Green Ocean Amazon 2014/5 (GoAmazon2014/5)

Atmospheric Chemistry and Anthropogenic Influence over the Amazon Tropical Forest

- Amazon basin in transition
- Essential component of regional and global climate system

Presented by Scot Martin (Harvard)
May 2018

Photo: Tropical Forest In Central Amazonia
Site Location

Manaus

60 km, 4-6 h

T0k, T0l, T0e, T1, T2, T3
GoAmazon2014/5: 1 Jan 2014 to 31 Dec 2015

Field experiment
Transverse Transects of Urban Plume

500 m
11 AM local
13 March 2014

Transverse Transects of Urban Plume

500 m 11 AM local 13 March 2014

Atmospheric Isoprene Photochemistry

Isoprene
\[ \text{C}_5\text{H}_8 \]

Gaseous Oxidation Products

Particulate Organic Matter

Isoprene Emission
\( (\mu\text{mol m}^{-2} \text{hr}^{-1}) \)

> 140
others

Amazonia

January July
Transverse Transects of Urban Plume

500 m
11 AM local
13 March 2014

Transverse Transects of Urban Plume

500 m
11 AM local
13 March 2014


Ground Site
14 March 2014
Saewung Kim et al.
Conclusions and Implications

- NO pathway is more important than expected under background conditions.
- Branching of pathways is severely altered by the anthropogenic emissions of NO.
- Past (many) studies that nominally measured MVK + MACR

Indirect approach for OH(NO$_x$)

In peer review

I. The controversy

![Graph showing the relationship between OH concentration and NO$_x$ concentration.]

Meta-study of reported OH concentration (4)

Classic understanding


II. Indirect approach applied here

\[
\text{[Oxidation Products]} \quad \text{Model Inversion} \quad \text{[OH]}
\]

The conclusion is that, compared to background conditions of low NO\textsubscript{x} concentrations over the Amazon forest, pollution increased NO\textsubscript{x} concentrations and amplified OH concentrations, indicating the susceptibility of the atmospheric oxidation capacity over the forest to anthropogenic influence and reinforcing the important role of NO\textsubscript{x} in sustaining OH concentrations.

**POLLUTED CONDITIONS**

**SOURCES**

**NO**: Soils + Manaus

**Sulfate**: In-basin: DMS/H$_2$S + Manaus

Out-basin: Atlantic ocean + African BB

[Bakwin et al., 1990; Andreae et al., 1990; Chen et al., 2009]

A CASE STUDY

Background conditions  March 3

Polluted conditions  March 13

Pollution indicators

Variables of interest

Explanatory variables

Met conditions

Local time = UTC – 4h

Sulfate: a first-order predictor of IEPOX-SOA

SE U.S.: $R^2 = 0.4 - 0.6$ [Xu et al., 2015; Hu et al., 2015; Budisulistiorini et al., 2013, 2015]

R² value shown in parentheses in plot

**Sulfate:** a first-order predictor of IEPOX-SOA

**NO:** an important modulator of IEPOX-SOA

\[ \text{NO}_y: \text{proxy of integrated NO chemistry} \]

\[ \text{(NO}_y = \text{NO} + \text{NO}_2 + \text{reservoir species}) \]

Sulfate: a first-order predictor of IEPOX-SOA

Background sources sustain concentrations

NO: an important modulator of IEPOX-SOA

Manaus contribution dominates over background sources

Amazon boundary layer aerosol concentration sustained by vertical transport during rainfall

Jian Wang, Radovan Krajcir […] Scot T. Martin

Substantial convection and precipitation enhancements by ultrafine aerosol particles

Jiwen Fan¹,², Daniel Rosenfeld², Yueli Zhang¹,³, Scott E. Gianserade⁴, Zhongqi Li⁵,⁶, Luiz A. T. Machado⁵, Scot T. Martin⁷…

See all authors and affiliations

Science 26 Jan 2018;
Vol. 359, Issue 6374, pp. 411-418
DOI: 10.1126/science.aan8461

Airborne observations reveal elevational gradient in tropical forest isoprene emissions

Dasa Gu, Alex B. Guenther, John E. Shilling, Haofei Yu, Maoyi Huang, Chun Zhao, Qing Yang, Scot T. Martin, Paulo Artaxo, Saewung Kim, Roger Seco, Tristevegeli Stavrou, Karla M. Long, Julioto Tota, Rodrigo Augusto Ferreira de Souza, Oscar Vega, Ying Liu, Manish Shrivastava, Elaine G. Alves, Fernando C. Santos, Guoyong Leng & Zhiyuan Hu

Sub-micrometre particulate matter is primarily in liquid form over Amazon rainforest


Nature Geoscience 9, 34–37 (2016)
doi:10.1038/ngeo2599
Received: 15 May 2015
Accepted: 15 May 2015
Published: 07 December 2015
Frontiers... Now
Science Question: Heterogeneity of Emissions and Reactivity at Scale of Ecosystem Emissions

- Heterogeneity of emissions across a length scale of <1 km
- VOC fingerprint changes under stress
- How forest ecosystems respond to climate stress

Adapted from M. Shrivastava et al., Recent advances in understanding secondary organic aerosol: Implications for global climate forcing, Rev. Geophys., 2017, 55, 509–559.
<table>
<thead>
<tr>
<th>Area Radius</th>
<th>Plateau (%)</th>
<th>Slope (%)</th>
<th>Valley (%)</th>
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<tbody>
<tr>
<td>0.5 km</td>
<td>95</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>1 km</td>
<td>66</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>2 km</td>
<td>49</td>
<td>24</td>
<td>27</td>
</tr>
</tbody>
</table>

Typical relief at MUSA

- Plateau
- Slope
- Valley

MUSA Tower

Streams
SVOCs from isoprene and α-pinene oxidation detected in the sorbent cartridge samples

Combined extracted-ion chromatogram (EIC) of calibration standards and an example of SVOC samples for pinonic acid (EIC: m/z 171), 2-methyltetrols (m/z 219), pinic acid (m/z 129), levoglucosan (m/z 204) and lauric-d$_{23}$-acid (m/z 280; internal standard). All the compounds shown are the TMS-derivatives.
Profile of ozone concentration from 0 to 500 m at night in Manaus, Brazil

Date: 03202018
Time: 20:55 LT
Location: UEA
Asc. Velocity: 0.5 m/s

Date: 03202018
Time: 20:55 LT
Location: UEA
Asc. Velocity: 0.5 m/s

![Graph showing ozone concentration profile with detection limit at 3 ppb. The graph includes data points for 77 Ascending and 78 Ascending with ascending velocity of 0.5 m/s.](image-url)
Thank you!