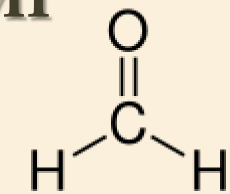
On the consistency of top-down hydrocarbon emissions inferred from GOME-2 and OMI formaldehyde observations



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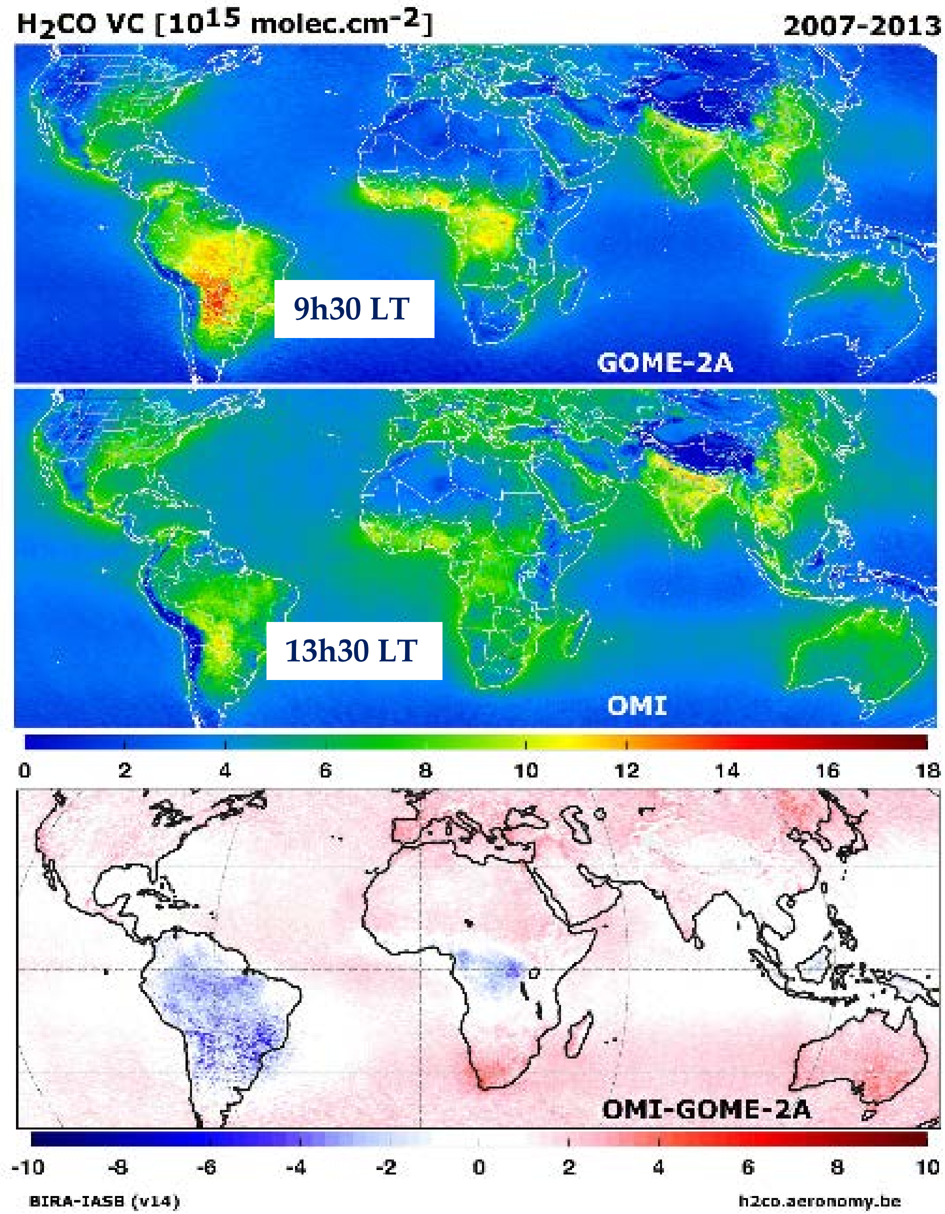
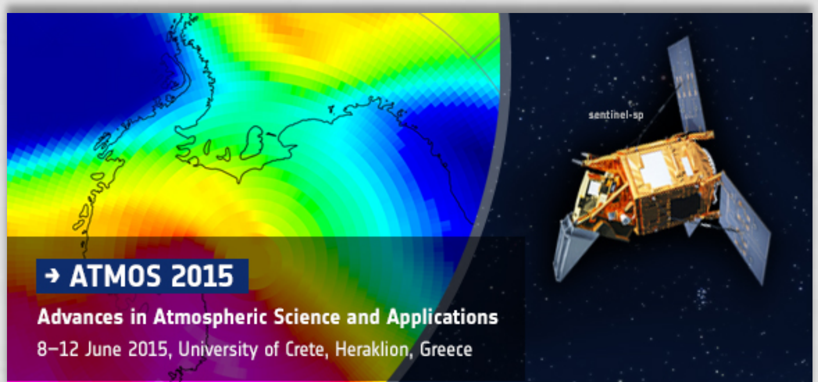




State-of-the-art

- Strong potential of HCHO columns to constrain VOC fluxes (*Palmer et al., Millet et al., Dufour et al., Barkley et al. , Stavrakou et al., Marais et al.)*
- In some cases conflicting results for the magnitude/variability of the sources, mostly due to differences in the satellite products, models & a priori inventories
- VOC emission derivation remains challenging (large number and diversity of HCHO precursors, uncertainties in their sources & chemical oxidation) and crucially depends on the quality of the retrievals (instrumental degradation, noise reduction, error characterization, *De Smedt et al., Hewson et al.*)

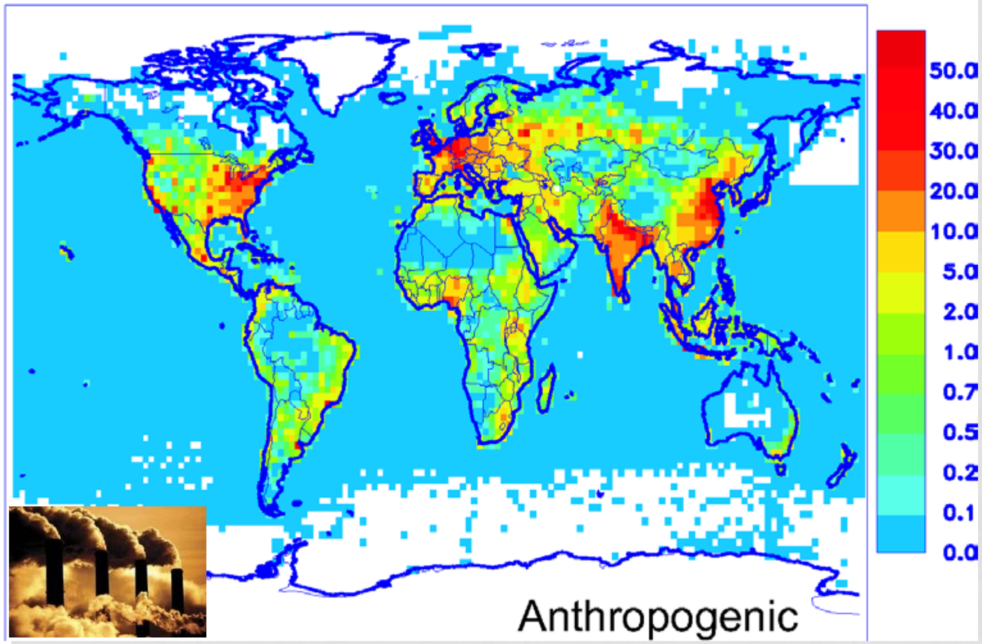
Our objective is to

- Investigate the diurnal variability of HCHO columns using a global CTM
- Evaluate the model skill to reproduce observations of diurnal cycle of HCHO columns at different locations
- Address consistency between VOC fluxes inferred from inversion of a complete year of GOME-2 and OMI HCHO columns

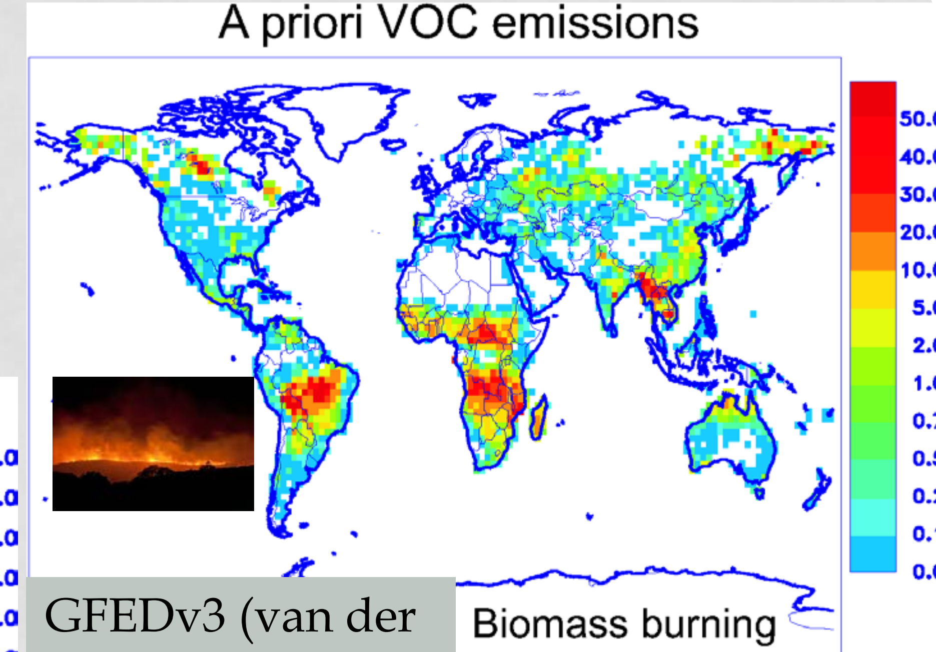
How?

- Use GOME-2 and OMI 2010 columns as constraints in 2 inversions based on IMAGESv2 model *(Stavrakou et al. 2015)*
- Satellite algorithms designed to ensure maximum consistency of the two datasets *(De Smedt et al. 2015)*

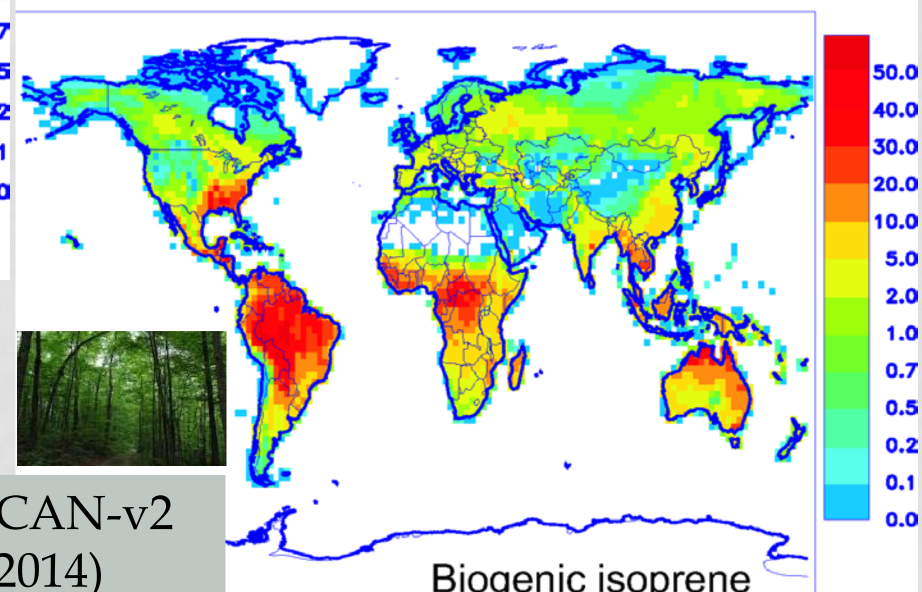
A priori emissions in IMAGES



REASv2+RETRO+NEI



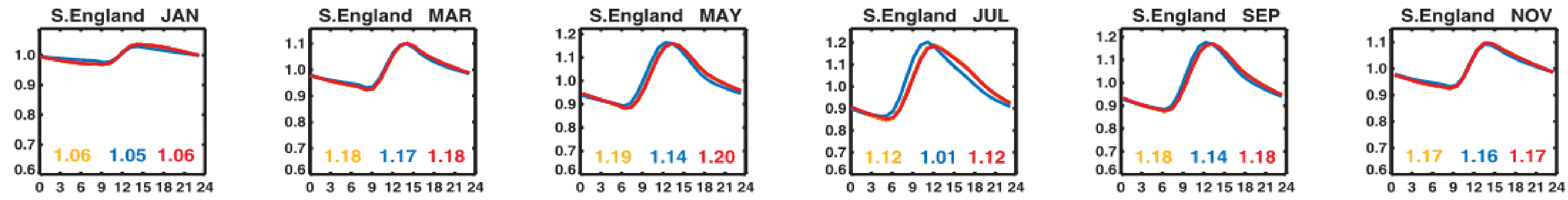
GFEDv3 (van der Werf et al. 2010)



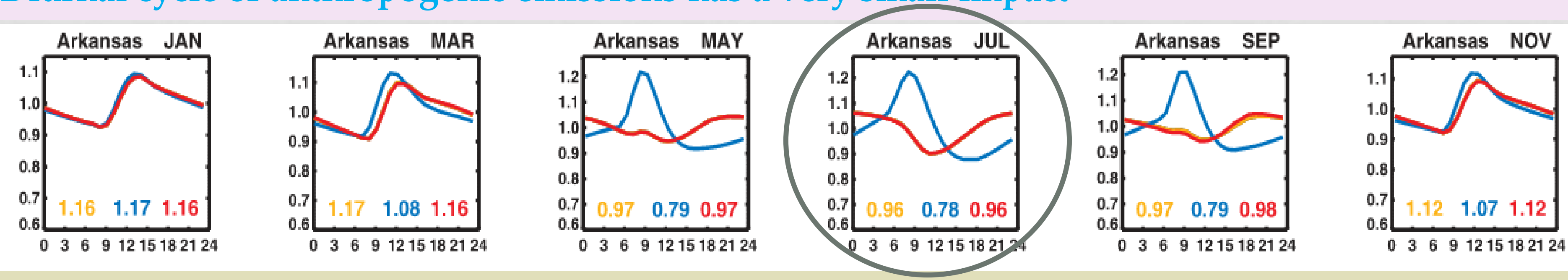
MEGAN-MOHYCAN-v2 (Stavrakou et al. 2014)

Diurnal variations of HCHO columns

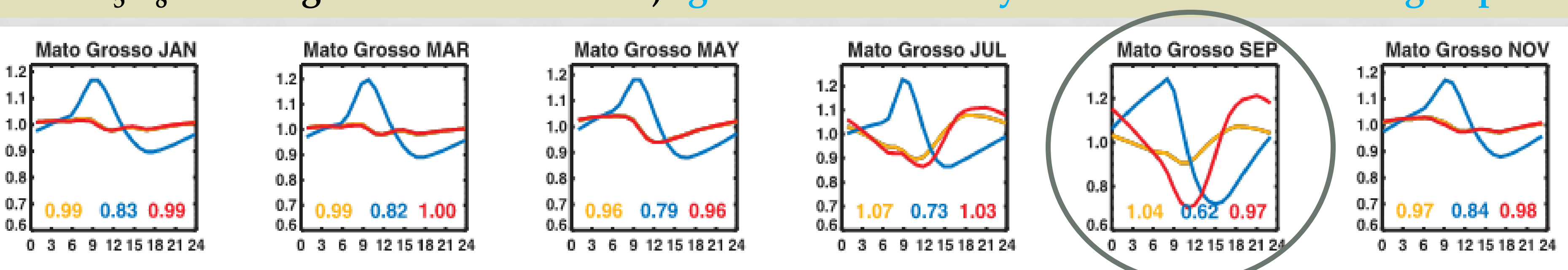
Standard No diurnal variation
No BB emissions



Anthrop. emissions are dominant → midday max. & nighttime min.
Diurnal cycle of anthropogenic emissions has a very small impact



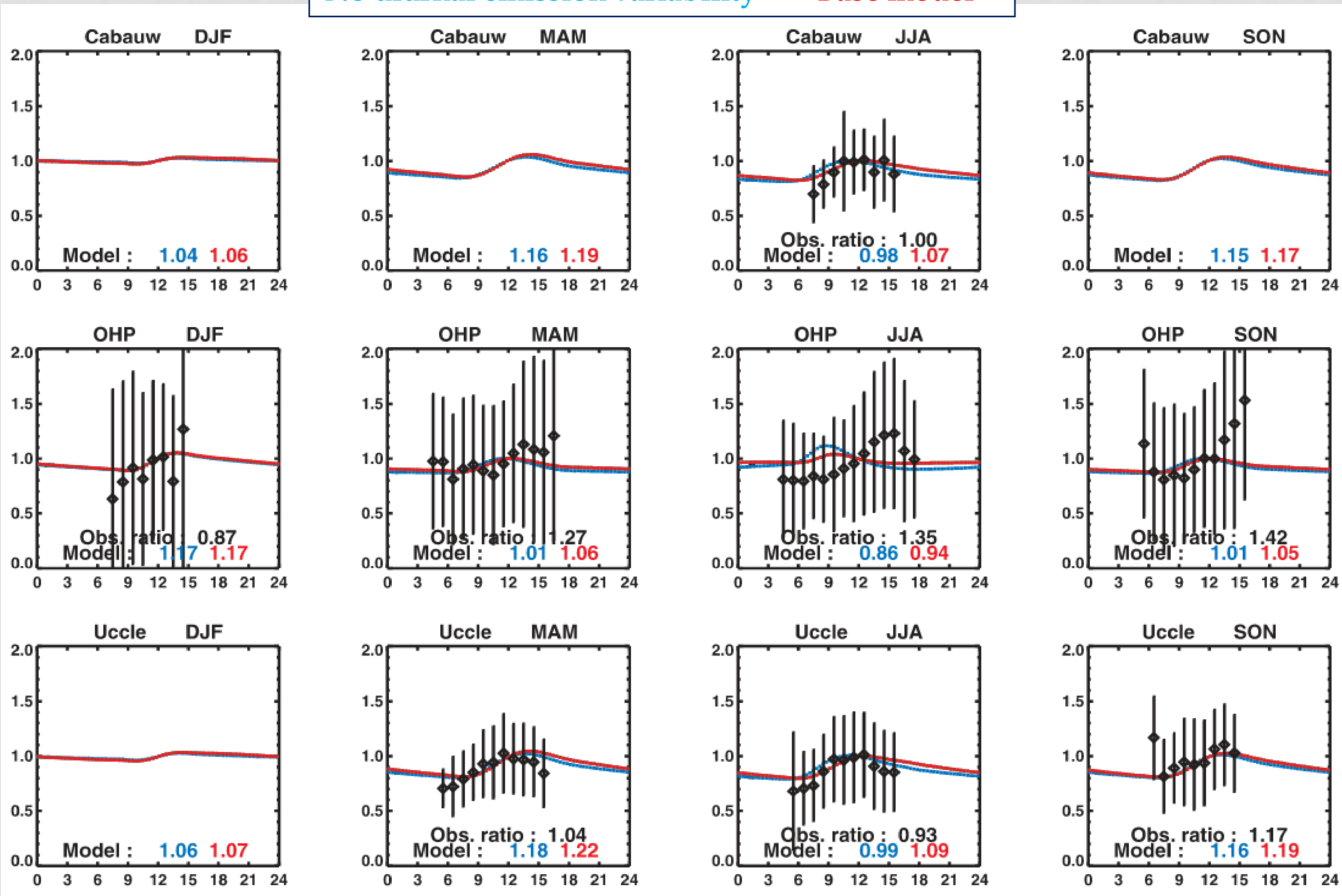
Isoprene emissions dominant → midday min., rise in the afternoon (delayed HCHO formation from C_5H_8 and long-lived intermediates) Ignore the diurnal cycle of emissions ? Strong impact !



Vegetation fires cause strong variations (Sept.)→ midday min. & max. in the evening (diurnal cycle of vegetation fires peaks in the afternoon), Ignore BB emissions ? Weaker diurnal cycle

Model and observed diurnal variations of HCHO columns

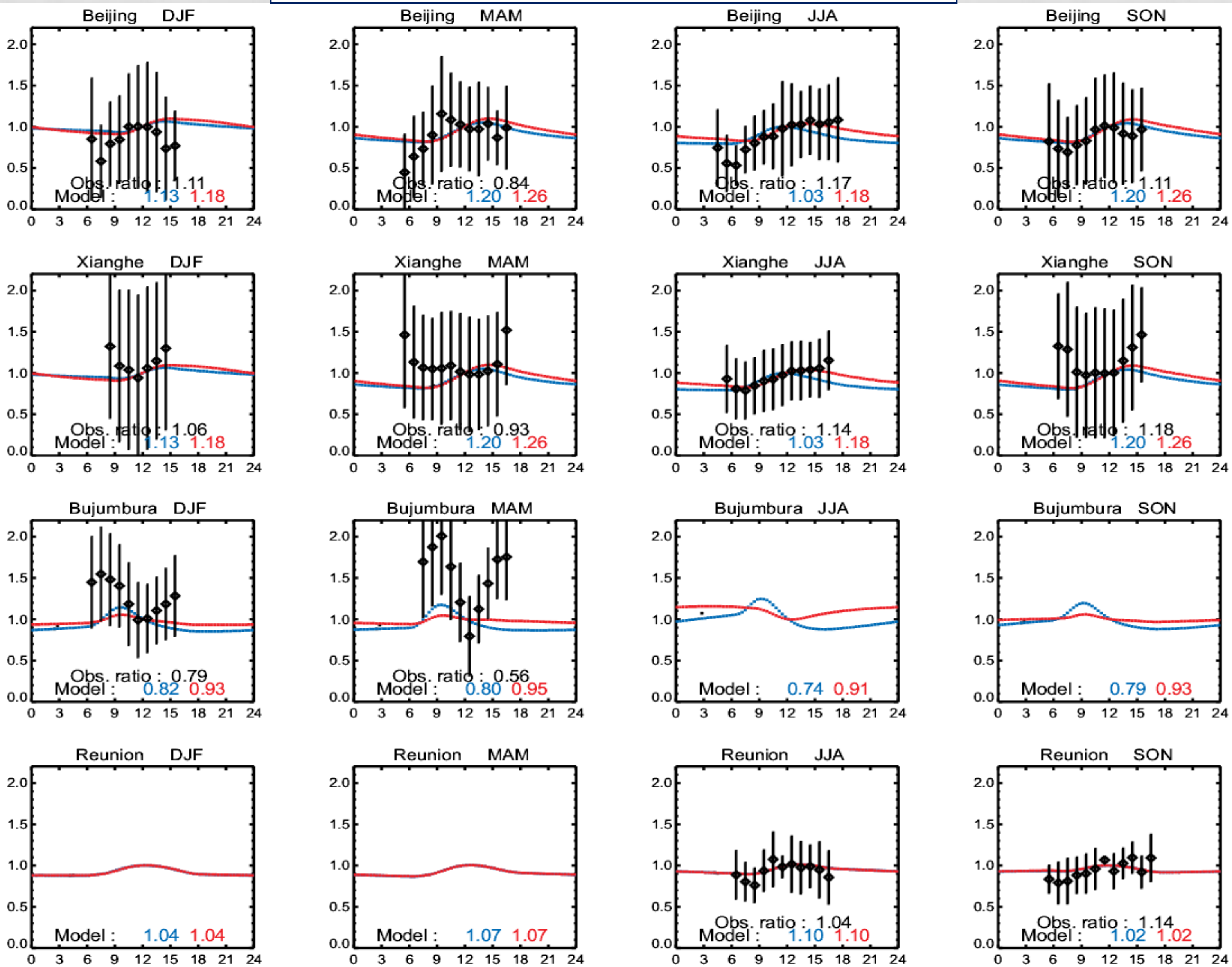
No diurnal emission variability   Base model



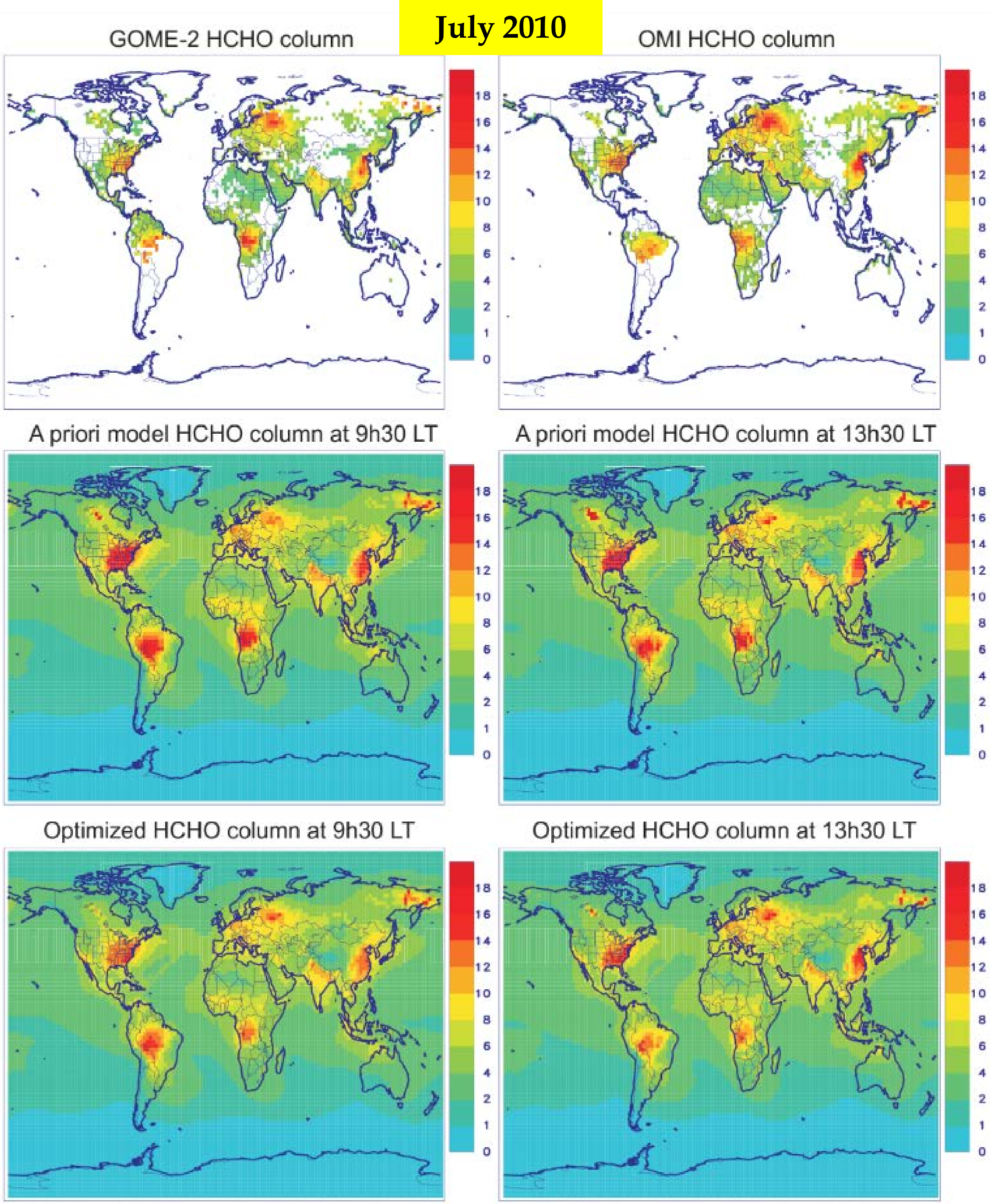
At polluted sites (Uccle, Cabauw) diurnal pattern very well reproduced

Representativity issues at OHP? **Observed 13h30/9h30 ratios : 0.8-1.2**

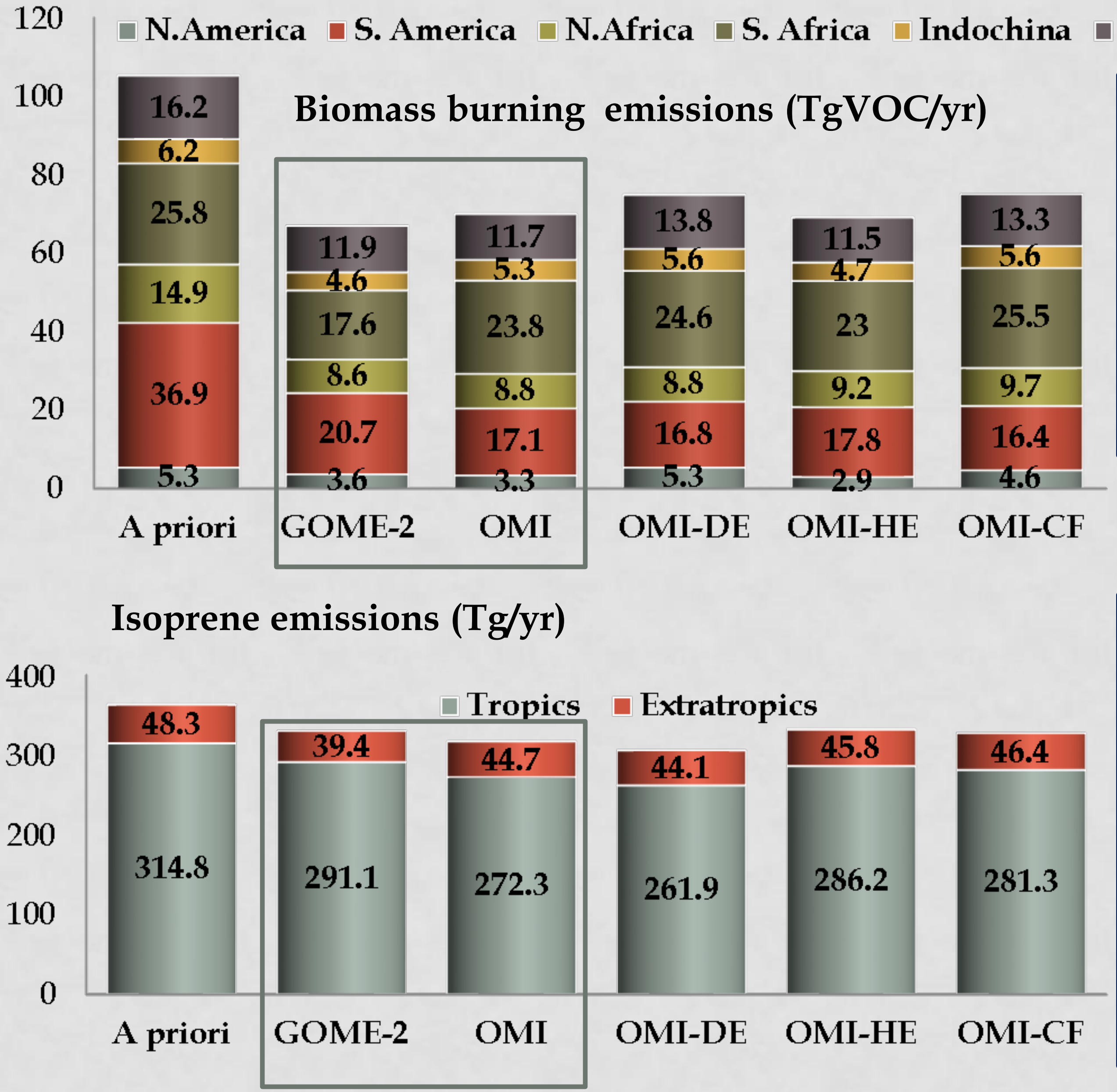
No diurnal emission variability Base model



Very good agreement at Reunion (remote site → CH_4 oxidation is dominant HCHO source)
Average ratio at all sites/locations is slightly higher in the model (1.126) than in the data (1.043)

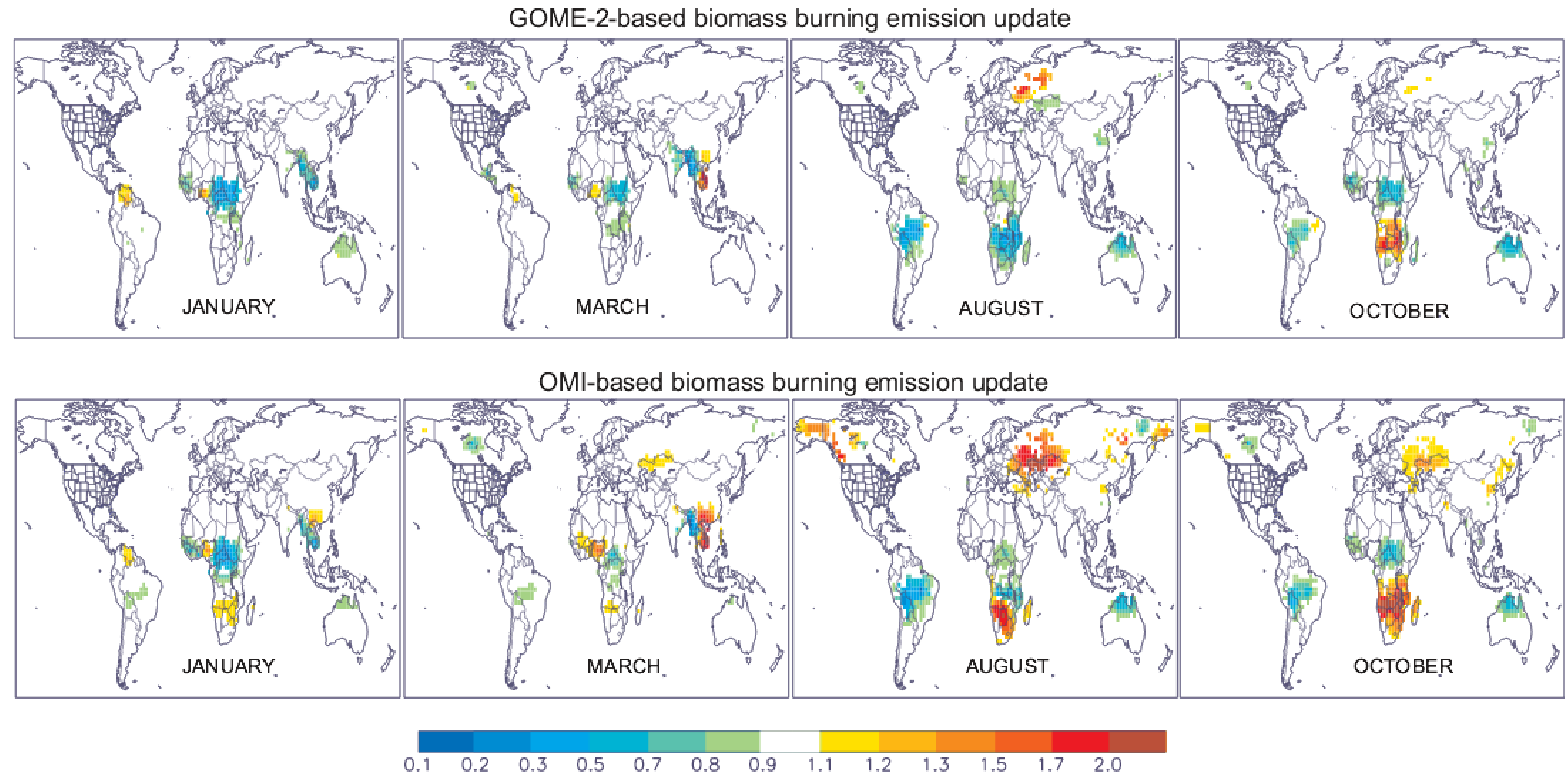


- **Early afternoon columns are higher than morning columns at mid-latitudes, but lower at tropical locations, in good agreement with gb and model**
- **A priori columns are generally higher than the observations**
- **Grid-based inversion approach based on IMAGESv2 CTM (Stavrakou et al. 2015) → infer emission rates per month and grid → 60000 variables**
- **Very good a posteriori agreement with the satellite, how is it realized?**

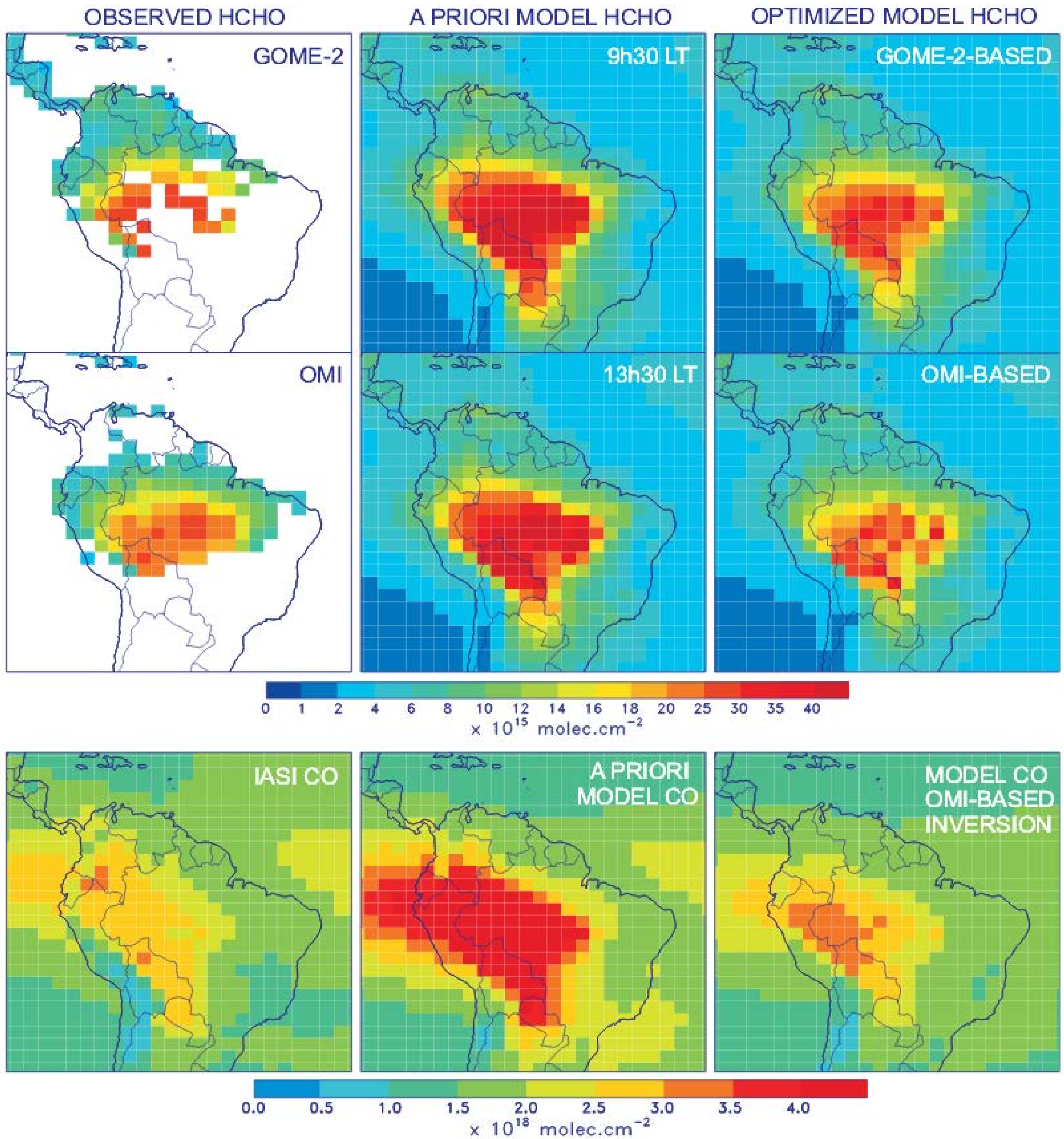


- Global BB fluxes decline by 36% (GOME-2) and 33% (OMI)
- Substantial drop over tropical forests (S.America/Indochina) and in N. Africa

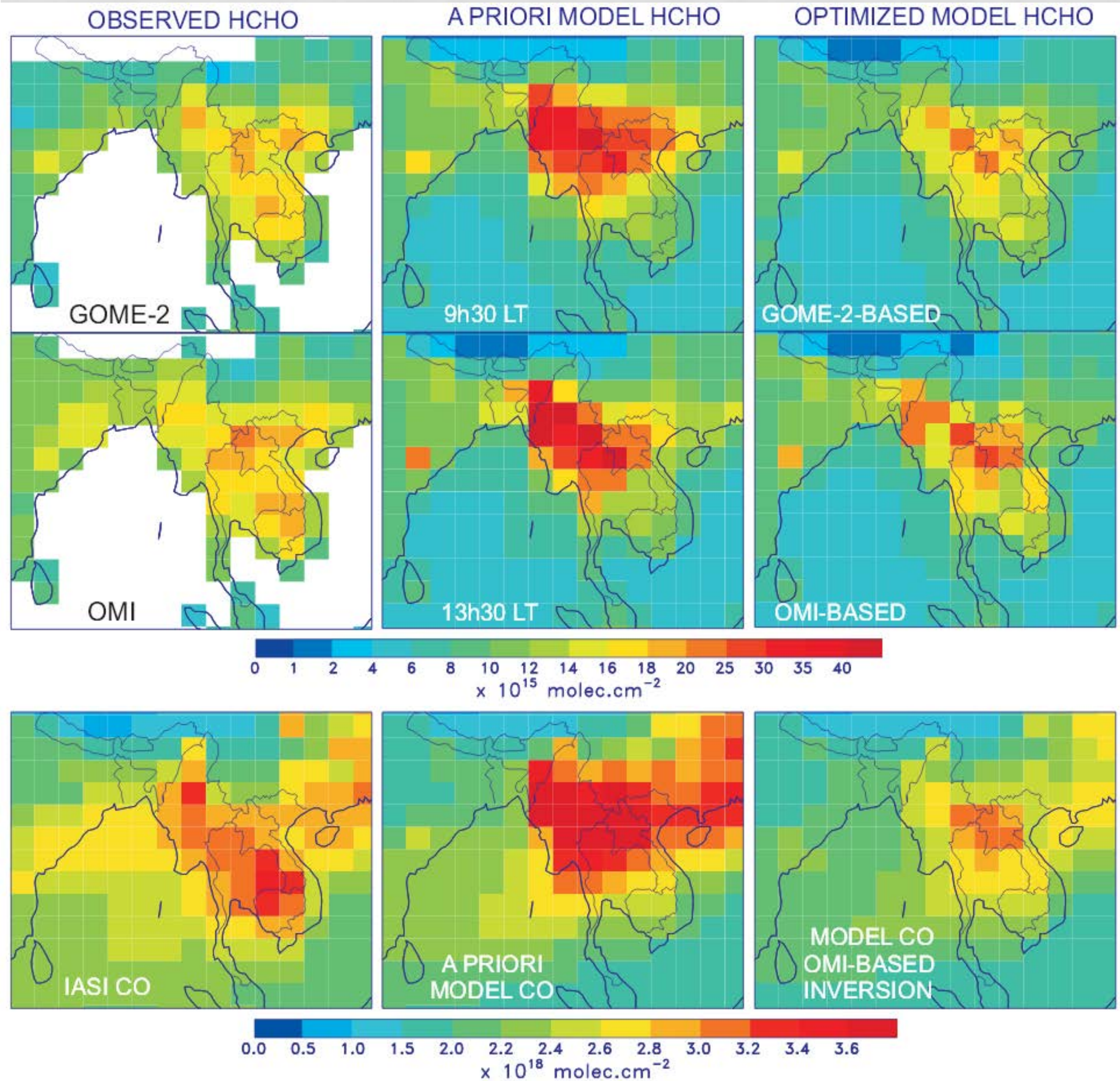
- Inferred decrease of the global isoprene source, by 9% (GOME-2) and 13% (OMI) wrt 363 Tg (prior)
- Sensitivity estimates lie within 7% of the standard inversion results (OMI) globally



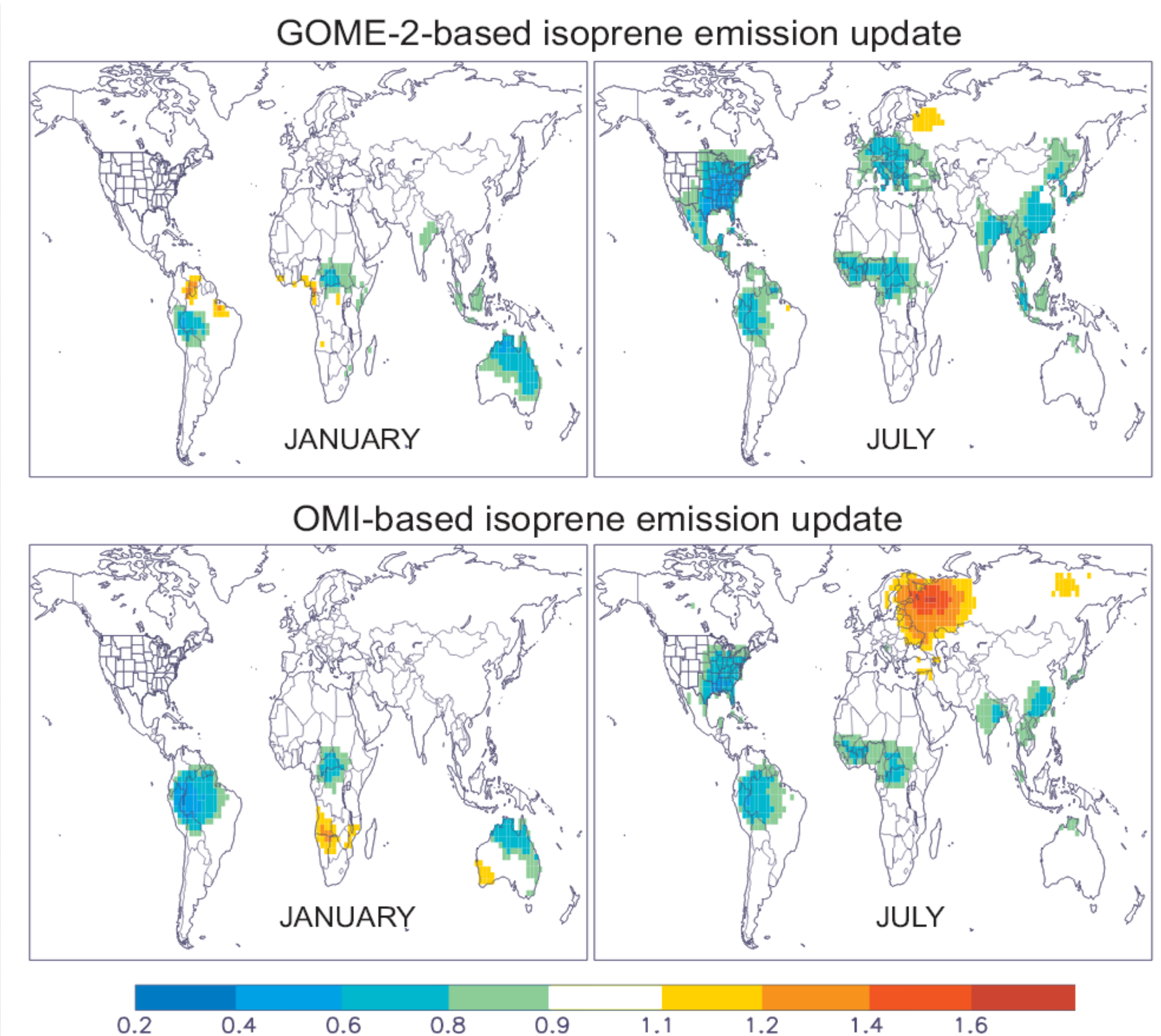
- Consistent decline of biomass burning fluxes in N. Africa, by up to 30-40%
- During the Russian fires both instruments point to a substantial rise of the emissions (63% OMI, 43% GOME-2), GOME-2 columns are lower than OMI
- Very good agreement over Amazonia during the severe drought of August 2010, and in former Indochina in March 2010, however, discrepancy is found in S.Africa in August



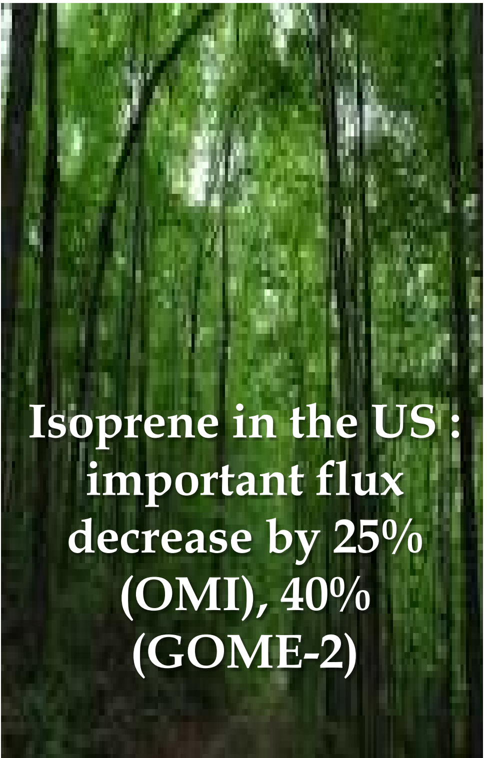
- Strong emission decrease in August 2010 supported by independent observations of CO columns by IASI
- GFEDv3 leads to a large overestimation by ca. x2 in Western Amazonia



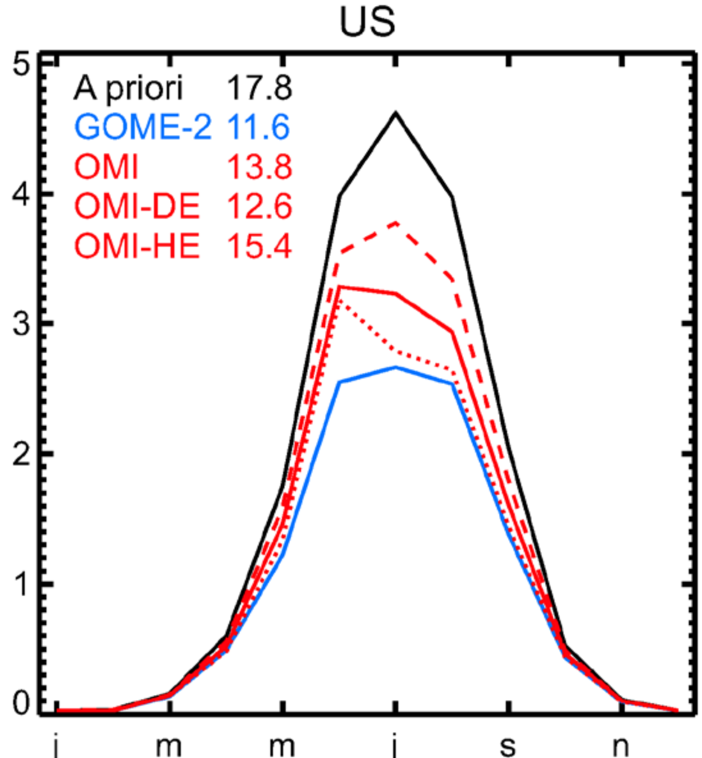
- **Strong emission decrease in March 2010 supported by IASI CO**
- **Emission enhancement required to match HCHO columns in SE Indochina might be due to agricultural fires, not well represented in GFEDv3 (but FINN suggests x10 higher emissions in this region)**

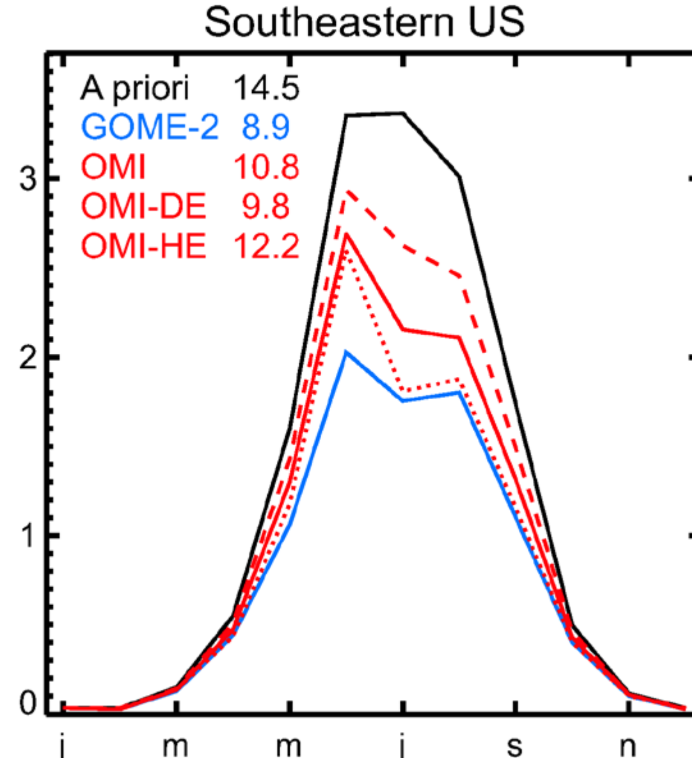


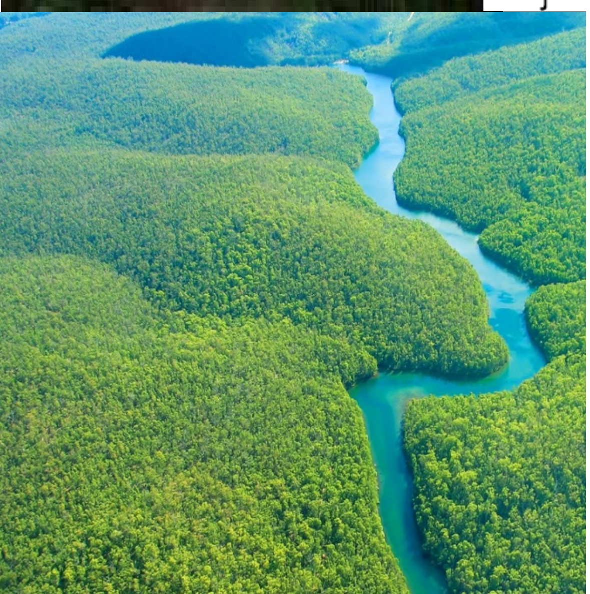
High overall consistency btw the inferred updates, decrease over the US, Amazonia and SE Asia, increase in Russia

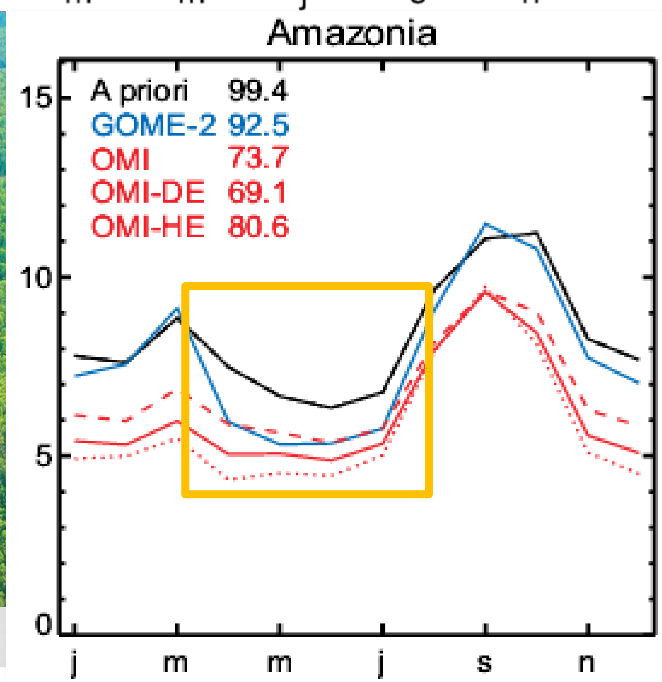


Isoprene in the US : important flux decrease by 25% (OMI), 40% (GOME-2)









Reduction during the wet-to-dry transition (Apr-Jun)

Conclusion

Our study

- demonstrates the high degree of consistency between top-down emissions derived from GOME-2 and OMI data, weak sensitivity to changes in key uncertain parameters
- identifies important large regions (SE US, Amazonia) with large discrepancies btw bottom-up and top-down estimates and where the satellite-based emissions show best consistency
- underscores the need for in situ observations as a basis for improving and assessing model simulations of diurnal variations

Thanks to data providers :
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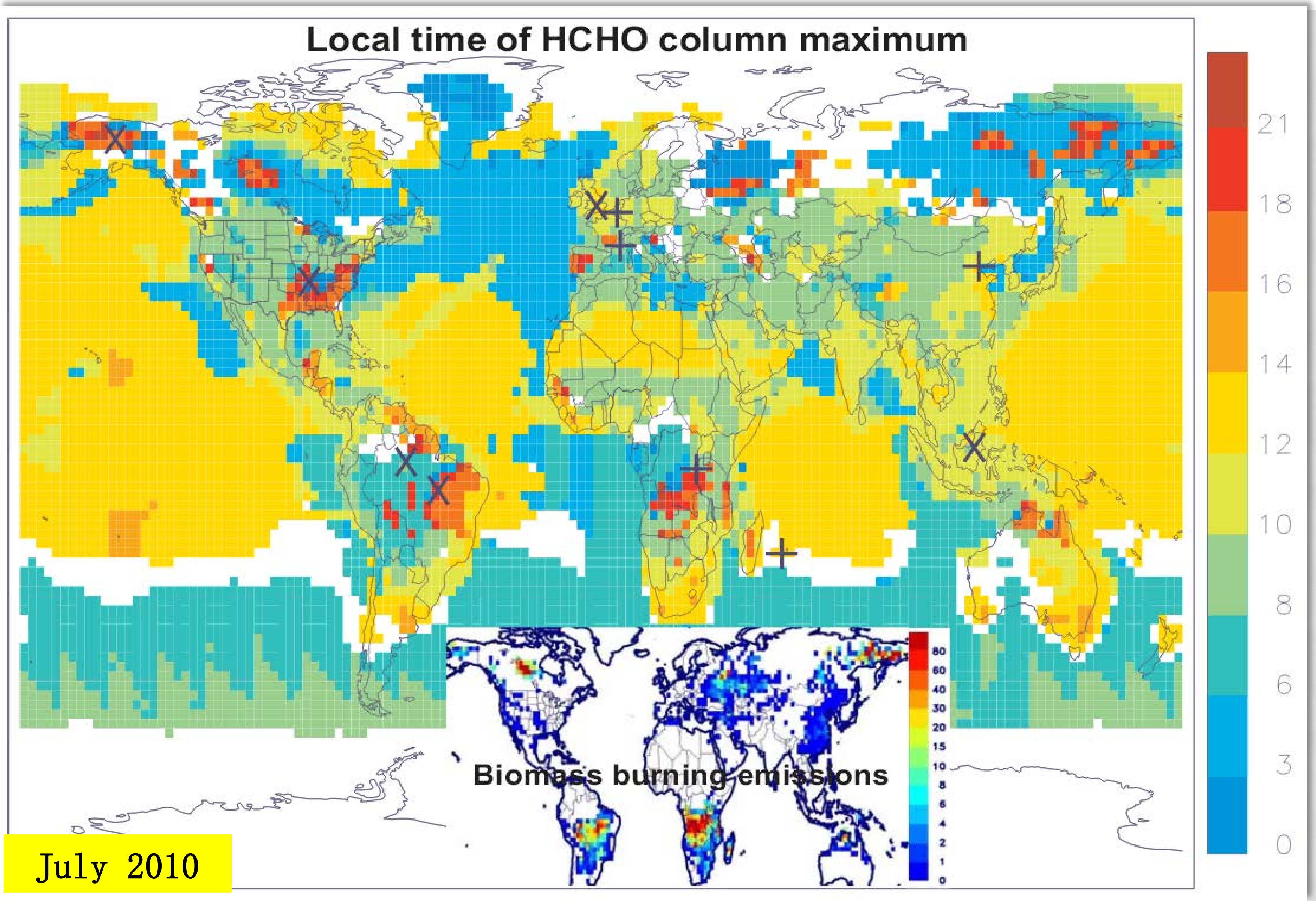
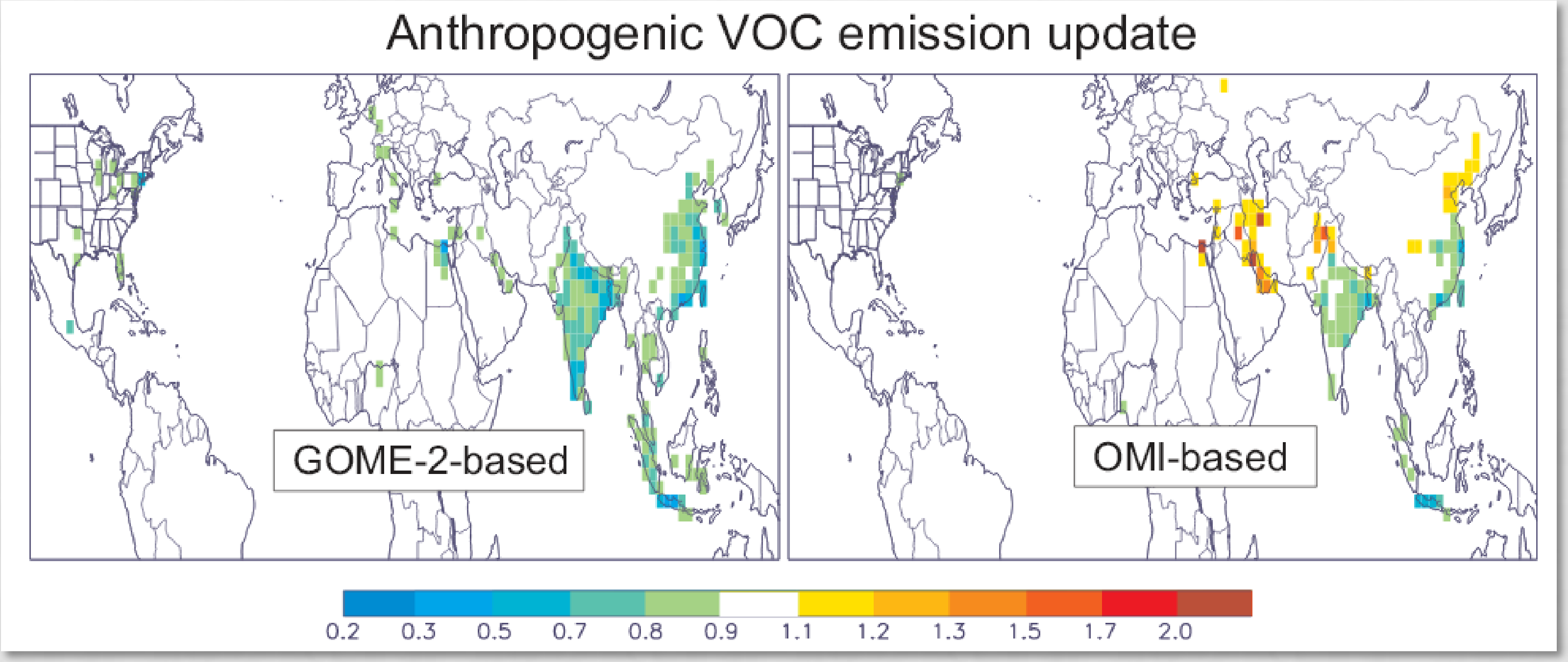
F. Hendrick (MAX-DOAS HCHO @ China)
C. Clerbaux, P.-F. Coheur (IASI CO)



- Large diversity of diurnal patterns across location (and season)
- Midday maximum over oceans, where the dominant source of HCHO is CH_4 oxid.
- Over continents, complex reasons (radiation, NOx levels, occurrence of fires, etc.)



- Global anthropogenic VOC fluxes not well constrained, negligible updates over most regions, except over highly polluted regions