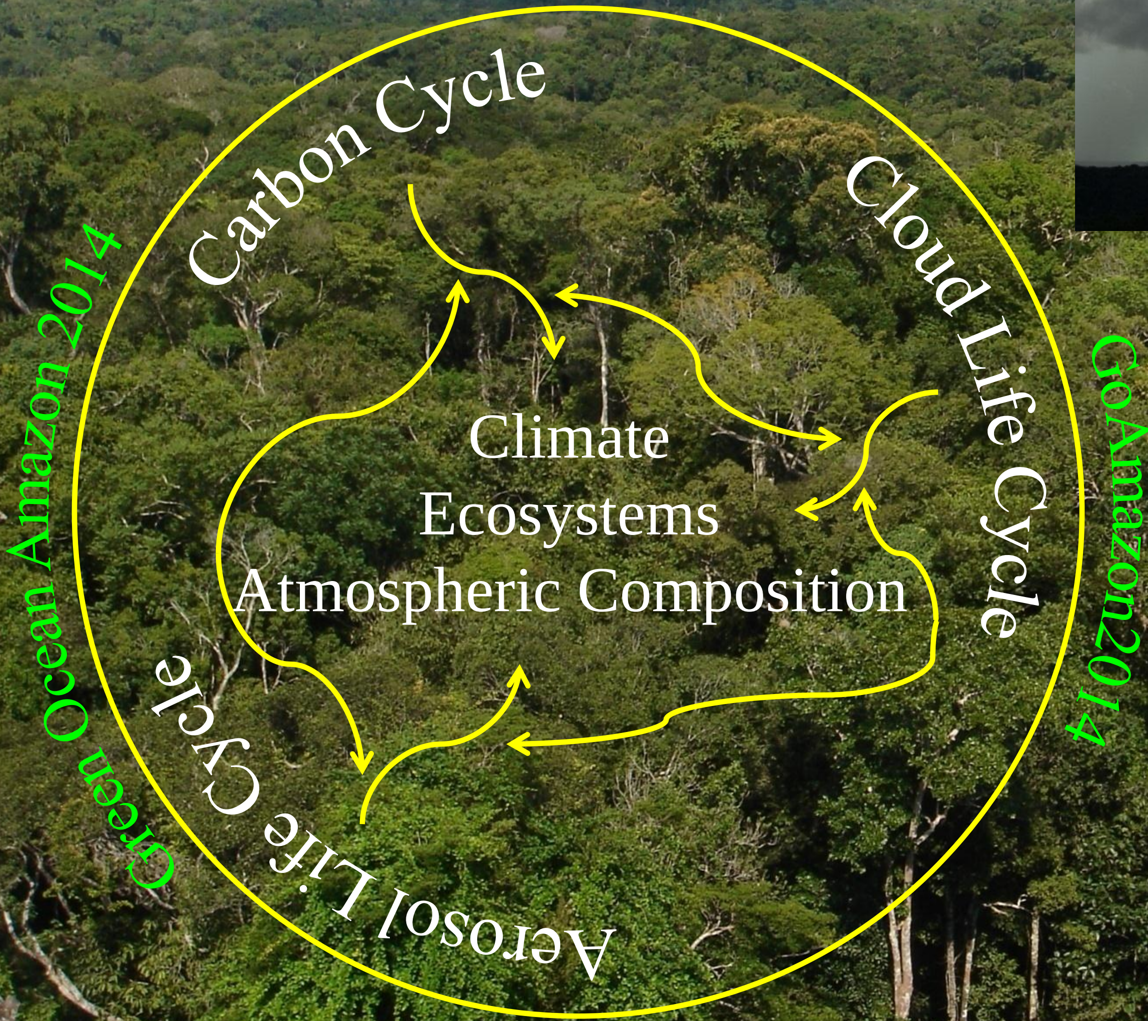
Observations and Modeling of the Green Ocean Amazon GoAmazon2014

Paulo Artaxo
CLIAMB, INPA, Manaus,
15/02/2012



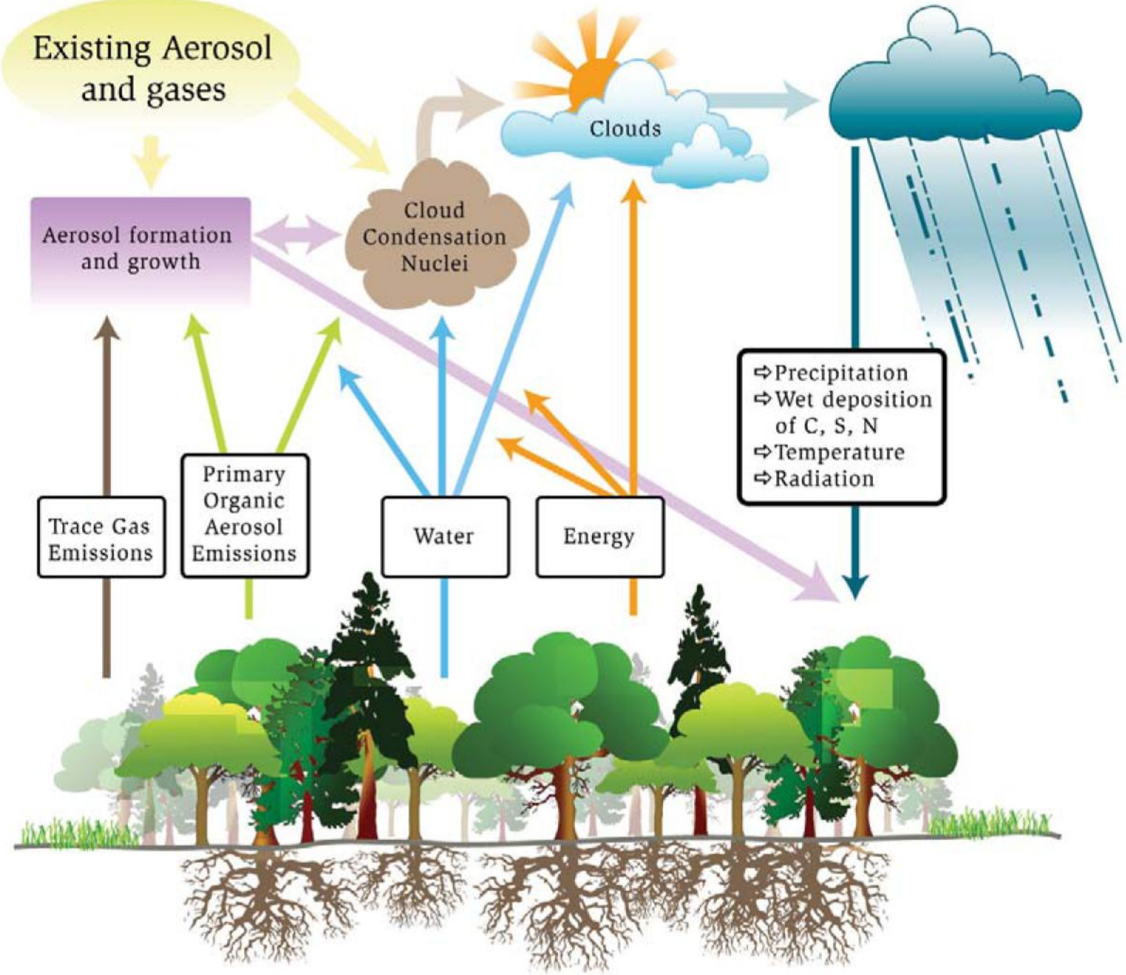
Brazil-UK Network for Investigation of Amazonian Atmospheric Composition and Impacts on Climate (BUNIAACIC)

The South American Biomass Burning Analysis (SAMBBA),

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?

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.

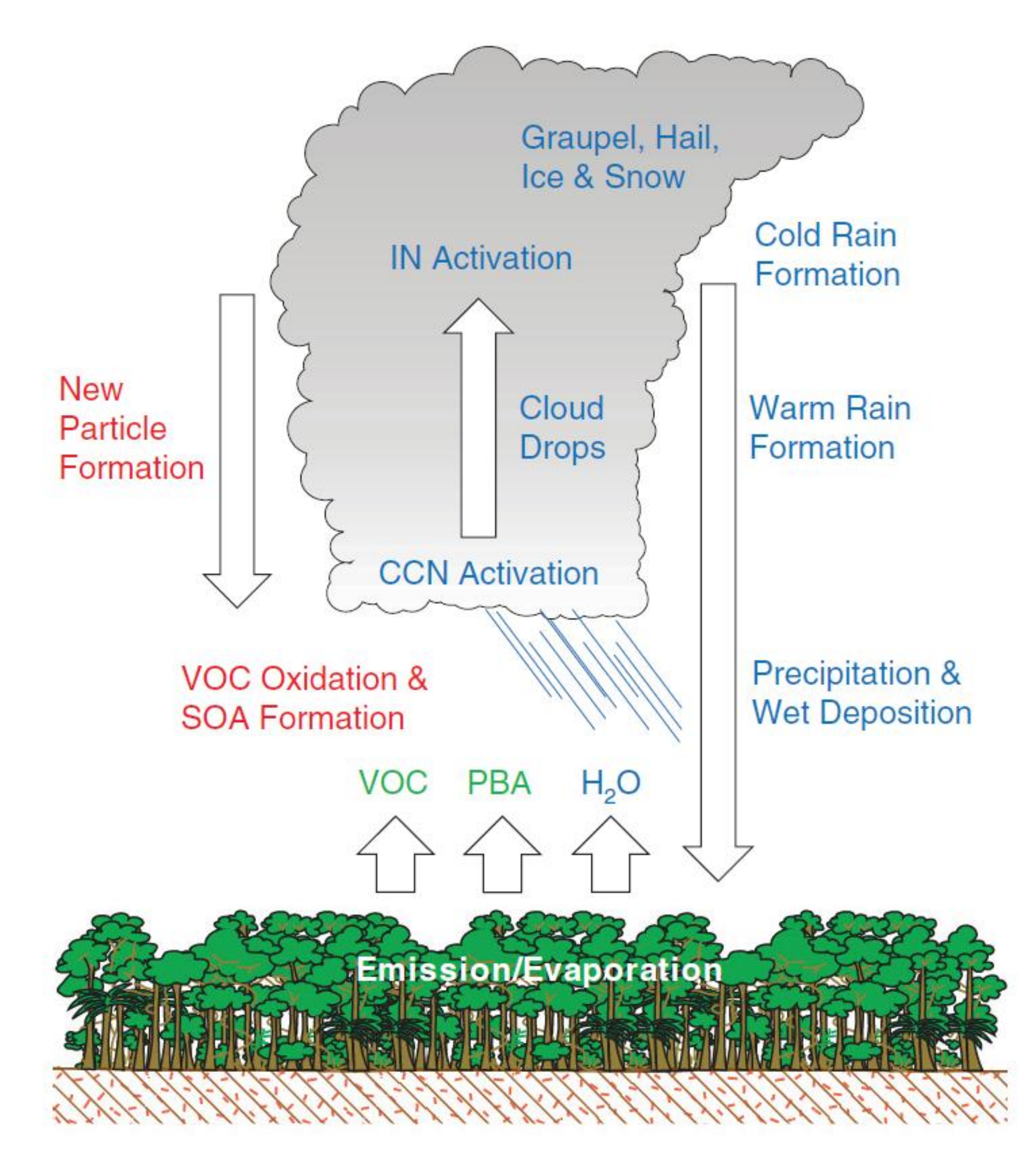


Source: Barth et al., "Coupling between Land Ecosystems and the Atmospheric Hydrologic Cycle through Biogenic Aerosol Particles," *BAMS*, *86*, 1738-1742, 2005.

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?

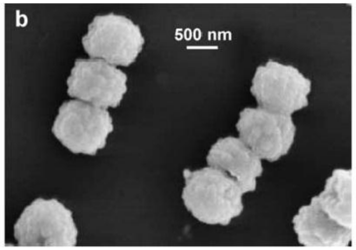


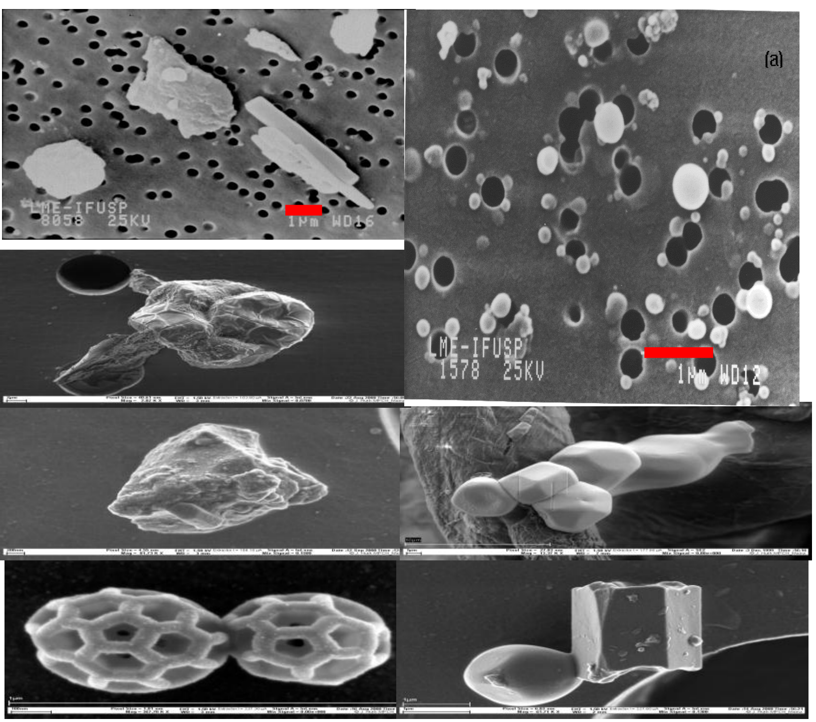
U. Pöschl, S.T. Martin, B. Sinha, Q. Chen, S.S. Gunthe, J.A. Huffman, S. Borrmann, D.K. Farmer, R.M. Garland, G. Helas, J.L. Jimenez, S.M. King, A. Manzi, E. Mikhailov, T. Pauliquevis, M.D. Petters, A.J. Prenni, P. Roldin, D. Rose, J. Schneider, H. Su, S.R. Zorn, P. Artaxo, M. O. Andreae, "Rainforest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

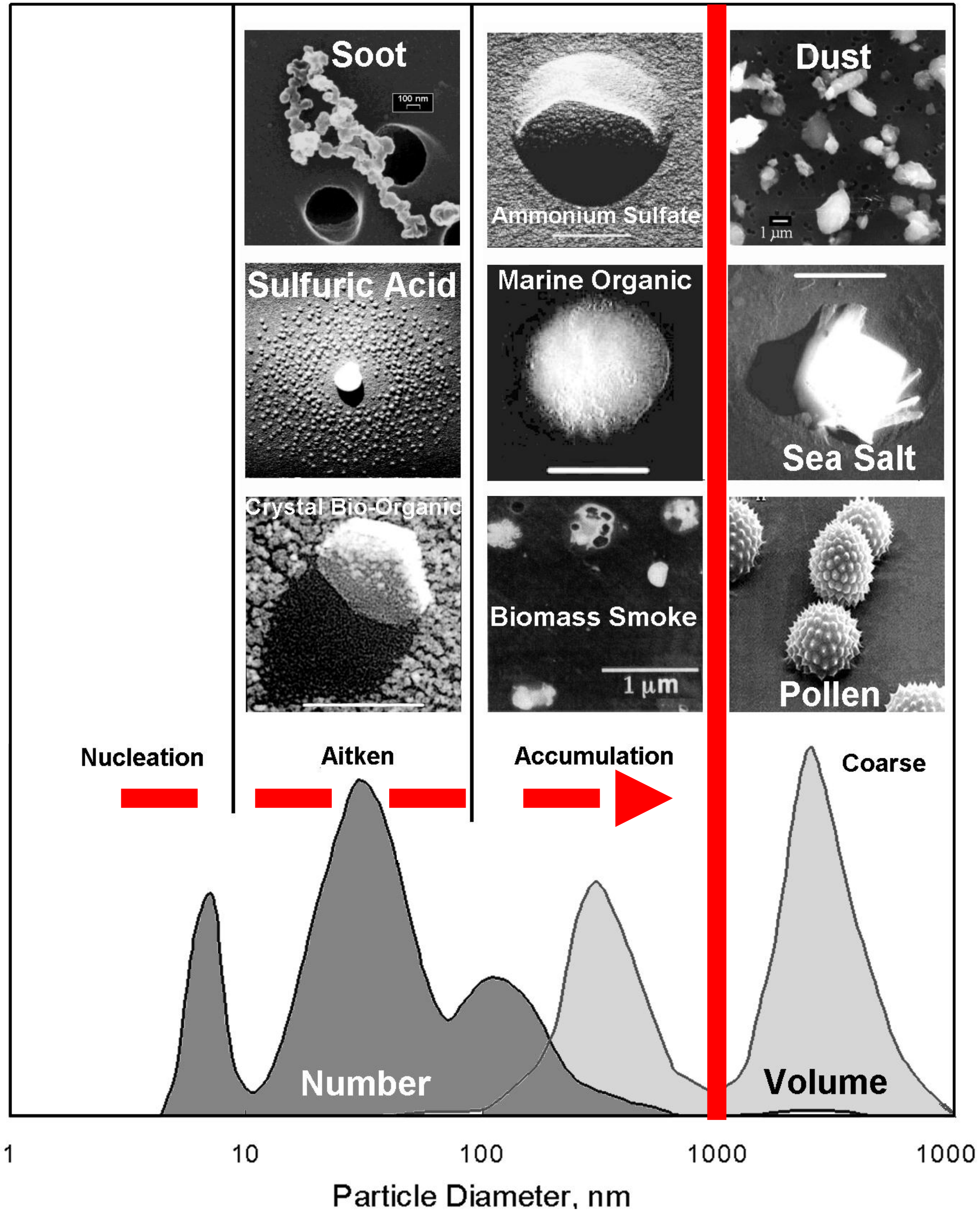
Aerosol particles

Huge size range

Different morphology, composition

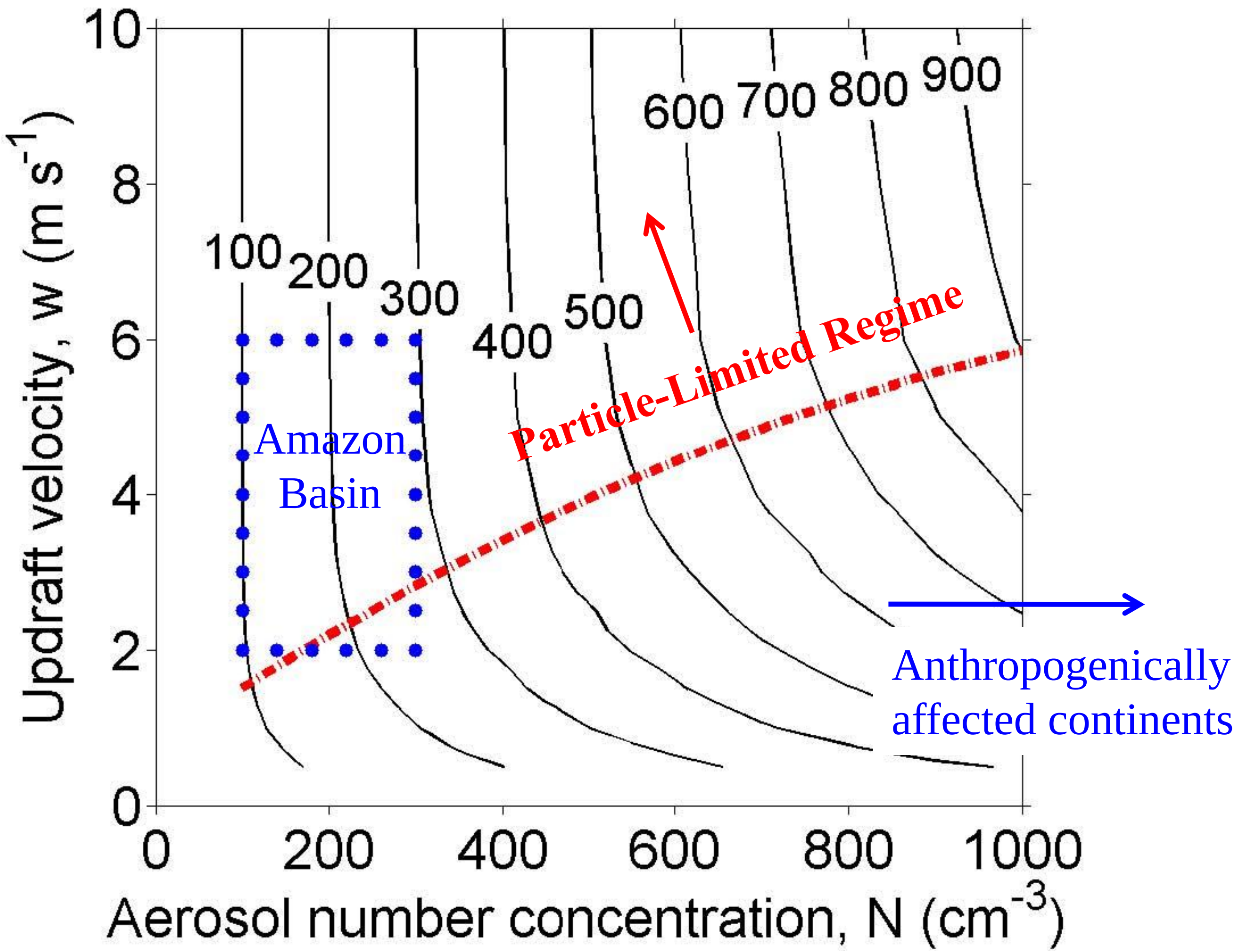






Cloud Droplet Number Concentration (CDNC):

Sensitivity to Pollution in Pristine Regions



Amazon Basin:

Low aerosol number concentrations +

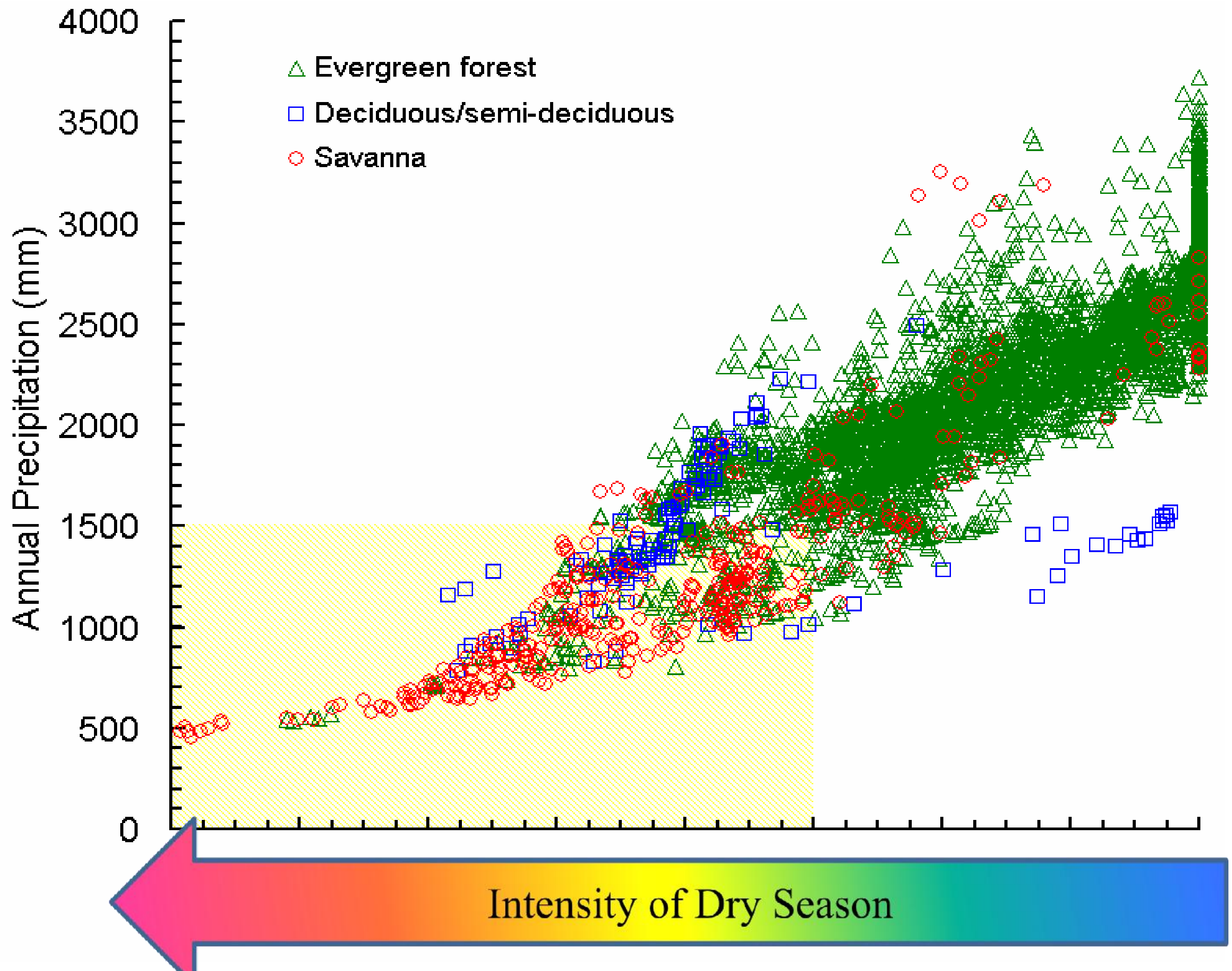
High water vapor concentration =

Especially susceptible.

Possibility of dramatic changes in energy flows and rainfall patterns

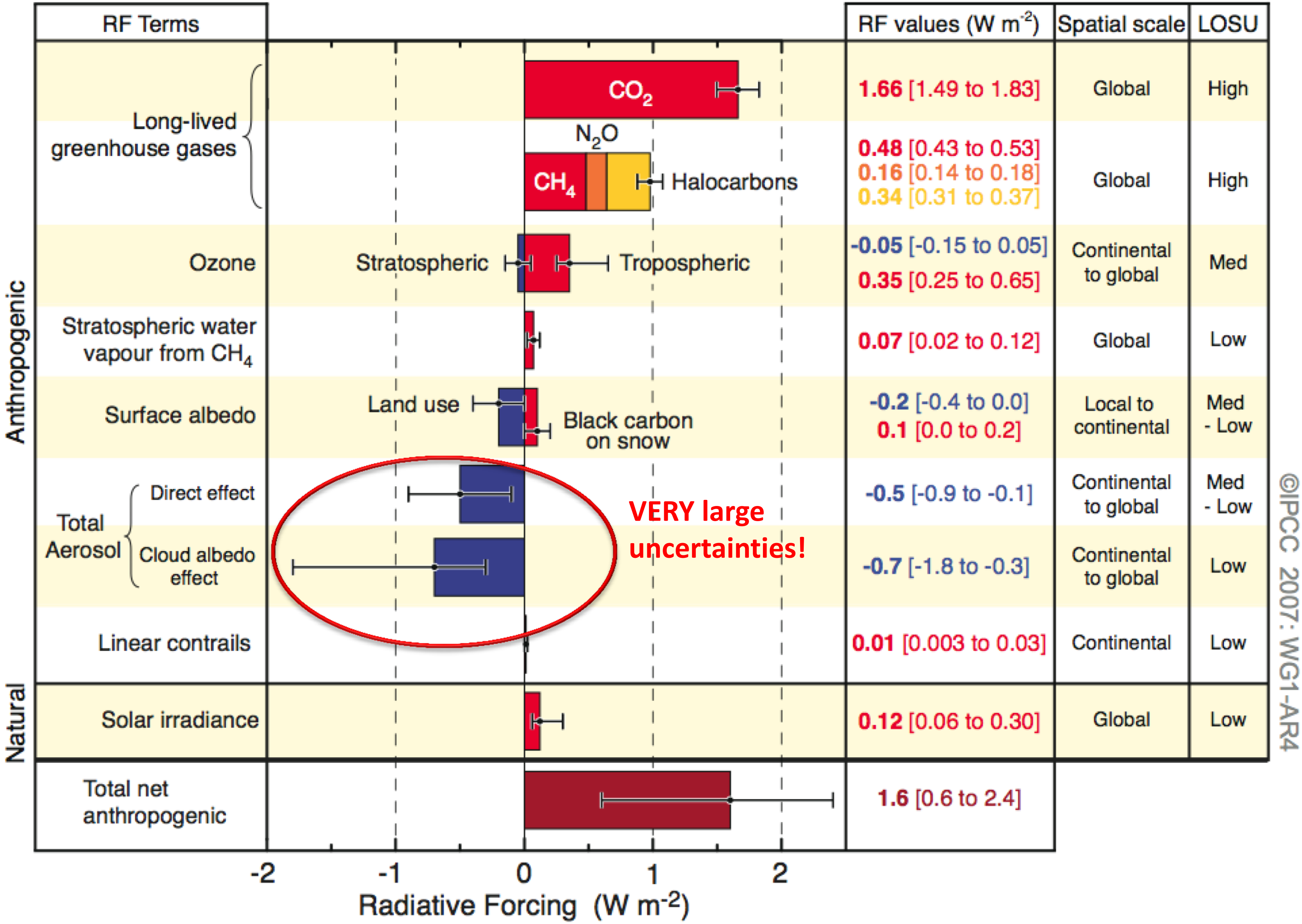
Ref: Pöschl et al., “Rainforest aerosols as biogenic nuclei of clouds and precipitation in the Amazon,” *Science*, **2010**, *329*, 1513-1516.

Linking biomass with precipitation in Amazonia: A rainfall biogeography of Amazonia



Source: Malhi *et al.*, **Exploring the likelihood and mechanism of a climate-change induced dieback of the Amazon rainforest,** *Proceedings of the National Academy of Sciences*, 2011 submitted

Radiative Forcing of the Global Climate System (IPCC 2007)



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.

Outline of Presentation

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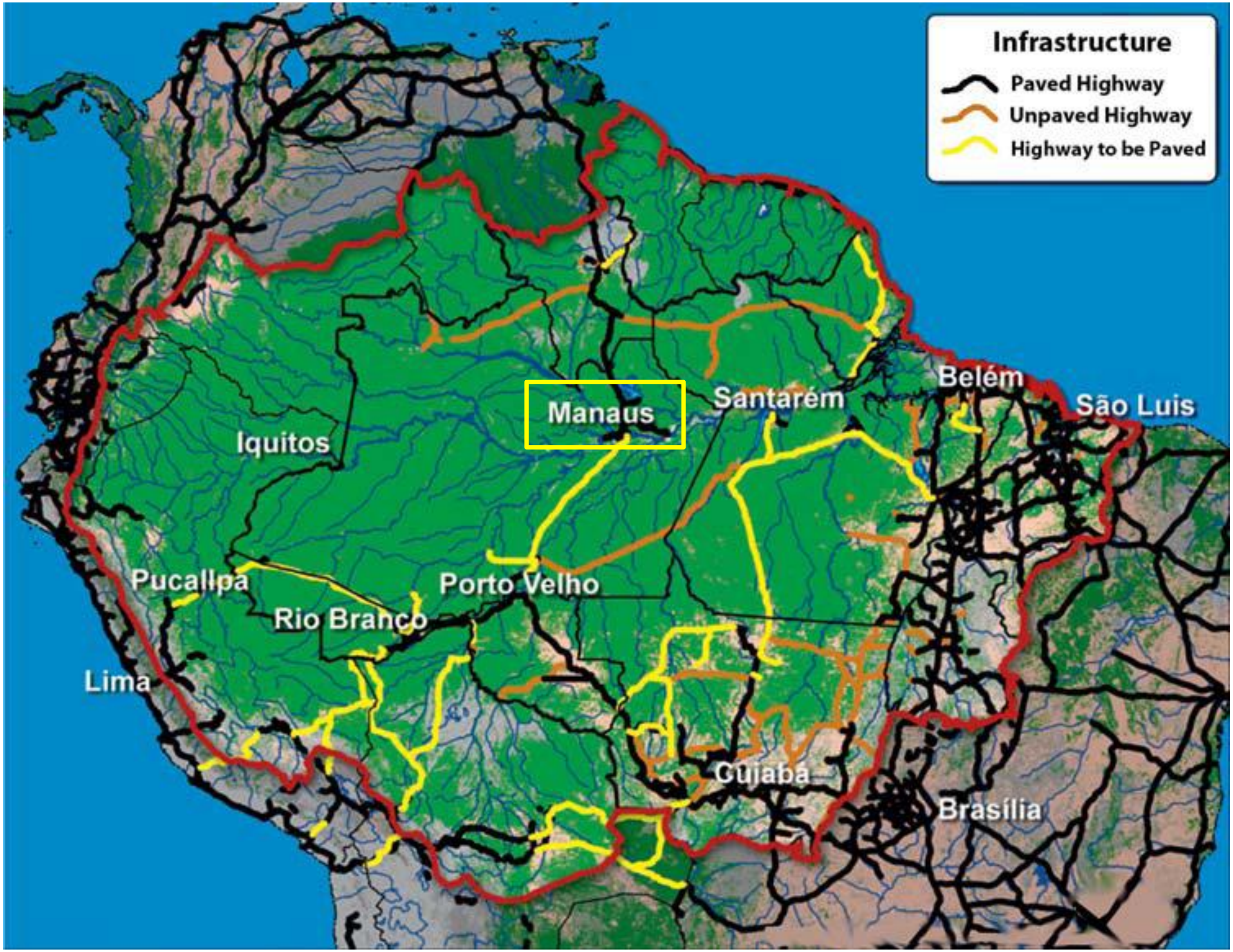
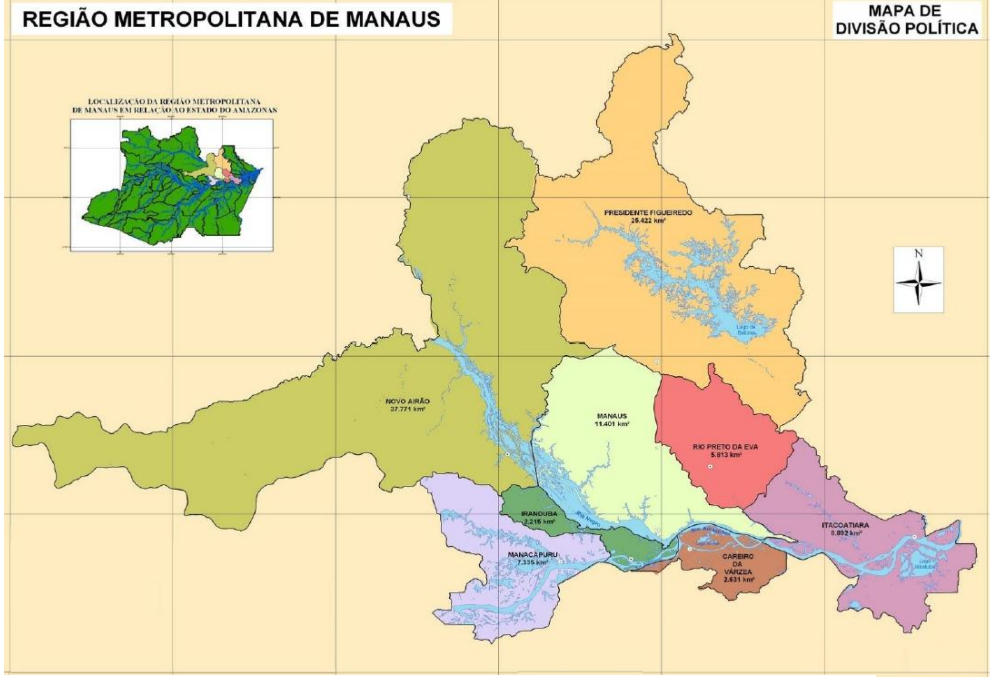
Site Location



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

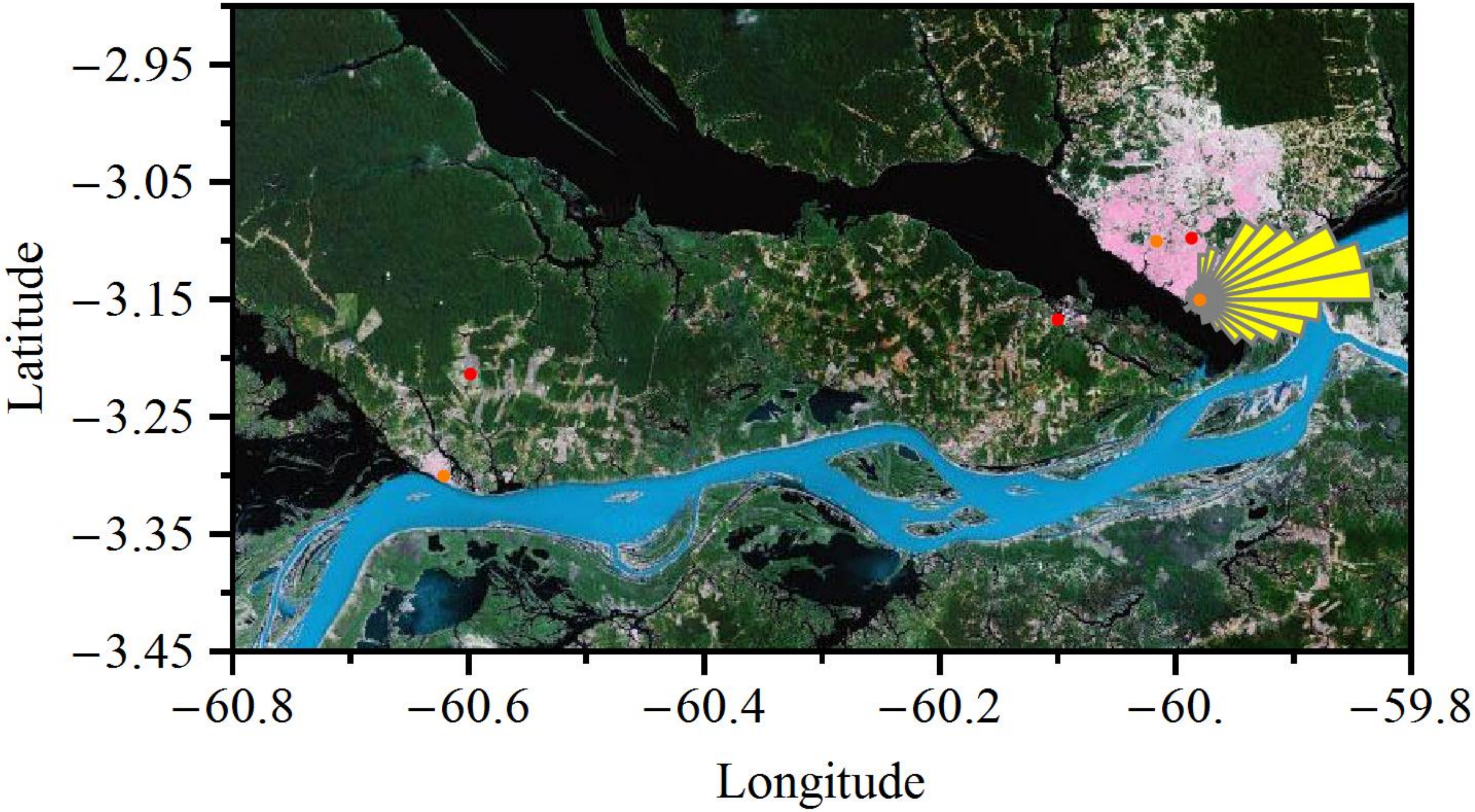
PTE - óleo leve "Para Turbina Elétrica"

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



(−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.

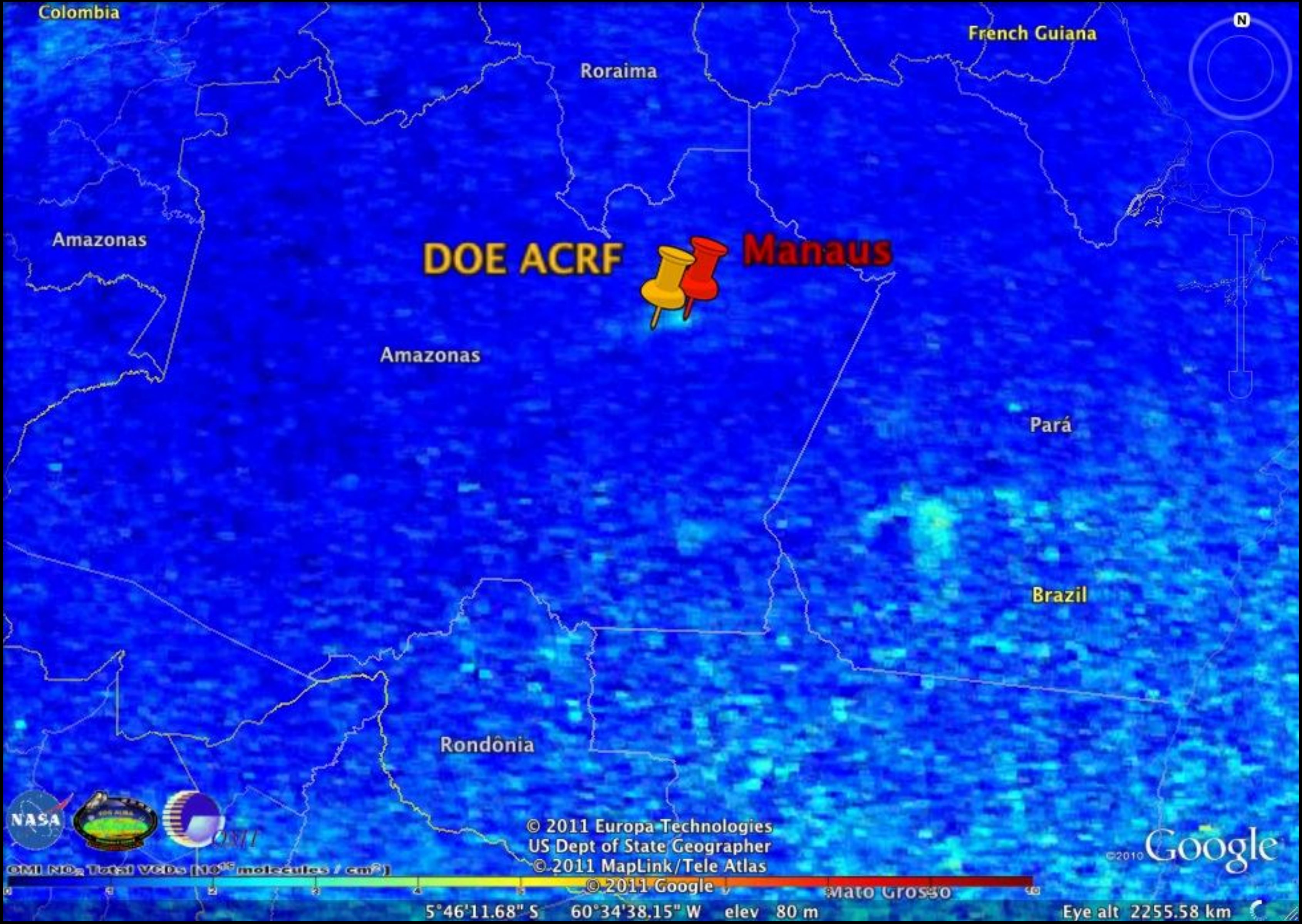
Downwind of Manaus

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.

NO_2 Outflow from Manaus in Aug 2010 observed by OMI



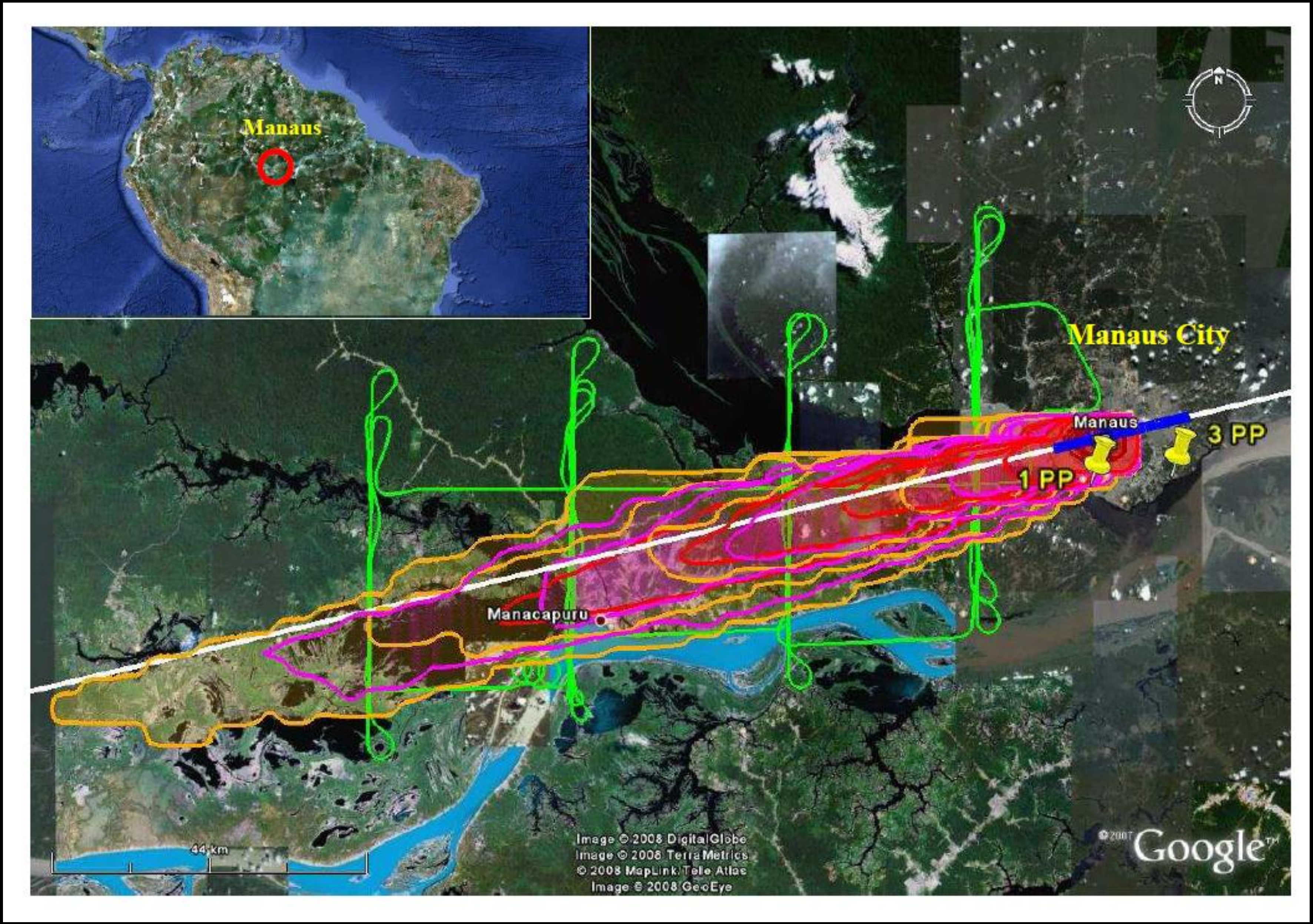
Acknowledgments: Jun Wang, Univ. Nebraska

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

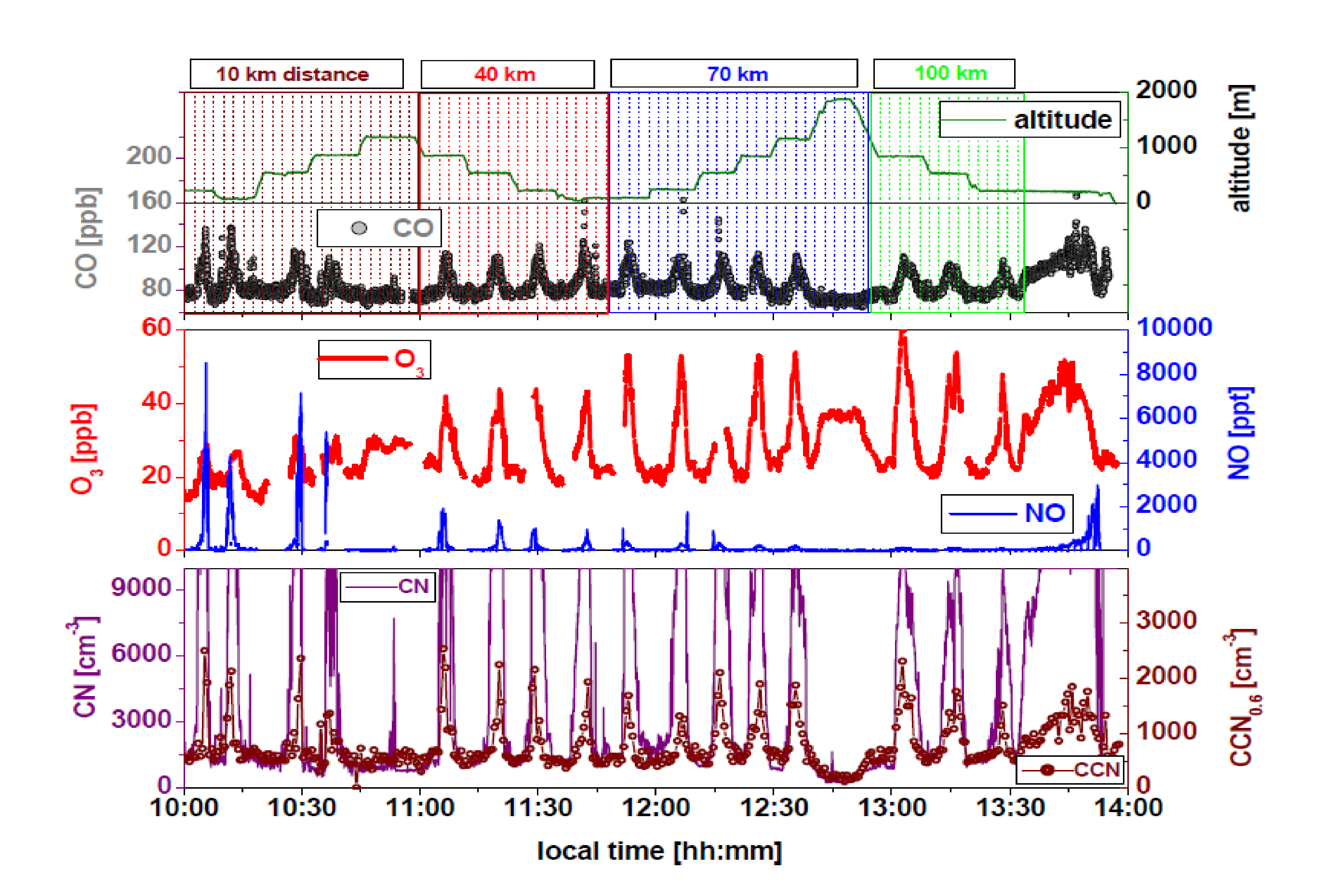
Outflow from Manaus first Crosses River: 2 to 10 km wide

Manaus Outflow Continues Across 60 km Forest

Arrival at AAA Large Pasture Site:
Location of ACRF Deployment

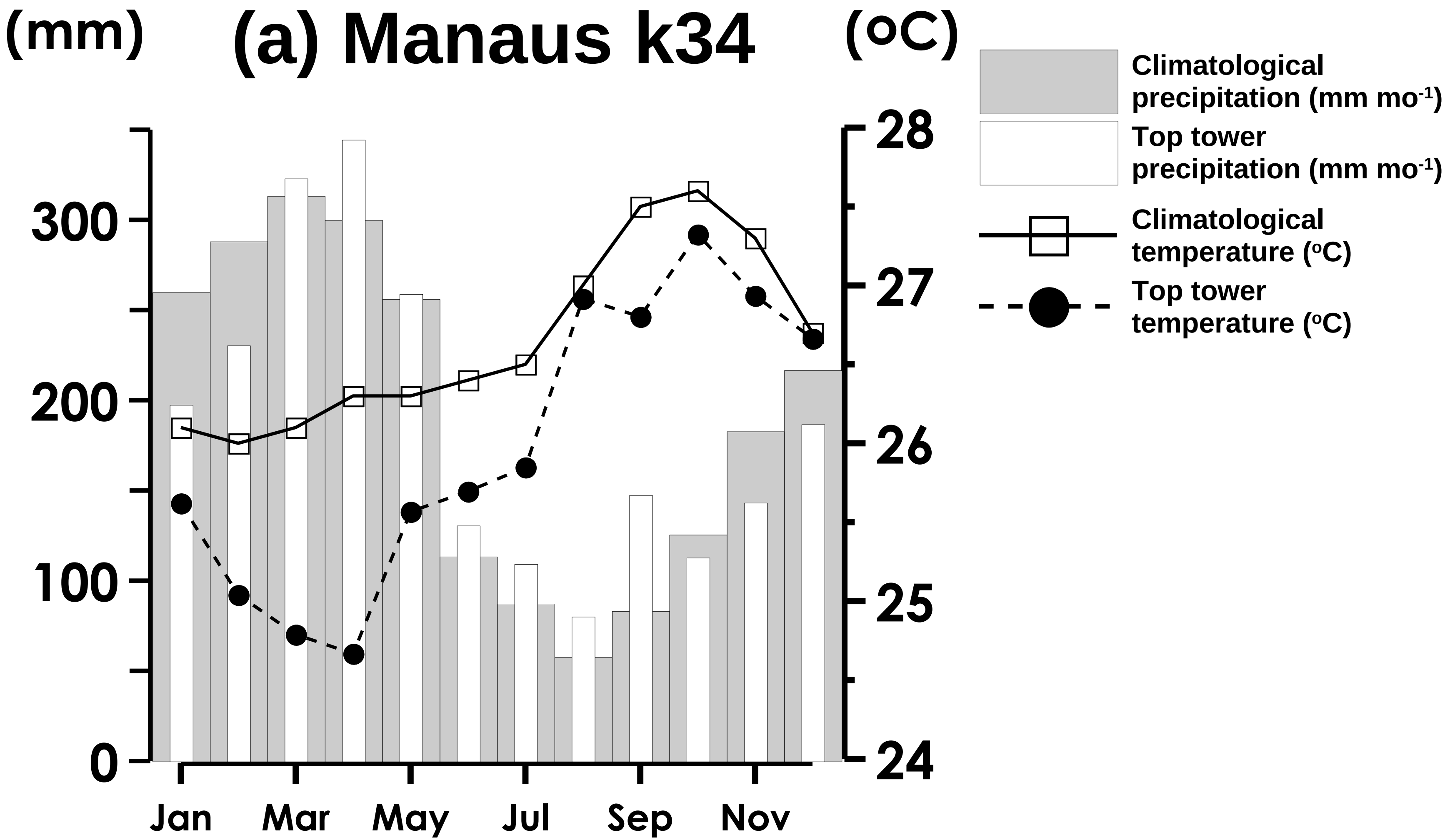


Reference: Kuhn, U.; Ganzeveld, L.; Thielmann, A.; Dindorf, T.; Welling, M.; Sciare, J.; Roberts, G.; Meixner, F. X.; Kesselmeier, J.; Lelieveld, J.; Ciccioli, P.; Kolle, O.; Lloyd, J.; Trentmann, J.; Artaxo, P.; Andreae, M. O., "Impact of Manaus City on the Amazon Green Ocean atmosphere: Ozone production,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



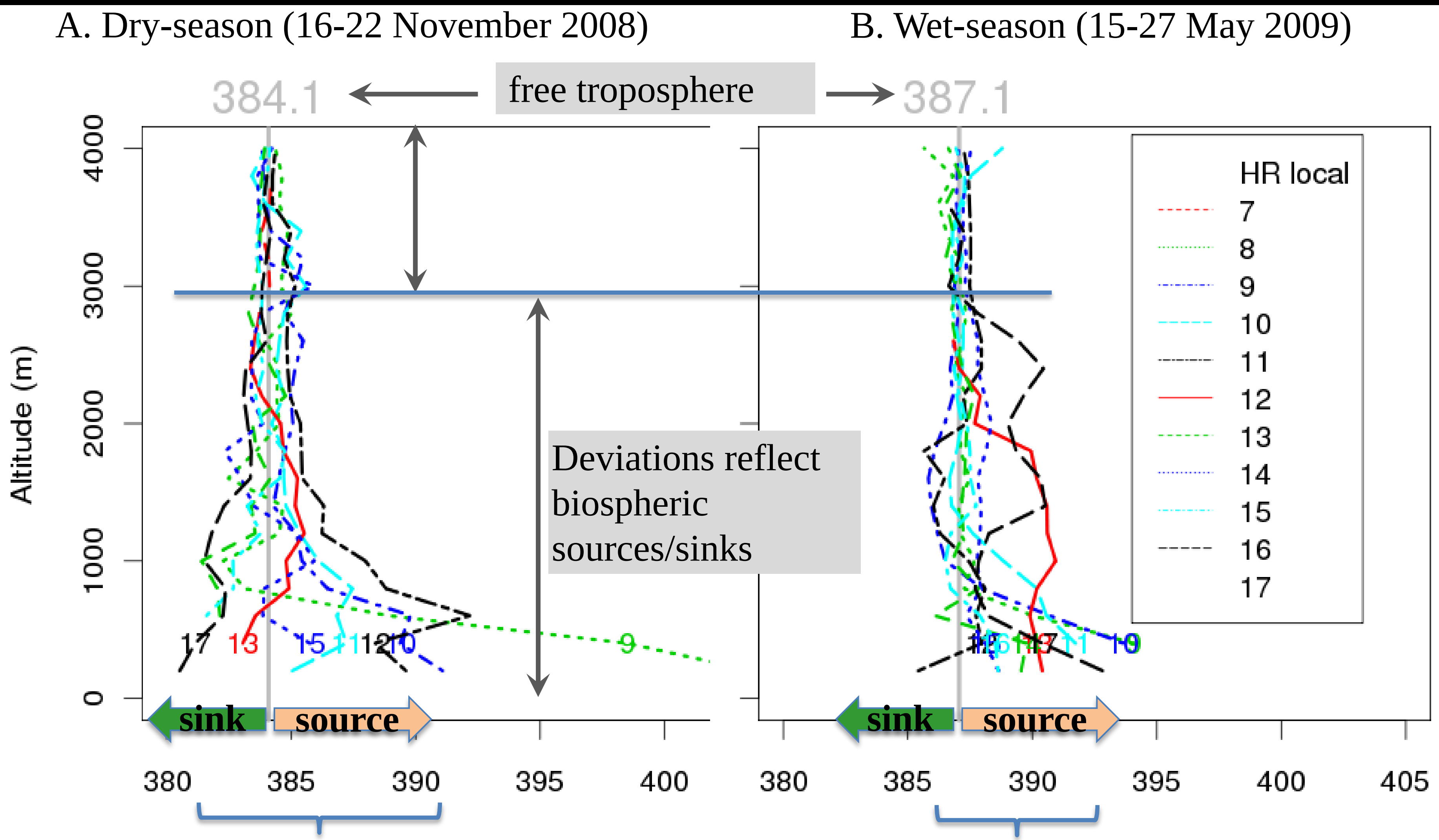
Reference: Kuhn, U.; Ganzeveld, L.; Thielmann, A.; Dindorf, T.; Welling, M.; Sciare, J.; Roberts, G.; Meixner, F. X.; Kesselmeier, J.; Lelieveld, J.; Ciccioli, P.; Kolle, O.; Lloyd, J.; Trentmann, J.; Artaxo, P.; Andreae, M. O., "Impact of Manaus City on the Amazon Green Ocean atmosphere: Ozone production,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

Seasonal Variability of Rainfall in Region



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

CO_2 Profiles in Manaus Region (BARCA)



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)

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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) and Paulo Artaxo (USP)

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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GOAMAZON2014
U.S. DEPARTMENT OF ENERGY

ARM
CLIMATE RESEARCH FACILITY

ARM – Brazil Ground Site Operations Overview

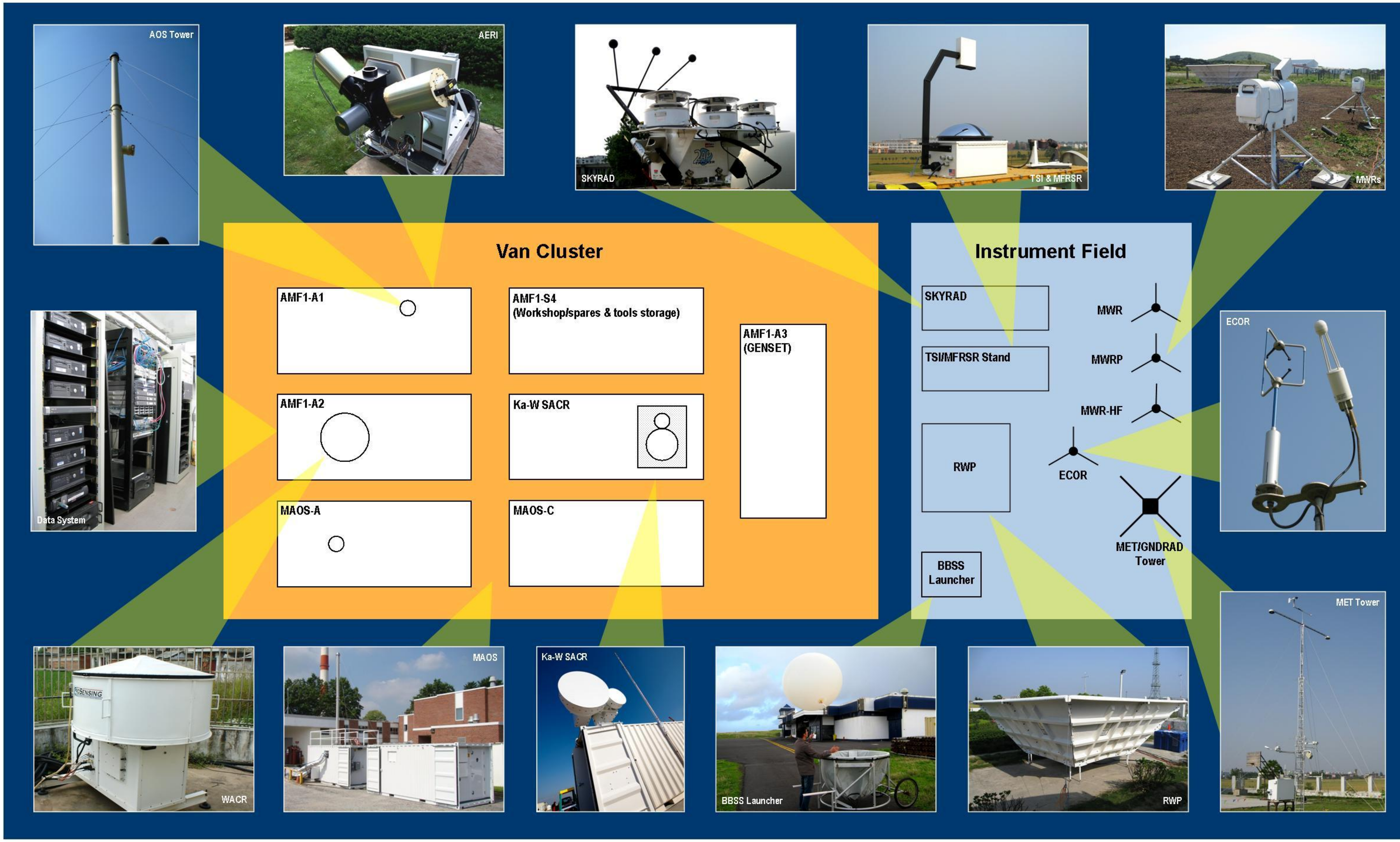
Kim Nitschke
Field Instrument Deployments and Operations (FIDO) Office
Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY
EST. 1943

U.S. DEPARTMENT OF ENERGY | Office of Science

LAUR 072442

ARM Mobile Facility One - Typical Deployment



Revised March 2011

AMF1

AMF1 – 7 x 20' sea containers
1 full-time on-site technician

- Precision Spectral Pyranometer (PSP) x 2
- Precision Infrared Radiometer (PIR) x 2
- Shaded Black & White Pyranometer (B/W)
- Shaded Precision Infrared Pyrgeometer (PIR)
- Normal Incidence Pyrhiliometer (NIP)
- Infrared Thermometer (IRT) x 2
- Multi-Filter Rotating Shadowband Radiometer (MFRSR)
- Narrow Field of View Zenith Radiometer (NFOV)
- Optical Rain Gauge (ORG)
- Anemometers (WND)
- Temperature/Relative Humidity Sensor (T/RH)
- Barometer (BAR)
- Present Weather Detector (PWD)
- Eddy Correlation Flux Measurement System (ECOR)
- Shortwave Array Spectrometer (SAS-He, SAS-Ze)
- Microwave Radiometer (MWR)
- Microwave Radiometer Profiler (MWRP)
- Microwave Radiometer 90/150 (MWR-HF)
- Doppler Lidar (DL)
- Ceilometer (CEIL)
- Balloon Borne Sounding System (BBSS)
- W-band ARM Cloud Radar - 95GHz (WACR)
- Ka-W Scanning ARM Cloud Radar (SACR)
- Atmospheric Emitted Radiance Interferometer (AERI)
- Total Sky Imager (TSI)
- Aerosol Observation System (AOS)
  - CCNC
  - PSAP
  - Nephelometers X 2
- Radar Wind Profiler – 1290MHz (RWP)
- Cimel Sunphotometer (CSPHOT)

LANL Solar Fourier Transform Spectrophotometer (FTS) (Dubey) (OCO-2 validation)

MAOS

Mobile Aerosol Observing System (MAOS) – 2 x 20’ sea containers (MAOS-A & MAOS-C)
2 x full time post-docs (supplied by ARM)
Guest operational personnel (approx. 5)

- SOnic Detection And Ranging (SODAR) System (1000 to 4000 Hz)
- Ultra-High Sensitivity Aerosol Spectrometer (enhanced)
- Dual Column Cloud Condensation Nuclei Counter (CCN)
- Single Particle Soot Photometer (SP2)
- Scanning Mobility Particle Sizer (SMPS)
- Photo-Acoustic Soot Spectrometer (PASS), 3 Wavelength
- Humidigraph (3 Relative Humidities with 3 single wavelength nephelometers)
- Humidigraph (Scanning Relative Humidity with 3 single wavelength nephelometers)
- Trace Gas Instrument System (Research-Grade)
- Particle Into Liquid Sampler-Ion Chromatography-Water Soluble Organic Carbon (PILS-IC-WSOC)
- Particle Soot Absorption Photometer (PSAP), 3 Wavelength
- Nephelometer, 3 Wavelength
- Condensation Particle Counter (CPC), 10 nm to >3000 nm particle size range
- Condensation Particle Counter (CPC), 2.5 nm to >3000 nm particle size range
- Hygroscopic Tandem Differential Mobility Analyzer (HTDMA)
- Proton Transfer Mass Spectrometer (PTRMS)
- 7-Wavelength Aethelometer
- Weather Transmitter (WXT-520)
- Aerosol Chemistry Speciation Monitor (ACSM)

“Intensive Airborne Research in Amazonia 2014”
(IARA-2014)
The ARM Aerial Facility (AAF) in Brazil

IARA-2014: AAF G1 Payload

Platform Position/Velocity/Altitude			
Instrument	**Trimble DSM**	**Trimble TANS 10 Hz**	
Measurement	position/velocity at 10 Hz	pitch/roll/azimuth	
Atmospheric State			
Instrument	**Rosemont 102 probe**	**Rosemount 1201F1**	**Rosemont 1221F2 (3)**
Measurement	temperature	static pressure	differential pressure (dynamic, alpha, beta)
Instrument	**GE-1011B chilled-mirror hygrometer**	**AIMMS-20**	
Measurement	dew-point temperature	5-port air motion sensing: true air speed, altitude, angle-of-attack, side-slip, temperature, relative humidity	
Aerosol Measurements			
Instrument	**TSI 3025 ultrafine condensation particle counter (UCPC)**	**TSI 3010 condensation particle counter (CPC)**	**fast integrated mobility spectrometer (FIMS)**
Measurement	total particle concentration (>3 nm)	total particle concentration (>10 nm)	aerosol particle size distribution (30 to 100 nm)
Instrument	**passive cavity aerosol spectrometer probe (PCASP)**	**particle/soot absorption photometer (PSAP)**	**TSI Nephelometer**
Measurement	aerosol particle size distribution (100 to 3000 nm)	aerosol particle light absorption at 3 wavelengths	aerosol particle light scattering at 3 wavelengths
Instrument	**Aerodyne HR-ToF-AMS**	**DMT Dual Cloud Condensation Nuclei Counter (CCNC)**	**isokinetic inlet (heated)**
Measurement	size-resolved particle composition	CCN concentrations at two supersaturations	sample stream of dry aerosol, sizes < 2.5 µm
Gas Measurements			
Instrument	**Ionicon Quadrupole PTR-MS**	**carbon monoxide analyzer**	**oxides of nitrogen instrument**
Measurement	real-time VOCs	CO	NO, NO_2, NO_y
Instrument	**Thermo environmental model 49i**	**Picarro cavity ringdown spectrometer**	
Measurement	O_3	CO_2, CH_4, H_2O	

IARA-2014: AAF G1 Payload

Cloud Measurements			
Instrument	**HVPS-3**	**2DS**	**Fast-CDP**
Measurement	cloud droplet size distribution (400 to 50000 µm)	cloud droplet size distribution (10 to 3000 µm)	cloud droplet size distribution (2 to 50 µm)
Instrument	**CIP**	**SEA WCM-2000**	
Measurement	images of cloud particles (2 to 1000 µm)	liquid water content and total water content	
Radiation			
Instrument	**SPN-1 unshaded**	**SPN-1 unshaded**	
Measurement	downwelling shortwave radiation	Upwelling shortwave radiation	
Other Measurements			
Instrument	**SEA M300**	**weather radar**	**TCAS**
Measurement	central data acquisition/ display system	cockpit display of precipitation returns	traffic collision and avoidance system
Instrument	**TAWS**		
Measurement	terrain awareness and warning system		

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Brazil-Side Organizations

- LBA - Large-Scale Biosphere Atmosphere Experiment, http://lba.inpa.gov.br/lba/
- INPA - National Institute for Research in the Amazon, http://www.inpa.gov.br/
- INPE - National Institute for Space Research, http://www.inpe.br/ingles/index.php
- CTA - Department of Science and Aerospace Technology, http://www.cta.br/
- UEA - University of the State of Amazonas, http://www1.uea.edu.br/
- USP - University of São Paulo, http://www.thefullwiki.org/University_of_Sao_Paulo, http://web.if.usp.br/ifusp/, http://www.master.iag.usp.br/index.php?pi=N
- Links to GPM-CHUVA (http://chuvaproject.cptec.inpe.br/portal/en/index.html), SAMBBA (http://www.ncas.ac.uk/fgam/index.php?option=com_content&task=view&id=194&Itemid=1), Andes-Amazon Initiative (http://www.moore.org/andes-amazon.aspx), Amazon-PIRE (http://www.amazonpire.org/)

LBA: A Program of the Ministry of Science and Technology (MCT)

Main research foci:

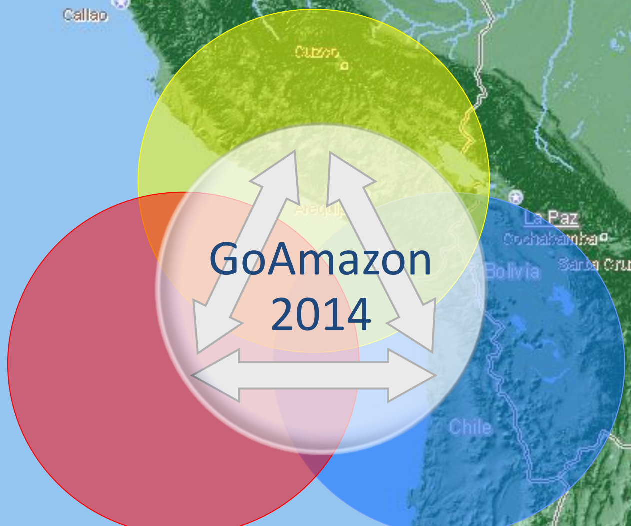
- The changing environment of Amazonia
- Environmental sustainability and the sustainability of current terrestrial and aquatic production systems
- Variability and changes in climatic and hydrologic systems – feedback, adaptation and mitigation

Integrated and interdisciplinary investigations:

Yellow: multi-scale physico-chemical interactions at biosphere-atmosphere interface;

Red: physico-chemico-biological processes in aquatic and terrestrial ecosystems and their interactions;

Blue: the social dimensions of environmental change and the dynamics of land cover change



Acknowledgments: Laszlo Nagy, INPA/LBA

GoAmazon2014: Known and Planned Activities

Cloud Life Cycle Project

GPM-CHUVA

Leader: Luiz Machado

IARA-2014

DOE AAF Deployment

NASA Satellite Science

Coordinators: Loretta Mickley and Jun Wang

iLEAPS IGAC ACPC

Point of contact: Meinrat Andreae

DOE AMF Deployment

Aerosol-Cloud-Precipitation Interactions

Aeroclima

Leader: Paulo Artaxo

Aerosol Life Cycle Project

BEACHON

Leader: Alex Guenther

An Aerosol Life Cycle Project

T2 → T3 Lagrangian experiment accompanying IARA-2014

Coordinator: Jian Wang

Cloud Life Cycle Project

NSF Facilities S-POL

Leader: Courtney Schumacher

More activities expected (some DOE, some not DOE):

Cloud Life Cycle, Aerosol-Cloud-Precipitation Interactions, Carbon Cycle, international partners, …

The South American Biomass Burning Analysis (SAMBBA),

Ben Johnson, Hugh Coe,
Jim Haywood[1]Karla Longo and Paulo Artaxo
The Met Office, Fitzroy Road, Exeter, EX1 3PB, UK
The University of Manchester, Oxford Road, *Manches*
University of Sao Paulo, Brazil
INPE – Instituto Nacional de Pesquisas Espaciais

FAAM BAe146 aircraft

September 2012

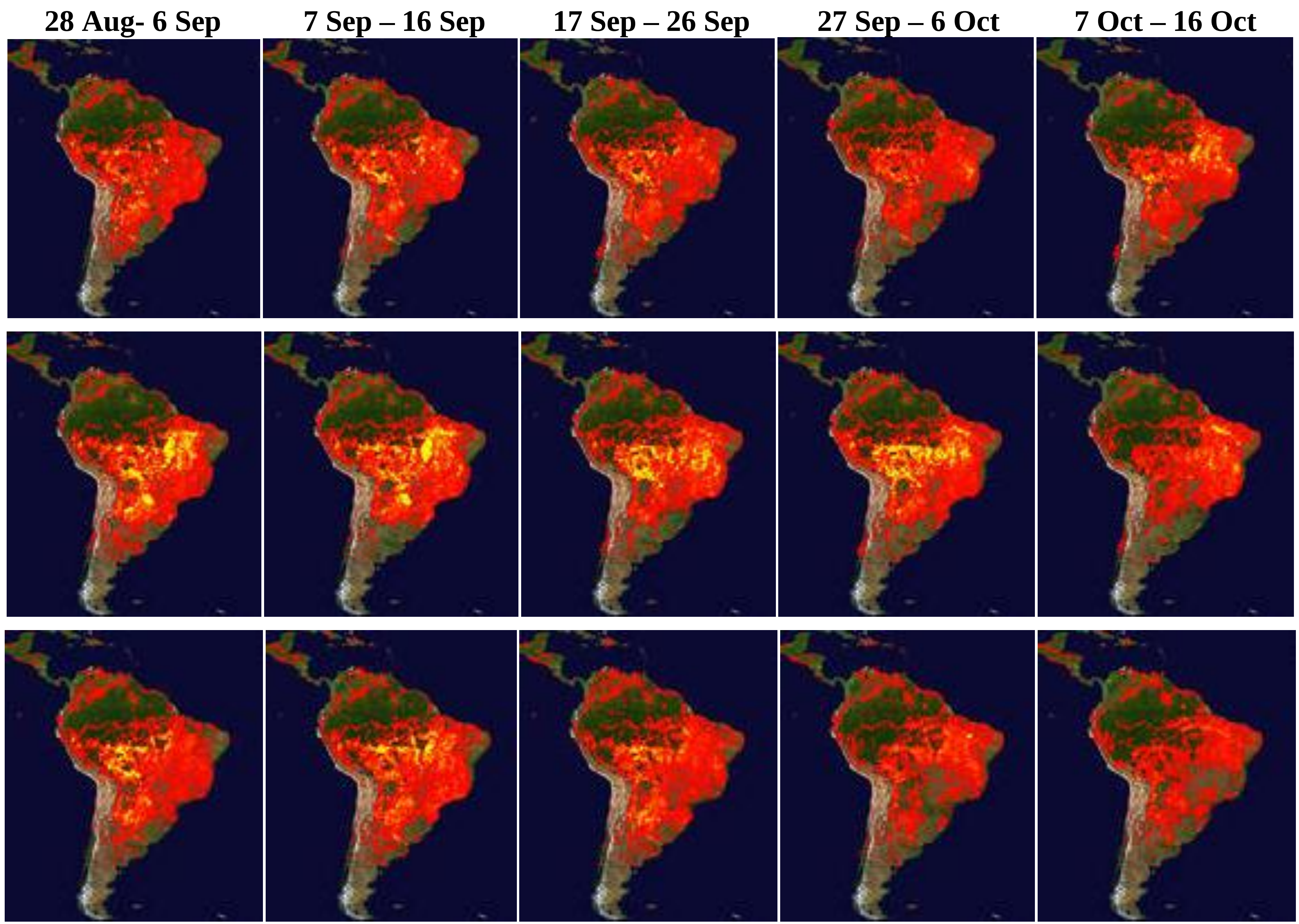
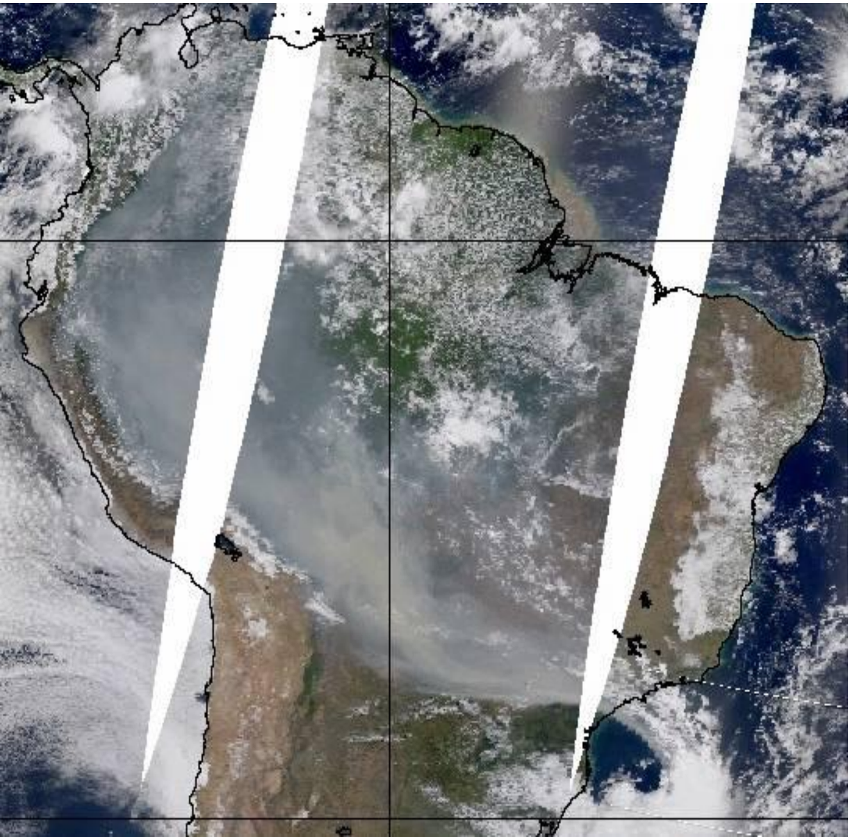
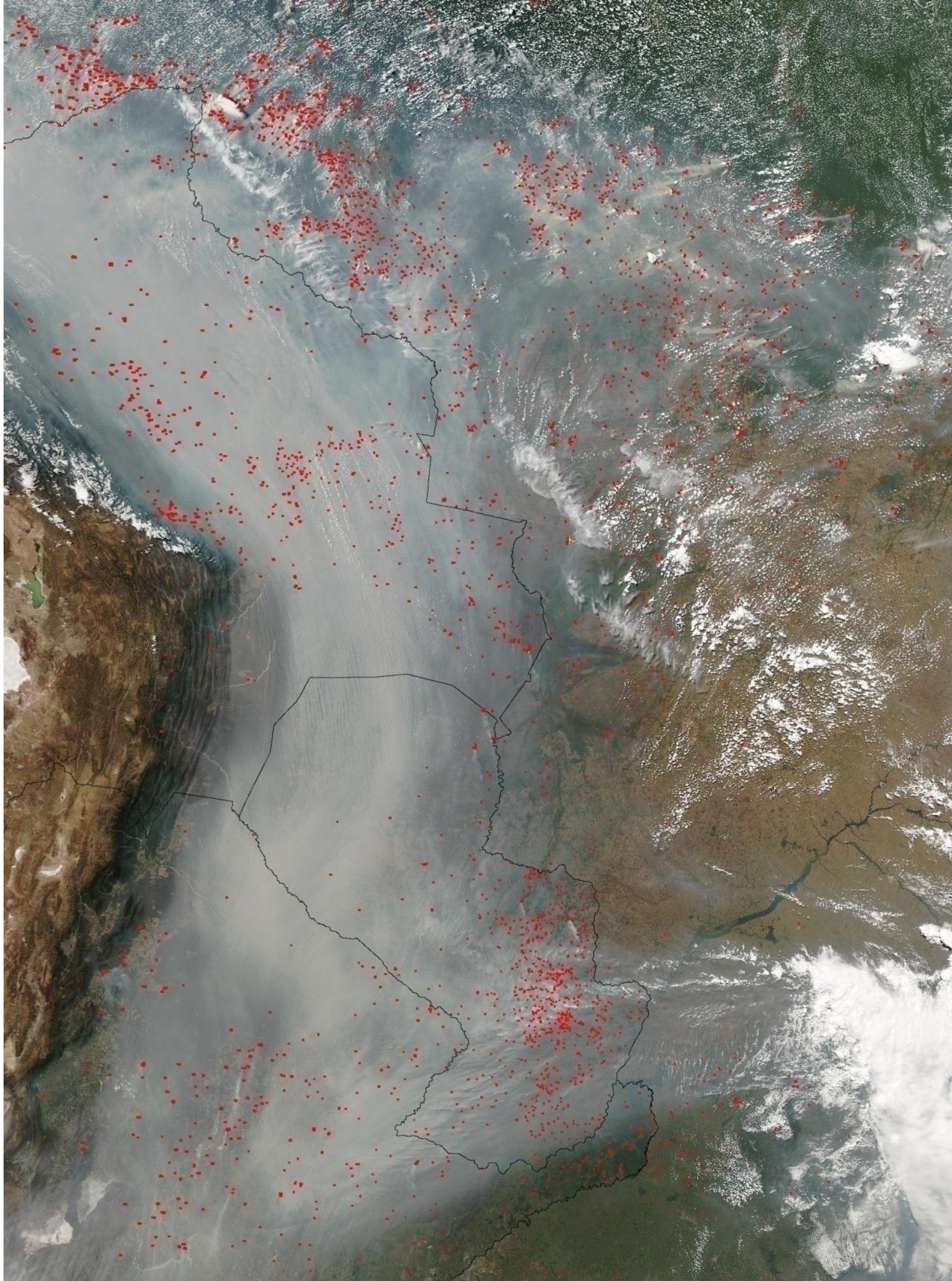
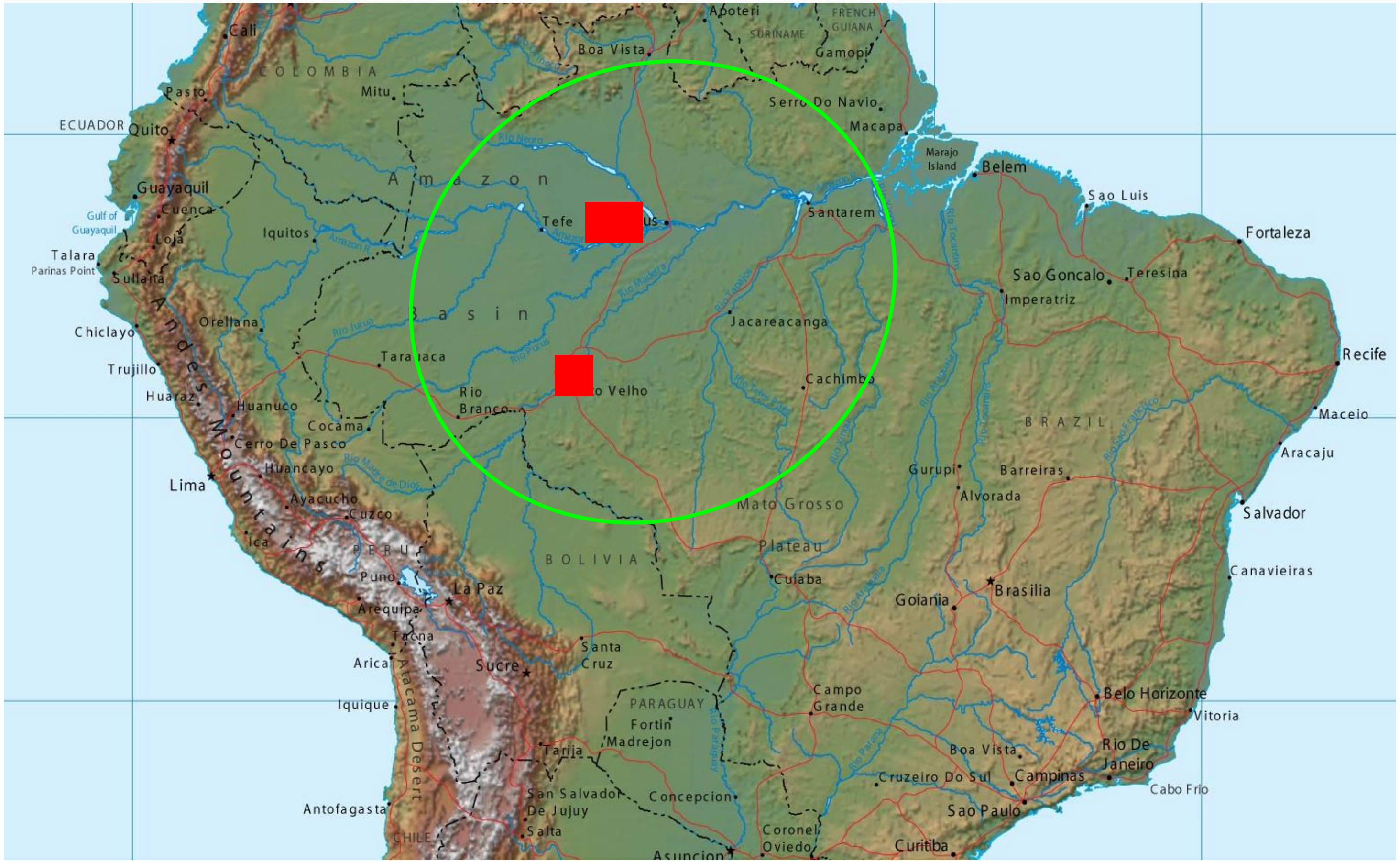


Figure 2. Fire activity derived from MODIS for September/October. Top row: 2008, middle row: 2007, bottom row: 2006.

Large scale distribution of biomass burning aerosols in South America







Baseado em Porto Velho com alcance na parte sudoeste da Amazonia

2. Scientific objectives

The overall aim of SAMBBA is to improve our ability (UK, Brazil and worldwide scientific community) to quantify the impact of biomass burning and biogenic aerosols over South America.

To achieve this we must determine aerosol precursors and key processes, assess their influence on the radiative budget, and improve our knowledge of their influence on clouds. Below is a summary of our scientific objectives outlining the strategy to address the overall aim and the fundamental issues detailed above:

•Measure the physical, optical and chemical properties of natural and biomass burning aerosol over South America including their mixing state and hygroscopicity. Asses how these properties relate to the emission source (natural emission, forest fire, agricultural fires in Cerrado regions) and its age / development cycle.

•Determine the emission rates of trace gases from biomass burning, including volatile and semi-volatile organic compounds. Investigate the formation and evolution of secondary organic aerosol and how this relates to the chemistry of the natural and polluted environment.

•Measure the direct effects of natural and biomass burning aerosol on solar radiation and assess how this affects the radiative budget of the region.

•Investigate the impact of biomass burning aerosol on cloud microphysics (cloud condensation nuclei, cloud droplet concentration and droplet size spectra) and the suppression of precipitation.

•Investigate the transport and vertical mixing of aerosols over South America, including aspects such smoke plume rise and mesoscale atmospheric circulations.

•Provide a regional context for measurements made as part of the CLARE 2010, including vertical profiles of insitu measurements and other information that is only achievable via airborne platform.

•Provide measurements for the validation of satellite remote sensing products such as those developed to identify active fires, burned areas, smoke plume height, aerosol optical depth and the atmospheric burden of chemical constituents over South America (MODIS, MISR, CALIPSO, SCHIAMACY, AATSR, etc).

•Provide observational data for the initialization and validation of modelling studies such as climate models, regional transport models and large-eddy simulations (small-scale cloud studies).

6. Instrumentation on the FAAM aircraft

The technical specifications of all instruments on the FAAM aircraft are listed on the website www.faam.ac.uk. Below is a summary of those most relevant to SAMBBA and brief explanations of how these will enable our scientific objectives.

Meteorological variables

The FAAM aircraft contains a comprehensive set of meteorological instruments measuring all basic atmospheric parameters (**pressure, temperature, humidity, winds, turbulence**). It also has the facility to launch dropsondes. These are small instrument packages that fall to the ground using a parachute and measure pressure, temperature, humidity and wind.

Aerosols

The FAAM aircraft also contains a wide range of instruments to characterize the physical, chemical and optical properties of aerosols including number concentration (**CN**), size distribution (**PCASP, FSSP**), scattering (**3-wavelength nephelometer**), absorption (**Particle Soot Absorption Photometer**), hygroscopicity (**humidified 3-wavelength nephelometer**). The will infer the black carbon content and mixing state using a Single Particle Soot Photometer (**SP2)**. We also have an **Aerosol Mass Spectrometer** that will be used to decipher the chemical composition of aerosols and the abundance of various organic and inorganic compounds. We also have an aerosol filter collection system.

Clouds

Cloud microphysics will be measured by many optical probes (**two FSSPs, CDP, 2D-C, 2D-P, CIP-25, CIP-100, CAPS, HVPS**). Each measures the size and concentration of cloud and precipitation droplets in different size ranges but with much overlap between probes. Bulk cloud properties of liquid water and total water are measured by **NEVZEROV** and **Johnson-Williams** instruments. We also have a Cloud Condensation Nuclei (**CCN**) counter.

Gas chemistry

We will make measurements of key trace gases to characterise the chemical environment. These include **CO, NO, NO2, NOx, NOy, O3, CO2, SO2, PAN and HCHO (Formaldehyde)**. In addition a PTR-MS instrument will be on board to measure more complex chemical species including oxygenated hydrocarbons, aromatic hydrocarbons, olefinic hydrocarbons and several others. For an even more comprehensive capability we will also run a bottle system allowing the collection of air samples for detailed inspection by **Gas Chromatograph** after the flight.

Radiation / remote sensing

The FAAM aircraft has a wide range of radiometers measuring broad band solar and terrestrial fluxes (up and down) plus high spectral resolution radiometers measuring solar irradiance (up and down) and solar radiance (any direction). We also have a leosphere aerosol lidar that remotely senses aerosol beneath the aircraft.

Communication / navigation

The aircraft is equipped with a satellite communication system for relaying messages, phone calls and internet access in the air. All navigation data (GPS position, speed etc) is recorded as standard part of the flight data.

Flight patterns

Our proposal is to conduct flights focussing on the following flight patterns:

1. **Investigation of smoke plumes from fires.** This would firstly involve flying high above the fire to survey the height, width and optical thickness of the smoke plume using our aerosol lidar and shortwave spectrometer. Secondly we would make passes through the smoke plume at various distances downwind of the fire to measure the properties of the evolving aerosol and trace gas chemistry. At some distance downwind the smoke plume would become indistinct from the background aerosol.

2. **Investigation of regional haze layers**. This simply requires flying at low to mid altitudes (below 15,000ft) over regions hazy regions, which are likely to be widespread near Porto Velho in the month of September. It would be important to compare such mean properties with measurements from the Bandeirante and at least once fly side by side together for instrument intercomparison.

1. **Investigation of the impact of aerosol on cloud.** This will involve making penetrations of clean clouds near Manaus and polluted clouds near Porto Velho. Learning from experience, when clouds are small and short –lived this is best achieved by performing long straight and level runs to sample clouds. For large and distinctive groups of clouds (e.g. pyro-cumulus) a more beneficial strategy would be to make repeated penetrations of the same cloud over a range of altitudes. During such flight patterns the Bandeirante could make more detailed observations of the aerosol properties below cloud base or investigate plumes of smoke entering the cloud from below.

2. **Radiative closure studies.** If possible we aim to gather some measurements in cloud-free conditions so that we can infer the impact of the aerosol on solar radiation. Radiative closure can then be examined by flying a sequence a runs and inter-linking profiles along a fixed track of about 100km. Ideally, this requires completely cloud free conditions, which we are more likely to find to the south-east of Porto Velho. During such patterns the Bandeirante would be a useful compliment focussing more time on insitu sampling of the aerosol allowing the FAAM to concentrate most of its time on runs needed for the radiative measurements.

3. **Regional surveys.** The aerosol lidar is a powerful tool for mapping the vertical and geographic distribution of aerosol from an aircraft. This requires extensive aircraft patterns at altitude well above the haze layers (e.g. 20,000ft). These kinds of flights will allow us to examine the spatial variability and transport of aerosol. Co-ordination with the Banderiante would be a advantage on some of these flights since the Brazilian plane could provide information on the insitu aerosol size distribution that affects the lidar sensitivity (backscatter to extinction ratio).

BUNIACCIC and SAMBBA workshops Manaus, Feb 15, 2012

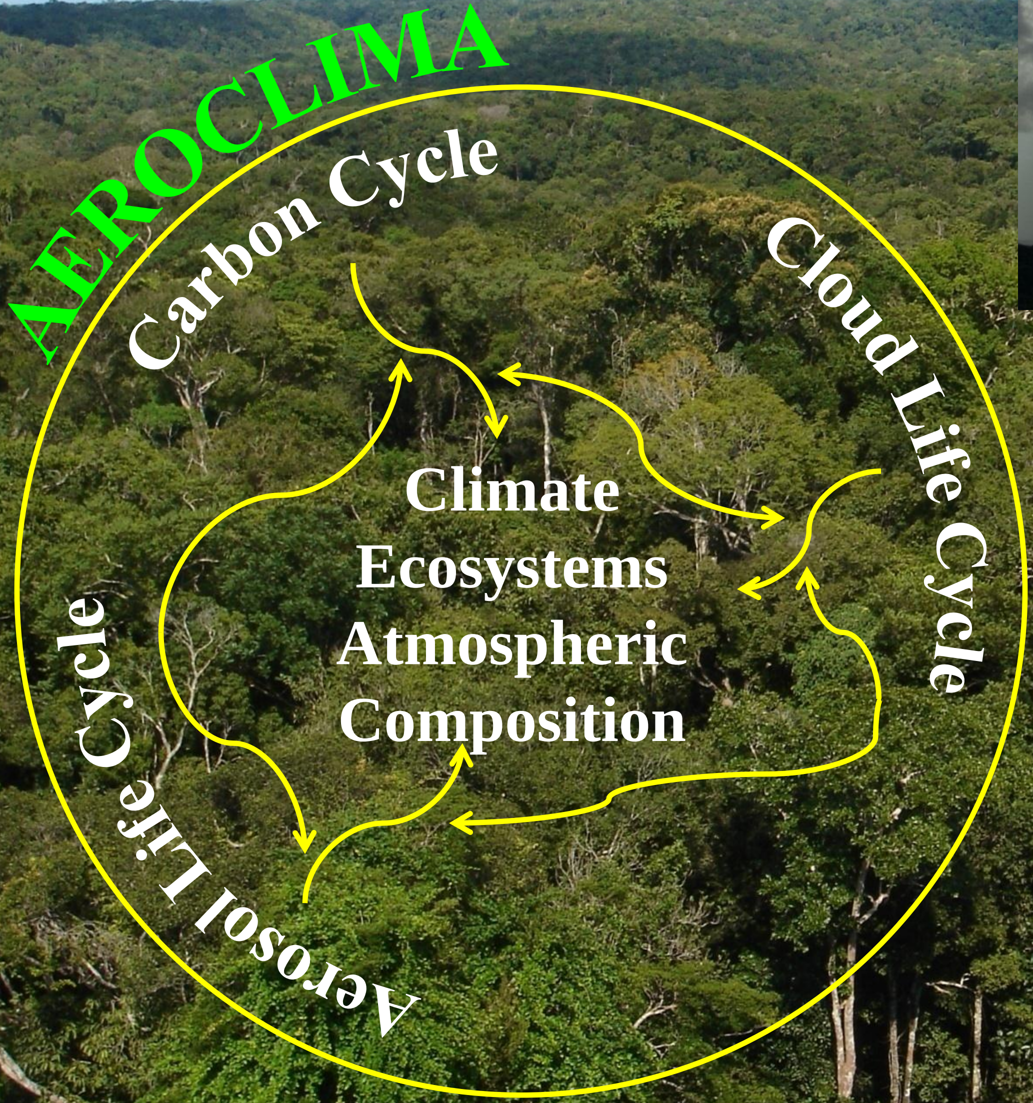
AEROCLIMA - Direct and indirect effects of aerosols on climate in Amazonia and Pantanal

Team: Paulo Artaxo (IFUSP), Maria Assunção F. da Silva Dias (IAG-USP),

Henrique M. J. Barbosa , (IFUSP), Alexandre L. Correia (IFUSP), Luciana V. Rizzo (UNIFESP-Diadema), Theotonio Pauliquevis (UNIFESP-Diadema), Márcia A. Yamasoe (IAG-USP), Karla M. Longo (INPE), Saulo de Freitas (INPE), Plínio Alvalá (INPE), Ênio B. Pereira (INPE), Fernando R. Martins (INPE), Kenia T. Wiedemann (IFUSP), Judith Hoelzemann (UFRGN), Rodrigo de Souza (UEA, Manaus), David Adams (UEA, Manaus), Wanderlei Bastos (UNIR, Rondônia), Sandra Hacon (FIOCRUZ), Hillândia Brandão (INPA-LBA), Fernando Gonçalvez (IFUSP), Alcides C. Ribeiro (IFUSP), Ana L. Loureiro (IFUSP), Fábio Jorge (IFUSP).

Meinrat O. Andreae (Max Planck Institute, Mainz, Germany), Scot T. Martin (Harvard University, USA), Steven Wofsy (Harvard University, USA), Markku Kulmala (University of Helsinki, Finland), José Vanderlei Martins (NASA Goddard, USA), William Cotton (Colorado State University (USA),
George Grell (NOAA, USA).

Observations and modeling of the Amazon atmosphere, radiation balance and precipitation



AEROCLIMA: Direct and indirect effects of aerosols on climate in Amazonia and Pantanal

Objectives: Investigate the connection between the concentration and physico-chemical properties of biogenic and biomass burning aerosol particles in the radiation balance and climate, including effects on cloud development and microphysics for two important regions in South America: Amazonia and Pantanal.

Scientific Strategy: AEROCLIMA has 4 integrated components:

1) Observations of aerosols, clouds, trace gases and radiation (*Paulo Artaxo*)
2) Remote sensing of aerosols and clouds (*Alexandre Correia*)
3) Modeling of clouds dynamics and evolution and precipitation: (*Maria Assunção F. Silva Dias*)
4) Large scale atmospheric transport modeling (*Henrique Barbosa, Karla Longo and Saulo Freitas)*

AEROCLIMA Specific aims

The **overall objective** of AEROCLIMA is to *investigate the connection between the concentration and physico-chemical properties of biogenic and biomass burning aerosol in the radiation balance and climate, including effects on cloud development and microphysics for two important regions in South America: Amazonia and Pantanal.* The basic concept for AEROCLIMA is that of an integrated study, combining field studies, remote sensing and modeling. To achieve this goal, we will perform the following tasks:

•Calculate long term direct and indirect radiative forcing of aerosols in Amazonia and Pantanal, using a combination of measurements and modeling tools.

•**Characterize in detail physico-chemical properties of aerosol particles** that are relevant for their impact on the environment and climatic effects.

•**Install and operate three aerosol field measurement stations** that for one year will study detailed properties of aerosols: size distribution, absorption, scattering, composition, CCN activity and others. Aerosol and water vapor vertical profiles will be measured with a Raman Lidar. These stations will be installed at: Manaus, Porto Velho (biomass burning region) and Campo Grande (Pantanal).

•Implement **intensive measurement programs** such as the proposed LBA/CLAIRE2010, were more detailed aerosol properties will be measured including aerosol mass spectrometry, ion cluster measurements and detailed organic aerosol composition, VOC concentrations, among others.

•Perform **large scale aircraft measurements** using the INPE Bandeirante aircraft to measure the large scale and vertical distribution of aerosols. Develop innovative instrumentation to measure water phase and cloud droplets in convective and stratus clouds.

•Use **remote sensing measurements** with MODIS, CALIPSO and CERES to study large scale and long term aerosol and radiation fields in Amazonia and Pantanal. This will be used to quantify the effect of smoke aerosol on cloud properties.

•Develop and evaluate semi-empirical parameterizations for the cloud-aerosol-radiation interaction suitable for the Amazon basin and Pantanal region for different aerosol burden regimes.

•Model the effect of biogenic and biomass burning aerosol on cloud microphysics at the individual cloud and at regional level with spectral bin microphysics coupled to BRAMS. Perform sensitivity studies to investigate the relative importance of each variable.

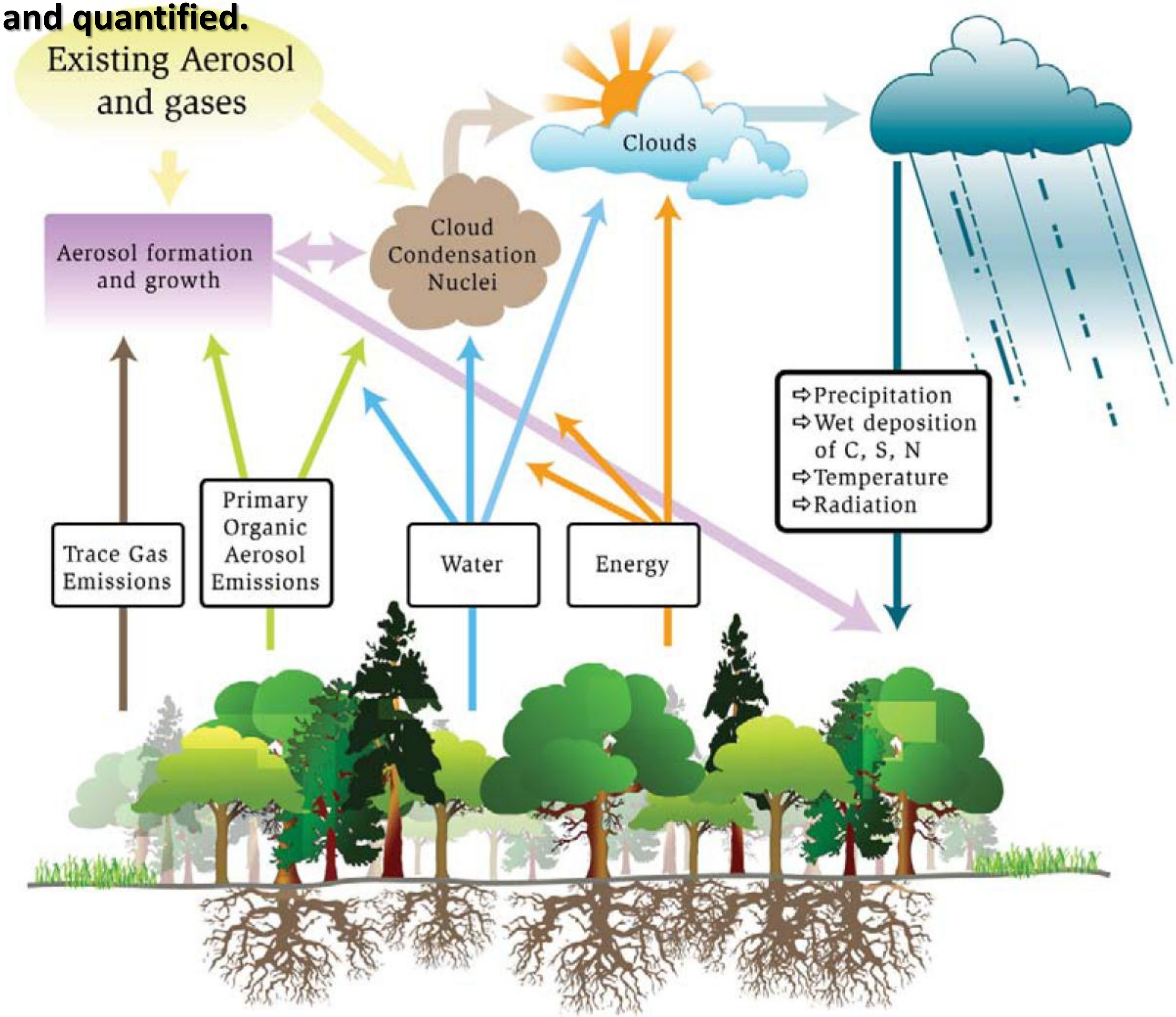
•Implement **regional models with full aerosol microphysics**, developed based on measurements in this project. The regional models will be based on CATT-BRAMS and WRF-CHEM models.

•To **contribute to the BMGCS development**, taking advantage of all expertise gained in the context of this proposal on the parameterizations for aerosol-cloud-radiation interactions and gaseous and aerosol chemistry.

AEROCLIMA measurements in Manaus and Porto Velho

- Continuous aerosol analysis is being done with:
- SFU for fine and coarse mode aerosols with analysis for trace elements.
- Organic and Elemental Carbon and ionic composition;
- MOUDI for aerosol size distribution
- TSI 3-Lambda Neph for light scattering
- MAAP (Multi Angle Absorption Photometer) for absorption
- Scanning Mobility Particle Sizer SMPS for aerosol size distribution (10-450nm)
- GRIMM OPC for 0.3-10 μm size distributions
- Cloud Condensation Nuclei (CCN) measurements.
- Ozone, CO, methane, CO_2 with Picarro CVRD.
- Raman Lidar continuosly up to 15 Km.
- Sun-photometry network (8 NASA AERONET instruments)
- Radiometers for visible and broadband radiation fluxes

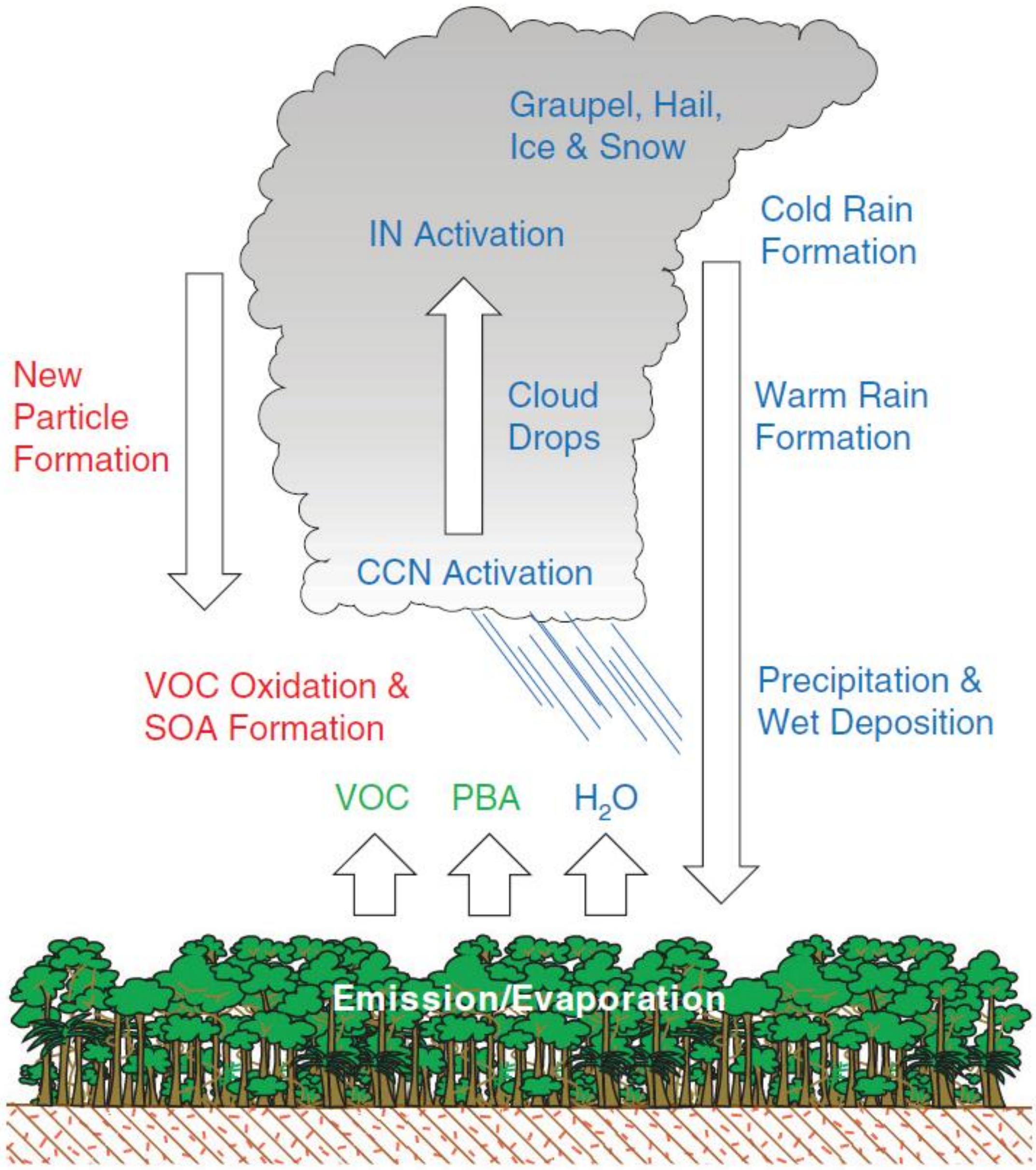
Amazonia has strong coupling between terrestrial ecosystem and the hydrologic cycle: The linkages among carbon cycle, aerosol life cycle, and cloud life cycle need to be understood and quantified.



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.

Aerosol and Water Cycling over the Pristine Rainforest

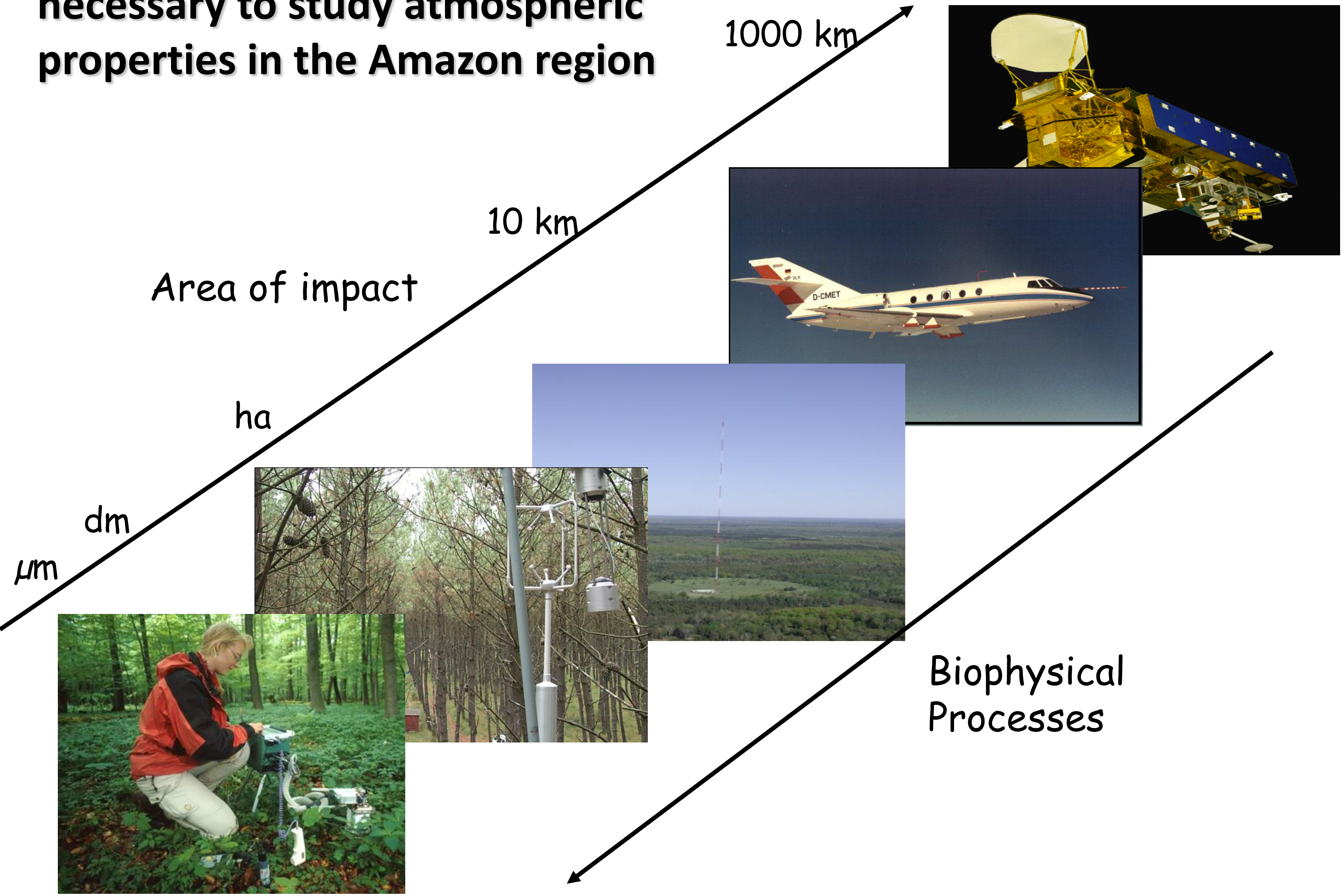
Secondary Organic Aerosols formed by photo-oxidation of volatile organic compounds (VOC) and PBA emitted from biota in the rainforest (plants and microorganisms) serve as biogenic nuclei for CCN and IN, which induce warm or cold rain formation, precipitation, and wet deposition of gases and particles.



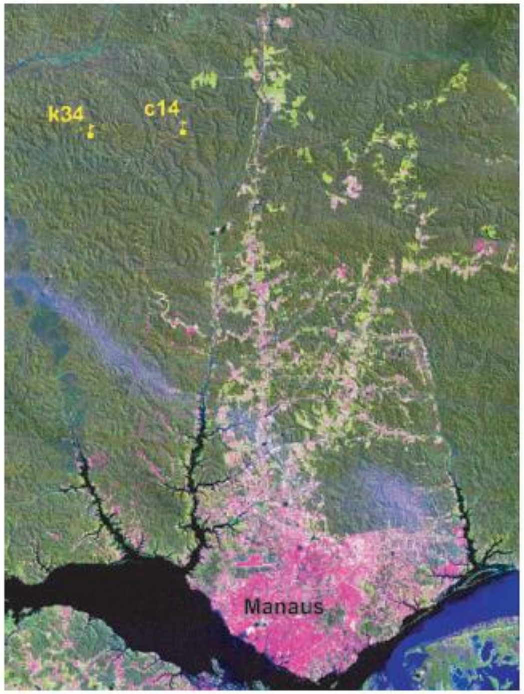
U. Pöschl, et al., "Rainforest aerosols as biogenic nuclei of clouds and precipitation in the Amazon," *Science*, 2010, 329, 1513-1516.

S.T. Martin, et al, "An Overview of the Amazonian Aerosol Characterization Experiment 2008 (AMAZE-08)," *Atmospheric Chemistry Physics*, 2010, 10, 11415-11438.

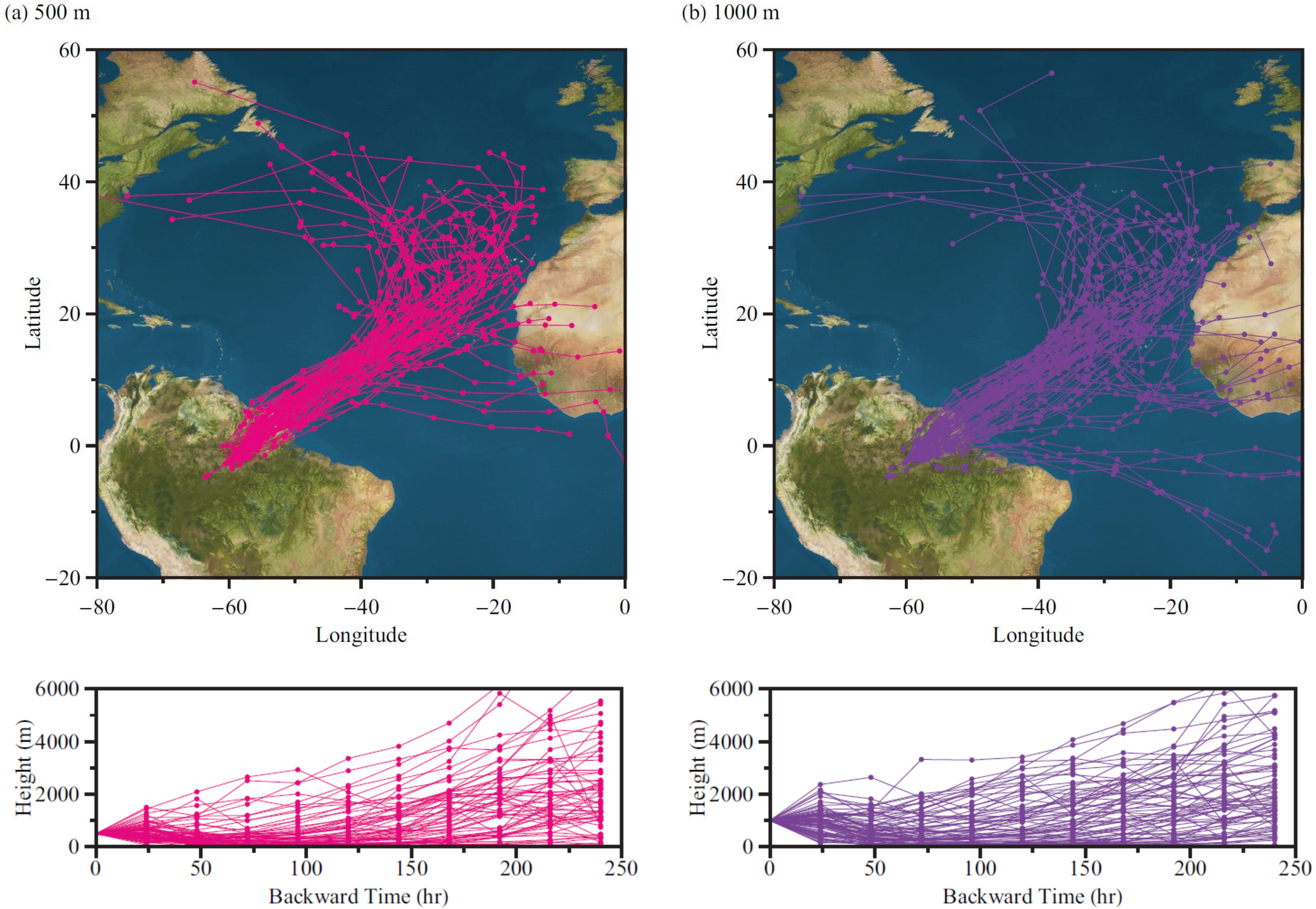
In AEROCLIMA, several scales are necessary to study atmospheric properties in the Amazon region



- Site: 100 Km North of Manaus. Measurements: from Feb 2008 up to now.
- Continuation as a permanent sampling site.
- Three towers at the site, from 35 to 55 meters.
- Dryer to get aerosol at 30-40% RH

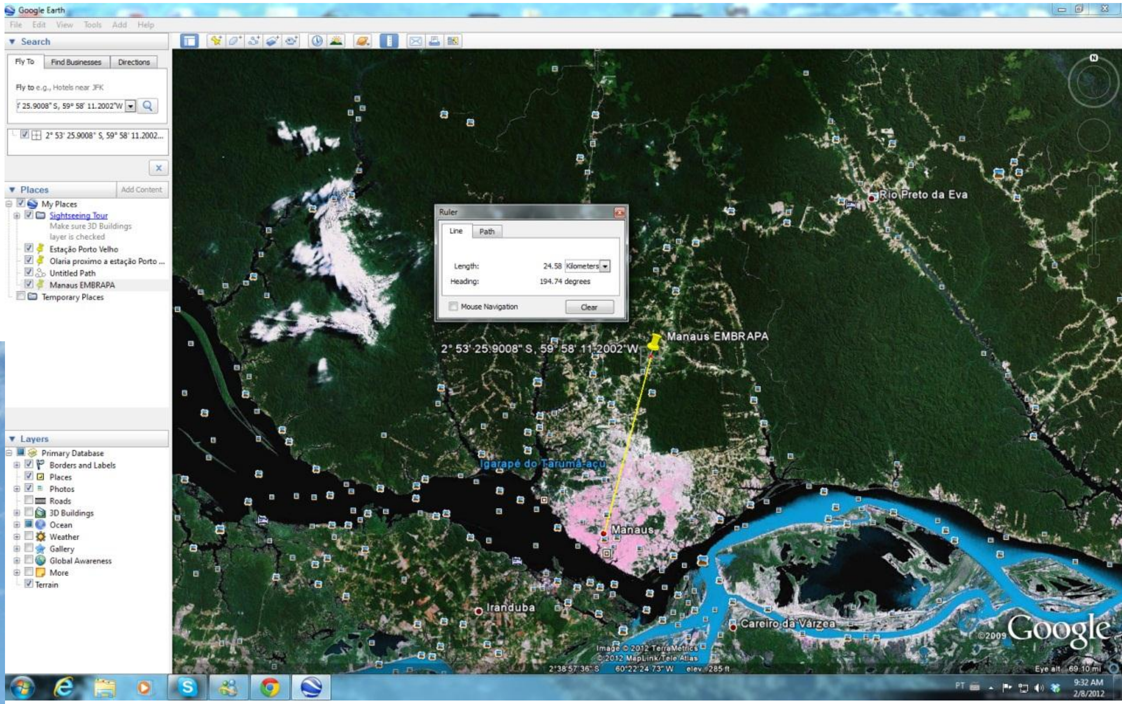


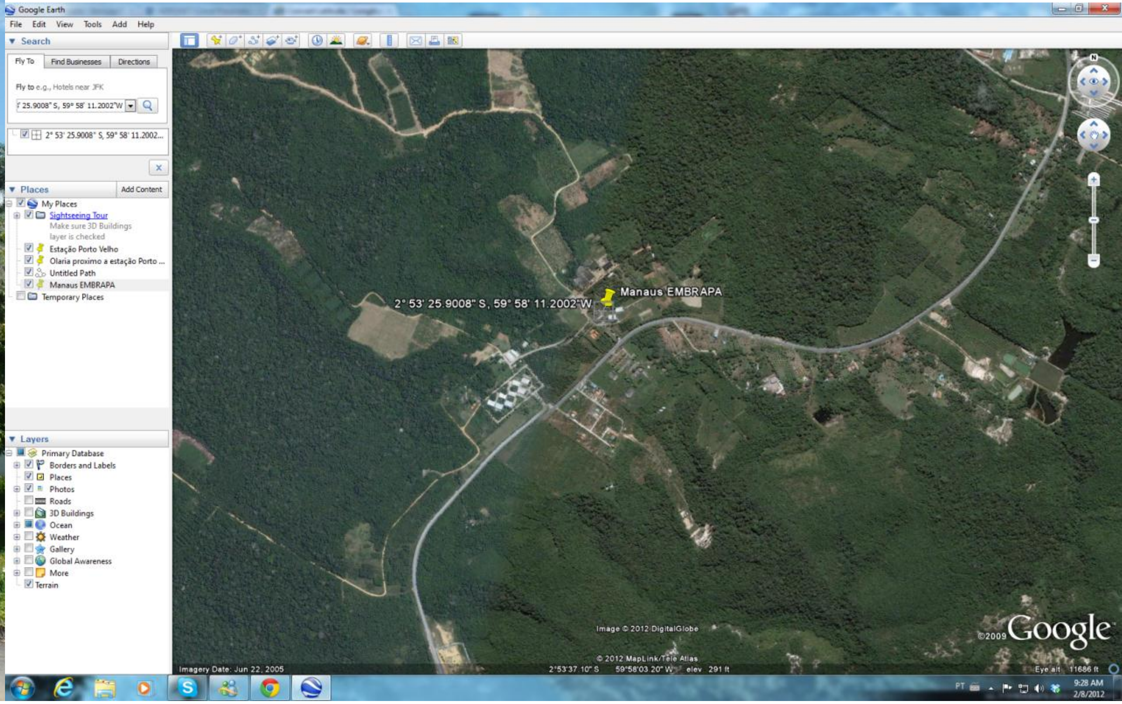
HYSPLIT air mass trajectories during for AEROCLIMA Manaus site



Container with equipment powered by generators

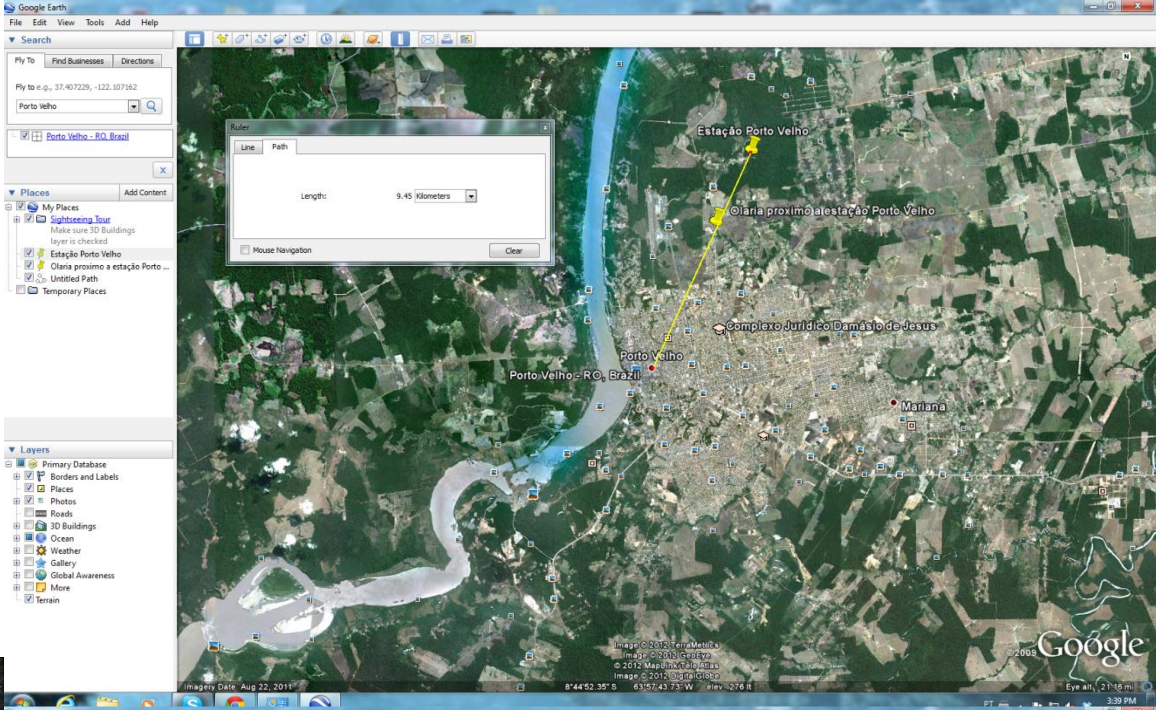
Manaus EMBRAPA AEROCLIMA site

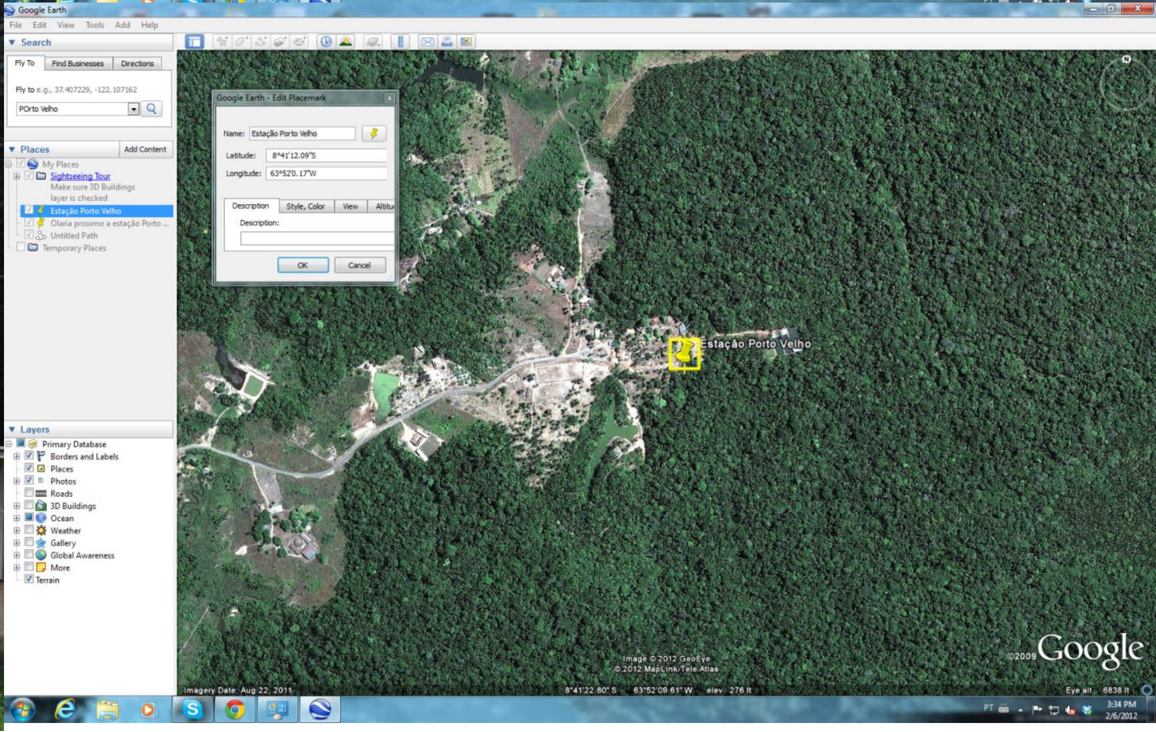




Rondonia - Porto Velho aerosol and trace gases measurement site

Porto Velho AEROCLIMA site

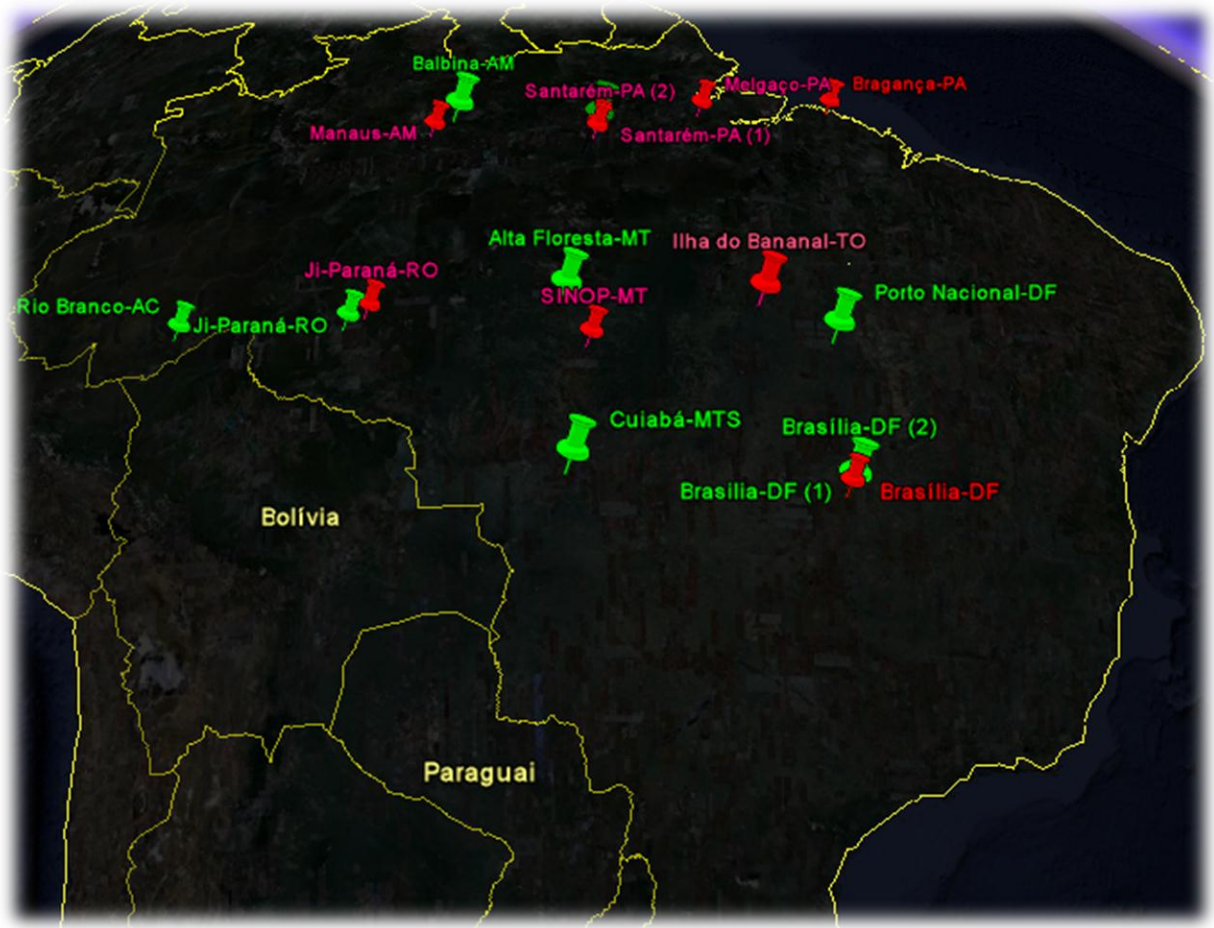




Medidas sendo realizadas em Porto Velho

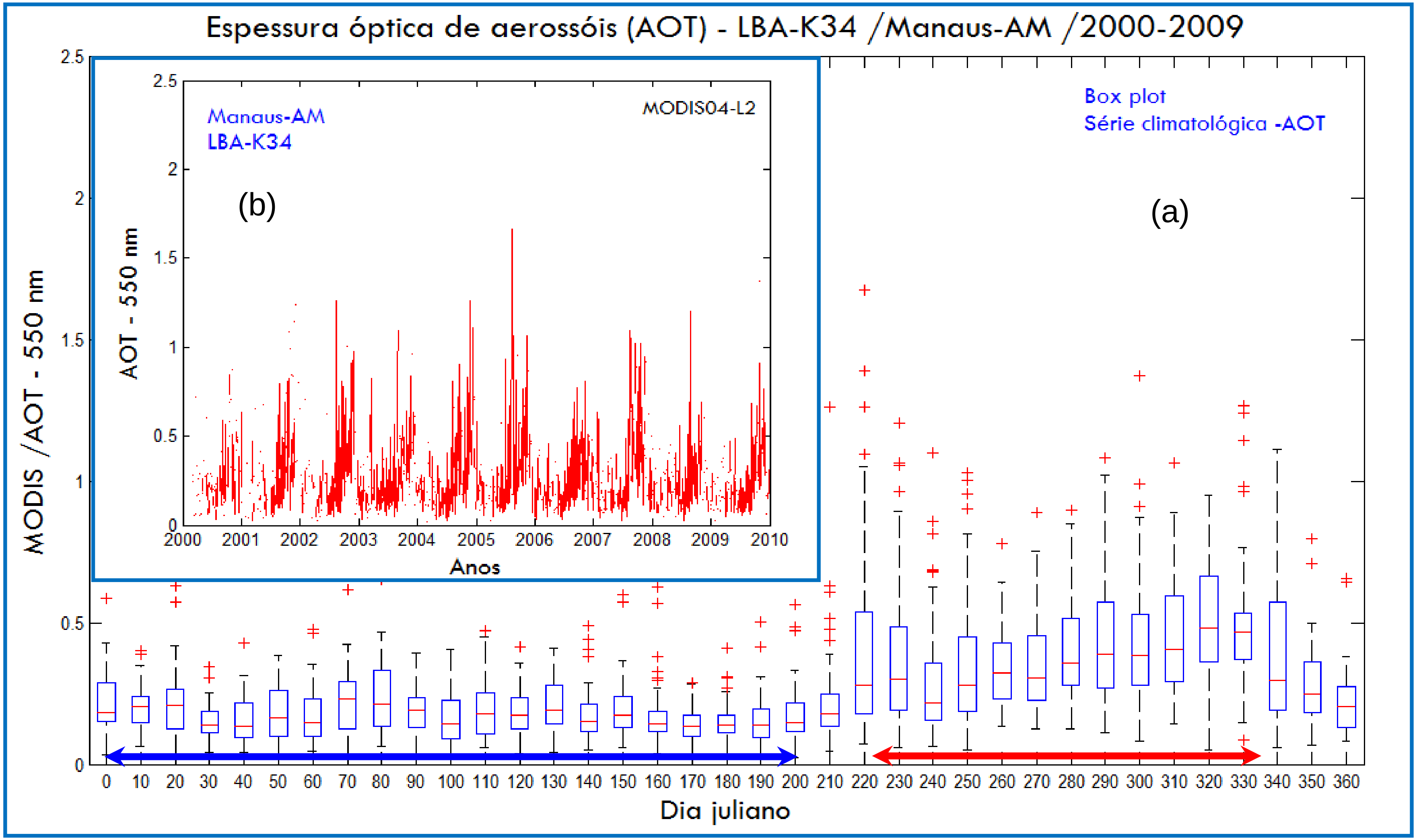
- Concentração de massa de aerossóis com SFU PM_{10}, $PM_{2.5}$
- Composição elementar com PIXE (Sódio a Chumbo)
- Distribuição de tamanho com SMPS – Partículas de 10 nm a 800 nm
- Espalhamento ótico (nefelometro)
- Absorção ótica (Black Carbon) com MAAP e Aethalometro.
- Ozônio com 2B Tech
- A partir de Dezembro: Mercúrio total e particulado

Fotômetros solares da rede AERONET (*Aerosol Robotic Network*): um sistema de monitoramento e caracterização de aerossóis mantidos pela NASA, a partir de uma rede de radiômetros solares operados na Amazônia e outras regiões do planeta.



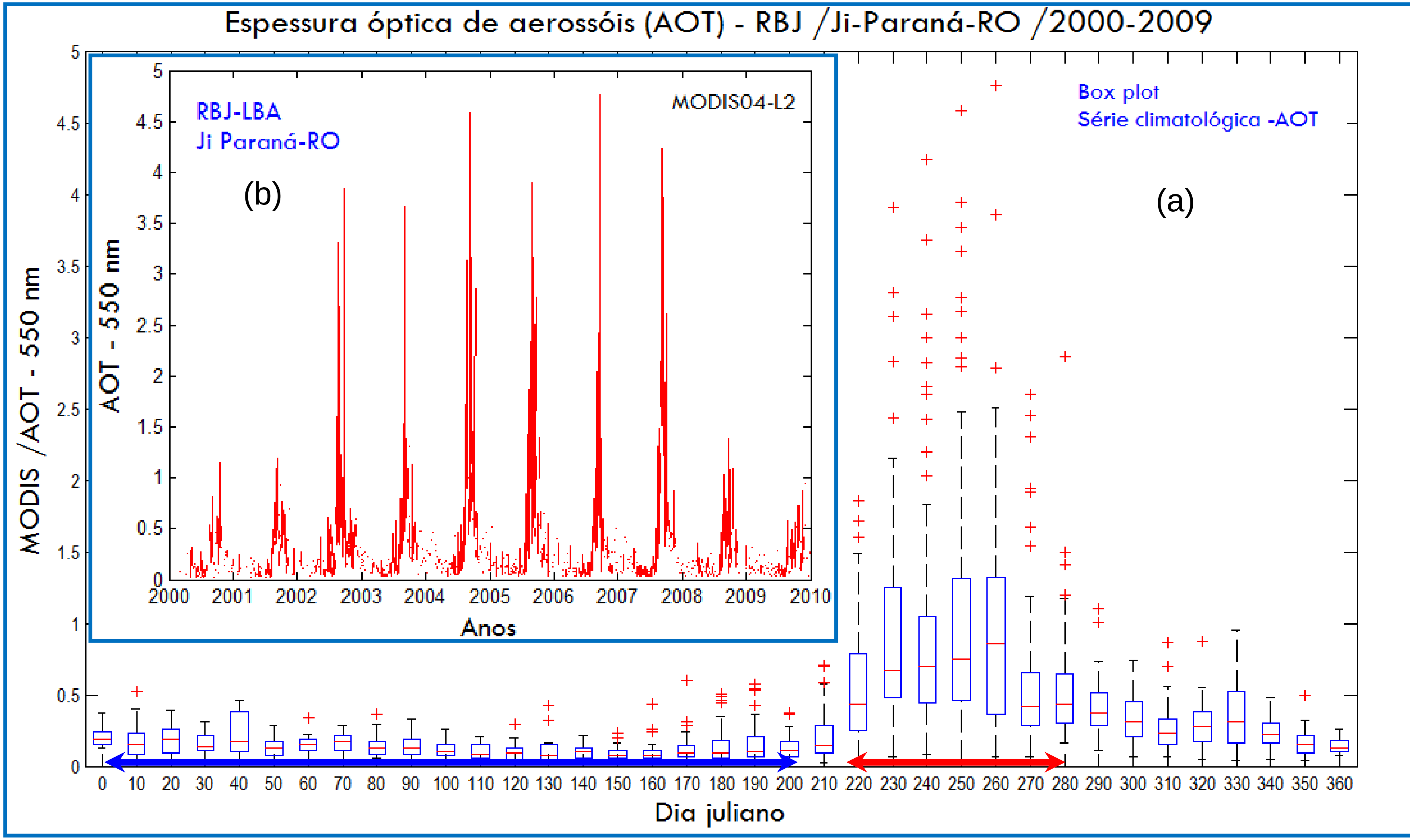
Medidas de espessura ótica de aerossóis (AOT) → (Comprimentos de onda: 340, 380, 440, **500**, 670, 870, 940 e 1020 nanômetros)

Aerosol optical thickness in Manaus

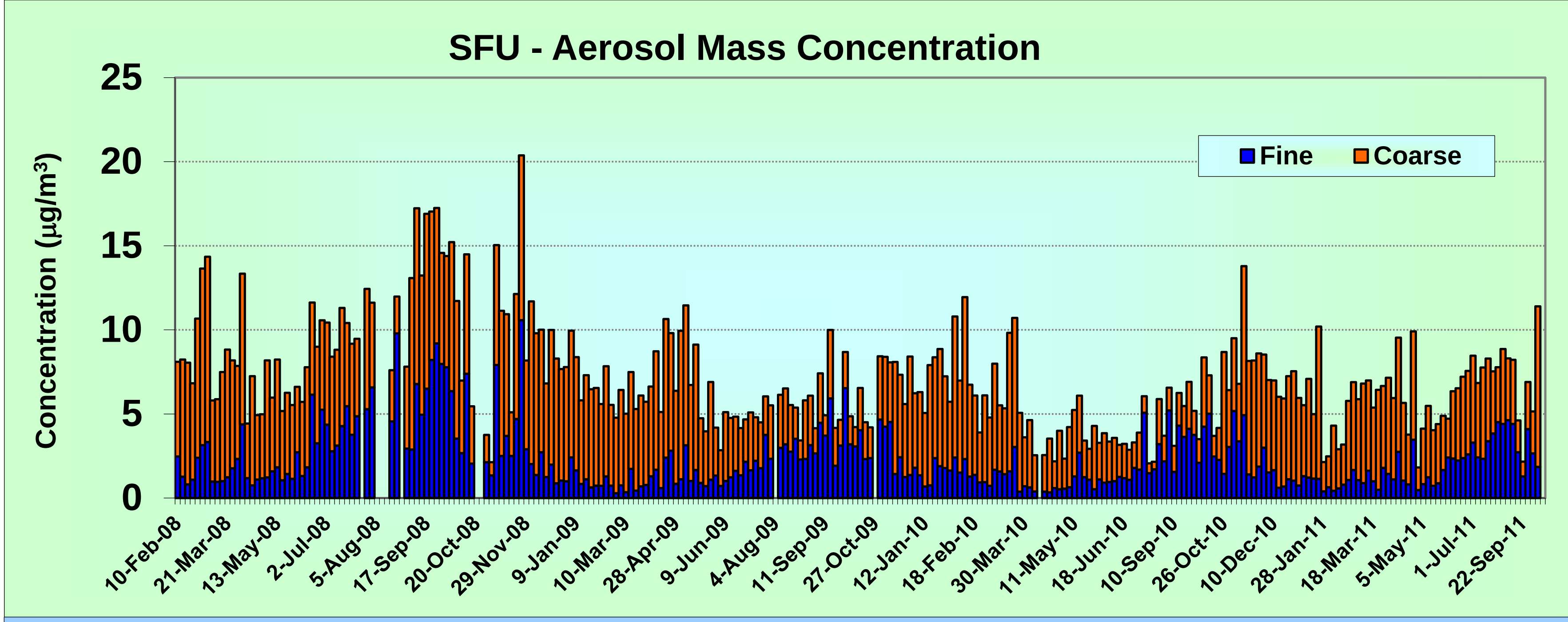


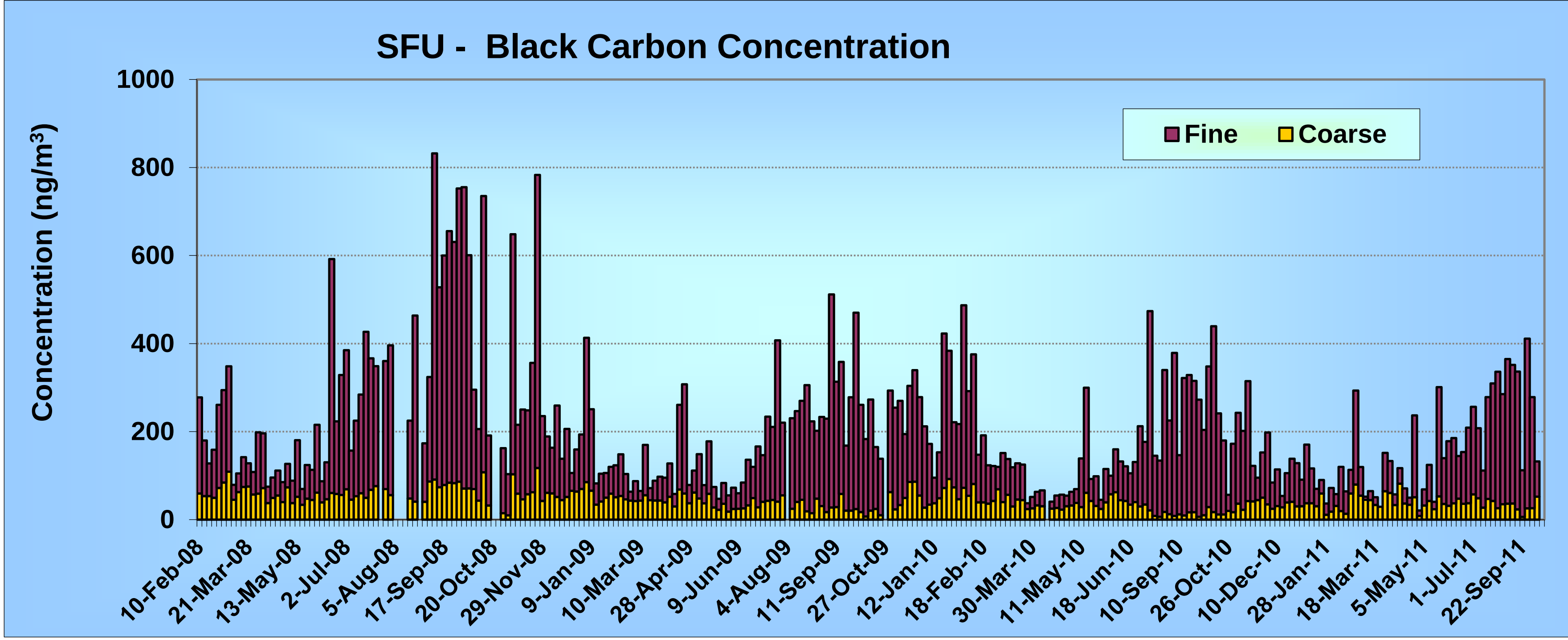
Glauber Cirino

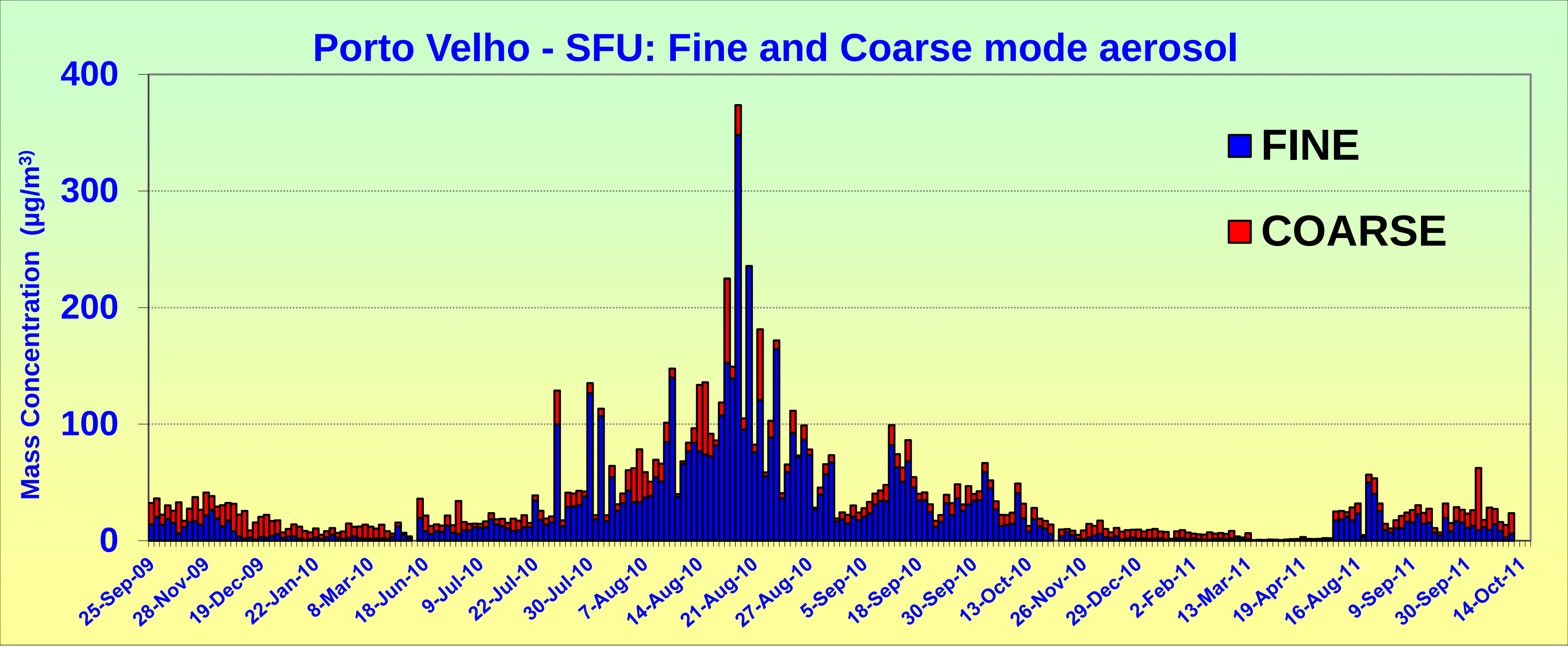
Aerosol optical thickness in Rondônia



Glauber Cirino


SFU - Aerosol Mass Concentration
Concentration (µg/m³)
0
5
10
15
20
25
Fine
Coarse
10-Feb-08
21-Mar-08
13-May-08
2-Jul-08
5-Aug-08
17-Sep-08
20-Oct-08
29-Nov-08
9-Jan-09
10-Mar-09
28-Apr-09
9-Jun-09
4-Aug-09
11-Sep-09
27-Oct-09
12-Jan-10
18-Feb-10
30-Mar-10
11-May-10
18-Jun-10
10-Sep-10
26-Oct-10
10-Dec-10
28-Jan-11
18-Mar-11
5-May-11
1-Jul-11
22-Sep-11


SFU - Black Carbon Concentration
Concentration (ng/m³)
0
200
400
600
800
1000
Fine
Coarse
10-Feb-08
21-Mar-08
13-May-08
2-Jul-08
5-Aug-08
17-Sep-08
20-Oct-08
29-Nov-08
9-Jan-09
10-Mar-09
28-Apr-09
9-Jun-09
4-Aug-09
11-Sep-09
27-Oct-09
12-Jan-10
18-Feb-10
30-Mar-10
11-May-10
18-Jun-10
10-Sep-10
26-Oct-10
10-Dec-10
28-Jan-11
18-Mar-11
5-May-11
1-Jul-11
22-Sep-11



Porto Velho - SFU: Fine and Coarse mode aerosol
Mass Concentration (µg/m³)
400
300
200
100
0
FINE
COARSE
25-Sep-09
28-Nov-09
19-Dec-09
22-Jan-10
8-Mar-10
18-Jun-10
9-Jul-10
22-Jul-10
30-Jul-10
7-Aug-10
14-Aug-10
21-Aug-10
27-Aug-10
5-Sep-10
18-Sep-10
30-Sep-10
13-Oct-10
26-Nov-10
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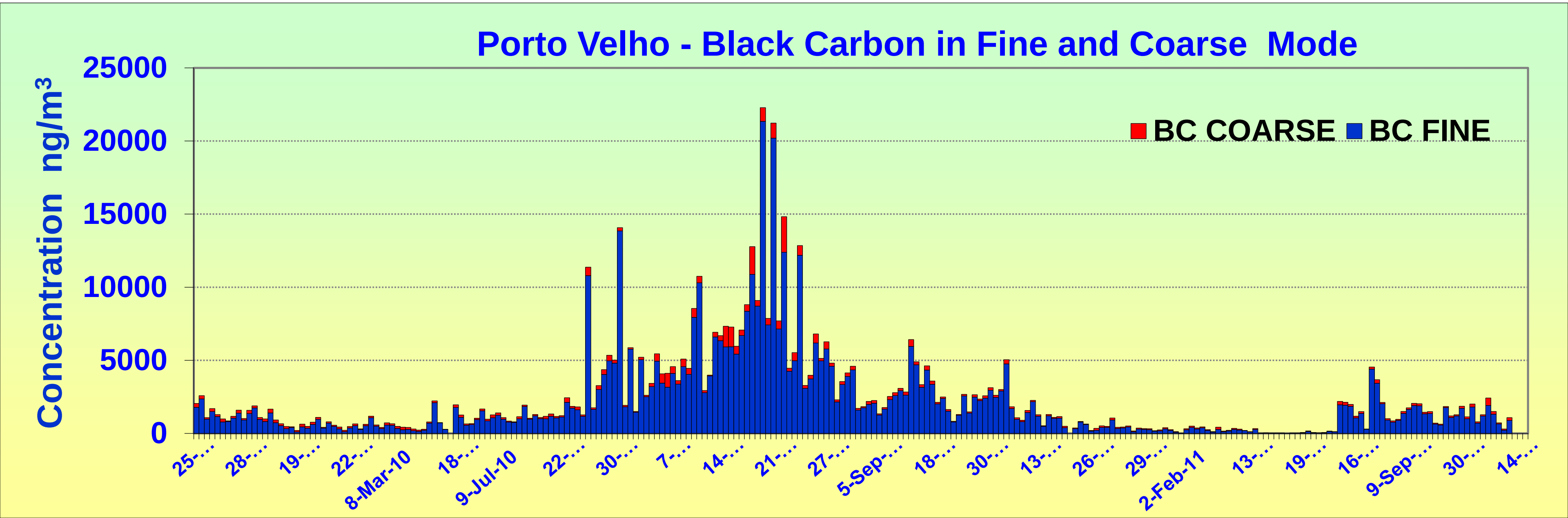
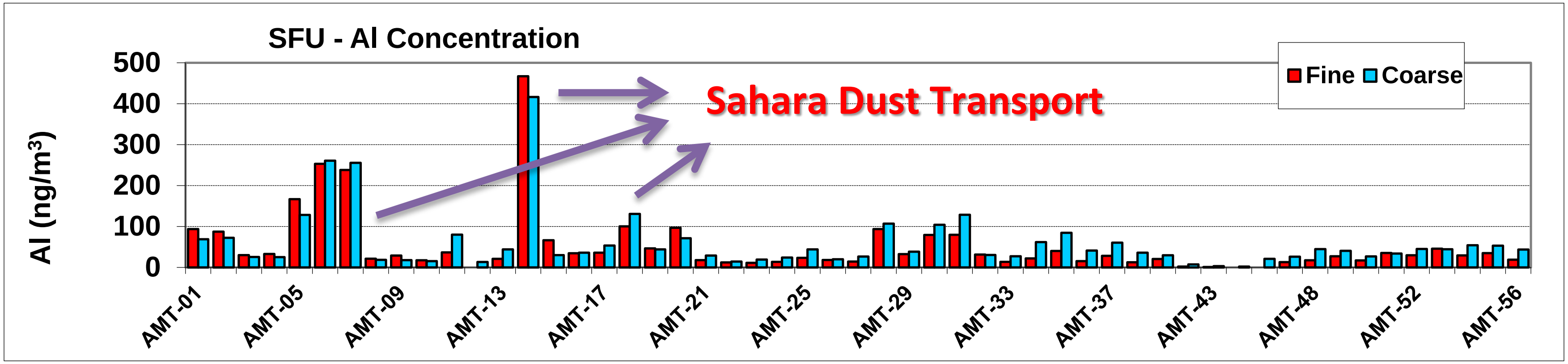
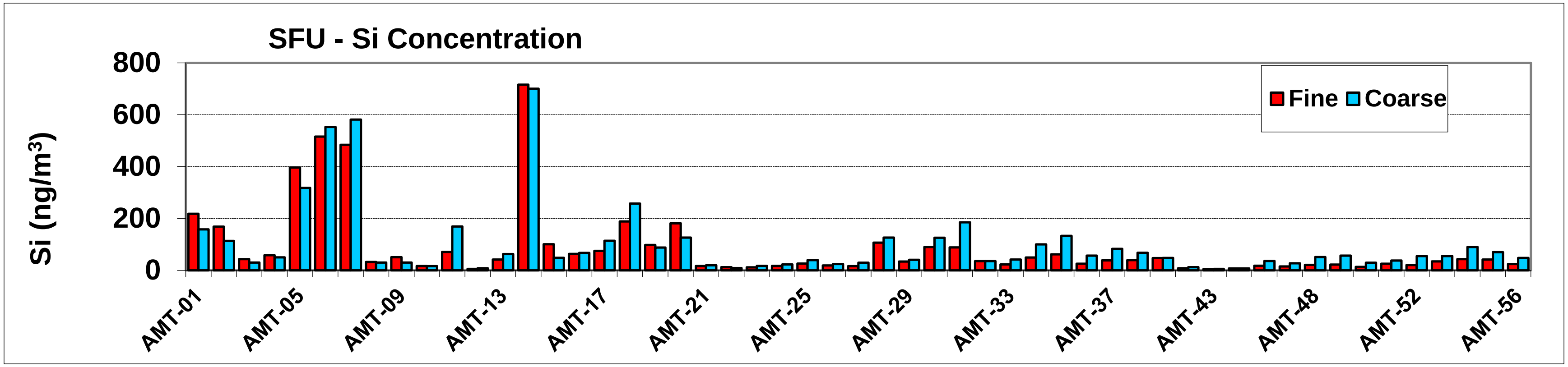
2-Feb-11
13-Mar-11
19-Apr-11
16-Aug-11
9-Sep-11
30-Sep-11
14-Oct-11

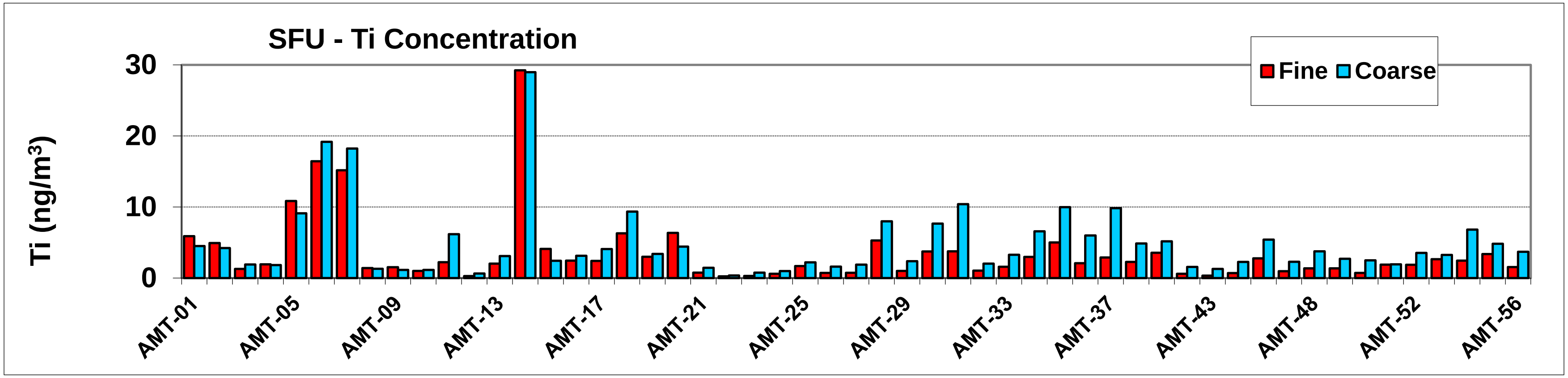


Porto Velho - Black Carbon in Fine and Coarse Mode
Concentration ng/m³
25000
20000
15000
10000
5000
0
BC COARSE
BC FINE
8-Mar-10
9-Jul-10
5-Sep-...
2-Feb-11
9-Sep-...

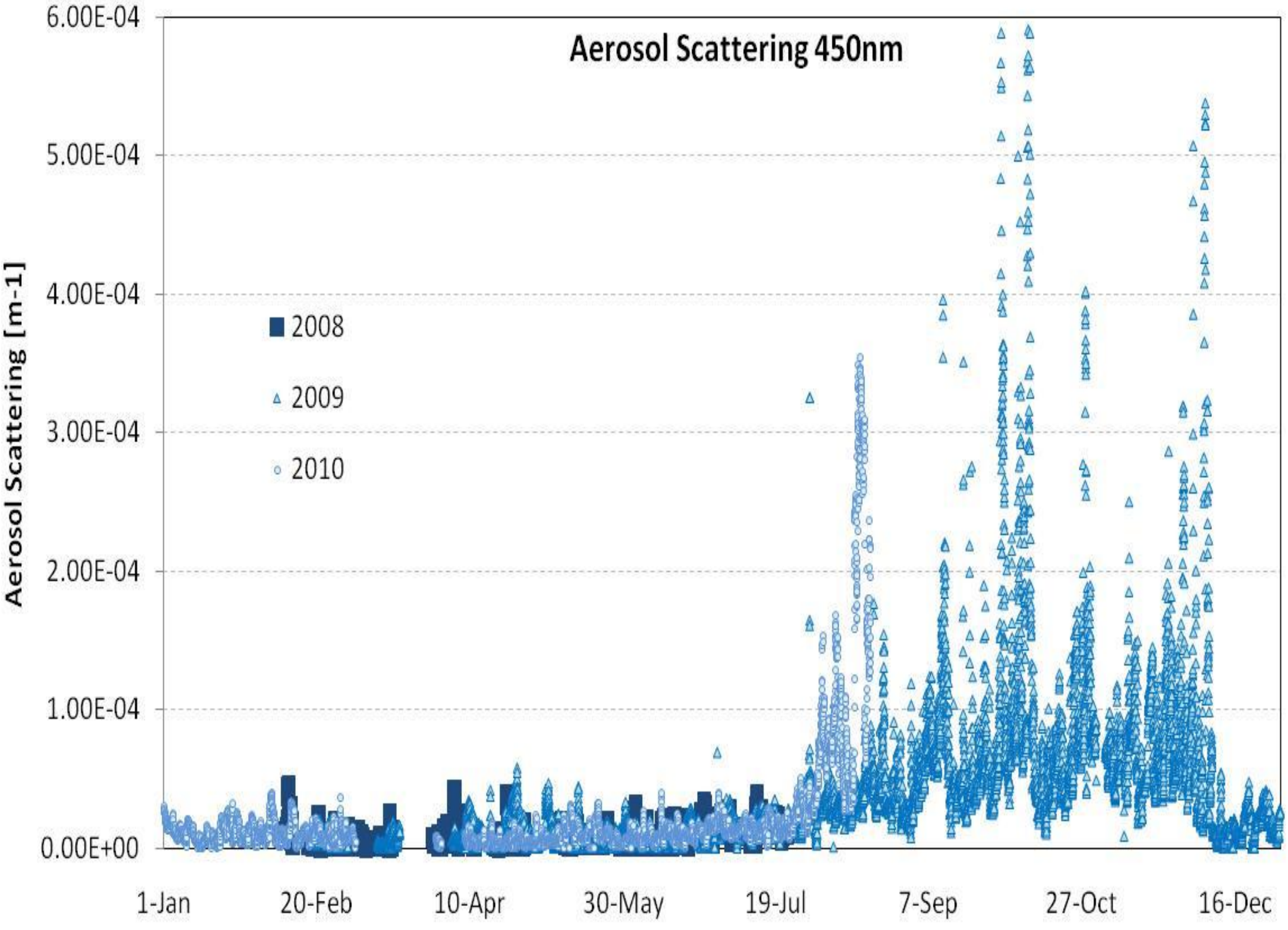
Al, Si and Ti elemental Concentration for fine and coarse mode aerosols Feb. to September



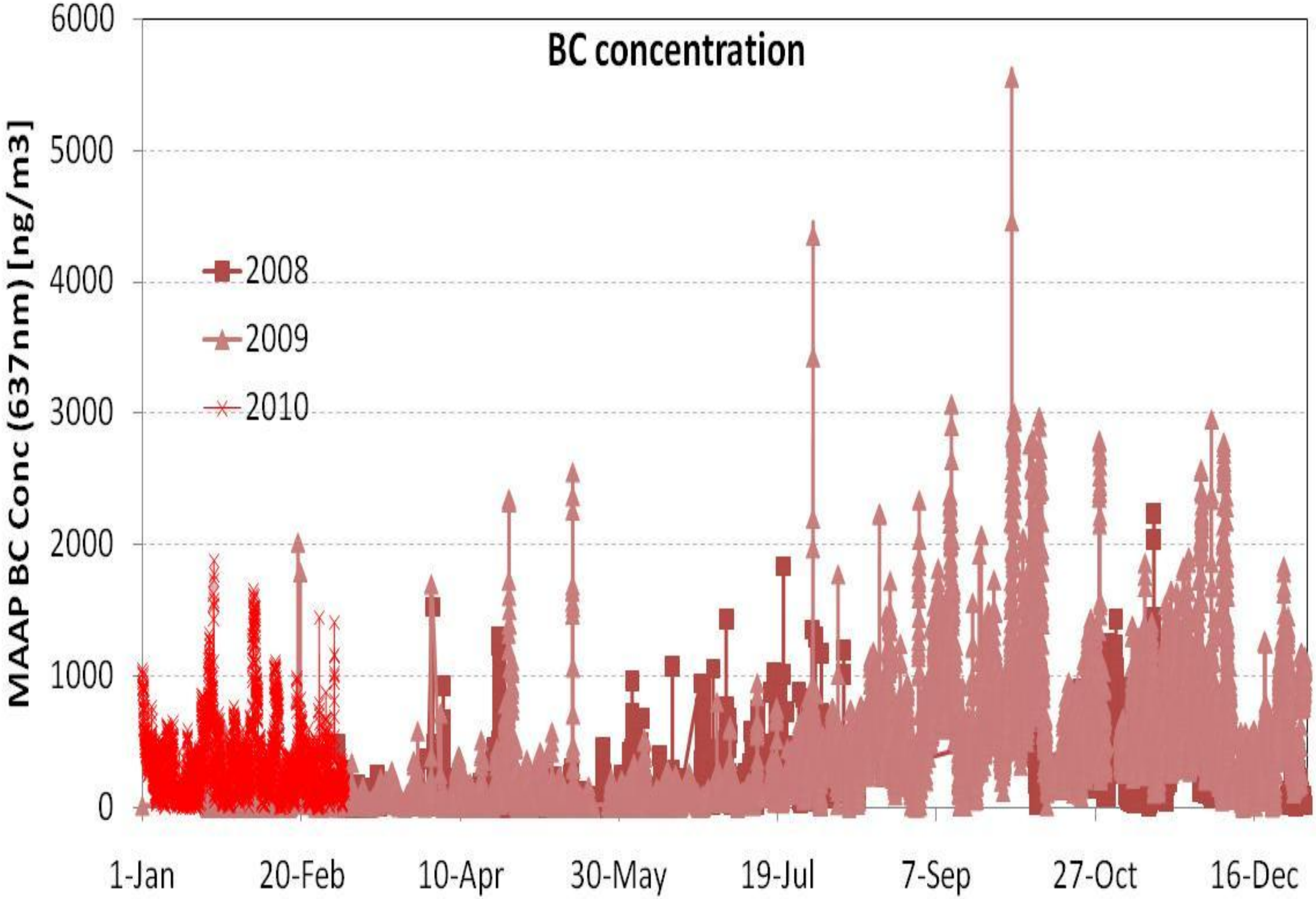


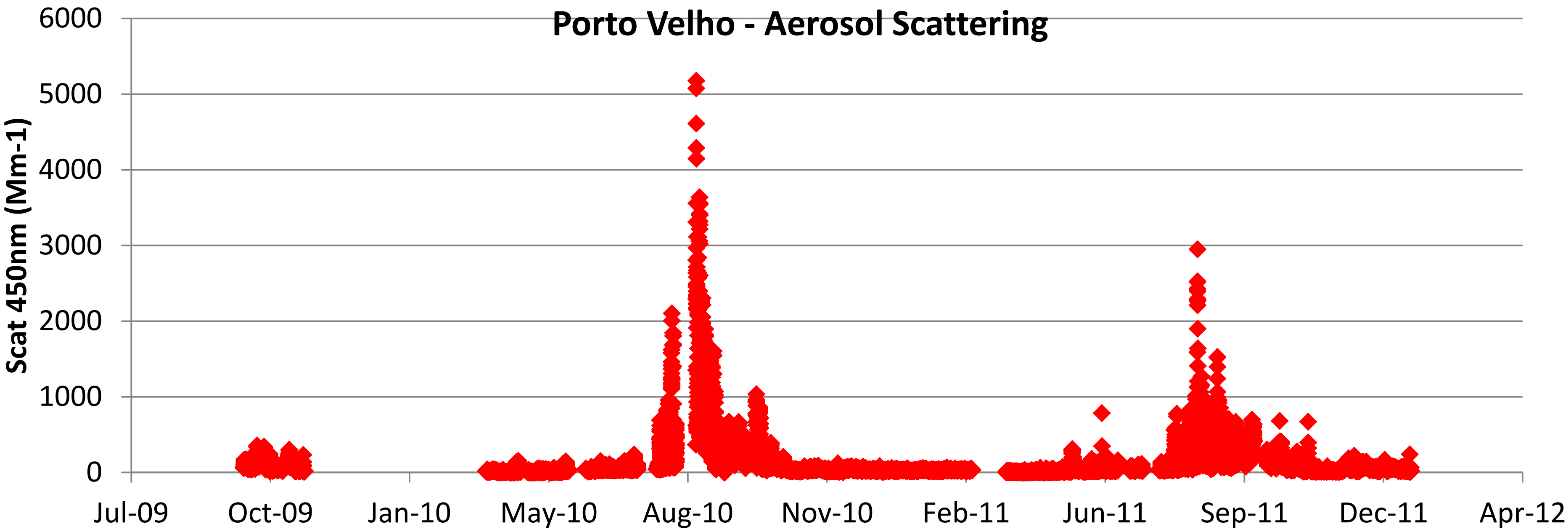


Manaus aerosol light scattering TSI Nephelometer 2008-2010

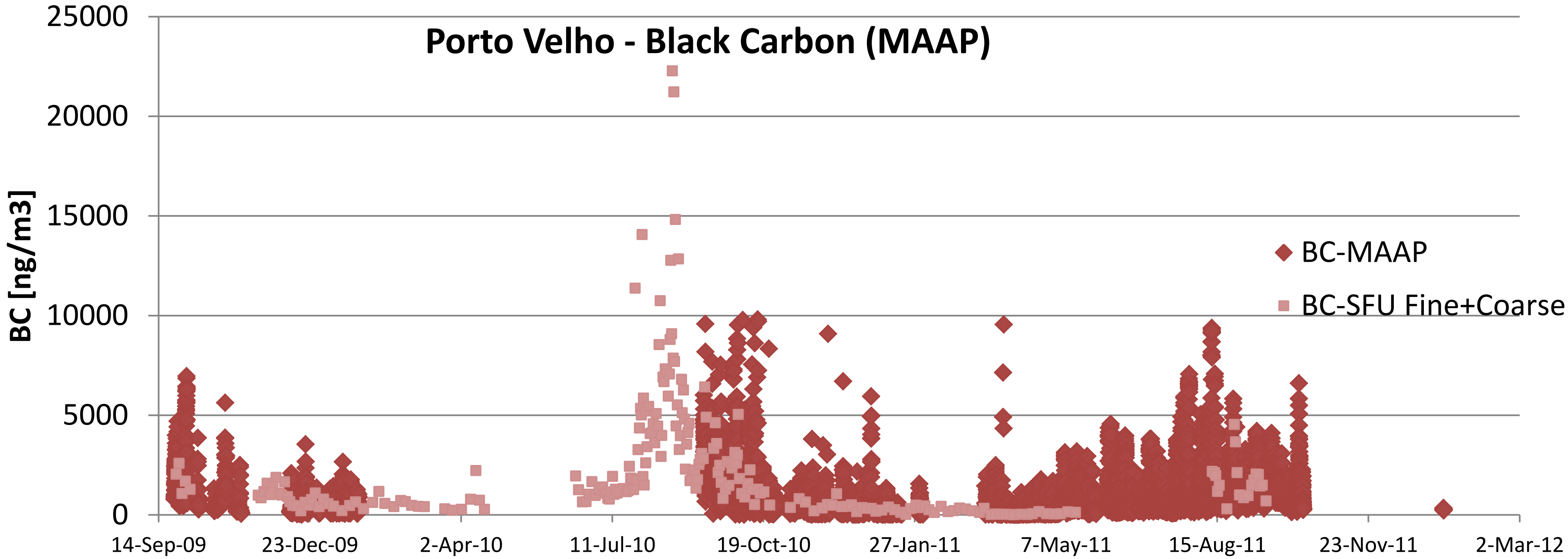


Manaus aerosol light absorption at 637 nm MAAP 2008-2010

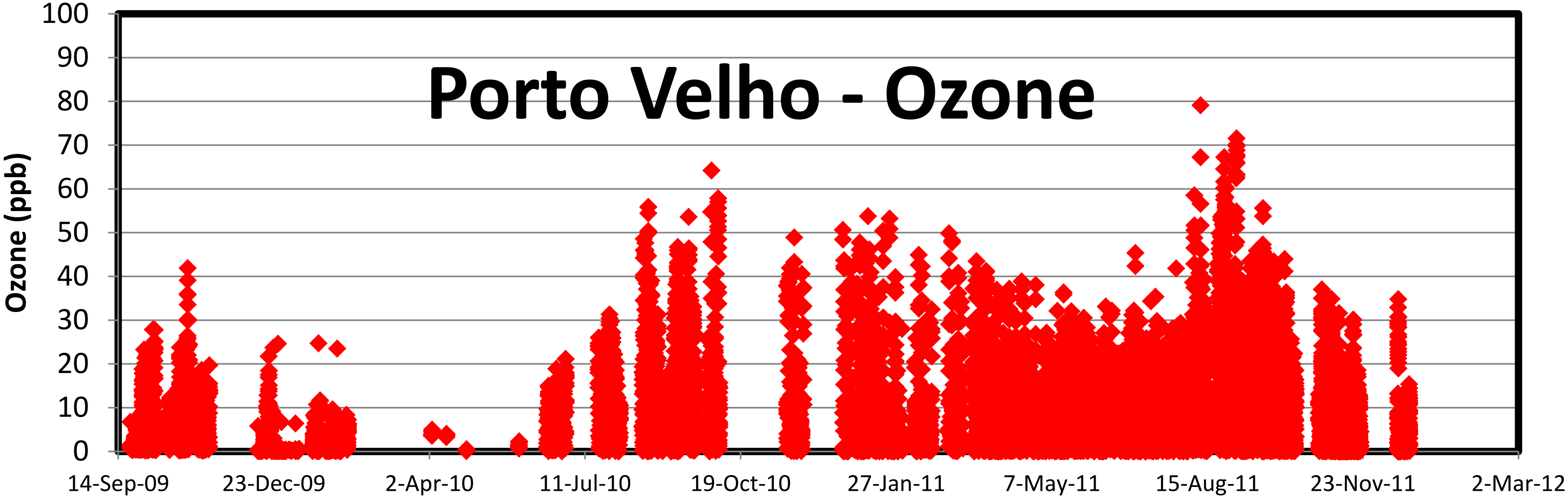




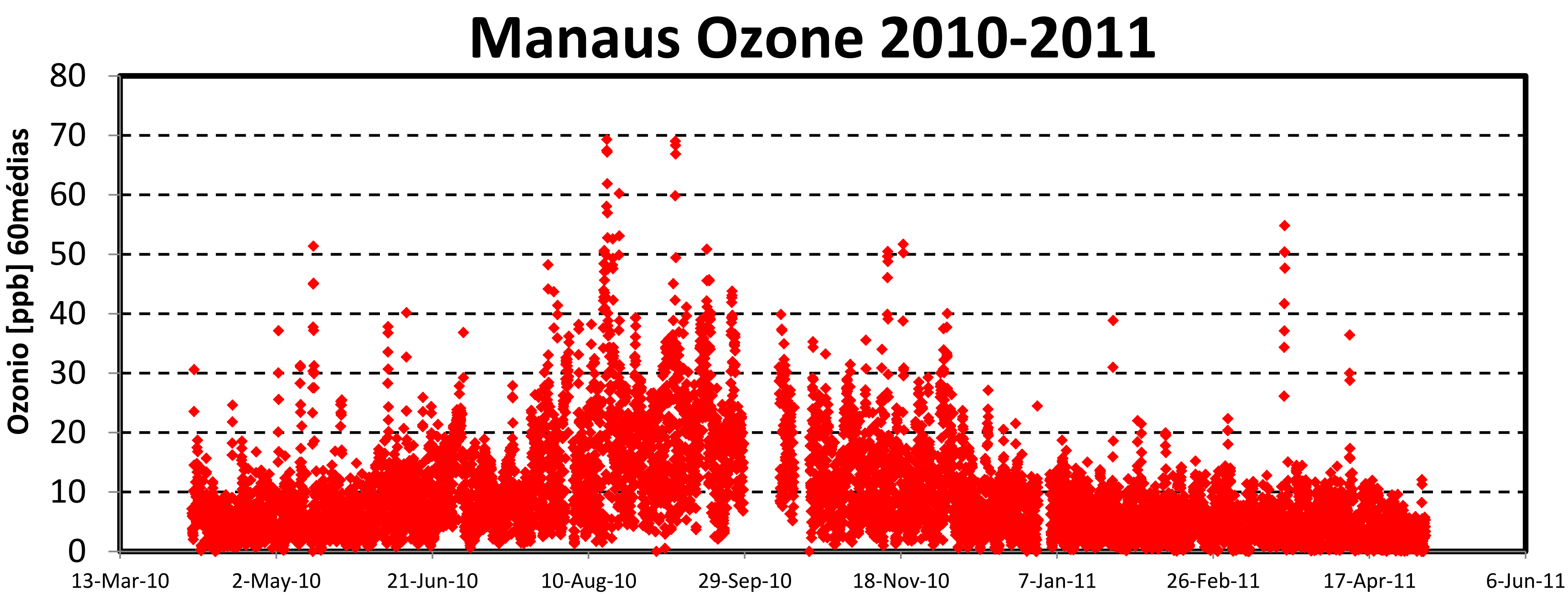
Porto Velho - Aerosol Scattering
Scat 450nm (Mm-1)
6000
5000
4000
3000
2000
1000
0
Jul-09
Oct-09
Jan-10
May-10
Aug-10
Nov-10
Feb-11
Jun-11
Sep-11
Dec-11
Apr-12



Porto Velho - Black Carbon (MAAP)
BC [ng/m3]
25000
20000
15000
10000
5000
0
14-Sep-09
23-Dec-09
2-Apr-10
11-Jul-10
19-Oct-10
27-Jan-11
7-May-11
15-Aug-11
23-Nov-11
2-Mar-12
BC-MAAP
BC-SFU Fine+Coarse



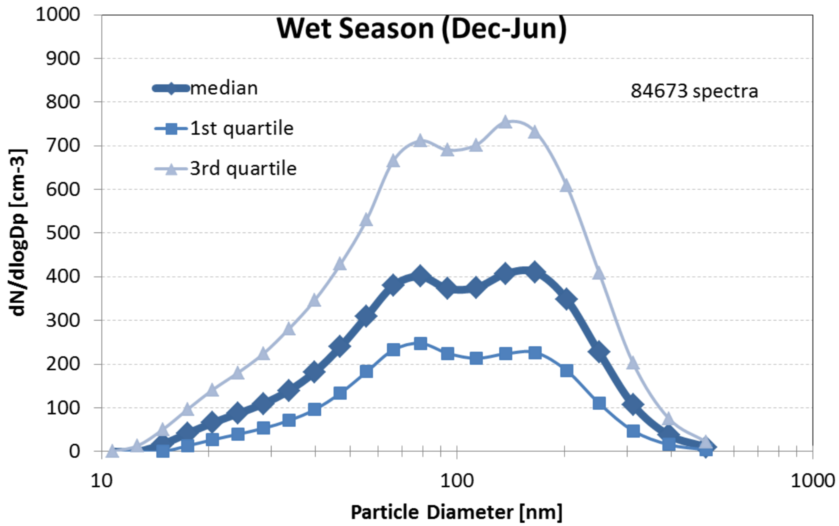
Porto Velho - Ozone
Ozone (ppb)
100
90
80
70
60
50
40
30
20
10
0
14-Sep-09
23-Dec-09
2-Apr-10
11-Jul-10
19-Oct-10
27-Jan-11
7-May-11
15-Aug-11
23-Nov-11
2-Mar-12



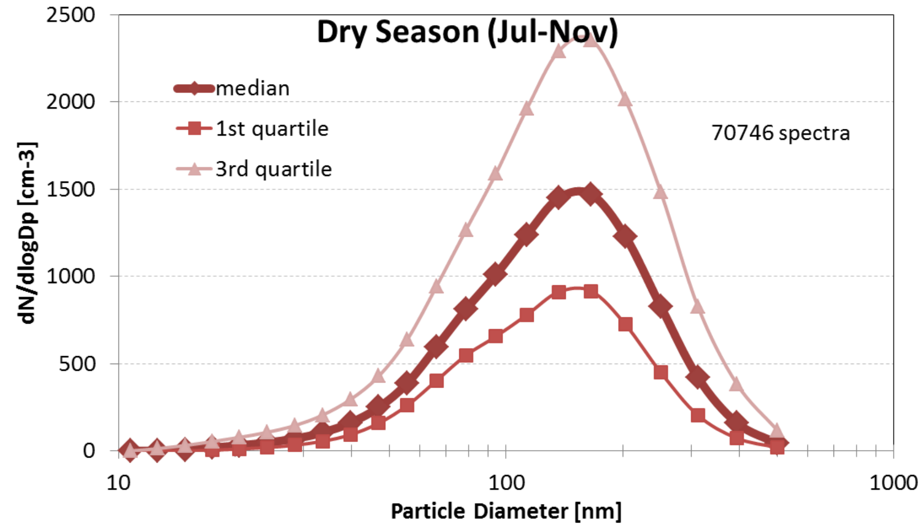
Manaus Ozone 2010-2011
Ozonio [ppb] 60médias
80
70
60
50
40
30
20
10
0
13-Mar-10
2-May-10
21-Jun-10
10-Aug-10
29-Sep-10
18-Nov-10
7-Jan-11
26-Feb-11
17-Apr-11
6-Jun-11

Amazonian aerosol size distributions 2008-2010

Wet season



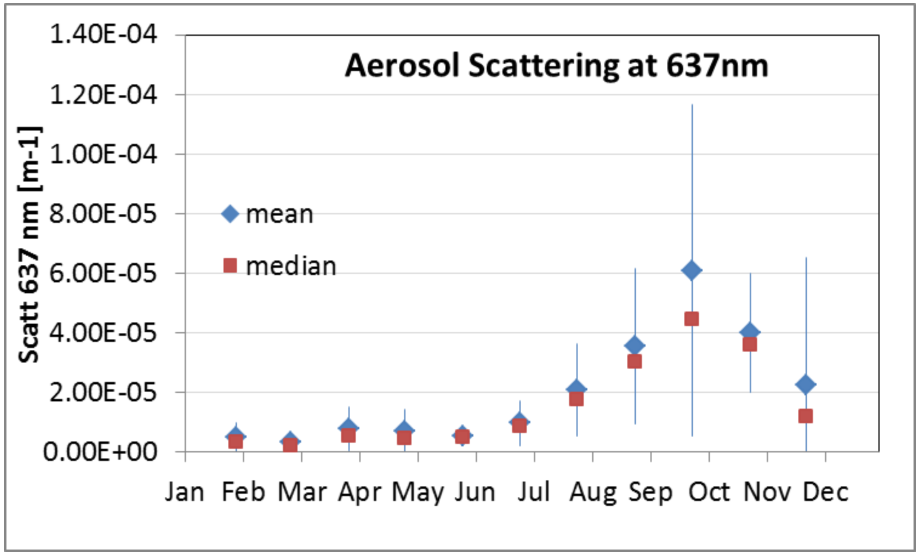
Dry season

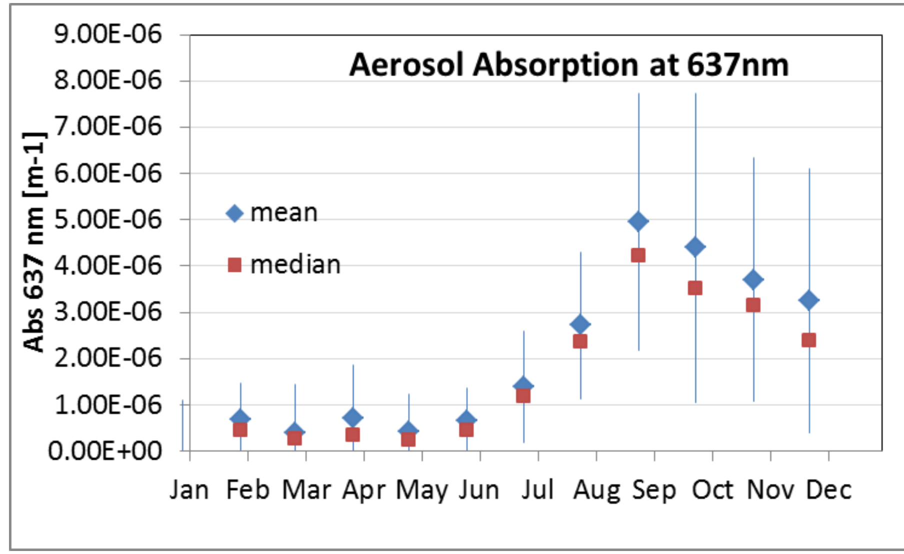


Fit Parameters for median size distributions:

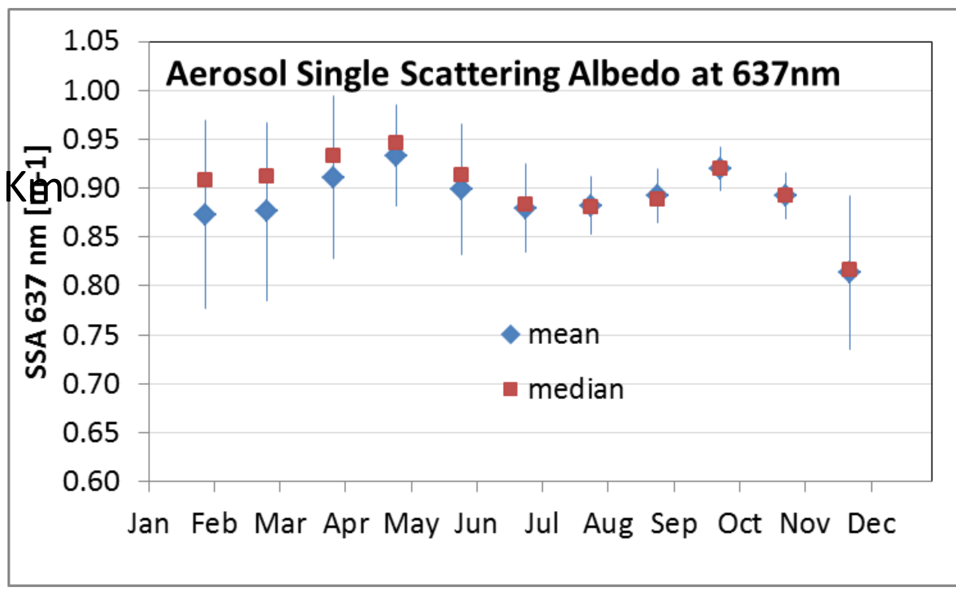
	Ultrafine mode			Aitken mode			Accumulation mode		
	N1 [cm-3]	Dpg1 [nm]	sg1	N2 [cm-3]	Dpg2 [nm]	sg2	N3 [cm-3]	Dpg3 [nm]	sg3
Wet season (Dec-Jun)	121	**34.9**	0.28	314	**71.0**	0.20	403	**163.5**	0.24
Dry season (Jul-Nov)				926	**117.3**	0.36	699	**175.9**	0.22

Monthly average optical properties





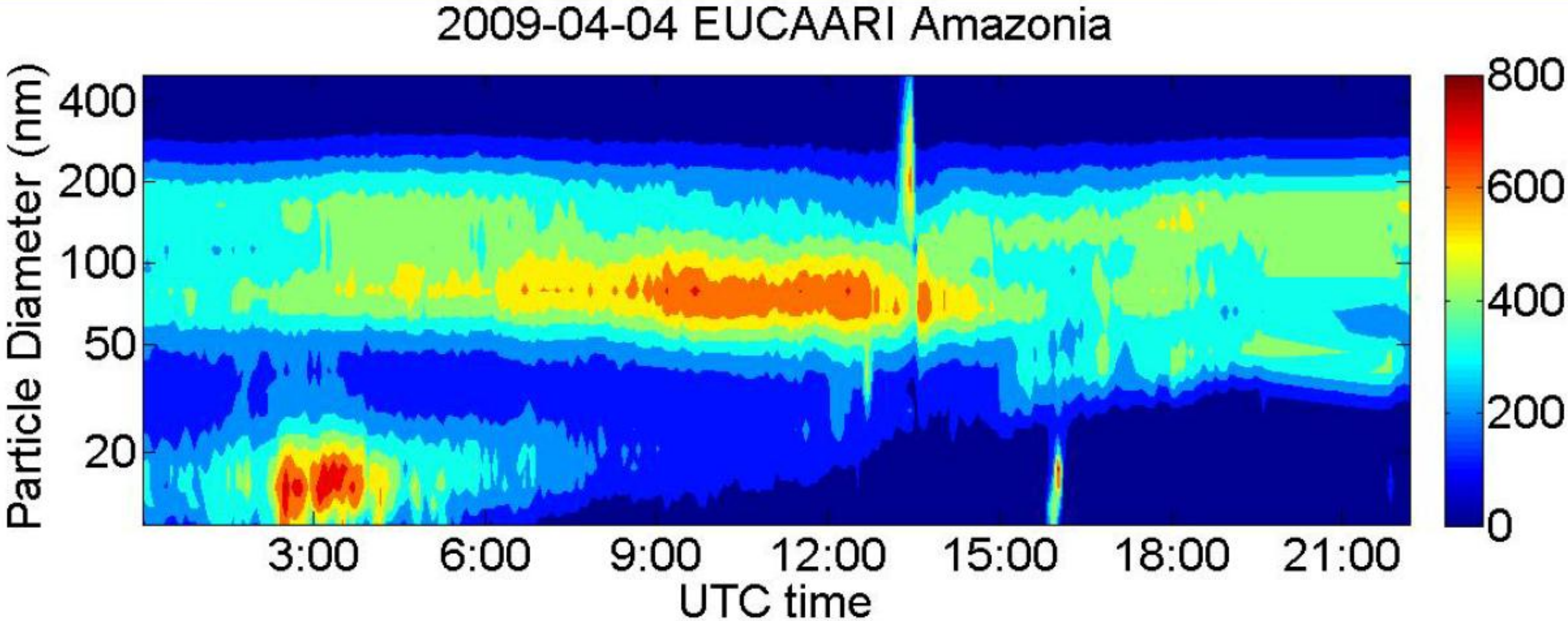
Single scattering albedo



Tambem:

Perfil vertical de aerossóis com Lidar até 15 Km
Vapor de água no perfil do Lidar
CCN continuamente
Cruzamento com medidas de CO, CO2, O3, VOCs contínuo
Etc...

New particle formation? Bursts of particles $10<D_p<40$ nm.

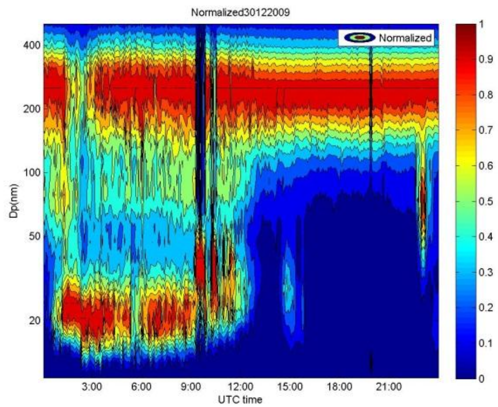


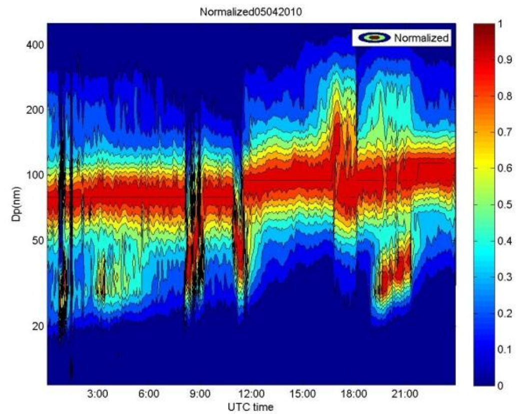
Aerosol size distributions measured in 2009 Apr 4th. There was a burst of ultrafine particles from 2:00 to 4:00 UTC time.

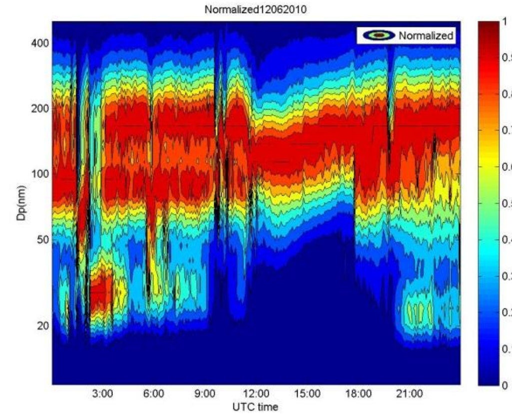
New particle formation and subsequent growth was seldom observed along two years of measurements. Nevertheless, in 70% of the days, bursts of particles with diameters in the range 10-40nm were detected. The events usually lasted from 20 to 120min, and the subsequent growth to larger sizes was not always clearly observed.

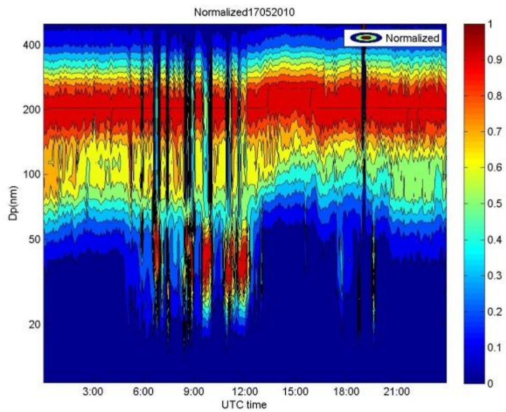
Particle production at about 20 nm

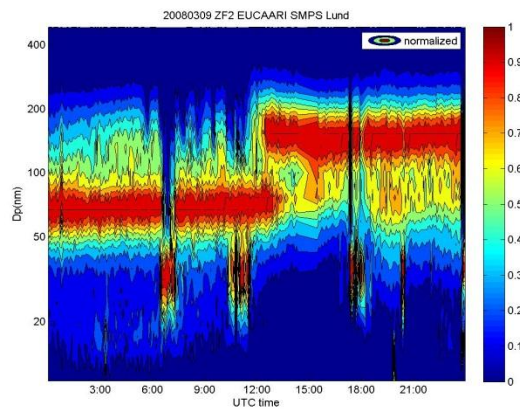
Which biological process is responsible for this new particle formation?

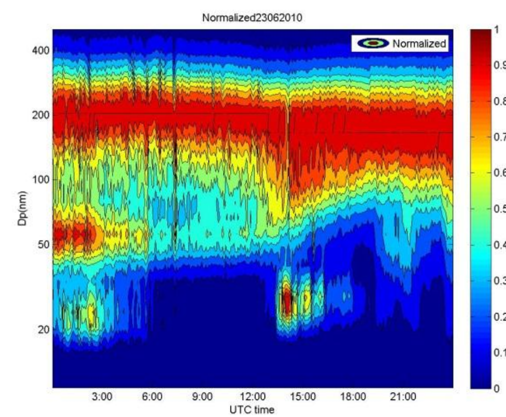


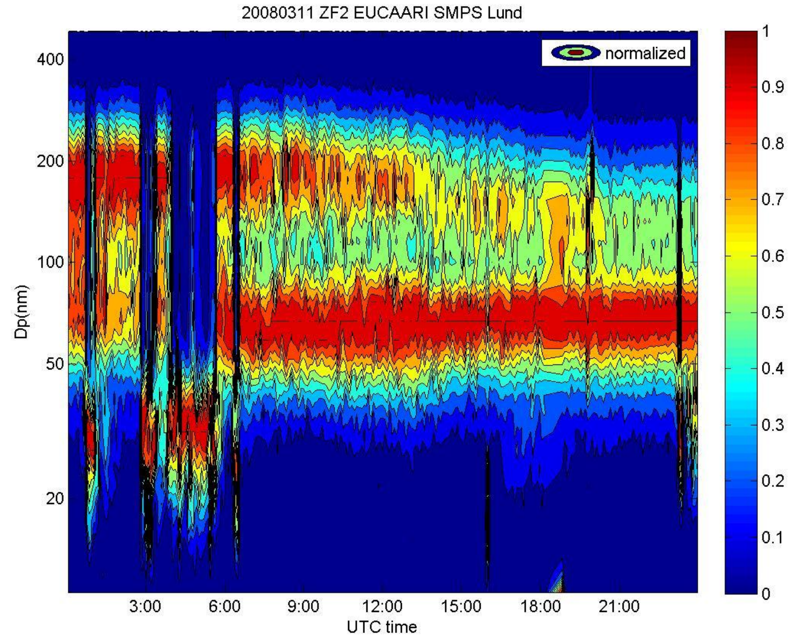


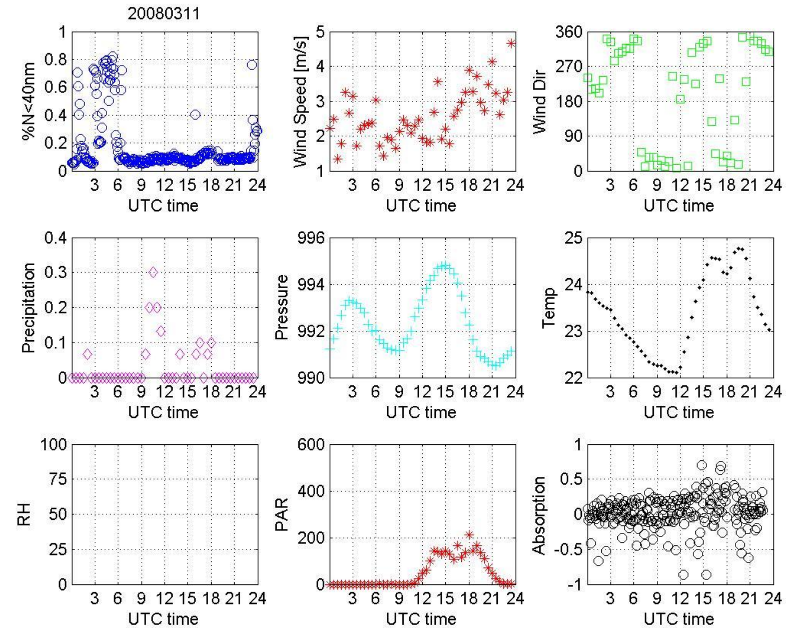


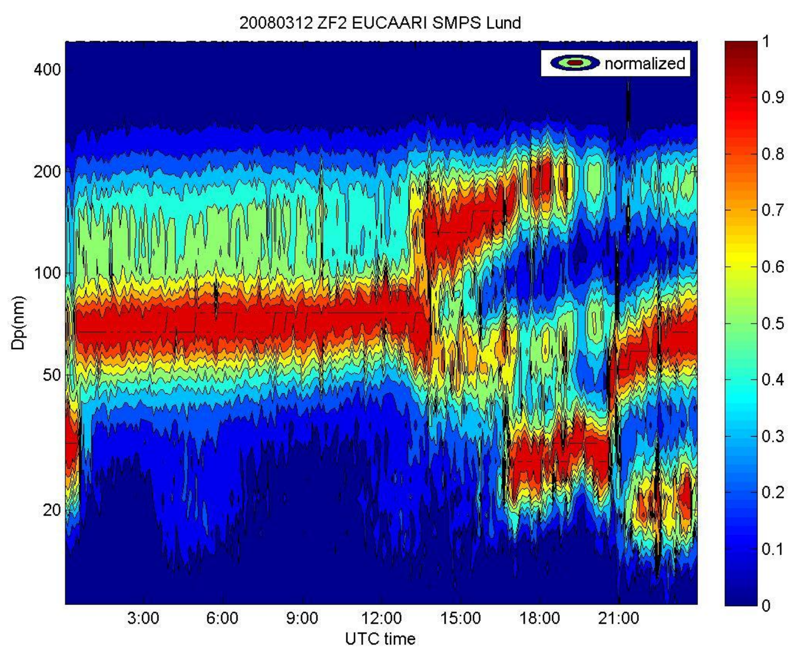


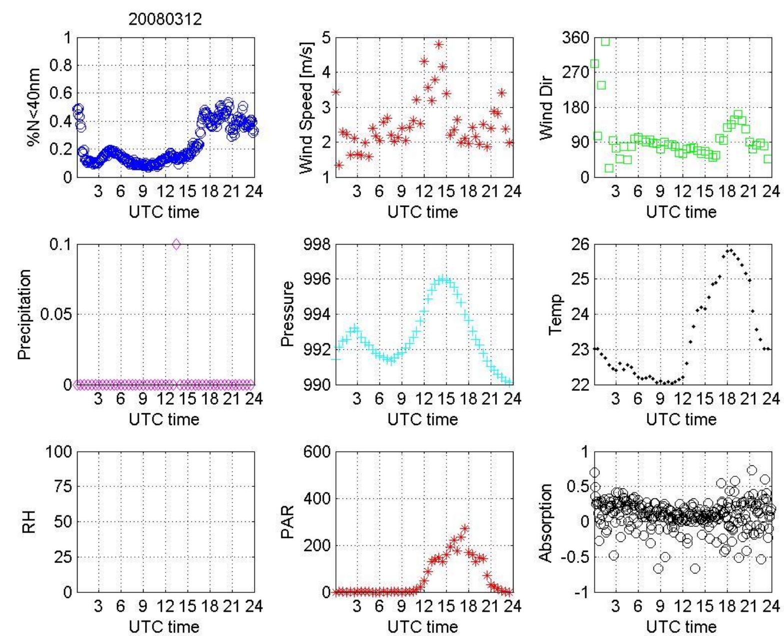




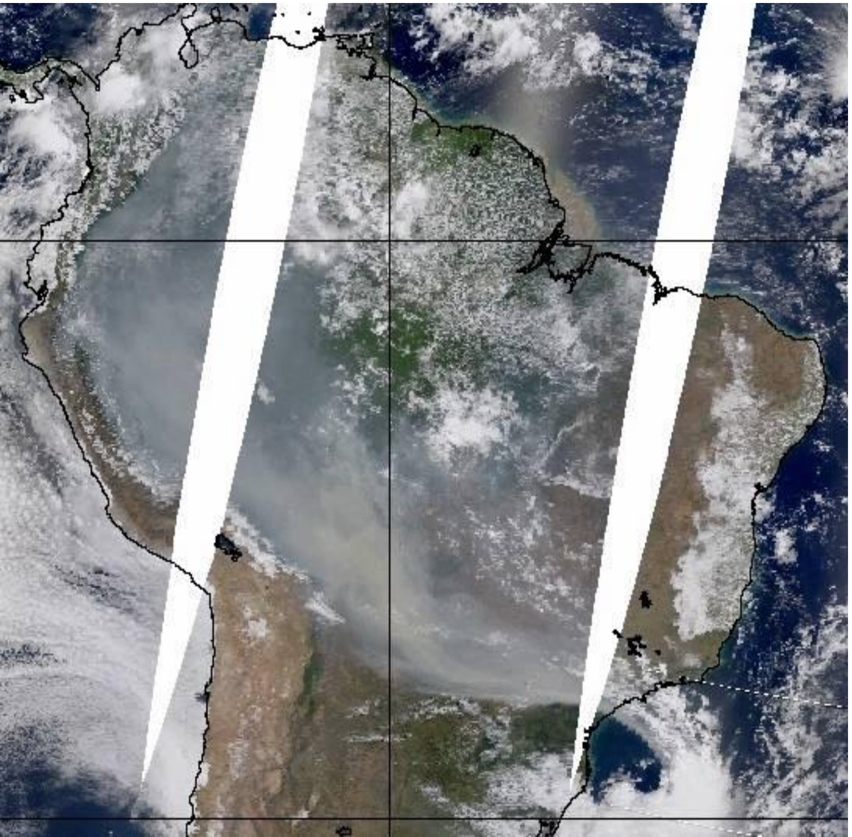

20080311 ZF2 EUCAARI SMPS Lund
normalized
Dp(nm)
UTC time

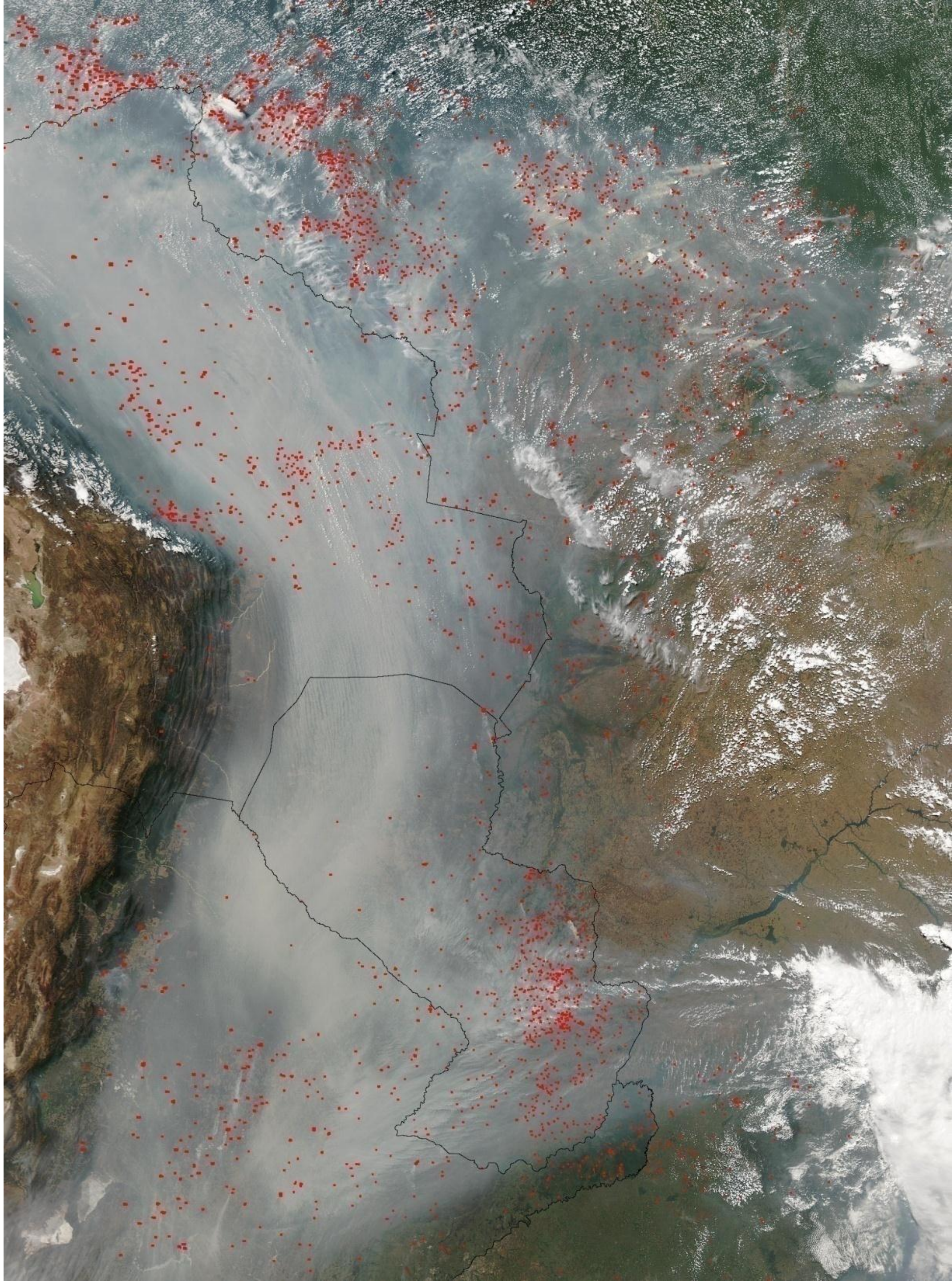

20080311
%N<40nm
Wind Speed [m/s]
Wind Dir
Precipitation
Pressure
Temp
RH
PAR
Absorption
UTC time


20080312 ZF2 EUCAARI SMPS Lund
normalized
Dp(nm)
UTC time


20080312
%N<40nm
Wind Speed [m/s]
Wind Dir
Precipitation
Pressure
Temp
RH
PAR
Absorption
UTC time

Large scale distribution of biomass burning aerosols in South America



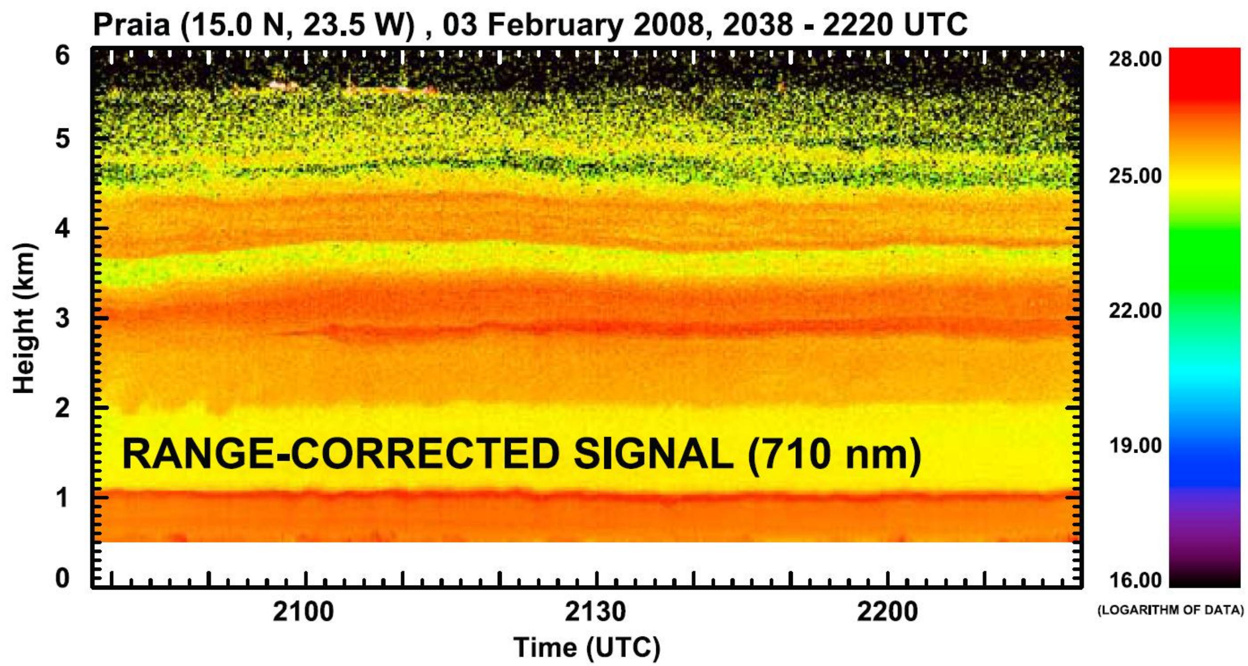


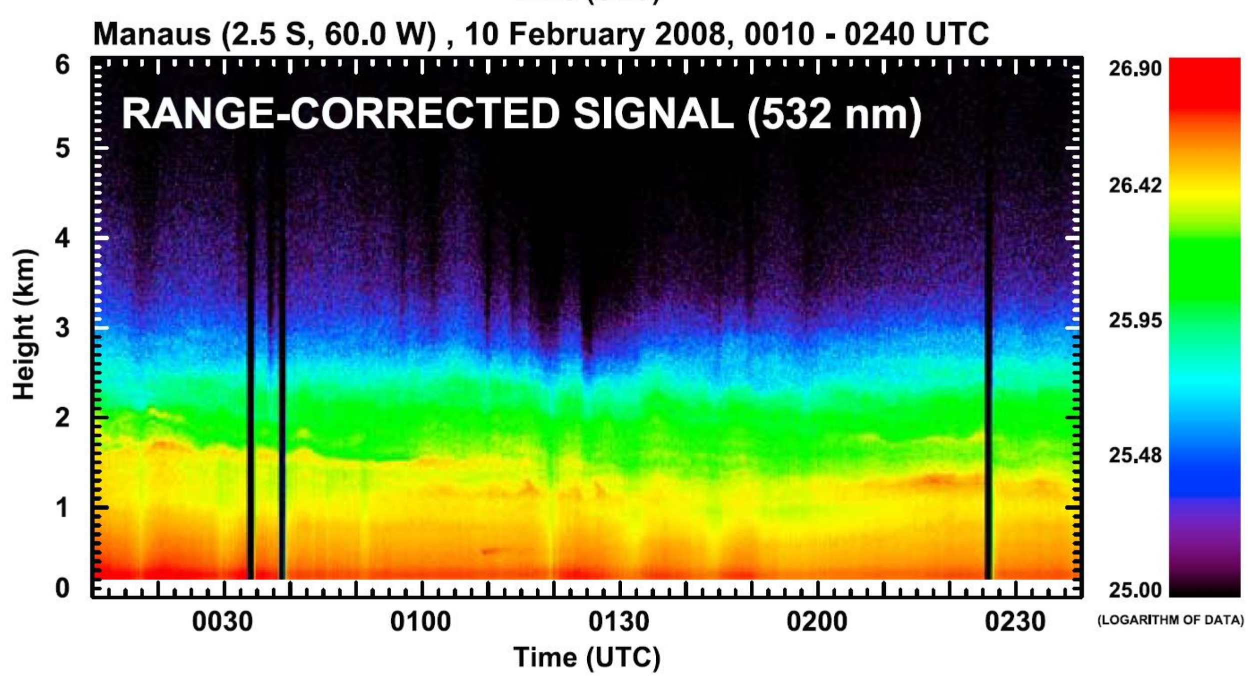
Raman Lidar observations of aerosols on Cape Verde and Manaus

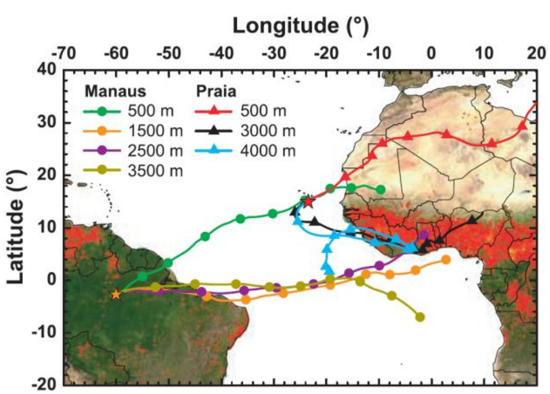
Range-corrected lidar signals

Complex vertical layering of dust and smoke up to 5.5 km height was observed over Praia, Cape Verde, on 3 February 2008. (top).

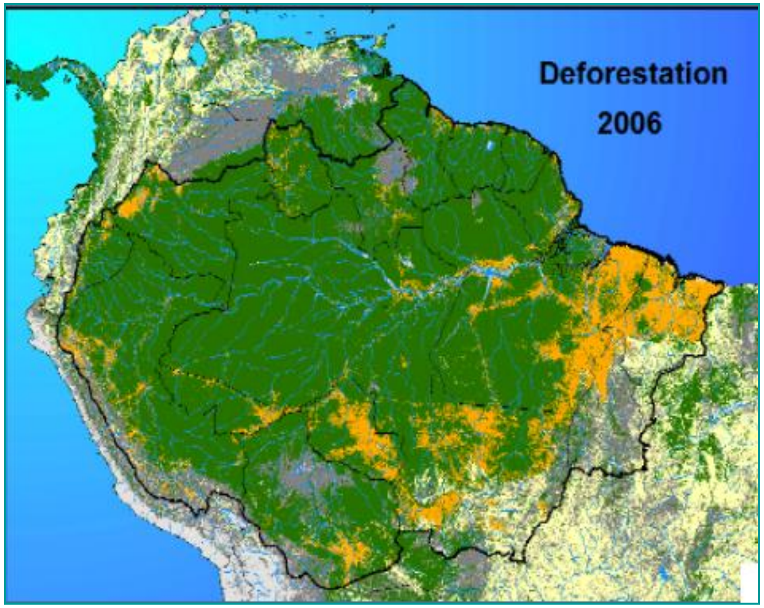
An homogeneous layer was observed in Manaus Feb. 10. (bottom)





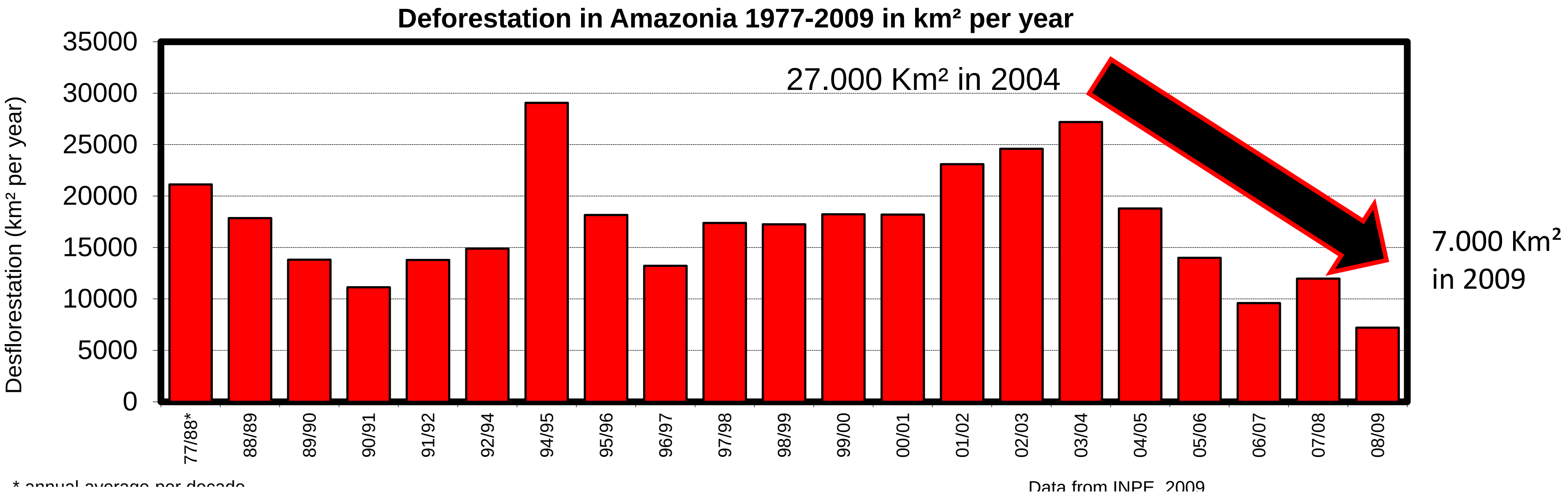


Ansmann et *al., GRL 2009*



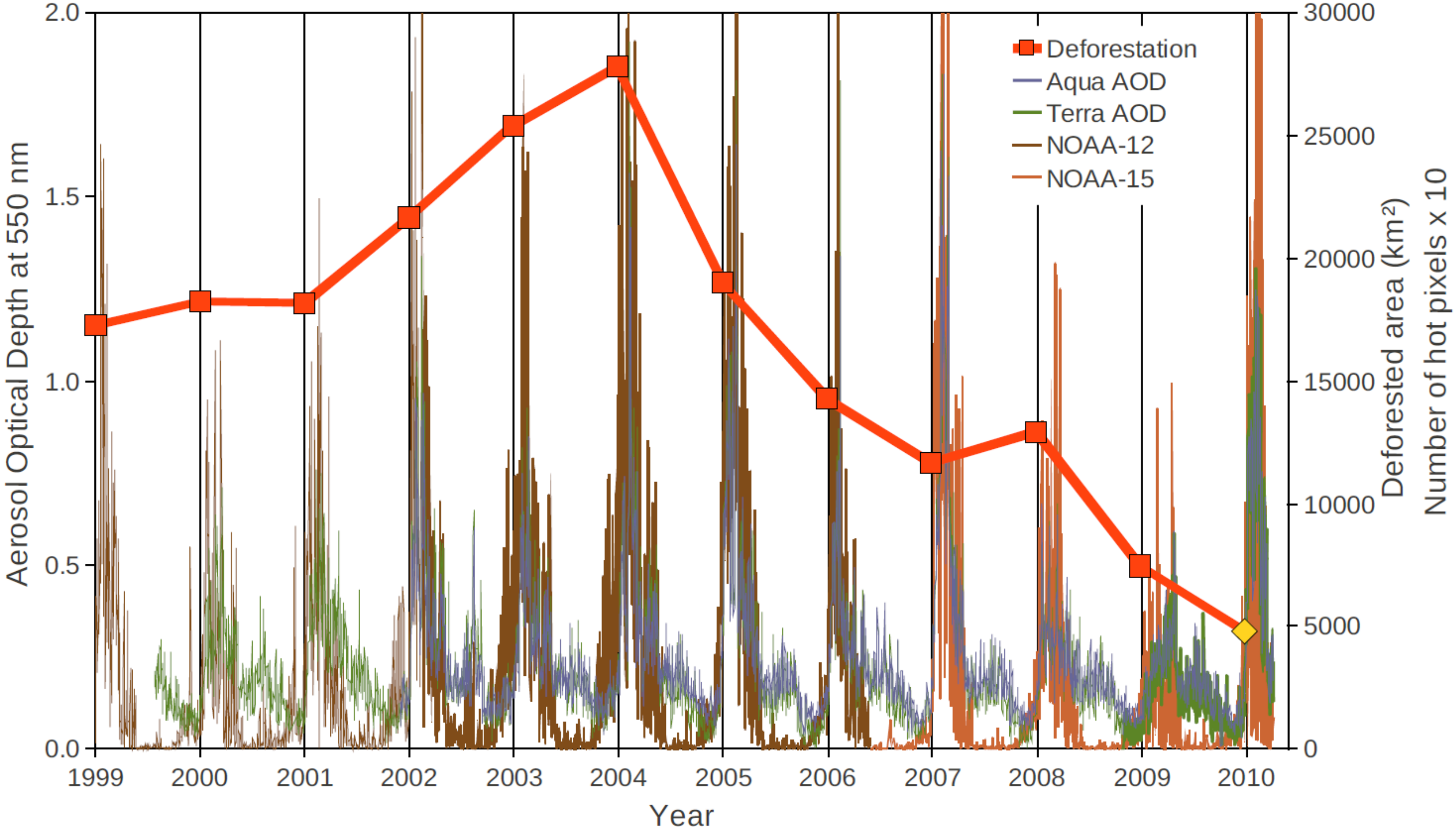
Deforestation was reduced from 27,000 Km² in 2004 to 7,000 Km² in 2009.

How much aerosols were reduced?



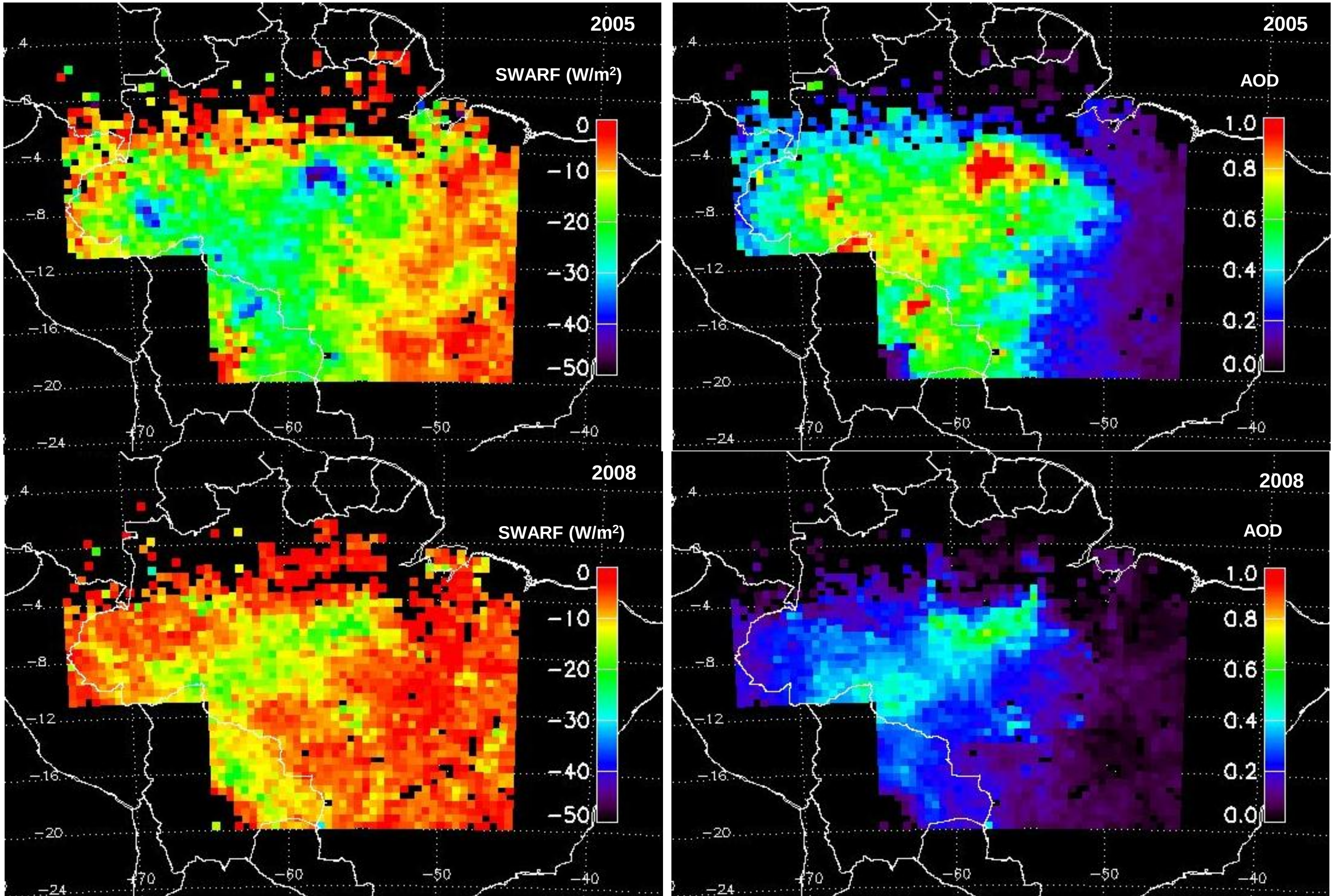
What public policies are needed to sustain this reduction?

Yearly deforestation with MODIS AOD and hot pixels from NOAA



Yearly deforestation over the Brazilian Amazon region (INPE, 2010) compared to MODIS daily smoke optical depth and the daily number of hot pixels from NOAA-12 and NOAA-15.

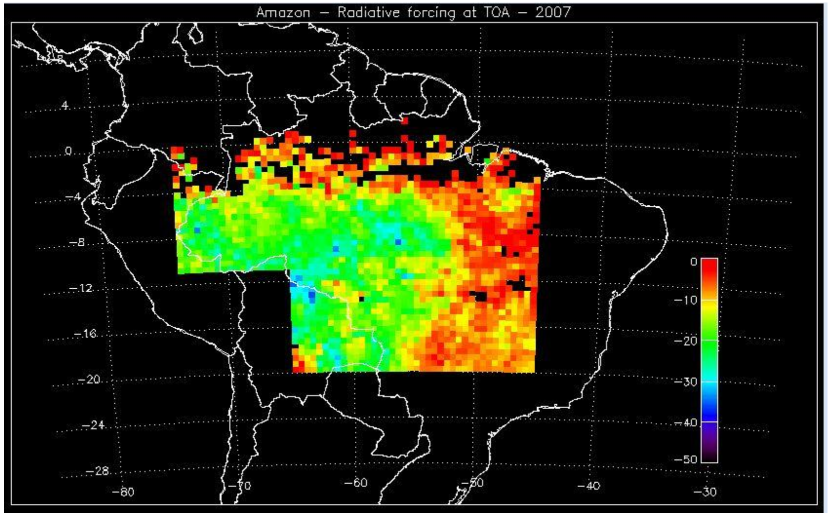
Examples of the spatial distribution of the SWARF at TOA

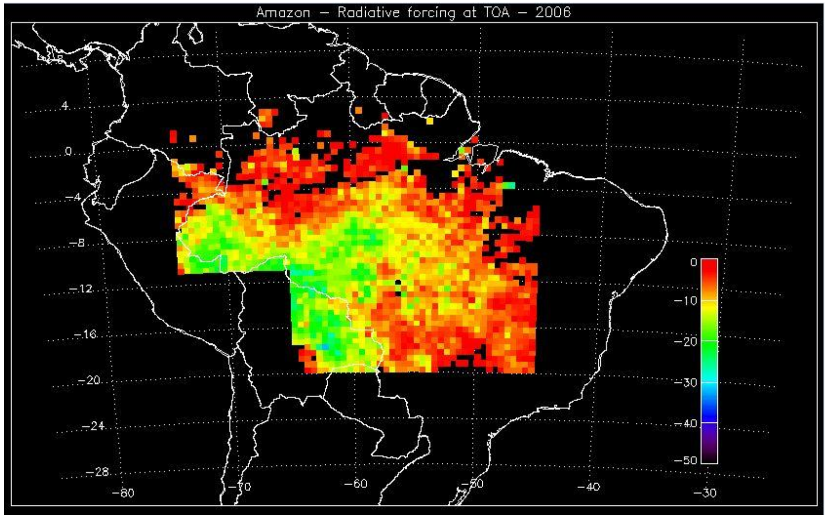


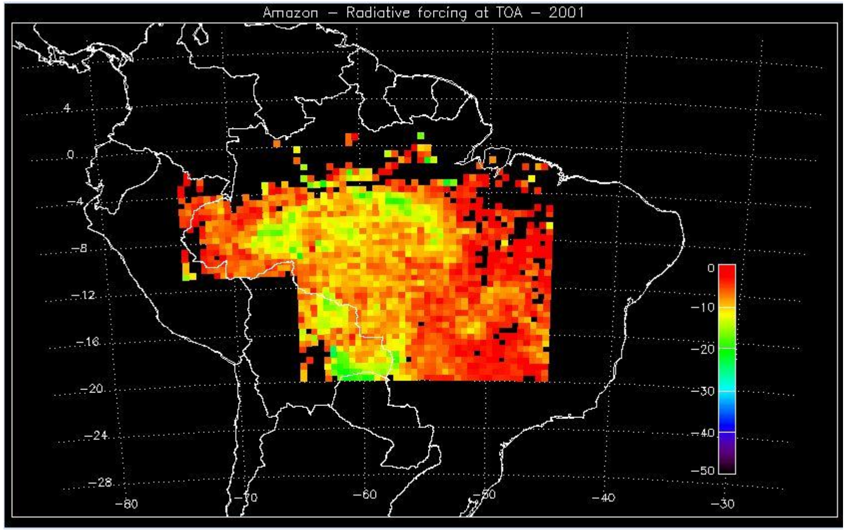
The higher the AOD the higher is the correlation between SWARF and AOD. For lower AOD values the influence of other parameters such as the surface reflectance also become important.

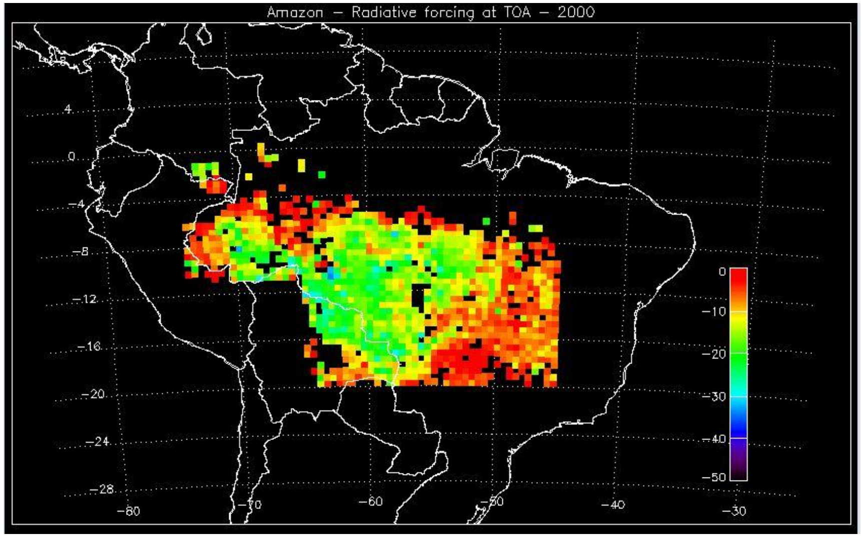
Large scale radiative forcing in Amazonia from 2000 to 2007

CERES ***(Clouds and the Earth's Radiant Energy System) and MODIS***







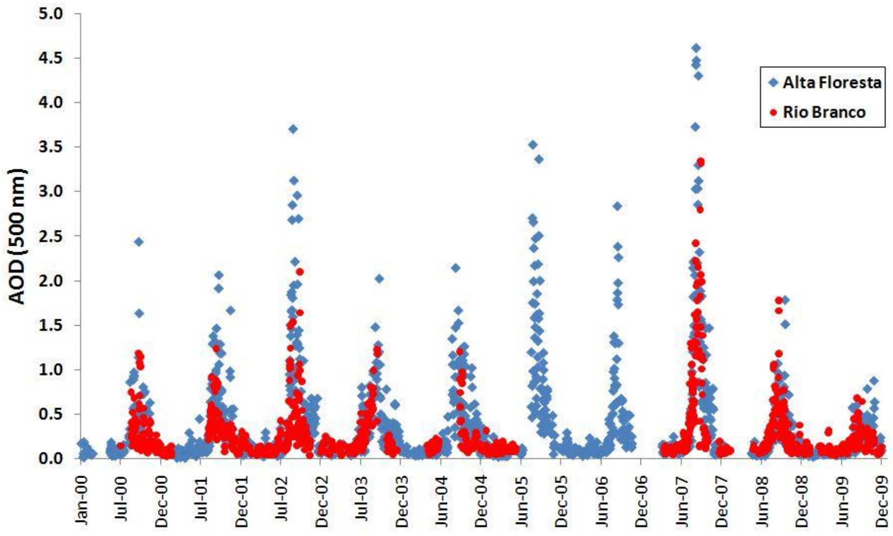


Elisa Thomé Sena, PhD Student IFUSP

Amazon shortwave aerosol radiative forcing (SWARF) at the top of the atmosphere (TOA) from 2000 to 2009 using shortwave (SW) flux at the TOA from the CERES sensor and AOD from MODIS.

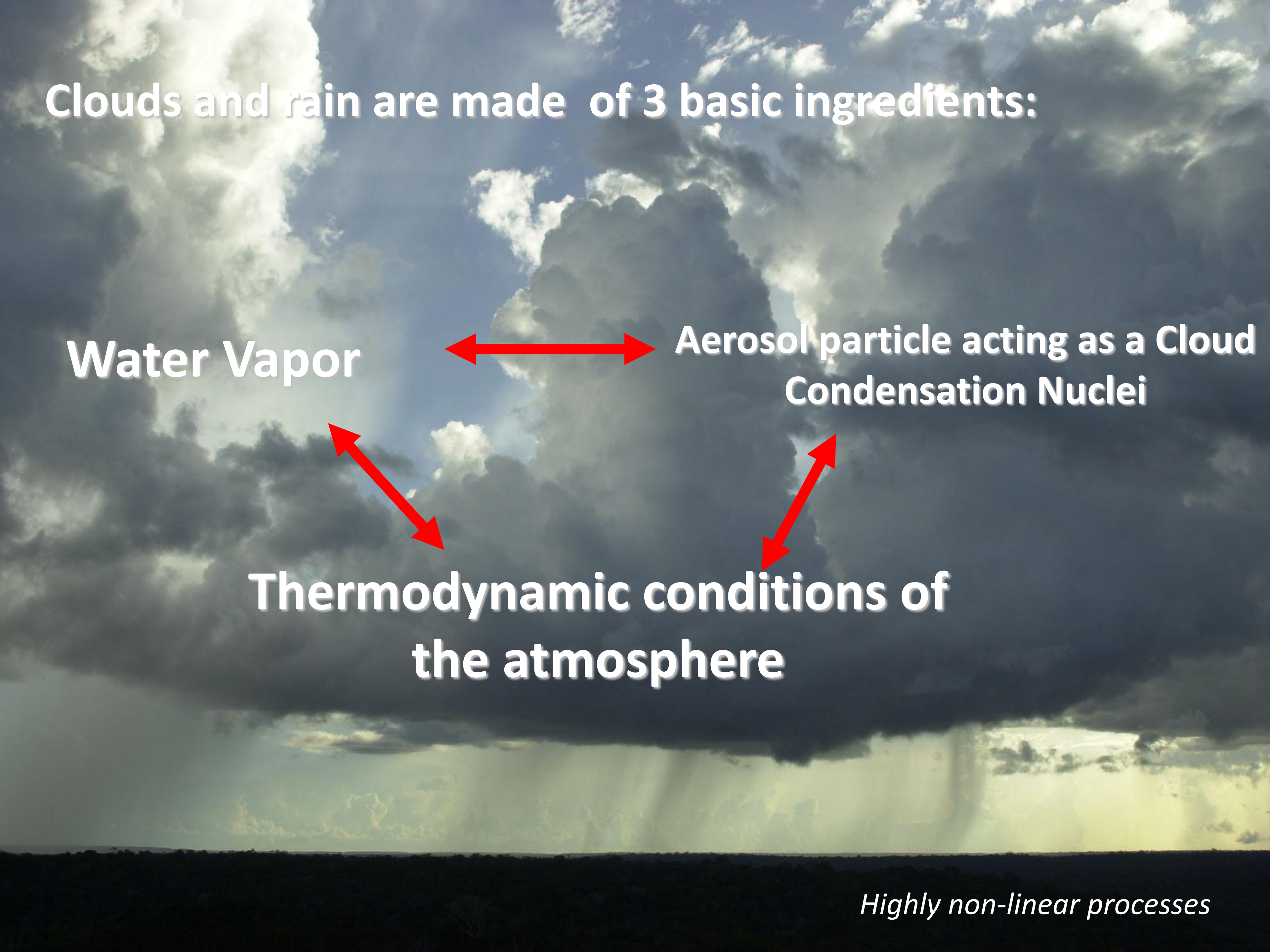
***Table 1** – Shortwave aerosol radiative forcing for Amazon region during the biomass burning season of the years 2000 to 2009.*

Year	Valid Cells	SWARF (W/m²)
2000	1163	-12.3 ± 12.5
2001	1492	-8.1 ± 13.3
2002	1447	-12.8 ± 11.8
2003	1392	-12.0 ± 12.5
2004	185	-13.4 ± 17.6
2005	1799	-15.0 ± 13.4
2006	1654	-9.5 ± 12.9
2007	1731	-13.9 ± 17.1
2008	1665	-8.2 ± 15.9
2009	1405	-4.7 ± 11.0
Average		**-10.6 ± 4.2**



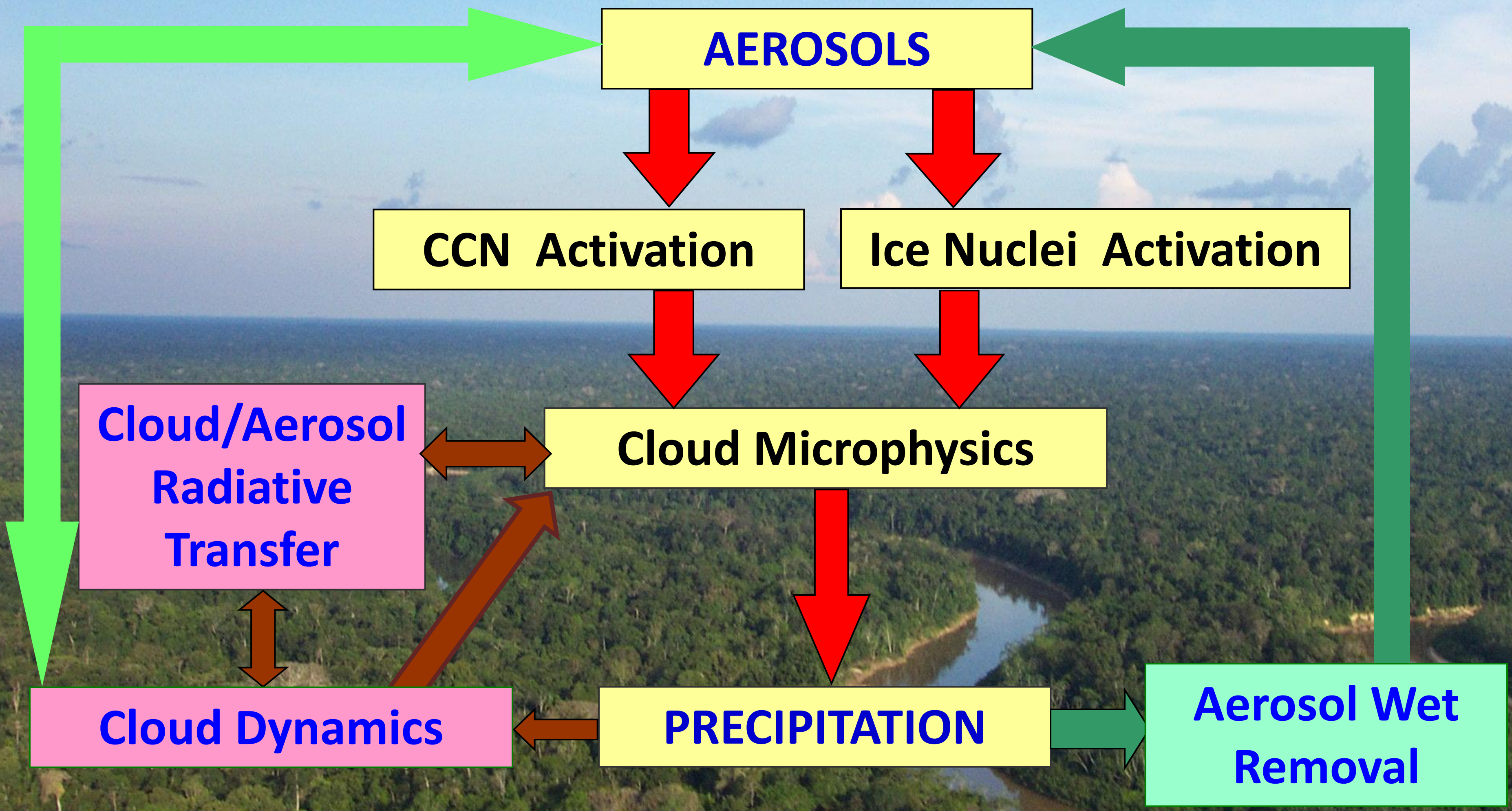
AERONET time series of the aerosol optical depth at 500 nm from 2000 to 2009 over two Amazon sites: Alta Floresta and Rio Branco.

Elisa Thomé Sena, PhD Student IFUSP


Clouds and rain are made of 3 basic ingredients:
Water Vapor
Aerosol particle acting as a Cloud Condensation Nuclei
Thermodynamic conditions of the atmosphere
Highly non-linear processes

Aerosol-cloud-precipitation feedbacks

CCN = cloud condensation nuclei and IN = ice nuclei.



Aerosol-clouds interactions and aerosol radiative forcing

- Optical, physical properties and chemical composition of biomass burning aerosols
- Properties of natural biogenic aerosols
- Cloud Condensation Nuclei (CCN) properties
- Long term measurements of ground, vertical distribution and column integrated optical properties
- Clouds physical properties and distribution coupled with cloud droplets microphysical properties.

nature geoscience

LETTERS

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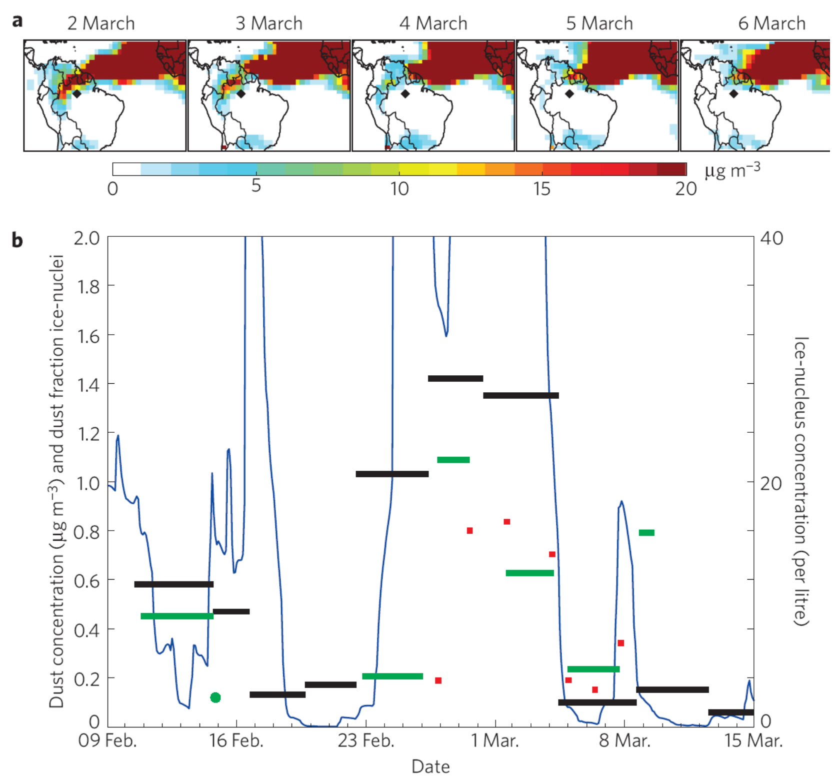
Relative roles of biogenic emissions and Saharan dust as ice nuclei in the Amazon basin

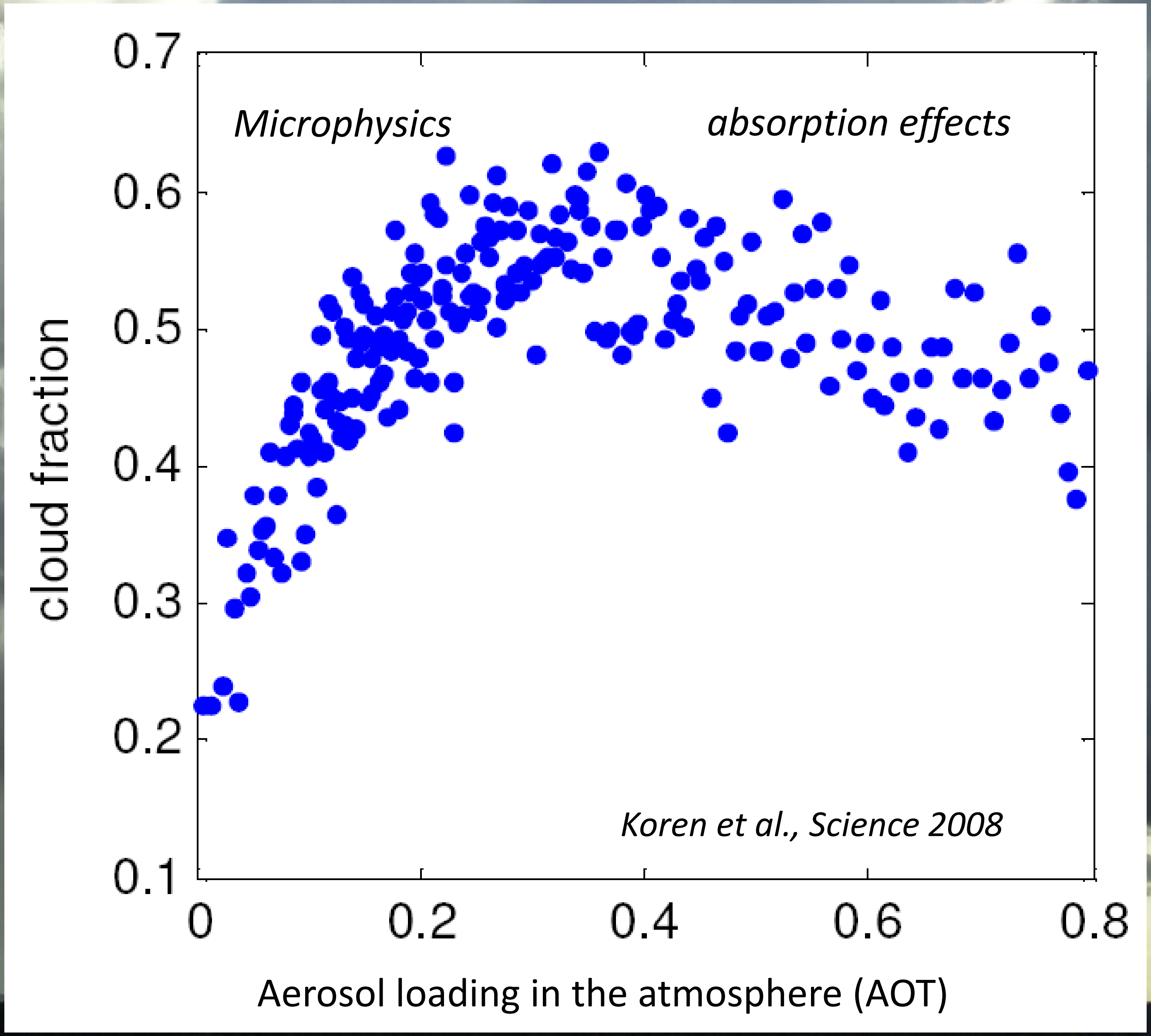
Anthony J. Prenni[1]*, Markus D. Petters[1], Sonia M. Kreidenweis[1], Colette L. Heald[1], Scot T. Martin[2], Paulo Artaxo[3], Rebecca M. Garland[4], Adam G. Wollny[4] and Ulrich Pöschl[4]

Ice nuclei from biogenic emissions and Sahara dust in Central Amazonia

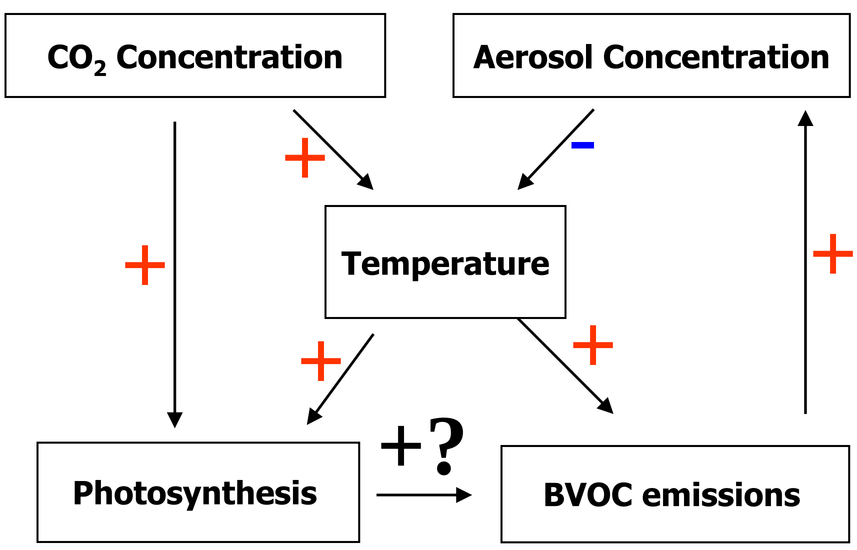


Dust relation to ice-nucleus measurements. Dust concentrations during AMAZE-08. a, GEOS-Chem simulated dust from 2–6 March at 18 UTC. The field site, shown as a black diamond, typically fell near the edge of the plumes. Fine-dust concentrations from PIXE measurements (black rectangles; μg/m³, dp<2μm.

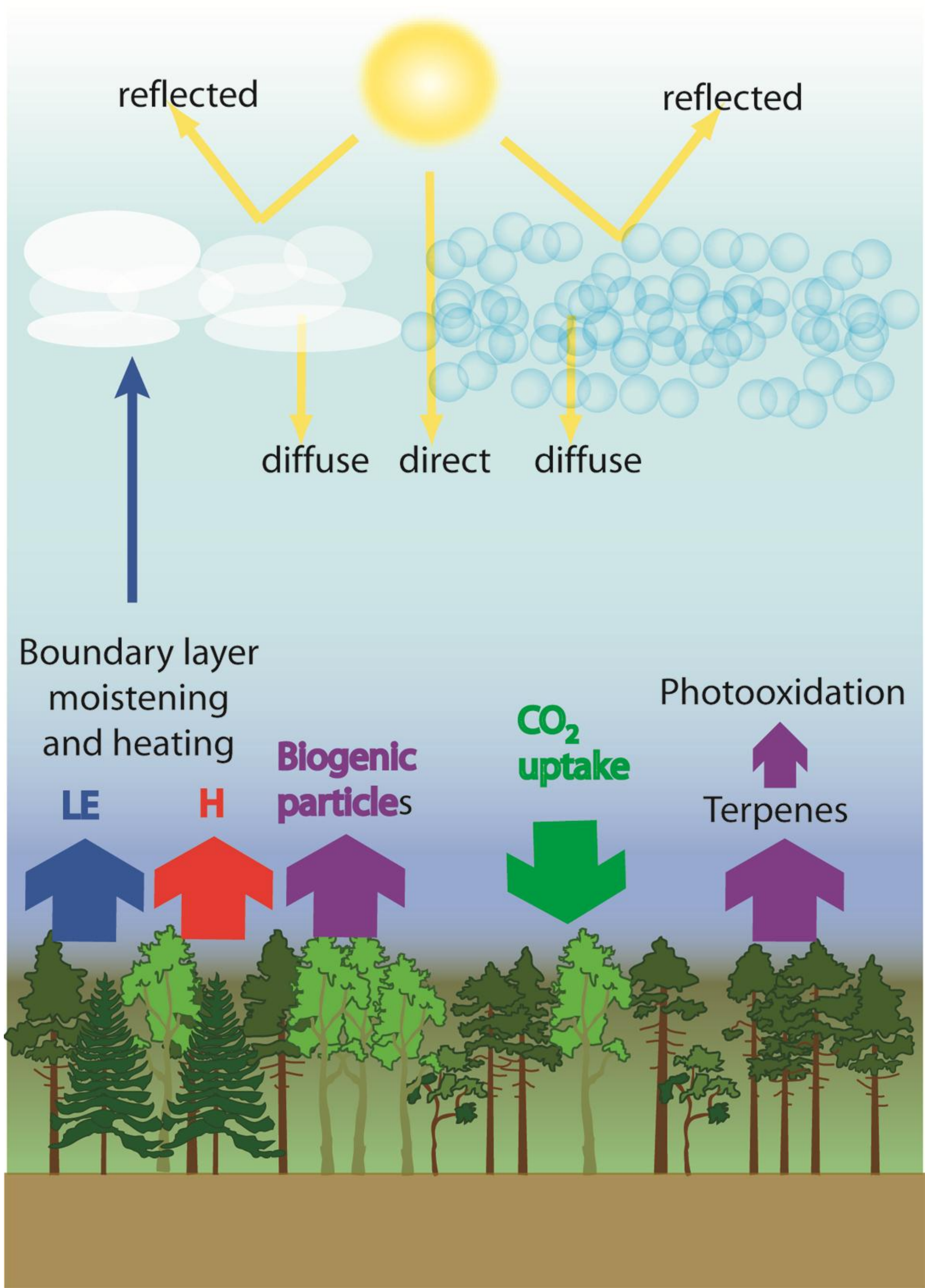
Relationships between cloud properties and aerosol loading in Amazonia



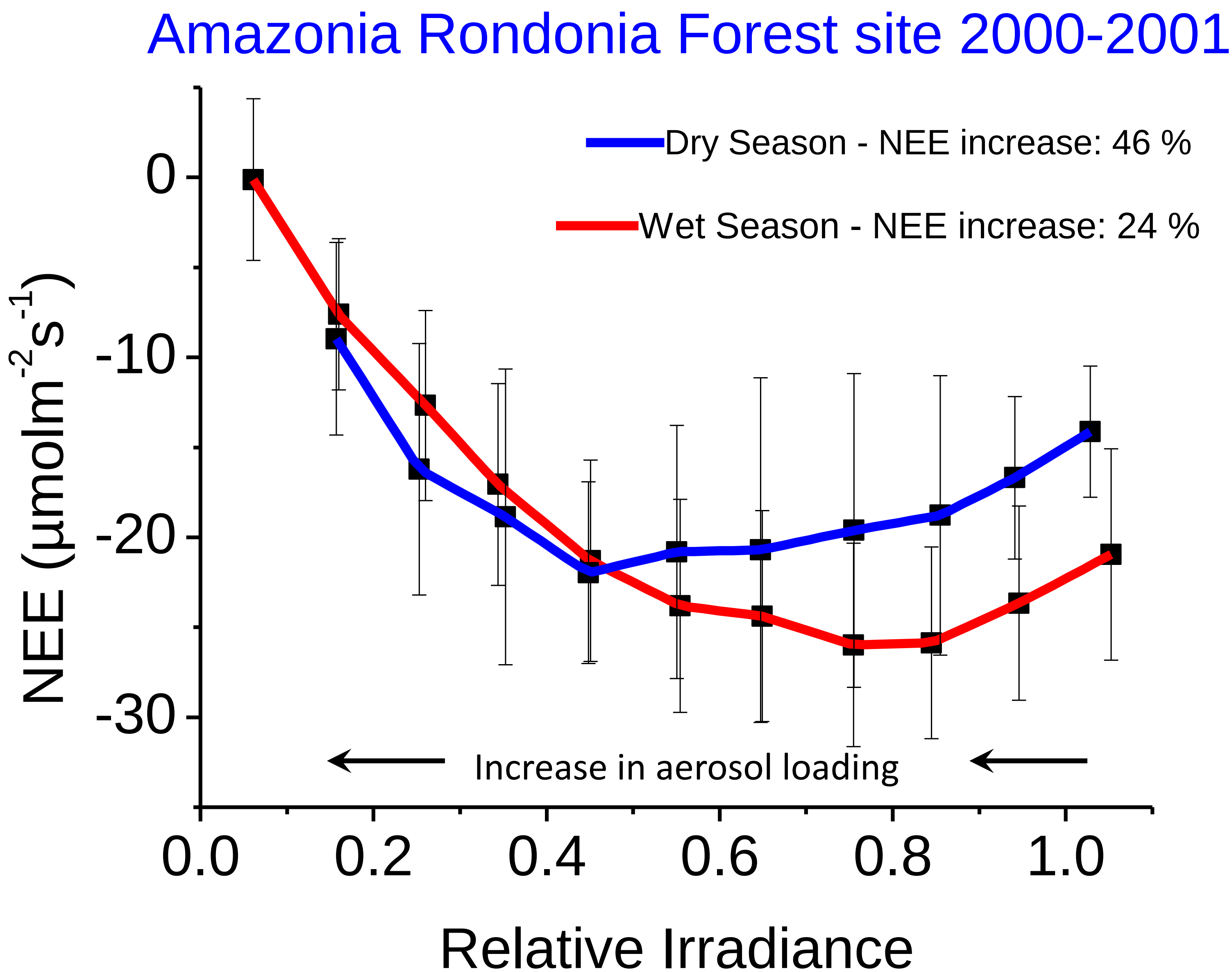
Aerosol effects on the Net Plant Productivity



Kulmala et al., 2004



Strong aerosol effect on forest photosynthesis diffuse radiation have a large effect on CO2 fluxes

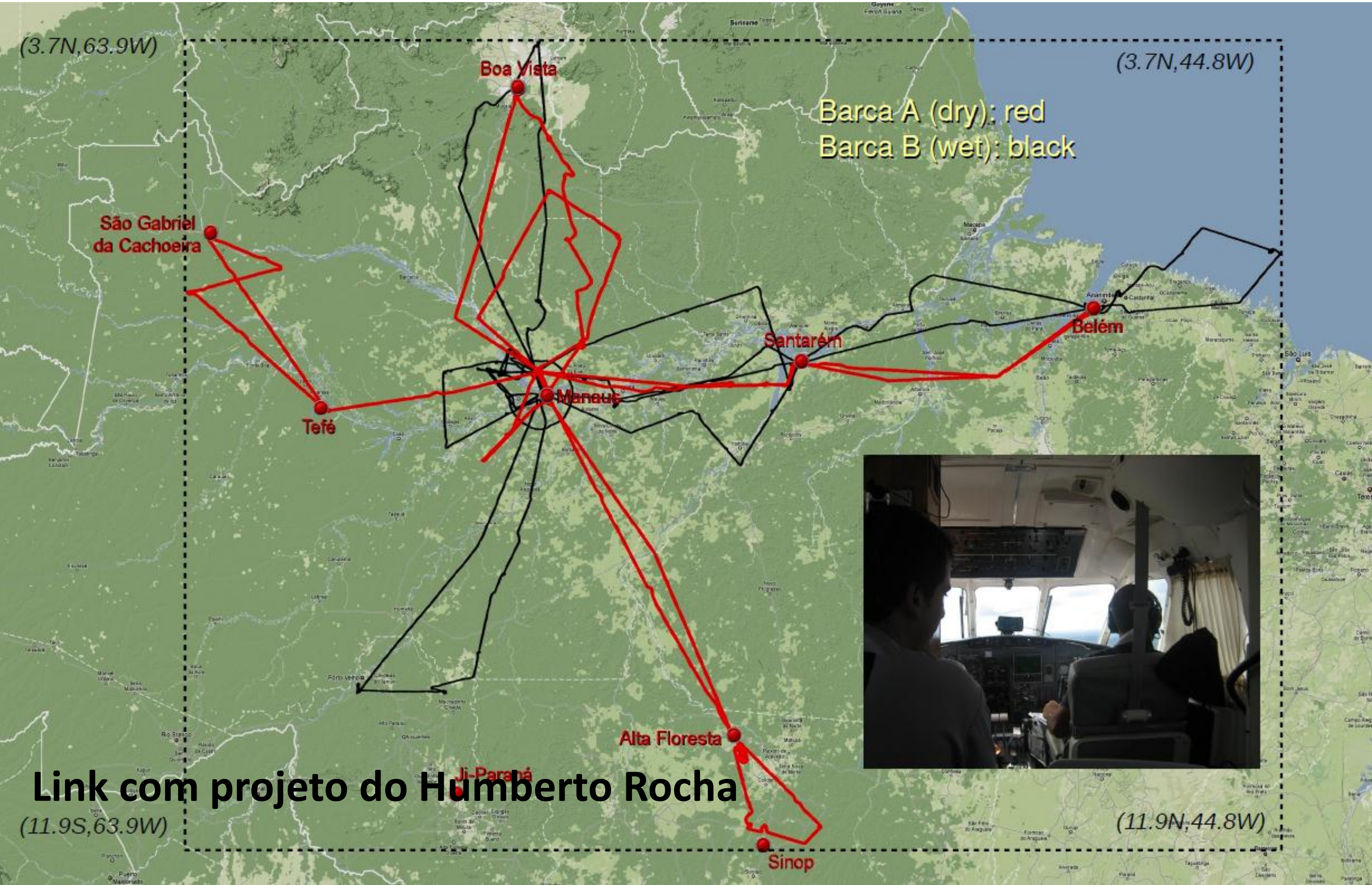


LBA BARCA

Balanço Regional de
Carbono na Amazonia
BARCA

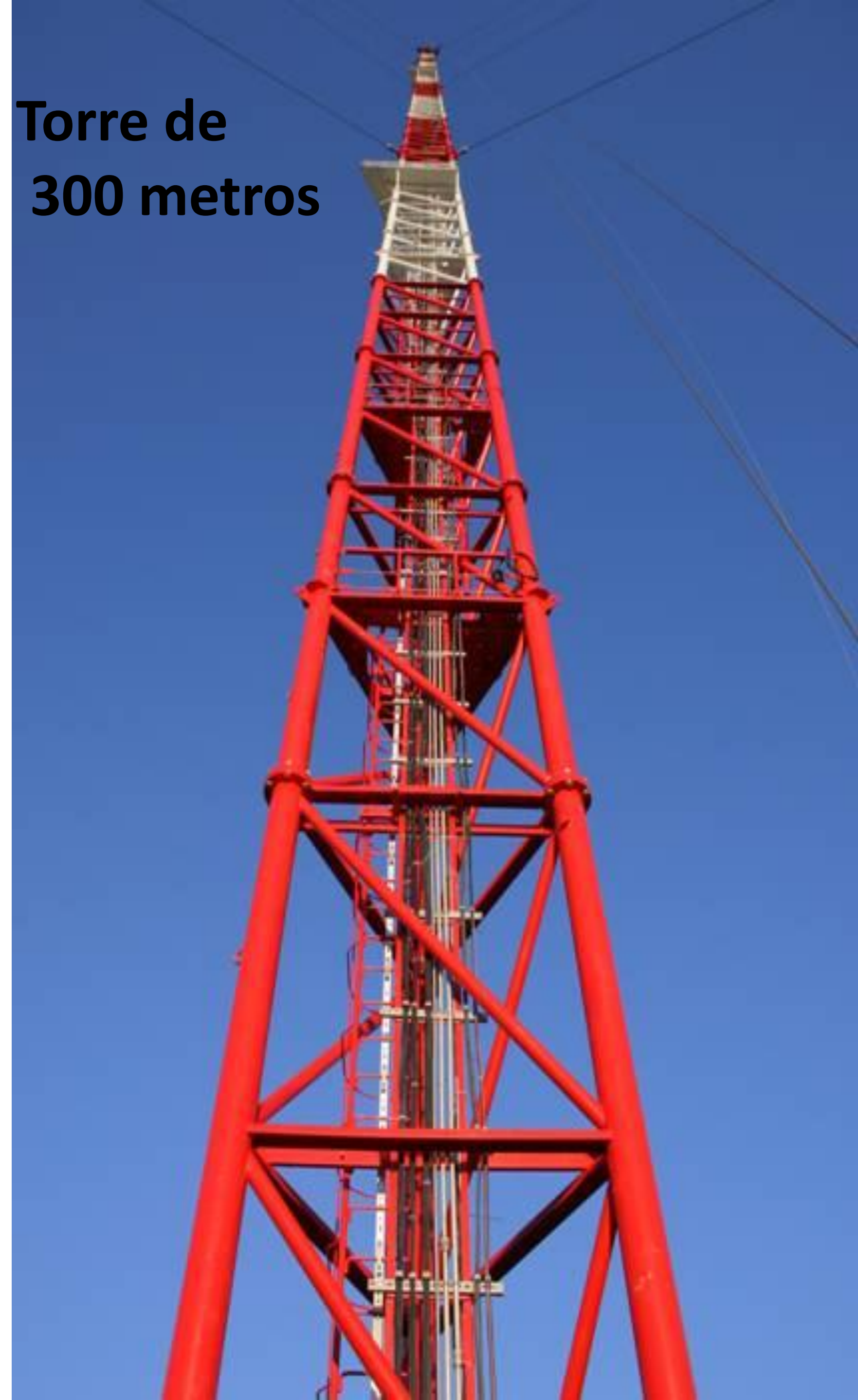



Balanço Regional de Carbono na Amazonia BARCA



Link com projeto do Humberto Rocha

O sítio experimental do projeto ATTO será composto de uma torre muito alta (300 m), ladeada por quatro torres de fluxos menores. O sítio experimental será estabelecido perto de Balbina.



Ainda há muito a fazer:

As principais questões a serem abordadas durante a segunda fase do LBA são:

1. O ambiente amazônico em mudança;
2. A sustentabilidade dos serviços ambientais e os sistemas de produção terrestres e aquáticos;
3. A variabilidade climática e hidrológica e sua dinâmica: respostas, adaptação e mitigação.

LINHAS TEMÁTICAS

1. Armazenamento e fluxo de carbono na biomassa e ecossistemas amazônicos
2. Fluxos de energia, gases traço, aerossóis e vapor de água na Amazônia
3. Interação entre desflorestamento e precipitação
4. Ciclos biogeoquímicos e taxa de deposição de nutrientes na Amazônia, no período seco e úmido
5. Integração entre as escalas locais, regionais e meso escala regional
6. Mudanças ambientais e sua influencia na mudança climática
7. Identificação e avaliação dos serviços ambientais dos ecossistemas amazônicos
8. Definição e avaliação dos indicadores de sustentabilidade
9. Aspectos social e econômico relacionado às mudanças na cobertura e uso do solo