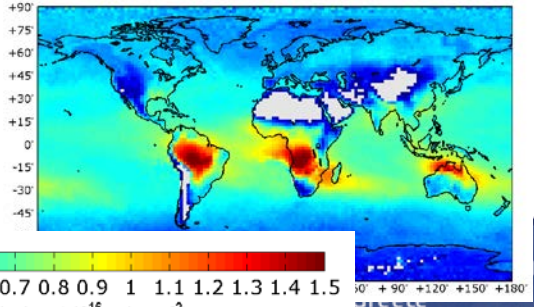
MAM



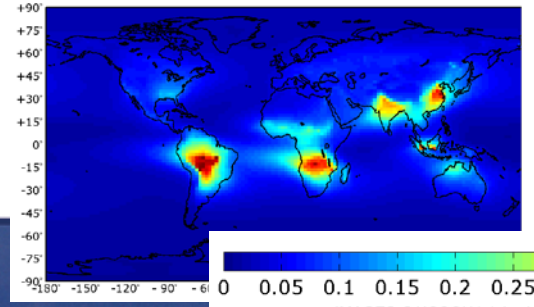


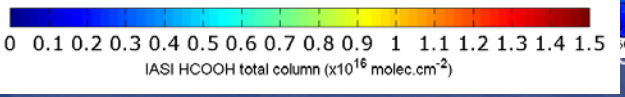
JJA

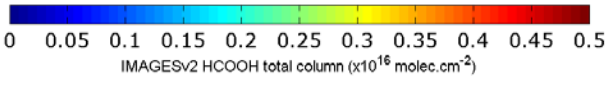


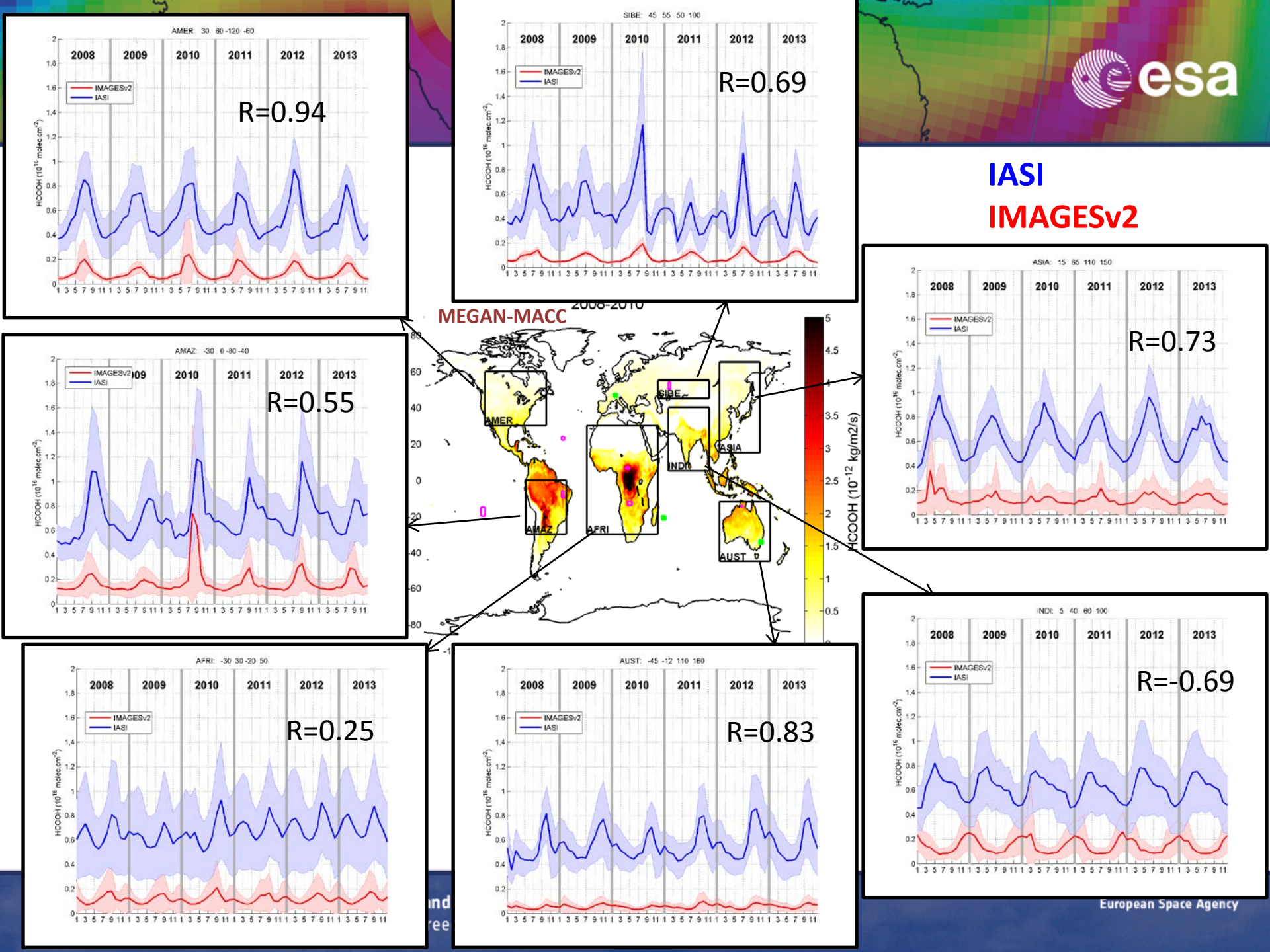


SON








IASI
IMAGESv2
MEGAN-MACC
2008-2010
AMER: 30 60 -120 -60
R=0.94
SIBE: 45 55 50 100
R=0.69
ASIA: 15 85 110 150
R=0.73
AMAZ: -30 0 -80 -40
R=0.55
AFRI: -30 30 -20 50
R=0.25
AUST: -45 -12 110 160
R=0.83
INDI: 5 40 60 100
R=-0.69
2008
2009
2010
2011
2012
2013
HCOOH (10^16 molec.cm^-2)
HCOOH (10^-12 kg/m2/s)
AMER
SIBE
ASIA
INDI
AMAZ
AFRI
AUST
European Space Agency

Conclusions

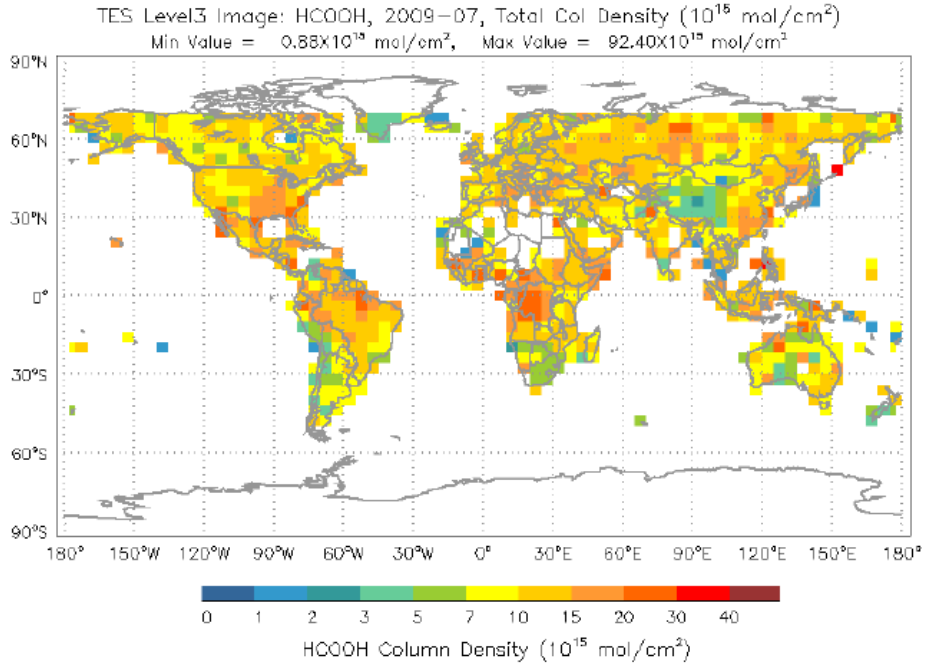
- Global overview of HCOOH
- 7 years of data to analyze
- Detection hotspots (MiddleEast US, Asia…) & seasonal cycle

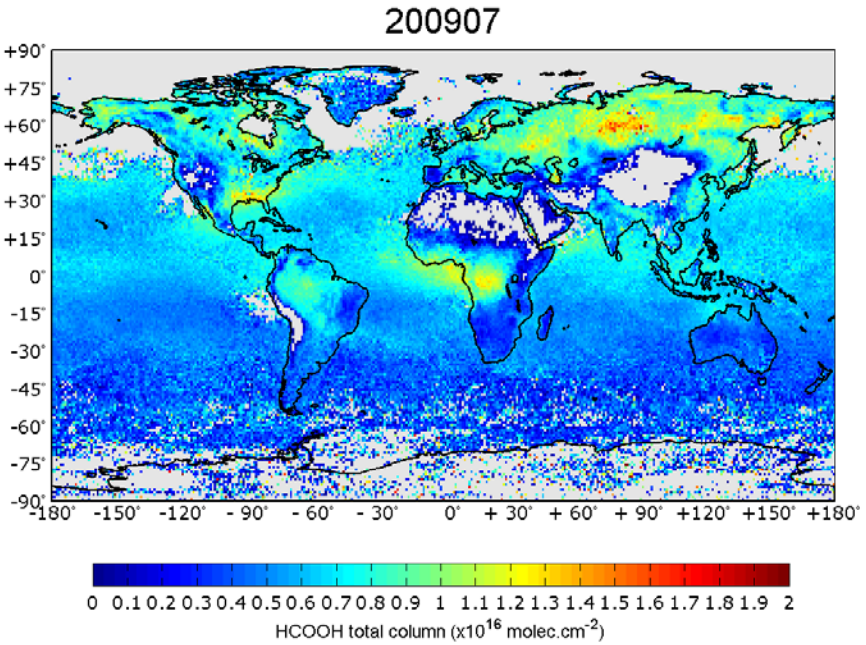
- No averaging kernels → difficulties to compare IASI total columns to FTIR and simultations

- Challenge in the interpretation of the data → misrepresentation of sources

?

Extra slides



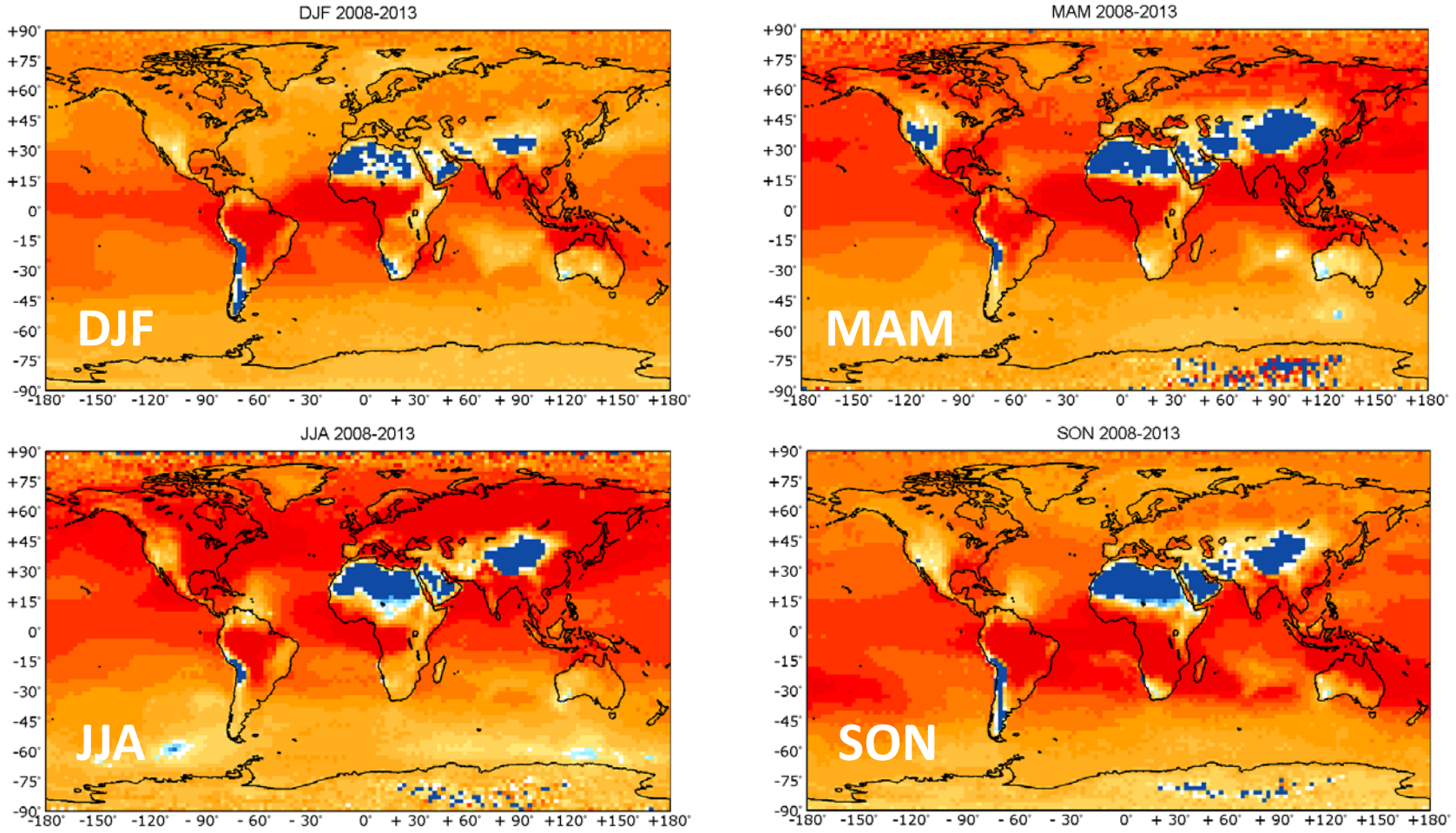


TES

Cady-Pereira et al. AMT 2014

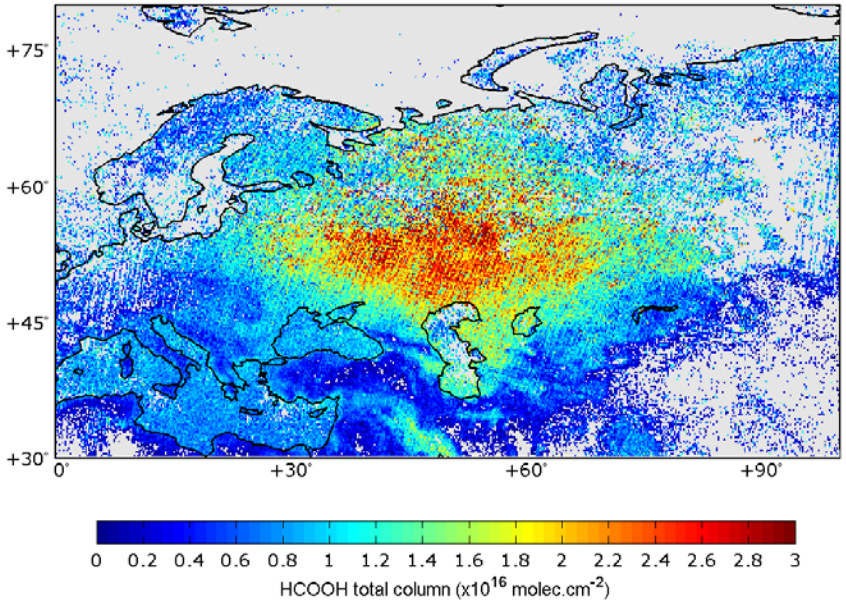
IASI

Seasonal Variation (global distribution)

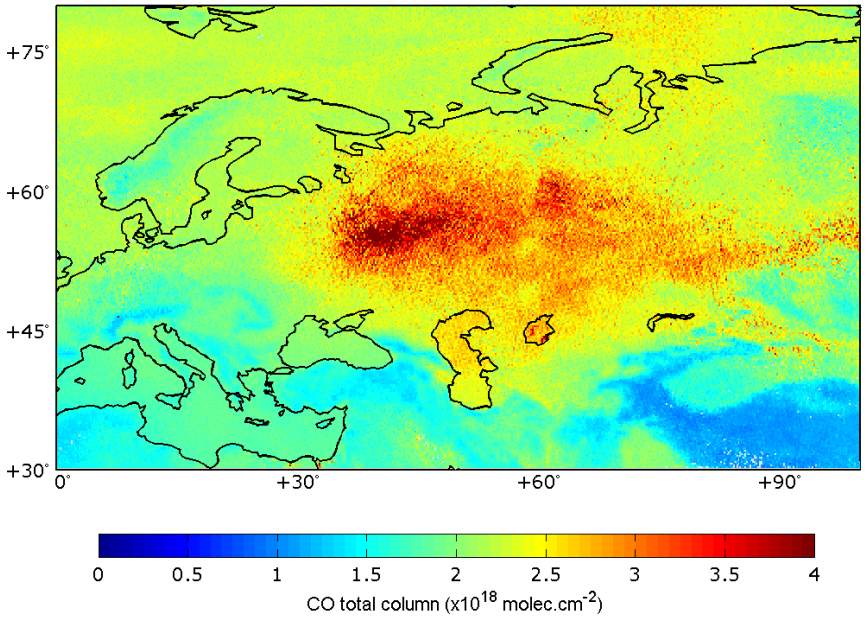


Detection of extreme events: fires over Russia

0.2°×0.2° 27 July – 27 August 2010 over Russia



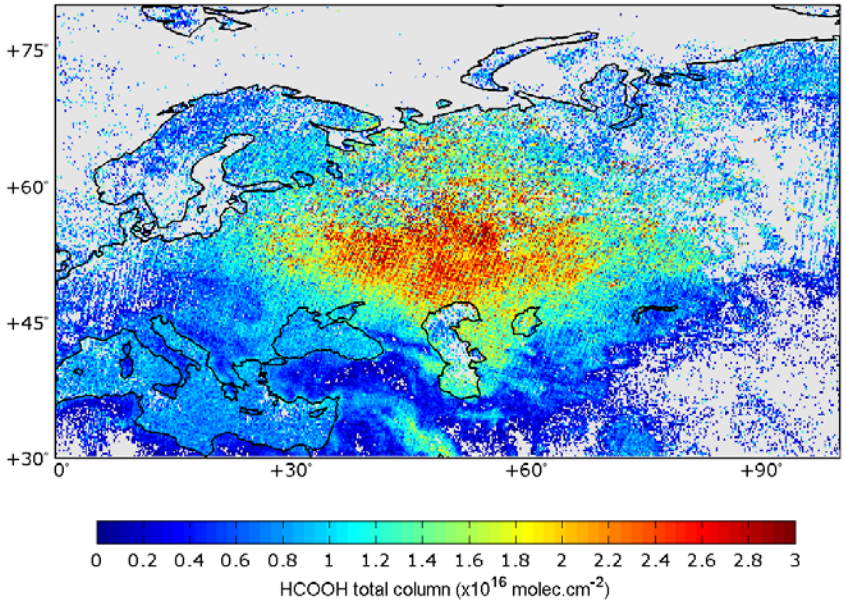
HCOOH total column



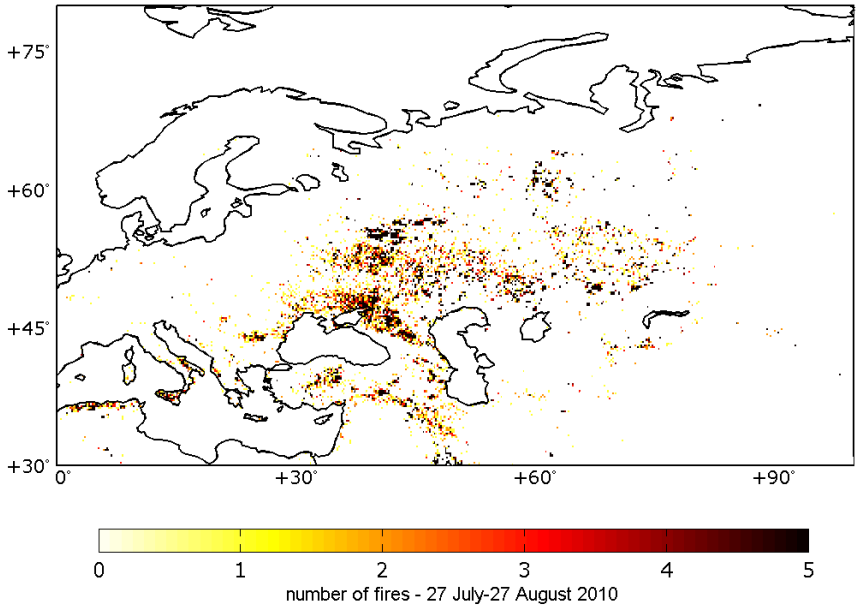
CO total column

Detection of extreme events: fires over Russia

0.2°×0.2° 27 July – 27 August 2010 over Russia



HCOOH total column



MODIS hotspot