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)

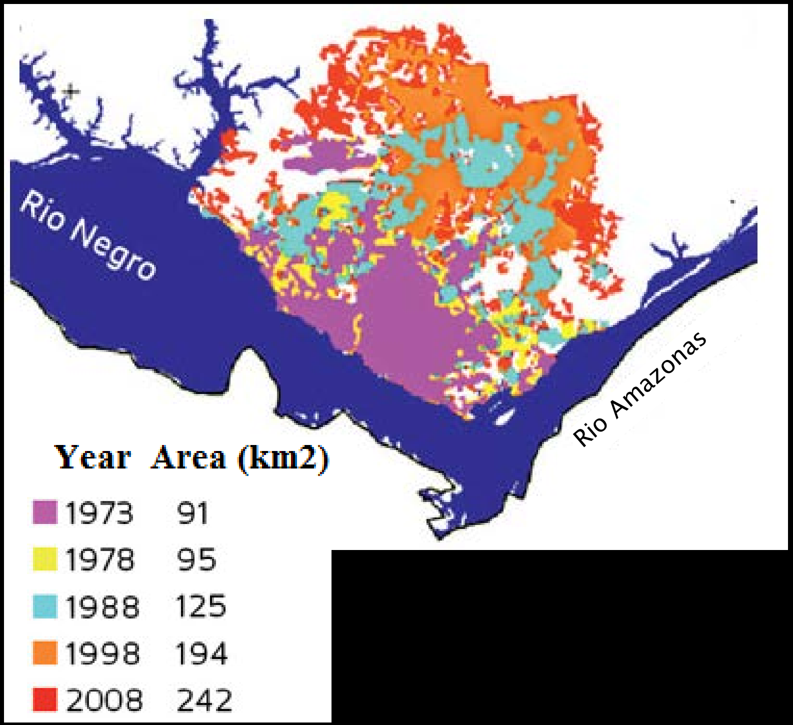
May 2018

Photo: Tropical Forest In Central Amazonia

Site Location

GoAmazon2014/5: 1 Jan 2014 to 31 Dec 2015

IOP1: wet season 2014 (1 Feb – 31 Mar), IOP2: dry season 2014 (15 Aug – 15 Oct)

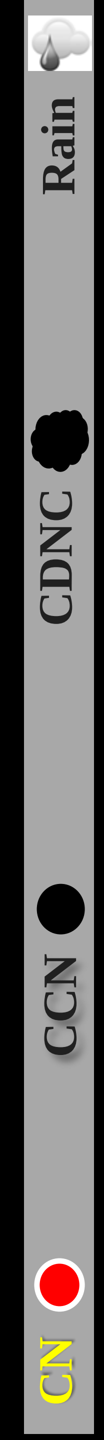


Martin et al., *Bull. Am. Meteorol*. Soc. **2017**, *98*, 981–997.

Field experiment

Transverse Transects of Urban Plume

500 m
11 AM local
13 March 2014



Martin et al., Bulletin of the American Meteorological Society, 2017, 98, 981-997.

Transverse Transects of Urban Plume

500 m
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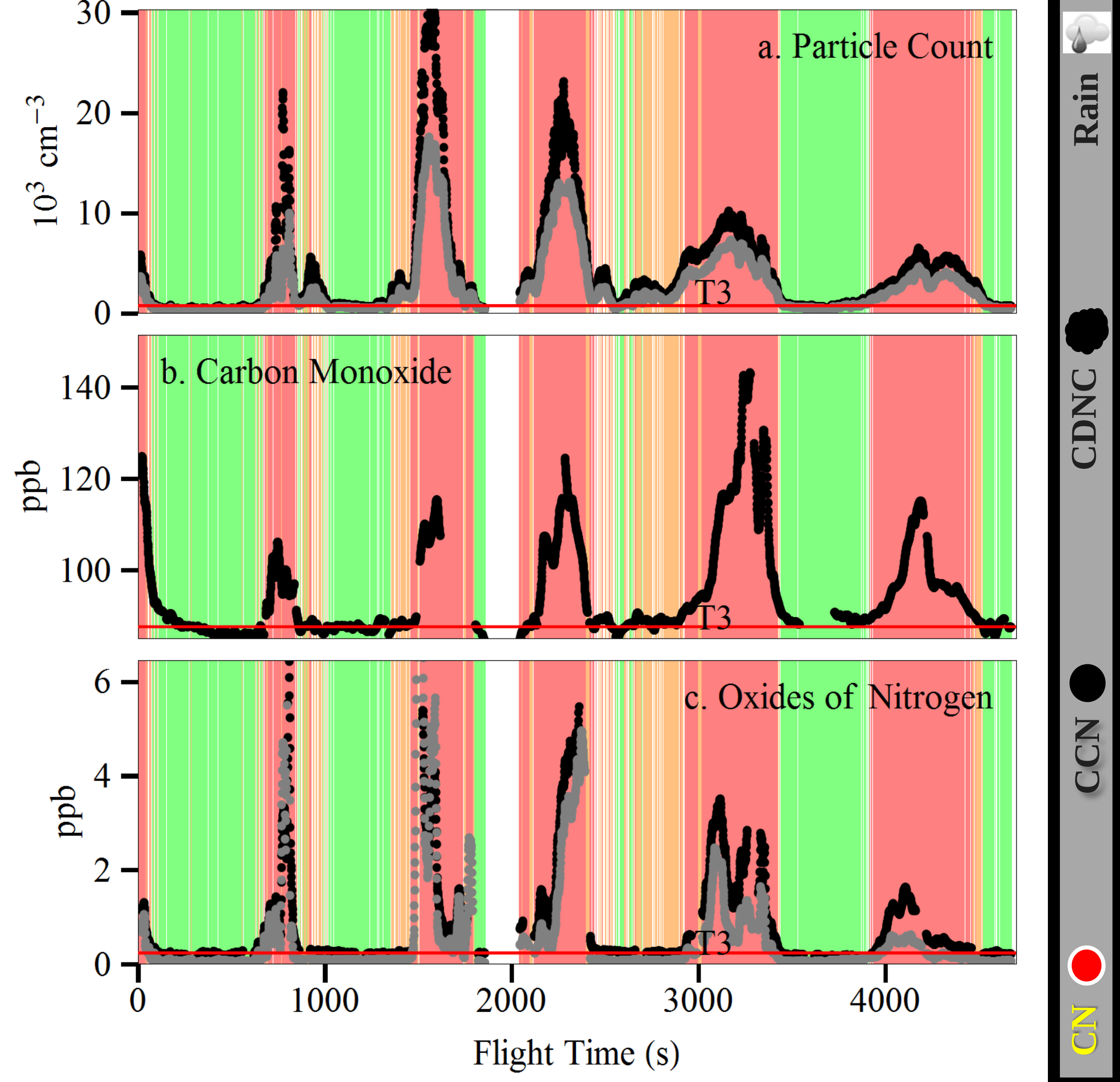
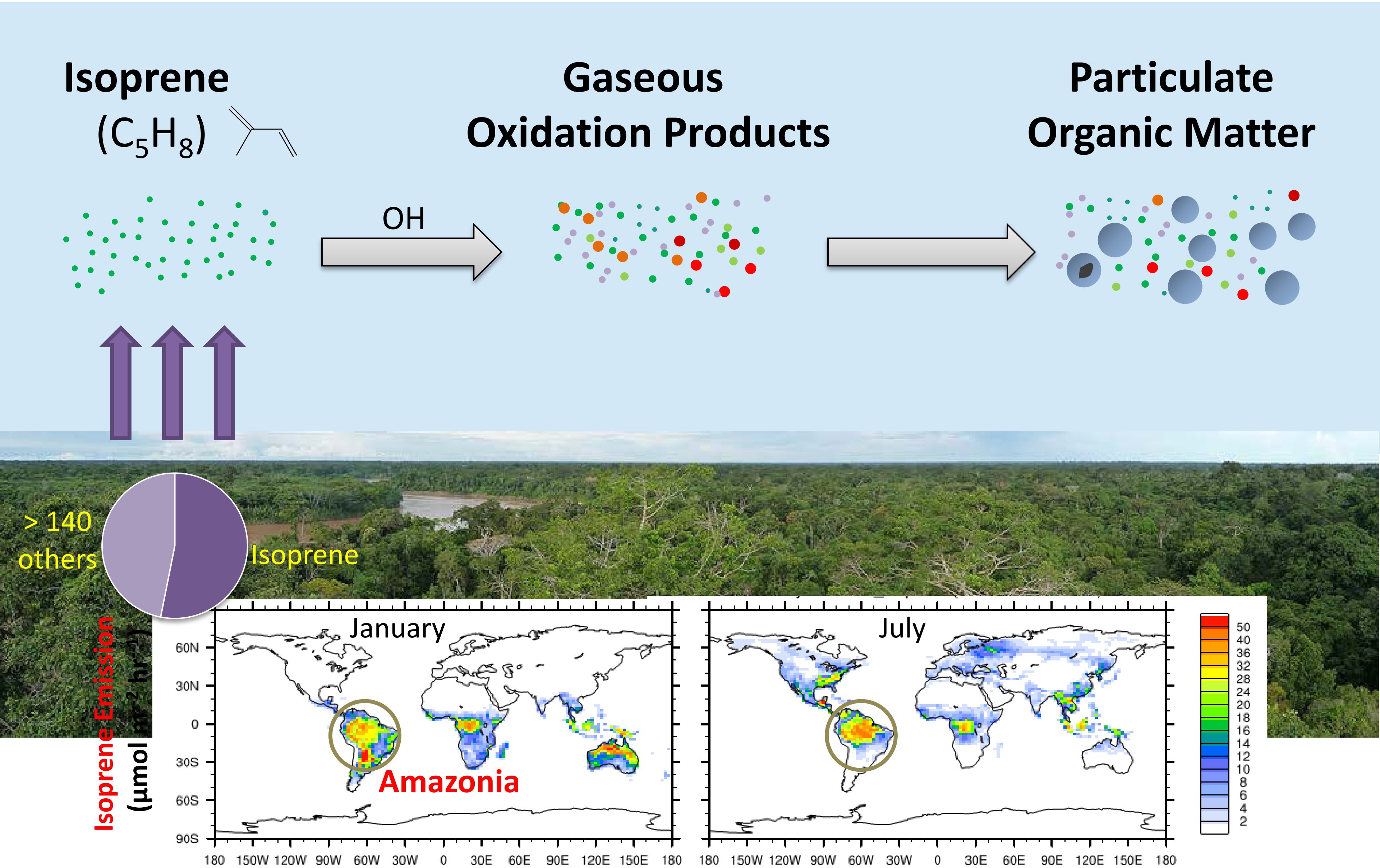


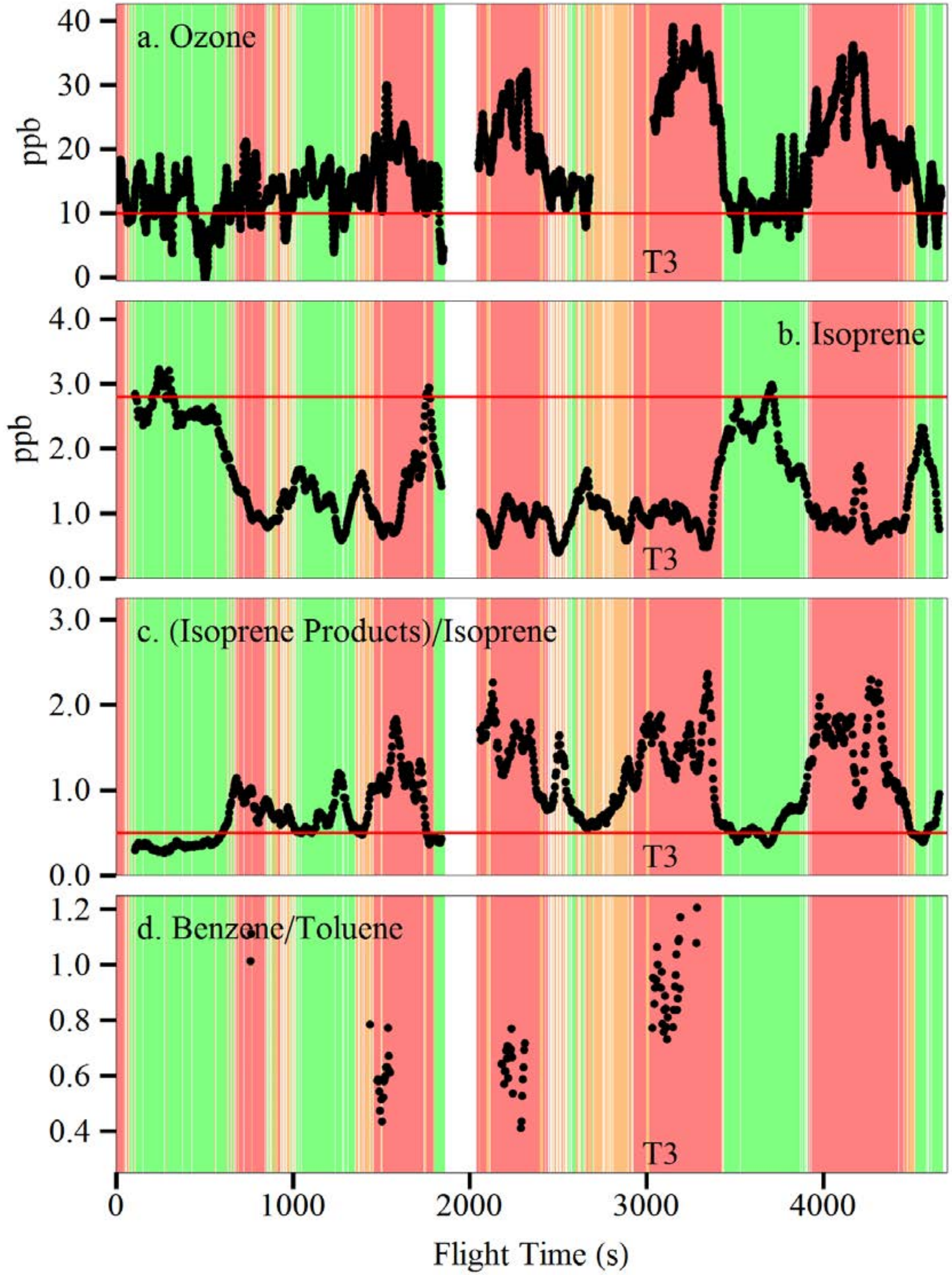
Martin et al., *Bull. Am. Meteorol.* Soc. **2017**, *98*, 981–997.

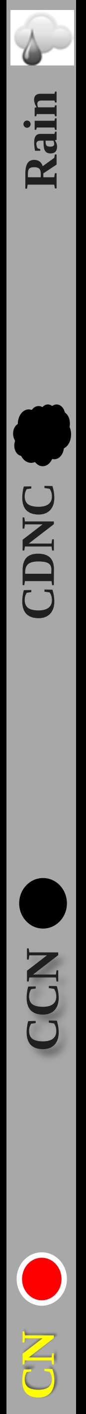
Atmospheric Isoprene Photochemistry



Transverse Transects of Urban Plume

500 m
11 AM local
13 March 2014





Martin et al., *Bull. Am. Meteorol*. Soc. **2017**, *98*, 981–997.

Transverse Transects of Urban Plume

500 m
11 AM local
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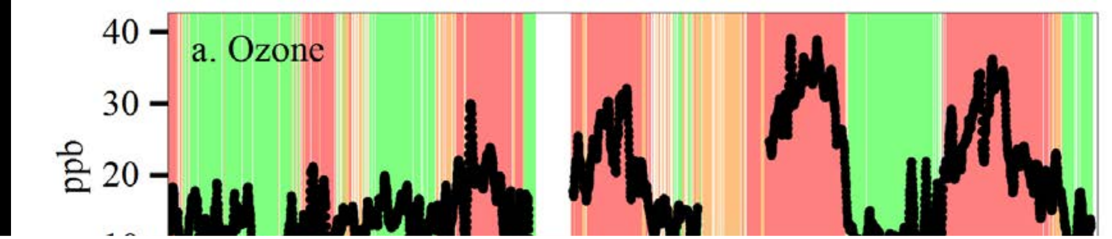
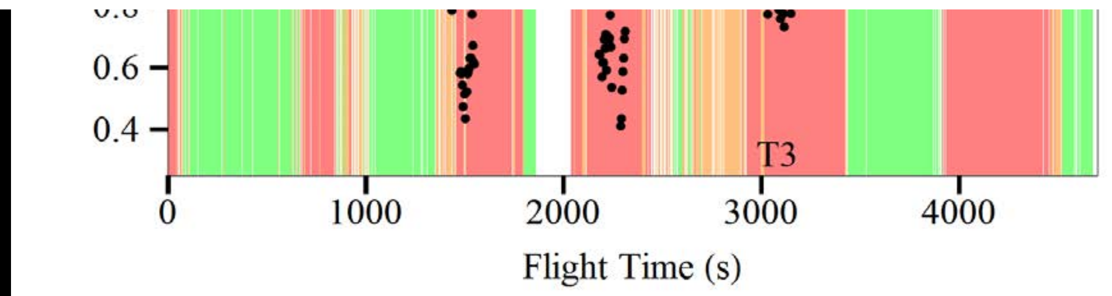
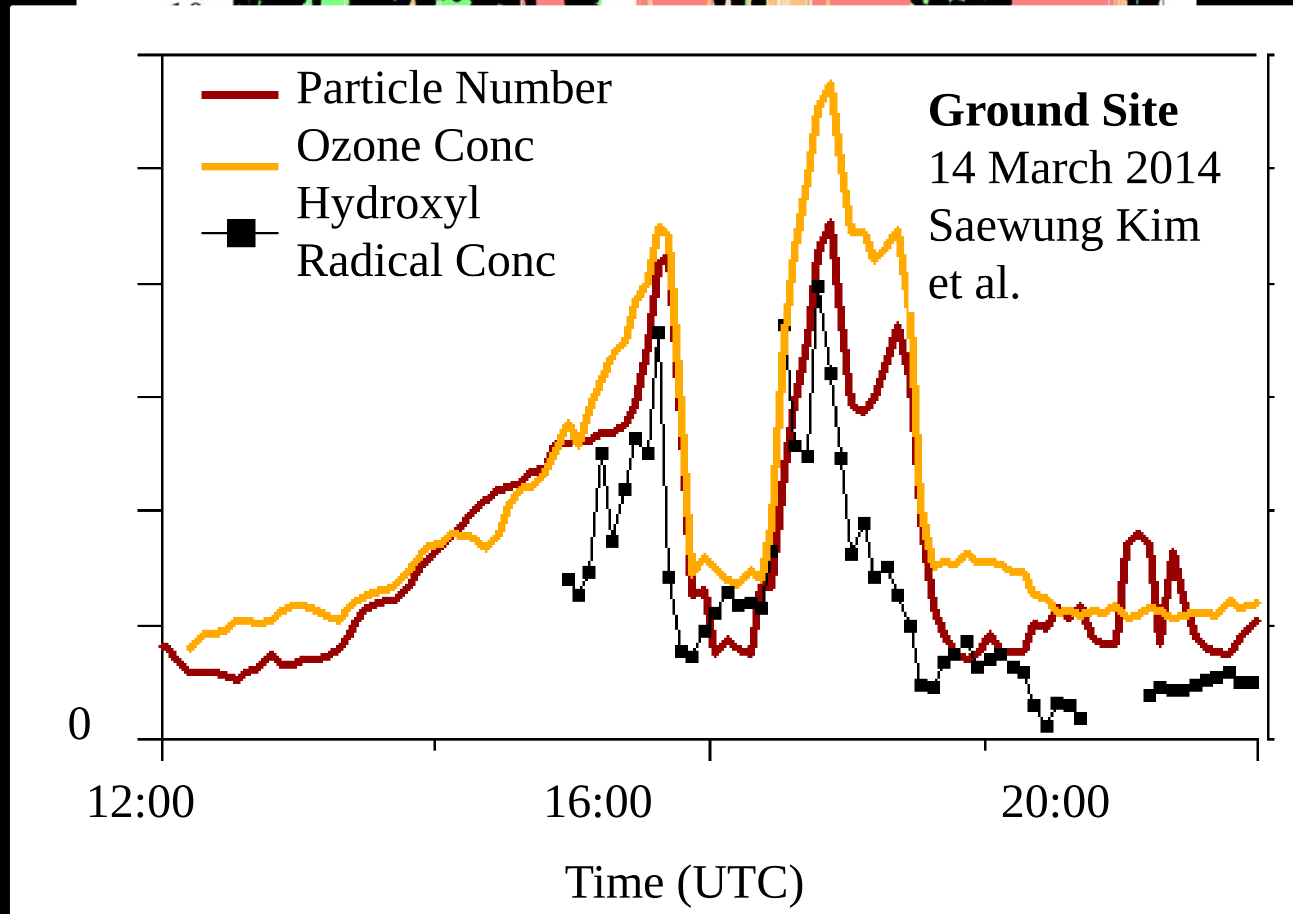
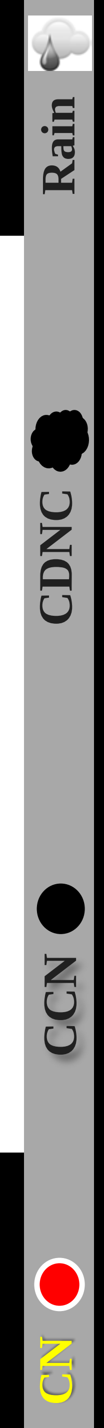


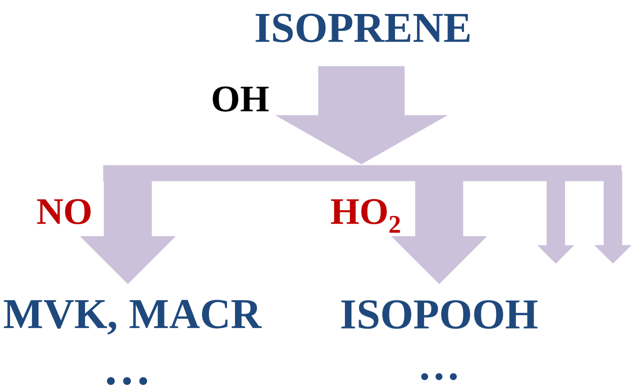


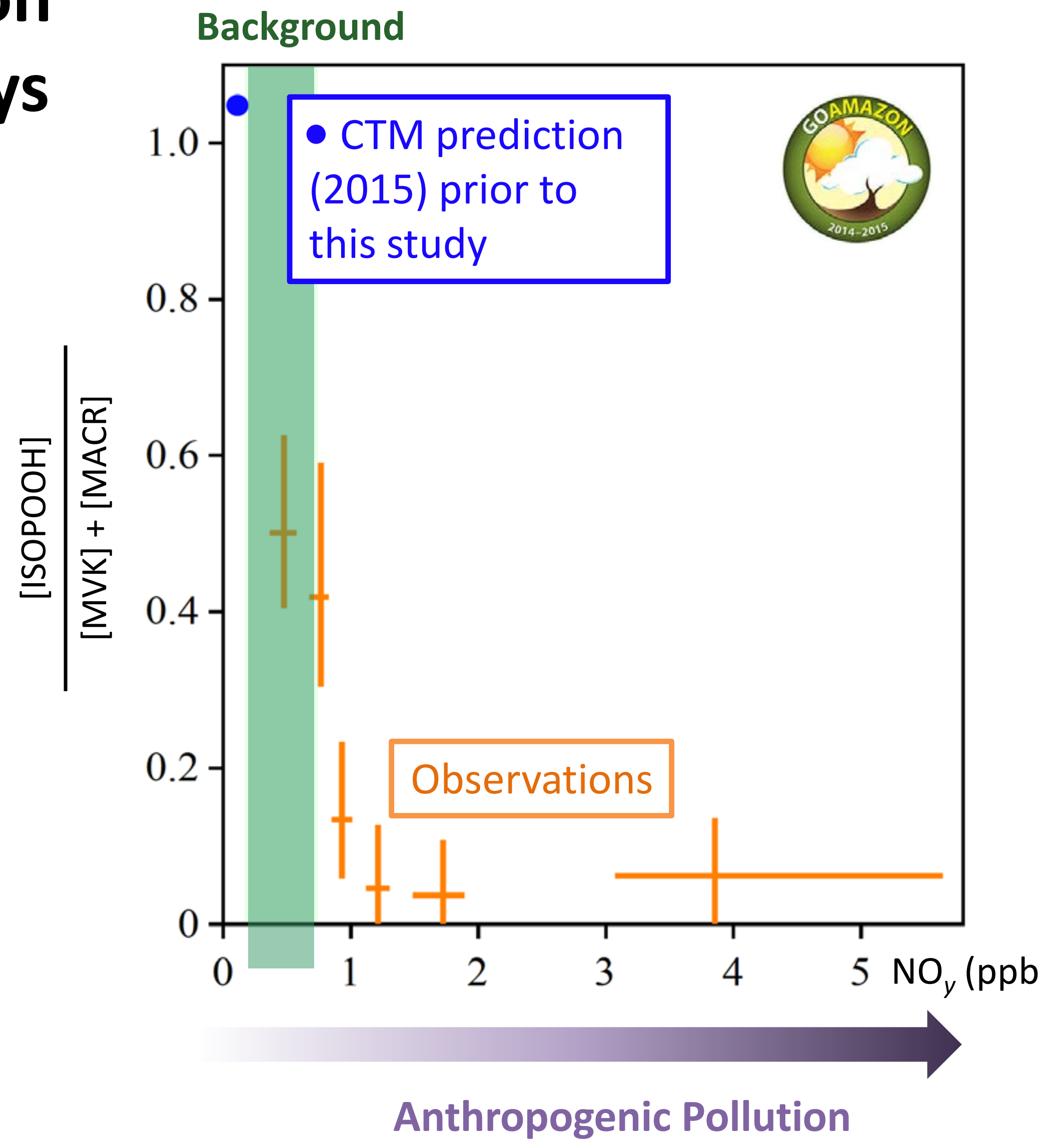




Martin et al., *Bull. Am. Meteorol*. Soc. **2017**, *98*, 981–997.

Anthropogenic influence on isoprene reaction pathways





Conclusions and Implications

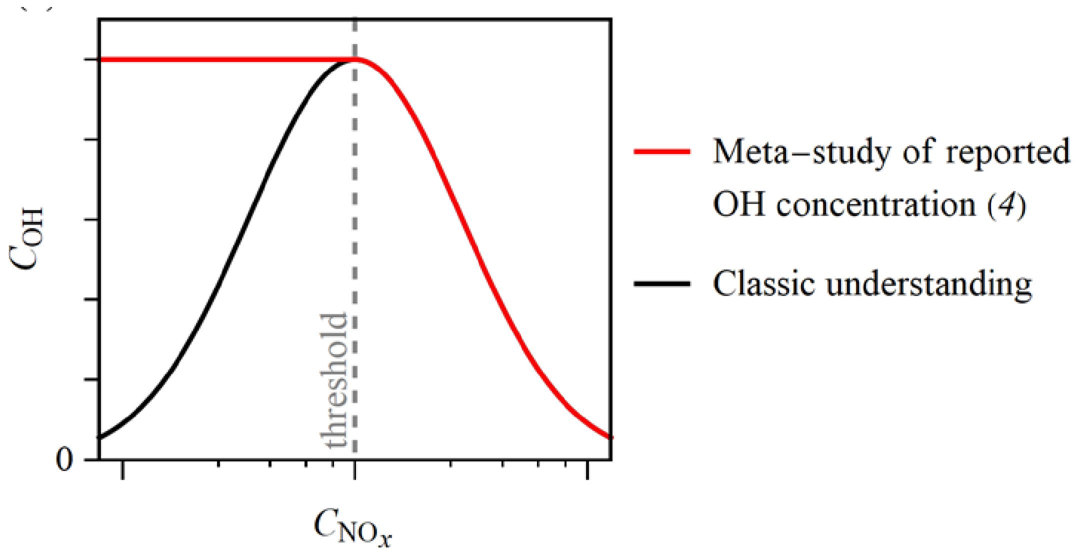
- NO pathway is more important than expected under background conditions.
- Branching of pathways is severely altered by the anthropogenic emissions of NO.
- Past (many) studies that nominally measured MVK + MACR

Liu, Y. J.; Brito, J.; Dorris, M. R.; Rivera-Rios, J. C.; Seco, R.; Bates, K. H.; Artaxo, P.; Duvoisin, S.; Keutsch, F. N.; Kim, S.; Goldstein, A. H.; Guenther, A. B.; Manzi, A. O.; Souza, R. A. F.; Springston, S. R.; Watson, T. B.; McKinney, K. A.; Martin, S. T., Isoprene photochemistry over the Amazon rainforest. *P. Natl. Acad. Sci. USA* **2016,** *113* (22). 6125-6130.

Indirect approach for $OH(NO_x)$

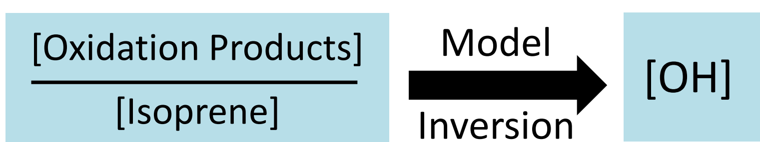
In peer review

I. The controversy



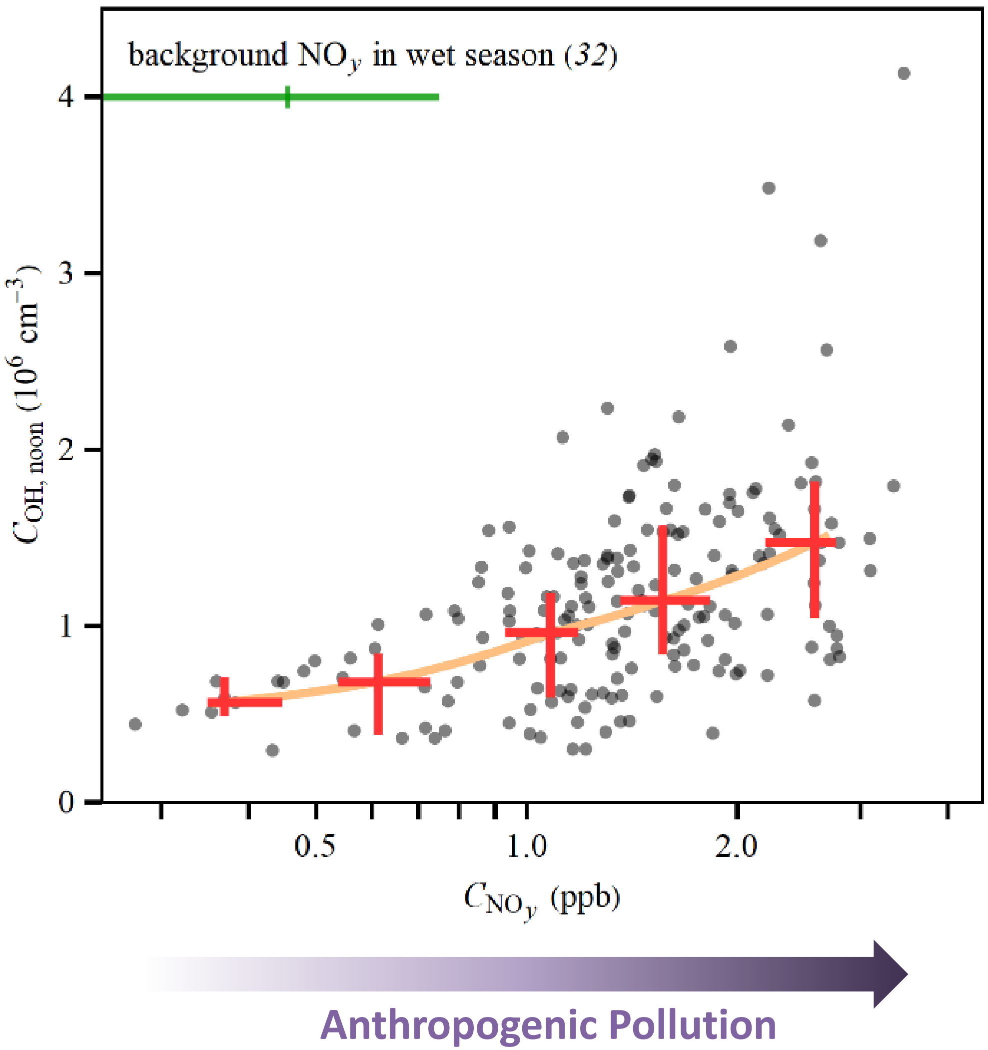
F. Rohrer et al., “Maximum efficiency in the hydroxyl-radical-based self-cleansing of the troposphere,” Nat. Geosci. **2014**, *7*, 559–563.

II. Indirect approach applied here



Yingjun Liu et al., "Isoprene photo-oxidation products quantify the effect of pollution on hydroxyl radicals over Amazonia," *Science Advances*, **2018**, *4*, eaar2547.

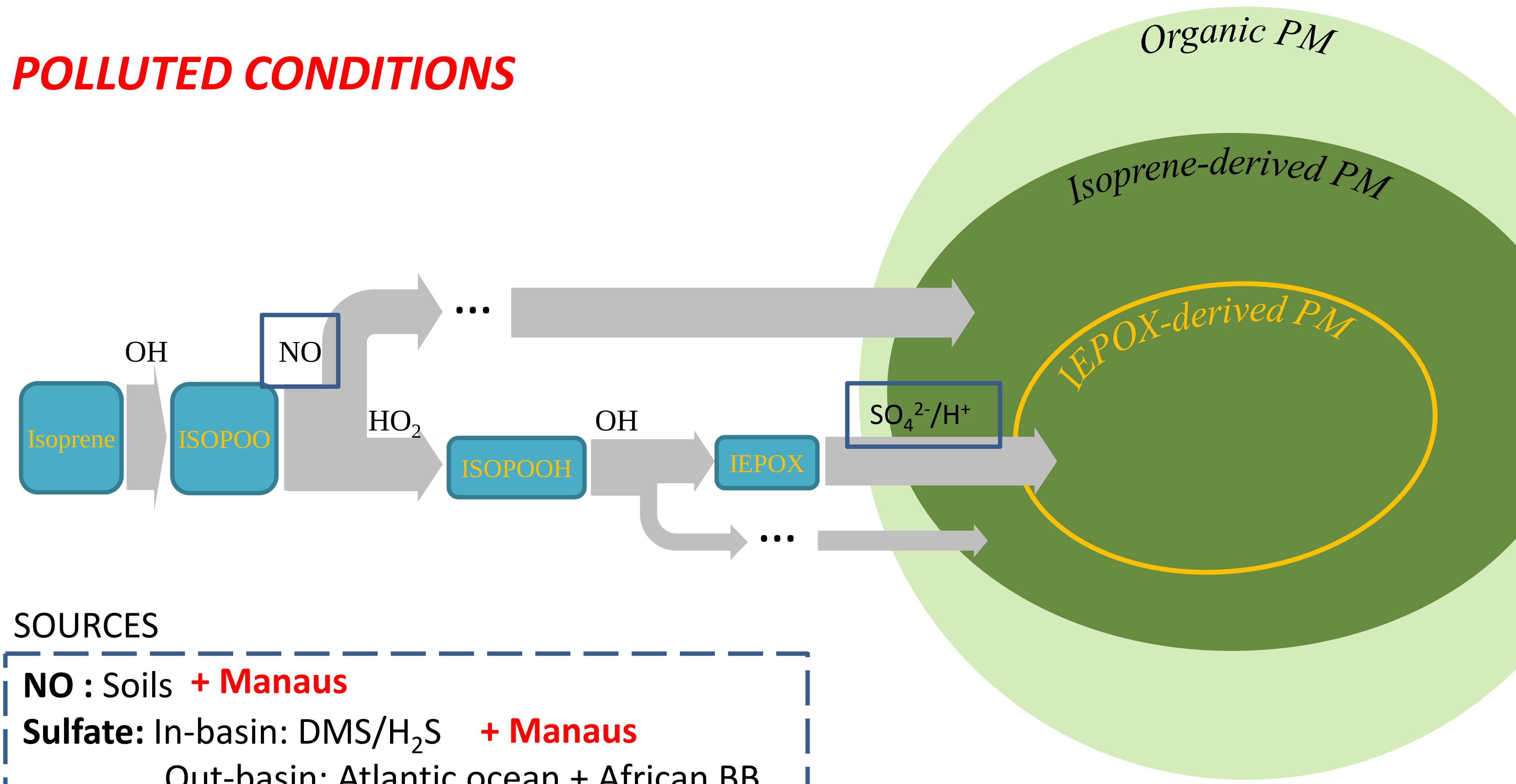
Dependence of inferred equivalent noontime OH concentration on NO_y concentration.



The conclusion is that, compared to background conditions of low NO_x concentrations over the Amazon forest, pollution increased NO_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_x in sustaining OH concentrations.

Yingjun Liu et al., "Isoprene photo-oxidation products quantify the effect of pollution on hydroxyl radicals over Amazonia," *Science Advances*, **2018**, *4*, eaar2547.

POLLUTED CONDITIONS



SOURCES

NO : Soils **+ Manaus**

Sulfate: In-basin: DMS/H_2S **+ Manaus**

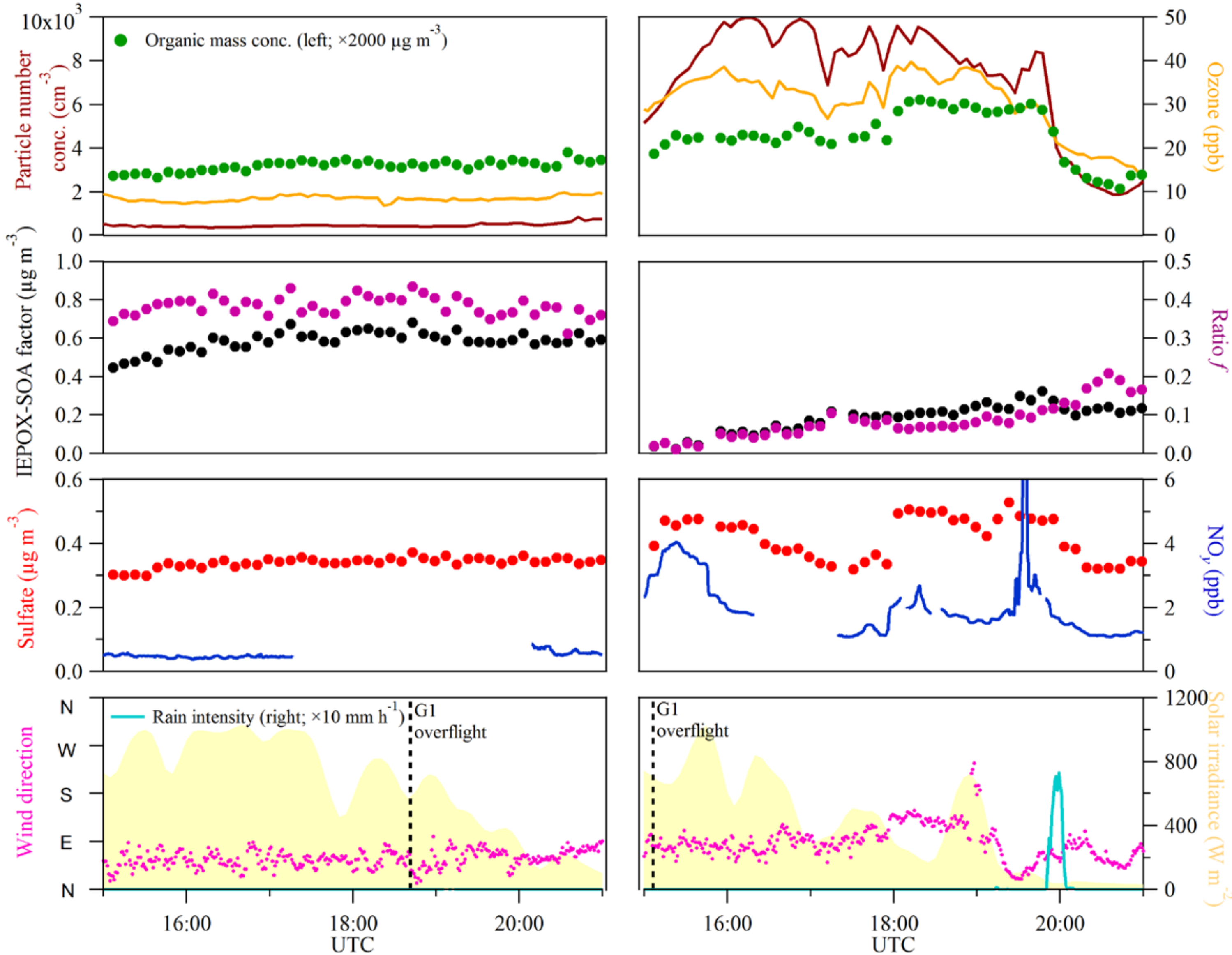
Out-basin: Atlantic ocean + African BB

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

S. de Sá et al., *Atmos. Chem. Phys.*, **2017**, *17*, 6611-6629.

A CASE STUDY

Background conditions March 3 | **Polluted conditions March 13**



Pollution indicators

Variables of interest

$\frac{\text{IEPOX-SOA factor}}{\text{Total organic}}$

Explanatory variables

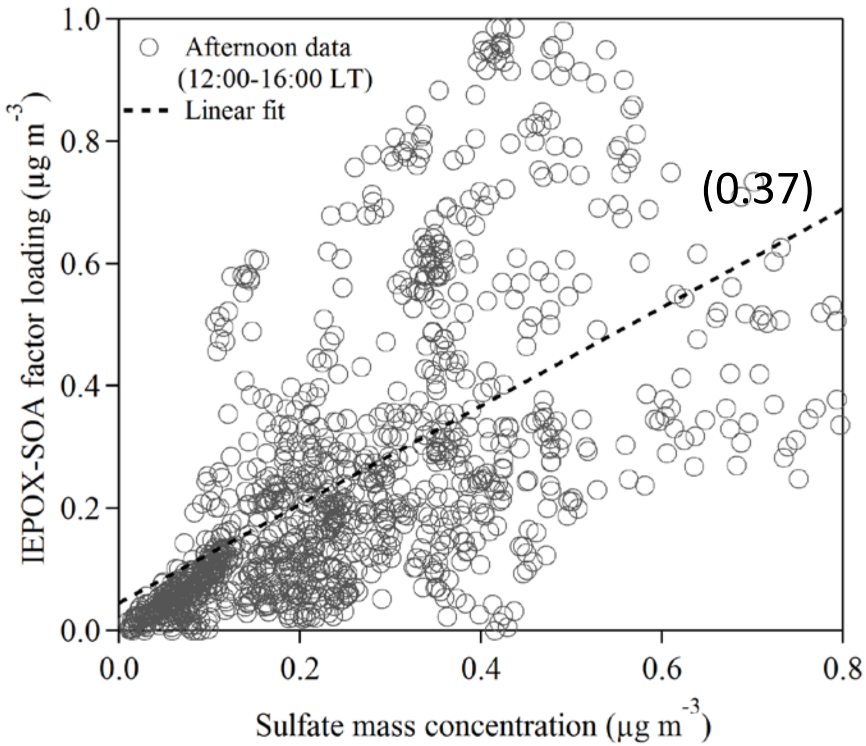
Proxy for NO chemistry

Met conditions

Local time = UTC – 4h

S. de Sá et al., *Atmos. Chem. Phys.*, **2017**, *17*, 6611-6629.

Sulfate:
a first-order predictor of IEPOX-SOA

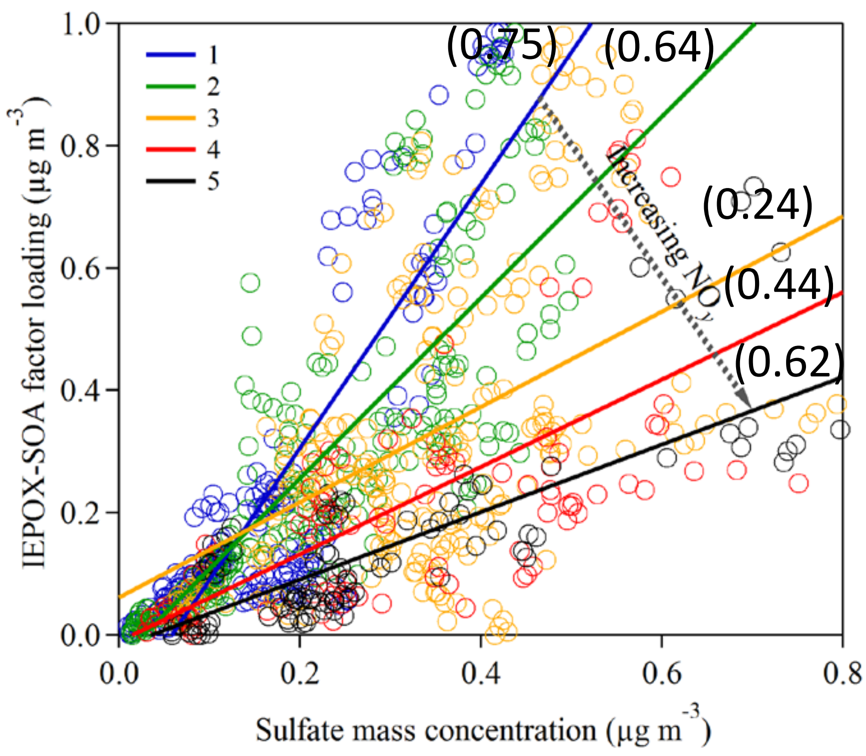


R^2 value shown in parentheses in plot

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

S. de Sá et al., *Atmos. Chem. Phys*., **2017**, *17*, 6611-6629.

Sulfate:
a first-order predictor of IEPOX-SOA



R^2 value shown in parentheses in plot

NO:
an important modulator of IEPOX-SOA

NO_y: proxy of integrated NO chemistry

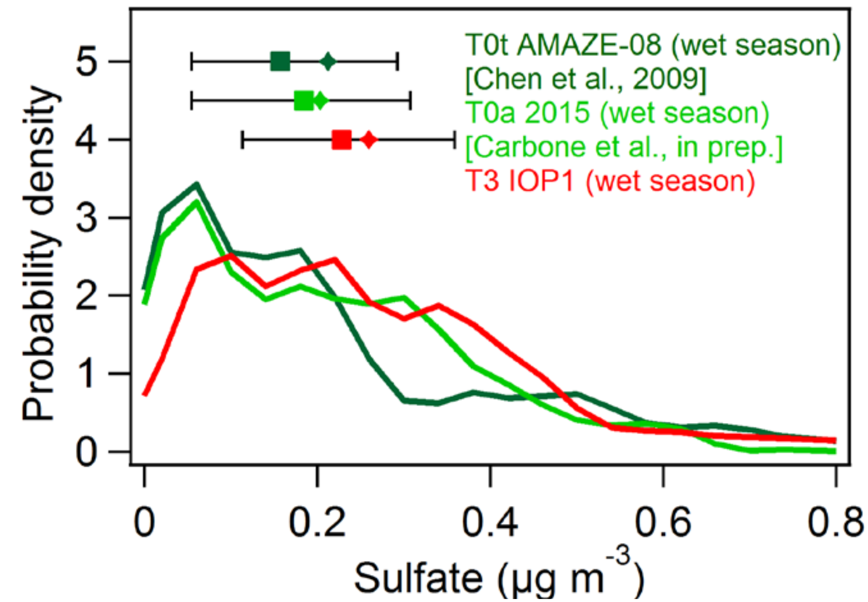
(NO_y = NO + NO_2 + reservoir species)

S. de Sá et al., *Atmos. Chem. Phys.*, **2017**, *17*, 6611-6629.

Sulfate:

a first-order predictor of IEPOX-SOA

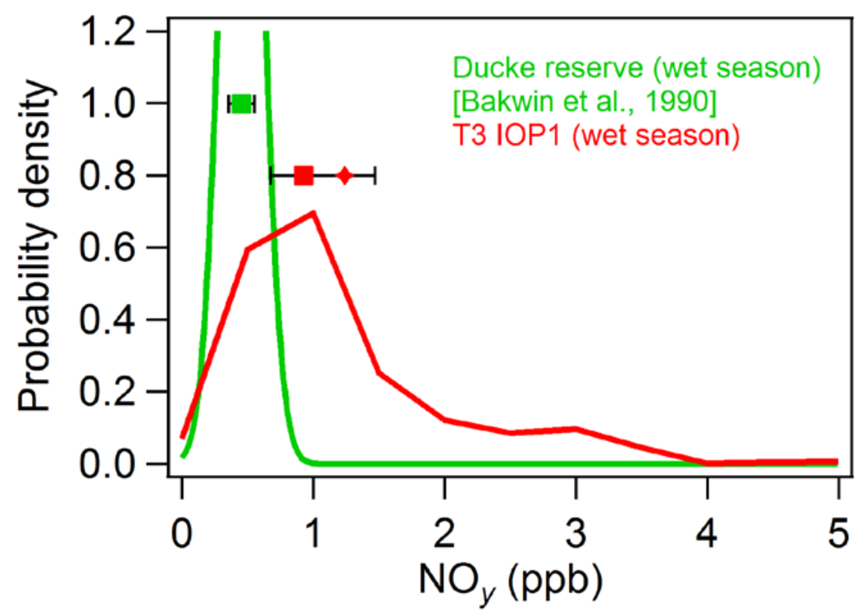
Background sources sustain concentrations



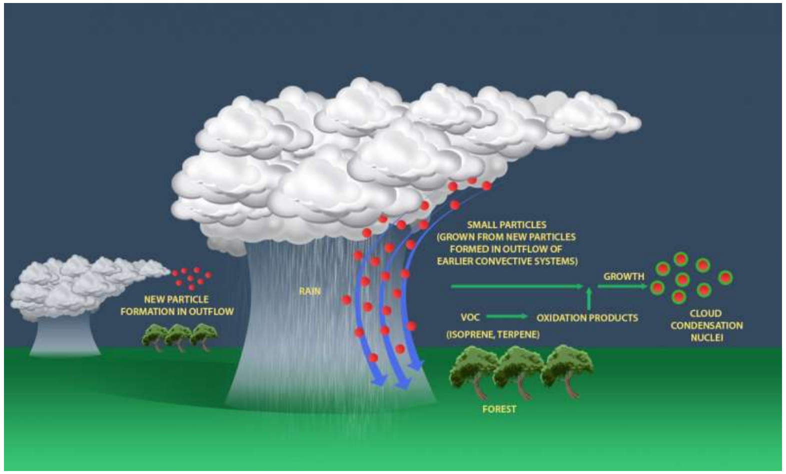
NO:

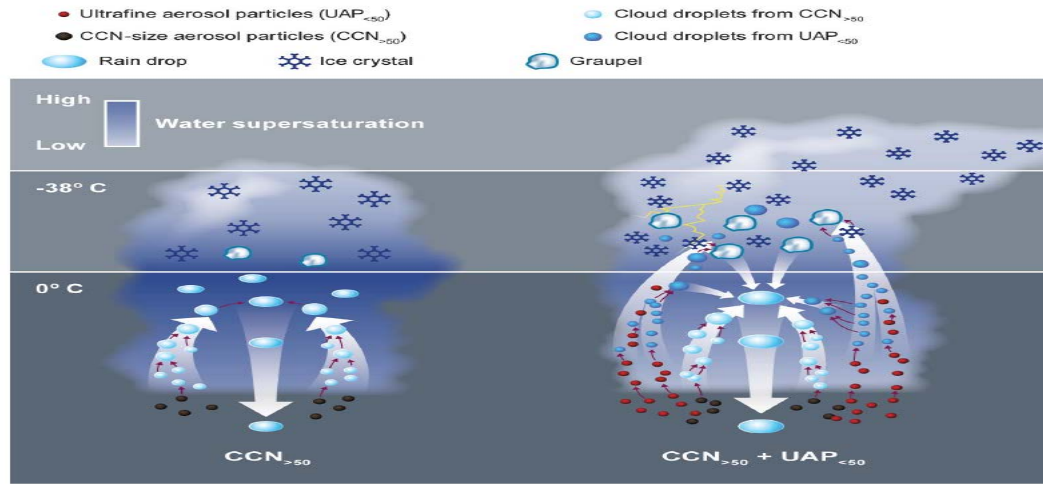
an important modulator of IEPOX-SOA

Manaus contribution dominates over background sources



S. de Sá et al., *Atmos. Chem. Phys.*, **2017**, *17*, 6611-6629.





Amazon boundary layer aerosol concentration sustained by vertical transport during rainfall

Jian Wang ✉, Radovan Krejci […] Scot T. Martin

Nature **539**, 416–419 (17 November 2016)
doi:10.1038/nature19819
Download Citation

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Accepted: 31 August 2016
Published: 24 October 2016

Substantial convection and precipitation enhancements by ultrafine aerosol particles

Jiwen Fan[1,*], Daniel Rosenfeld[2], Yuwei Zhang[1,3], Scott E. Giangrande[4], Zhanqing Li[3,5], Luiz A. T. Machado[6], Scot T. Martin[7]...
+ 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, Trissevgeni Stavrakou, Karla M. Longo, Julio Tóta, Rodrigo Augusto Ferreira de Souza, Oscar Vega, Ying Liu, Manish Shrivastava, Eliane G. Alves, Fernando C. Santos, Guoyong Leng & Zhiyuan Hu

Nature Communications **8**,
Article number: 15541 (2017)
doi:10.1038/ncomms15541
Download Citation

Received: 10 January 2017
Accepted: 07 April 2017
Published: 23 May 2017

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

Adam P. Bateman, Zhaoheng Gong, Pengfei Liu, Bruno Sato, Glauber Cirino, Yue Zhang, Paulo Artaxo, Allan K. Bertram, Antonio O. Manzi, Luciana V. Rizzo, Rodrigo A. F. Souza, Rahul A. Zaveri & Scot T. Martin ✉

Nature Geoscience **9**, 34–37 (2016)
doi:10.1038/ngeo2599
Download Citation

Received: 15 May 2015
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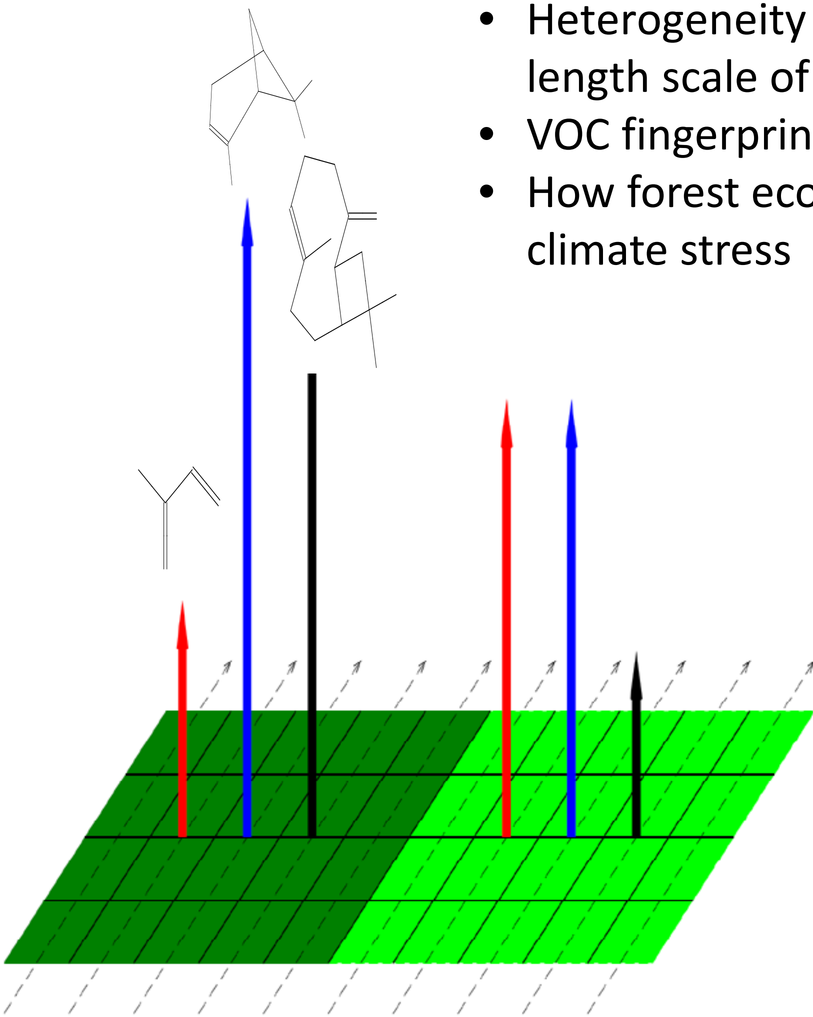
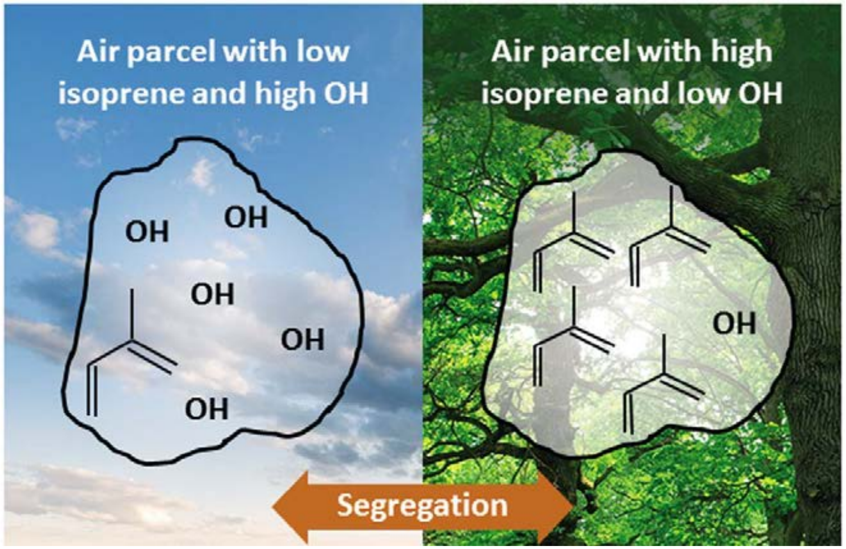
Published: 07 December 2015

Frontiers… Now

Science Question: Heterogeneity of Emissions and Reactivity at Scale of Ecosystem Emissions

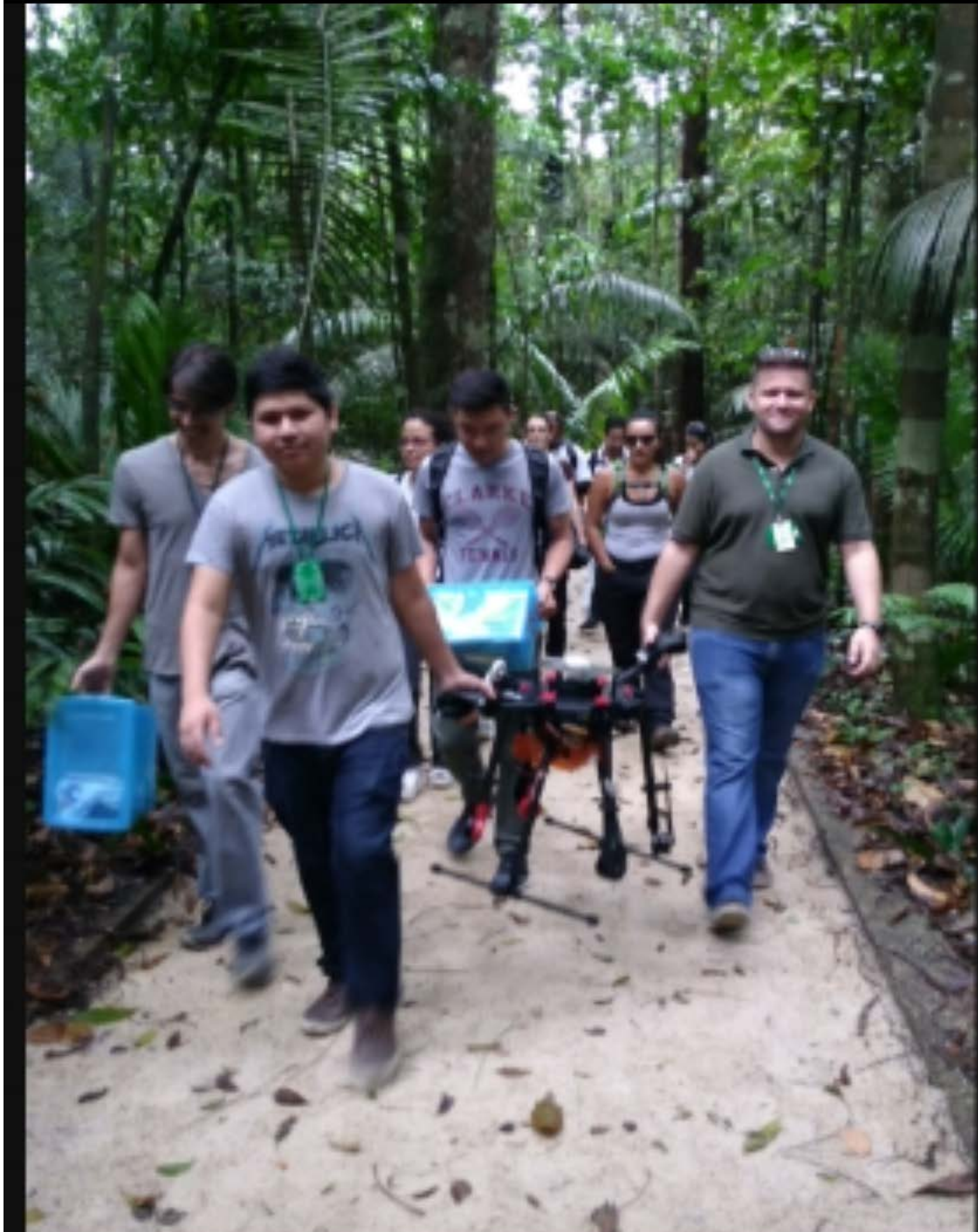


- Heterogeneity of emissions across a length scale of <1 km
- VOC fingerprint changes under stress
- How forest ecosystems respond to climate stress

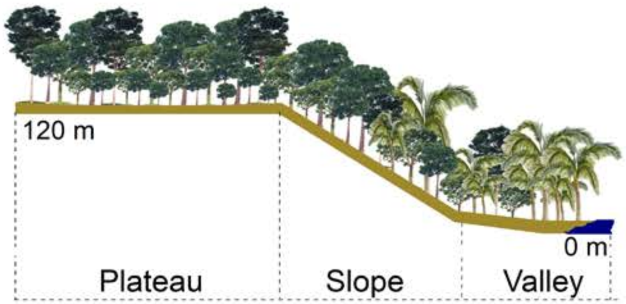


Adapted from M. Shrivastava et al., Recent advances in understanding secondary organic aerosol: Implications for global climate forcing, *Rev. Geophys.*, **2017**, *55*, 509–559.

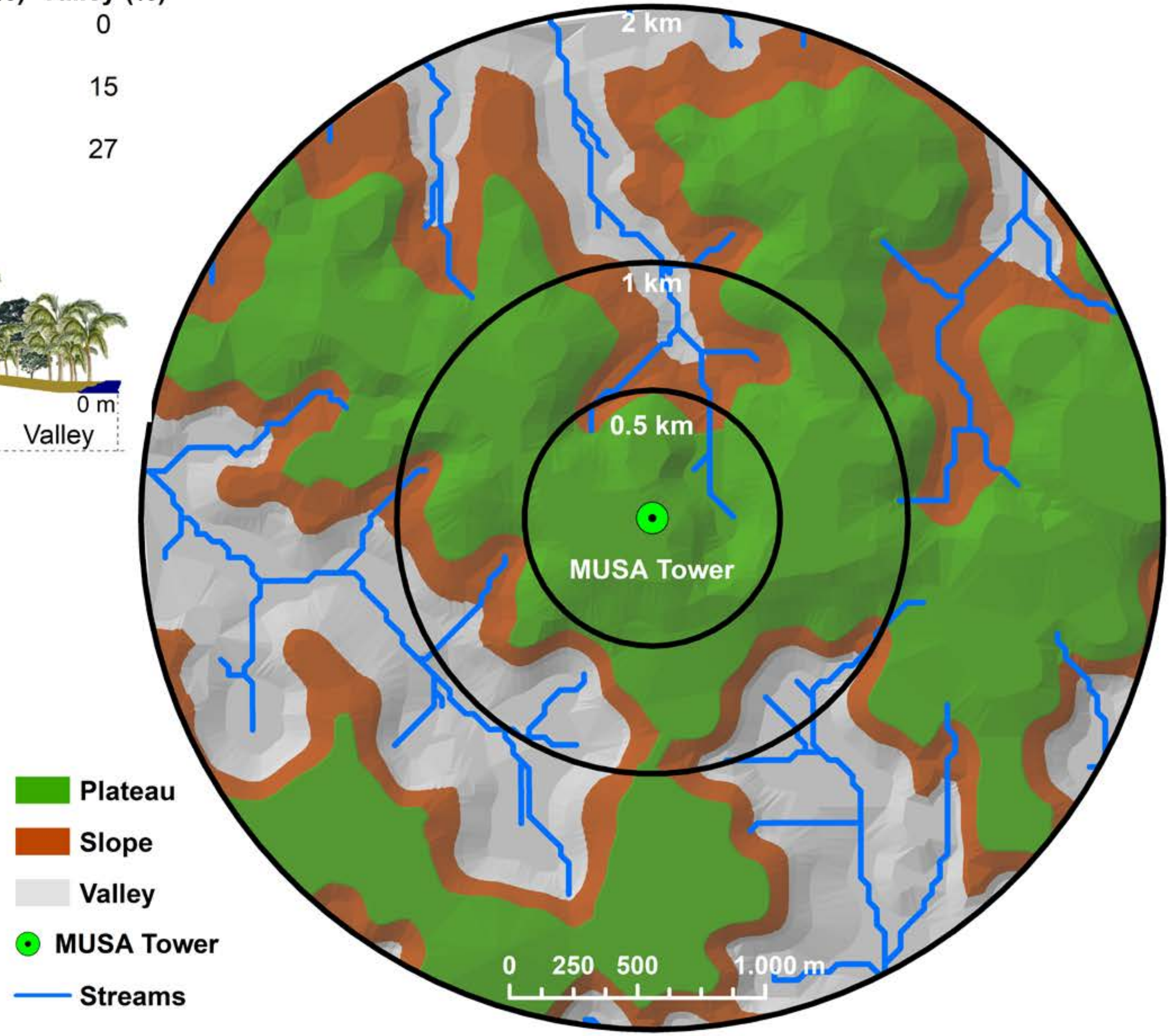
Adapted from Ouwersloot et al., *Atmos. Chem. Phys.*, **2011**, *11*, 10681–10704.



Area Radius	Plateau (%)	Slope (%)	Valley (%)
0.5 km	95	5	0
1 km	66	19	15
2 km	49	24	27



Typical relief at MUSA



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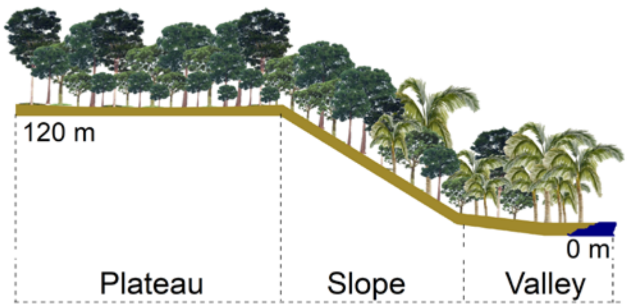
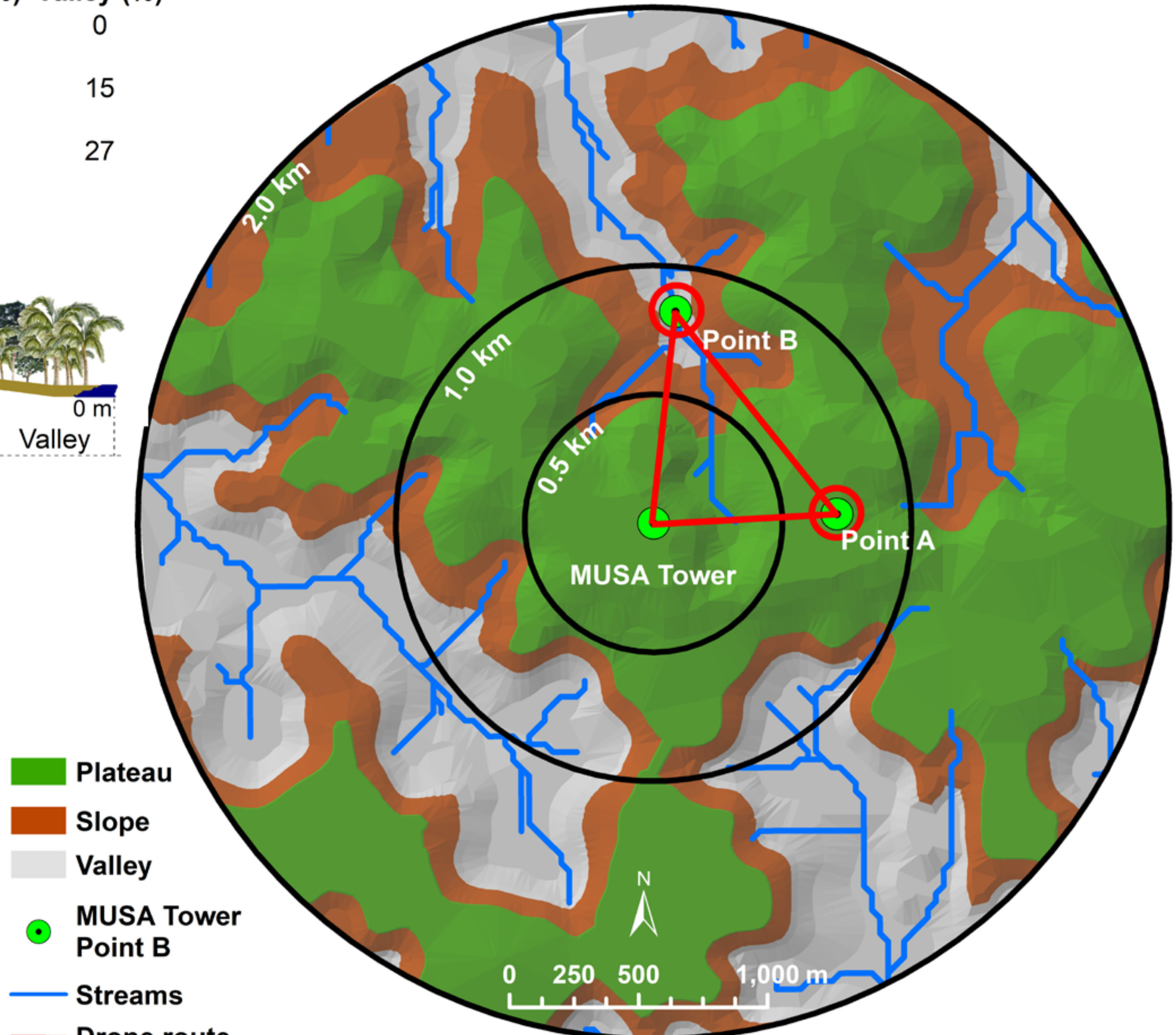
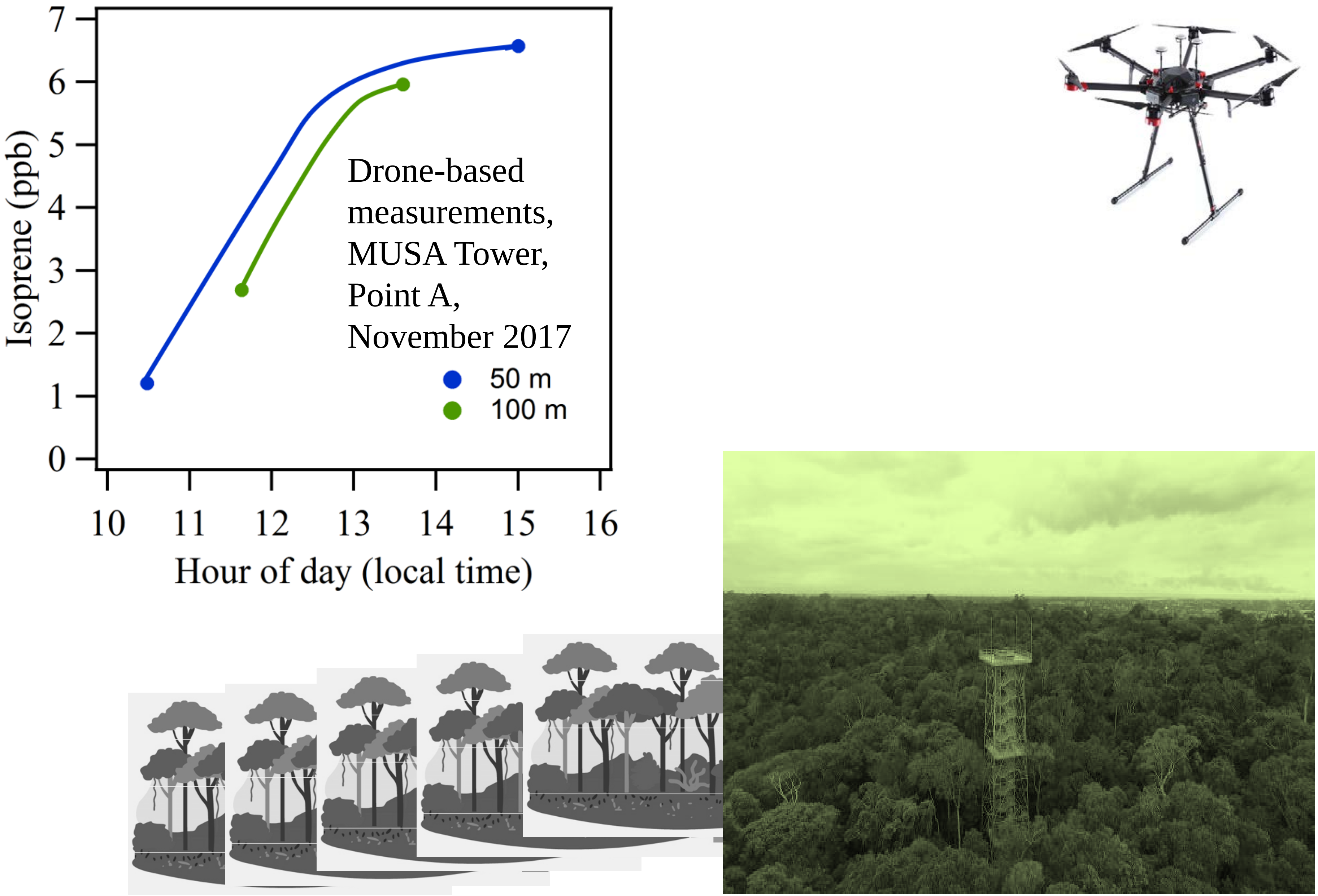
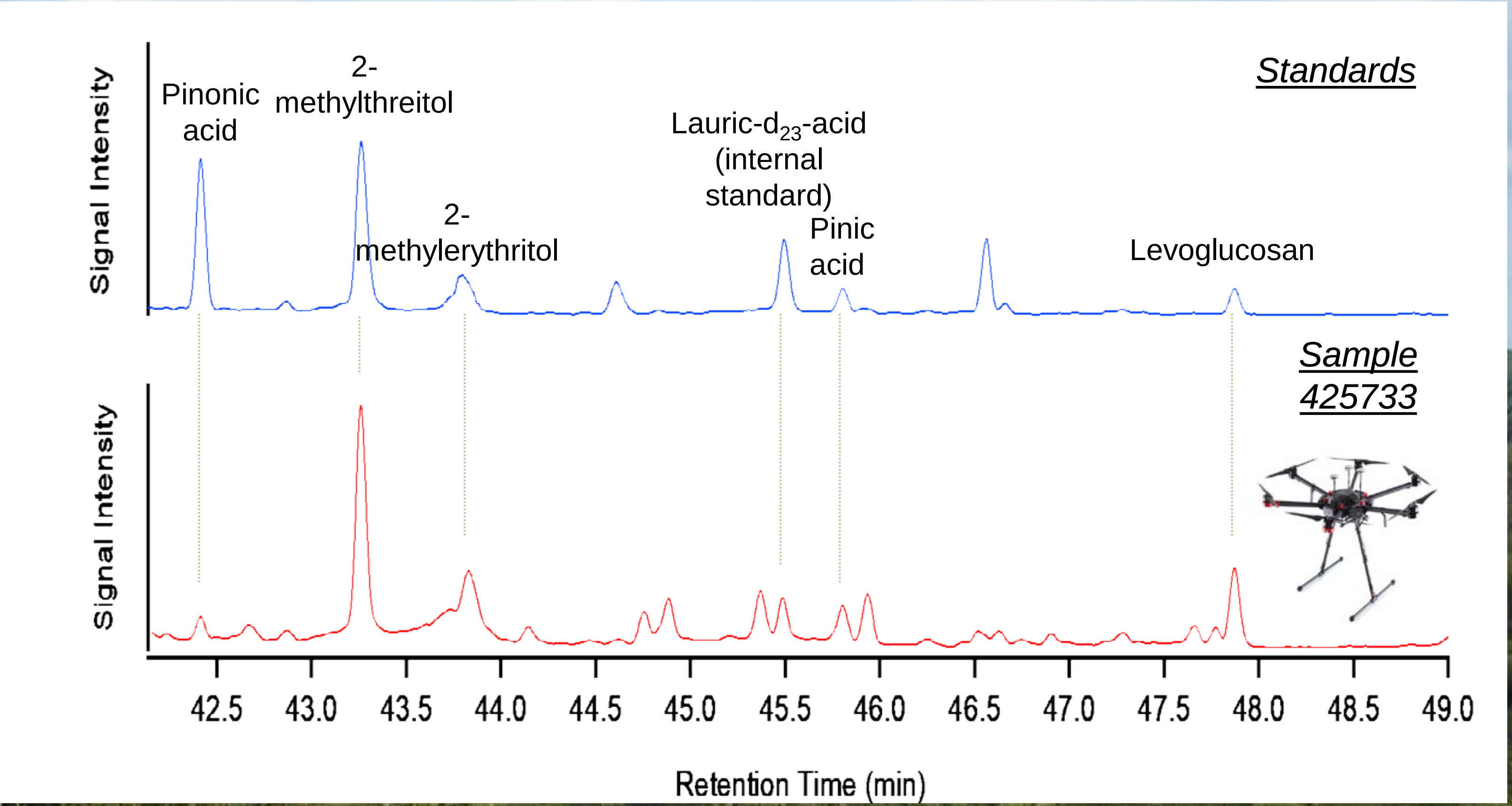


Typical relief at MUSA



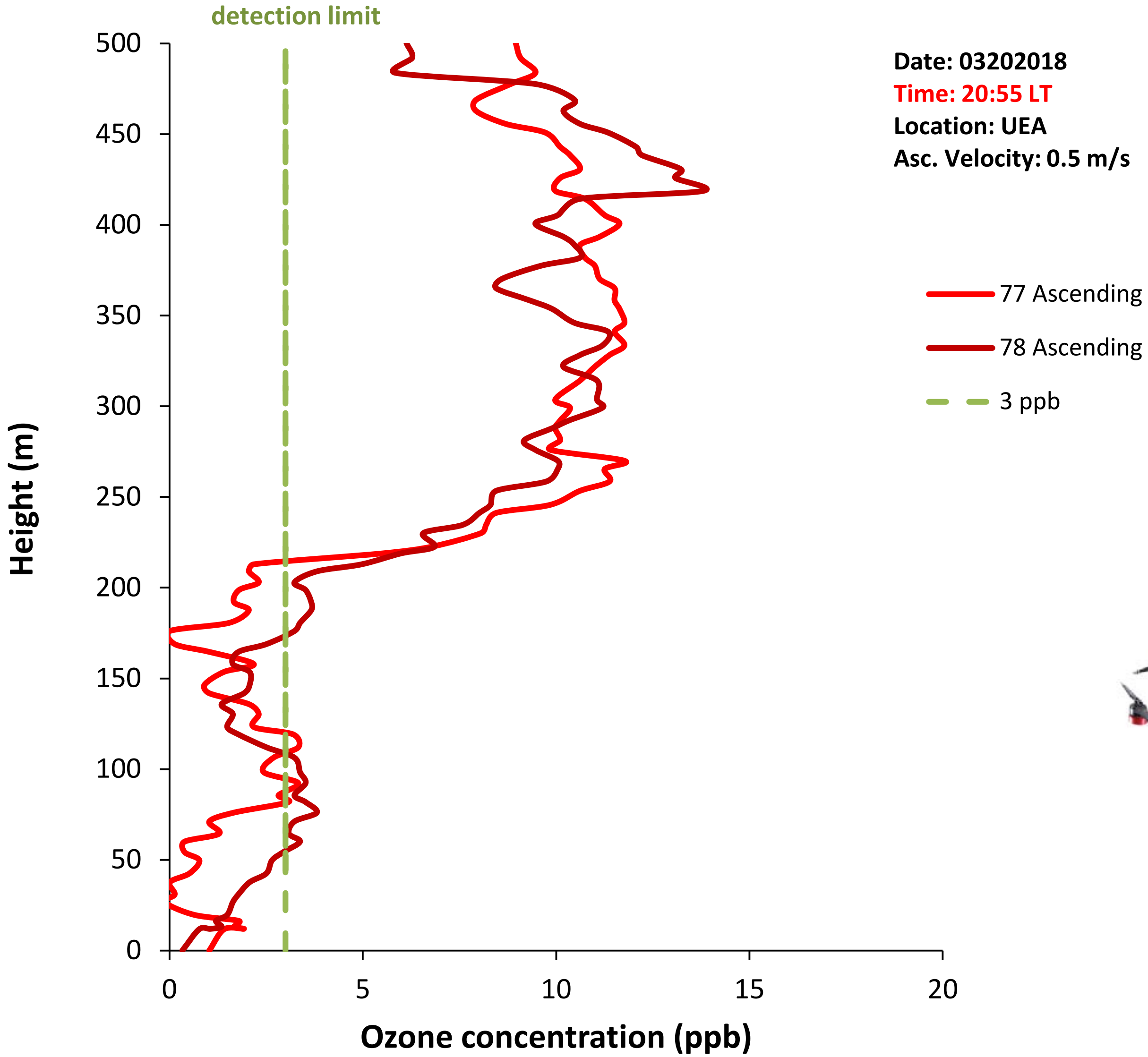

Isoprene (ppb)
0
1
2
3
4
5
6
7
Hour of day (local time)
10
11
12
13
14
15
16
Drone-based measurements, MUSA Tower, Point A, November 2017
50 m
100 m

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




Thank you!