Using OMI formaldehyde (HCHO) observations to estimate isoprene emissions over Africa

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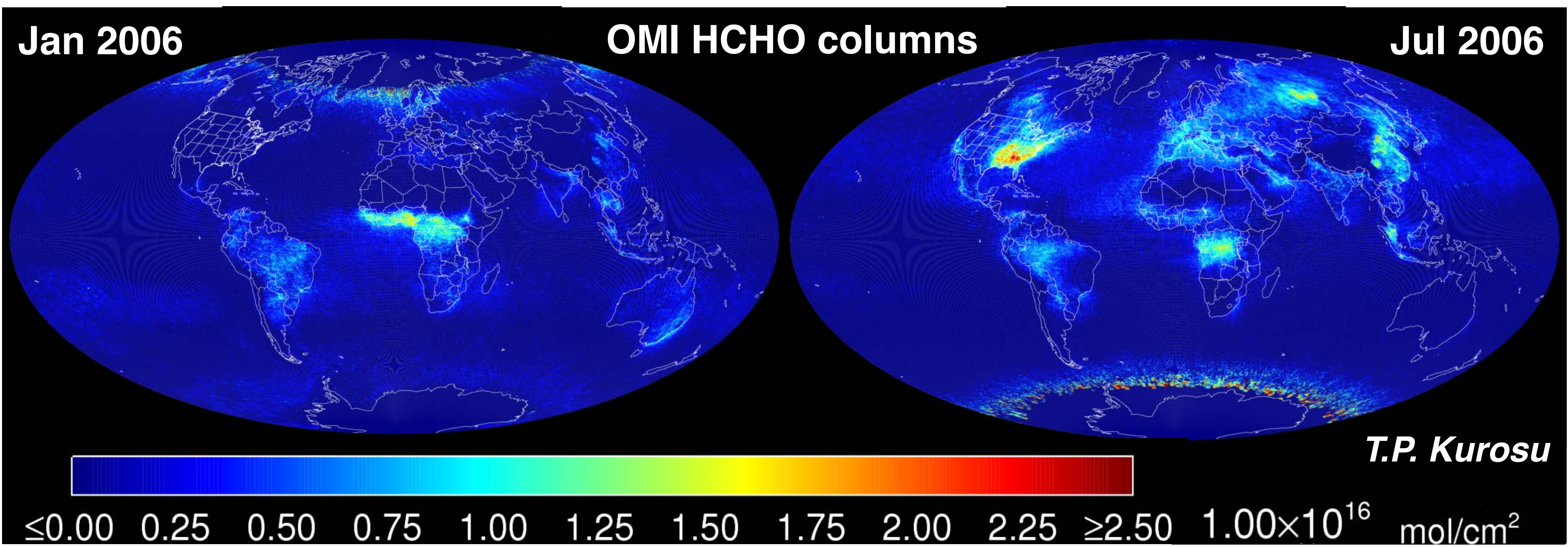
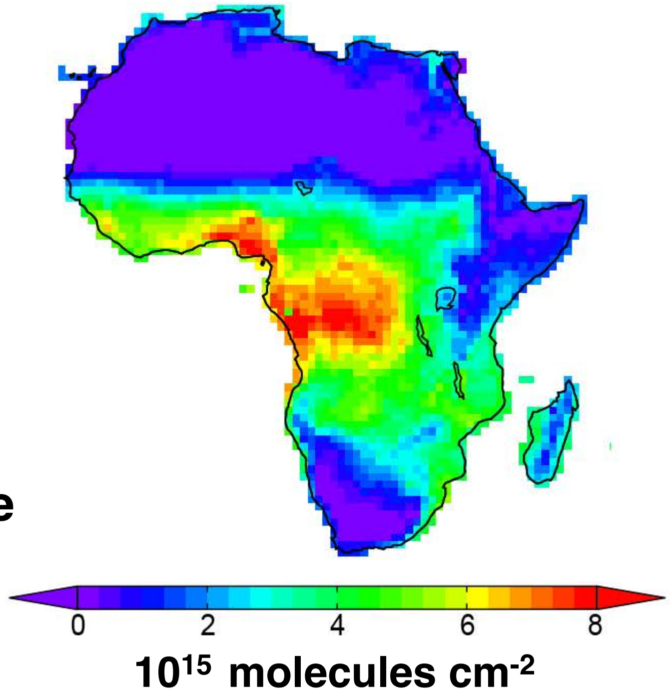


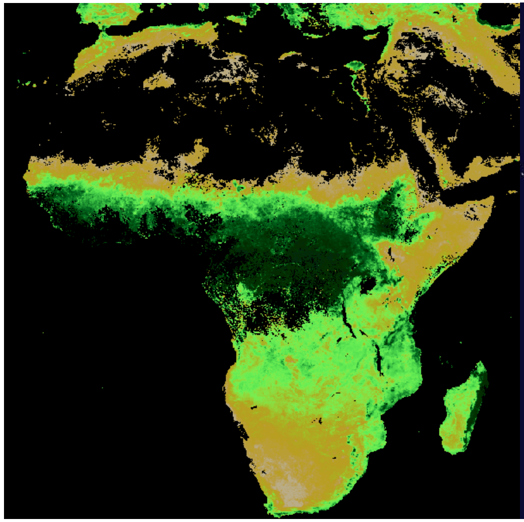
OMI HCHO over Africa (2005-2009)

- Formaldehyde (HCHO) is produced by atmospheric oxidation of volatile organic compounds (VOCs)
- Observed patterns point to sources from (1) biosphere, (2) open fires, (3) oil and gas industry
- Africa accounts for 20% of global biogenic isoprene emissions in MEGAN inventory

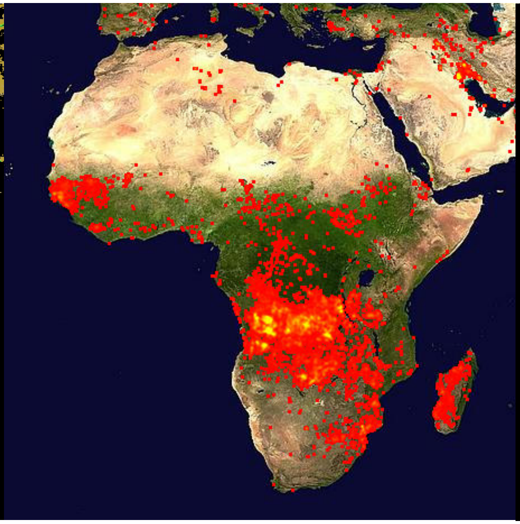
OMI annual mean HCHO slant columns



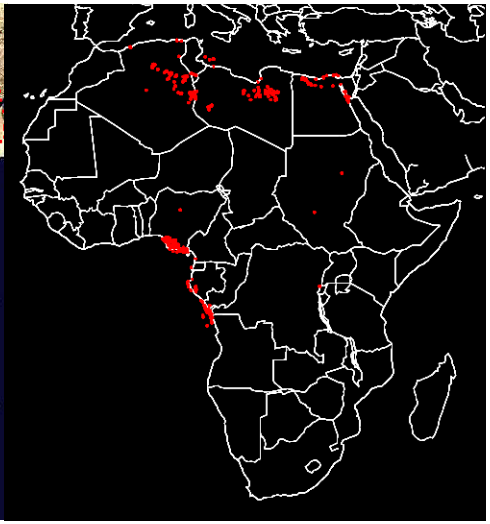
MODIS leaf area index



MODIS fire counts

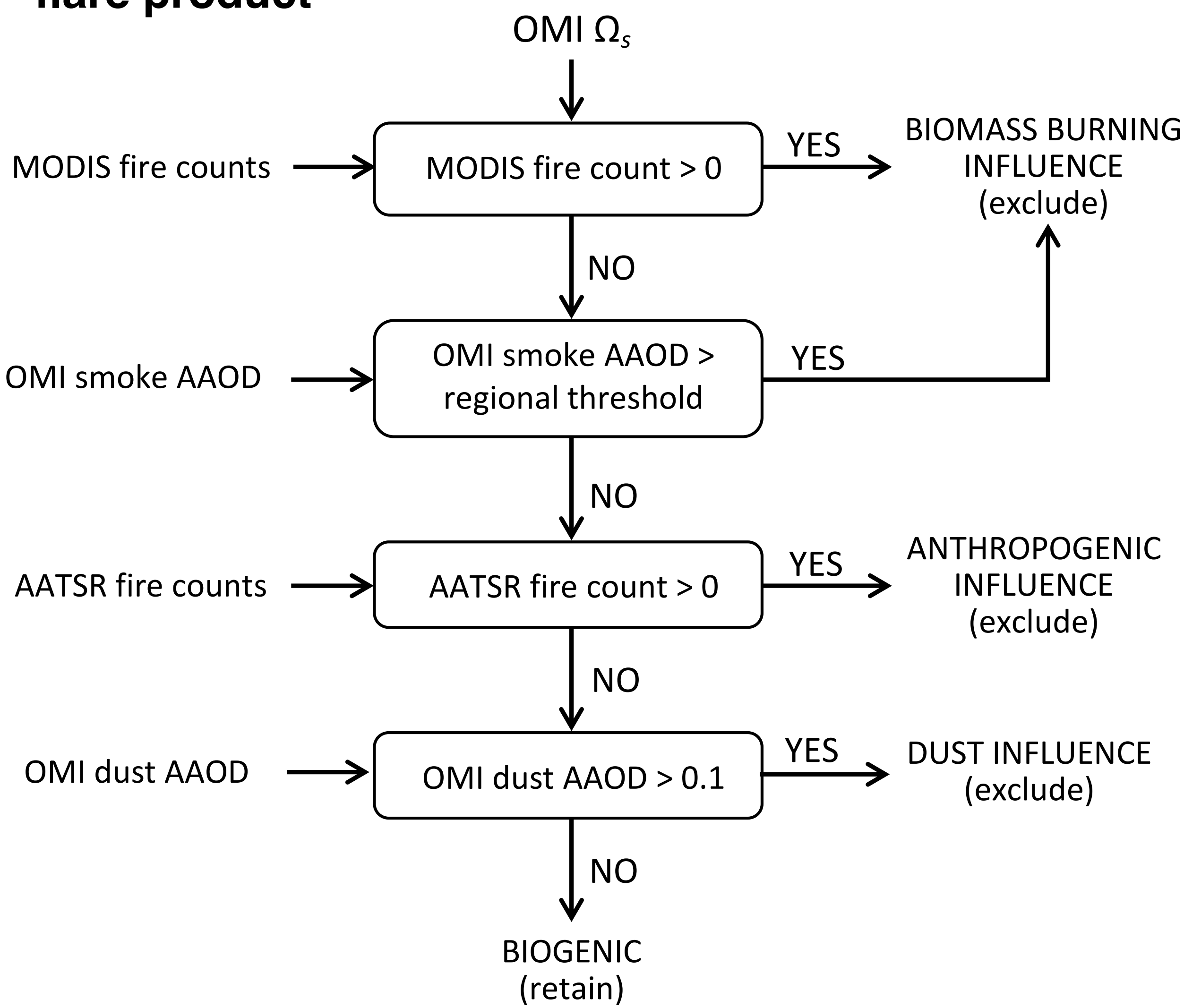


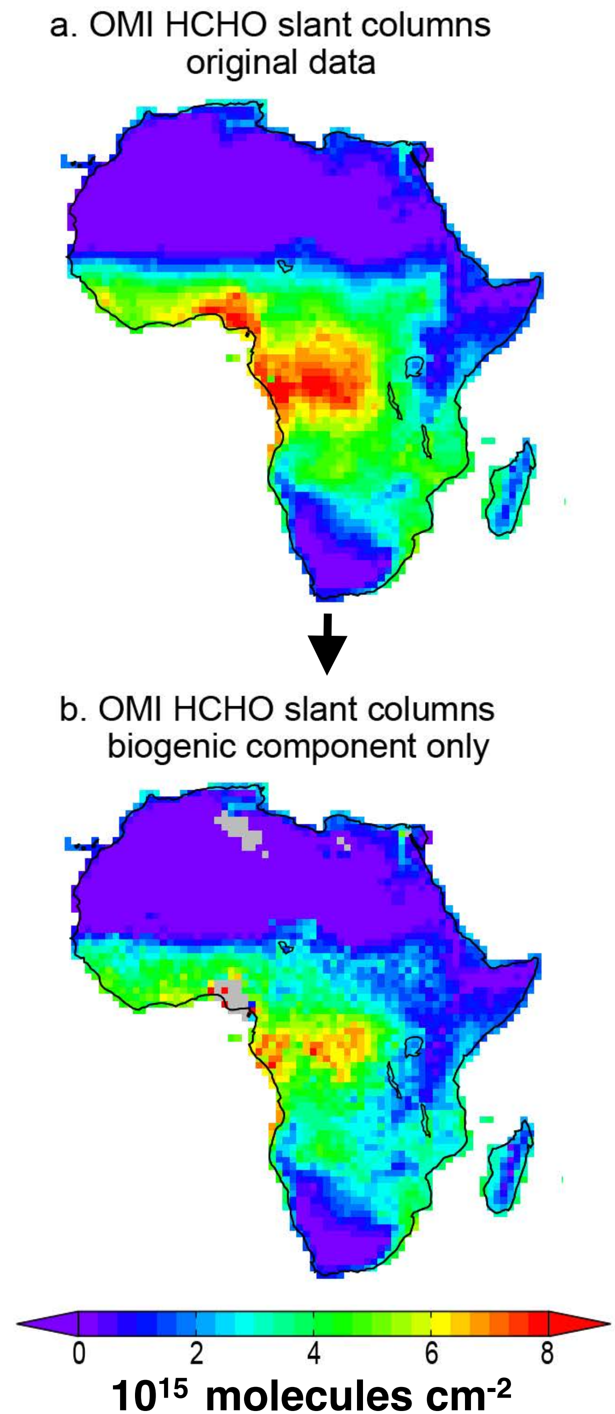
AATSR gas flares



Isolating biogenic HCHO in the OMI data

- **Exclude open fire (and dust) influence using MODIS fire counts, OMI absorbing aerosol optical depth**
- **Exclude oil/gas industry influence using AATSR gas flare product**





Converting slant to vertical HCHO columns

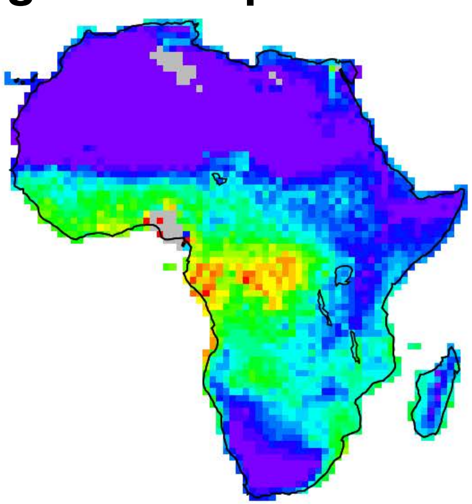
$$\Omega = \Omega_S \,/\, AMF$$

vertical column — slant column — air mass factor

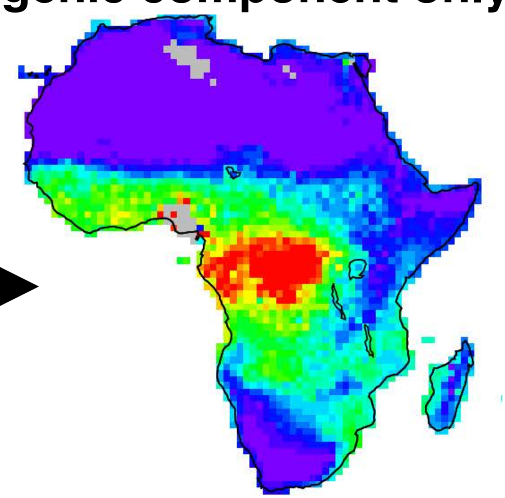
$$AMF = \int_0^\infty w(z)S(z)dz$$

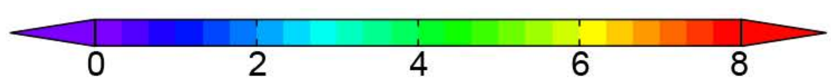
scattering weight = f(albedo, cloud, aerosol) — HCHO shape factor (GEOS-Chem)

OMI HCHO slant columns biogenic component only



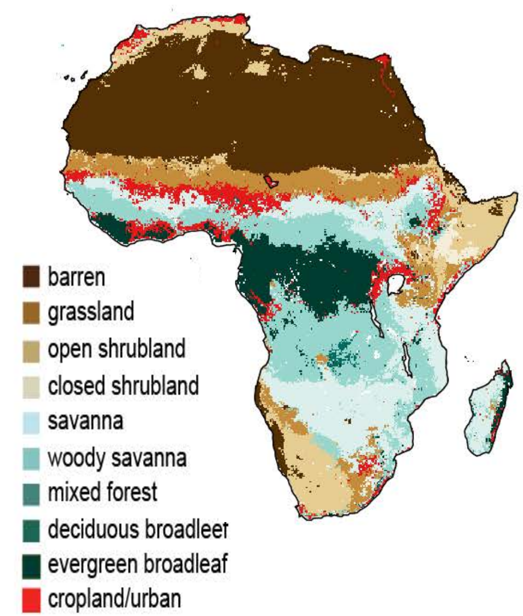
OMI HCHO vertical columns biogenic component only



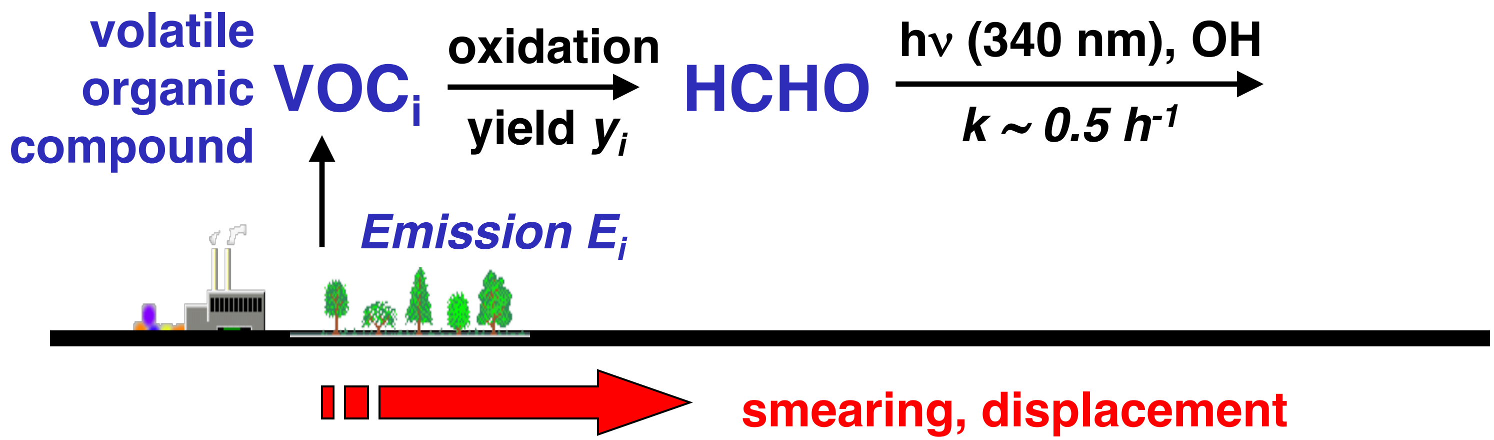


10^{15} molecules cm^{-2}

MODIS IGBP land cover



Relating HCHO columns to isoprene emission

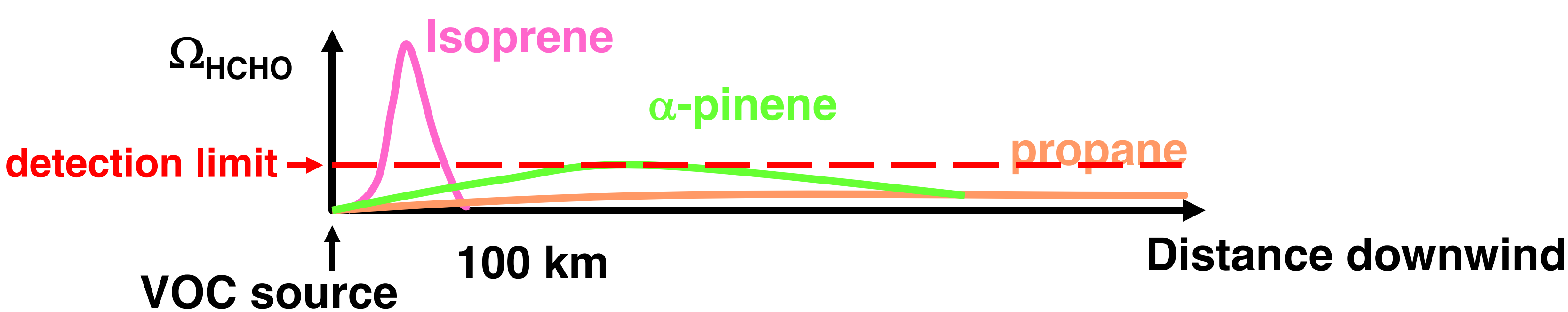


In absence of horizontal wind, mass balance for HCHO column Ω_{HCHO}:

$$\Omega_{HCHO} = \frac{\sum_i y_i E_i}{k}$$

Local linear relationship between HCHO and *E*

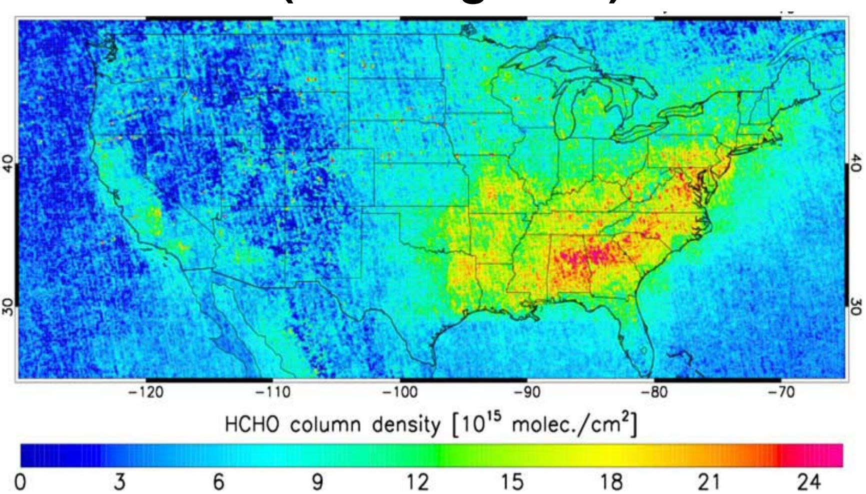
but wind smears this relationship depending on VOC lifetime wrt HCHO production:



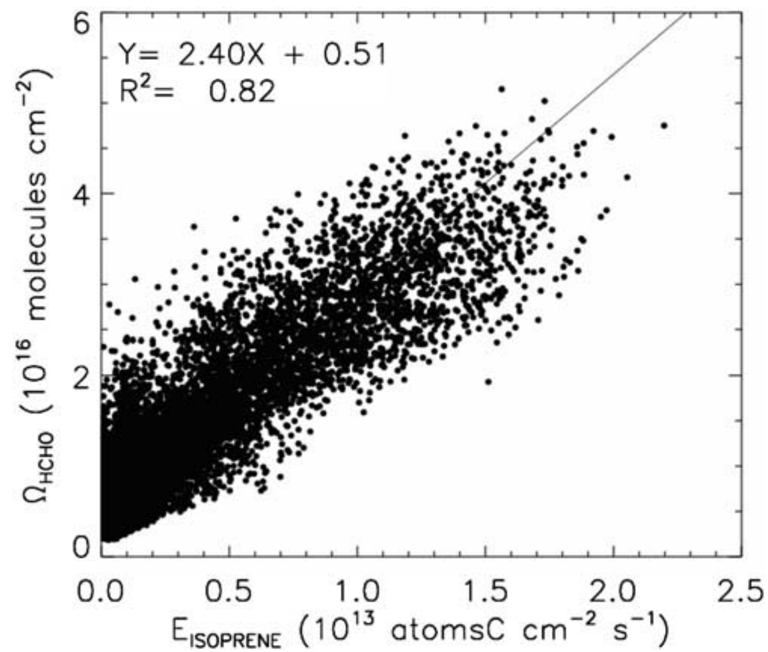
…so that HCHO is mainly sensitive to isoprene emission on ~100 km scale

Previous work for N. America showed that HCHO columns provide quantitative constraints on isoprene emission

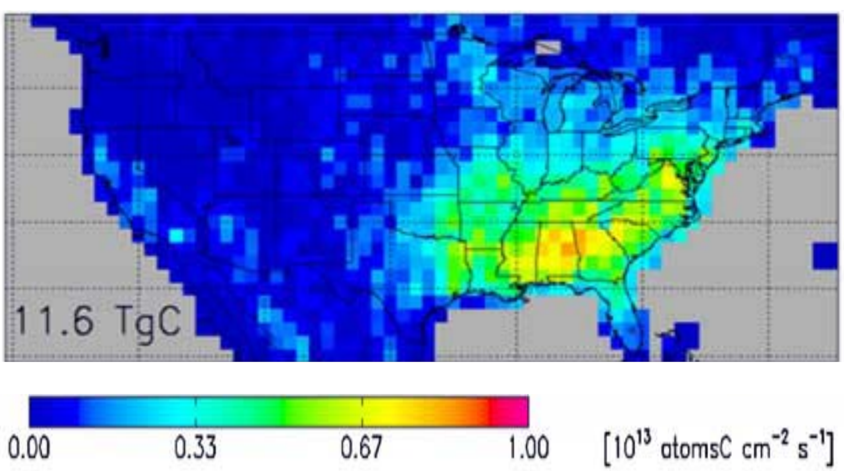
OMI HCHO (Jun-Aug 2006)



GEOS-Chem relationship between HCHO column and isoprene emission



OMI-constrained isoprene emission

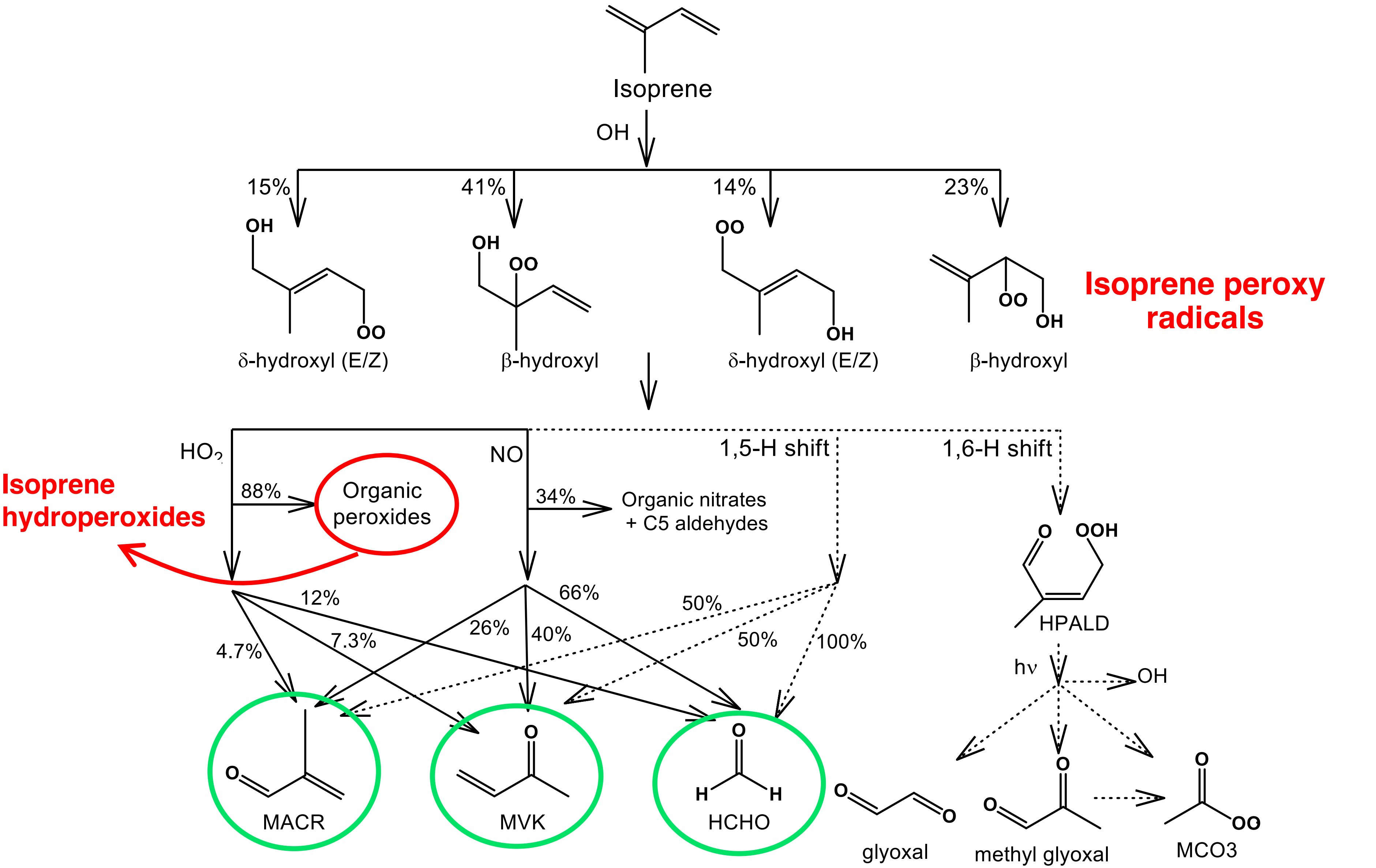


Model slope (2.4 s) agrees with INTEX-A vertical profiles (2.3), PROPHET Michigan site (2.1)

Millet et al. [2008]

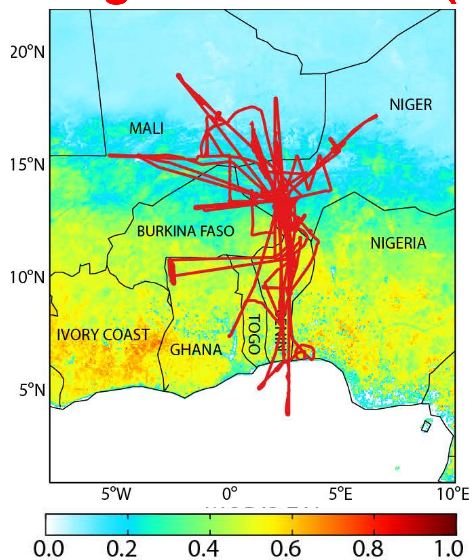
New developments in isoprene oxidation mechanism

- OH regeneration from isoprene hydroperoxides (Paulot et al., 2009ab)
- Isomerization of isoprene peroxy radicals (Peeters et al., 2009, 2010)



Model simulation of AMMA aircraft profiles over W. Africa: sensitivity to isoprene oxidation mechanism

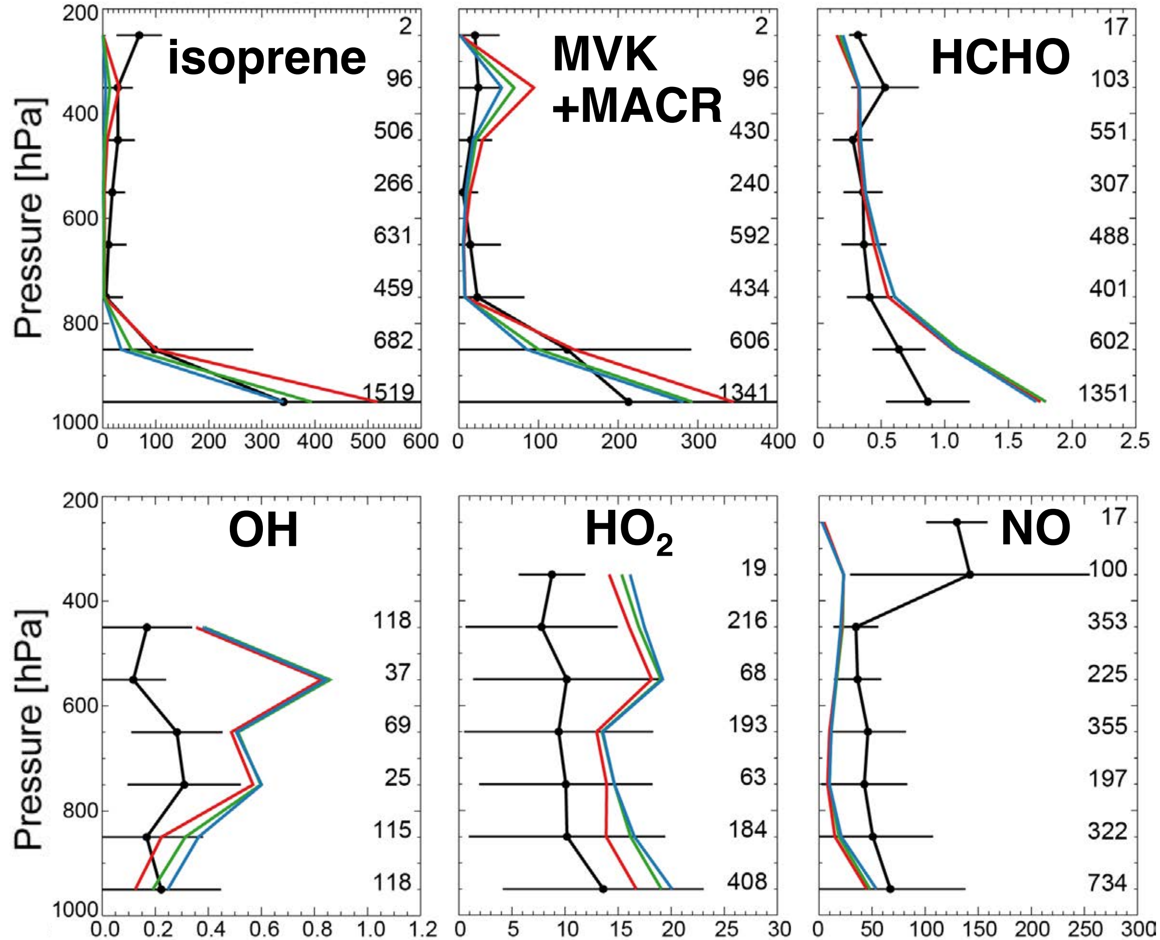
Flight tracks (Jul-Aug 2006) and vegetation index (EVI)



Observations (J. Murphy, C. Reeves, D. Heard)

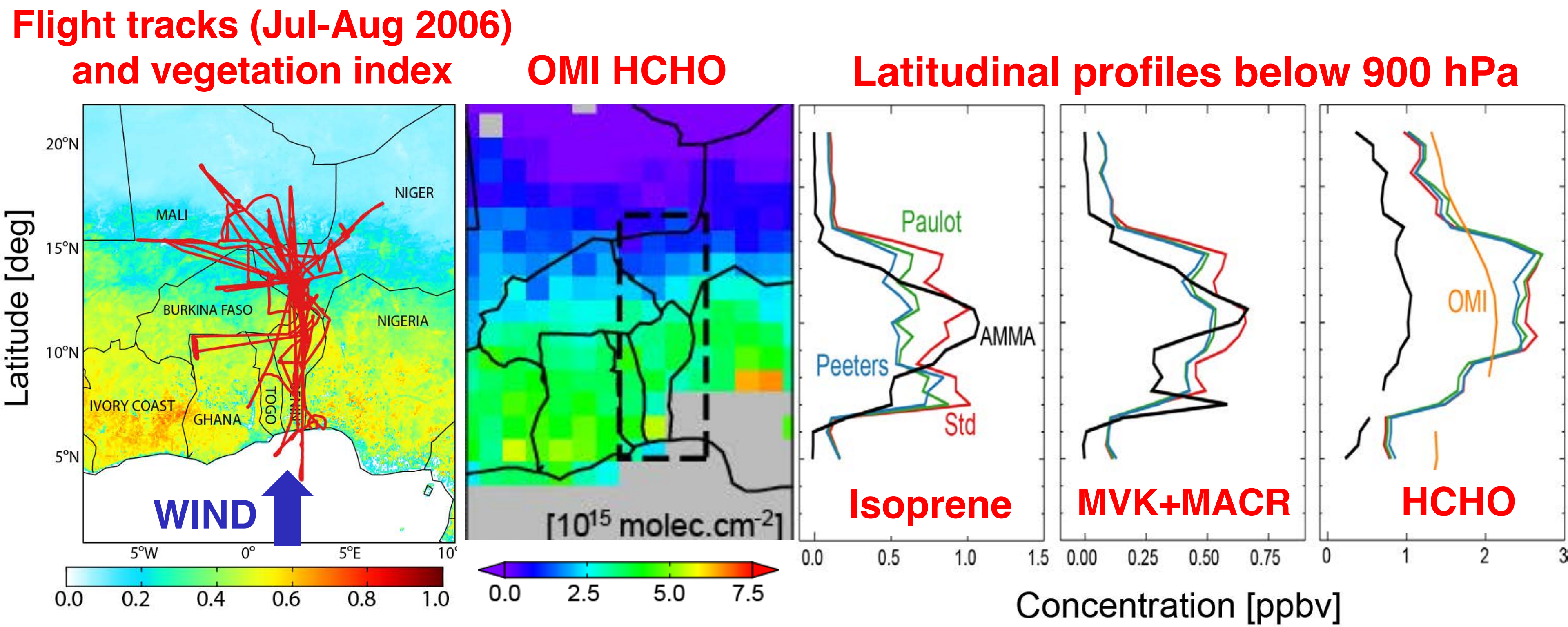
Model
- **Standard**
- **Paulot**
- **Peeters**

Mean vertical profiles (model uses MEGAN isoprene)



- **Simulation of MVK+MACR, lack of OH titration lends confidence in chemistry**
- **Model HCHO is insensitive to choice of mechanism**
- **Discrepancy with boundary layer HCHO: model or measurement error?**

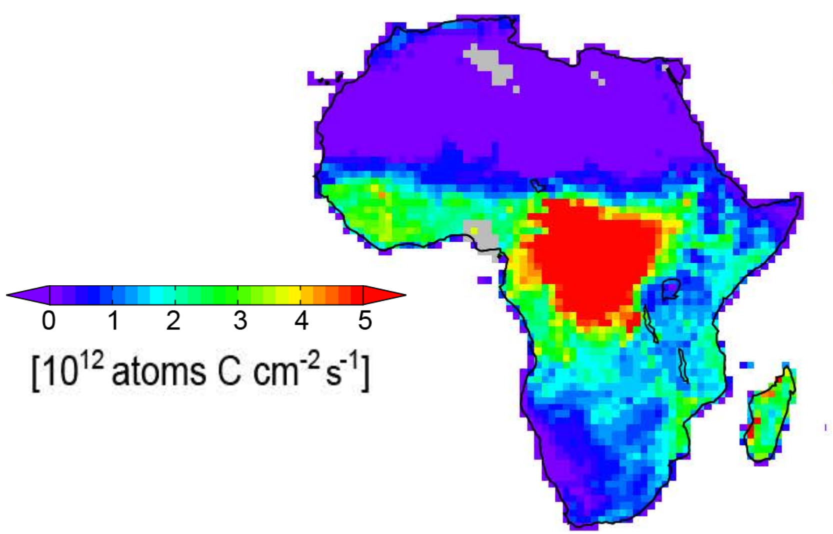
Latitudinal profiles along vegetation gradient in AMMA



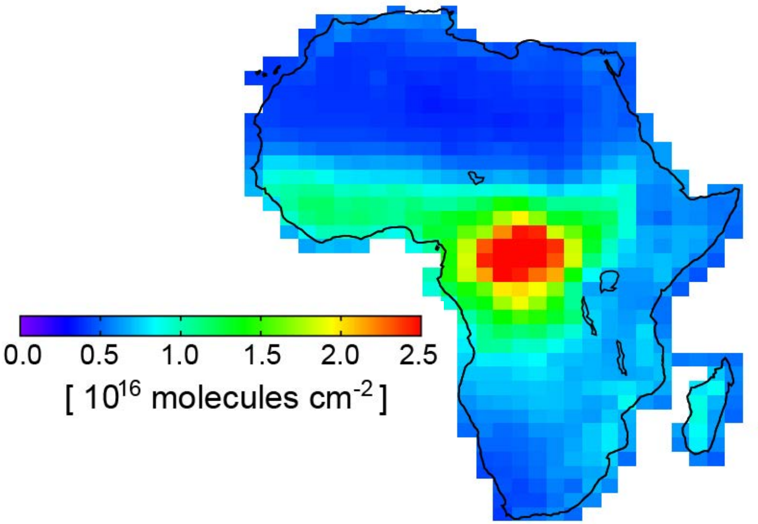
- **OMI HCHO observations closely track the vegetation gradient**
- **AMMA observations indicate no significant lag between isoprene emission and HCHO enhancement**

GEOS-Chem local relationship between HCHO column and isoprene emission

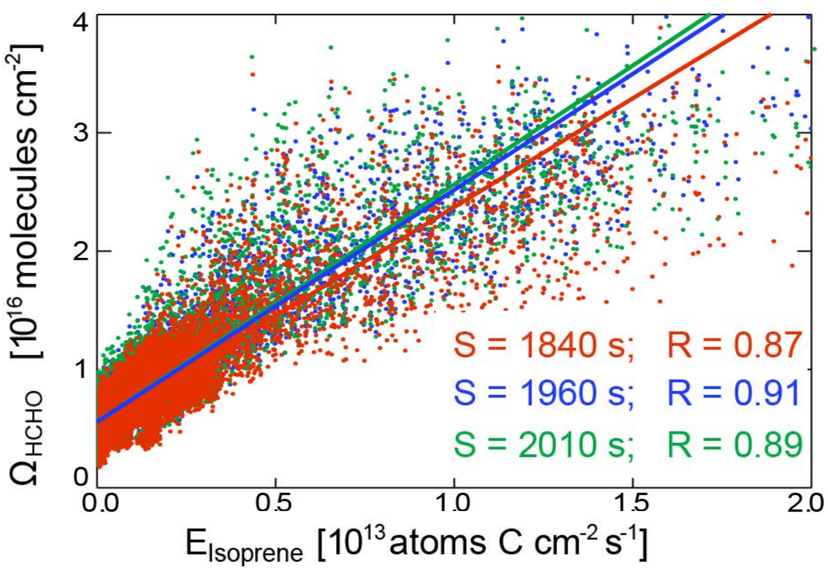
Annual mean isoprene emission (2006) MEGAN inventory



Annual mean column HCHO (2006) Peeters mechanism



Scatterplot for African continent (2006)

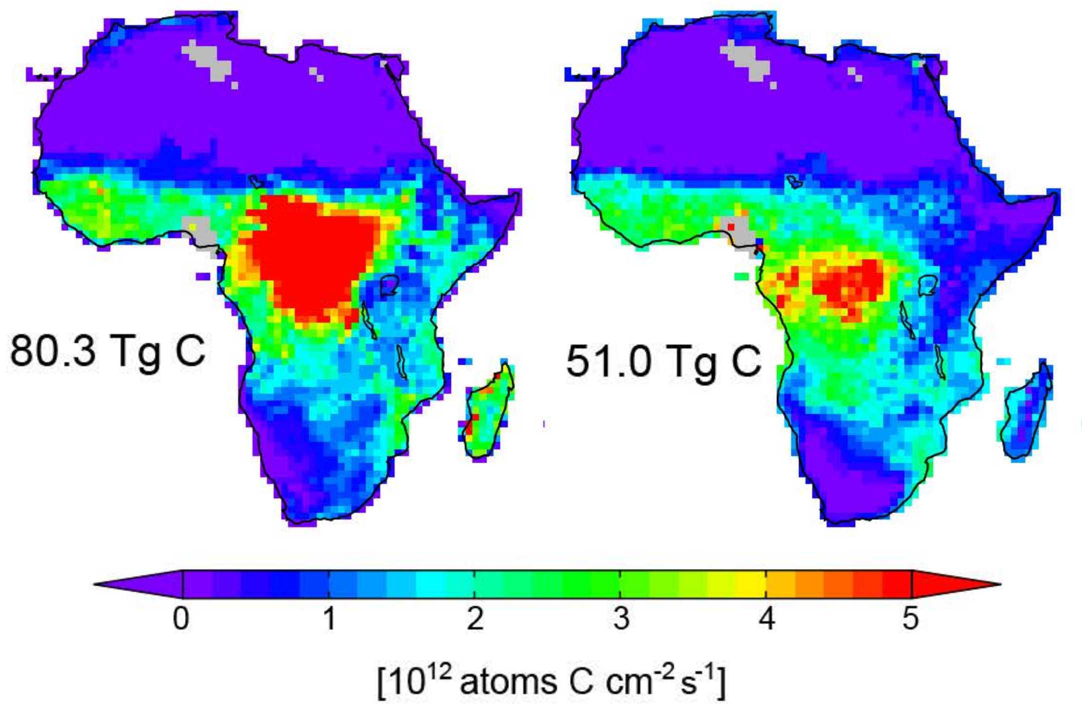


- **Daily model values at 2° x 2.5° resolution show strong linear correlation**
- **Slope is insensitive to choice of model isoprene oxidation mechanism, local NO_x concentrations**
- **Standard mechanism shows effect of OH titration at high isoprene emissions**

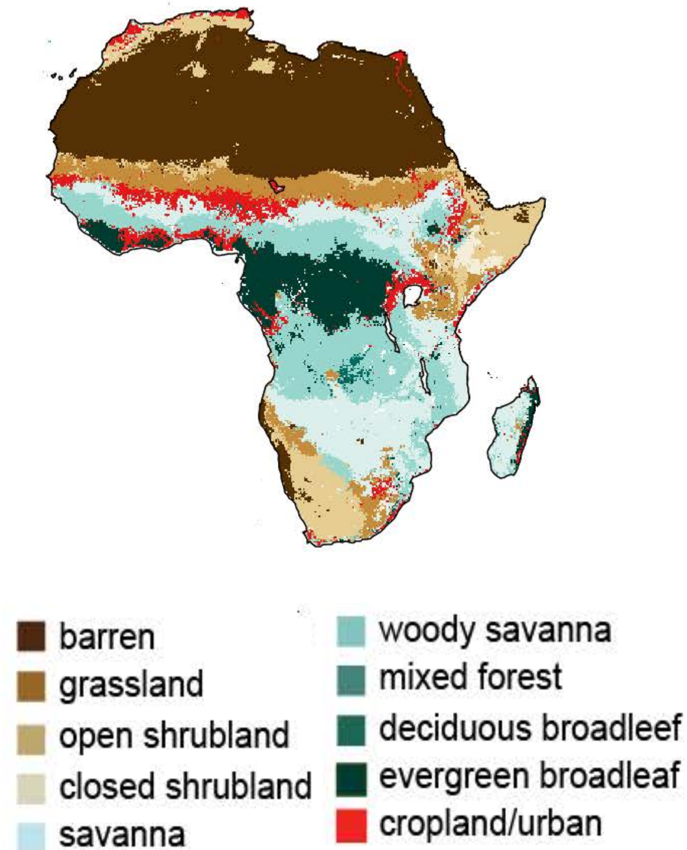
OMI-constrained isoprene emissions from Africa: comparison to MEGAN inventory

Isoprene emission (annual mean, 2006)

MEGAN **OMI**



MODIS IGBP land cover



- **MEGAN overestimates tropical forest emissions in central Africa, underestimates savanna emissions in southern Africa**
- **overall African emissions overestimated by 60%**