Analysis of the impact of biomass burning on air quality using IASI satellite observations And the CHIMERE regional model

Case study: Greek fires August 2007

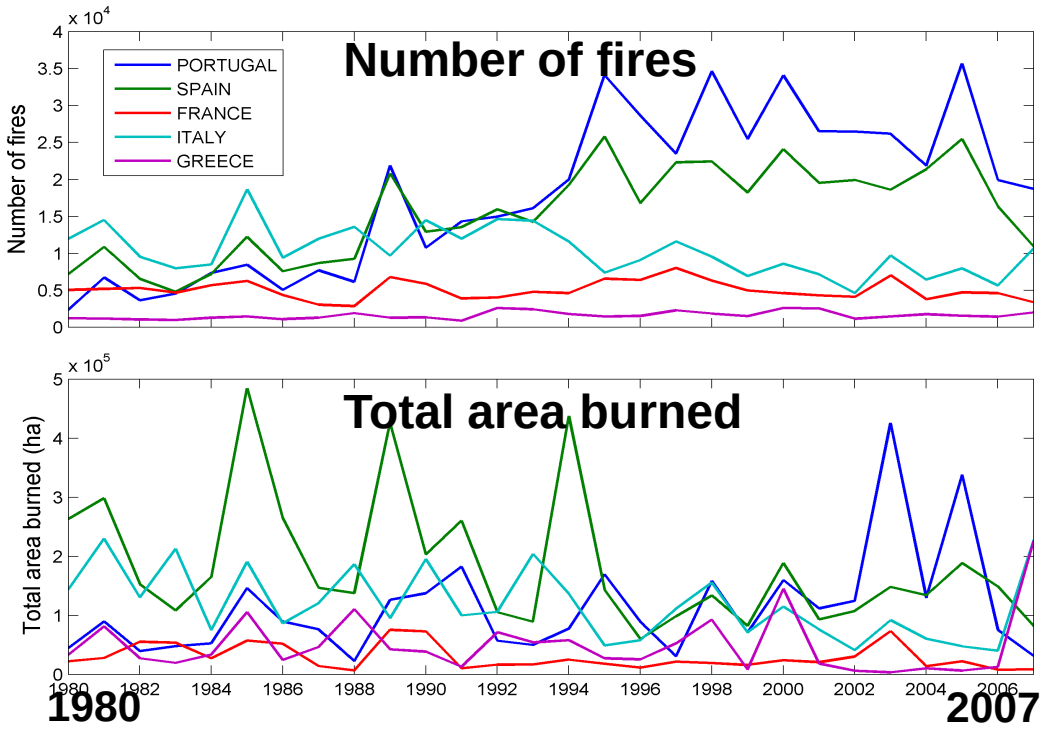
LMD/IPSL
S. Turquety, L. Menut

INERIS
B. Bessagnet

ULB IASI Team
P.-F. Coheur, D. Hurtmans, L. Clarisse

LATMOS/IPSL IASI Team
C. Clerbaux, J. Hadji-Lazaro, M. George

Impact of fires on air quality: strong perturbation?



- Extremely large emissions of aerosols and trace gases

⇒ Strong direct and indirect (ozone) impact on air quality expected

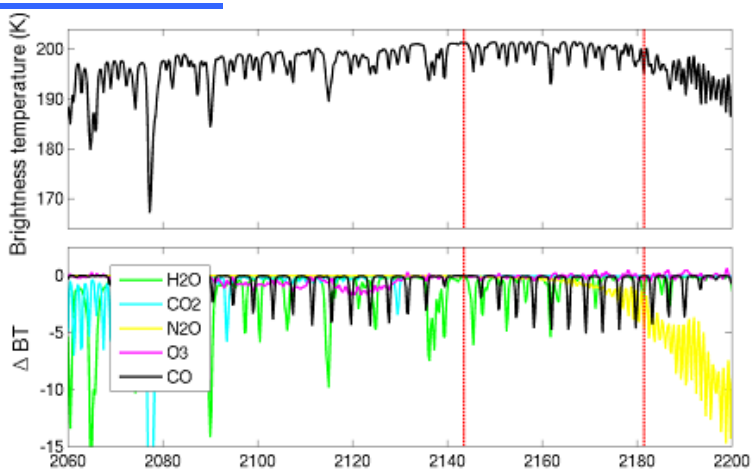
- Highly variable / largely unpredictable
- Large uncertainties on emission estimates (area, emission factors, fuel loadings, burned fraction…)
- Chemistry in BB plumes not well understood

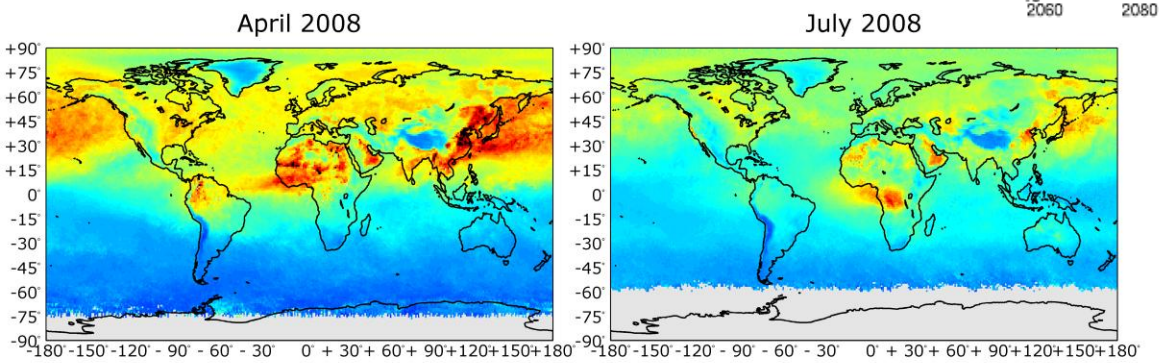
⇒ Generally not included in air quality analysis / forecasting

What information from IASI could be used to reduce these uncertainties?

IASI retrievals of CO using FORLI-CO (ULB/LATMOS)

Use retrievals from FORLI-CO
T, H20: ECMWF

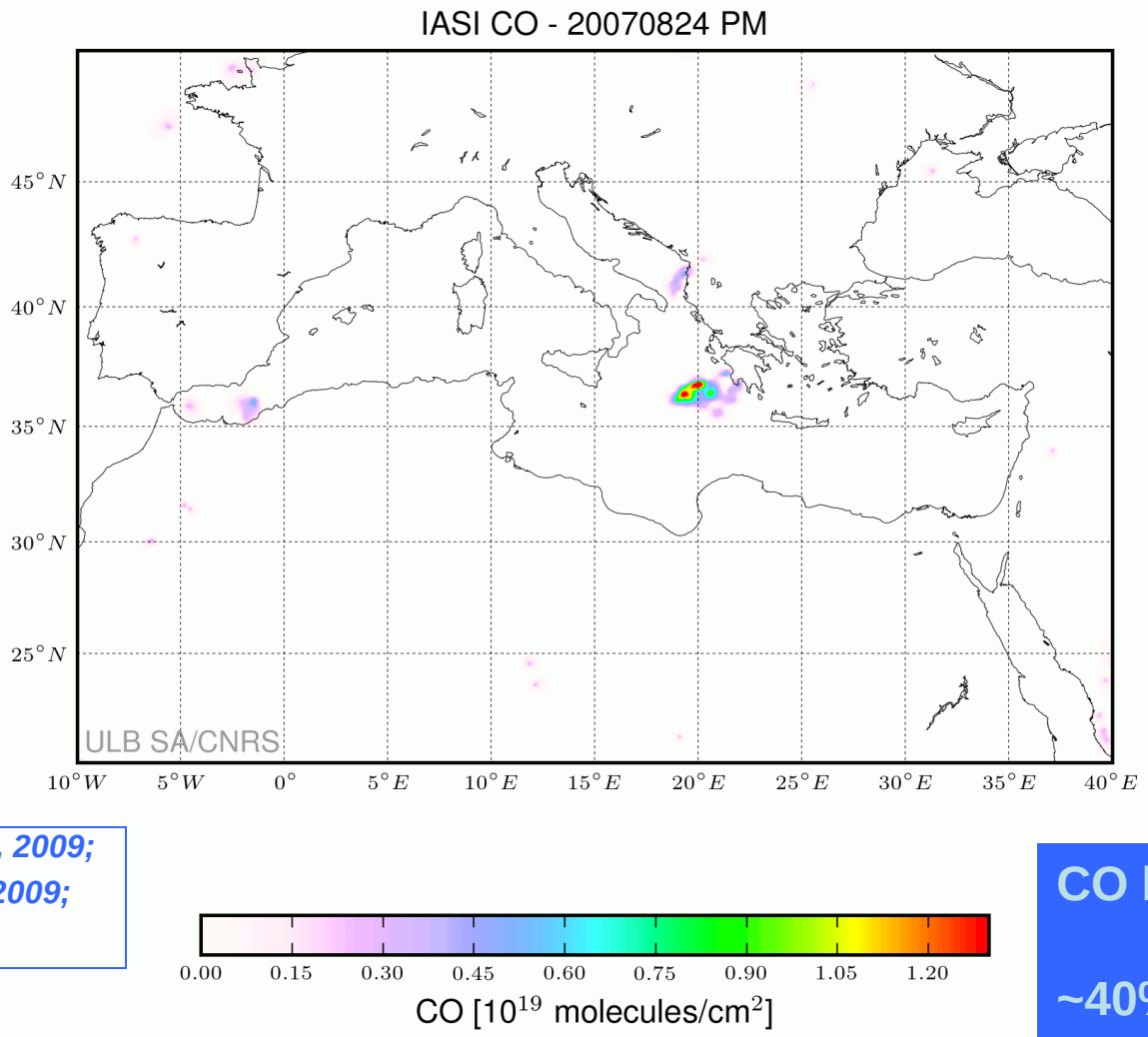




Clerbaux et al, ACP, 2009

George et al., ACP, 2009

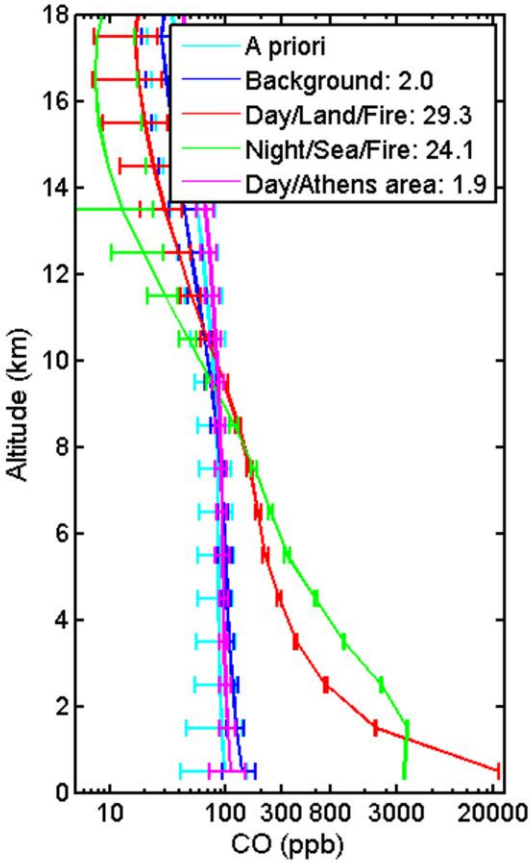
IASI retrievals of CO during the 2007 Greek fires

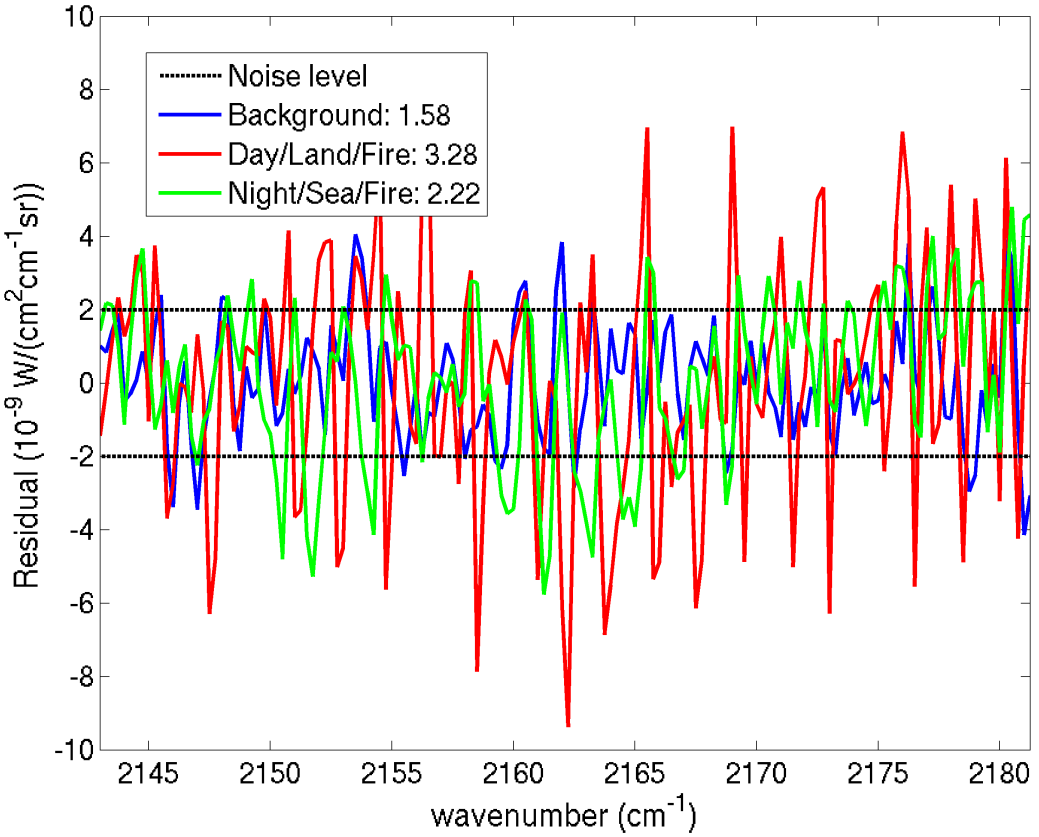


Turquety et al, ACP, 2009;
Coheur et al., ACP, 2009;
(IASI Special Issue)

CO burden from fires = 0.321 Tg, ~40% annual Anthropogenic emissions in Greece

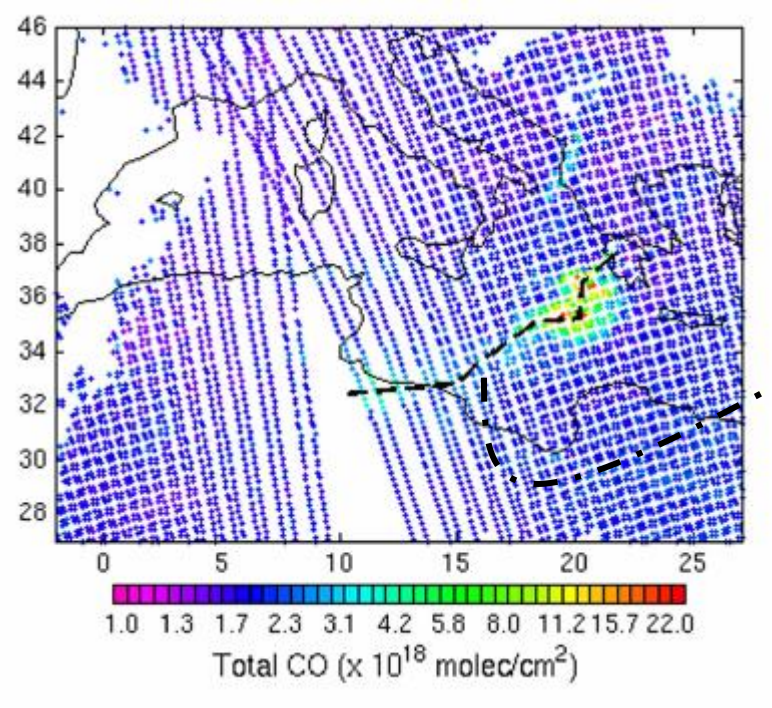
Evaluation of CO retrievals during the 2007 Greek fires





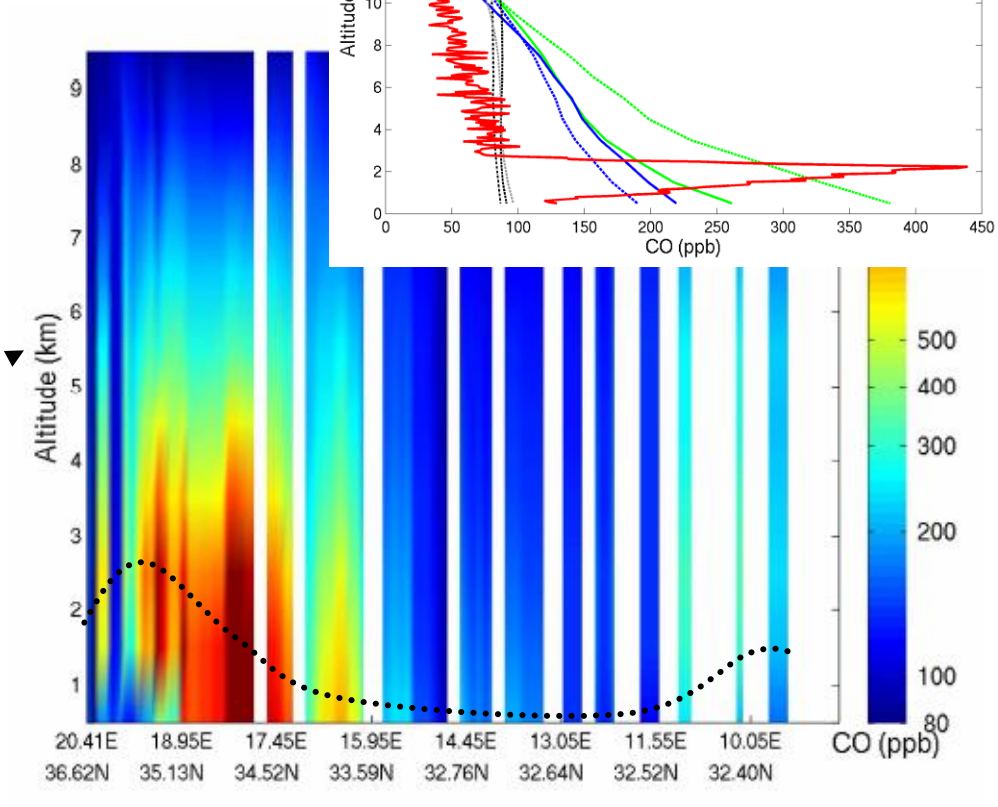
Information on vertical transport?

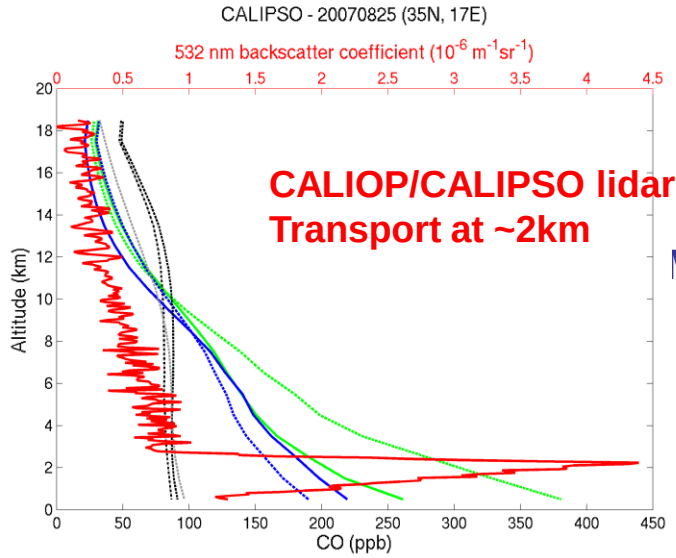
Total CO, August 25, PM



Turquety et al., ACP 2009

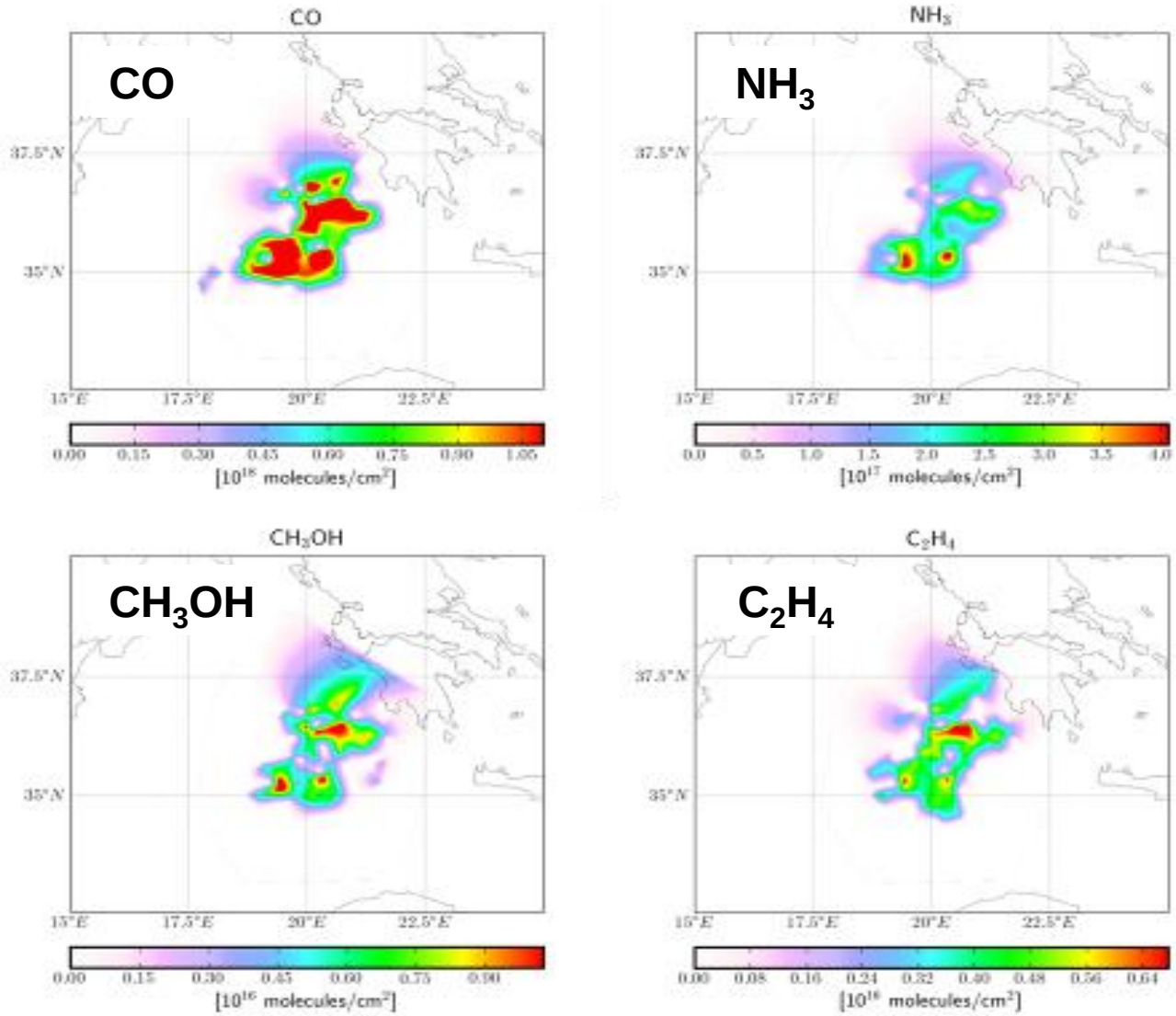
CO vertical prof … **M**





CALIOP/CALIPSO lidar: Transport at ~2km

Detection of short lived species



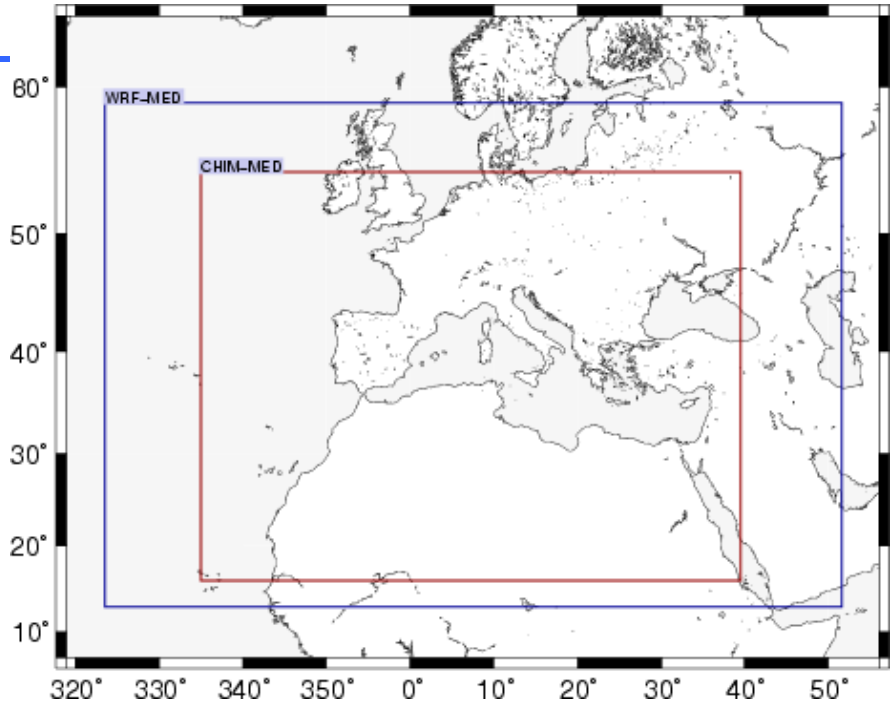
August 25, PM

(Coheur et al., ACP, 2009)

Next step: what constraint on BB emissions and their impact on air quality?

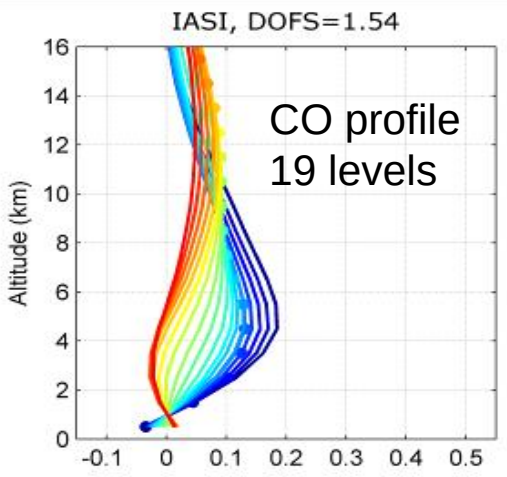
CHIMERE regional model with:

- 0.5°x0.5° resolution
- 16 levels up to 200hPa
- WRF meteorology
- LMDz-INCA climatology for initial and boundary conditions
- EMEP anthropogenic emissions
- Biomass burning emissions (first test):
  - o FLAMBE (E. Hyer et al.)
    - ➔ **hourly inventory**
  - o Emission factors from *Andreae and Merlet* + updates.

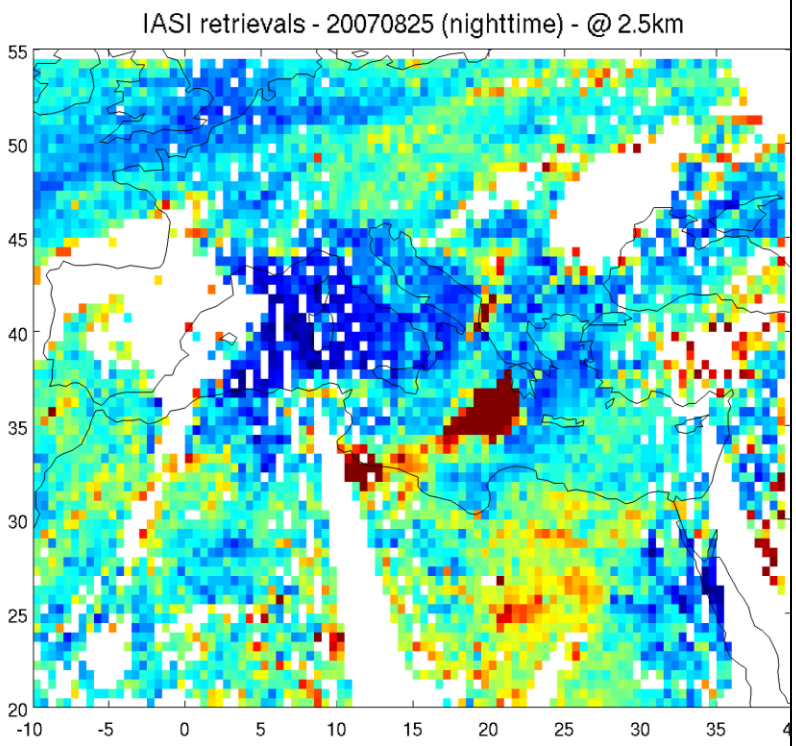


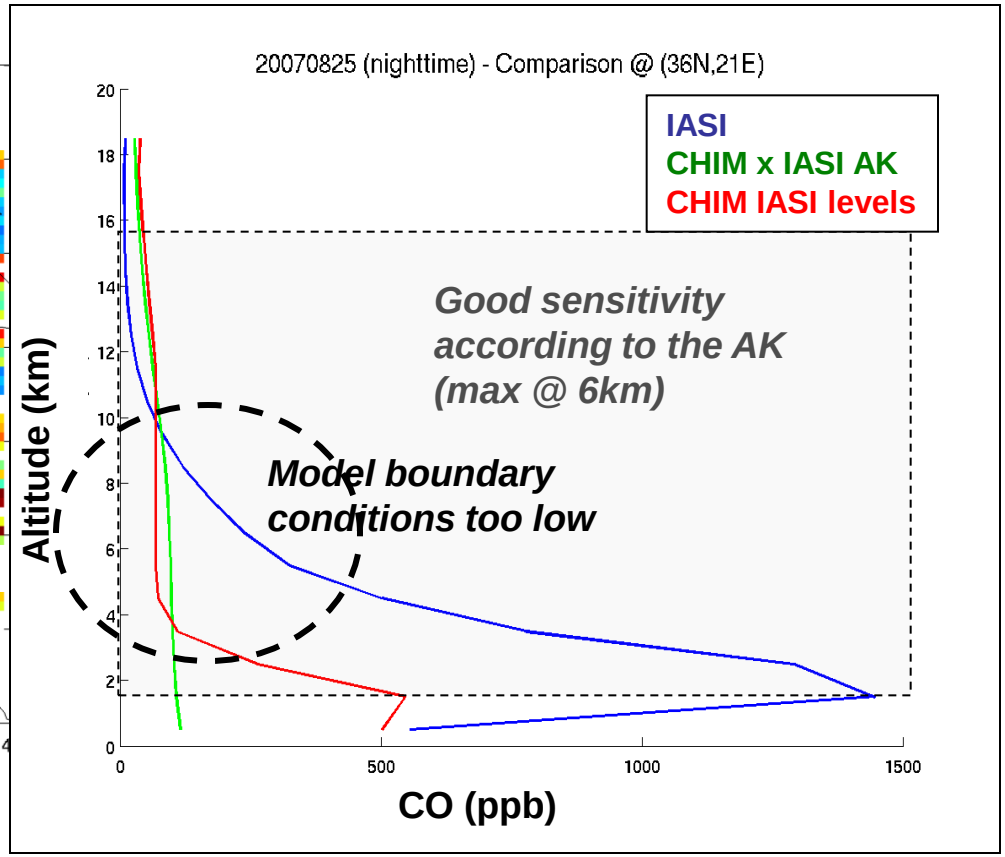
Smoothing in order to derive comparable quantities:

$$\mathbf{x}_{comp} = \underbrace{\mathbf{A}\mathbf{x}_{chimere}}_{\text{CHIMERE profile on IASI retrieval levels smoothed by the IASI AK}} + \underbrace{(\mathbf{I}-\mathbf{A})\mathbf{x}_{aprioriIASI}}_{\text{Estimated contribution from the a priori in the retrieval}}$$



Preliminary comparison between CHIMERE and IASI





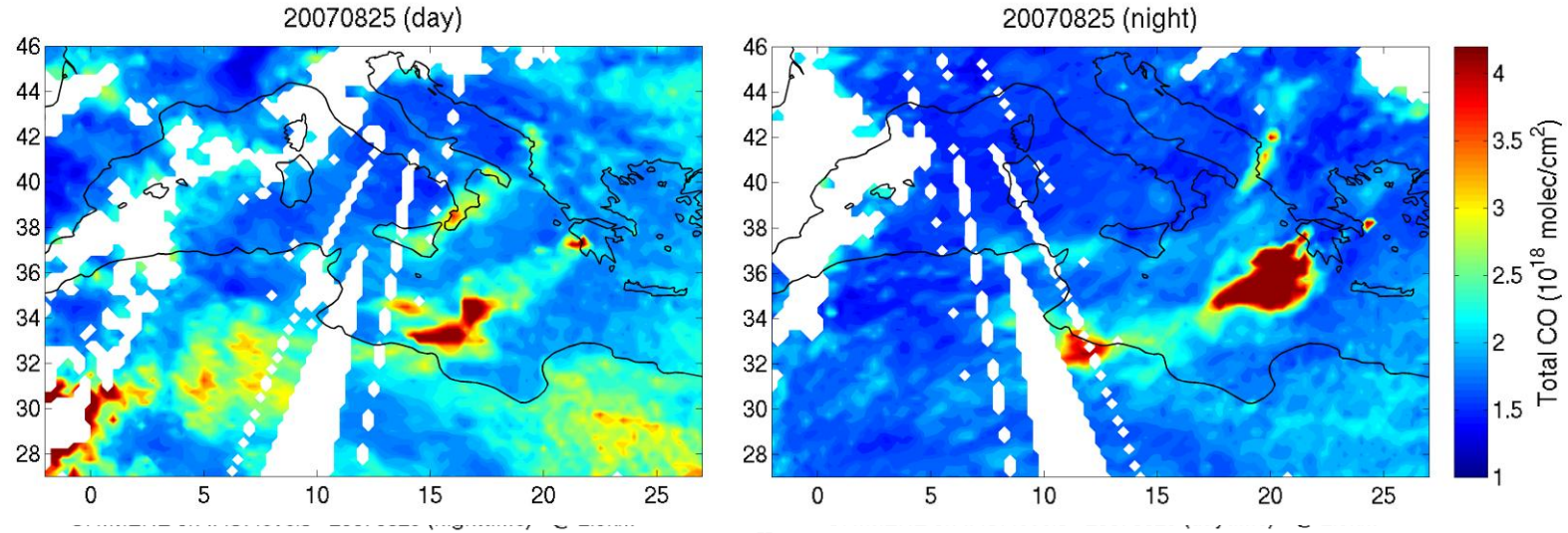
Difficulty:
CHIMERE is a pollution model => evaluation mainly at the surface in polluted areas.

Serious bias in the CO simulation.
Main update required: boundary and initial conditions from the global model.

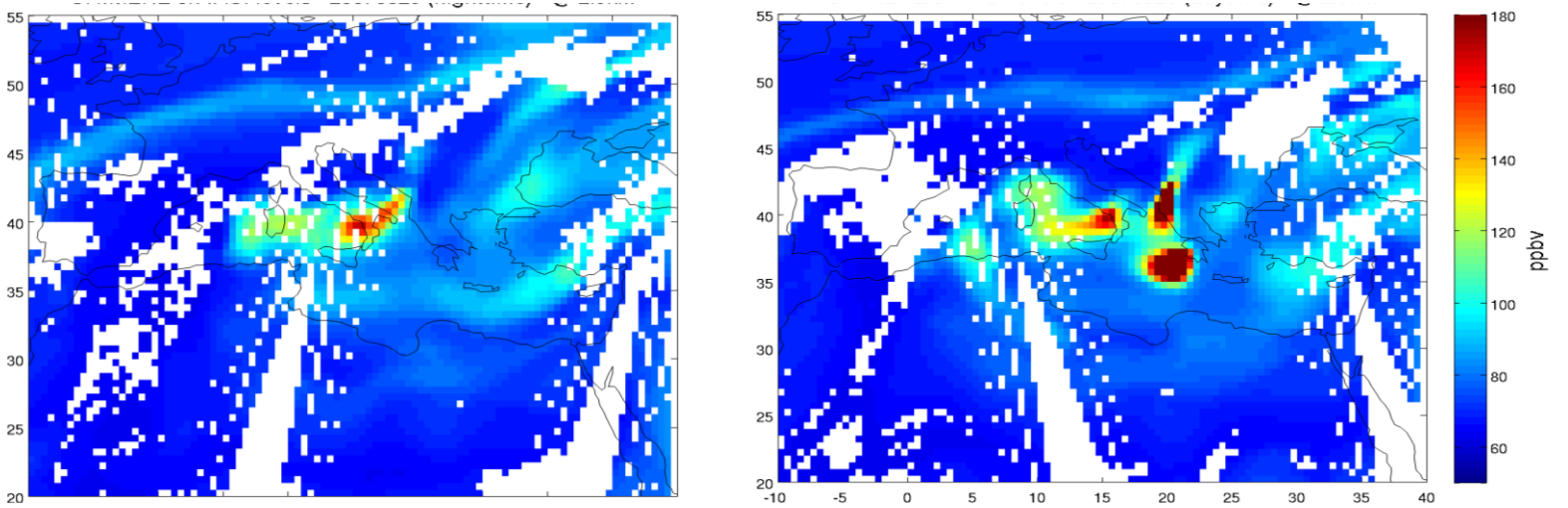
Preliminary comparison between CHIMERE and IASI

Quantitative comparison: can the model capture the observed BB plumes?

IASI Total CO



CHIMERE CO vmr ~2km

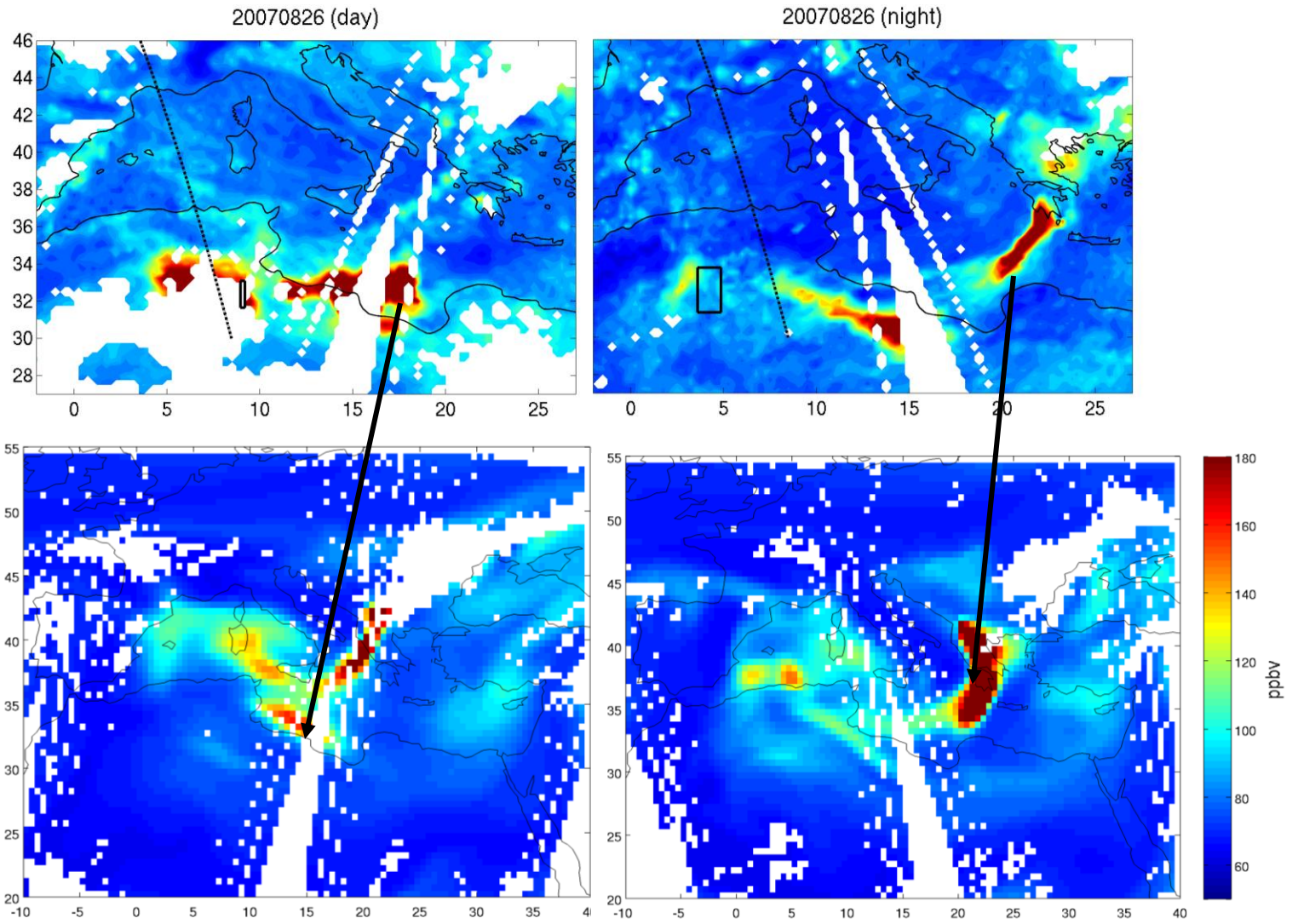


Uncertainties on temporality of fires => signatures not exactly at the right location.
Main signature captured but seem to overestimate fires in the Balkans?

Preliminary comparison between CHIMERE and IASI

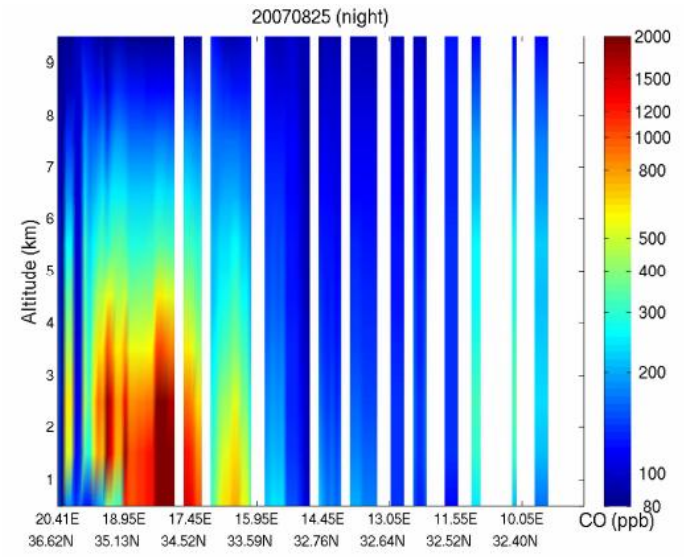
IASI

CHIMERE
CO vmr
~2km

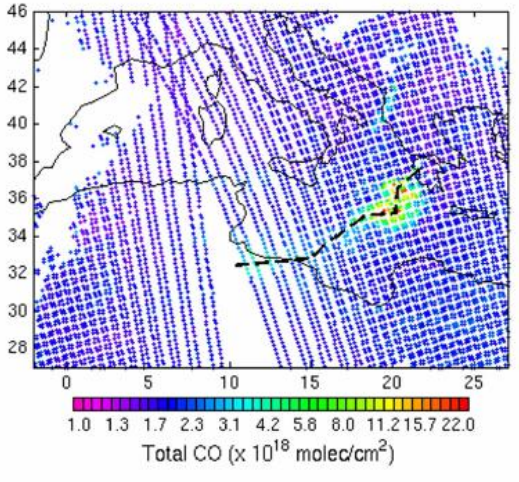


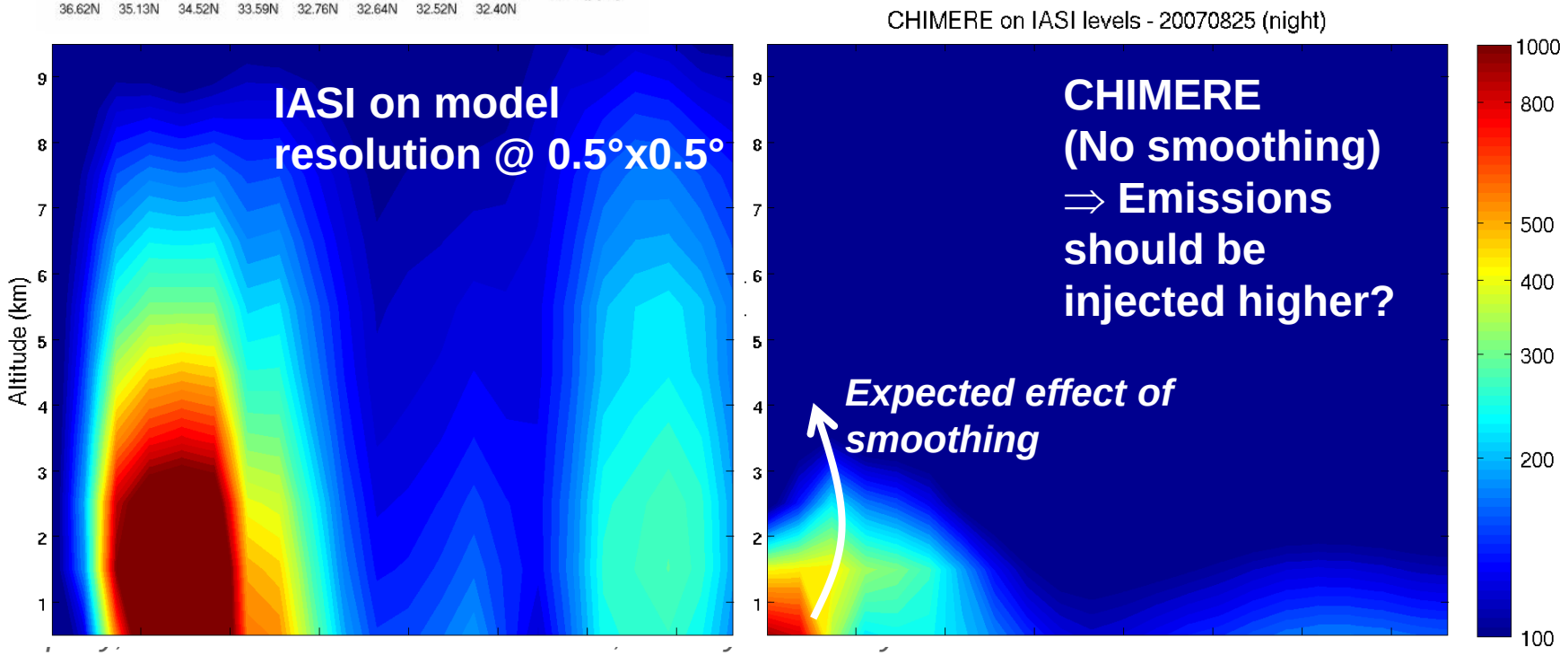
Again: fires in the Balkans seem overestimated in the biomass burning inventory

Preliminary comparison between CHIMERE and IASI



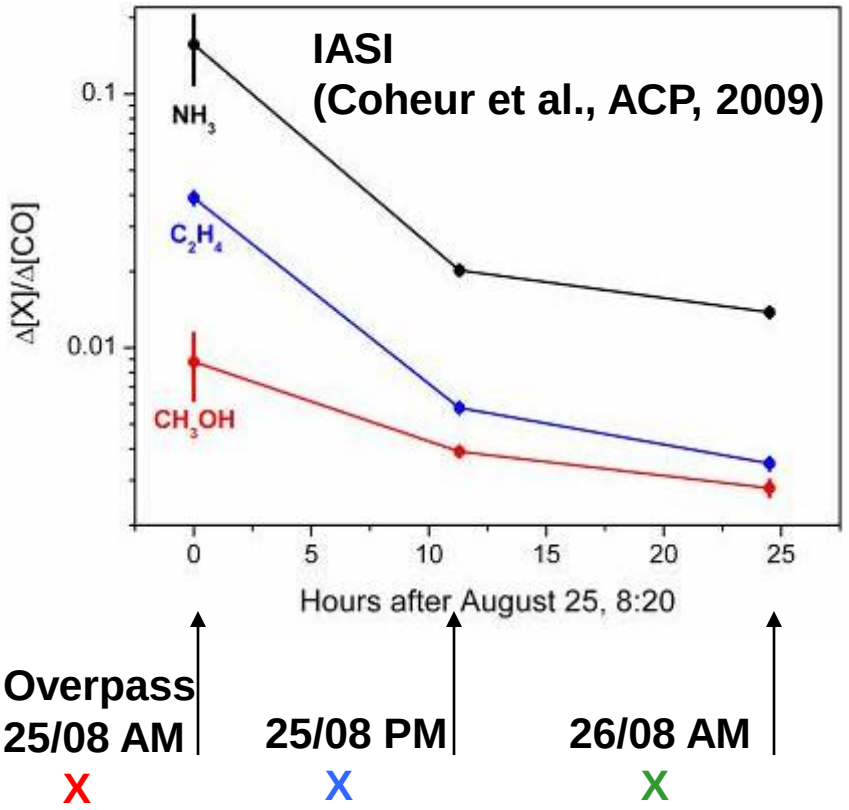
Cross section
along BB plume
Avg. @ 0.2°x0.2°

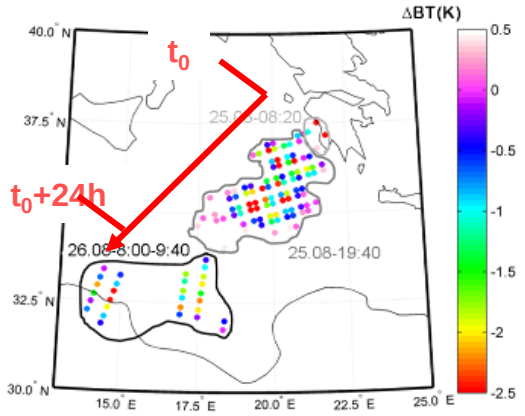




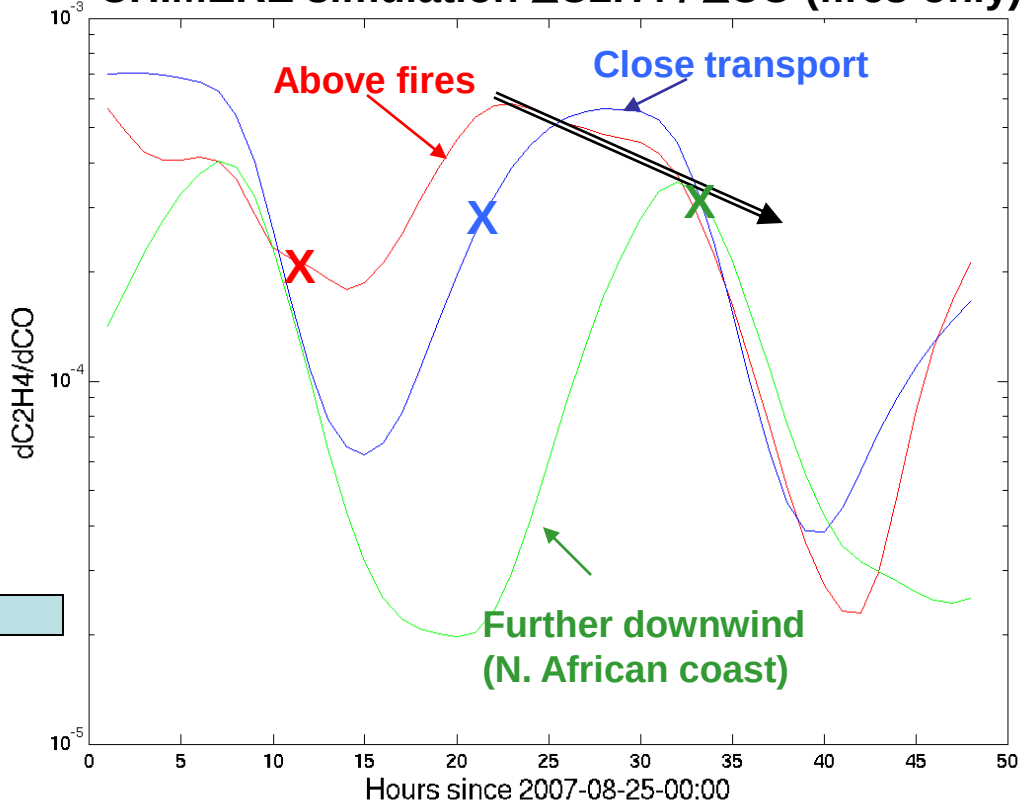
New information on the emissions: short lived species

Use IASI to follow chemical evolution of fire plume:





CHIMERE simulation ΔC2H4 / ΔCO (fires only)



Temporality of fires in the BB emissions used does not seem correct considering the IASI observations

New information on the emissions: short lived species

Linear regression $\Delta[X]_{fires} = a\,\Delta[CO]_{fires} + b$
➔ information on emission factors

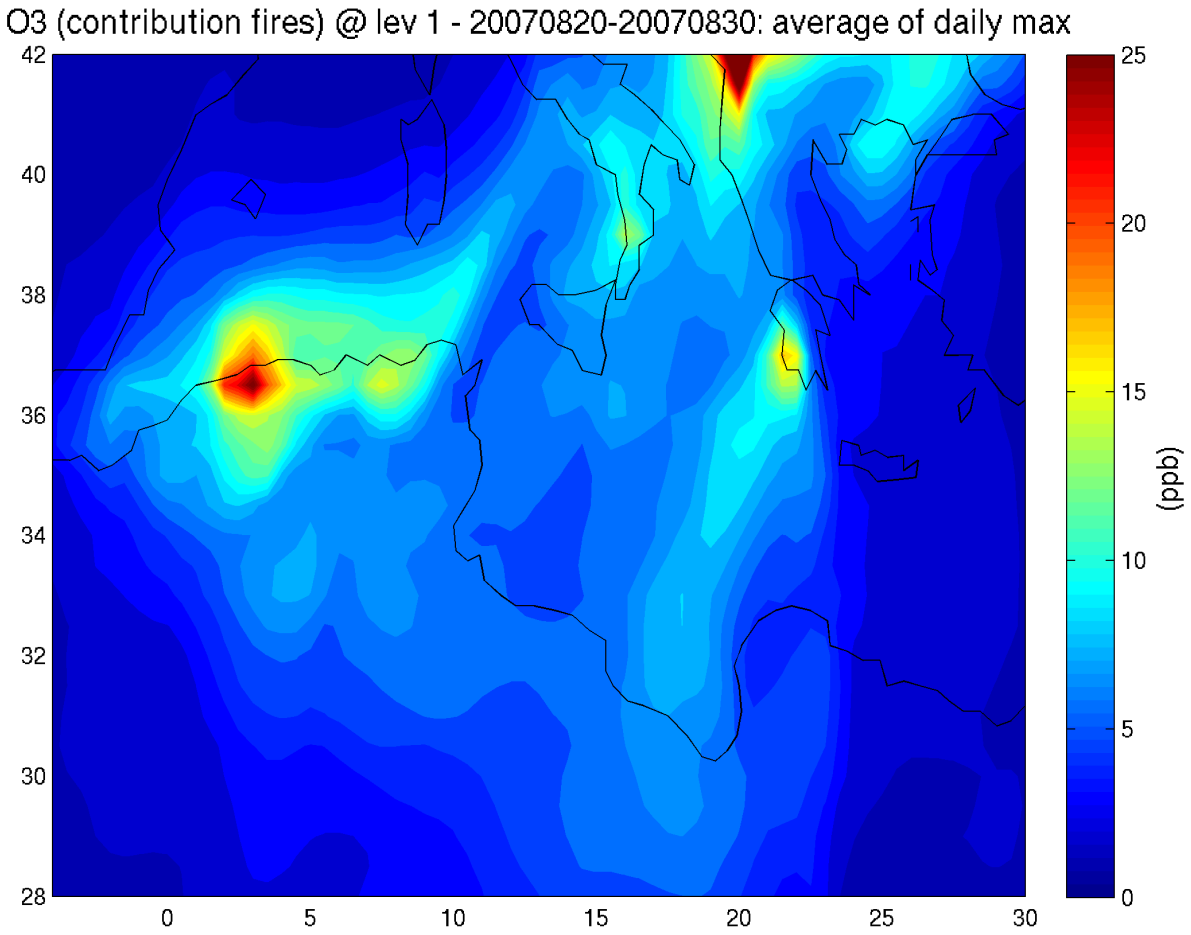
Observed event on the 25-26 August 2007 from the Greek fires:

Species X	Reported emission factor ratios *(M. Andreae)* EF(X)/EF(CO)	Model simulation	IASI retrieval *(Coheur et al., 2009)*
C2H4	0.01 ± 0.007*	0.008-0.009 (fresh plume)	0.04 above fires 0.006 in fresh plume
NH3	0.015 ± 0.017*	0.014 (fresh plume)	0.02 above fires 0.014 further downwind

Uncertainty == standard deviation of the reported emission factors for X and CO.

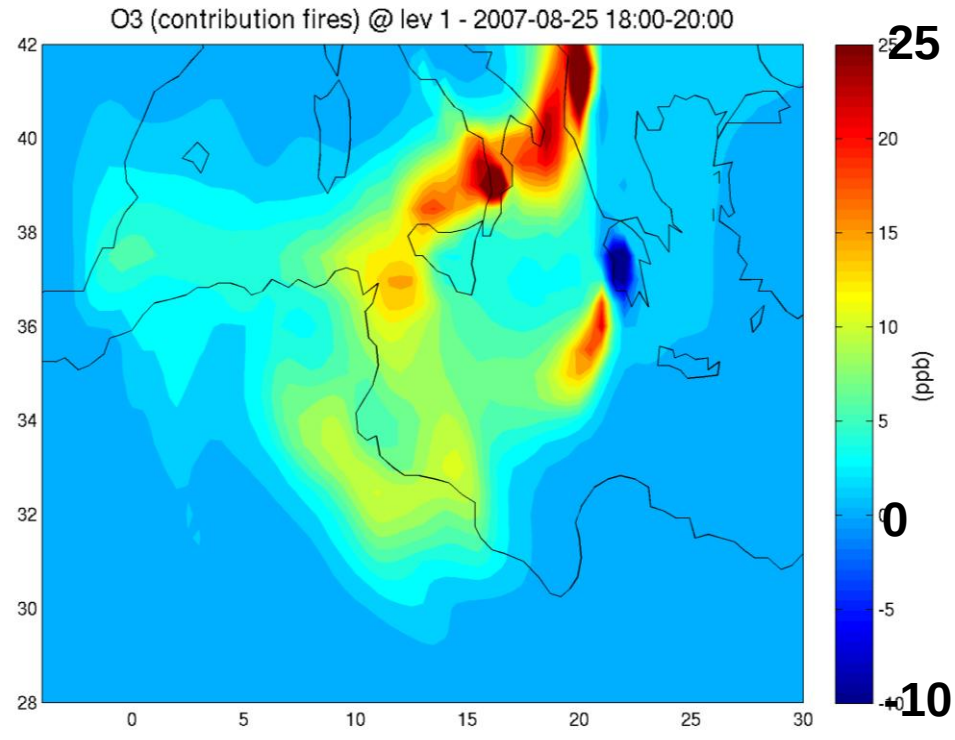
However:
- **few reported emission factors are as large as those obtained for IASI above the fires;**
- **very different values for the boreal fire case in Coheur et al. (2009), although also in the "extratropical forest" class for Andreae emission factors…**

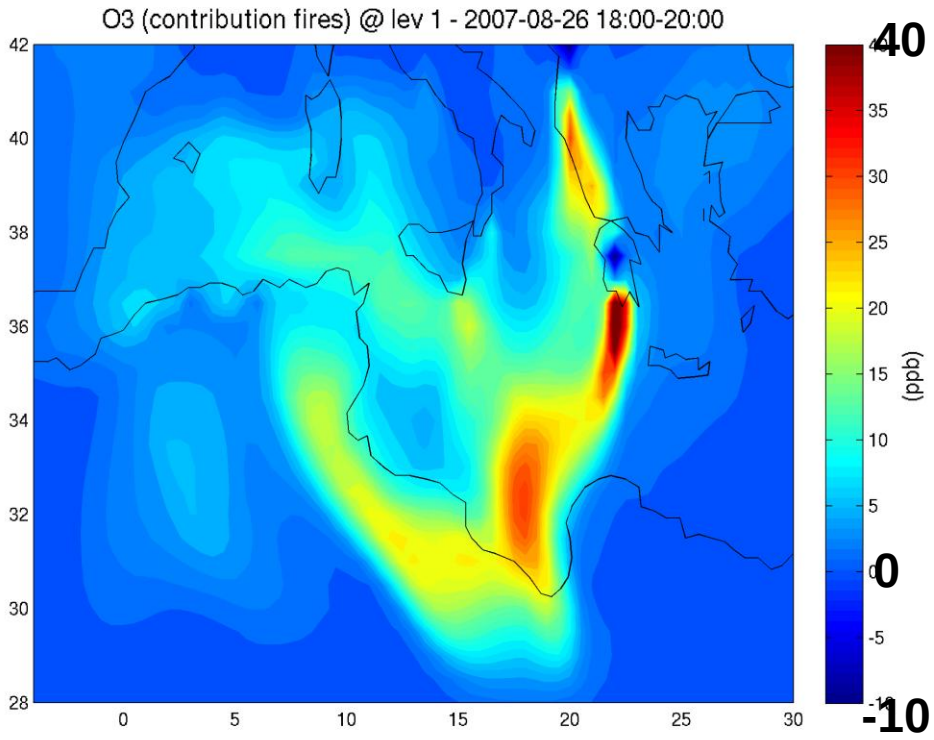
What possible impact on air quality?



Impact on average daily max show significant impact on regional scale.
Even with apparently underestimated transport of emitted primary pollutants.

What possible impact on air quality?





Above fires: titration of ozone due to large NOx?
Downwind: large ozone production predicted.

Is it real????
Retrievals from IASI do not suggest significant impact for these events.
Chemical production of ozone needs to be better understood.

Summary and Conclusions

Trace gas observations from satellite:

(+) Good spatial and temporal coverage allow the monitoring of plumes
(+) Relatively long records
(+) Fires: many species detected => info on emission factors and chemical evolution
(-) Lack vertical resolution
(-) Retrieval error often difficult to assess accurately!

Specific retrieval problems for fire plumes:

- Huge pollution: far from the a priori statistics
- Impact of aerosols (reduced sensitivity? Errors for O3?)
- LACK VALIDATION DATA

Efforts needed for the modeling of the impact of fire emissions:

- Correct background levels for long lived species (CO, O3)
- Reevaluate emissions and their daily variability
- Simulate injection height depending on fire size and energy release
- Analyze photochemistry in the fire plumes

Evaluation of the impact on air quality:

- Comparisons to IASI => trace gases / ozone
- Comparisons to A-Train (POLDER/PARASOL, CALIPSO) => PM2.5
- Comparisons to surface sites

Thank you for your attention!

Acknowledgements:

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

EUMETSAT

Ether

Programme de Recherche Interorganisme pour une Meilleure Qualité de l'Air à l'Echelle Locale
Primequal Predit

INERIS

UPMC
PARIS UNIVERSITAS

Institut Pierre Simon Laplace
Sciences de l'environnement