

# Using IASI observations to evaluate the uncertainty on wildfire plume modeling

## Application to Portugal in summer 2016

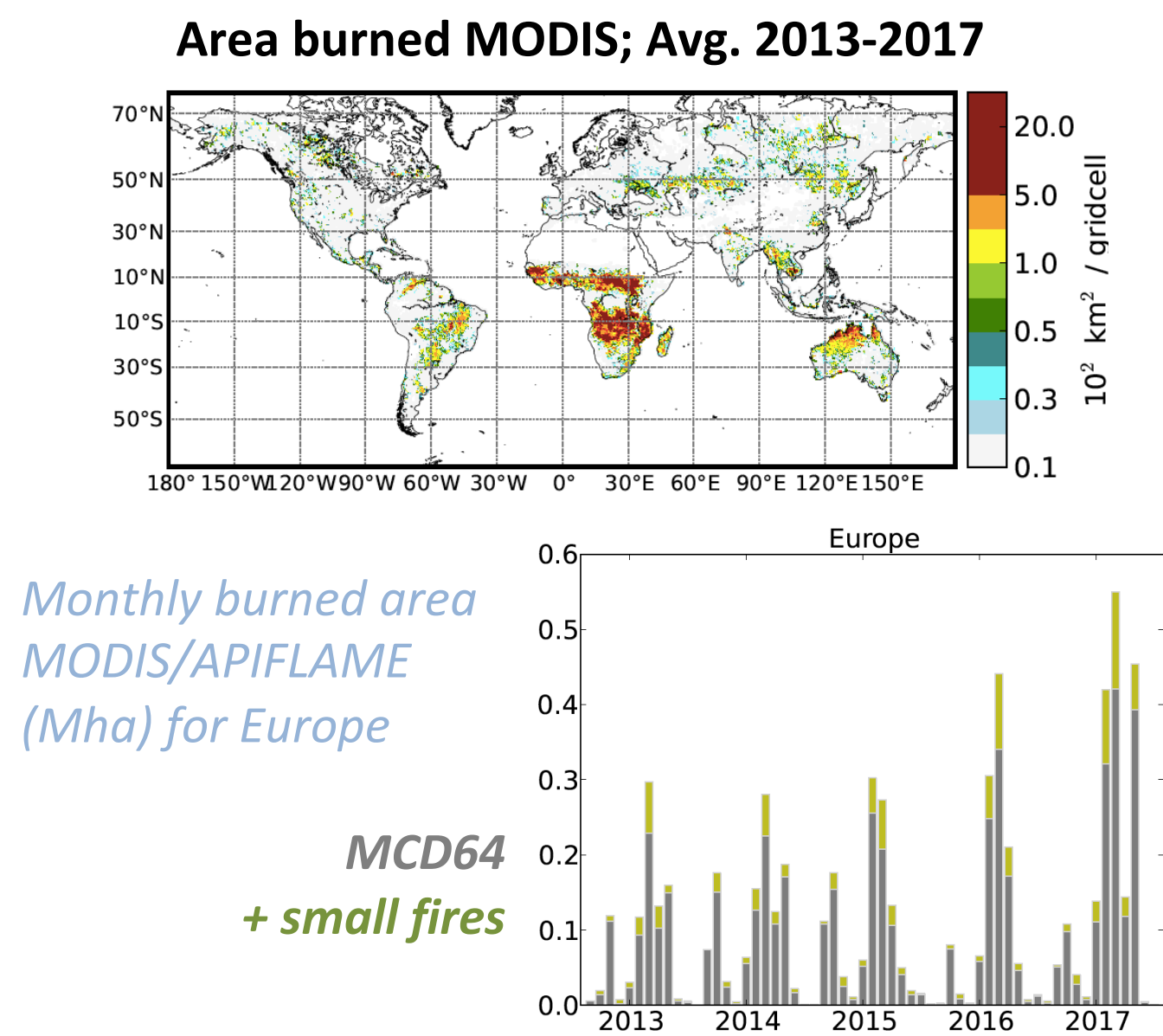
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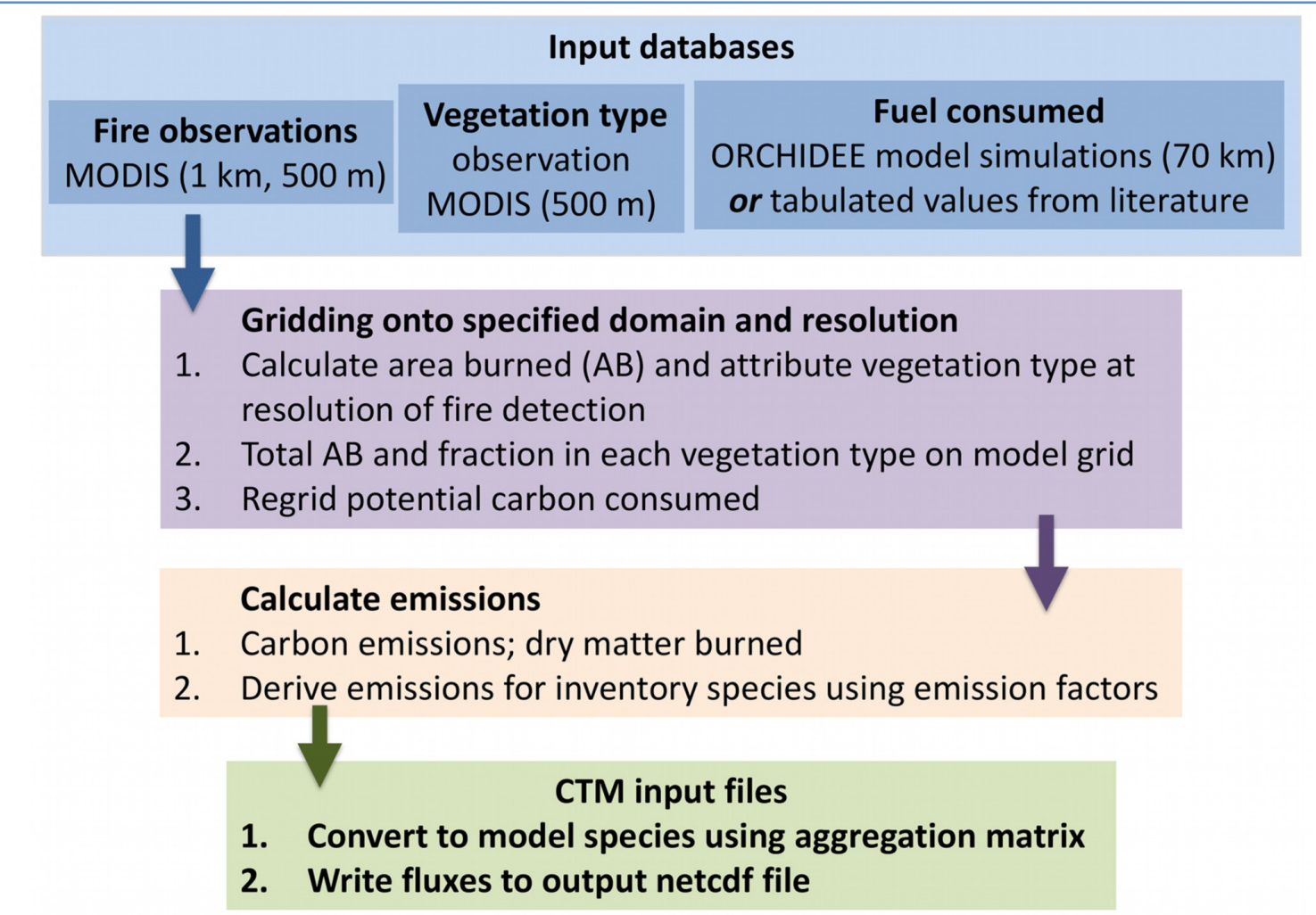
## Context

- Wildfires are a significant source of pollutants.
- The fire risk is increasing and fire seasons are lengthening as a result of climate change in the mid and high latitudes of the Northern Hemisphere.
- Fire risk is strongly linked to heat waves, also enhanced by drought (Guion et al., *Climate Dynamics*, 2021) and fire spread peaks for particularly low and high surface wind speed (Hernandez et al., *Nat. Hazards Earth Syst. Sci.*, 2015).
- In Europe and the Mediterranean area, fires mainly of anthropogenic origin.



## APIFLAME fire emissions

- Fires emissions are calculated using the APIFLAME fire emissions' model (Turquety et al., 2020)
- Flexible resolution (~1km), domain, chemical scheme; high temporal resolution (daily to hourly)
- Uncertainty on carbon ~100%:
- Applied to various regions for air quality analysis (integration in CTM simulations): good performance wrt observations



Code available for download at <https://doi.org/10.14768/20190913001.1>

A documentation and a test case are available at <http://www.lmd.polytechnique.fr/chimere/CW-fires.php>

## Simulation of the atmospheric impact of the 2016 wildfires in Portugal

### Case study: 2016 fire season in south-western Europe

Fire season close to average for most European states except Portugal, where the burned area in 2016 was twice the average over the previous decade (similar number of fires). Peak during august: 115,788ha burned (EFFIS, JRC), 63% wooded land, mostly eucalyptus and pine stands, 47% of shrubland.



Name	Burned area <sup>a</sup>	Vegetation type	Fuel consumed	Emission factors
BA-CLC	MCD64	CLC	ORCHIDEE	Default
BA-MODIS	MCD64	MODIS	ORCHIDEE	Default
BA-FRP-CLC	Merge MCD64 with MOD14 FRP	CLC	ORCHIDEE	Default
BA-FRP-MODIS	Merge MCD64 with MOD14 FRP	MODIS	ORCHIDEE	Default
BA-sf-CLC	MCD64 + small fires	CLC	ORCHIDEE	Default
BA-sf-MODIS	MCD64 + small fires	MODIS	ORCHIDEE	Default
BA-sf-MODIS-lit	MCD64 + small fires	MODIS	van Leeuwen et al. (2014)	Default
BA-sf-MODIS-lit-forest	MCD64 + small fires	MODIS	van Leeuwen et al. (2014) for temperate forest	Default
BA-FRP-MODIS-EF	Merge MCD64 with MOD14 FRP	MODIS	ORCHIDEE	Alves et al. (2011b) for forest and CO, OC, BC
BA-sf-MODIS-EF	MCD64 + small fires	MODIS	ORCHIDEE	Alves et al. (2011b) for forest and CO, OC, BC

### APIFLAME ensemble

Several options may be chosen, allowing the calculation of ensembles of emissions

### CHIMERE CTM simulations

(Menut et al., GMD, 2021)

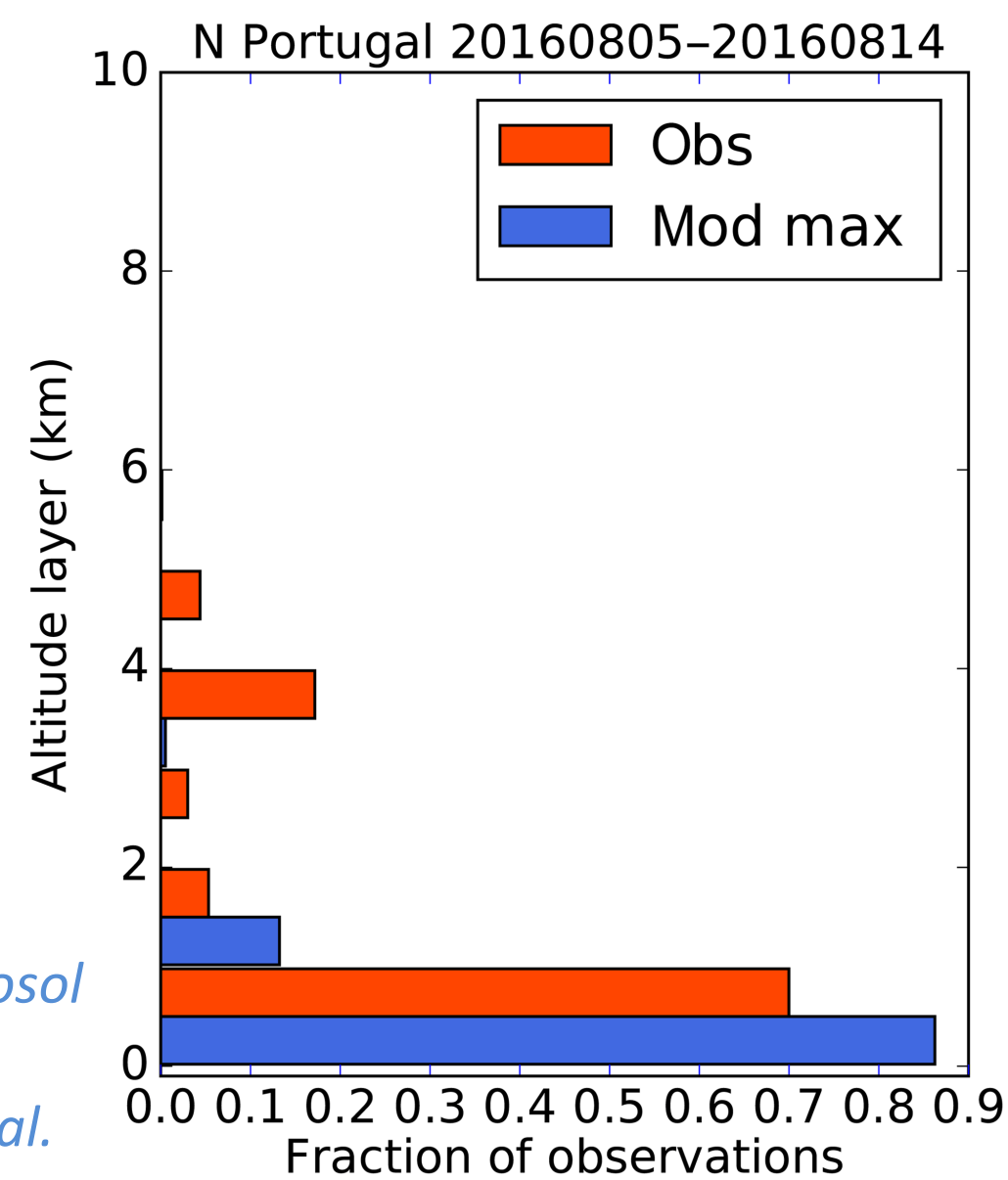
[www.lmd.polytechnique.fr/chimere](http://www.lmd.polytechnique.fr/chimere)

- WRF met simulation at 10km
- EMEP anthropogenic emissions 2016
- APIFLAME fire emissions
- Online dust, sea salt, bio emissions
- Boundary conditions global 5 year climatology

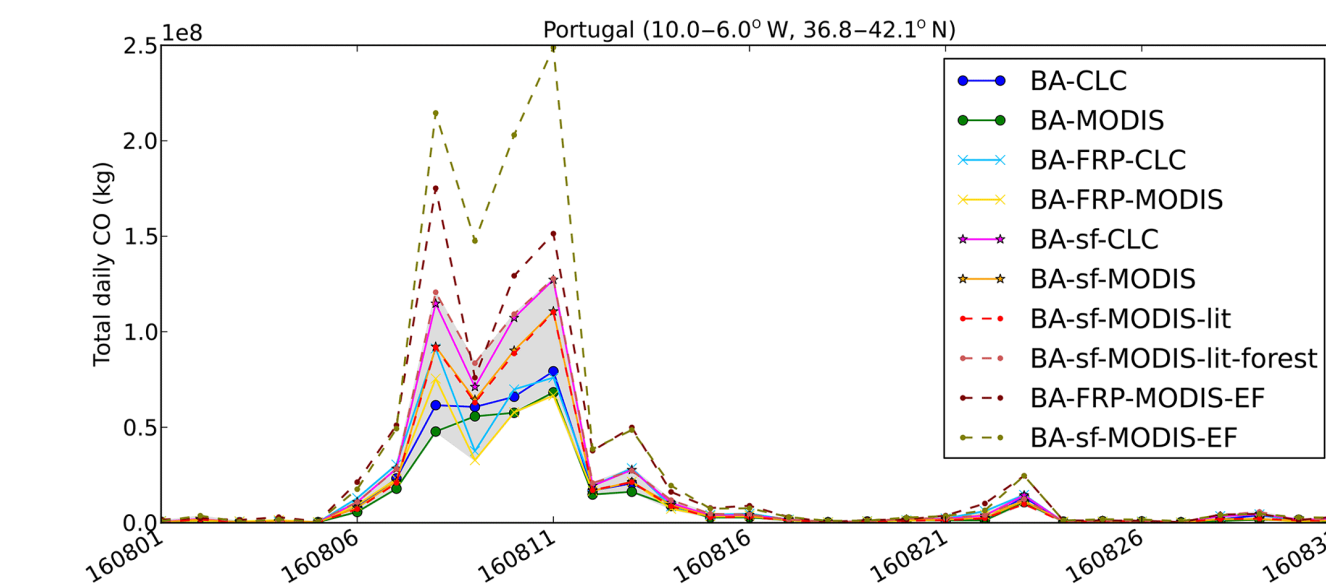
### Configurations for the BB emissions vertical profile

- Injection height scheme by Sofiev et al. (100% below 2km)
- Profile estimated from MISR observations of aerosol height (~30% around 3-5km)

Distribution of observed (MISR) and simulated aerosol layer height in grid cells affected by fires in Portugal.



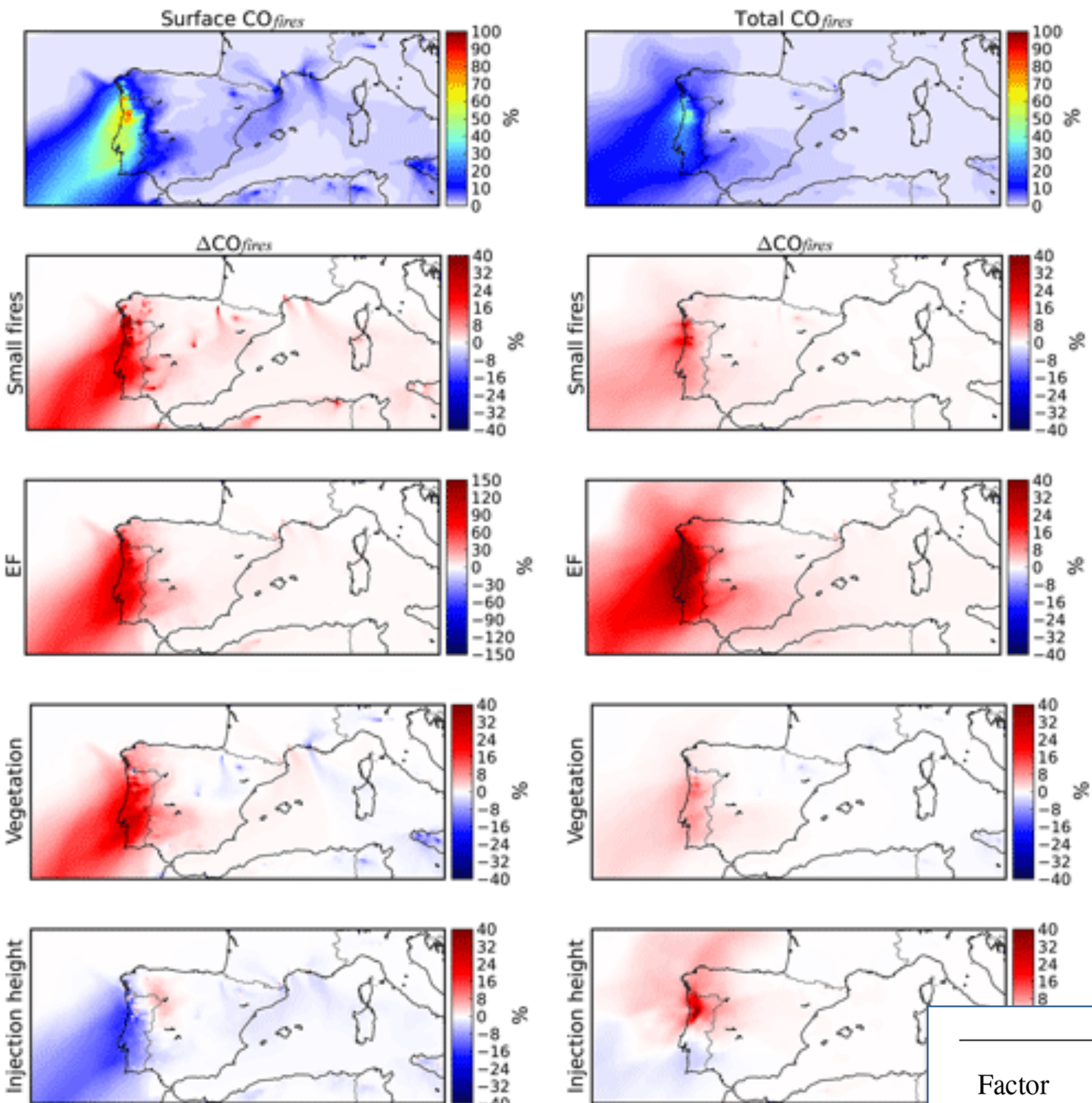
### Daily CO emissions in Portugal during August 2016, calculated using different options in APIFLAME.



Ensemble spread on average for daily emissions at 10km resolution:

- 140% all experiments
- 80% excluding small fires
- Diff. due to fuel consumption ~ 40%

### CHIMERE regional model simulations



Simulated impact on surface (left) and total (right) CO of different configurations for emissions in CHIMERE

- On average over the summer, fire contribution to surface CO ~ 66% over the fire region, 10 %–20% downwind. For total CO: 17% maximum over the fire region and 3% downwind.
- Large increase due to possible missing small fires and corrected emission factors.
- The effect of the vegetation database is lower but still very significant
- Injection at higher altitude lowers surface concentrations and increases northward transport

Difference compared to default (BA-CLC) for total emissions and avg atmospheric conc (%)

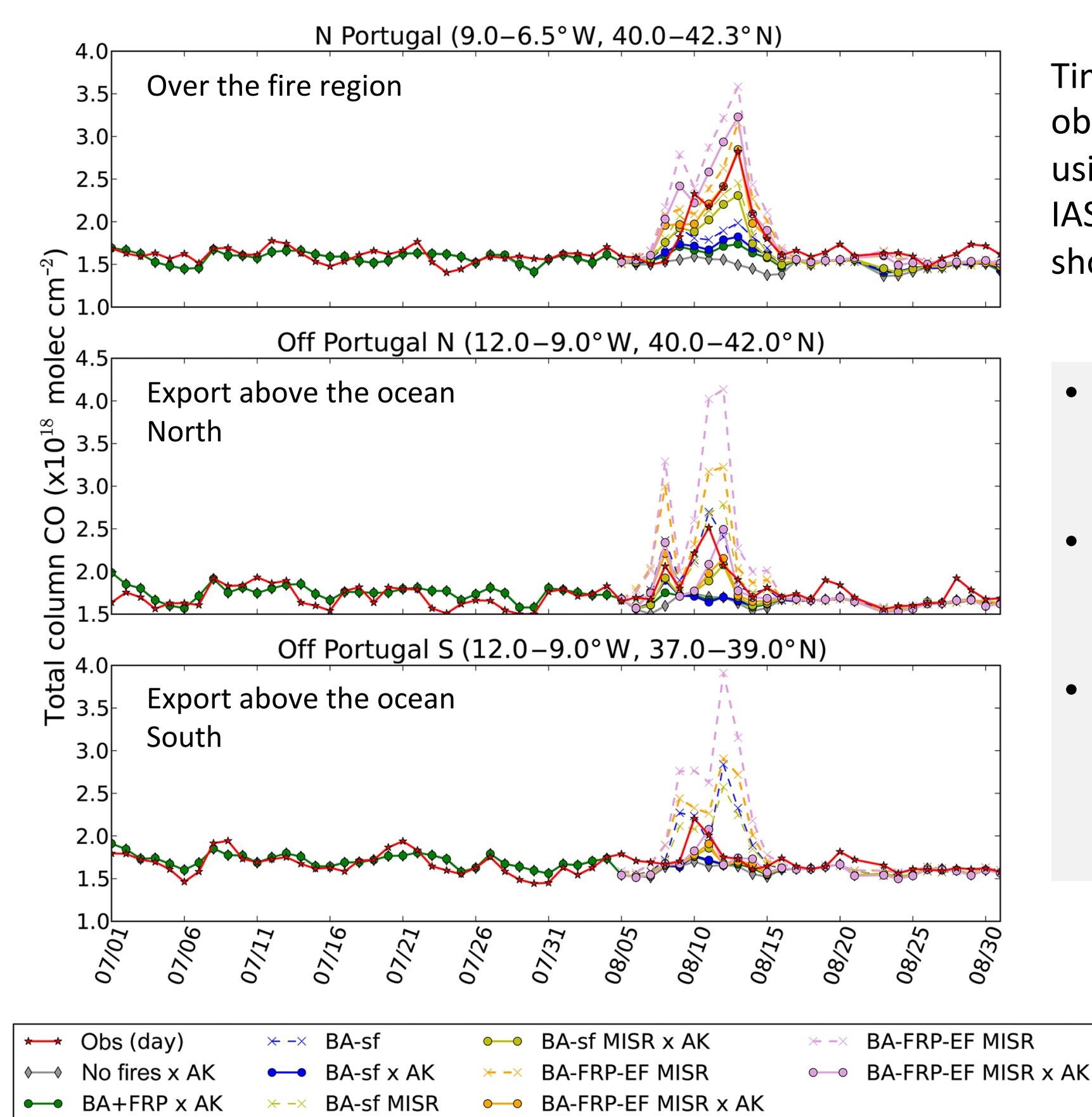
Factor	$\Delta E_{CO}$	$\Delta E_{OCAR}$	$\Delta CO$		$\Delta PM_{10}$	
			surface	total	surface	total
Merge BA-FRP	+10	+8	–	–	–	–
Small fires	+33	+36	+43	+48	+41	+47
Vegetation	+17	–0.3	–30	–17	–11	–29
Fuel consumption	+2	–2	–	–	–	–
Emission factor	+126	+50	+152	+118	+40	+14
Injection height	–	–	–25	+11	–22	+32

## Evaluation using IASI observations

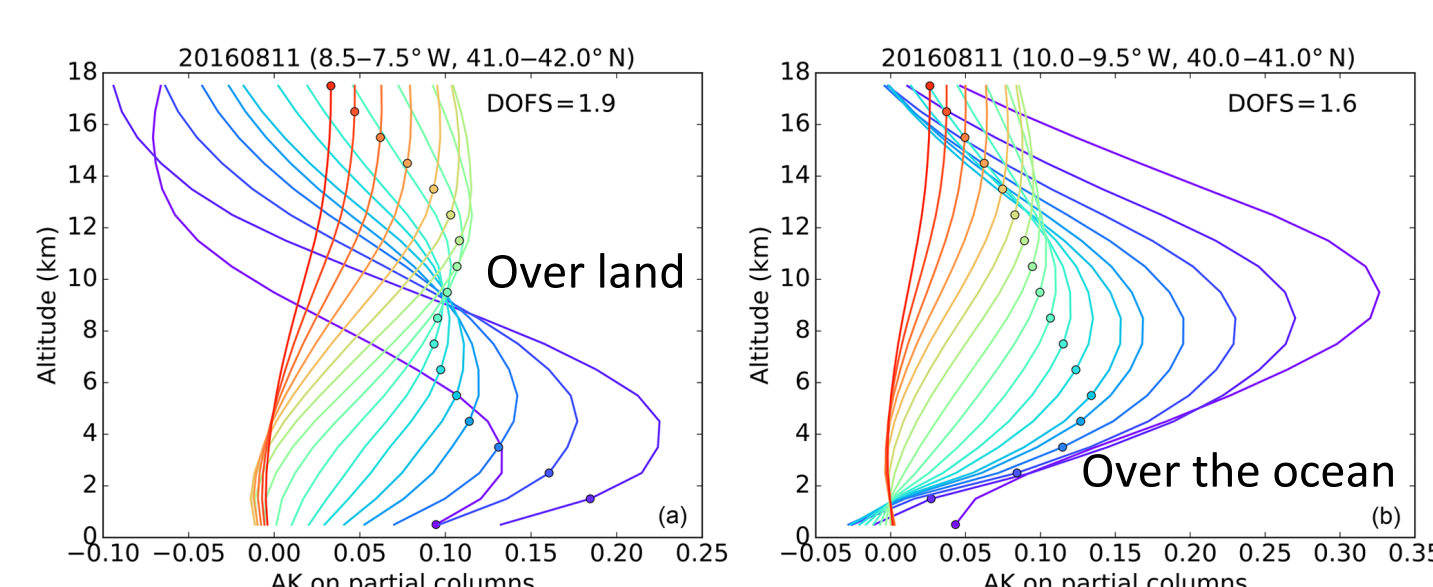
### IASI CO observations

- FORLI CO retrieval (Hurtmans et al., 2012) for MetOp-A and MetOp-B platforms, daytime only
- Uncertainty < 20 % in the lower troposphere
- Tendency to overestimate concentrations

### Comparison IASI vs CHIMERE



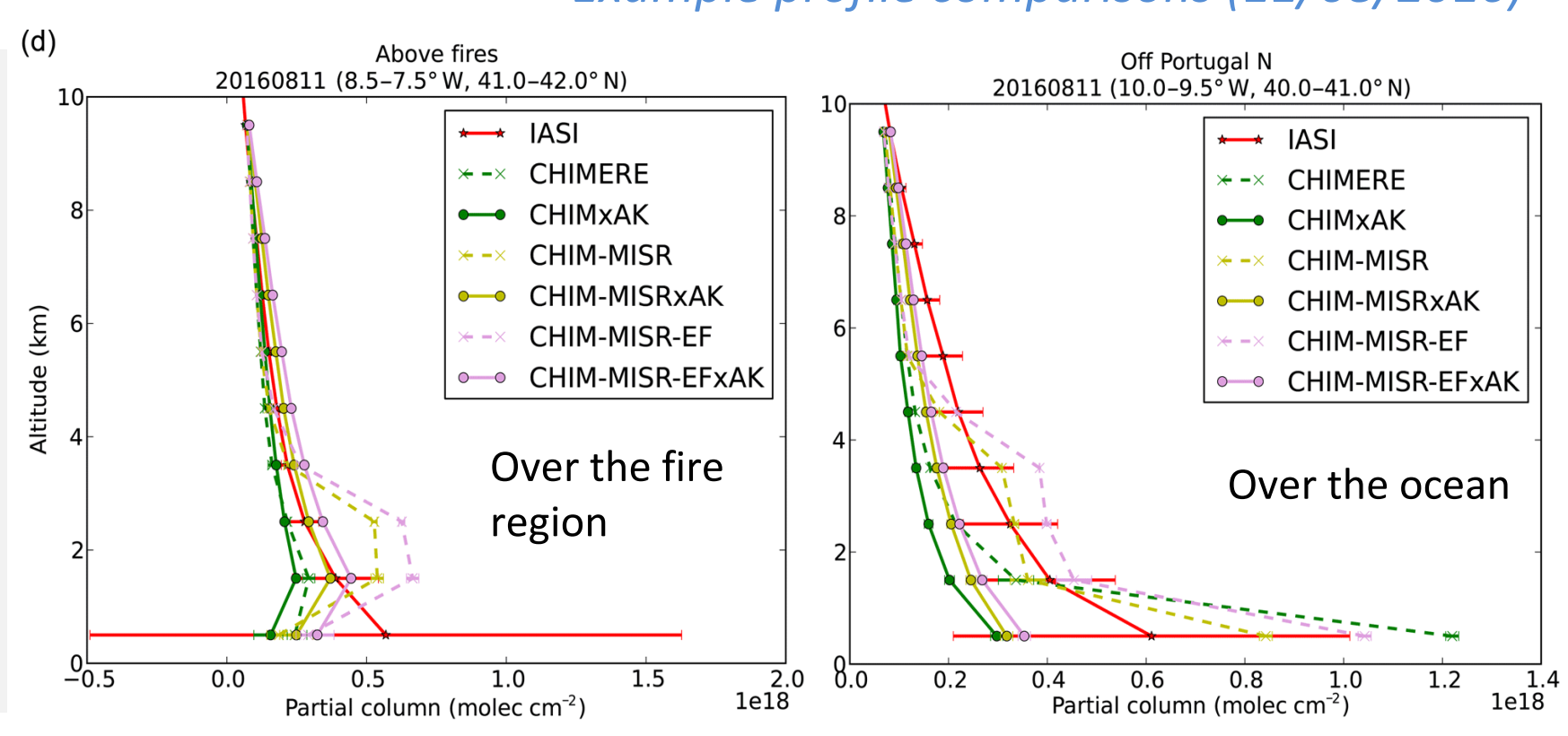
### Mean averaging kernel for the case study analyzed



Time series of regionally averaged total CO observed by IASI (red) and simulated by CHIMERE using different configurations (collocated with IASI). The differences btw solid and dashed lines show the effect of the averaging kernel.

- Best agreement using MISR vertical profile and prescribed emission factors (higher for CO from Alves et al., 2011);
- Underestimate above the ocean may partly be due to too large diffusion of the simulated transported plume;
- Southward transport: comparison to CALIOP shows that the plume is transported at too low altitude in the model.

### Example profile comparisons (11/08/2016)

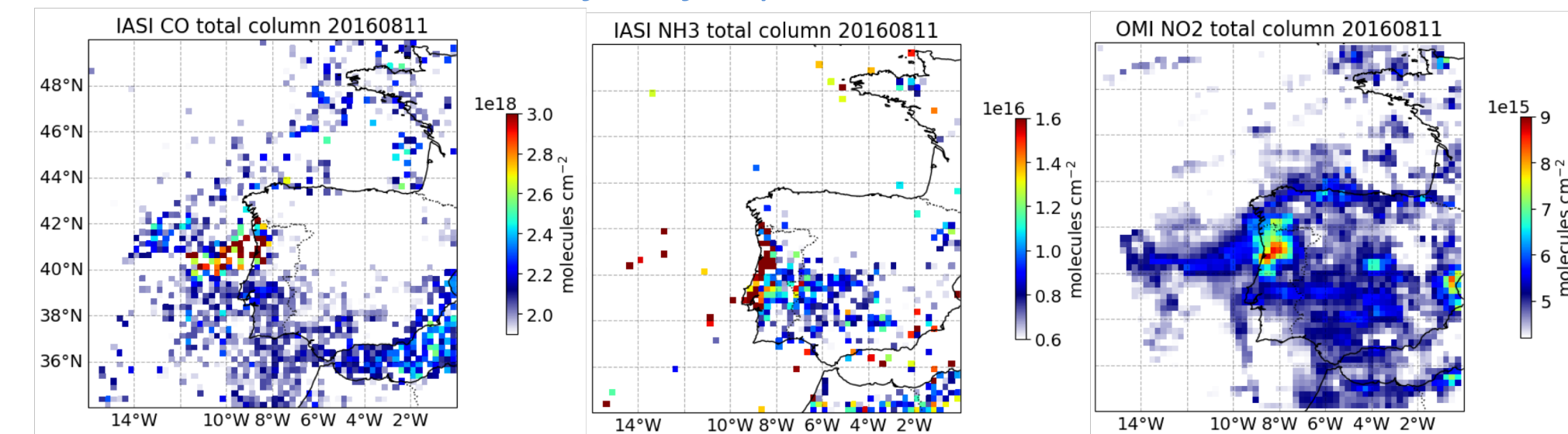


### Preliminary analysis of emission ratios

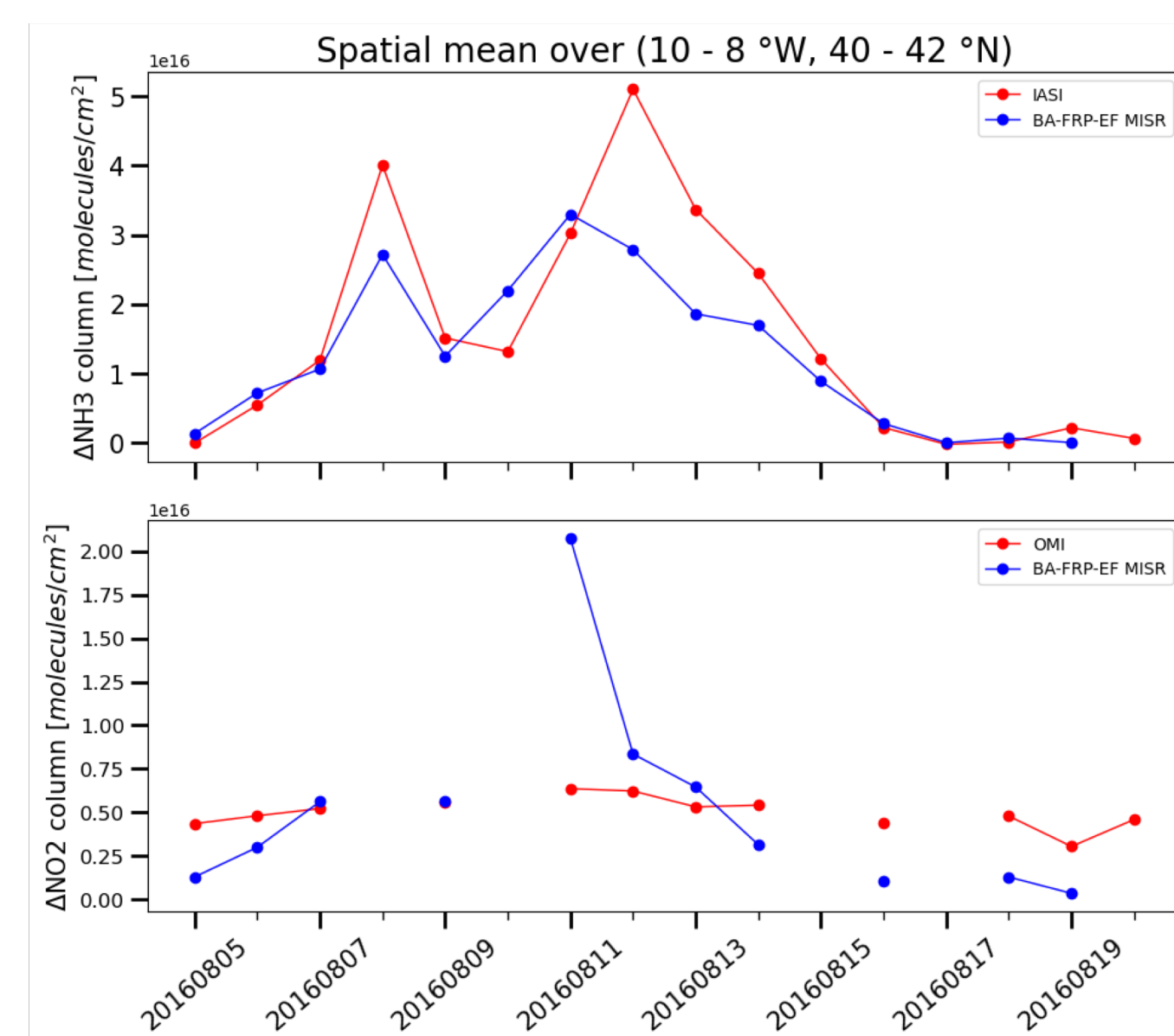
IASI NH<sub>3</sub> (van Damme, 2017; Franco 2018) gridded at 0.25° resolution (morning overpass)

OMI/Aura NO<sub>2</sub> (Krotkov et al., 2019); gridded at 0.25° res. (afternoon overpass)

### Observations of the fire plume 11/08/2016



### Enhancement above background (ΔX)



Calculation of enhancement due to fires for each species (ΔX in molec/cm<sup>2</sup>) and enhancement ratio ER with respect to total CO. Model results are collocated with observations.

Mean value 07/08 - 15/08	Observations	Simulation s
Background CO	1.33e+18	1.10e+18
Background NH3	1.276e+14	1.68e14
Background NO2	0	0
ΔCO	9.636e17	1.699e18
ΔNH <sub>3</sub>	2.575e16	1.973e16
ΔNO <sub>2</sub>	5.682e15	8.331e15
ER(ΔNH <sub>3</sub> /ΔCO)	2.8e-2	1.18e-2
ER(ΔNO <sub>2</sub> /ΔCO)	7.07e-3	4.92e-3

- CO enhancement in simulations larger than in observations, partly due to the fact that the IASI AK is not accounted for in this calculation;
- NH<sub>3</sub> enhancement slightly underestimated, but difference in ER well within the uncertainty in EF;
- NO<sub>2</sub> enhancement strongly overestimated in the simulations. The NO<sub>2</sub> map on the 11/08 shows enhancements up to 9x10<sup>15</sup> molec/cm<sup>2</sup> above the fire region, closer to the averaged model value. The extent of the NO<sub>2</sub> plume in CHIMERE is larger, either due to overestimated emissions, wrong temporal variations and/or overestimated NO<sub>2</sub> lifetime.

### References.

Turquety, S., Menut, L., Siour, G., Mailler, S., Hadji-Lazaro, J., George, M., Clerbaux, C., Hurtmans, D., and Coheur, P.-F.: APIFLAME v2.0 biomass burning emissions model: impact of refined input parameters on atmospheric concentration in Portugal in summer 2016, Geosci. Model Dev., 13, 2981–3009, <https://doi.org/10.5194/gmd-13-2981-2020>, 2020.

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