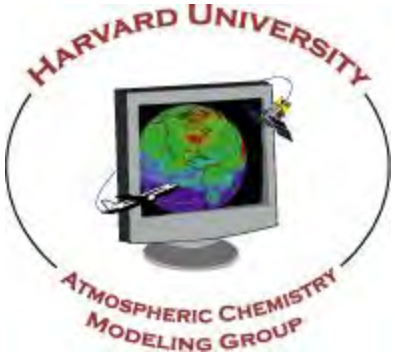
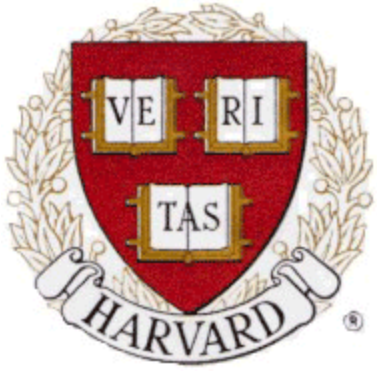
Using GEOS-Chem and OMI HCHO to estimate isoprene emissions over Africa



Eloïse Marais, *Harvard Earth and Planetary Sciences*

also D. Millet, J. Murphy, C. Reeves, M. Barkley, S. Casadio, T. Kurosu, K. Chance, R. Koster, S. Mahanama, J. Mao, F. Paulot, A. Padmanabhan, D.J. Jacob

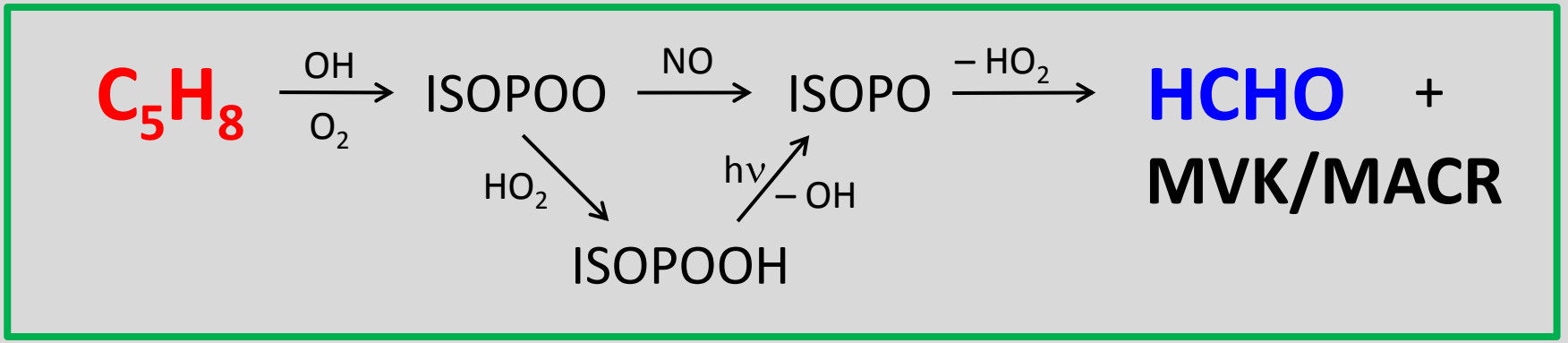


Project funded by **NASA ACMAP**

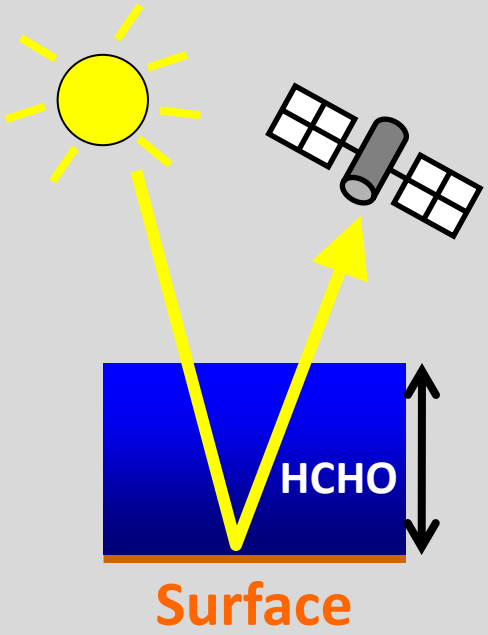
5th International GEOS-Chem User's Meeting

2-5 May 2011

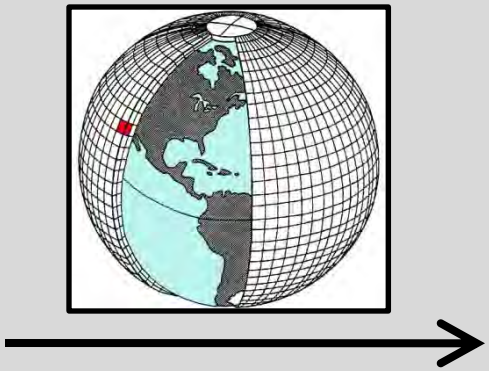
Estimating isoprene emissions from GEOS-Chem



OMI HCHO



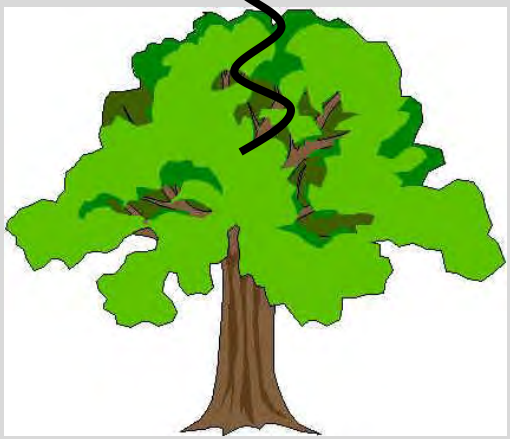
GEOS-Chem



$$E_{isop} = \Omega_{HCHO} \times \frac{k_{HCHO}}{Y_{Isop \rightarrow HCHO}}$$

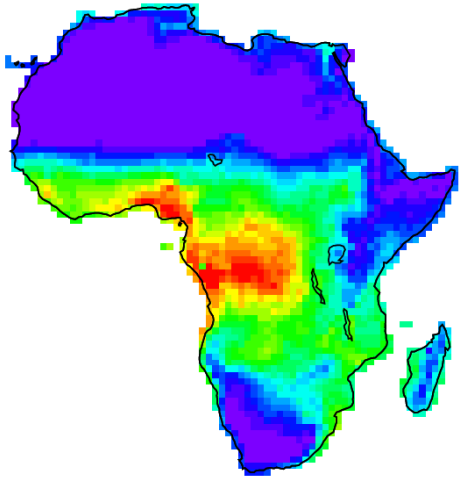
OMI Isoprene emissions

C_5H_8



Deriving a biogenic HCHO signal over Africa

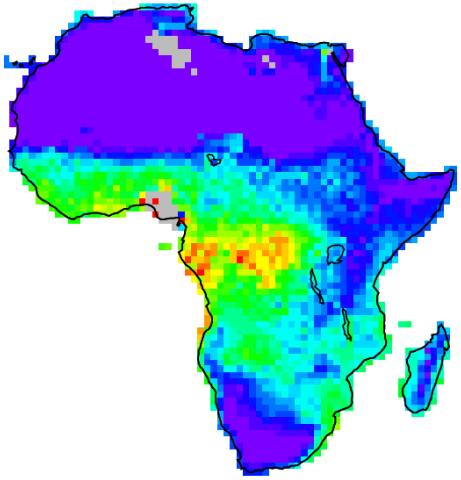
Original OMI HCHO slant columns for 2005-2009



Remove biomass burning and anthropogenic HCHO

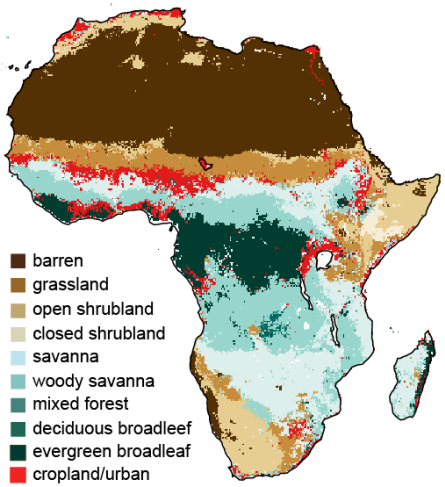
USE:
MODIS fire counts
OMI AAOD
AATSR fire counts

Biogenic OMI HCHO slant columns for 2005-2009



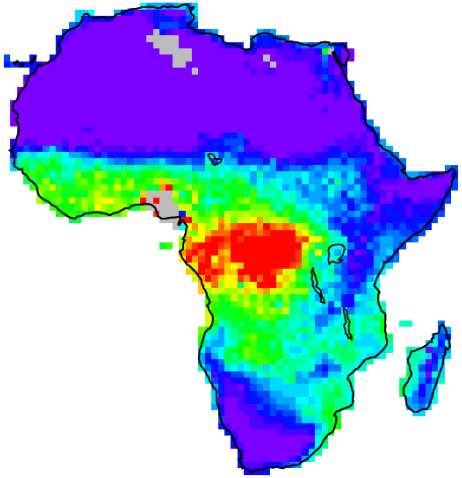
Apply AMF

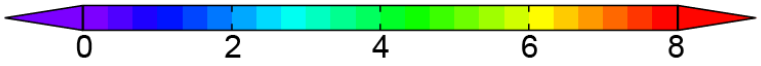
MODIS IGBP land cover data



Spatial consistency with land cover data

Biogenic OMI HCHO vertical columns for 2005-2009

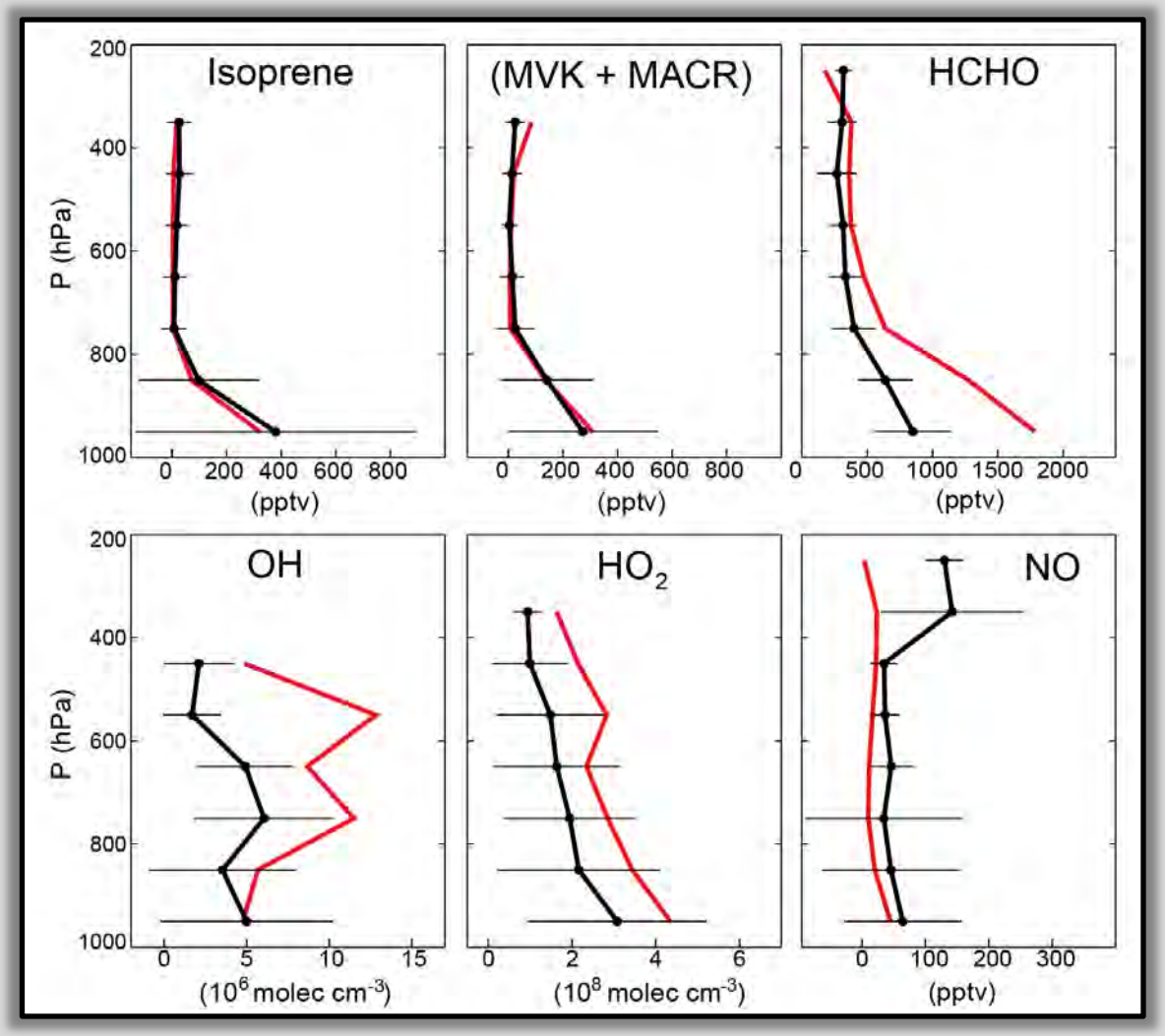




[10^{15} molecules cm^{-2}]

Test GEOS-Chem using AMMA aircraft observations

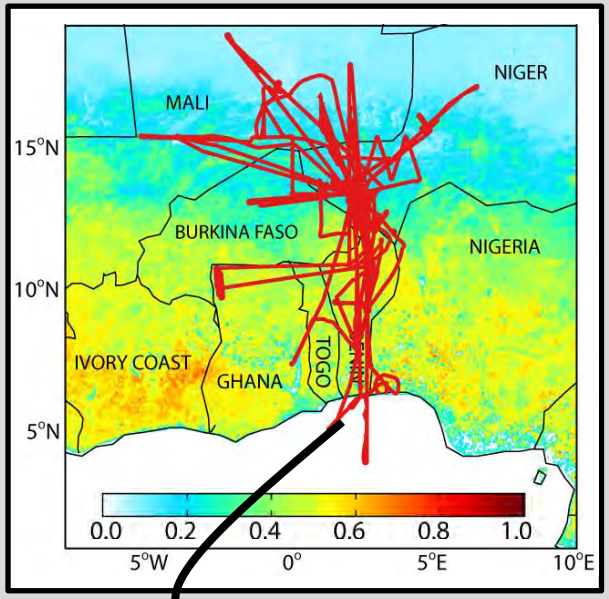
Mean vertical profiles of species simulated by GEOS-Chem using **MEGAN** and the **Paulot et al. (2009) isoprene scheme** coincident with AMMA observations



AMMA

GEOS-Chem

MODIS EVI for Jul-Aug 2006 (West Africa wet season)

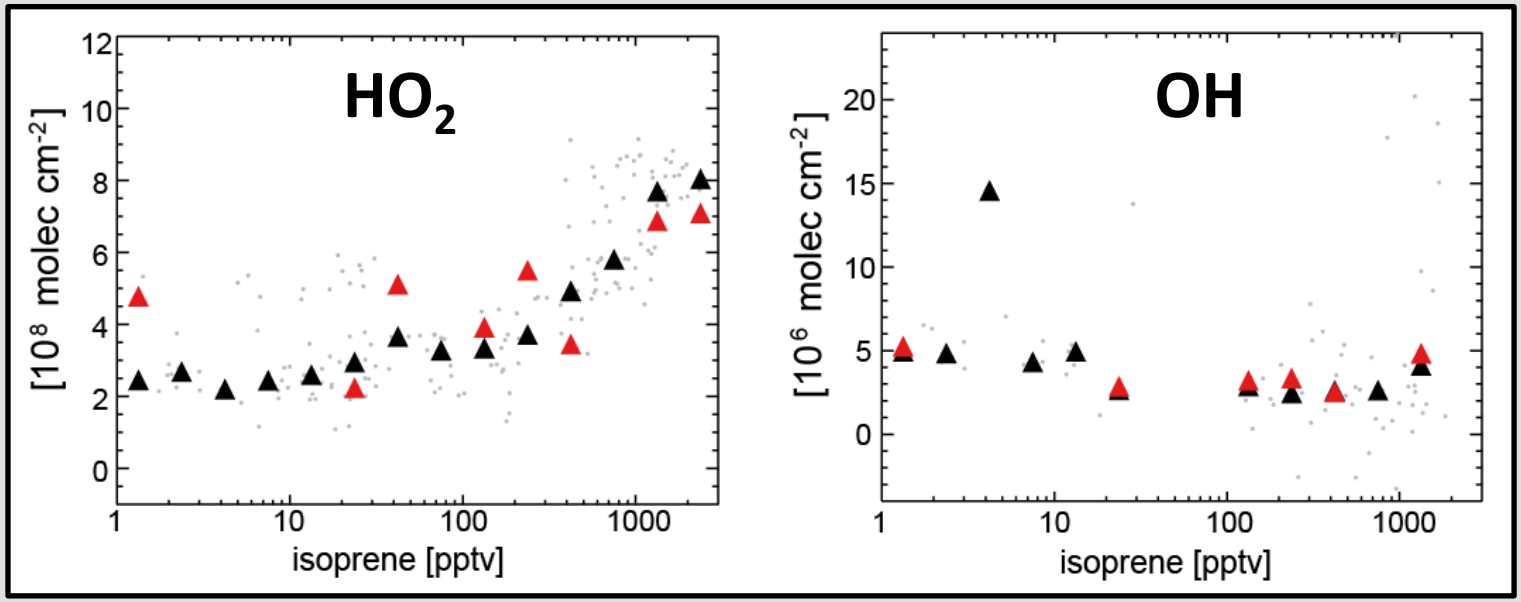


Flight tracks

Isoprene and (MVK+MACR) show good agreement, but large discrepancies between model and observations in the HCHO vertical profile over the AMMA domain.

OH and HO_2 dependence on isoprene

HO_2 and OH variability below 950 hPa as a function of isoprene during AMMA



HO_x levels from GEOS-Chem are consistent with observations

OH and HO_2 from GEOS-Chem do not exhibit an isoprene-dependent bias

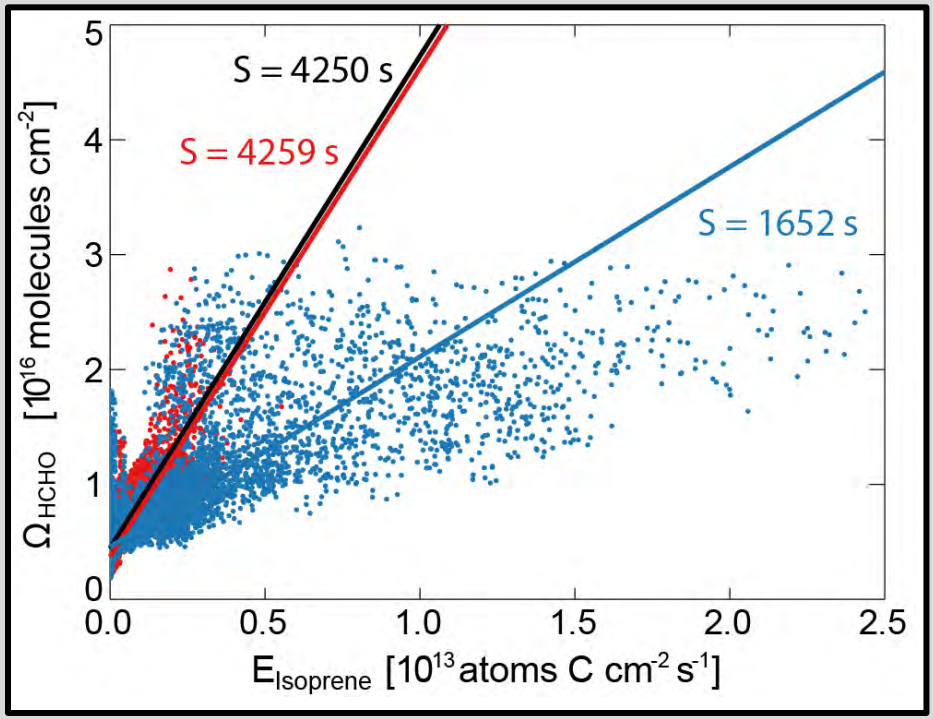
Estimate HCHO yields using GEOS-Chem

Estimate the yield of HCHO from MEGAN isoprene emissions using the relationship between Ω_{HCHO} and $E_{isoprene}$ in the model:

$$\Omega_{HCHO} = SE_{isoprene} + B$$

$$S = \frac{Y_{isoprene \rightarrow HCHO}}{k_{HCHO}}$$

HCHO from GEOS-Chem as a function of $E_{isoprene}$ from MEGAN over Africa in Jan



$NO_x < 0.01$ ppbv
$0.01 < NO_x < 0.1$ ppbv
$NO_x > 0.1$ ppbv

HCHO yields affected by NO_x in the model due to **smearing** of the HCHO signal in the model

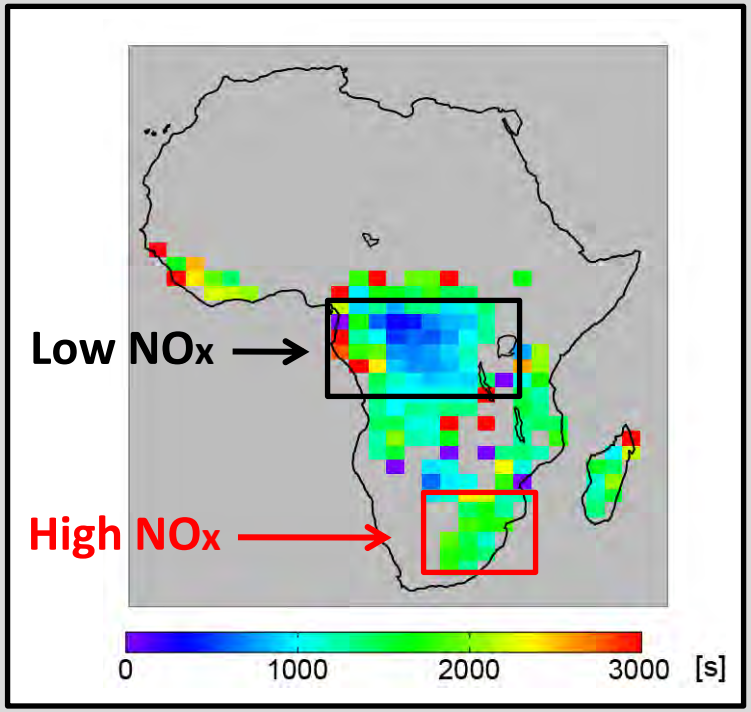
Slope values over Africa for January 2006

Instead use the relationship between (MVK+MACR) and isoprene emissions in the model:

$$S = \frac{Y_{\text{isoprene}\rightarrow\text{HCHO}}}{k_{\text{HCHO}}} = \frac{Y_{\text{isoprene}\rightarrow(\text{MVK+MACR})}}{k_{(\text{MVK+MACR})}} \times \frac{k_{(\text{MVK+MACR})}}{k_{\text{HCHO}}}$$

Accounts for the difference in loss rates of HCHO and (MVK+MACR)

Spatial variability of *S* for $E_{isop} > 2 \times 10^{12}$ atoms C cm^{-2} s^{-1}



Yields reflect spatial variability of NO_x over Africa – higher (lower) yields are obtained over high (low) NO_x regions.

Therefore, apply NOx-dependent yields of HCHO from GEOS-Chem over Africa to estimate isoprene emissions from OMI HCHO

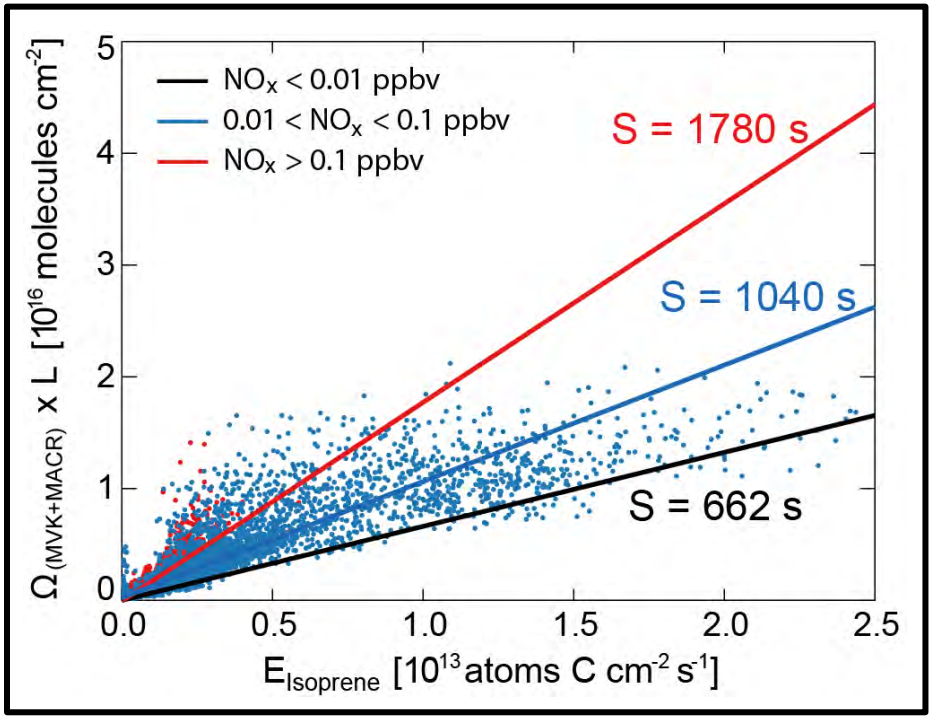
Concluding Remarks

- **The model is able to capture the variability of isoprene and (MVK+MACR) over the AMMA domain**
- **OH and HO_2 are well reproduced in the model as a function of isoprene concentration in a region that is subject to low-NO_x and high-NO_x reaction pathways**
- **(MVK+MACR) columns from GEOS-Chem can be used to obtain Nox-dependent yields of HCHO from isoprene**

Future Work: **Estimate NOx-dependent yields of isoprene from GEOS-Chem to calculate annual isoprene emissions over Africa from the OMI HCHO biogenic vertical columns for comparison with MEGAN.**

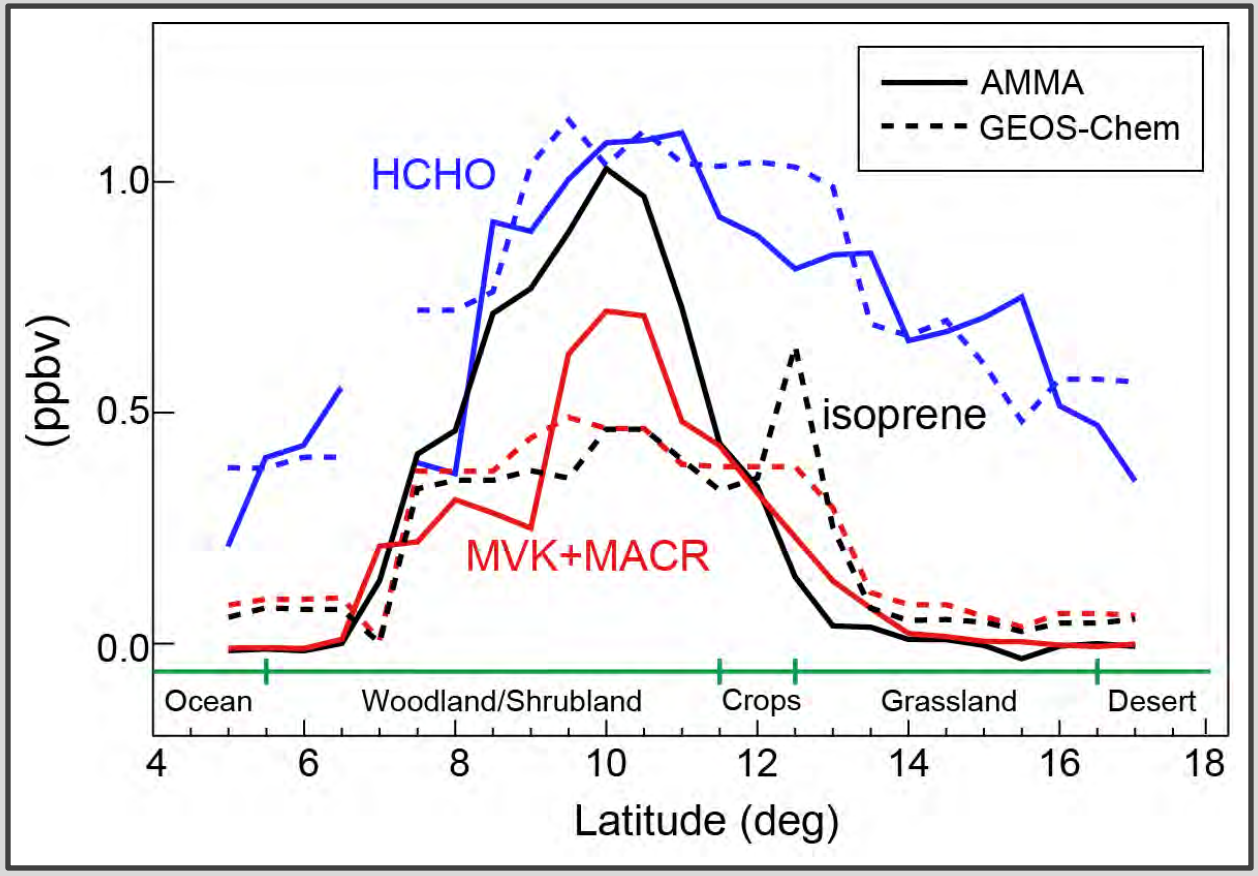
Additional Slides

Variability of *S* as a function of NO_x

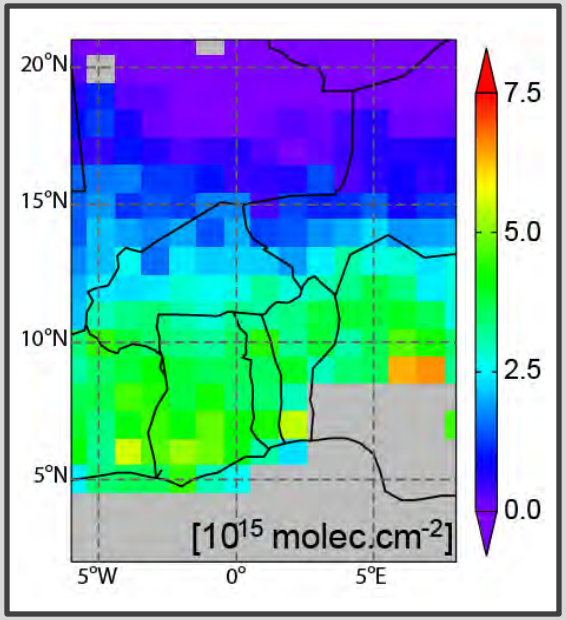


Latitudinal profile of isoprene, (MVK+MACR) and HCHO

Isoprene, (MVK+MACR) and HCHO averaged over 0.5° latitude bins



OMI biogenic HCHO for July – Aug 2005-2009

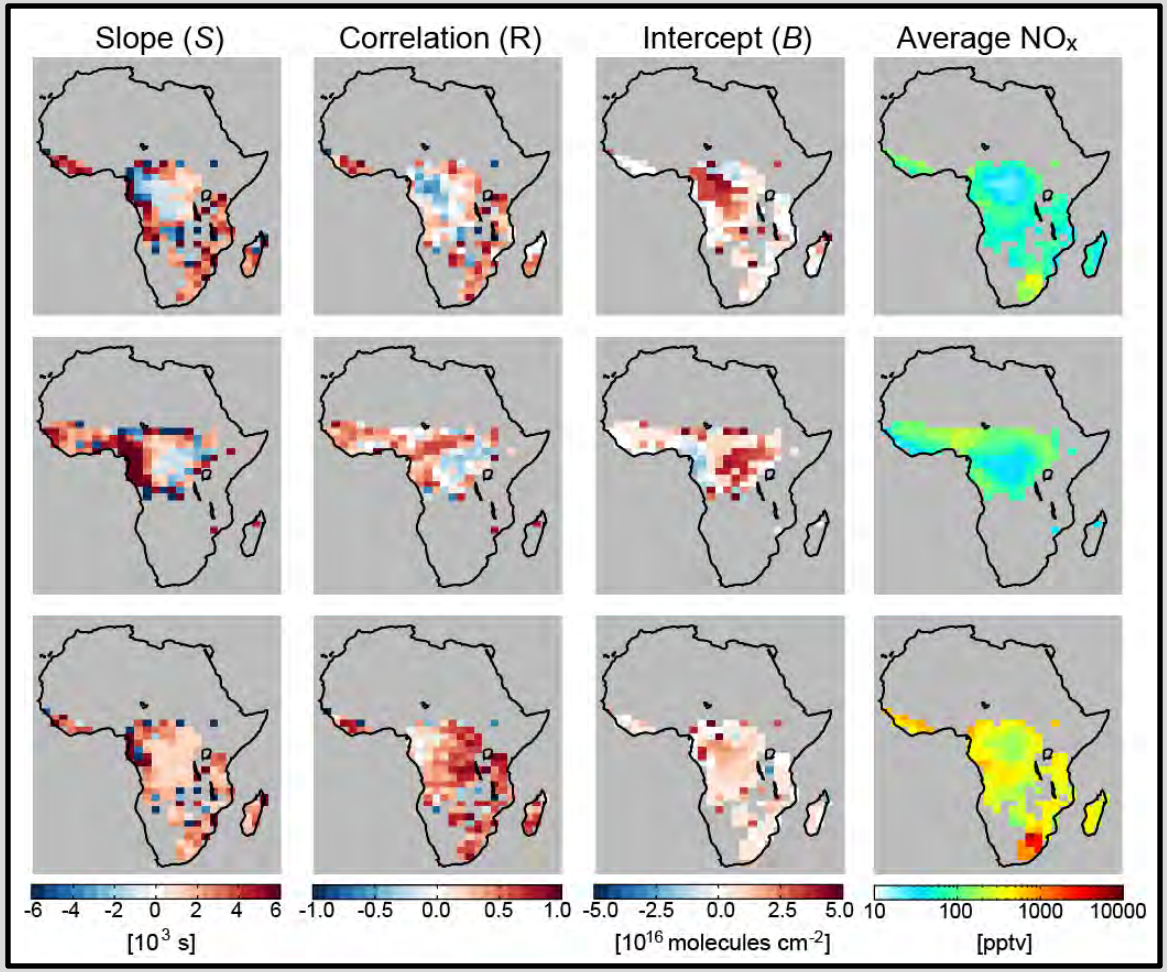


→ GC HCHO divided by 2 in plot for visual comparison

HCHO yields over Africa from GEOS-Chem

$$\Omega_{\mathrm{HCHO}} = SE_{\mathrm{Isoprene}} + B$$

Spatial variability of *S* where $E_{\mathrm{Isoprene}} > 2 \times 10^{12}$ atoms C cm^{-2} s^{-1}

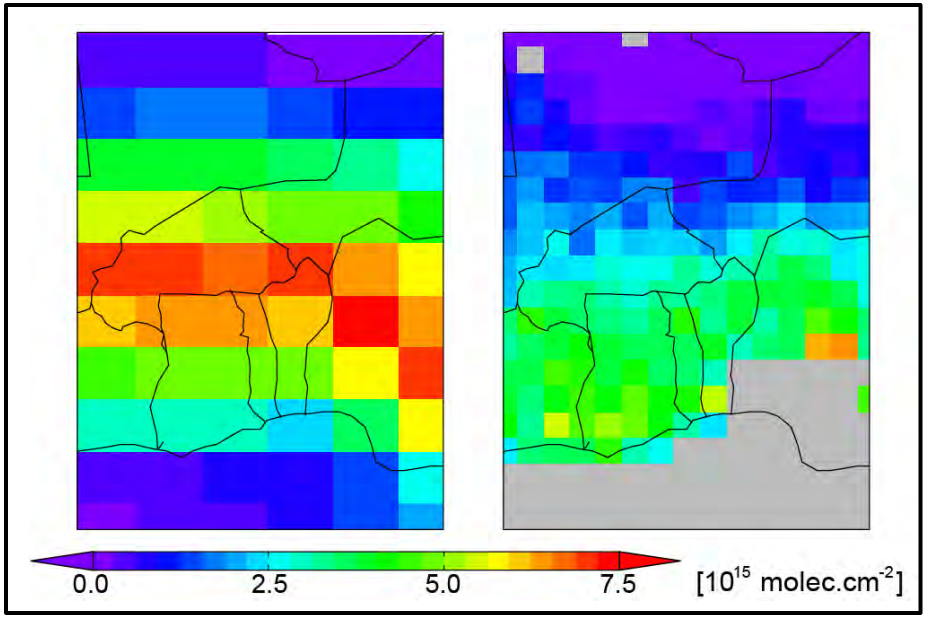


Poor correlation between HCHO and isoprene emissions in regions with low NO_x, due to delay in HCHO formation

Apply single HCHO yield over Africa to avoid introducing spatial variability from the model (**S = 1.9 × 10^3 s**)

HCHO columns from GEOS-Chem (left) and OMI HCHO (right) over the AMMA domain from July-August.

2°×2.5° resolution (2006) 1°×1° resolution (2005-2009)



Yields of HCHO over the US are lower (**1.5 × 10³ s**) than those obtained using Ω_{HCHO} (**2.1 × 10³ s**) due to additional formation of second-generation HCHO.

Use ratio value of 1.4 for the US to adjust the yield and apply to all NO_x regimes:

$$\Omega_{\mathrm{HCHO}} = 1.4 \times SE_{\mathrm{isoprene}}$$