Biogenic VOC emissions estimated from GoAmazon2014/5 airborne observations and implications for atmospheric chemistry over the tropical forest

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Motivation

- Biogenic volatile organic compounds (BVOCs) emitted from terrestrial ecosystems play an important role in atmospheric chemistry and global climate feedbacks.
- The immense biological and chemical diversity of BVOC is a challenge for the numerical modeling of BVOC emissions, especially for tropical forests.
- The uncertainties in BVOC oxidation processes limit our ability to predict OH and aerosol distributions and the associated climate impacts.

Methodology

G-1 airborne measurements

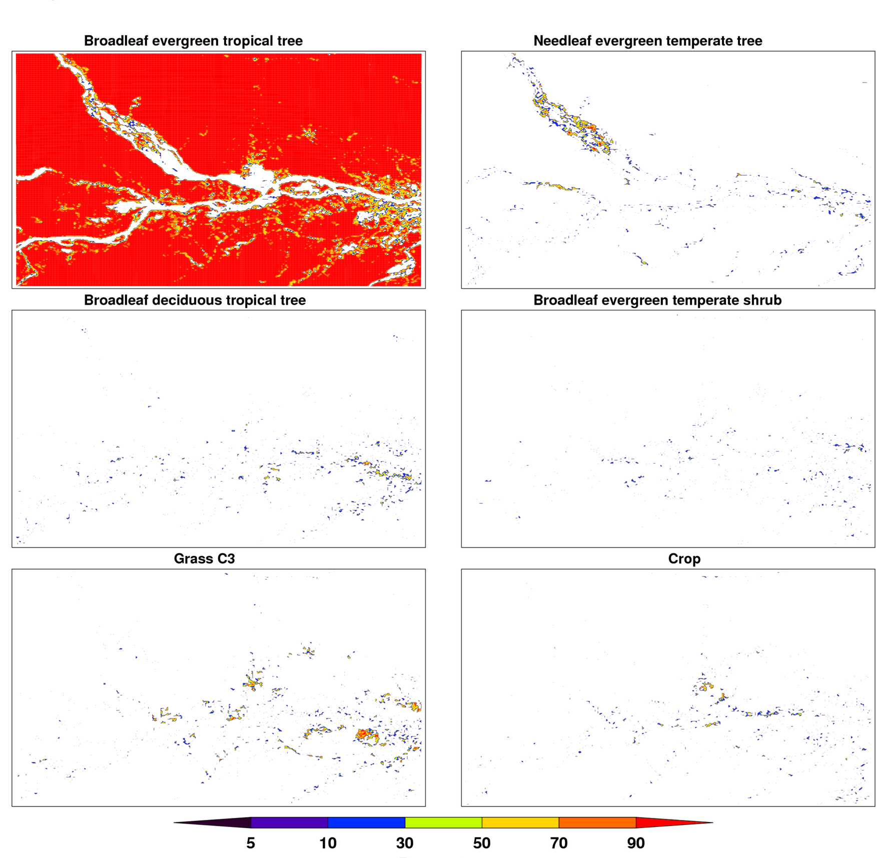
- Total of 16 flights during wet season (Feb 15 ~ Mar 26) and 19 flights during dry season (Sep 1 ~ Oct 10).
- Selected 4 flights in each season for BVOC study.
- PTR-MS measured BVOC and oxidation products (i.e., isoprene, MVK+MACR) mixing ratios.

MEGAN within CLM 4.5 framework

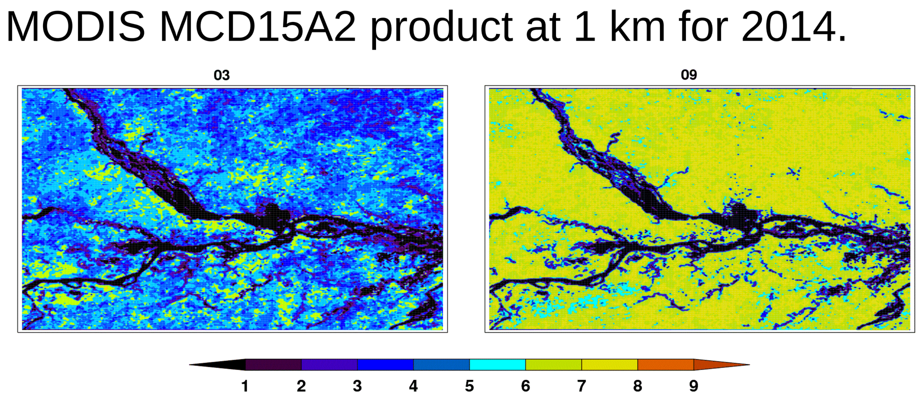
- MEGAN v2.1 biogenic emission model with 1 km resolution (292x234 grids) is coupled with CLM 4.5 to simulate BVOC emissions.
- CLM 4.5 used land cover input from MODIS observations and meteorological forcing from WRF (NCEP reanalysis).

Land cover and vegetation datasets

- Plant Function Type (PFT) derived from the MODIS MCD12Q1 C5 PFT classification at 500 meters for 2012.

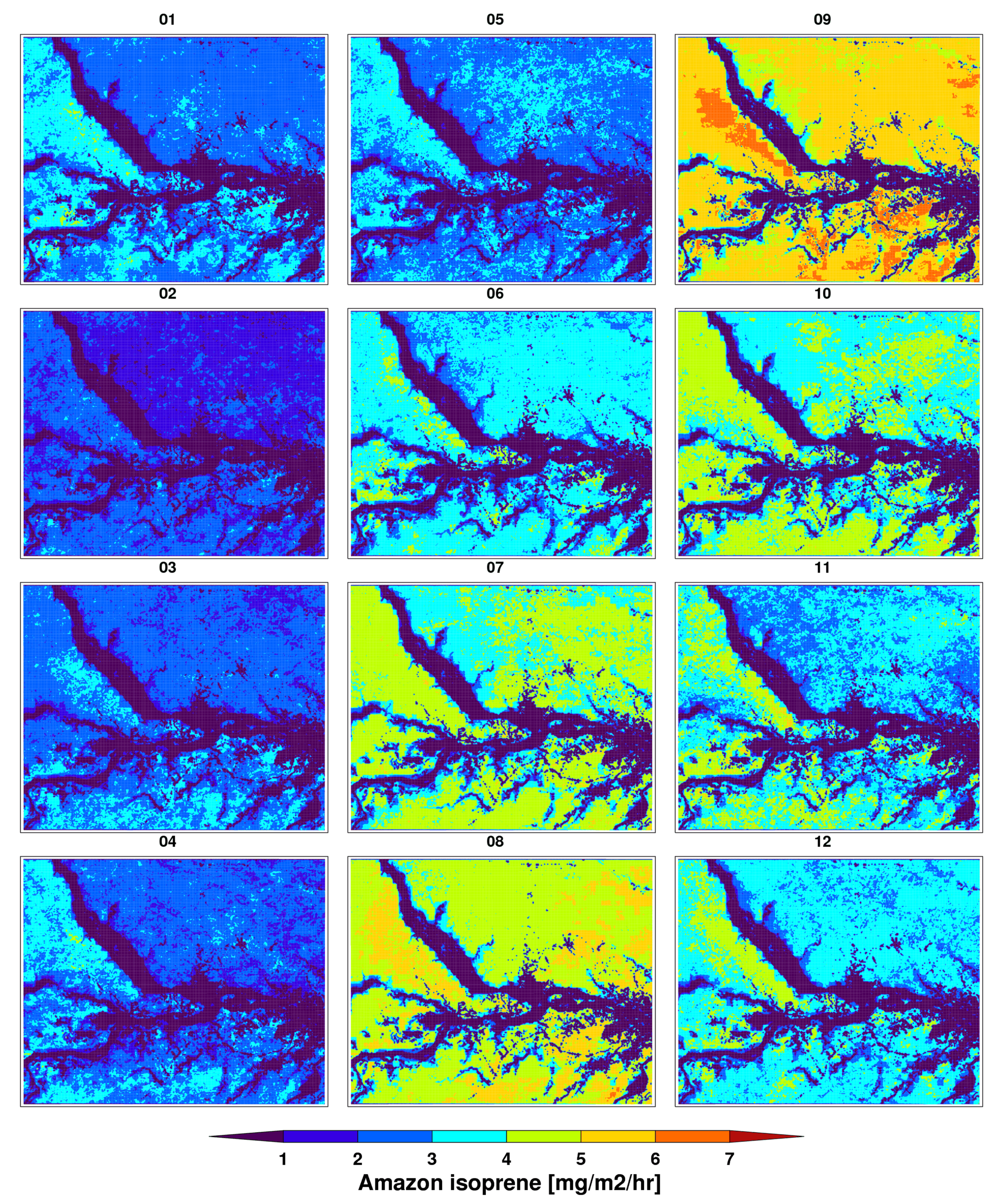


- Broadleaf evergreen tropical trees are the dominant PFT. The diversity in the Amazon requires us to increase the PFT categories to better represent BVOC emission.
- Leaf Area Index (LAI) and Stem Area Index (SAI) derived from MODIS MCD15A2 product at 1 km for 2014.



Results and Discussion

1. MEGAN simulated isoprene emission



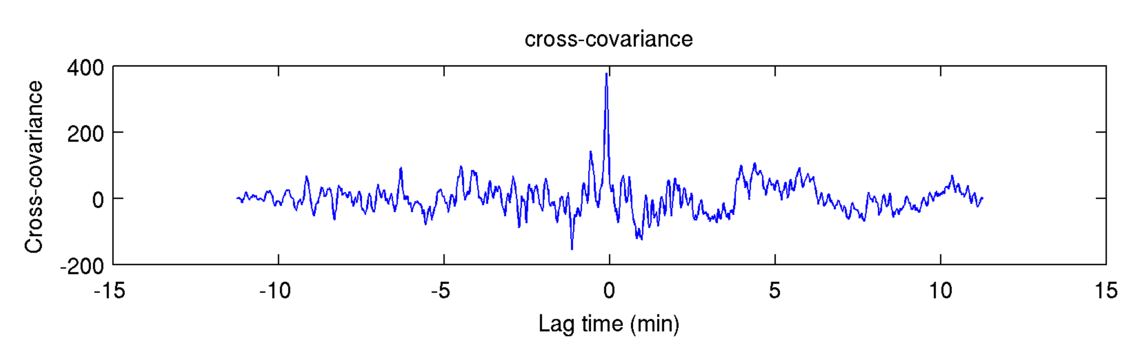
MEGAN simulates 2X higher isoprene emissions in dry season compared to wet season.

2. Isoprene emission from airborne measurements

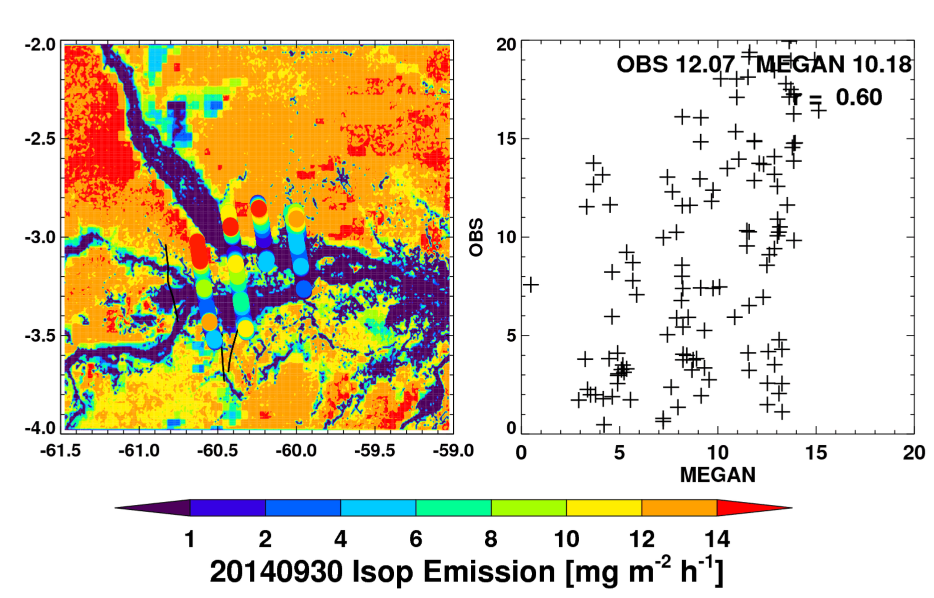
Wavelet eddy covariance (WEC) method

$$F = \overline{w'C'}.$$

- Covariance between measured w' and c'



- Significant correlation between isoprene emissions from MEGAN and WEC methods



Mixed layer covariance (MLV) method

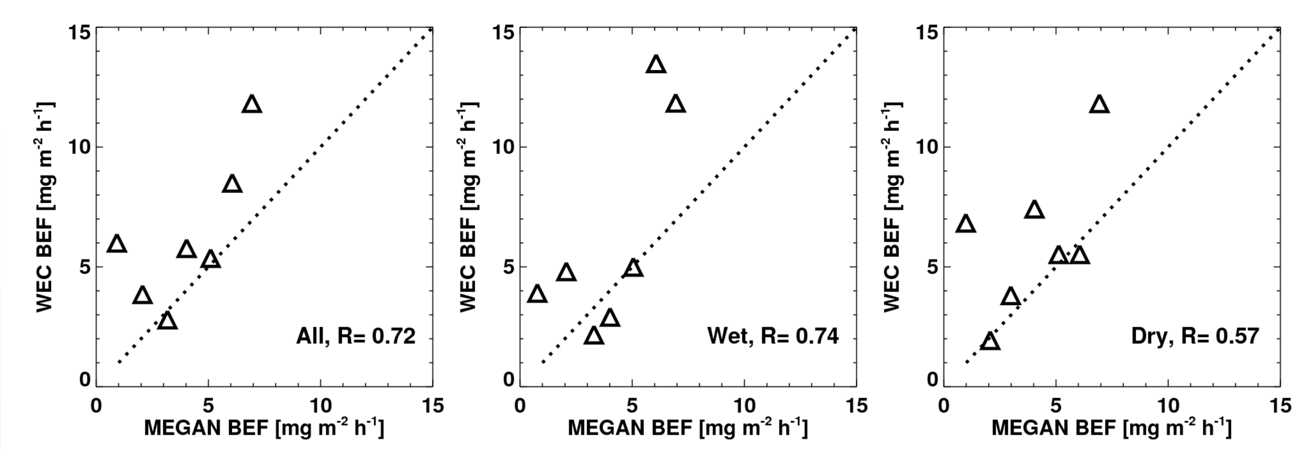
$$\sigma_C^2 = \left(\frac{F_e}{w^*}\right)^2 f_t(z/z_i) + \left(\frac{F_s}{w^*}\right)^2 f_b(z/z_i) + 2\cdot\left(\frac{F_e F_s}{w^{*2}}\right) f_{tb}(z/z_i)$$

- The MLV results are comparable with those from MEGAN and WEC, but are also impacted by city plumes.

Isoprene emission estimates

$mg\ m^{-2}\ h^{-1}$	WEC	MLV	MEGAN
All seasons	10.66±6.57	8.36±3.57	7.91±3.63
Wet season	6.16±4.62	7.17±3.12	5.61±2.69
Dry season	12.89±8.93	9.52±4.73	9.04±3.49

3. Basal emission factor (BEF)

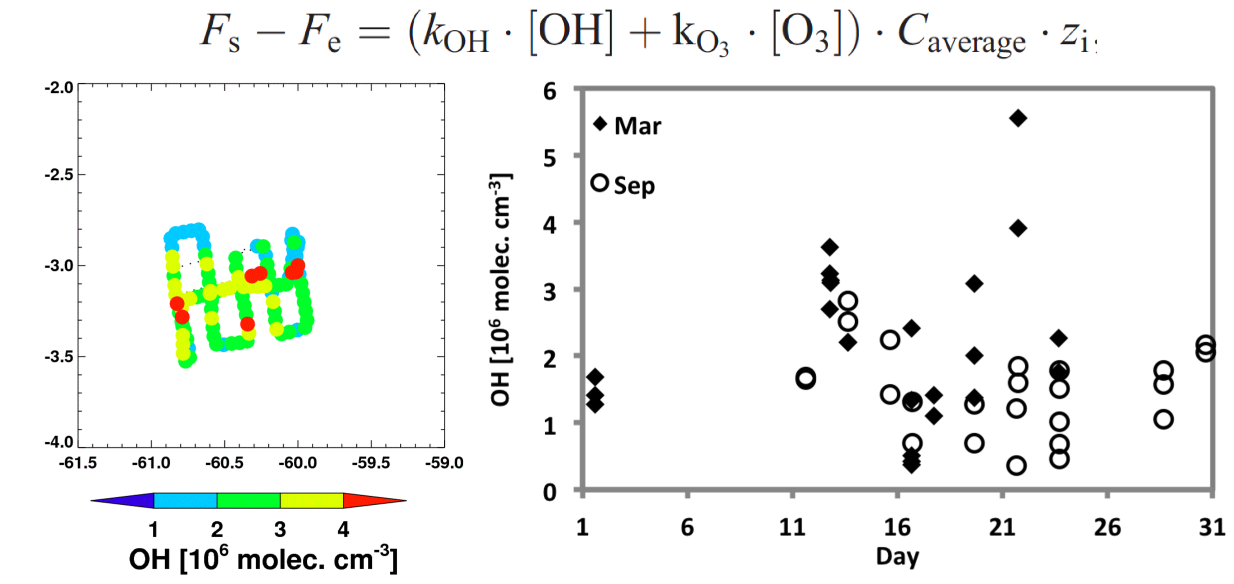


- BEFs based on WEC are higher than MEGAN BEFs, with good correlations between the two.
- Plan to increase the number of MEGAN PFTs to include a higher isoprene emitting tropical forest type.

4. OH estimation

PBL-mixed box technique

$$F_s - F_e = (k_{OH}\cdot[OH] + k_{O_3}\cdot[O_3])\cdot C_{average}\cdot z_i.$$



OH levels are comparable with CIMS measurement at T3 site.

(MVK+MACR)/Isoprene

$$\frac{MVK + MACR}{Isoprene} = 0.55\cdot\frac{k_{isop}}{k_{isop} - k_{carbonyl}}\cdot[1 - \exp((k_{isop} - k_{carbonyl})\cdot[OH]\cdot t)]$$

This approach results in much higher OH estimates

Implications

- **The isoprene emissions estimated from airborne measurements are comparable with MEGAN simulations, and values are higher in dry season than in the wet season.**
- **The BEFs from aircraft WEC method have a good correlation with MEGAN BEF, but some values are higher. Need to add a high isoprene emission PFT type.**
- **OH levels estimated from isoprene flux and concentrations are comparable with ground measurements. Need to reconcile with estimates based on ratio of isoprene and isoprene products and examine regional distributions.**

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