Observations and Modeling of the Green Ocean Amazon

Presented by Scot Martin
at Fall 2011
CESM PI Meeting

Outline of Presentation

- WHY this experiment?
- WHERE will this experiment take place?
- WHEN will this experiment take place?
- WHAT instrumentation and facilities are part of experiment?
- HOW is the experiment organized?

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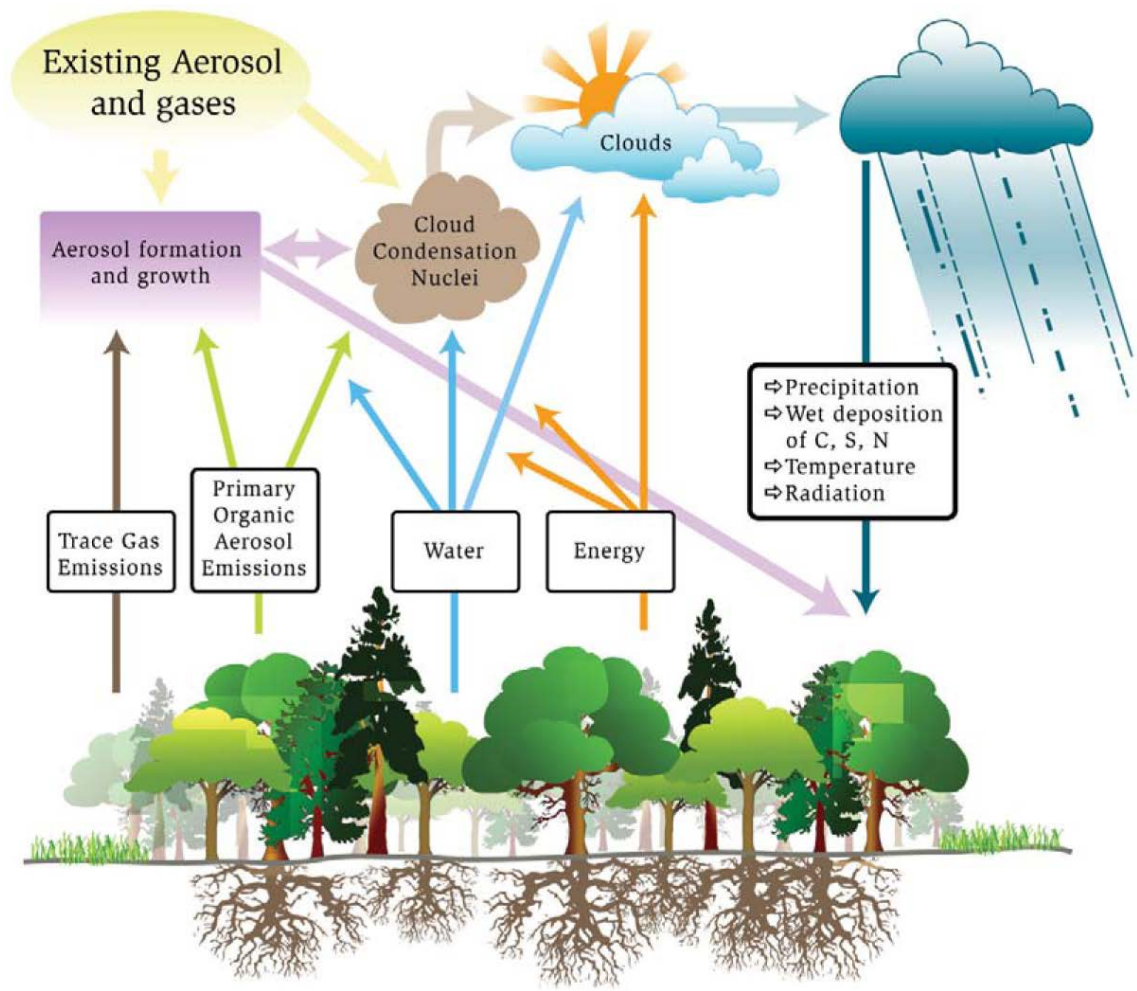
Amazon Basin has strong coupling between terrestrial ecosystem and the hydrologic cycle: The linkages among carbon cycle, aerosol life cycle, and cloud life cycle need to be understood and quantified.

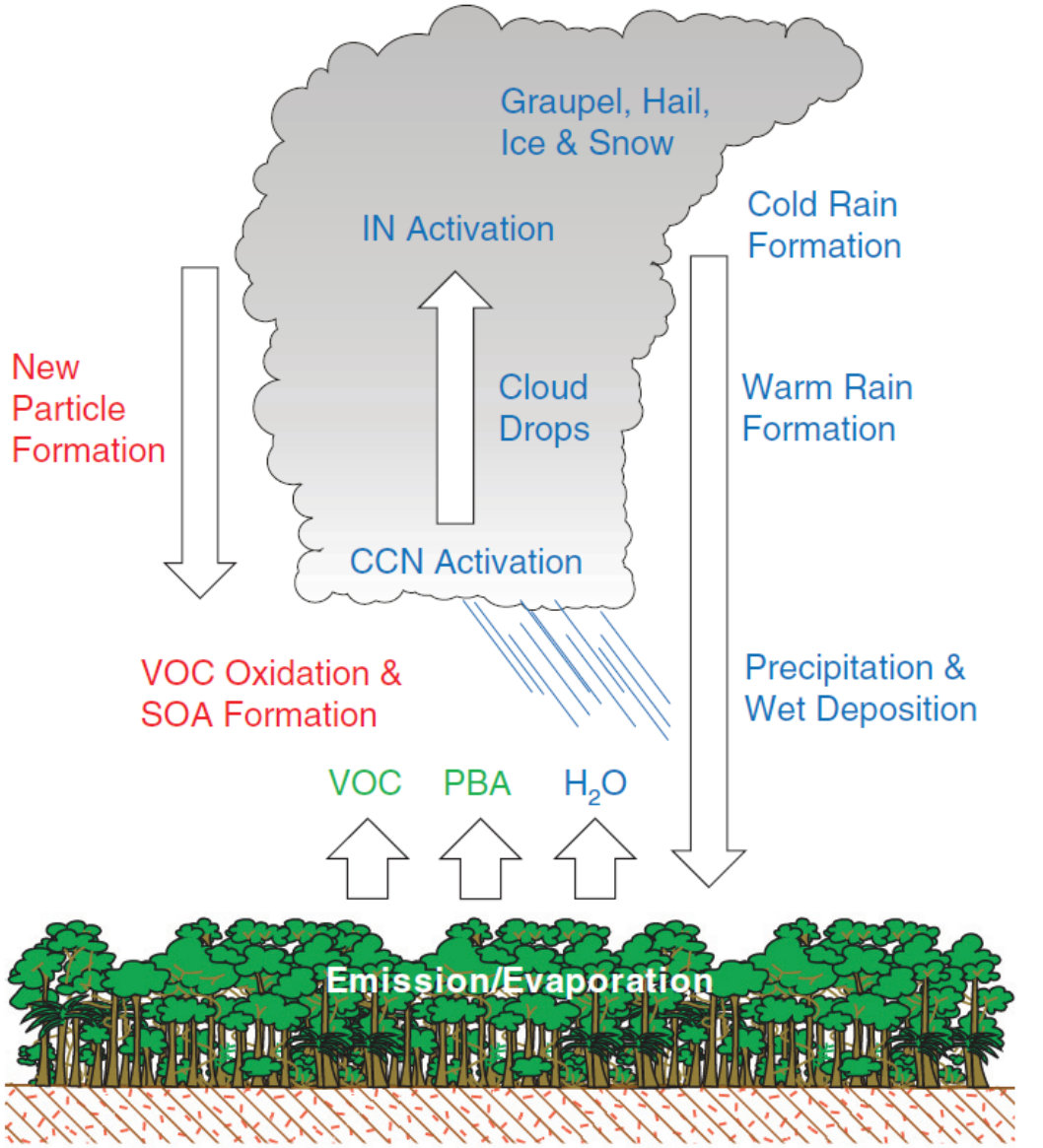


Source: Barth et al., "Coupling between Land Ecosystems and the Atmospheric Hydrologic Cycle through Biogenic Aerosol Particles," *BAMS*, *86*, 1738-1742, 2005.

Susceptibility and expected reaction to stresses of global climate change as well as pollution introduced by future regional economic development are not known or quantified at present time.

Cloud Life Cycle, Aerosol Life Cycle, Aerosol-Cloud-Precipitation Interactions, Carbon Cycle are all represented in this schematic.

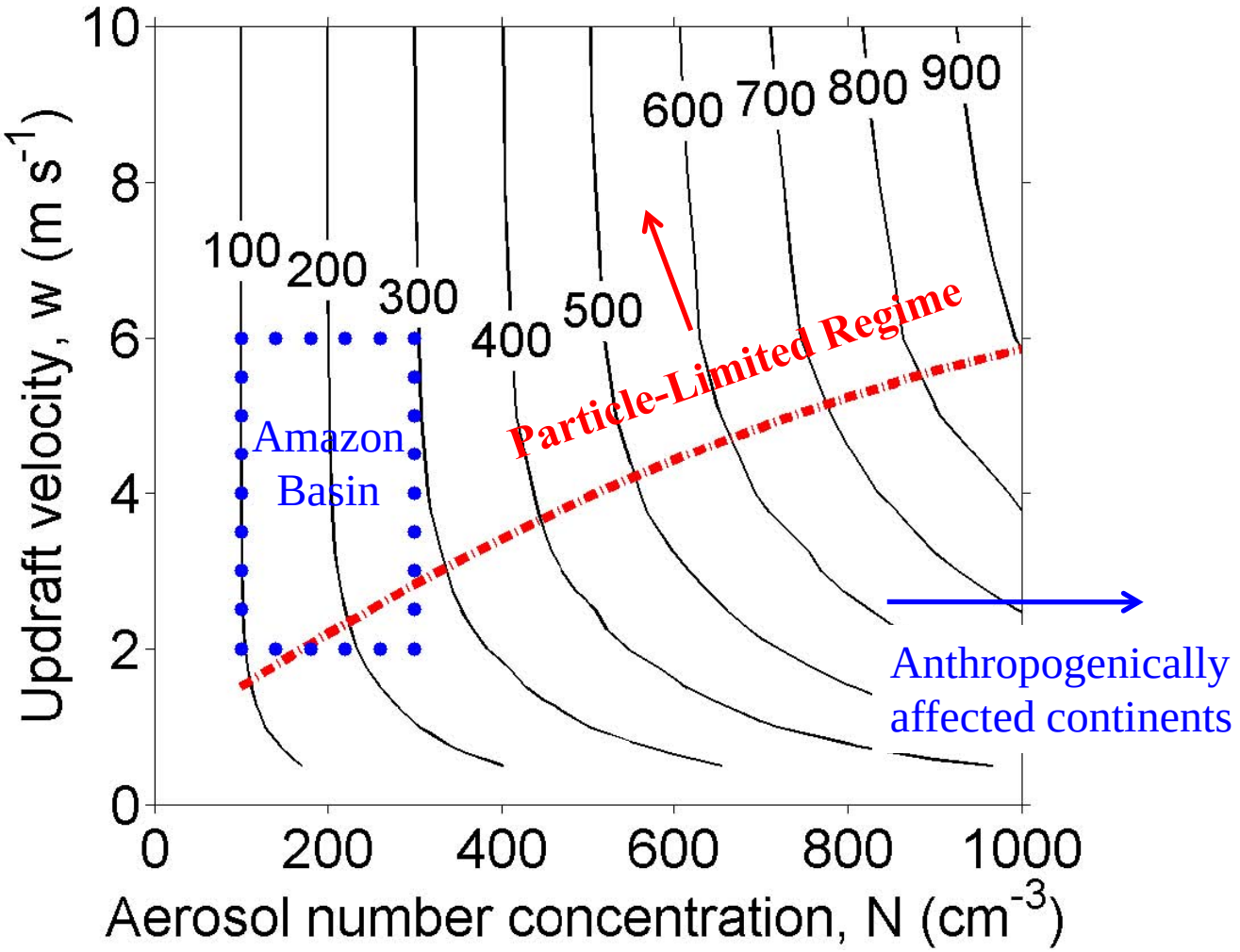
GoAmazon2014: *What is the effect of pollution on…* these cycles and the coupling among them?



U. Pöschl, S.T. Martin, B. Sinha, Q. Chen, S.S. Gunthe, J.A. Huffman, S. Borrmann, D.K. Farmer, R.M. Garland, G. Helas, J.L. Jimenez, S.M. King, A. Manzi, E. Mikhailov, T. Pauliquevis, M.D. Petters, A.J. Prenni, P. Roldin, D. Rose, J. Schneider, H. Su, S.R. Zorn, P. Artaxo, M. O. Andreae, "Rainforest aerosols as biogenic nuclei of clouds and precipitation in the Amazon," *Science*, 2010, 329, 1513-1516.

Cloud Droplet Number Concentration (CDNC):

Sensitivity to Pollution in Pristine Regions



Amazon Basin:

Low aerosol number concentrations +

High water vapor concentration =

Especially susceptible.

Possibility of dramatic changes in energy flows and rainfall patterns

Ref: Pöschl et al., "Rainforest aerosols as biogenic nuclei of clouds and precipitation in the Amazon," *Science*, **2010**, *329*, 1513-1516.

Scientific Questions for GoAmazon2014

Note: Non-exhaustive selected list. Further development anticipated.

Carbon Cycle - improve Community Earth System Model (CESM) for land-atmosphere processes in the Amazon Basin, including aerosol-cloud-precipitation connections

- Objective - Reduce uncertainties in our knowledge of feedbacks between vegetation-hydrology that underlie the Amazon forest dieback hypothesis. The uncertain range of feedbacks at present leads to large differences in ESM predictions.
- Objective - Response of photosynthesis and transpiration, including BVOC emissions, to changes in the direct and diffuse components of incoming solar radiation, i.e., in the context of current and future scenarios of aerosols and clouds in the Amazon Basin.

Aerosol Life Cycle - accurate modeling of aerosol sources/sinks and aerosol optical, CCN, and IN properties, as affected by pollution of pristine tropical environments

- Objective - The interactions of the urban pollution plume with biogenic volatile organic compounds in the tropics, especially the impact on the production of secondary organic aerosol, the formation of new particles, and biogenic emissions of aerosols and their precursors..
- Objective - Influence of anthropogenic activities on aerosol microphysical, optical, cloud condensation nuclei (CCN), and ice nuclei (IN) properties in the tropics.

Scientific Questions for GoAmazon2014

Note: Non-exhaustive selected list. Further development anticipated.

Cloud Life Cycle - development of a knowledge base to improve tropical cloud parameterizations in GCMs

- Objective - The transition from shallow to deep cumulus convection during the daily cycle of the Amazon Basin, with comparison and understanding to other environments.
- Objective - The role of landscape heterogeneity—the Manaus urban area as well as the 10-km-scale of river width—on the dynamics of convection and clouds (+carbon cycle)
- Objective - The evolution of convective intensity from severe storms in the dry season to moderate storms in the wet season.

Cloud-Aerosol-Precipitation Interactions - improvement of parameterizations of aerosol-cloud interactions in climate models

- Objective - Aerosol effects on deep convective clouds, precipitation, and lightning under different aerosol and synoptic regimes, including the roles of aerosols in changing regional climate and atmospheric circulation.
- Objective - Data-driven improvement of parameterizations of aerosol-cloud interactions in the climate models.

Scientific Questions for GoAmazon2014

Note: Non-exhaustive selected list. Further development anticipated.

The theme uniting these objectives is the development of a data-driven knowledge base for predicting how the present-day functioning of energy, carbon, and chemical flows in the Basin might change, both due to external forcing on the Basin from global climate change and internal forcing from past and projected demographic changes in the Basin.

The ultimate goal is to estimate future changes in direct and indirect radiative forcing, energy distributions, regional climate, ecosystem functioning, and feedbacks to global climate.

In this regard, the presented objectives are representative, and further definition and broadening can be expected as the science team spins up prior to deployment.

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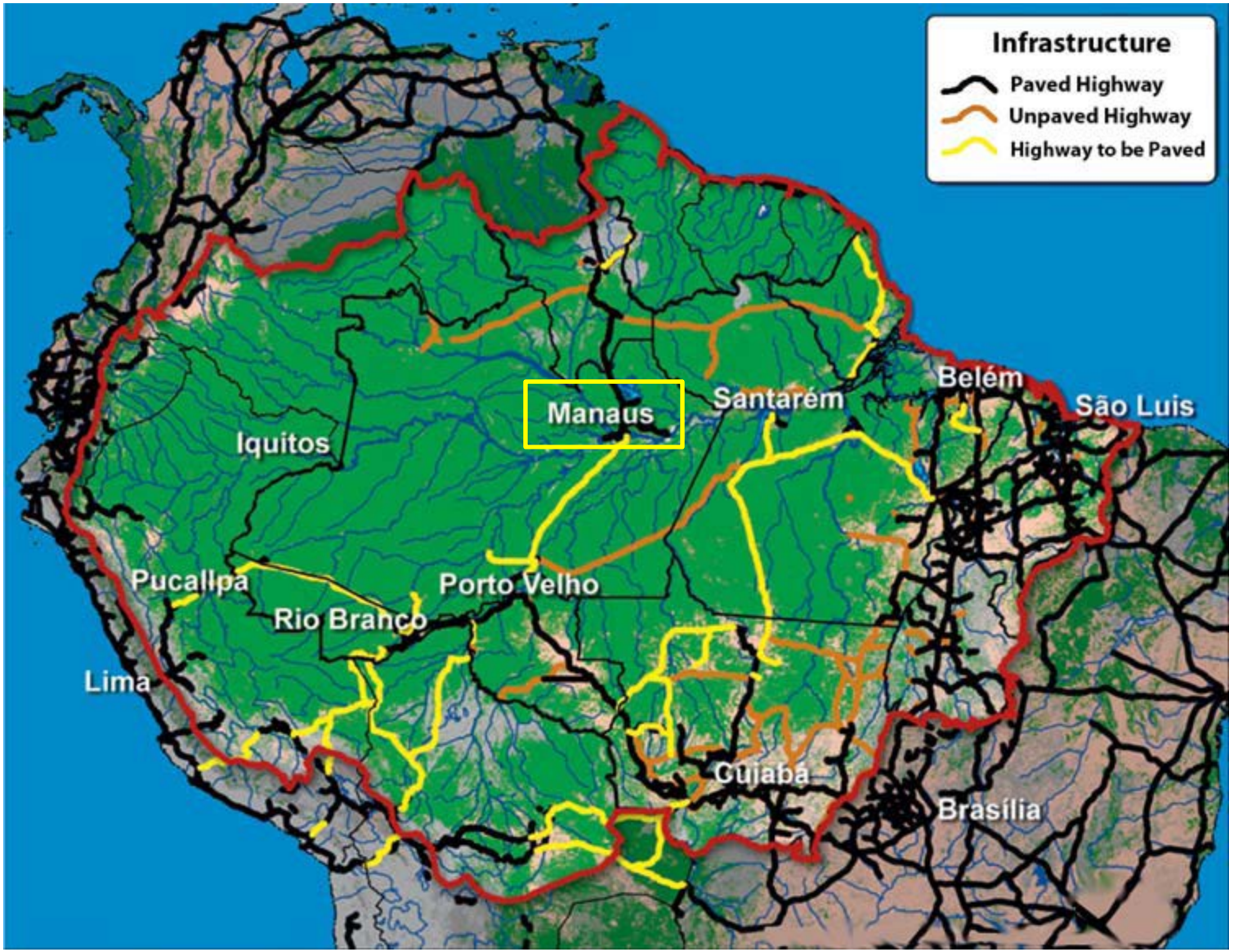
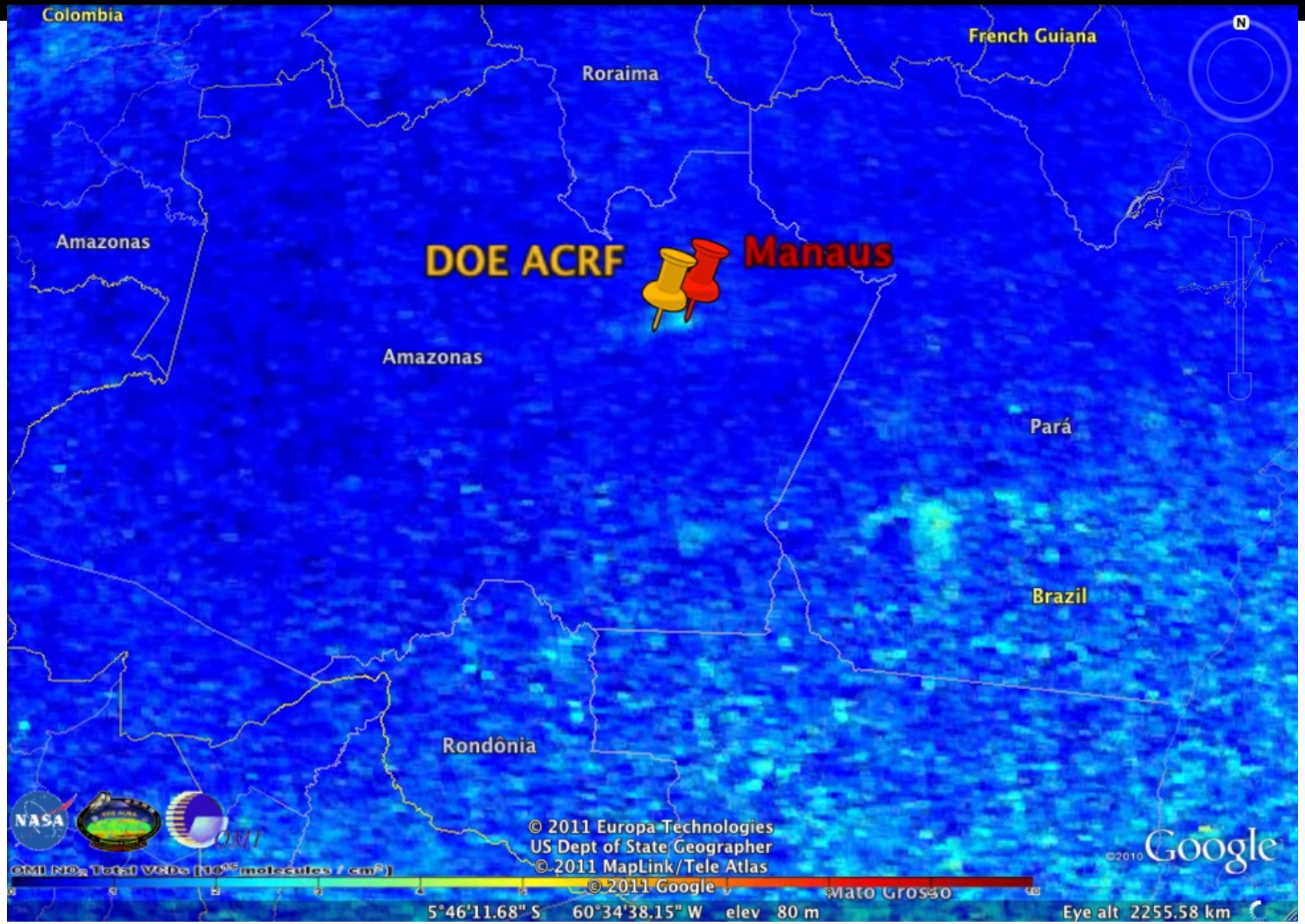
Site Location

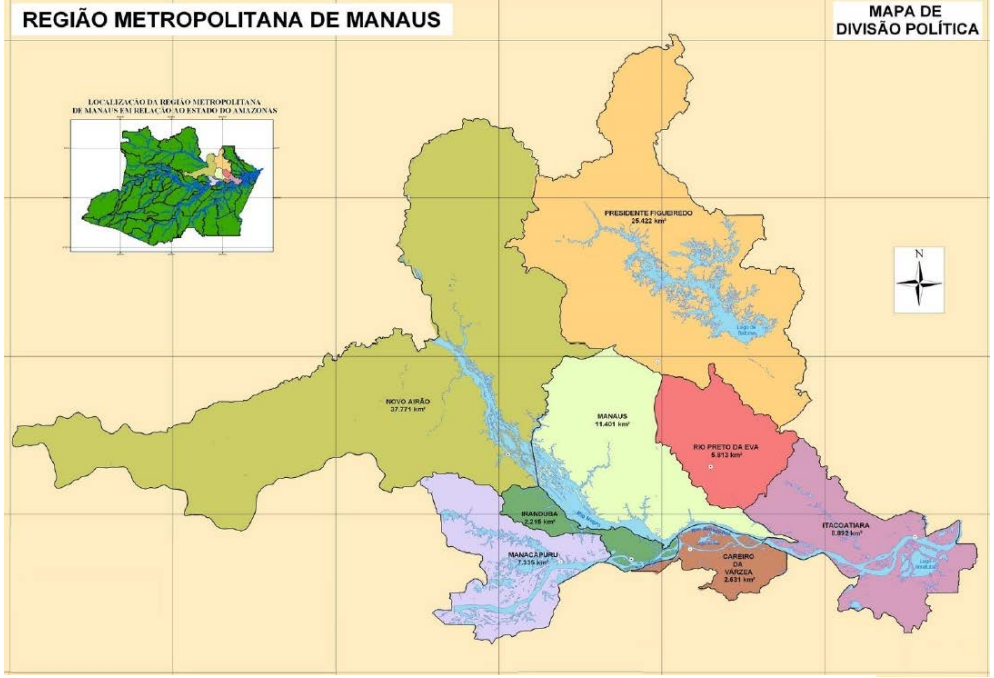


NO_2 Outflow from Manaus in Aug 2010 observed by OMI



Manaus

Population for the metropolitan region of Manaus: 2002/2009



POPULAÇÃO PARA A REGIÃO METROPOLITANA DE MANAUS - 2002 / 2009

Municípios	2002	2003	2004	2005	2006	2007	2008	2009
MANAUS	1.488.805	1.527.314	1.592.555	1.644.690	1.688.524	1.646.602	1.709.010	1.738.641
CAREIRO DA VÁRZEA	17.079	16.992	16.844	16.725	16.626	23.023	24.030	24.704
IRANDUBA	35.128	36.439	38.661	40.436	42.812	32.869	33.834	33.884
ITACOATIARA	74.914	76.217	78.425	80.190	81.674	84.676	87.896	89.440
MANACAPURU	77.171	78.785	81.518	83.703	84.656	82.309	85.279	86.472
NOVO AIRÃO	8.731	8.304	7.580	7.002	6.516	14.630	15.343	15.915
PRESIDENTE FIGUEIREDO	19.562	20.569	22.273	23.636	24.781	24.360	25.474	26.282
RIO PRETO DA EVA	19.910	20.990	22.820	24.283	25.513	24.858	26.004	26.847
REGIÃO METROPOLITANA	**1.741.300**	**1.785.610**	**1.860.676**	**1.920.665**	**1.971.102**	**1.933.327**	**2.006.870**	**2.042.185**

FONTE: IBGE

Acknowledgments: Rodrigo Souza, UEA

Manaus: Vehicle Fleet 2010

Frota de Veículos -

	Quantidade
Motoneta	8.563
Motocicleta	83.459
Automóvel	252.274
Microônibus	2.334
Ônibus	5.807
Reboque	1.677
Semi-reboque	9.754
Camioneta	18.812
Caminhão	14.631
Caminhão-Trator	2.019
Caminhonete	49.981
Ciclomotor	329
Trator rodas	48
Triciclo	100
Utilitários	2.403
Outros	109
	452.300

Fonte: DETRAN/AM

FUEL MIX:

-tractor, truck and bus: almost 100% diesel

-car and bikes : > 60% gasoline (*)

(*) Ethanol price is very high in Manaus and gasoline is preferred by the consumer.

Acknowledgments: Rodrigo Souza, UEA

Manaus: Power Plant 2009: Fuel Oil

TABELA 1 - CONFIGURAÇÃO DO PARQUE GERADOR DO SISTEMA MANAUS AMAZONAS - AGOSTO DE 2009

Usina		Potência do Sistema (MW)			Tipo de UG	Tipo de óleo
		Nominal	Efetiva	Disponível		
Geração hídrica	**UHE Balbina**	250,0	250,0	250,0	Turbina hidráulica	
Geração Térmica	Aparecida	198,0	172,0	75,0	Turbina a Gás	PTE
	Mauá	452,4	437,0	259,6	Turbina a Vapor, Gás e Motor	Combustível, PTE e PGE
	Electron	120,0	102,2	0,0	Turbina a Gás	PTE
Diesel	UTE*	149,8	120,8	94,2		Óleo
TOTAL GERAÇÃO PRÓPRIA		1.170,6	1.081,3	678,45		
Produtor Independente	Breitener Tambaqui	83,5	60,0	60,0	Turbina a Gás	OCA-1
	Breitener Jaraqui	83,5	60,0	56,7	Turbina a Gás	OCA-1
	Manauara	85,4	60,0	60,0	Turbina a Gás	OCA-1
	Rio Amazonas	85,4	65,0	65,0	Turbina a Gás	OCA-1
	GERA	85,4	60,0	60,0	Turbina a Gás	OCA-1
TOTAL DE COMPRAS		423,1	305,0	301,7		
TOTAL GERAL DO SISTEMA		1.593,7	1.386,3	980,2		

* inclui as UTE-Cidade Nova, UTE-São José e UTE-Flores
Fonte: Adaptado das informações obtidas junto a Eletrobras Amazonas Energia

Hydropower

Oils of different grades

PTE - óleo leve "Para Turbina Elétrica"
PGE - óleo combustível "Para Gerador Elétrico"

OCA-1 = Óleo Combustível com Alto teor de enxofre = Fuel Oil with High Sulfur

Acknowledgments: Rodrigo Souza, UEA

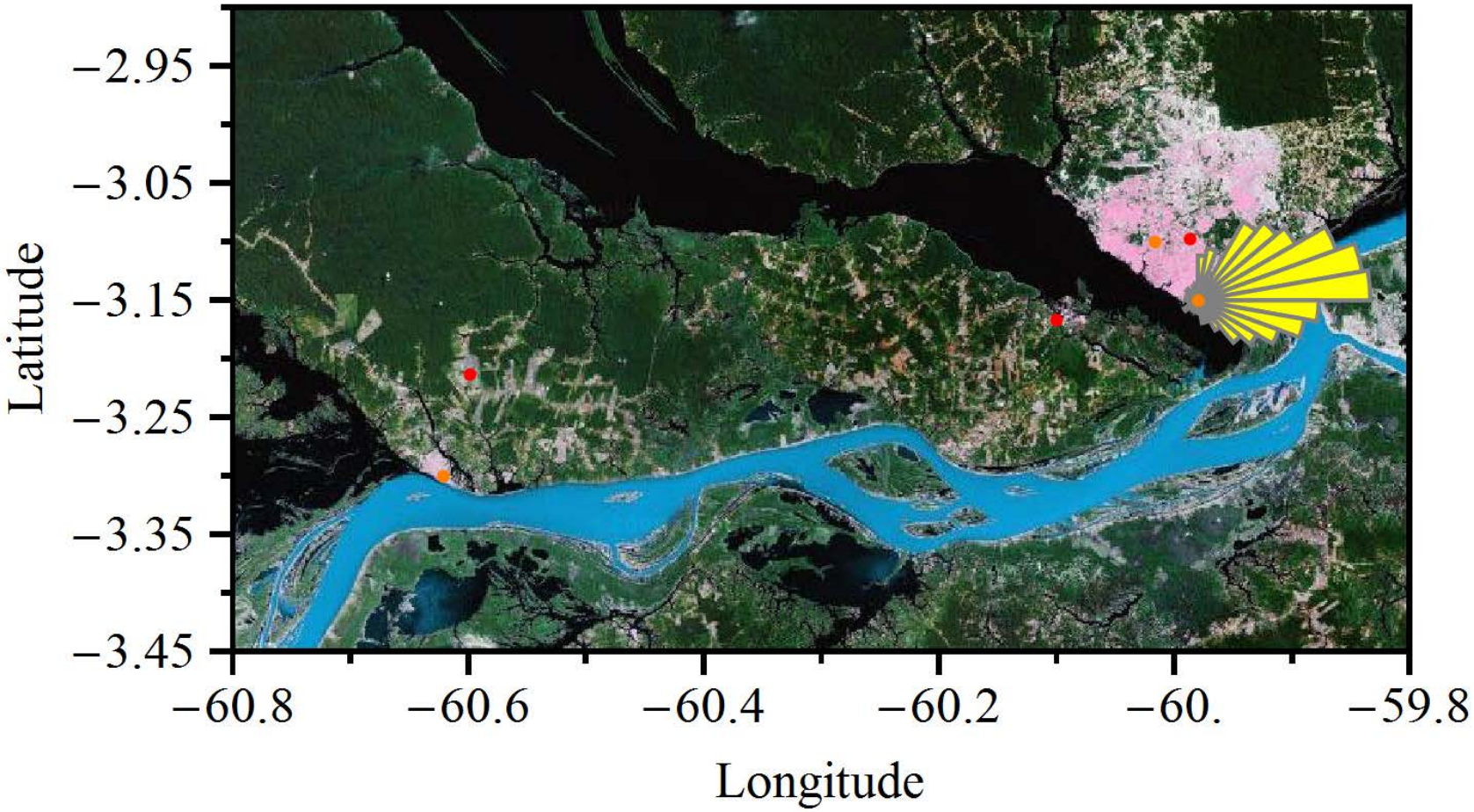
Downwind of Manaus

The deployment site is situated such that it experiences the extremes of:

(i) a pristine atmosphere when the Manaus pollution plume meanders; and

(ii) heavy pollution and the interactions of that pollution with the natural environment when the plume regularly intersects the site.

Downwind of Manaus



(−3.21328 ,	−60.5987)	DOE ARM ACRF	T3
(−3.16667 ,	−60.1)	TBD	T2
(−3.09722 ,	−59.9867)	INPA/UEA	T1
(−2.14663 ,	−59.005)	ATTO	T0
(−2.60908 ,	−60.2093)	K34	K34
(−2.59458 ,	−60.2093)	AMAZE08	TT34

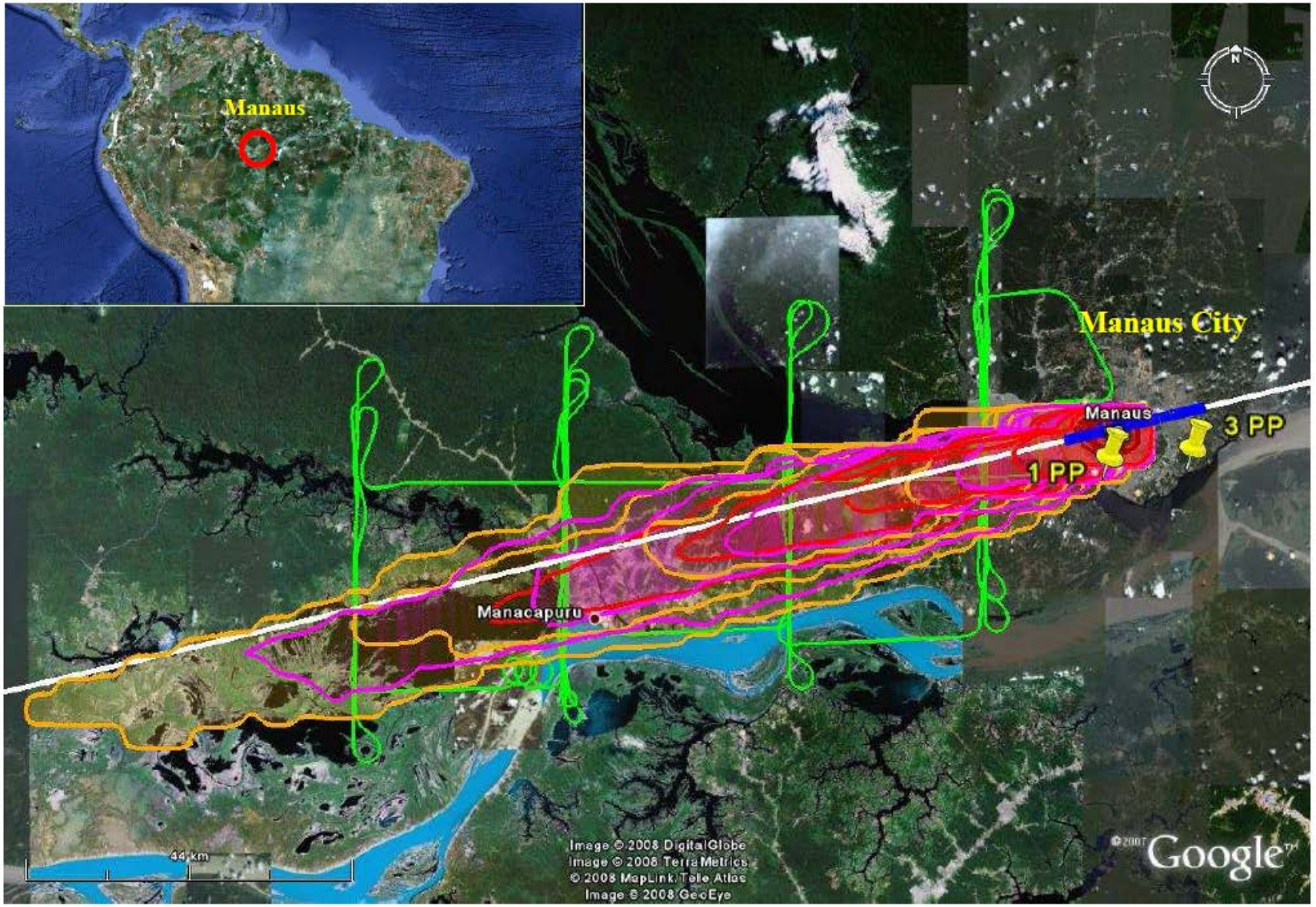
- 111 by 60.8 km represented by this box.
- Wind speeds at 1 km altitude are typically 10 to 30 kph.
- T2→T3 transit time of 2 to 6 hr.

Large Point Source of Pollution in Manaus: *High-Sulfur Diesel for Electricity*

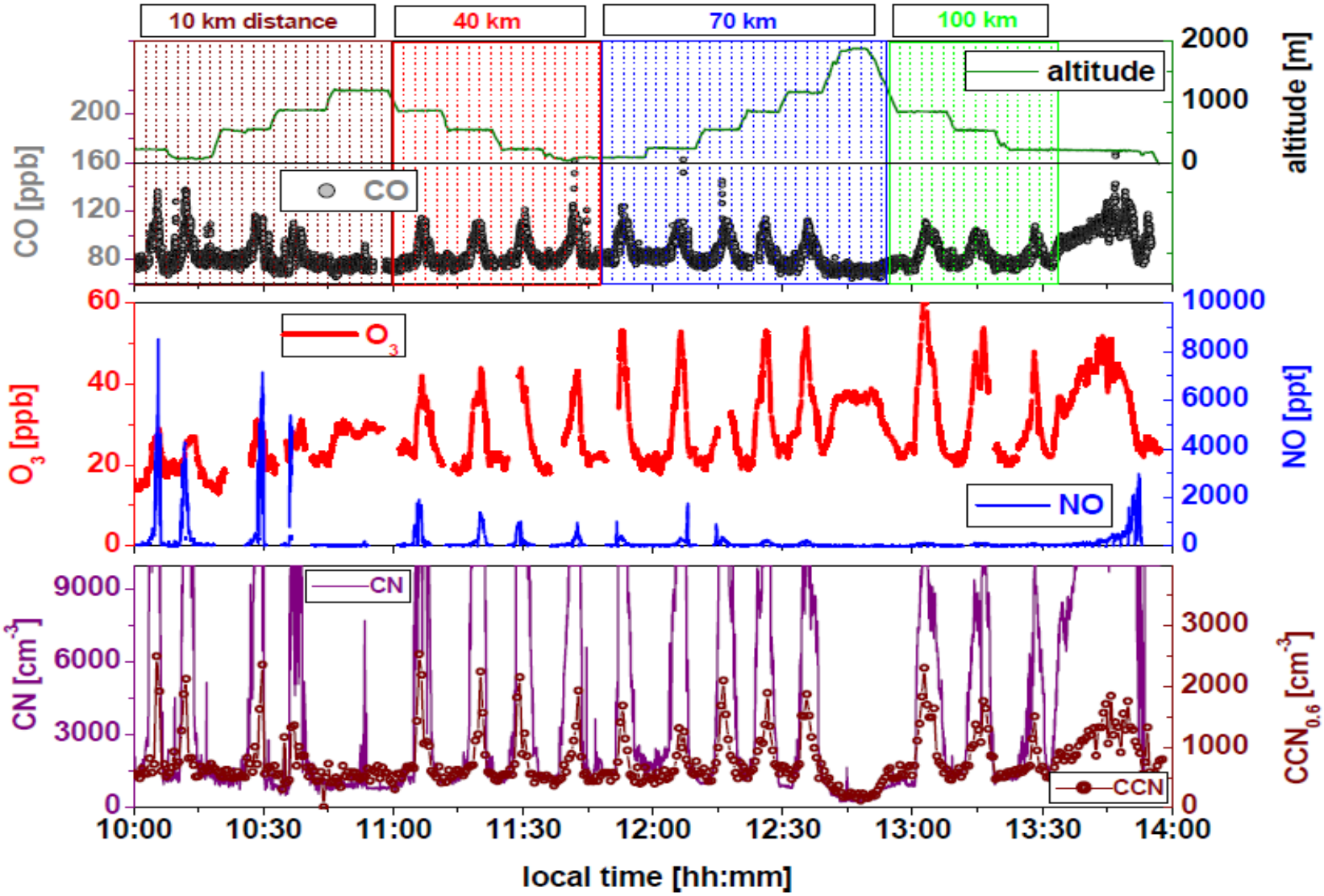
Outflow from Manaus first Crosses River: 2 to 10 km wide

Manaus Outflow Continues Across 60 km Forest

Arrival at AAA Large Pasture Site:
Location of ACRF Deployment



Reference: Kuhn, U.; Ganzeveld, L.; Thielmann, A.; Dindorf, T.; Welling, M.; Sciare, J.; Roberts, G.; Meixner, F. X.; Kesselmeier, J.; Lelieveld, J.; Ciccioli, P.; Kolle, O.; Lloyd, J.; Trentmann, J.; Artaxo, P.; Andreae, M. O., "Impact of Manaus City on the Amazon Green Ocean atmosphere: Ozone production, precursor sensitivity, and aerosol load," *Atmos. Chem. Phys.* **2010**, *10*, 9251-9282.



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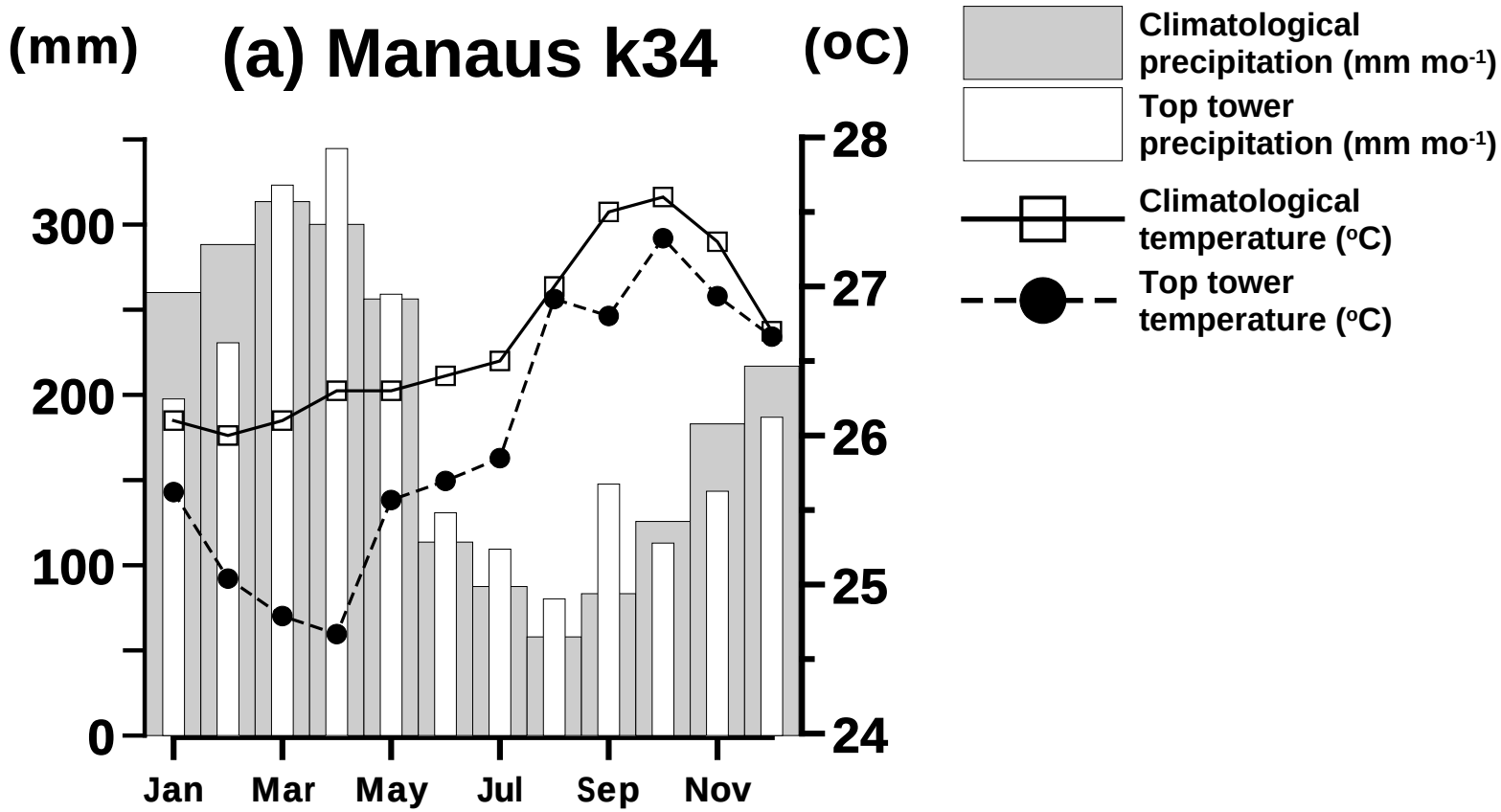
Seasonal Variability of Rainfall in Region

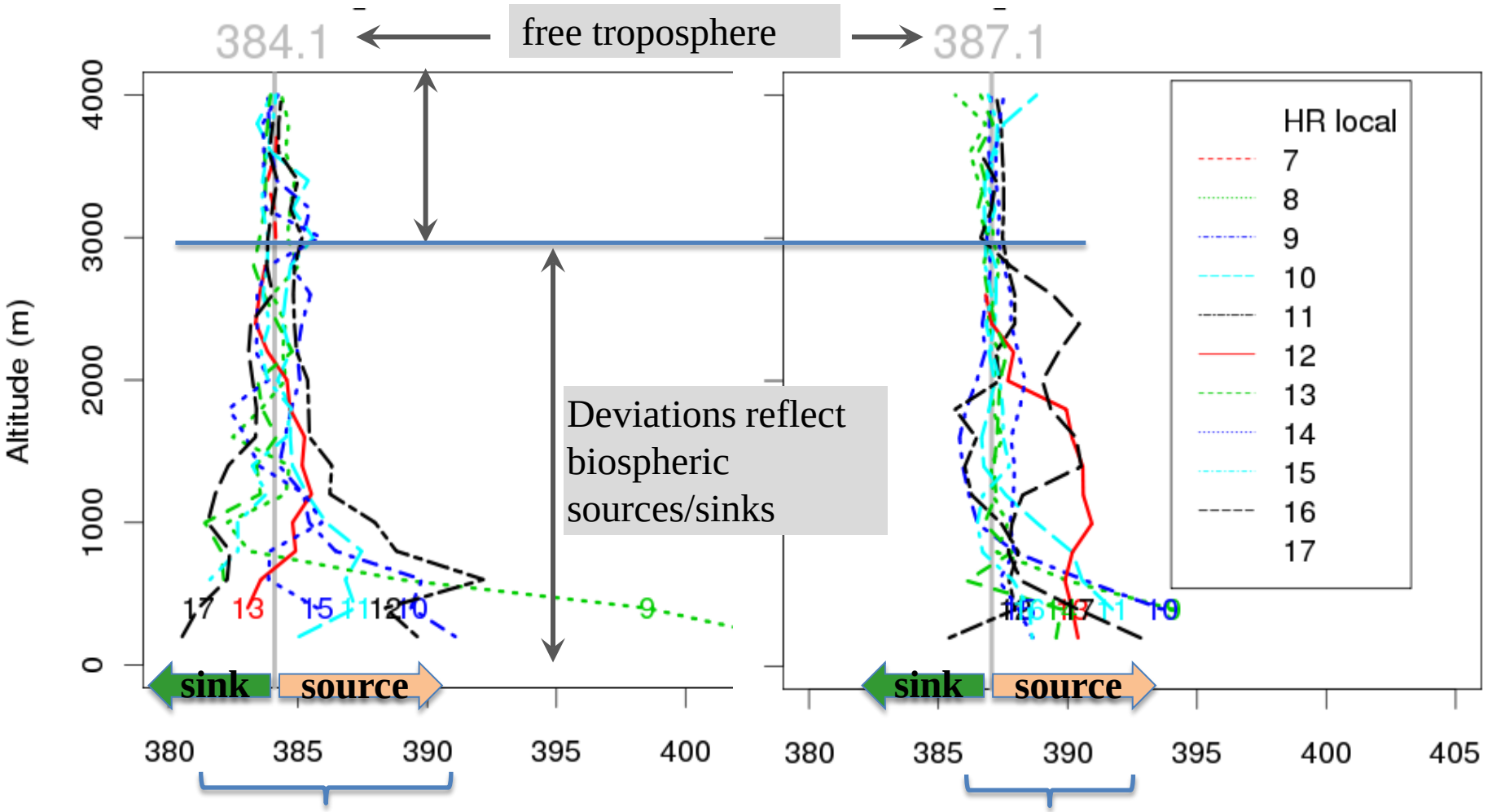


Source: Rocha et al. 2009 (JGR), 2010 (LBA book)

CO_2 Profiles in Manaus Region (BARCA)

A. Dry-season (16-22 November 2008)

B. Wet-season (15-27 May 2009)

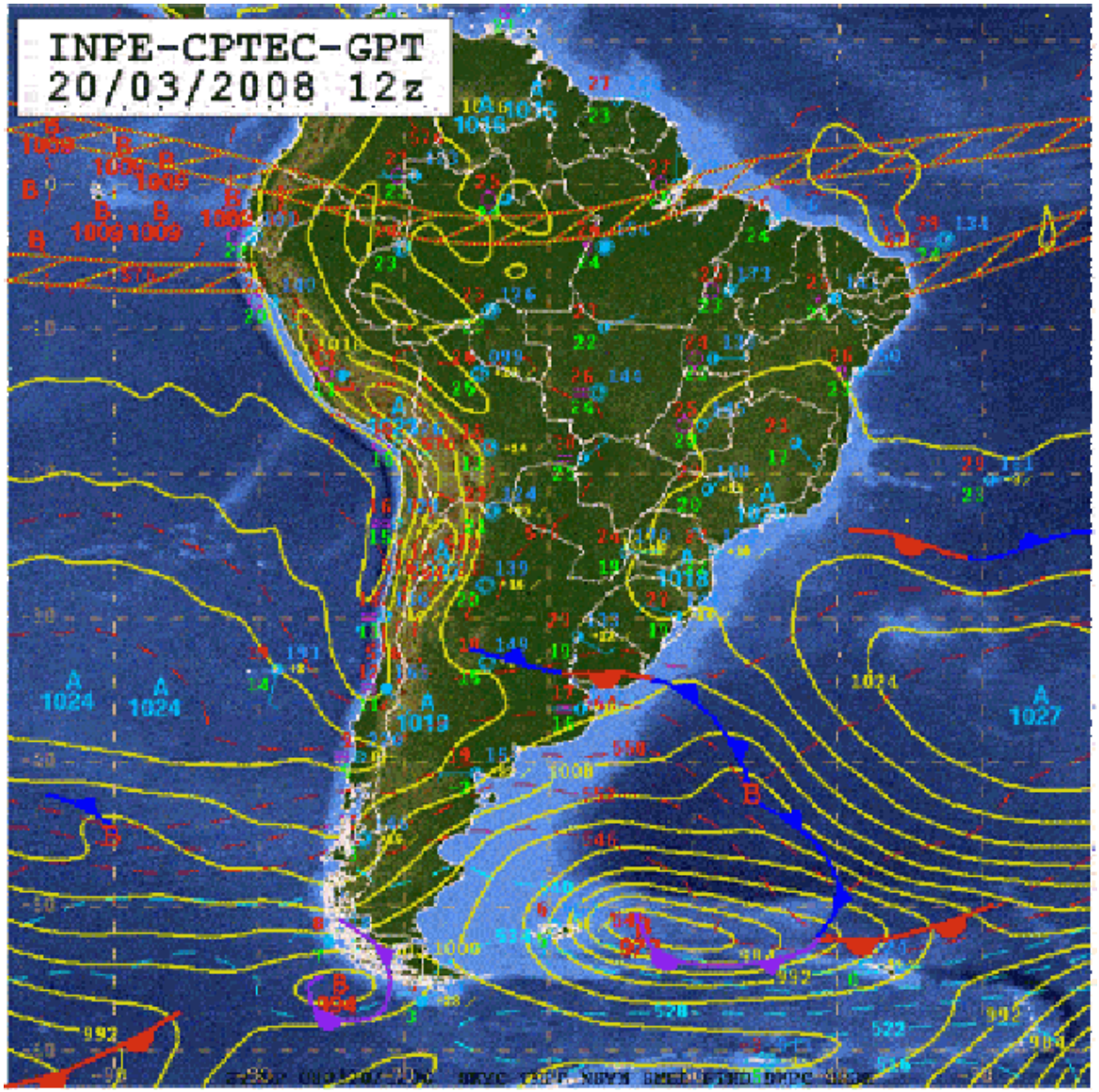


Deviations show biosphere to be neutral or a weak CO_2 source (dry season)

Deviations show biosphere to be a strong CO_2 source (wet season)

Source: Saleska, Wofsy, et al. (personal communication)

ITCZ: Northern Hemisphere and Southern Hemisphere



Source: Saulo Freitas, CPTEC, Brazil.

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Dates of GoAmazon2014

AMF Operations (T3 ground site)

- 1 January until 31 December 2014
- Primaries
  - Brazil-side: INPA/LBA Office program manager (TBD)
  - USA side: Kim Nitschke (DOE LANL)
  - Scientific License: Rodrigo Souza (UEA)

Dates of GoAmazon2014

AAF Operations (aircraft)

- 40 flight days in period of 15 February until 31 March 2014
- 40 flight days in period of 1 September until 15 October 2014
- Primaries
  - Brazil-side: Karla Longo (INPE), Luiz Machado (INPE), and Gilberto Fisch (CTA)
  - USA side: Beat Schmid (DOE PNNL)
  - Scientific License: Karla Longo (INPE)

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Join this Google group to receive email from PI:
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Website maintained by PI:
http://www.seas.harvard.edu/environmental-chemistry/GoAmazon2014/

Website maintained by DOE:
http://campaign.arm.gov/goamazon2014/

See there a workshop report of July 2011.