Understanding the contribution from fires on atmospheric composition over the Euro-Mediterranean region

Solene Turquety[1], Palmira Messina[1], Stavros Stromatas[1], Géraldine Réa[1], Laurent Menut[1], Myrto Valari[1], Maya George[2], Yasmina R'honi[3], Pierre-Francois Coheur[3], Cathy Clerbaux[2,3], Bertrand Bessagnet[4], Augustin Colette[4]

(1) LMD-IPSL, UPMC – Paris 6, CNRS, Ecole Polytechnique
(2) LATMOS-ISPL, CNRS, UPMC – Paris 6
(3) Spectroscopie de l'Atmosphere, Université Libre de Bruxelles, Brussels
(4) INERIS, France

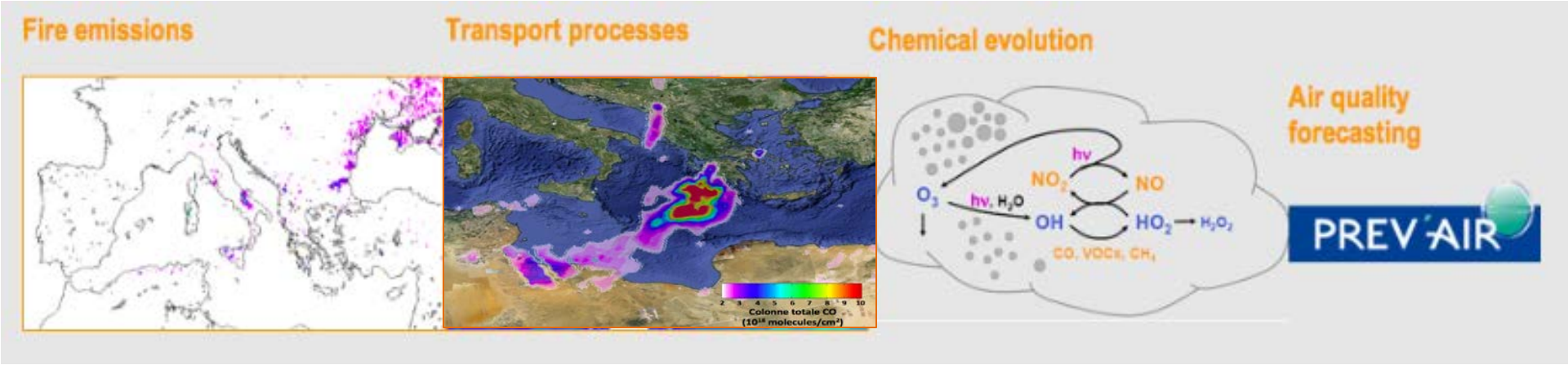
Understanding and quantifying impacts on air quality

APIFLAME project (www.lmd.polytechnique.fr/apiflame)

Analysis and Prediction of the Impact of Fires on Air Quality in the Mediterranean and Europe

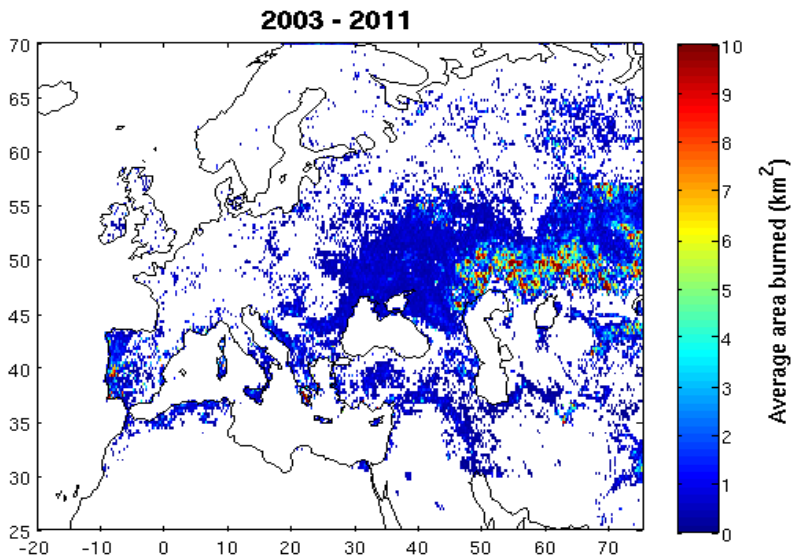
- Emissions?
- Injection height?

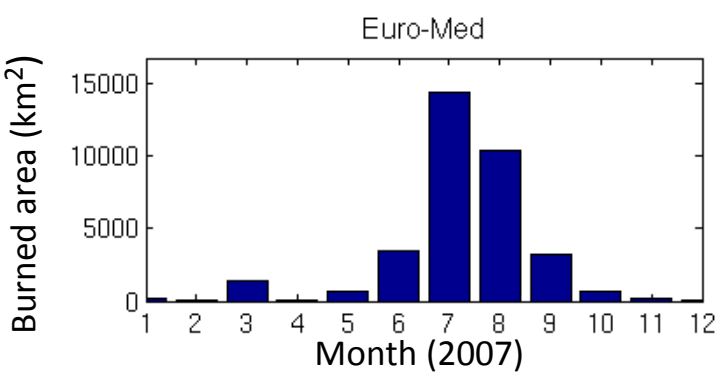
- Chemical evolution?
- Ozone production?
- Long-range impact?
- AQ Forecast?



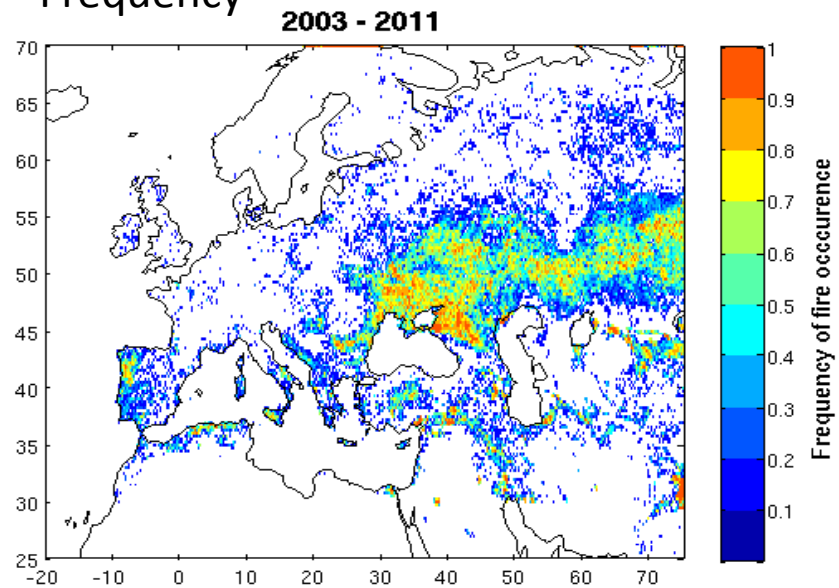
Fires in the Euro-Mediterranean region

MODIS area burned product
8 years analysis (20 km grid)

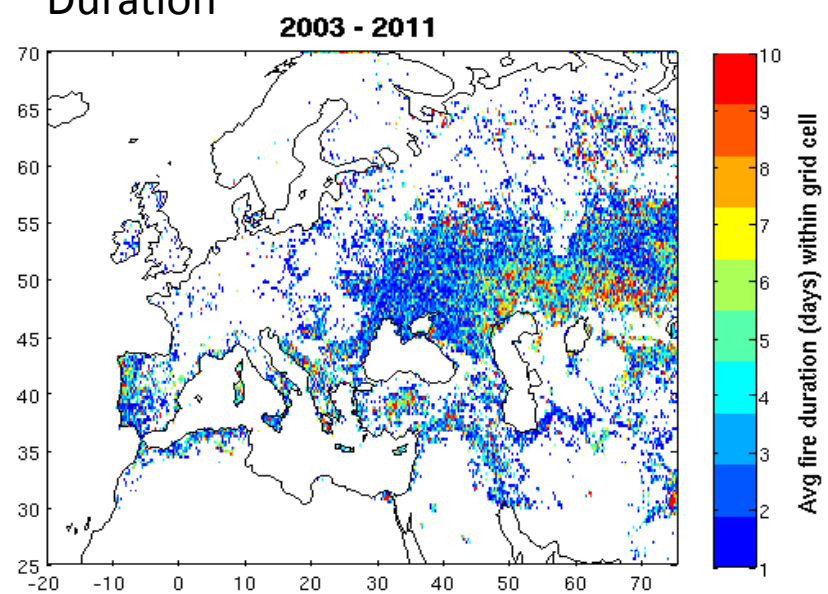




Frequency



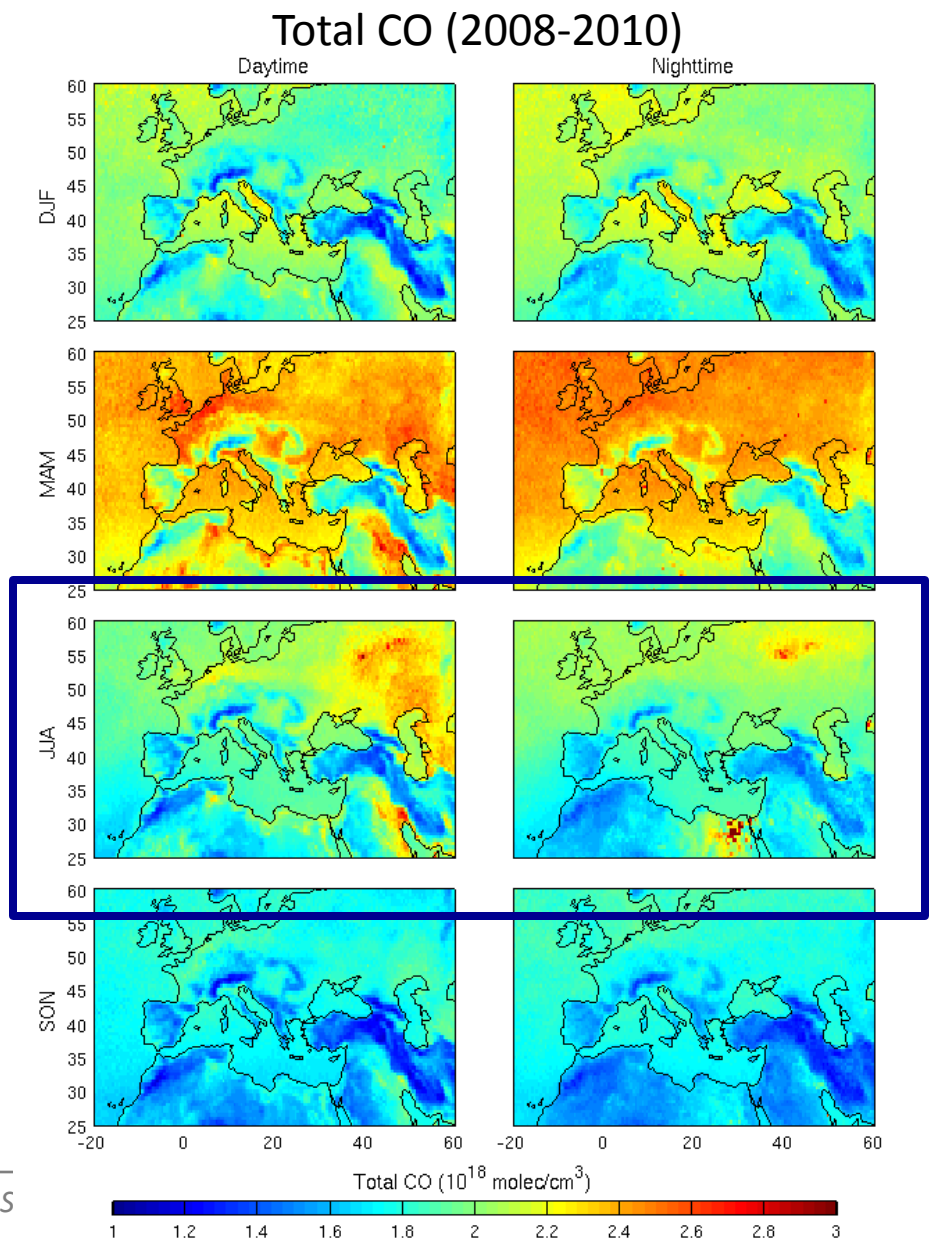
Duration

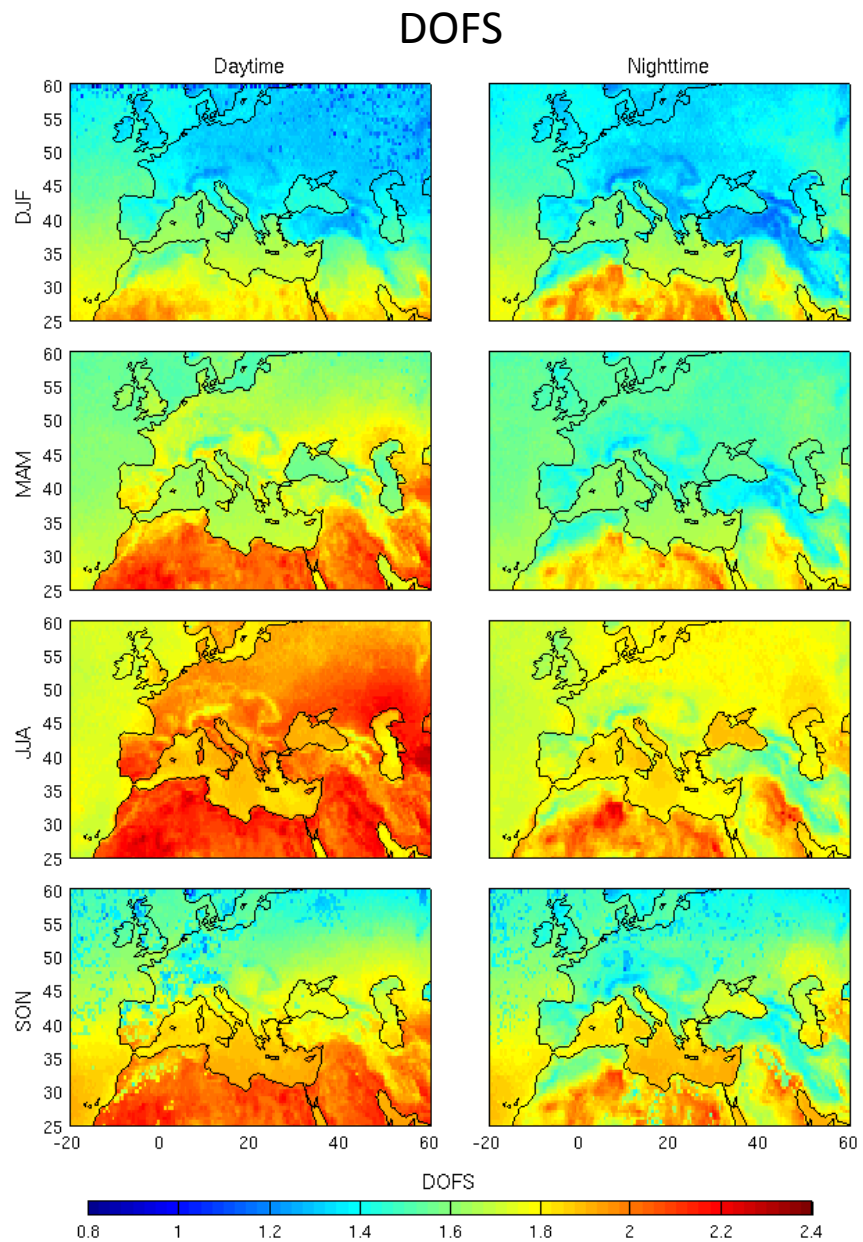


Solène Turquety et al., UPMC, LMD/IPSL (solene.turquety@lmd.polytecl

IASI observations of trace gases

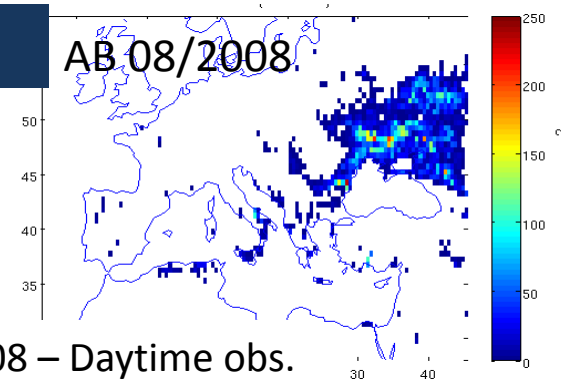
Retrievals ULB/LATMOS from the FORLI algorithm (Hurtmans et al., 2012)



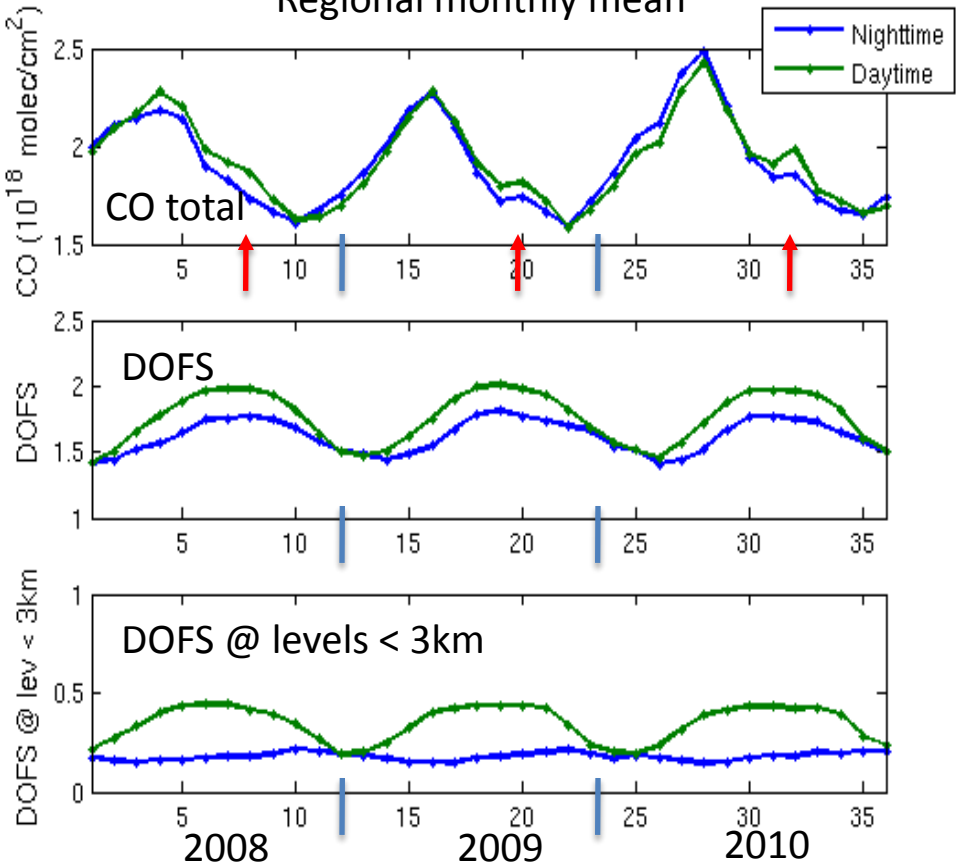


IASI observations of trace gases

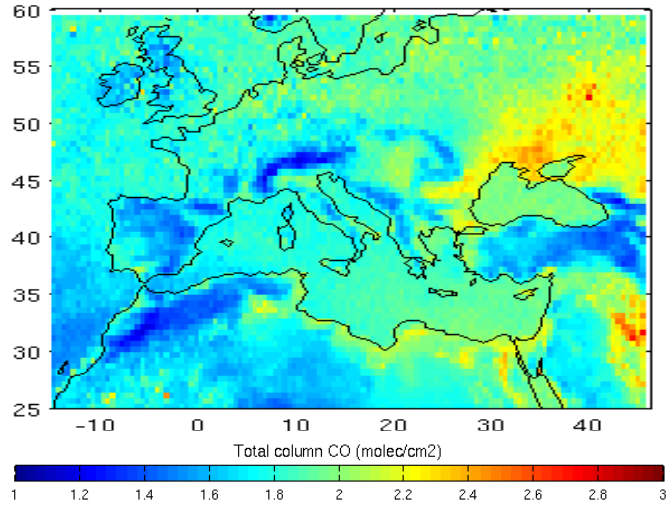
Retrievals from ULB/LATMOS
Summer 2007: Research (Turquety et al., 2009; Coheur et al., 2009)
After 2008: FORLI algorithm (Hurtmans et al., 2012)



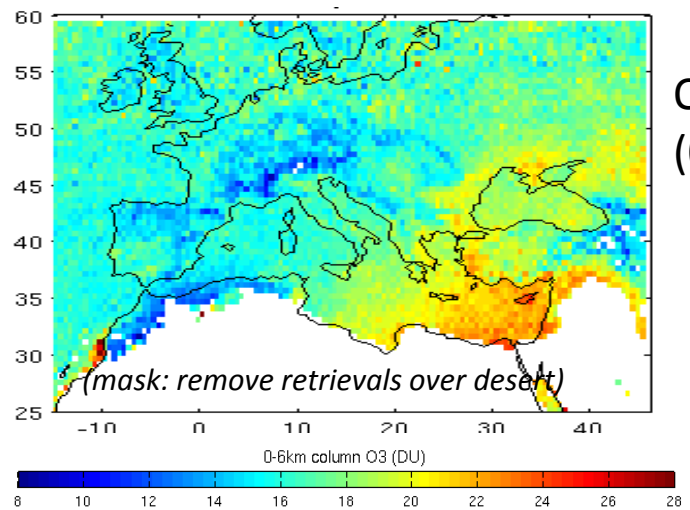
Regional monthly mean



August 2008 – Daytime obs.



CO total



O3
(0-6km)

Impact on atmospheric composition: approach

Meteo
(WRF regional)

T°, sunlight, entrainment, etc.

Emissions
- Anthropogenic
- Biogenic
- Dust
- **Fires**

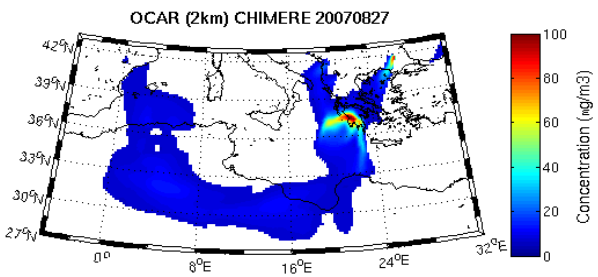
Boundary and initial conditions

Chemistry-Transport Model
CHIMERE (regional)

Transport, chemistry, deposition, etc.

Output : concentrations for each species

Validation with observations: *Simulate observations*



In the following: WRF-CHIMERE simulation
- 20 km horizontal resolution
- 19 levels up to 200 hPa
- EMEP anthr., MEGAN biog, dust
- MOZART boundary conditions

Trace gases:
- Smoothing with averaging kernels

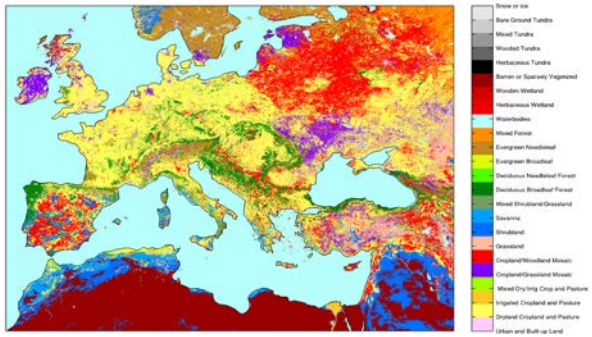
Aerosols:
- optical properties
- lidar att. backscatter signal

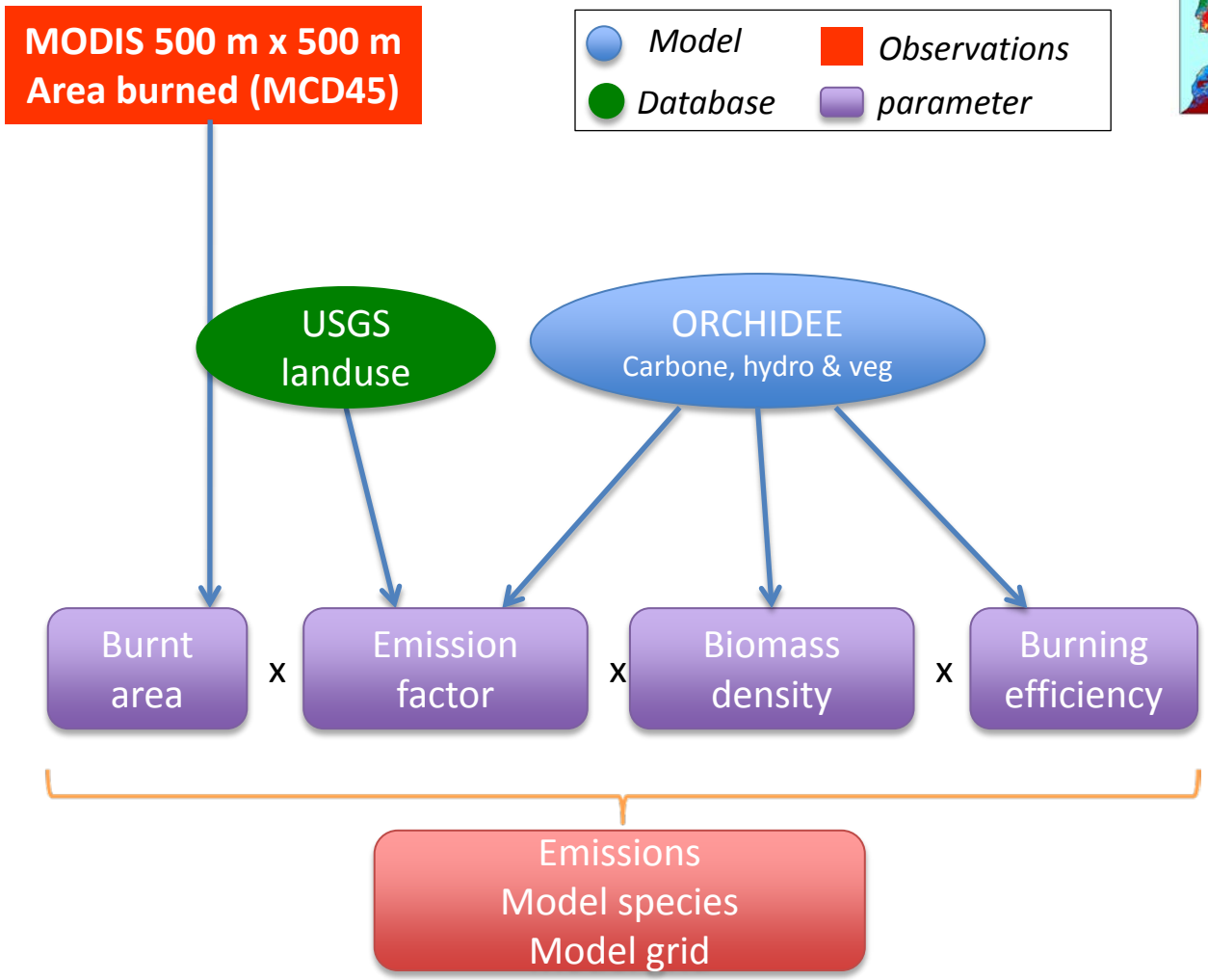
(Stromatas et al., GMD, 2012)

APIFLAME regional inventory of fire emissions

General approach:

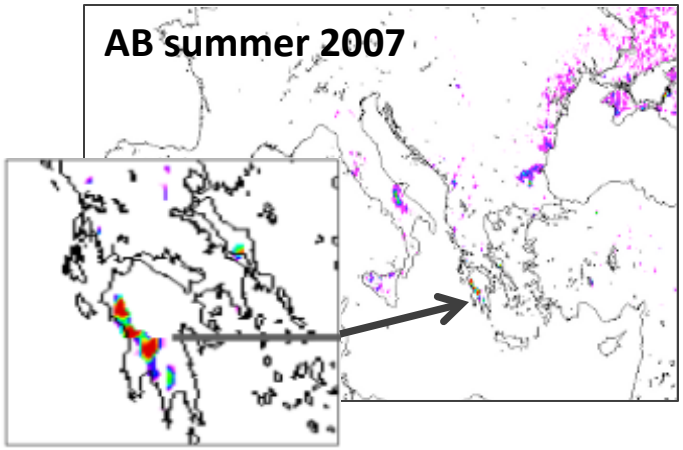
$$E_i = \sum_{fueltype(f)} A_f \times FC_f \times EF_{i,f}$$

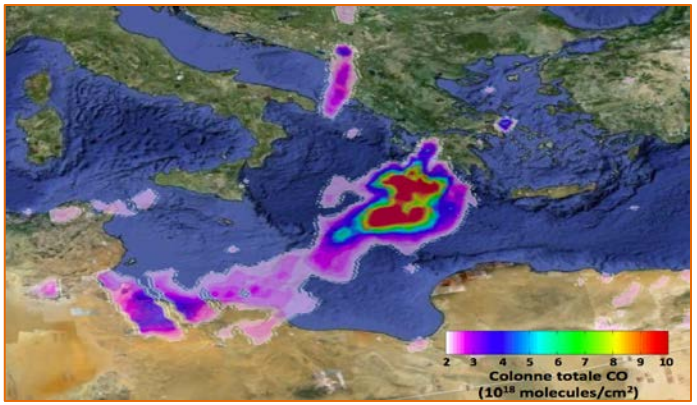


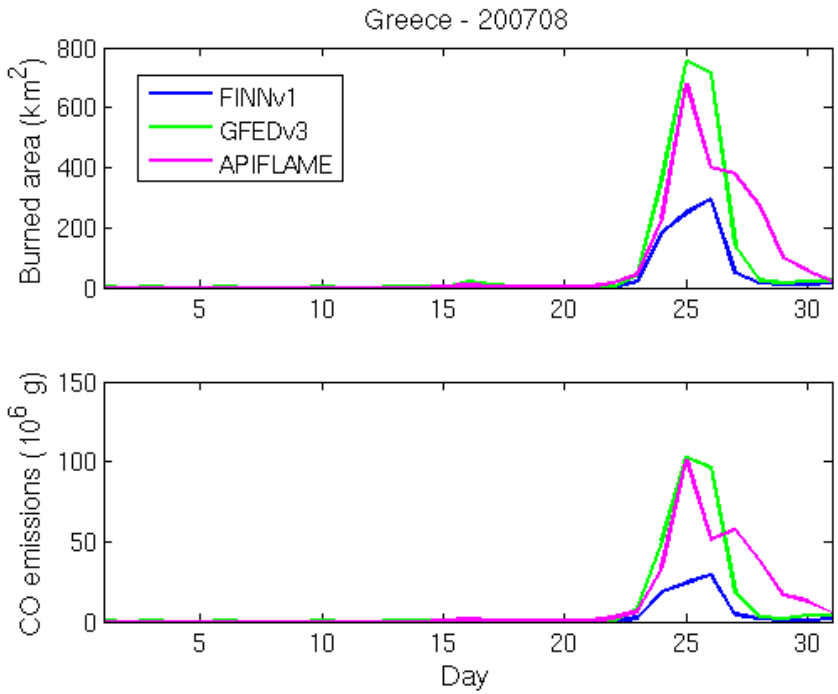


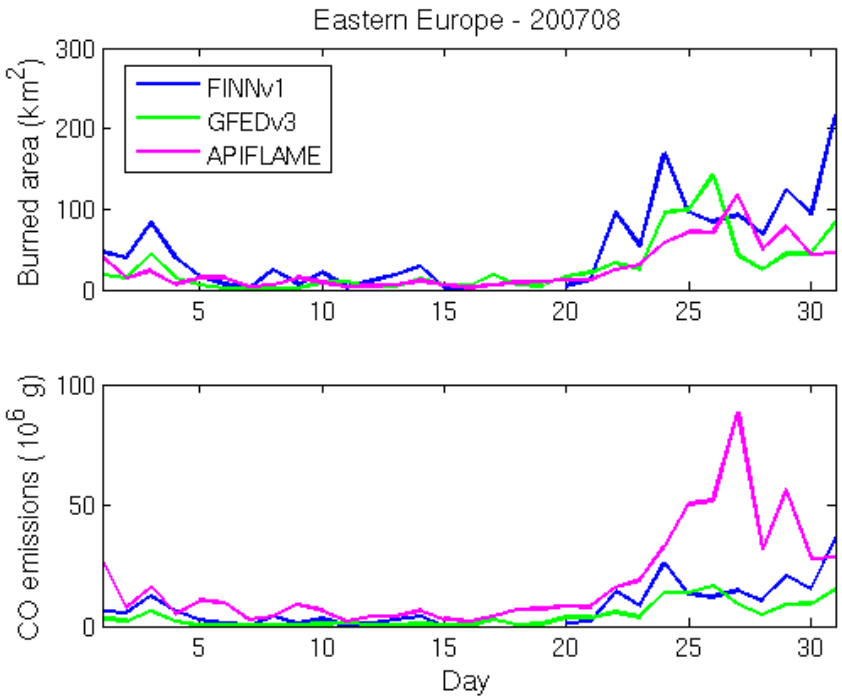
- Emission factors
Akagi et al., 2011

Case study of the Greek fires in 2007





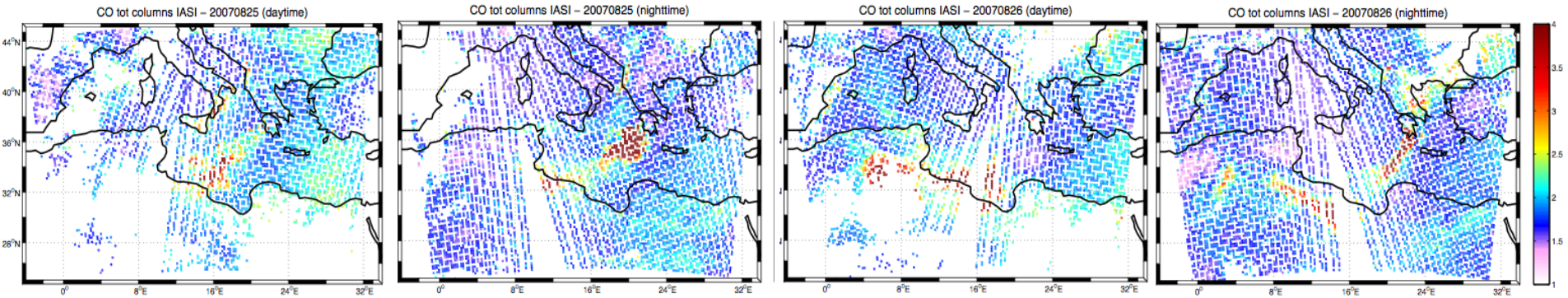




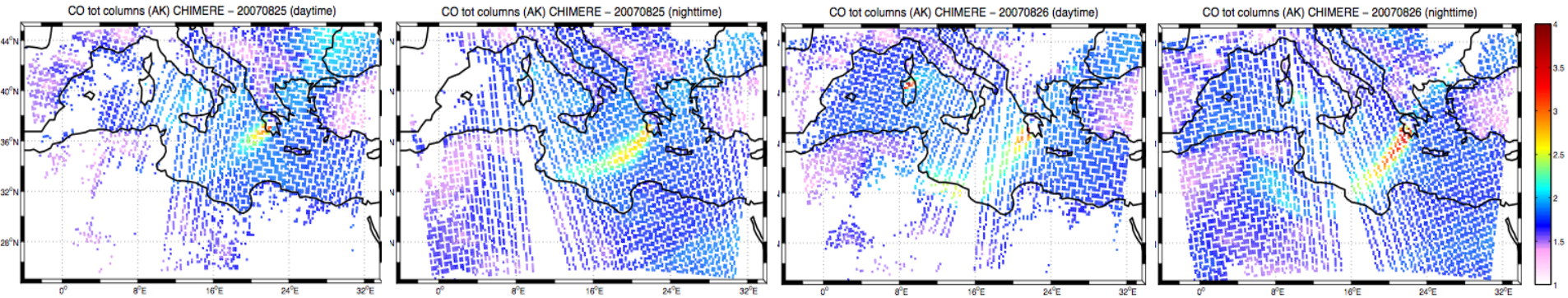
Evaluation based on satellite observations: CO

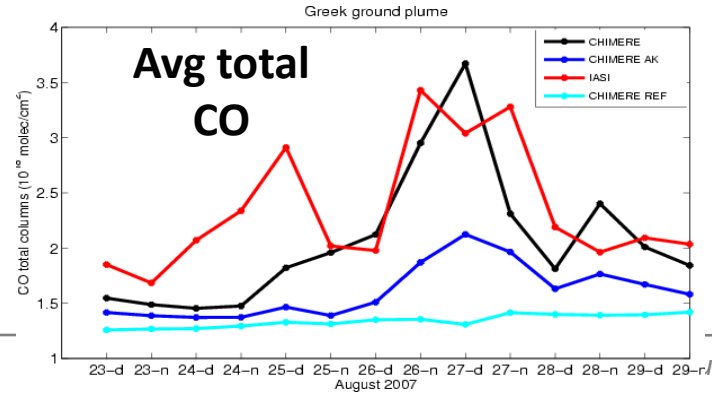
25 Aug. 2007 – 9:30 am **25 Aug. 2007 – 9:30 pm** **26 Aug. 2007 – 9:30 am** **26 Aug. 2007 9:30 pm**

IASI



CHIMERE x IASI AK



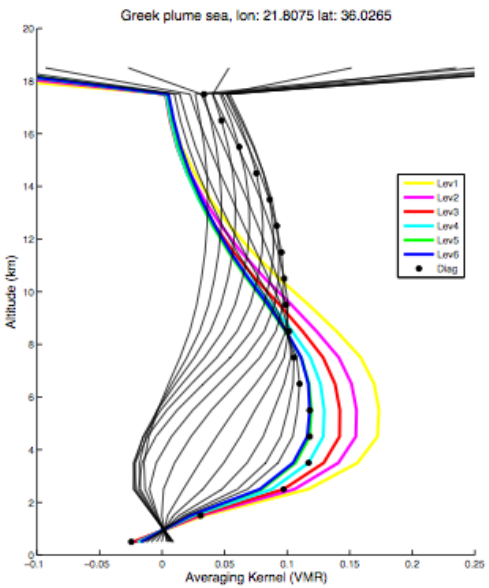


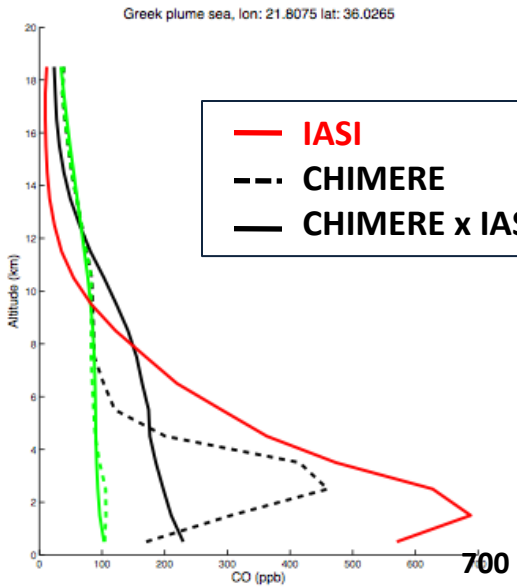
→ Consistent transport pathways
→ Fires start too late
→ Underestimate when AK applied

Similar results for WRF-Chem IASI comparisons (Hodneborg et al., 2012)

(P. Messina)

Evaluation based on satellite observations: CO

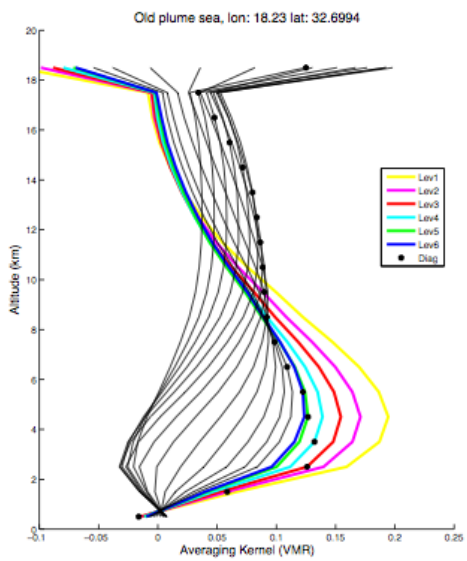


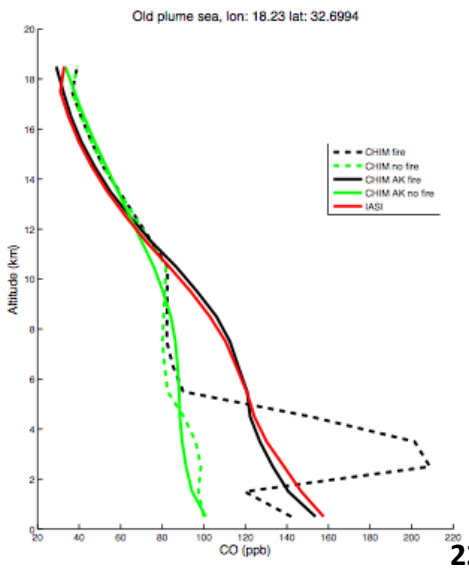


700

Plume above the sea, close to fire

After ~1 day



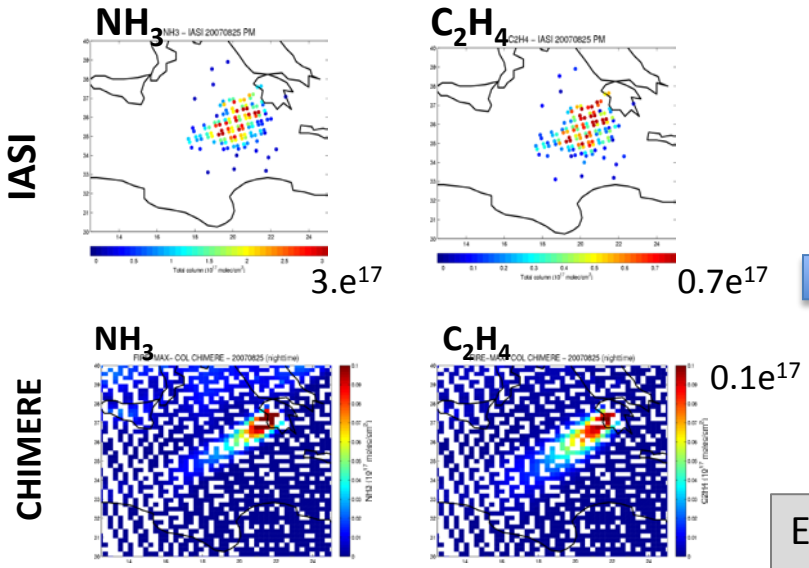


220

(P. Messina)

Evaluation of emission factors using IASI/METOP

$$ER_X = \frac{\Delta X}{\Delta CO}$$



X	Emiss. Ratio EF(X)/EF(CO)	CHIMERE model plume	IASI retrieval (Coheur et al., 2009)
C_2H_4	0.012 (Emiss)	0.011 (fresh plume)	0.005 fresh plume 0.003 transport
NH_3	0.015 (Emiss)	0.012 (fresh plume)	0.02 fresh plume 0.013 transport

ER seems too high for C_2H_4; C_2H_4 too low => CO even lower?
ER seems too low for NH_3 => NH_3 way too low? Vegetation?

Akagi et al., ACP, 2011

	Temp. forest	Crop residue	Pasture maint.	Savanna	Chaparral
CO	89	102	135	63	67
NH_3/CO	0.009	0.02	0.01	0.008	0.015
C_2H_4/CO	0.012	0.014	0.009	0.013	0.011

Here, assume (USGS):
- 50% savanna and shrubland
- 32% cropland
- 18% forest

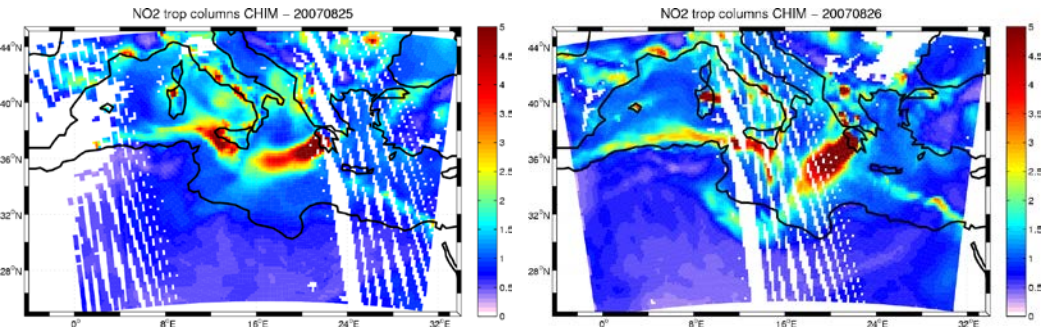
(P. Messina)

Alves et al., 2011: CO Portuguese fires: 231 ±117 g /kg

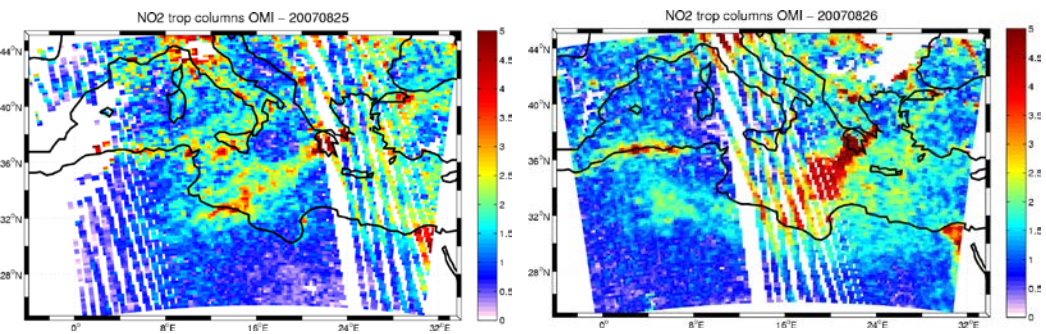
Evaluation based on satellite observations: NO2

25 Aug 2007 **26 Aug 2007**

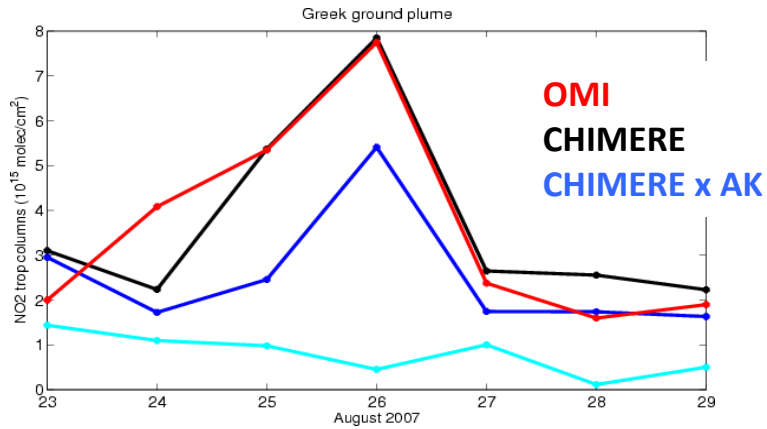
CHIMERE x OMI AK



OMI



Average tropospheric NO_2 above fires in Greece



NO_2 slightly underestimated; less than CO
=> ER NO_2/CO too large in the inventory

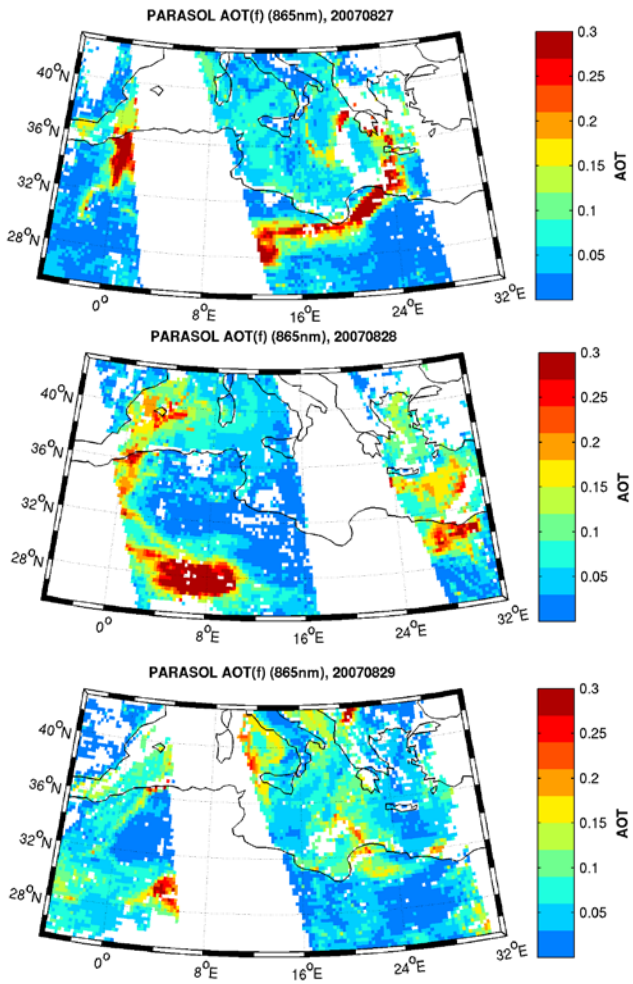
→ Consistent transport pathways
→ Fires start too late
→ Underestimate downwind

(P. Messina)

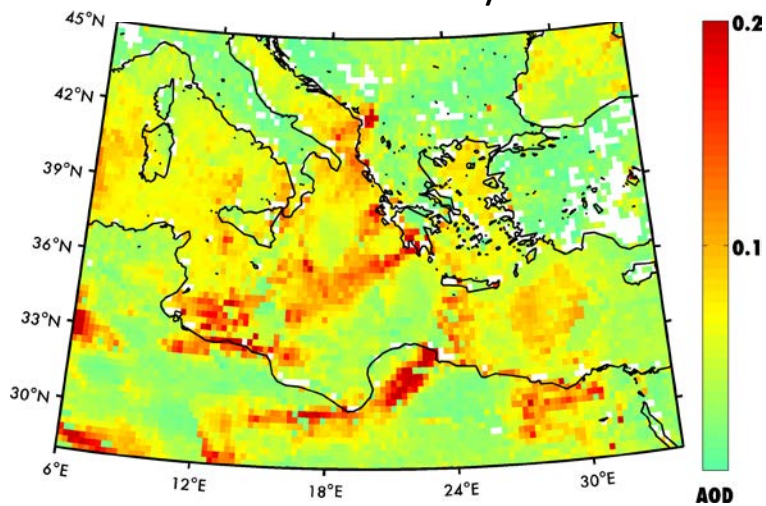
Evaluation based on satellite observations: aerosols

Comparison to aerosol remote sensing: PARASOL (A-Train) AOD @ 865 nm

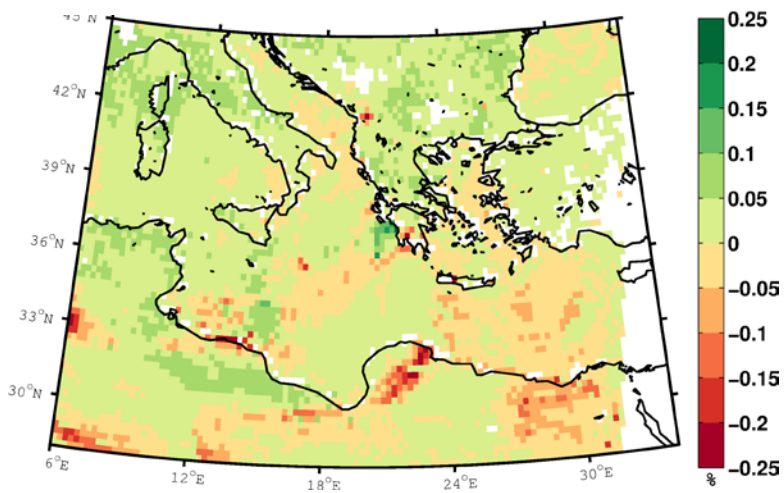
PARASOL 27/08



PARASOL 24-28/08

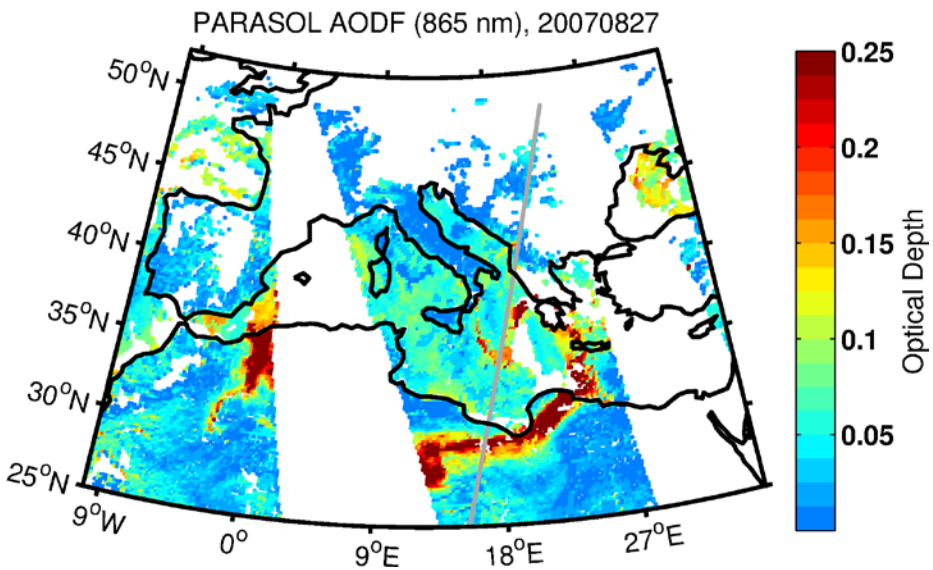


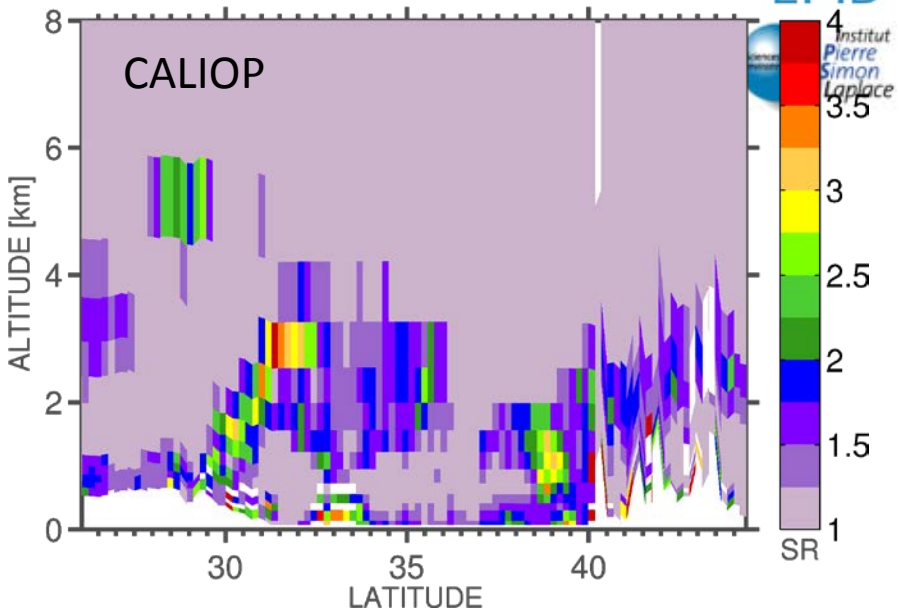
PARASOL-CHIMERE 24-28/08

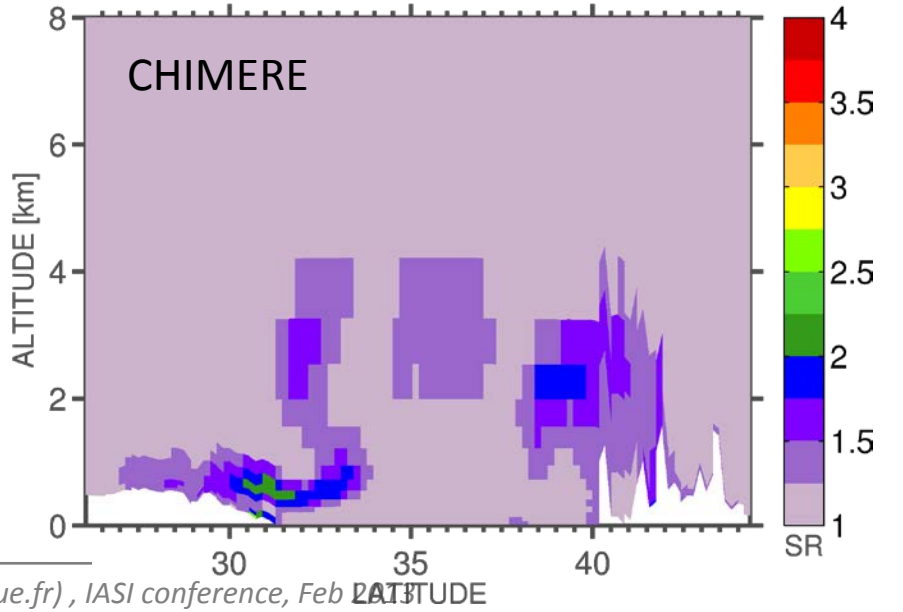


(S. Stromatas)

Evaluating vertical transport using CALIOP

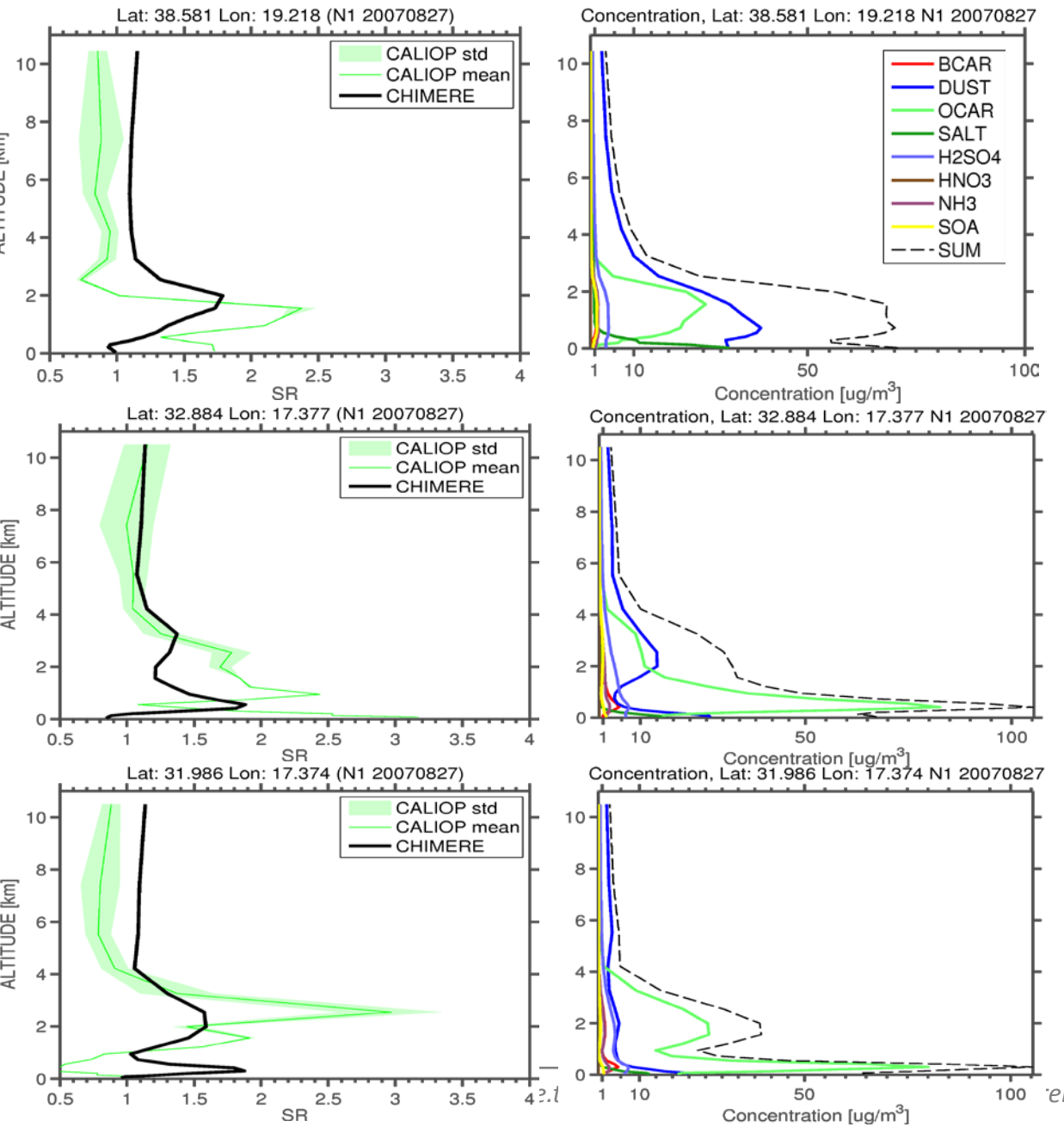


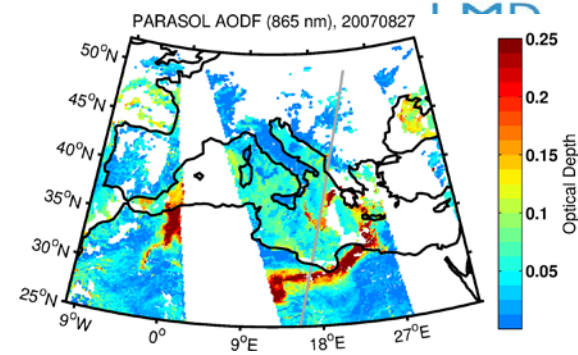




- 3 observations of fire plumes
- Main features well simulated
- Values of R' often underestimated
- Simulated plume seems too extended / advected too high

Evaluating vertical transport using CALIOP





- Emissions underestimated
- Improve injection altitude
- Variability of emissions and of injection altitude?
- Transport model error?

Summary and ongoing work

APIFLAME fire emission inventory in the Euro-Mediterranean area

- Daily emission inventory for trace gases and aerosols based on MODIS fire observations
- High resolution over Europe – adaptable for any region
- Specific EF for Mediterranean vegetation (chaparral/maquis or scrub)
- Emission profiles using pyroconvection code (Rio et al., 2010)

Emissions estimates (2003-..) will be available through

ECCAD *soon (Ether database)*

- NRT version of the emissions (same methodology but with NRT MODIS fire detection)

http://www.lmd.polytechnique.fr/cosy/fires-modis-europe.php

Impact on air quality: ongoing work

- Case study of the 2007 summer:
    - Strong influence on regional PM
    - No clear contribution in ozone observations
- Interannual variability and mapping of regions influenced

Thank you for your attention!

Acknowledgments

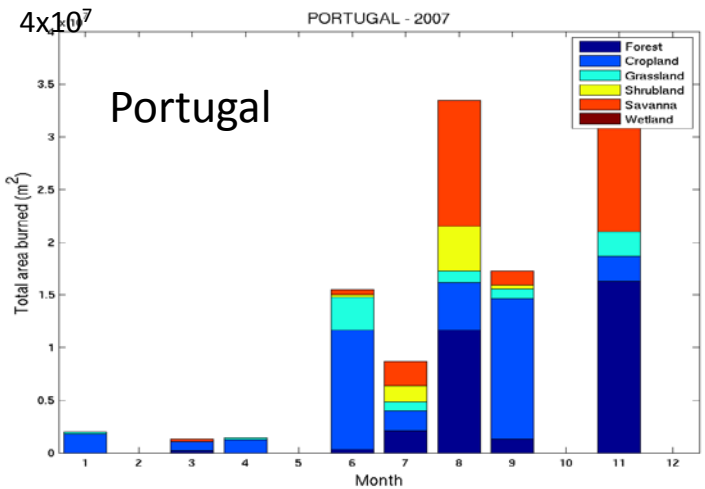
PRIMEQUAL program (APIFLAME project), CNES (TOSCA IASI-Chimie, EECLAT) for funding

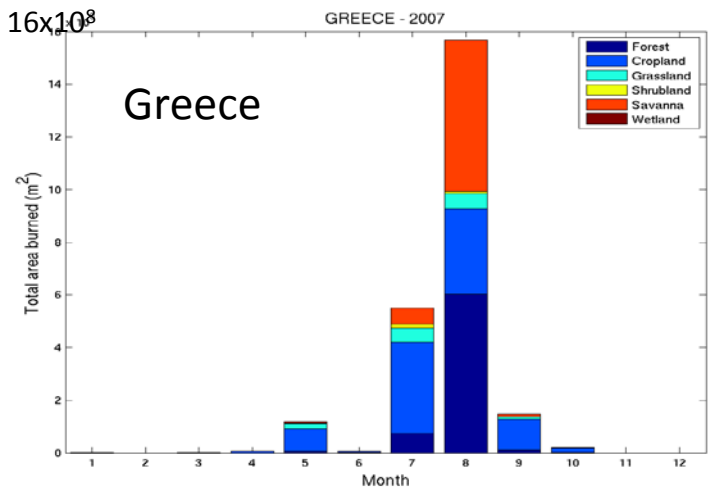
LATMOS /ULB retrieval teams & Ether for IASI L2 data

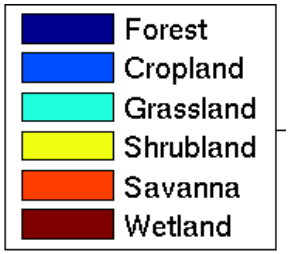
LOA and ICARE for support in the use of the A-Train data

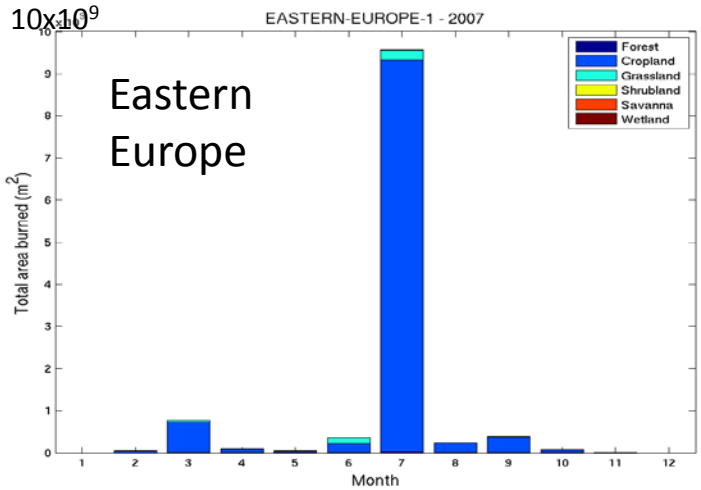
Fires in the Euro-Mediterranean region

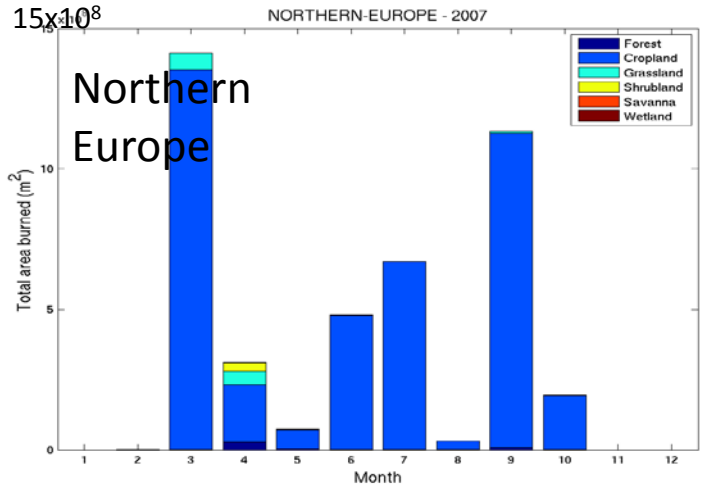
Exemples: 2007 fire activity (MODIS AB veg.)





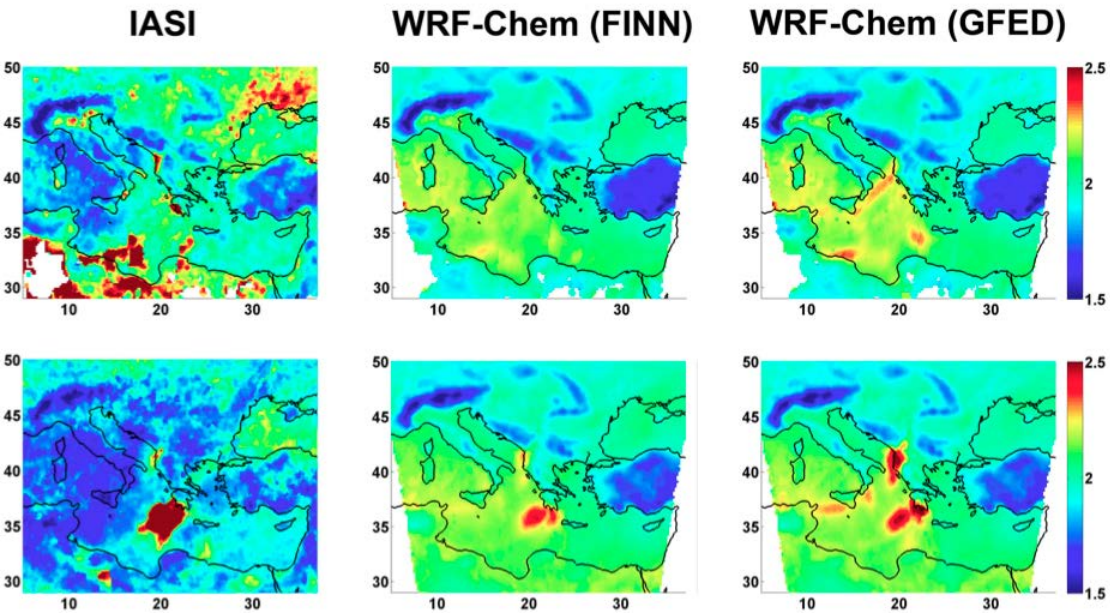






Evaluation based on satellite observations

WRF-Chem (O. Odnebrog et al., ACP, 2012) – JJA 2007



CHIMERE O3 – Aug 20-30 2007
Impact of fires on daily max