Monitoring emission, chemistry and transport of vegetation fires from IASI

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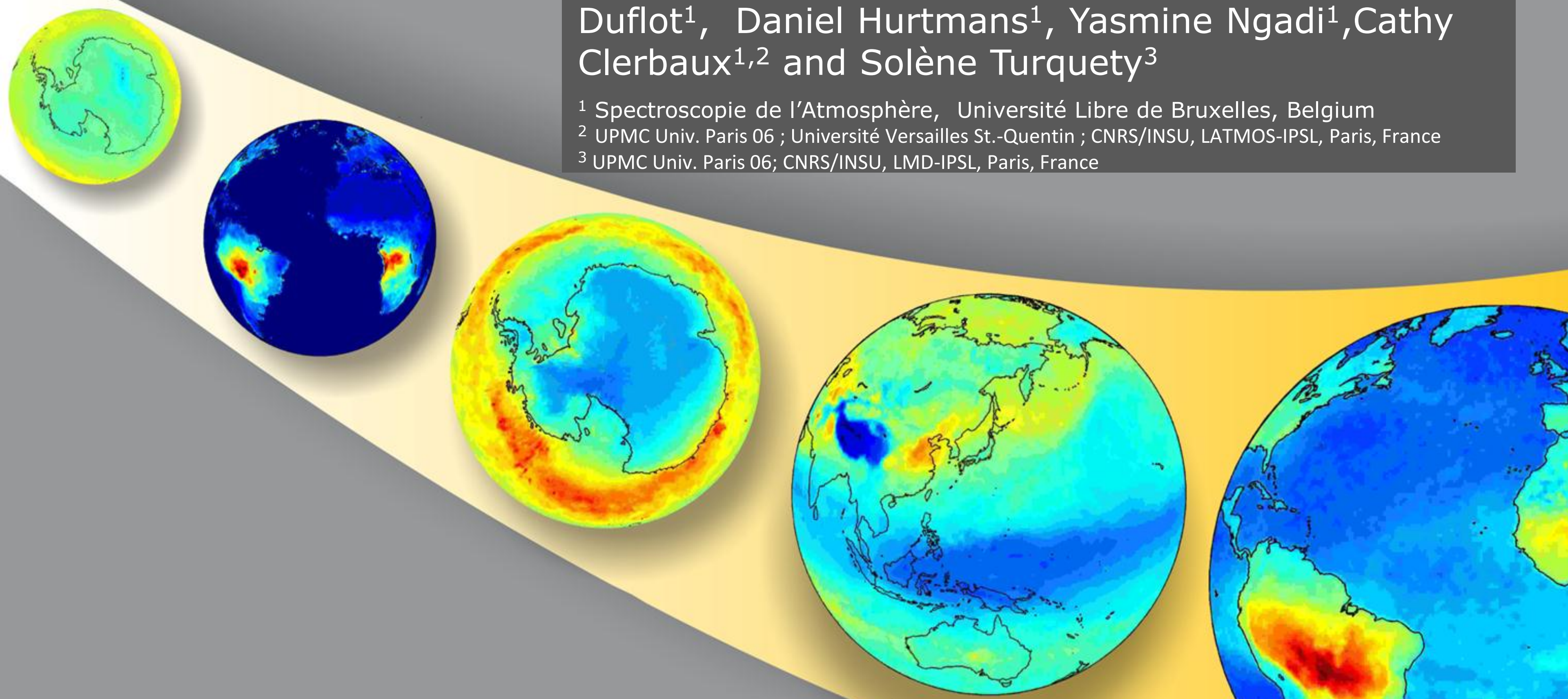

Chemistry

- What controls ozone production in the fire plumes?
- How do aerosols impact photochemistry?
- What controls nitrogen chemistry and acid deposition?

Composition?

- Which and how many *gases and aerosols are released?*

Transport?

- Injection height?

Chemistry

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Composition?

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Transport?

- Injection height?

Large uncertainties in all parameters.

→ How can IASI contribute?

OUTLINE…

- **Local scale :**

1. Greek Fires – Aug. 2007 (Coheur et al., ACP 2009)
2. Australian Fires – Feb. 2009 (Clarisse et al. GRL 2011)
3. **Russian Fires – Jul.-Aug. 2010** **(R'Honi et al., ACPD 2012)**
   - Time evolution of the maxima and the average total columns
   - Time evolution in total masses → extra burden due to fires → daily emissions as fluxes
   - Enhancement ratios ($\Delta NH_3 / \Delta CO$ and $\Delta HCOOH / \Delta CO$)

- **Global scale :**

Artificial Neural Network (ANN) outputs

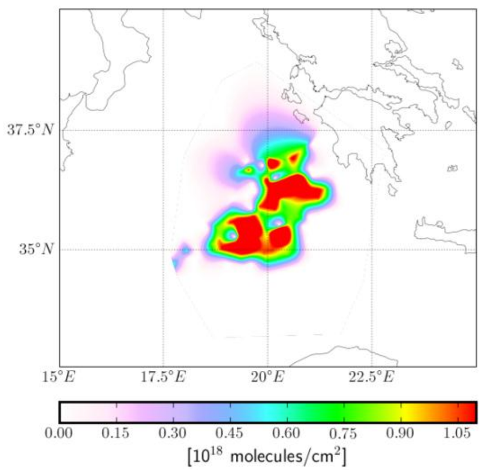
See poster # 41 : Yasmine Ngadi

- **Conclusions**

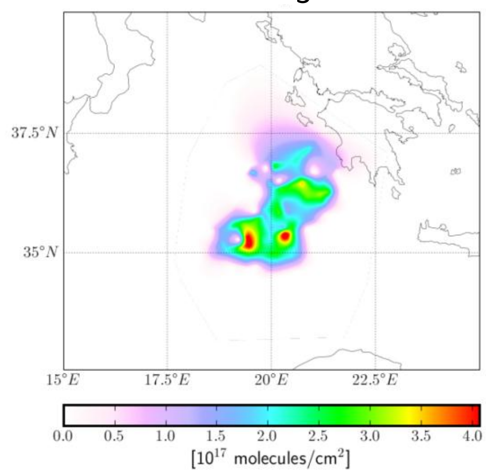
Atmospheric composition measurements with IASI hyperspectral sounder

- **Fires in Greece – 2007** (Coheur et al., ACP 2009)

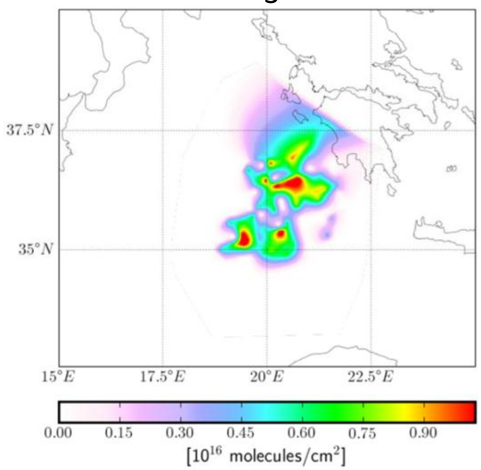
CO



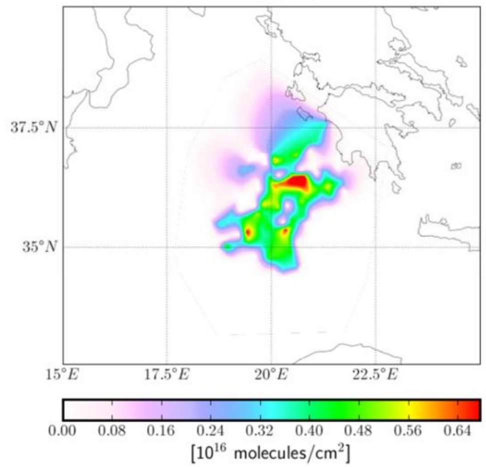
NH_3

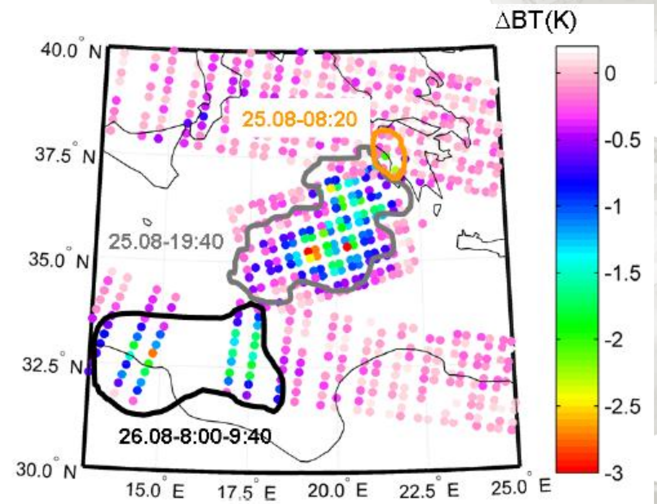


CH_3OH



C_2H_4





Atmospheric composition measurements with IASI hyperspectral sounder

- **Fires in Australia – 2009** (Clarisse, R'Honi et al., GRL 2011)

14 "unexpected" species

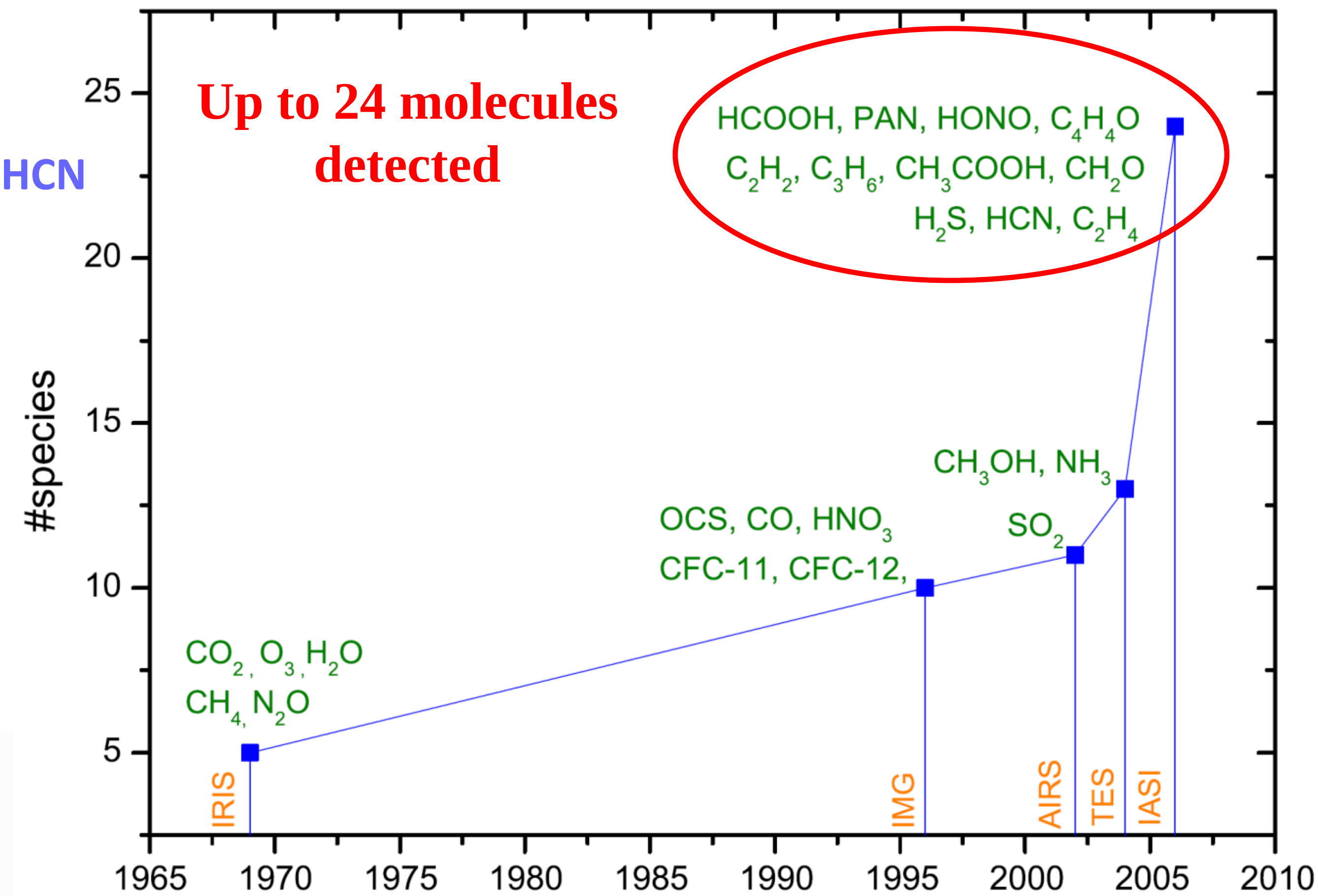
N compounds:
NH_3, **HONO**, PAN, **HCN**

Hydrocarbons:
C_2H_4, **C_2H_2**, C_3H_6

VOCs:
CH_3OH, HCOOH, CH_3COOH, **C_4H_4O**, H_2CO

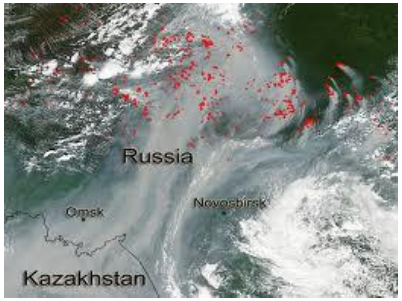
S compounds:
H_2S, SO_2

History of thermal infrared sounding of the atmosphere from space



Atmospheric composition measurements with IASI hyperspectral sounder

- **Fires in Russia – 2010** (R'Honi et al., ACPD 2012)



- Several hundreds fires occurred around Moscow during one month.
- Temperature reached 35-41°C

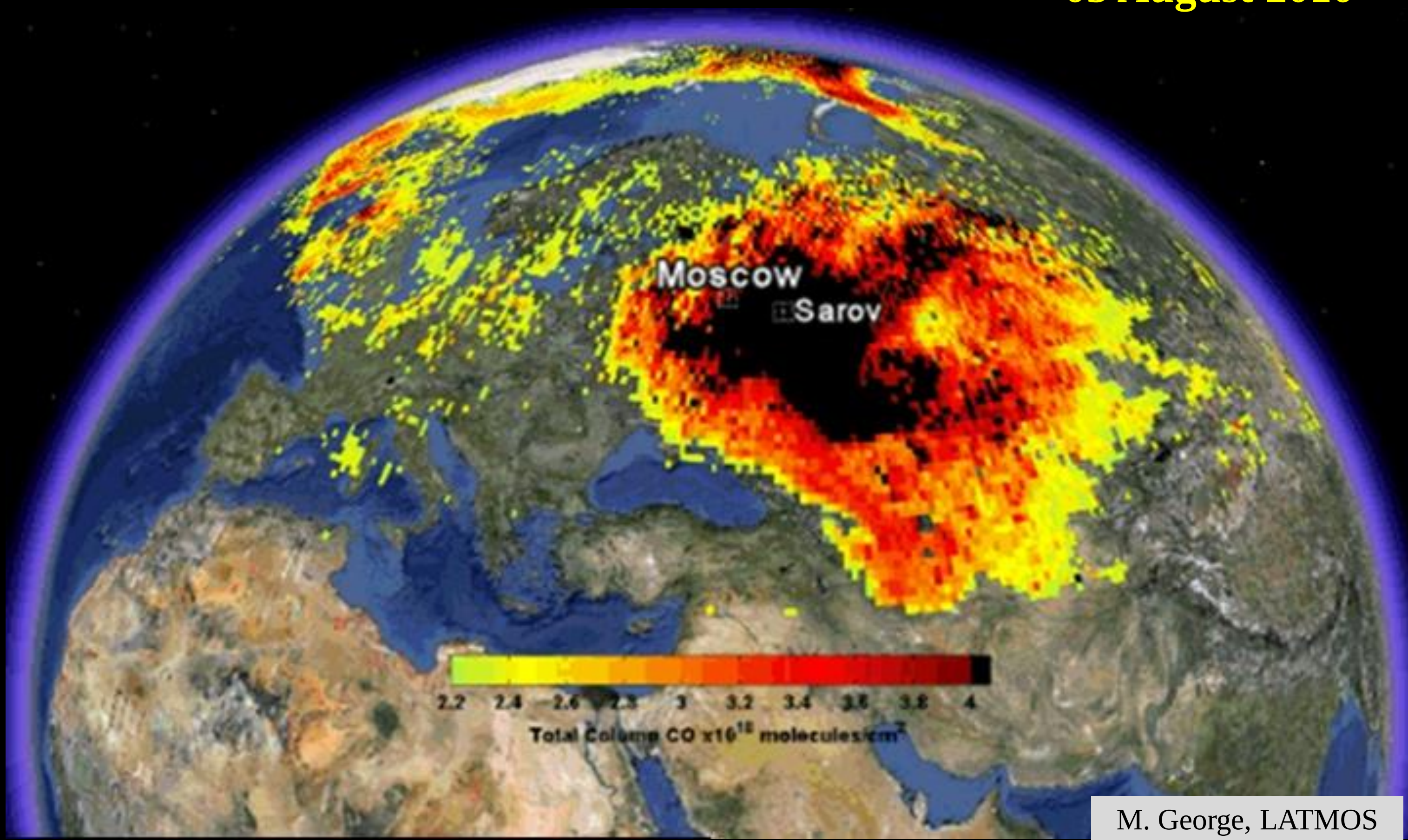
- Affected air quality
- Burned area around 10,000 km²
- FRP reached 19,000MW close to Moscow

- Aerosols and trace gases : **CO**, NO_2, O_3, HCHO, **HCOOH** and **NH_3**

LOCAL… 3. Russian Fires – Jul.-Aug. 2010

The period of the fires
July 27 to August 15-18 of 2010

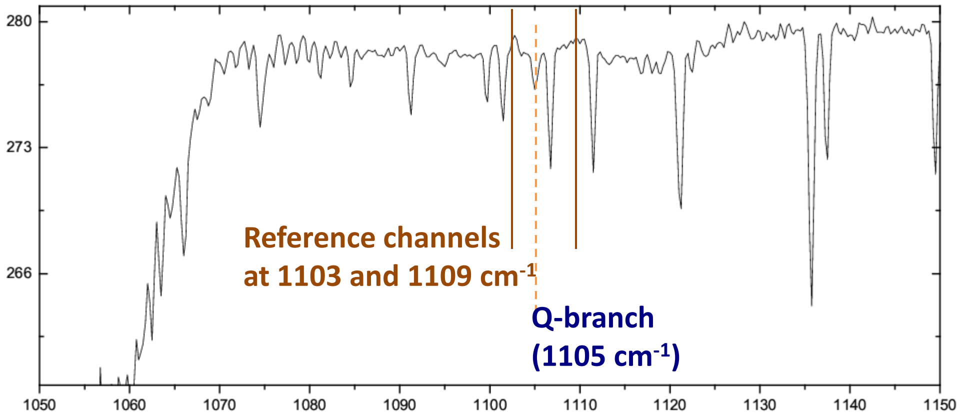
2010 Fires in Central Russia
05 August 2010



CO Total columns from the IASI/MetOp observations (FORLI-CO).
Data are averaged on a 0.5°x0.5° grid – only daytime with CO above 2.2 10^{18} molecules/cm^2

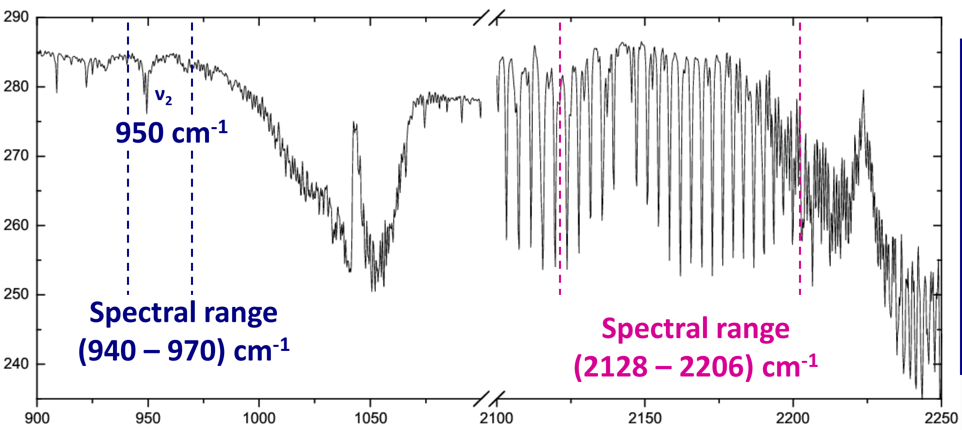
→ Retrieval methods

HCOOH



- Simplified method based on **Brightness Temperature Differences** (Razavi et al., 2010)
- Retrievals with thermal contrast > 5K
- Columns in molec cm^{-2}

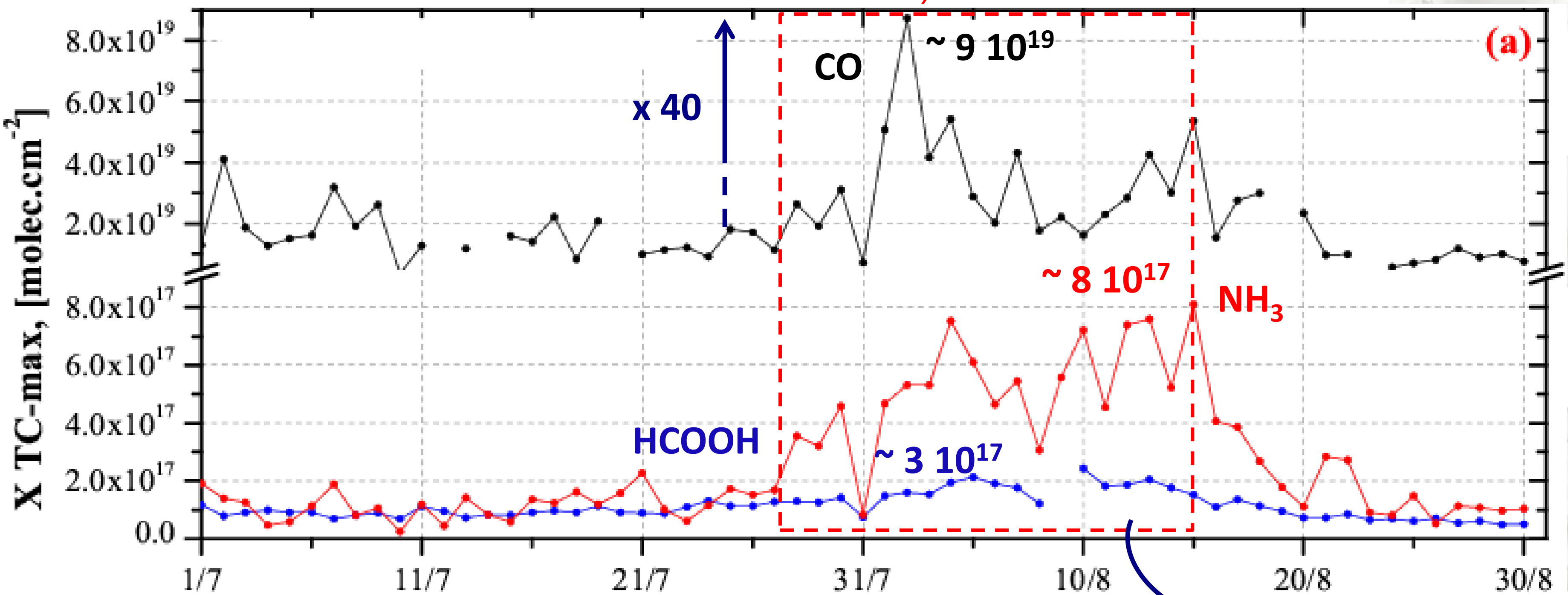
NH_3 - CO

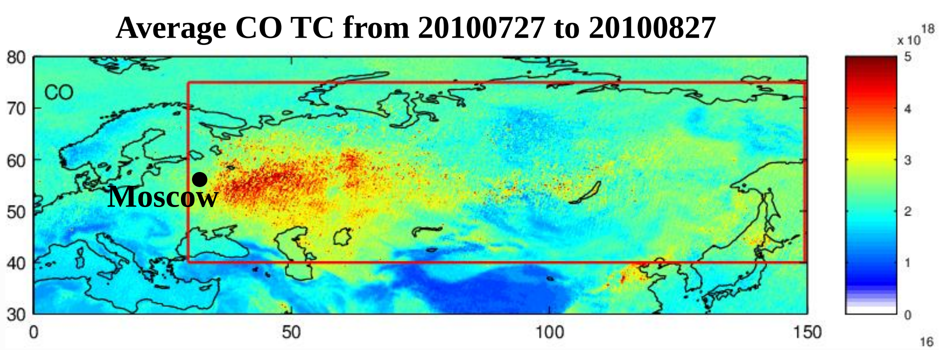


- **FORLI CO-NH_3**
(Hurtmans et al., 2012) based on the Optimal Estimation Method.
- Columns in molec cm^{-2}

→ Observations

The period of the fires
July 27 to August 15-18 of 2010



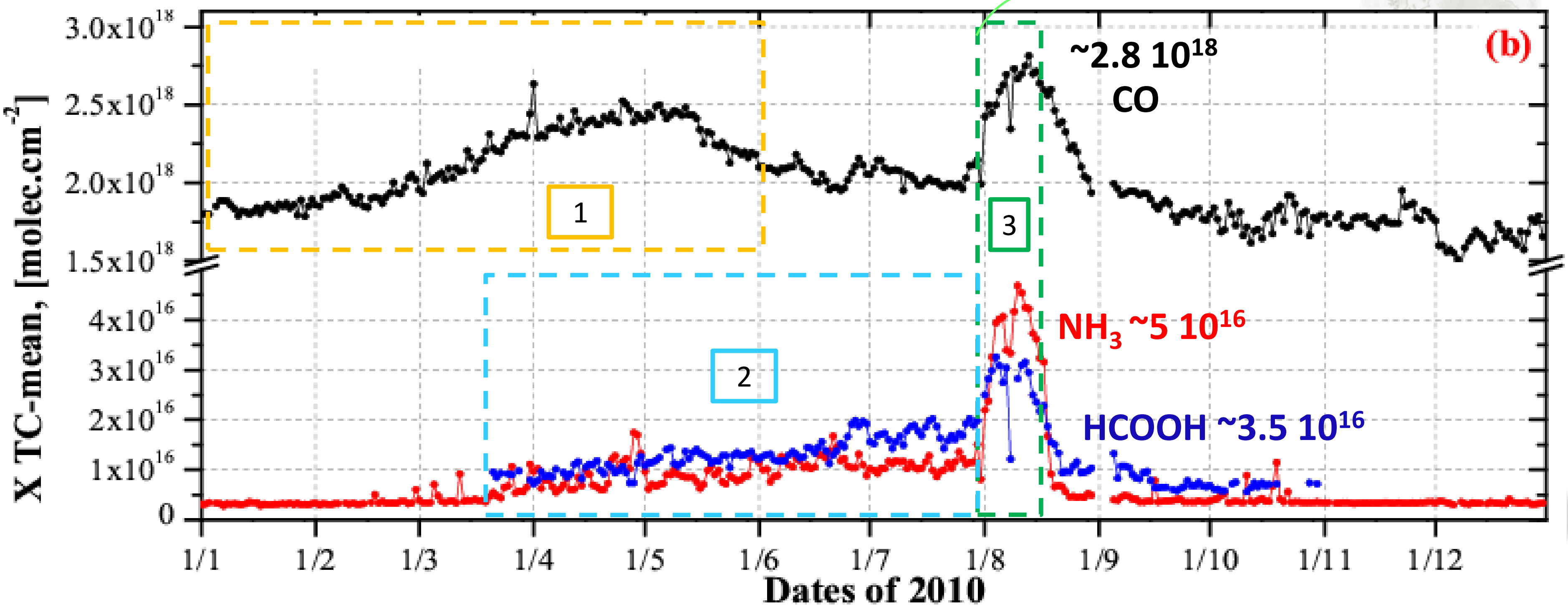


Total columns up to
40 (CO and HCOOH)
and
200 (NH_3)
times higher than typical backgrounds around Moscow

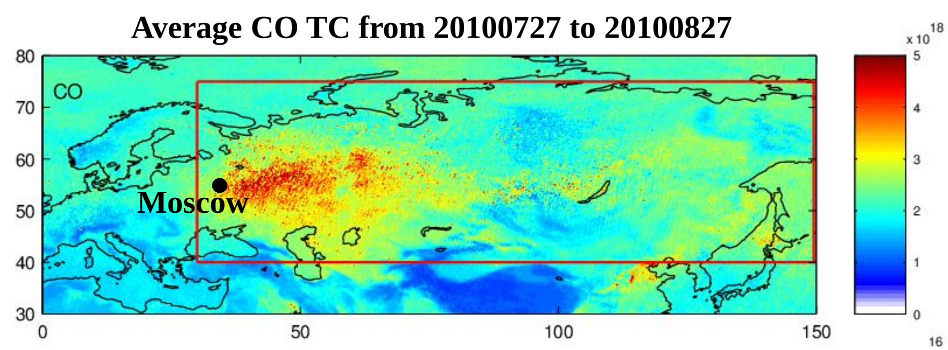
3. Russian Fires – Jul.-Aug. 2010

→ Observations

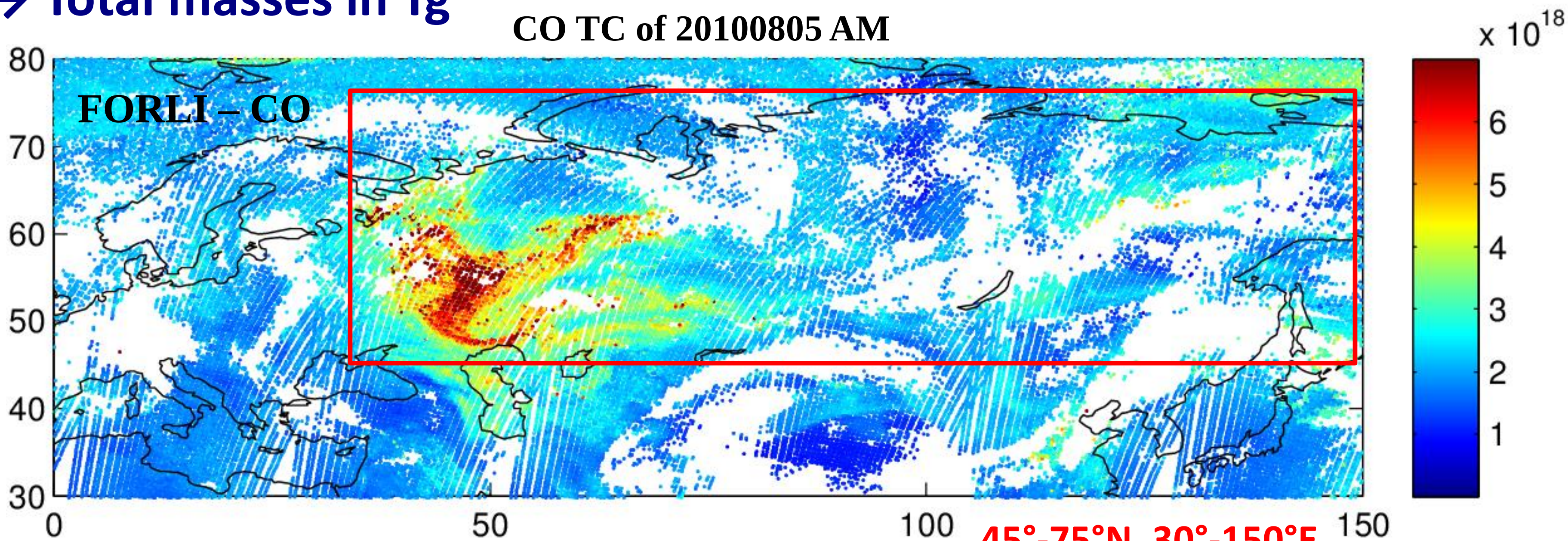
The period of the fires
July 27 to August 15-18 of 2010



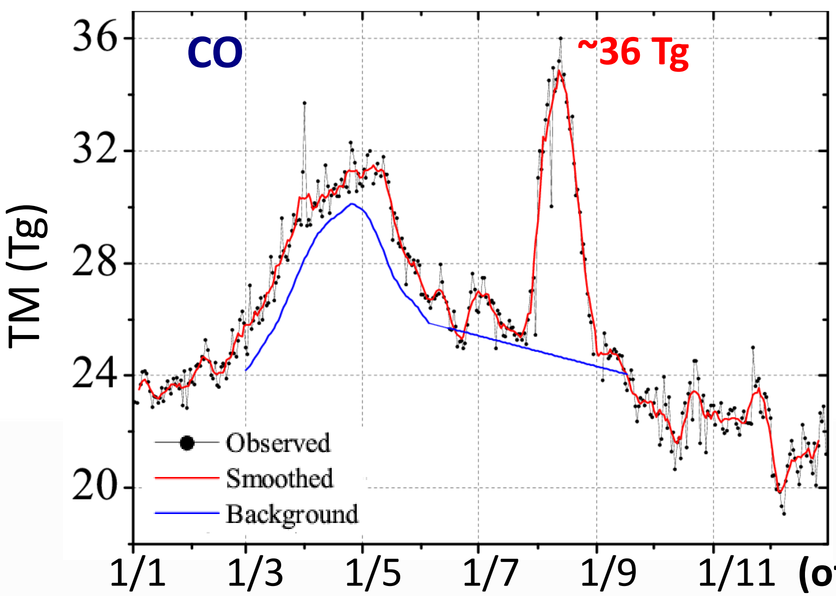
1 : seasonality of CO + remote boreal fires
2 : agricultural activity + plant growth
3 : the Russian wildfires event



→ Total masses in Tg



45°-75°N, 30°-150°E
(similarly area to Yurganov et al., 2011)



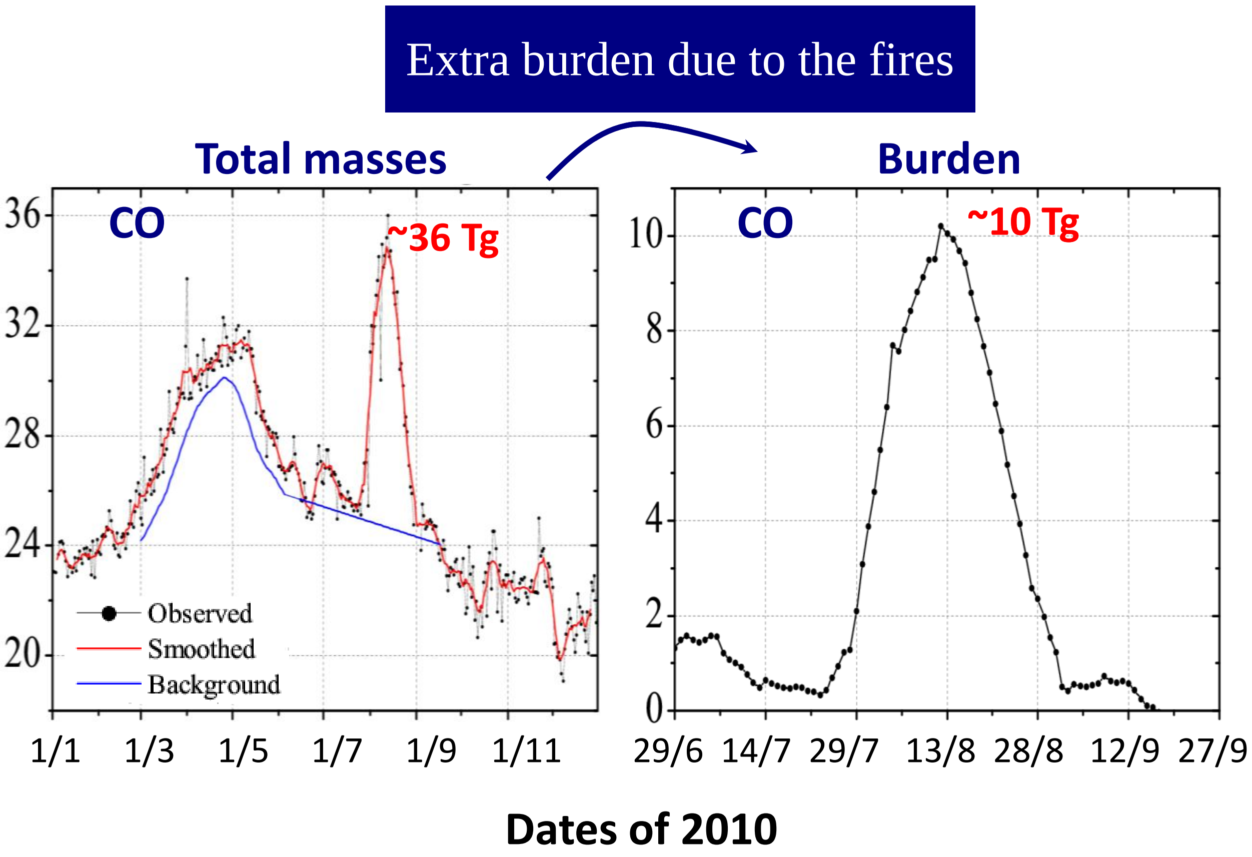
(of 2010)

Daily total masses of the species X :

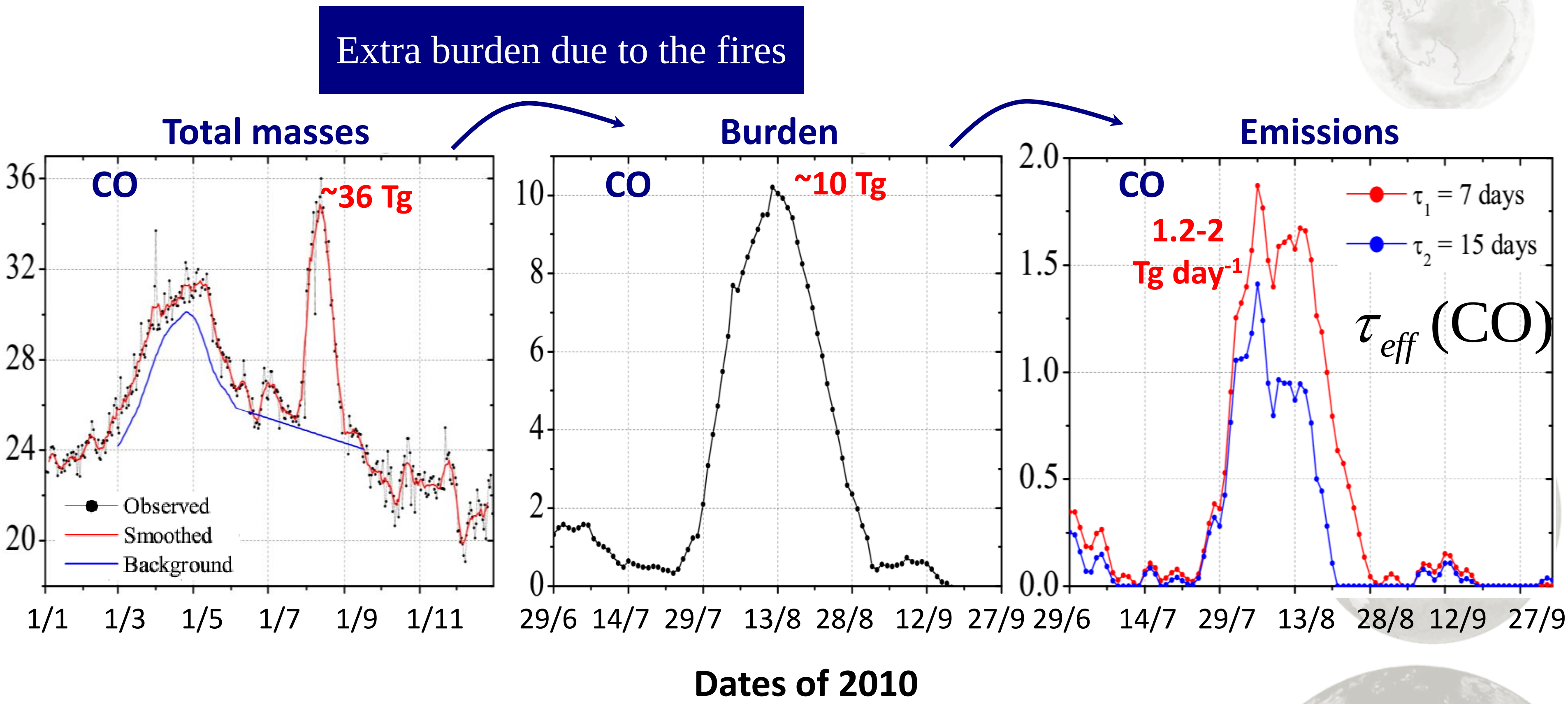
$$TM_X = \frac{M_X C_X S}{Na}$$

- M_X : Molar Mass of X in g mol^{-1}
- C_X : The mean columns in molec cm^{-2}
- Na : Avogadro Number
- S : Surface area ($2.75\ 10^{17}$ cm²)

→ Extra burden in Tg



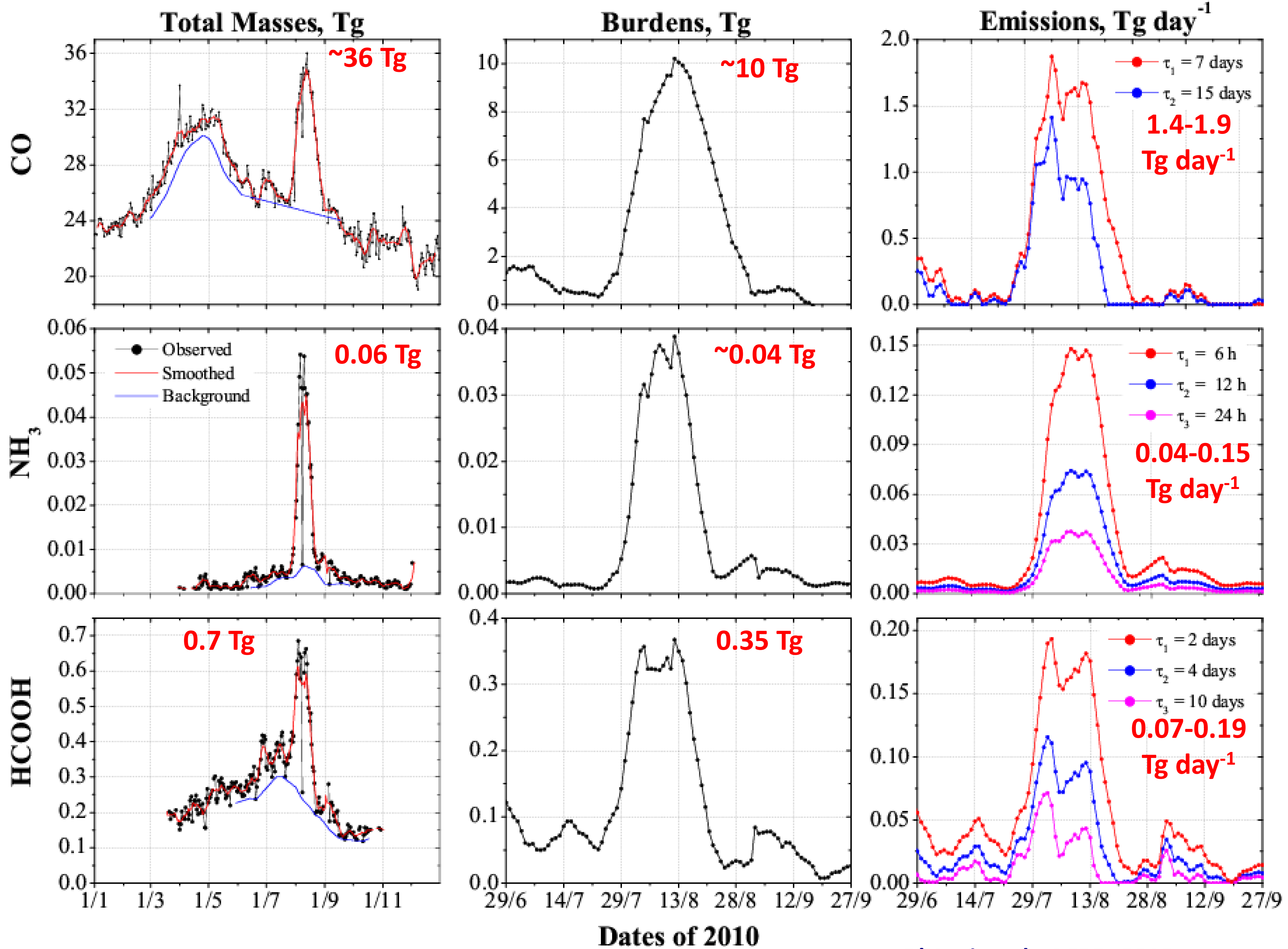
→ Daily emissions in Tg day^{-1}



Jacob, 1999.

$$E_{i+1}(X) = \frac{B_{i+1} - B_i e^{-t/\tau_{eff}}}{\tau_{eff}\,(1 - e^{-t/\tau_{eff}})}$$

E and B : the fluxes and burden respectively at the time i,
t : step of one day,
τ_{eff}: the effective lifetime of the species X.



R'Honi et al., ACPD, 2012

→ Comparison with literature

Total emitted (Tg)				
	CO	NH_3	HCOOH	
Fokeeva et al., 2011	19-26	-	-	AIRS-MOPITT ,standard
	36-42	-	-	AIRS-MOPITT, adjusted
	12-14	-	-	MODIS, inventory method
Huijnen et al. (2012)	12.2	-	-	MODIS, inventory method (GFASv1.0)
Konovalov et al. (2011)	9.7	-	-	MODIS, inverse modeling
Krol et al. (2012)	20-25	-	-	IASI, inverse modeling
Yurganov et al. (2011)	26.2	-	-	IASI-OE, standard
Yurganov et al. (2011)	34-40	-	-	Estimate from 3 different sounders (IASI, AIRS and MOPITT), adjusted
This work	**19-33**	**0.7-2.6**	**0.9-3.9**	**IASI-OE, standard**

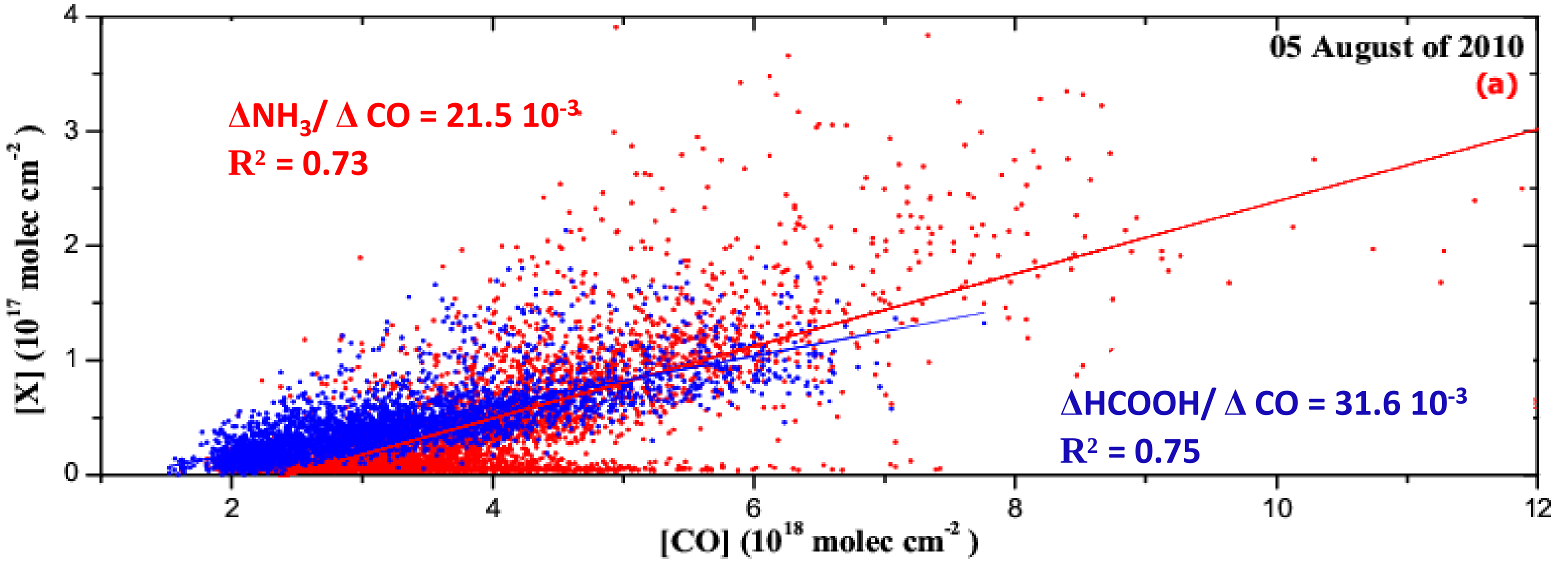
Andreae and Merlet, 2001	**68**	**0.88**	**1.8**	**Total annual emissions of extratropical fires**
Galloway et al., 2004	**-**	**2.1**	**-**	
Stavrakou et al., 2004	**-**	**-**	**2.28**	

→Transport / chemistry

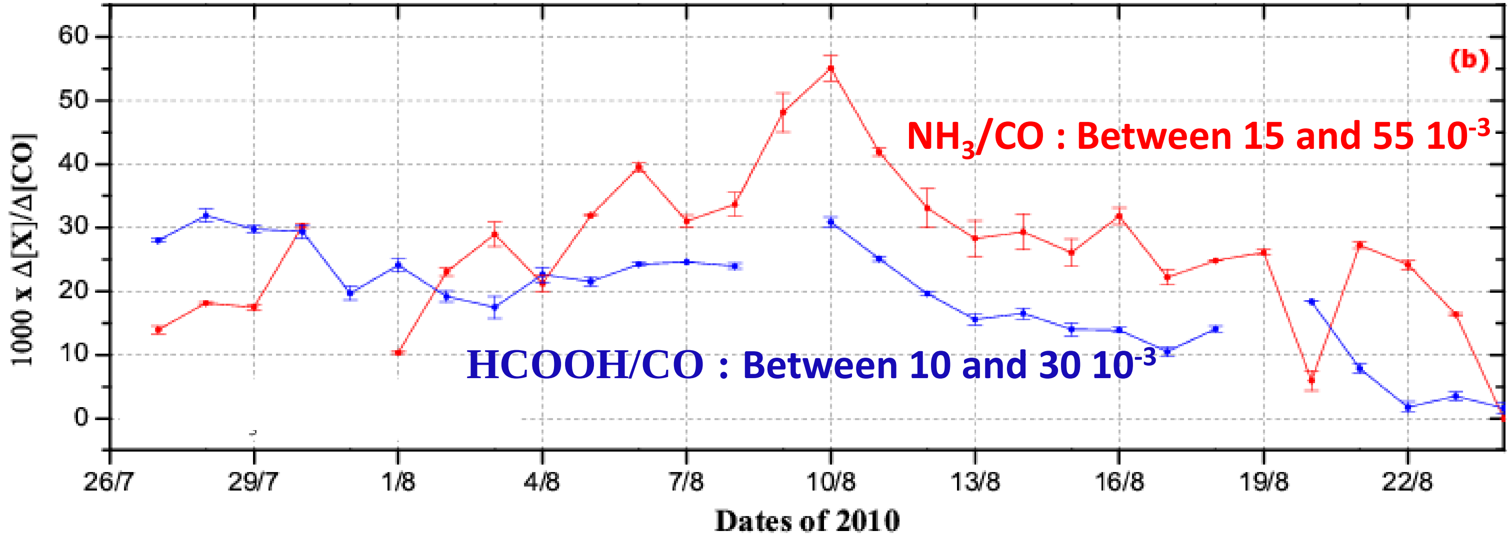
Emission factors → quantification of trace gas emissions in the fresh fire plumes
Emission ratios → generated from emission factors

As the plume ages, the time evolution of the enhancement ratios gives insight into the chemical loss processes within the plume.

Enhancement Ratios $\Delta X/\Delta CO$

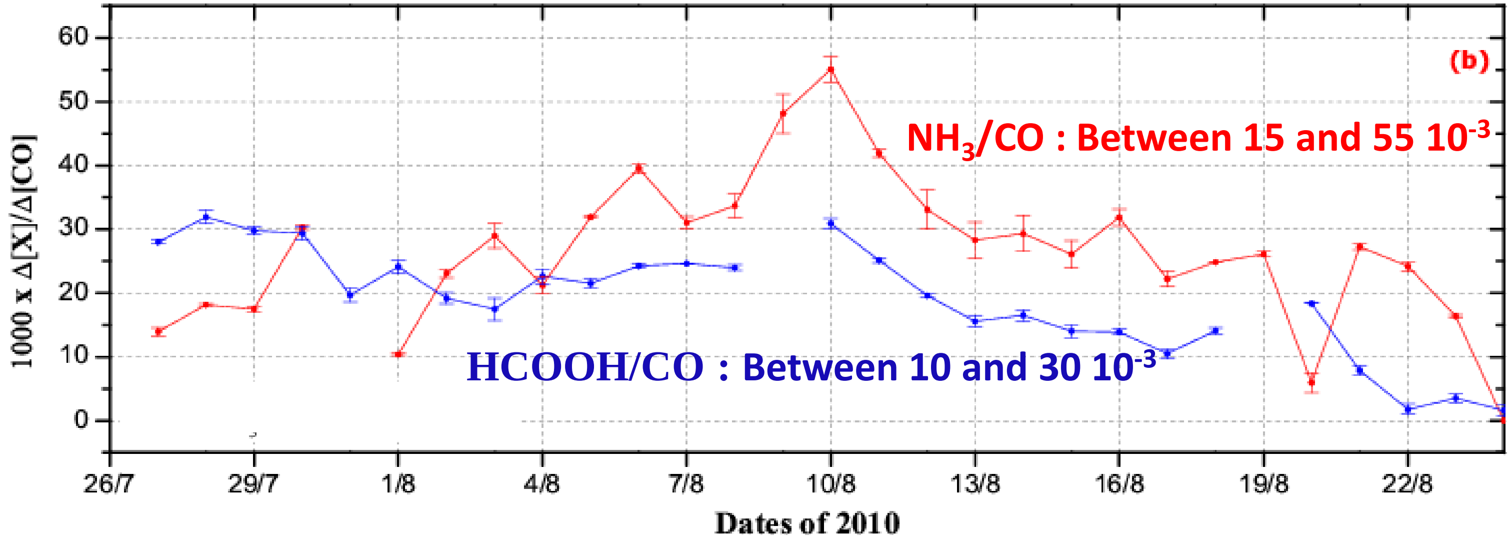


→ Transport / chemistry



Enhancement ratios $\Delta[X]/\Delta[CO]$					
	This work	Akagi et al., 2010 — In fresh plumes			Good and Yokelson, 2000; Yokelson et al., 2007 — In aged plumes
		Peat lands	Boreal Forests	Extratropical Forests	
$\Delta NH_3/\Delta CO$	$(15 – 55)\ 10^{-3}$	$97.7\ 10^{-3}$	$35.6\ 10^{-3}$	$33.2\ 10^{-3}$	-
$\Delta HCOOH/\Delta CO$	$(10 – 30)\ 10^{-3}$	$1.8\ 10^{-3}$	$2.7\ 10^{-3}$	$2.7\ 10^{-3}$	$(23\text{-}29)\ 10^{-3}$

→Transport / chemistry



Enhancement ratios Δ[X]/ Δ[CO]					
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		lands	Forests	…al Forests	In aged plumes
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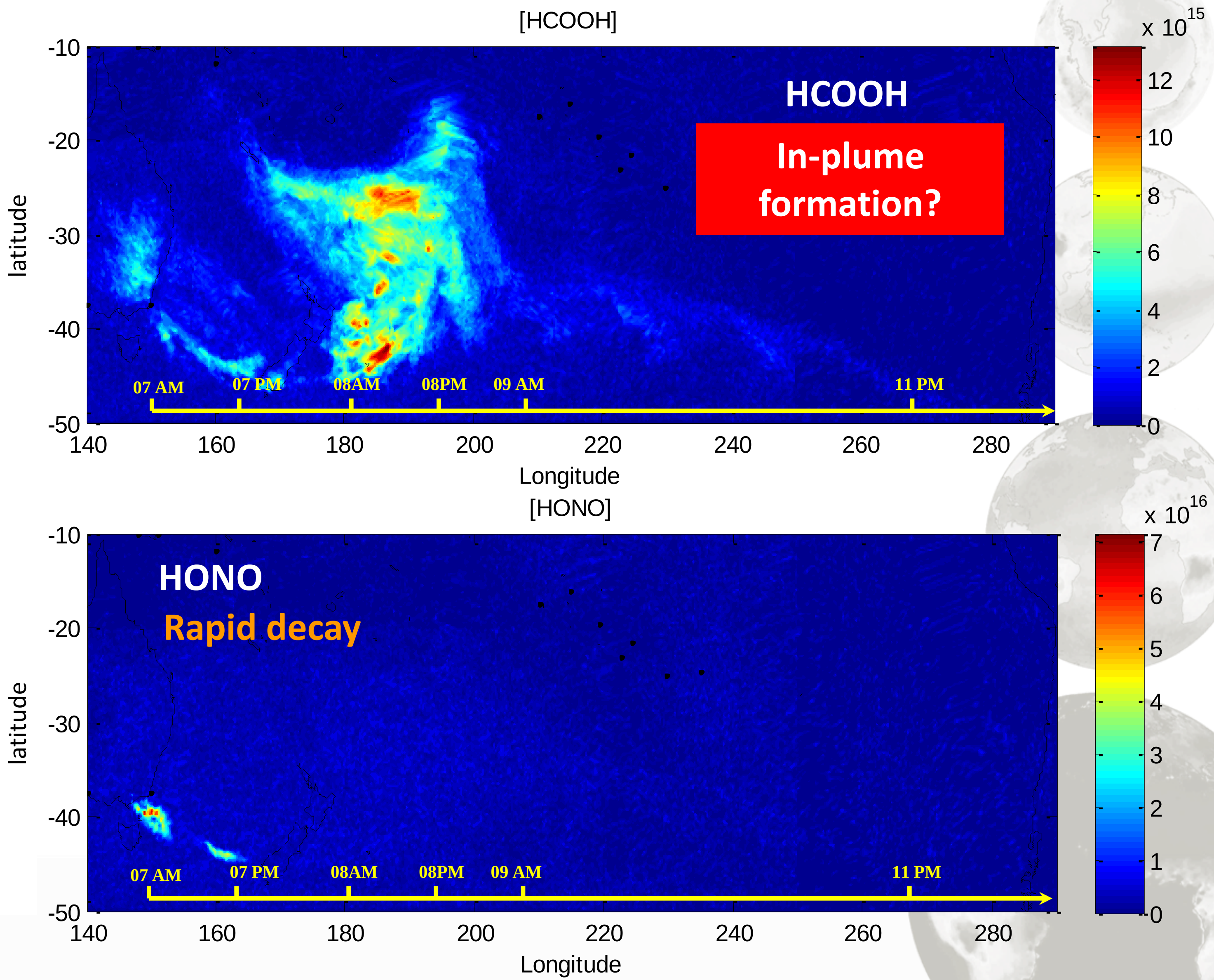
ΔHCOOH/ΔCO	(10 – 30) 10^{-3}	1.8 10^{-3}	2.7 10^{-3}	2.7 10^{-3}	(23-29) 10^{-3}

Secondary production of formic acid in the plumes

LOCAL…

Australian fires (Feb. 2009)



OUTLINE…

- **Previous and current studies**

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- **Global scale :**

  Artificial Neural Network (ANN) outputs

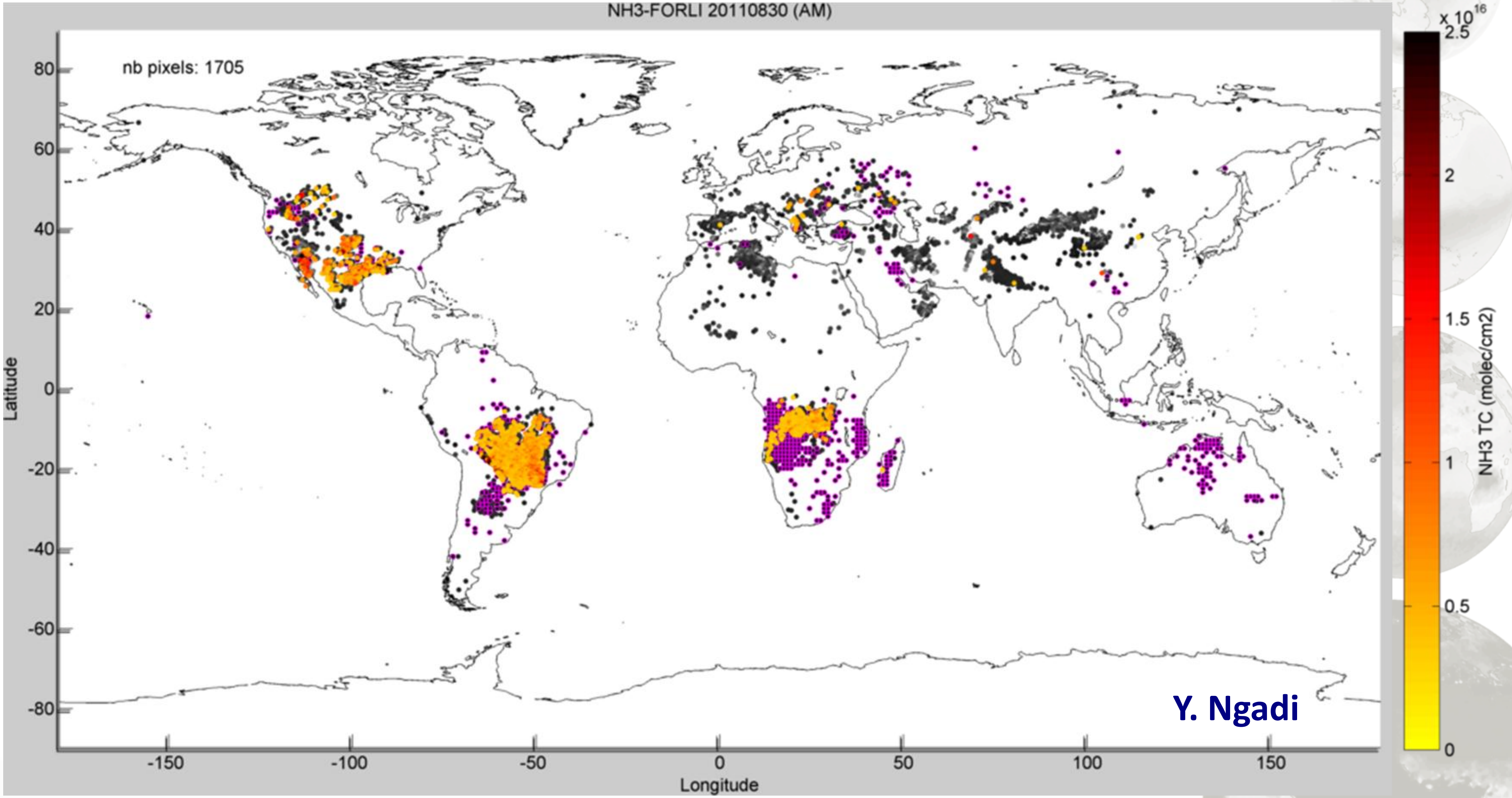
  <u>**See poster # 41 : Yasmine Ngadi**</u>

- **Conclusions**

GLOBAL…

ANN outputs

See poster #41 : Yasmine Ngadi



MODIS fire pixels (purple) FORLI-NH_3 (grey) ANN's pyrogenic class (yellow)

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CONCLUSIONS…

→ How can IASI contribute?

Observations :

- We have a better understanding of the fires composition due to the high performance of IASI

Emissions estimate :

Even for extreme biomass burning events : Russian fires

→ CO total masses are in good agreement with previous studies;

→ NH_3 and HCOOH total masses calculated in this work are the first reported values

Chemistry :

- Calculation of enhancement ratios

→ Production of secondary species in the fire plumes : **HCOOH**

R'Honi et al. ACPD 2012

Thank you for your attention