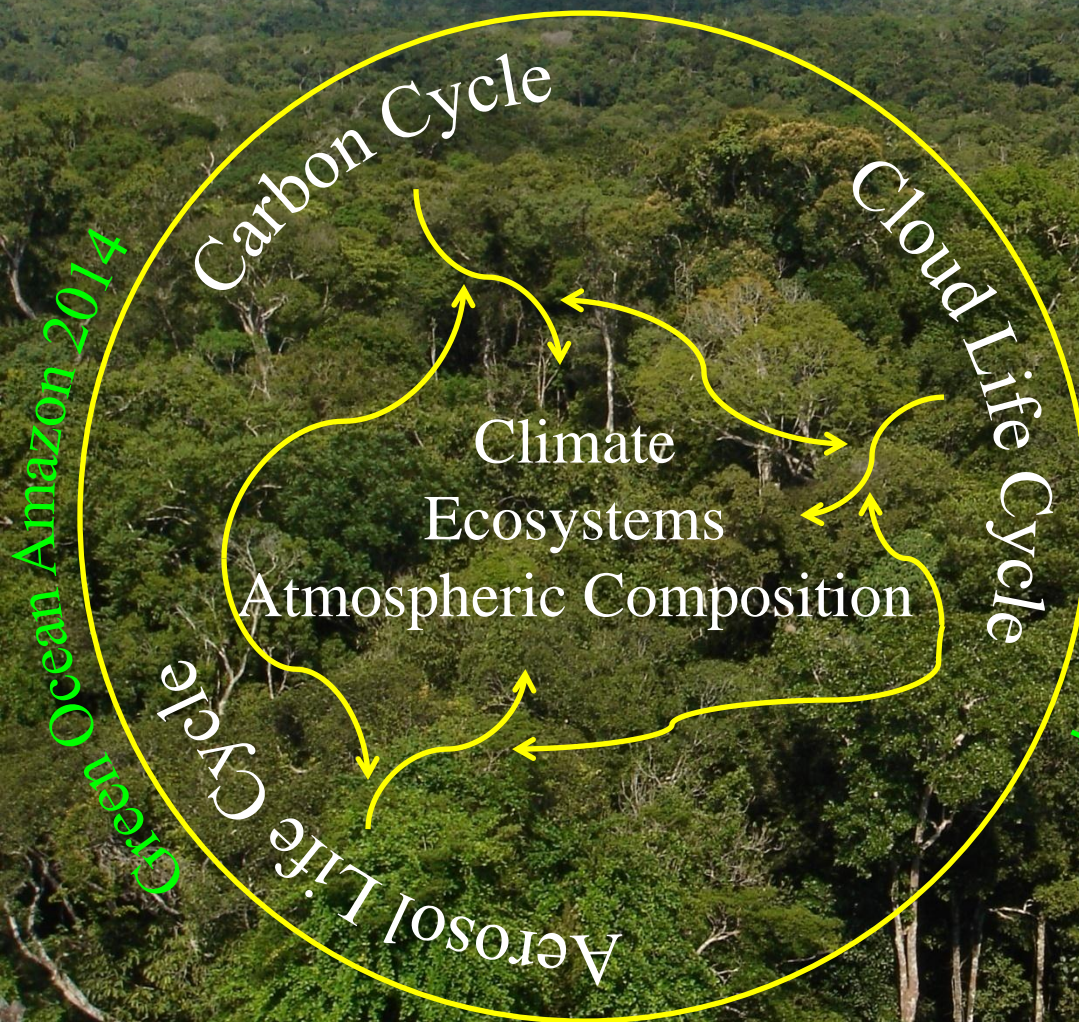


Observations and Modeling of the Green Ocean Amazon GoAmazon2014

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),**

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 Gonçalves (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)

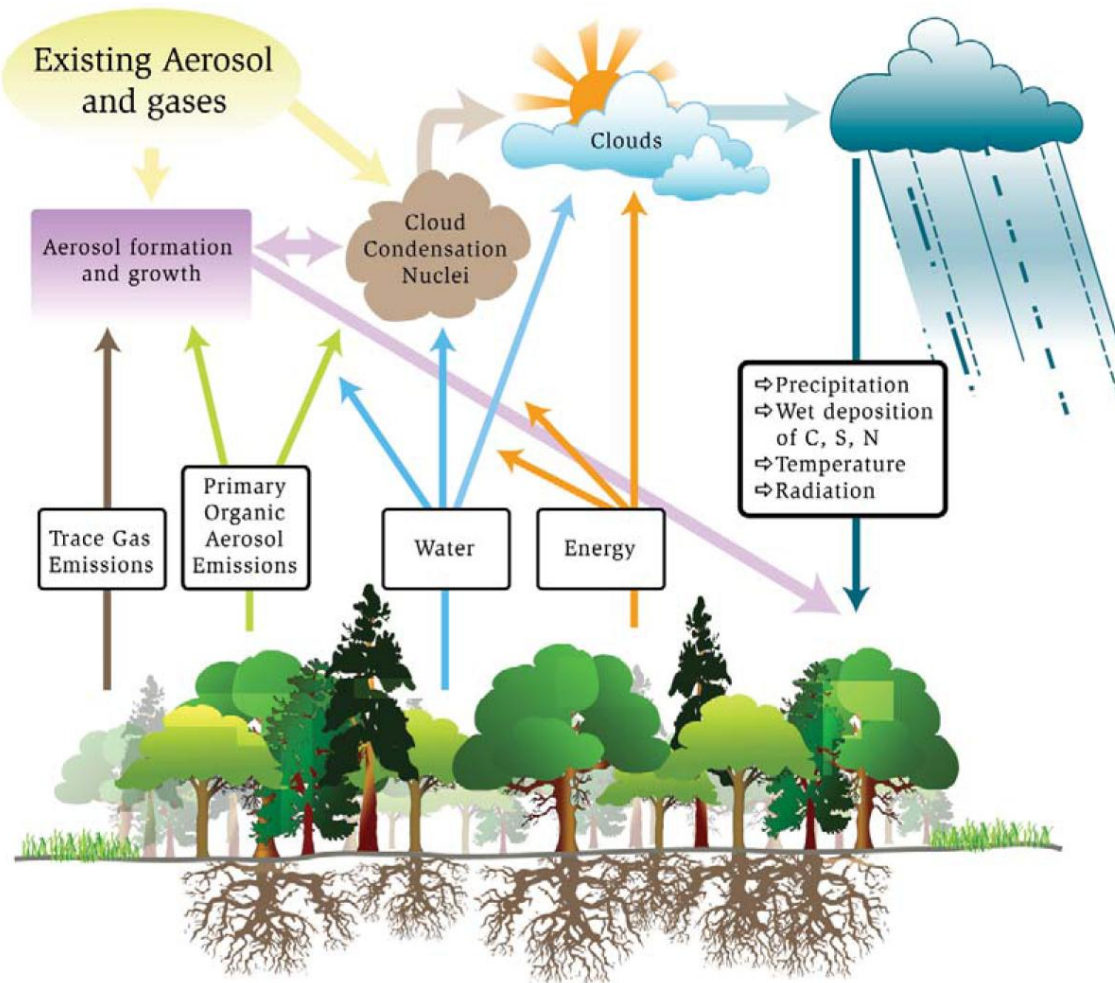
AEROCLIMA: Direct and indirect effects of aerosols on climate in Amazonia and Pantanal

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*)

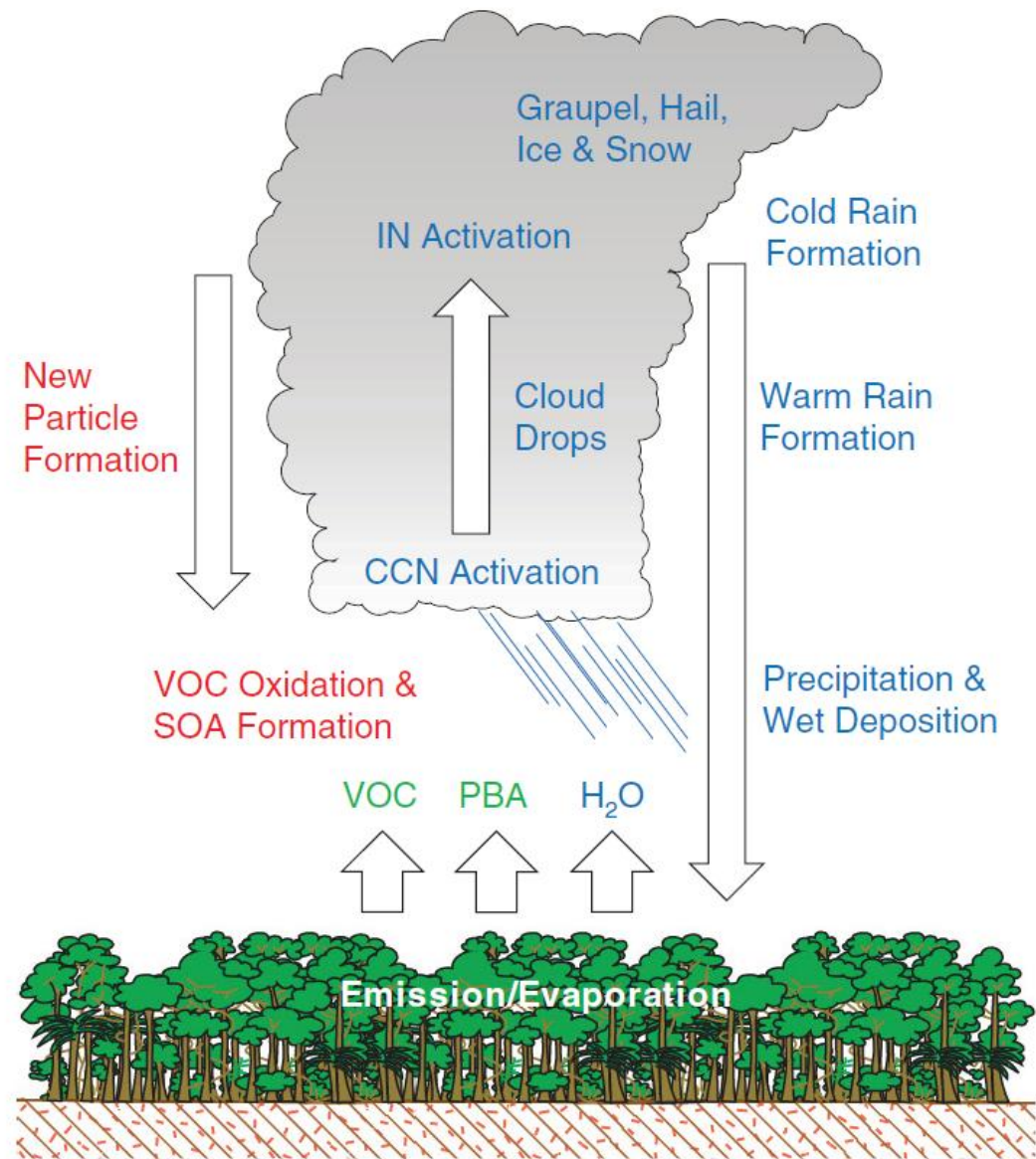
Amazon Basin has strong coupling between terrestrial ecosystem and the hydrologic cycle: The linkages among carbon cycle, aerosol life cycle, and cloud life cycle need to be understood and quantified.



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.

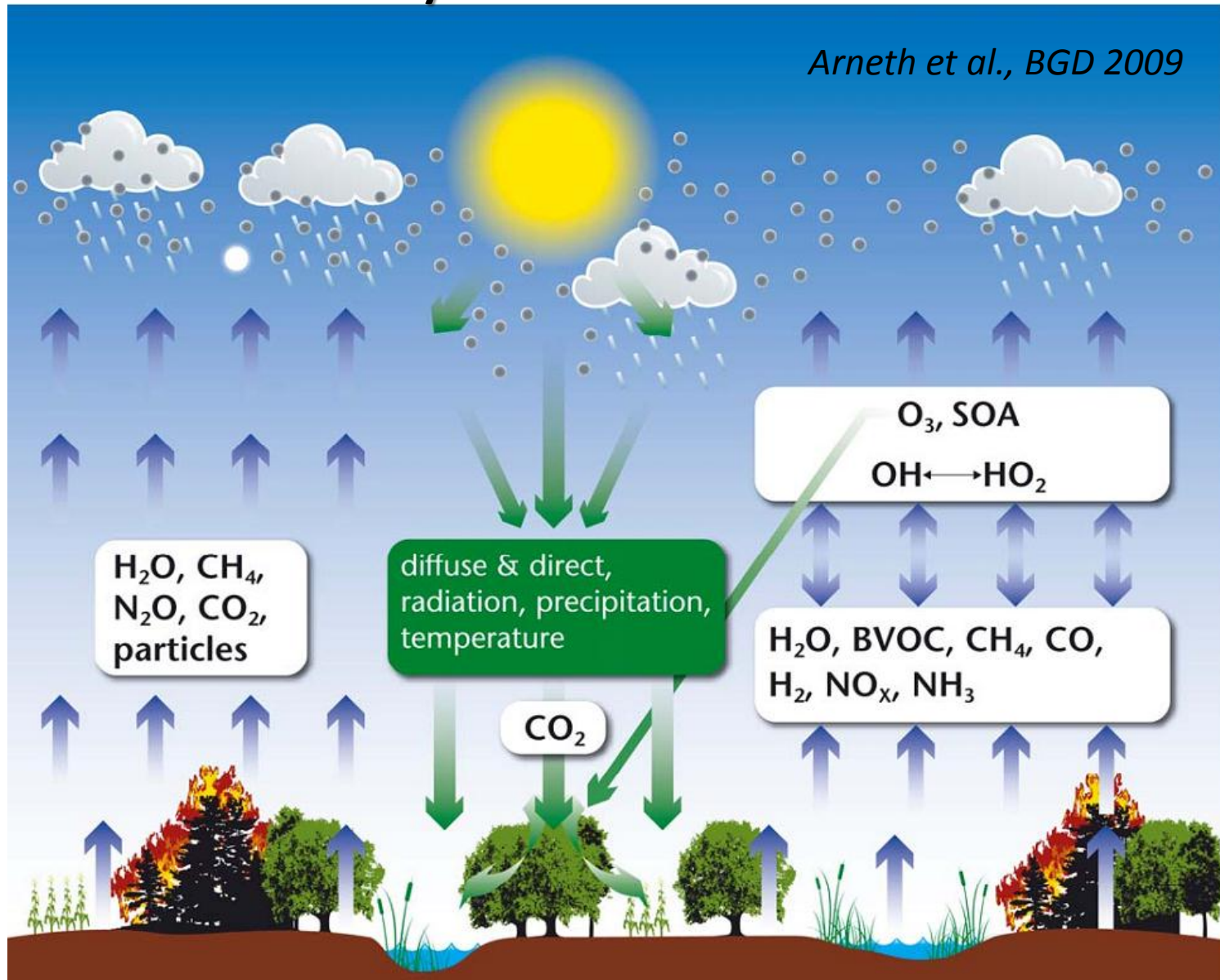
Cloud Life Cycle,
Aerosol Life Cycle,
Aerosol-Cloud-
Precipitation
Interactions, Carbon
Cycle are all represented
in this schematic.

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



Conceptual overview of terrestrial carbon cycle – chemistry – climate interactions

Arneth et al., BGD 2009



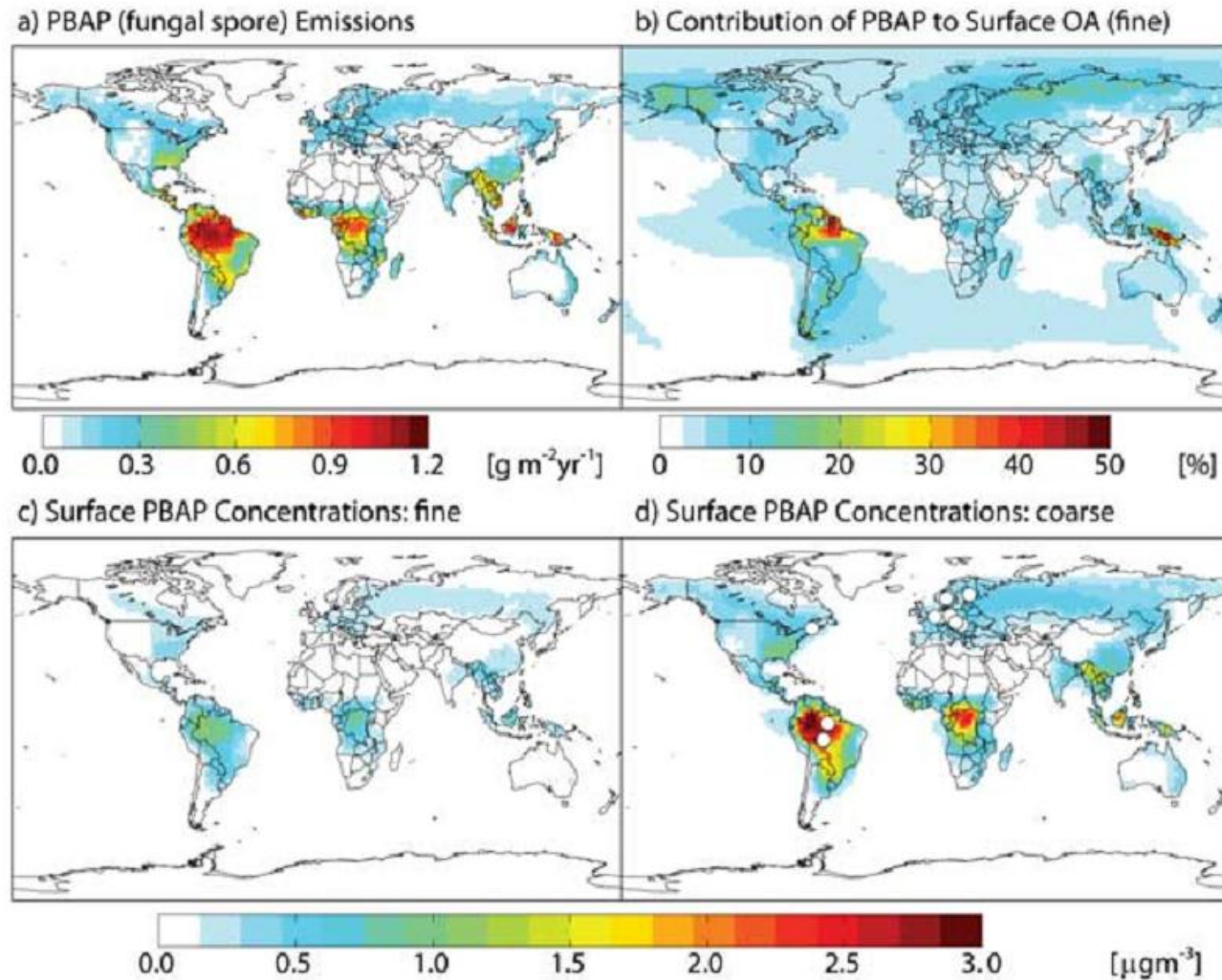
In Amazonia a unique biological system “controls” the climate

Vegetation source of both: water vapor and VOCs that makes up CCN



Biology matters

Atmospheric budget of primary biological aerosol particles from fungal spores



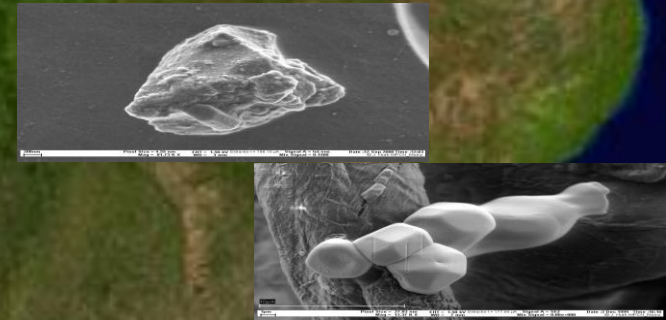
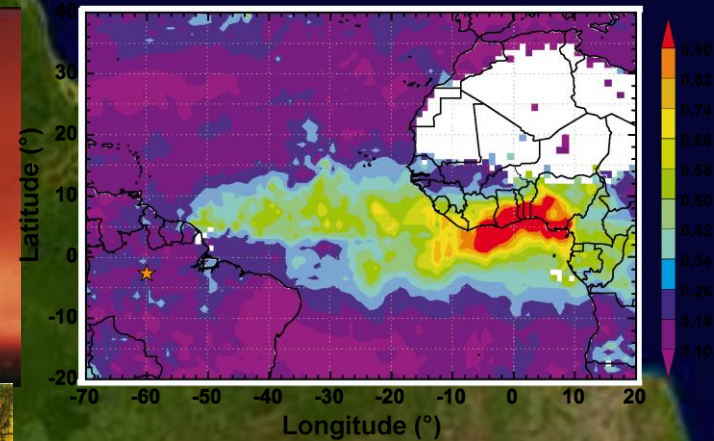
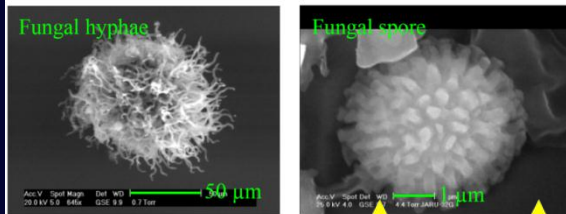
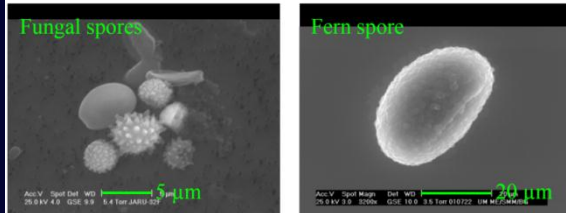
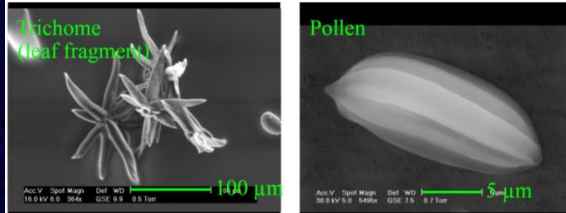
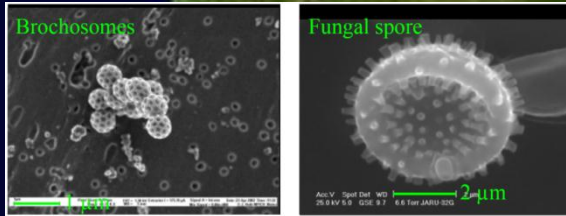
Annual mean of optimized GEOS-Chem simulation of fungal PBAP: (a) PBAP emissions, (b) percentage contribution of fungal PBAP to fine organic aerosol (OA) surface concentrations, (c) fine-mode fungal PBAP surface concentrations, and (d) coarse-mode fungal PBAP surface concentrations.

Amazonia: 3 different types of aerosols

Biogenic (primary and SOA)

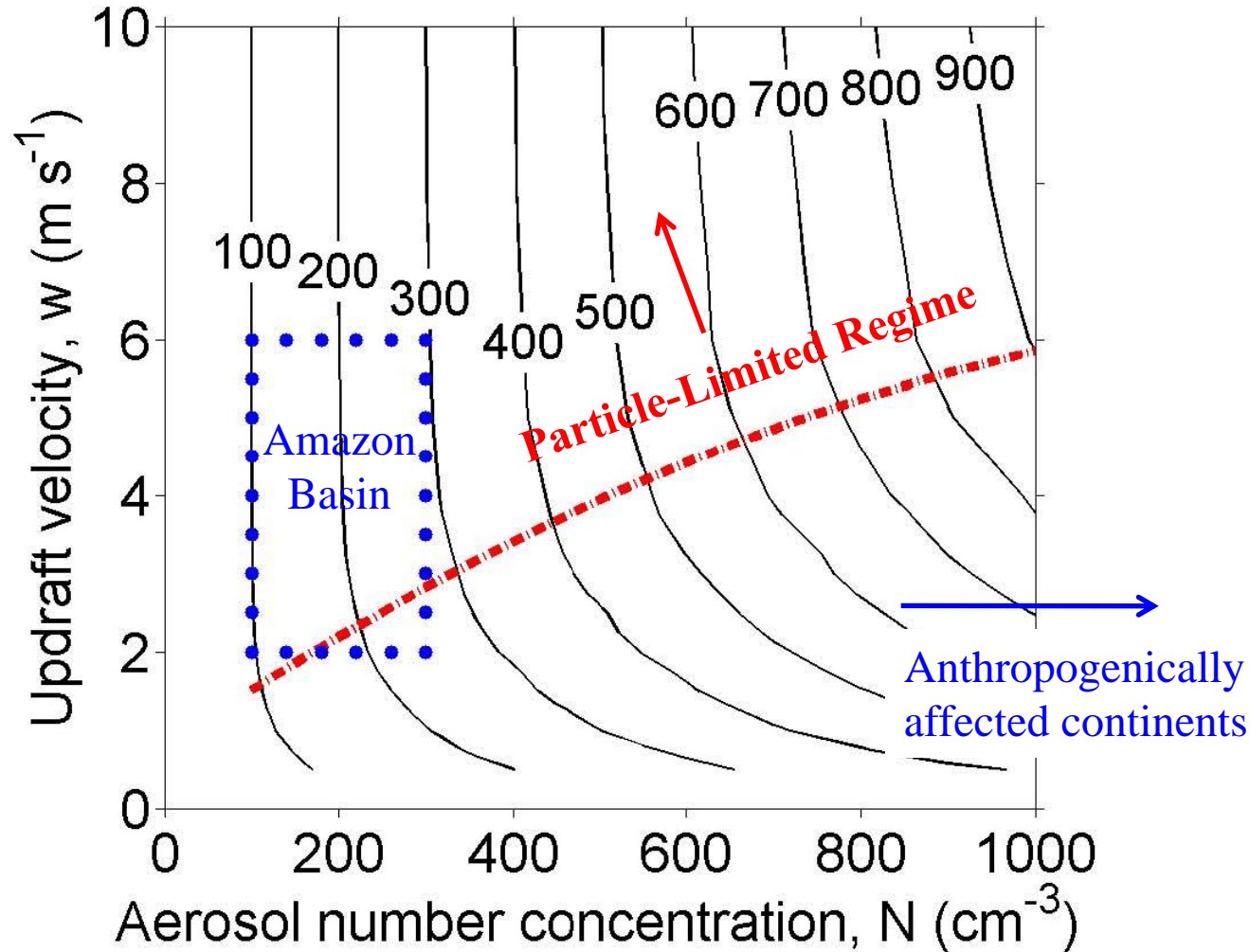
Biomass Burning

Dust from Sahara



Each with VERY different properties and impacts

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

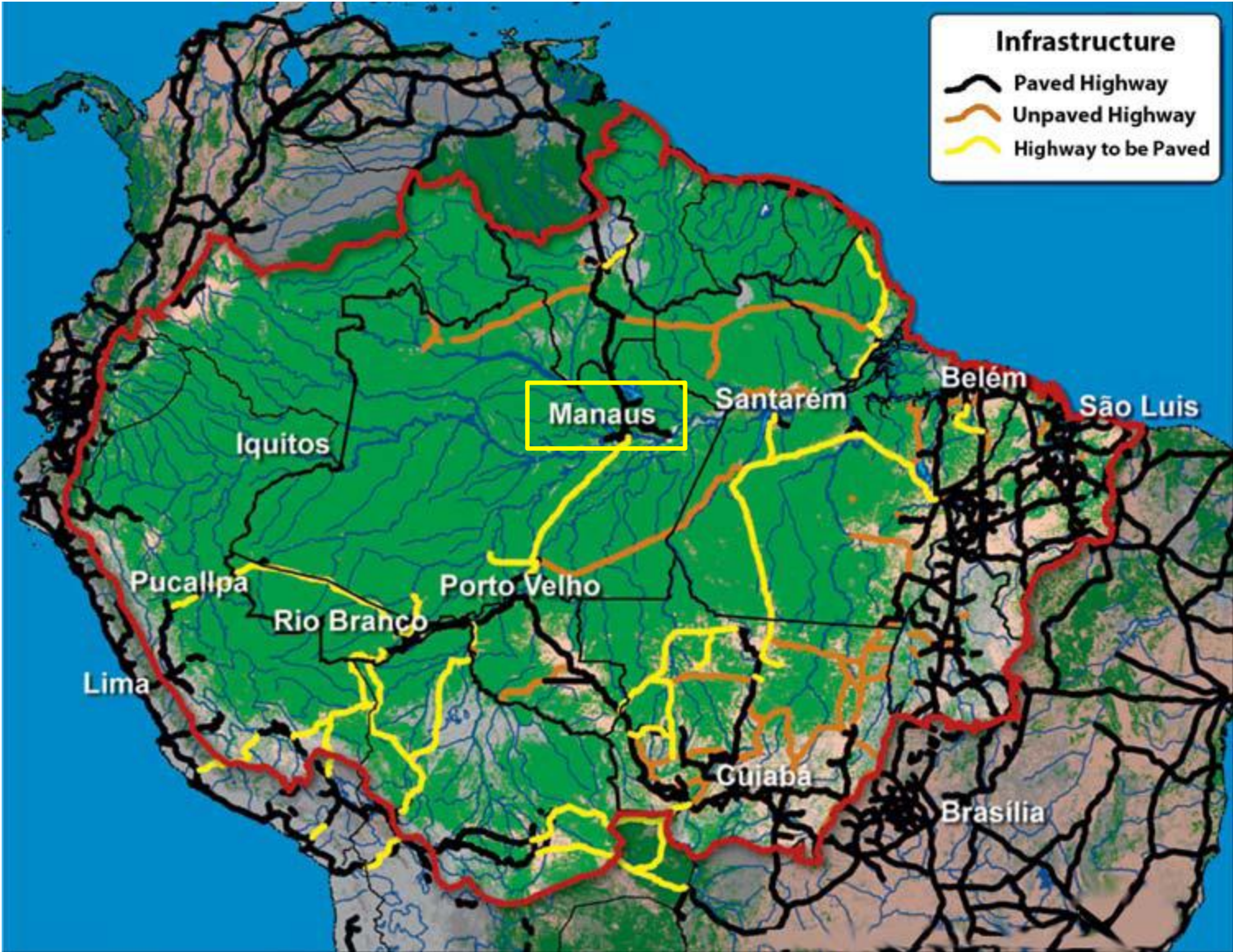
Note: Non-exhaustive selected list. Further development anticipated.

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.

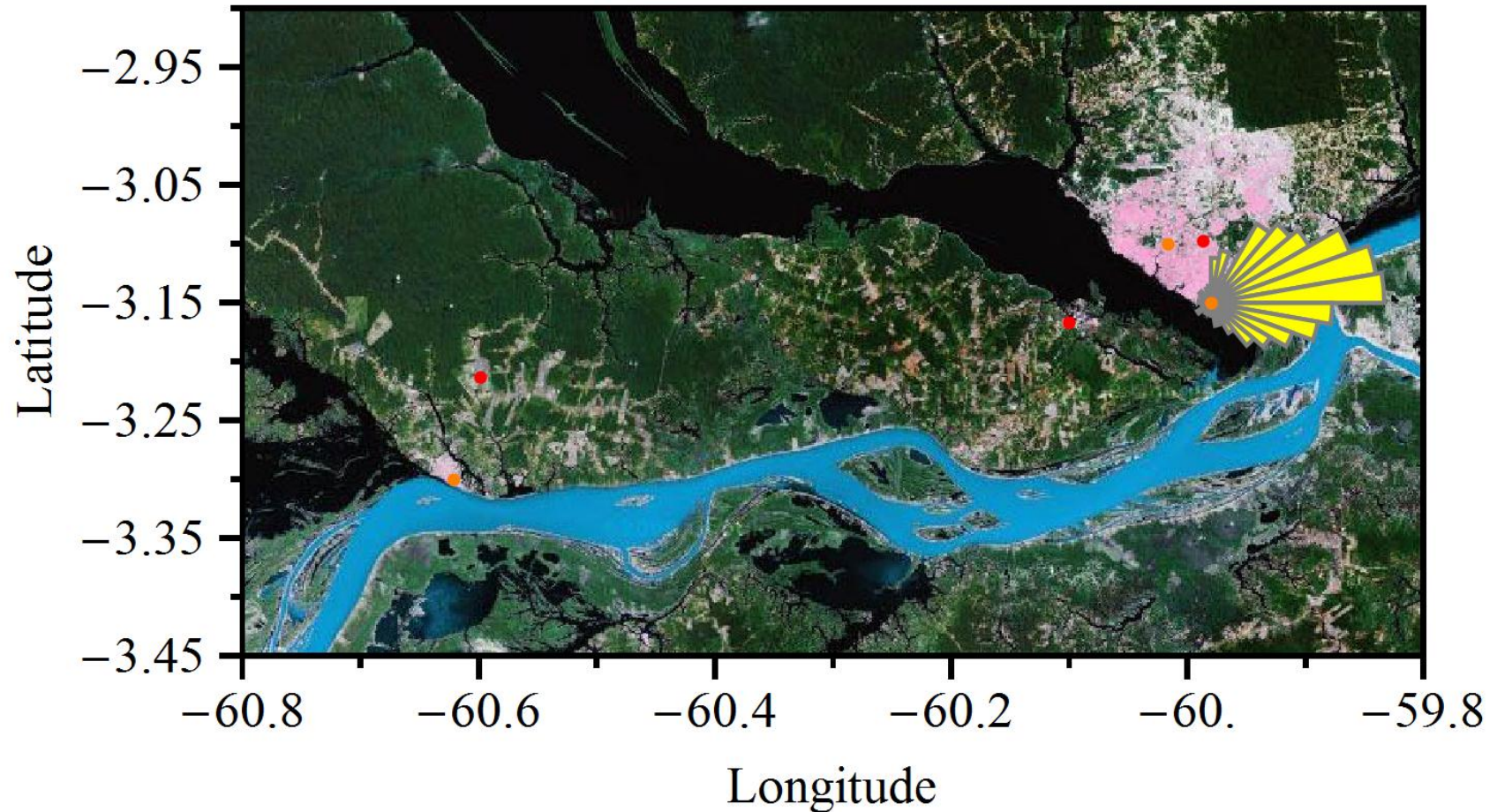
The ultimate goal is to estimate future changes in direct and indirect radiative forcing, energy distributions, regional climate, ecosystem functioning, and feedbacks to global climate.

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.

Site Location



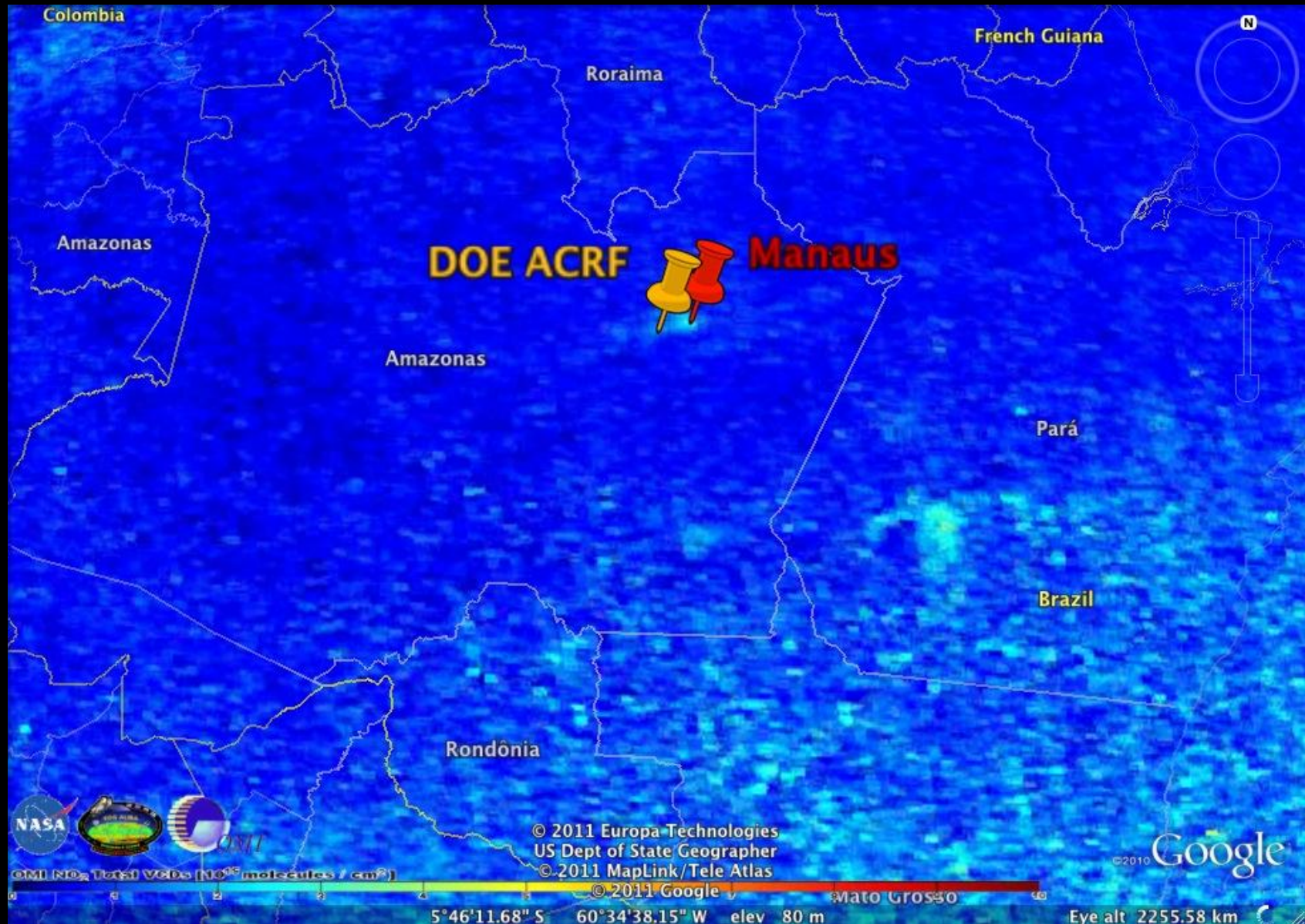
Downwind of Manaus



(-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.

NO₂ 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*

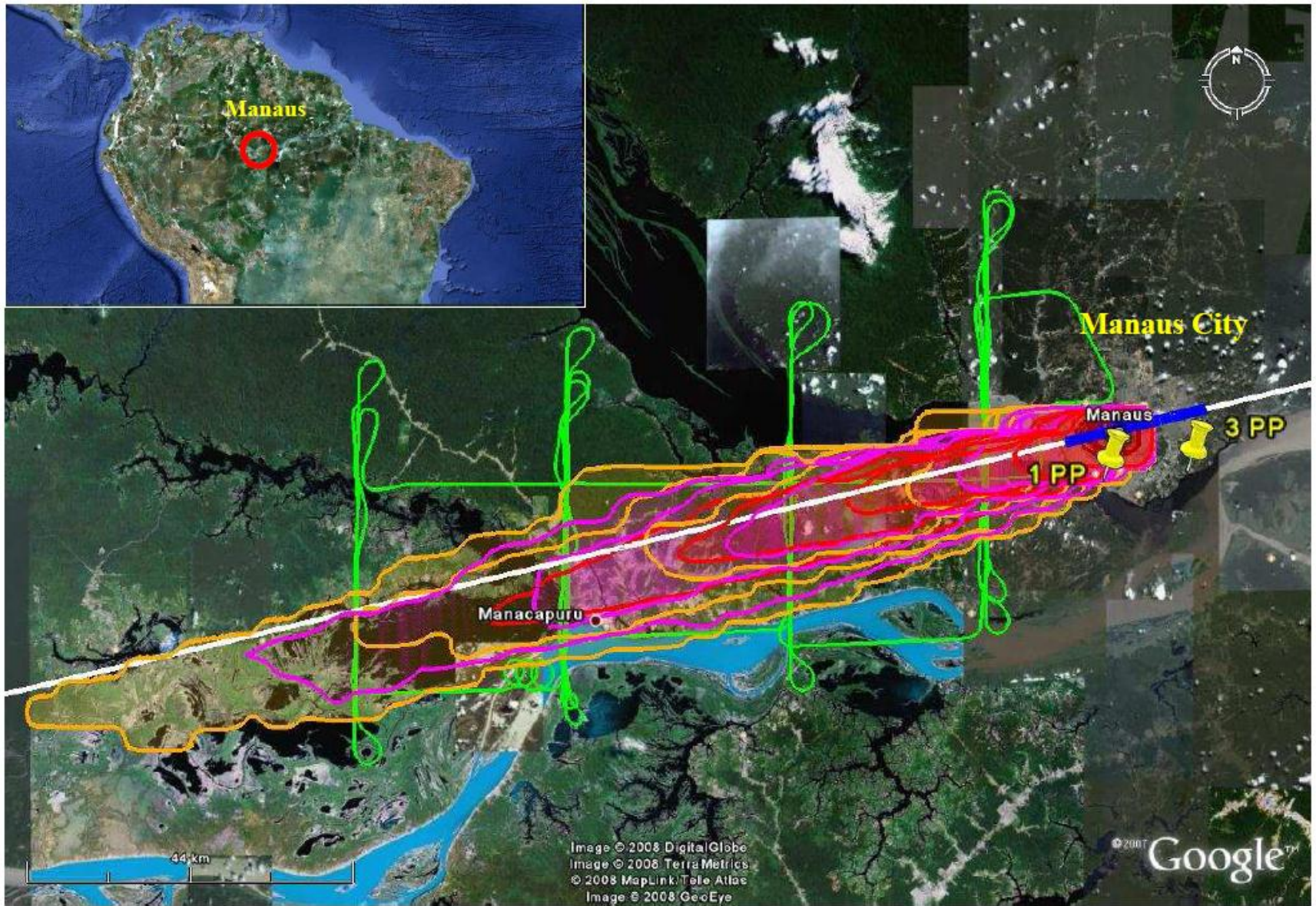


Manaus Outflow Continues Across 60 km Forest

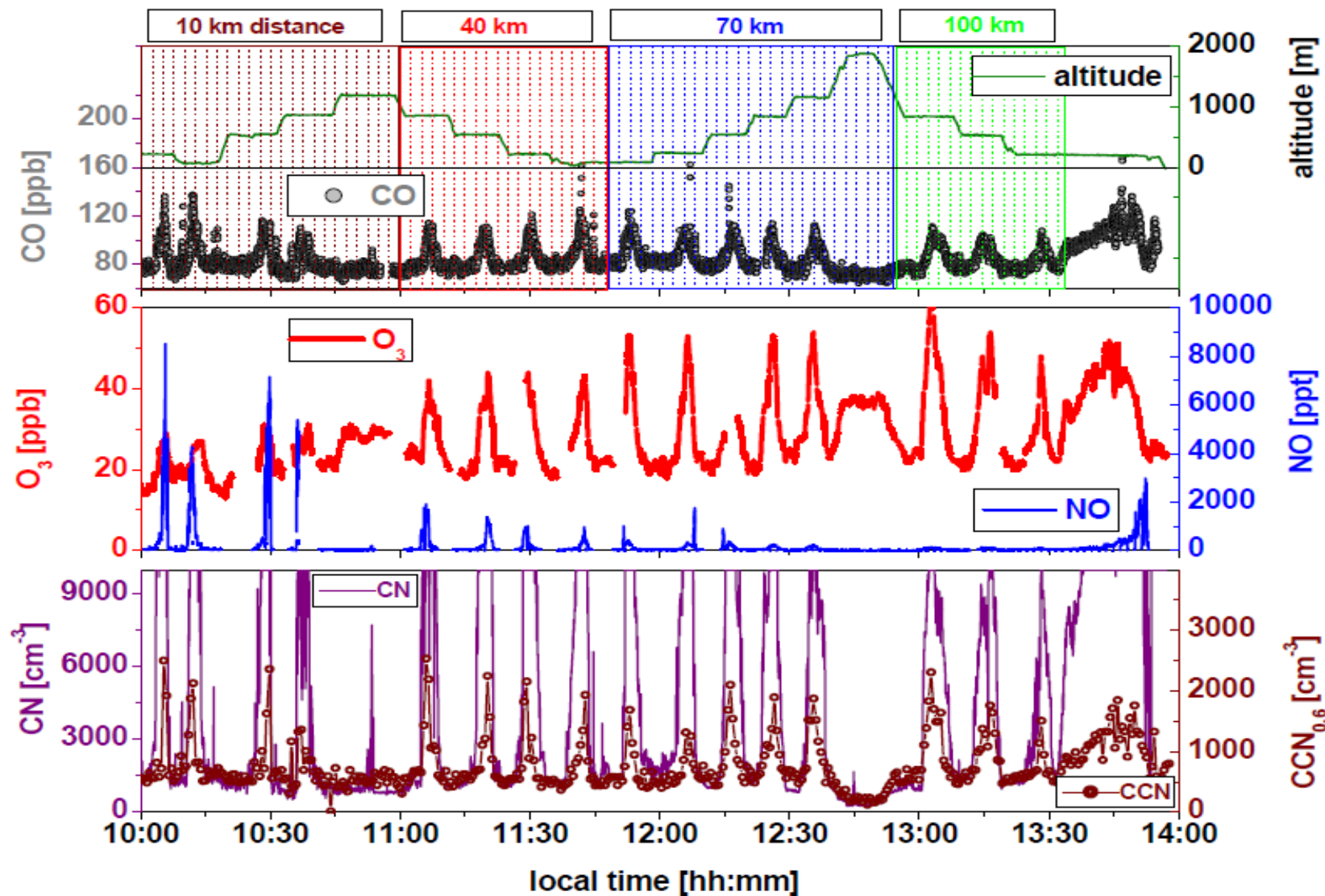


Arrival at AAA Large Pasture Site: *Location of ACRF Deployment*





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.

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)



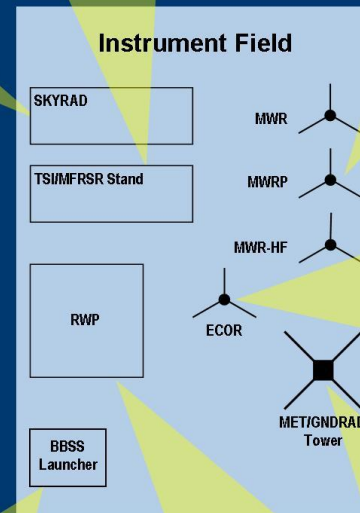
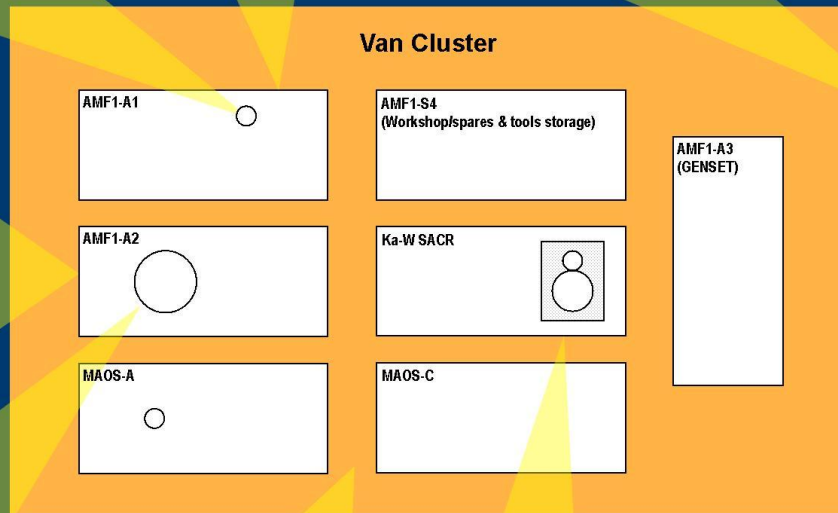
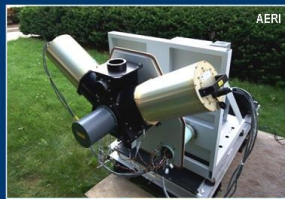
ARM – Brazil Ground Site Operations Overview

Kim Nitschke

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



ARM Mobile Facility One - Typical Deployment



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 Pyrheliometer (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 ₂ O	

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		

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



GoAmazon
2014

The logo features three overlapping circles in yellow, red, and blue, with a white triangle in the center containing the text 'GoAmazon 2014'. The circles are positioned over the Amazon basin on the map.

Acknowledgments: Laszlo Nagy, INPA/LBA

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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, where 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.

In Amazonia a unique biological system “controls” the climate

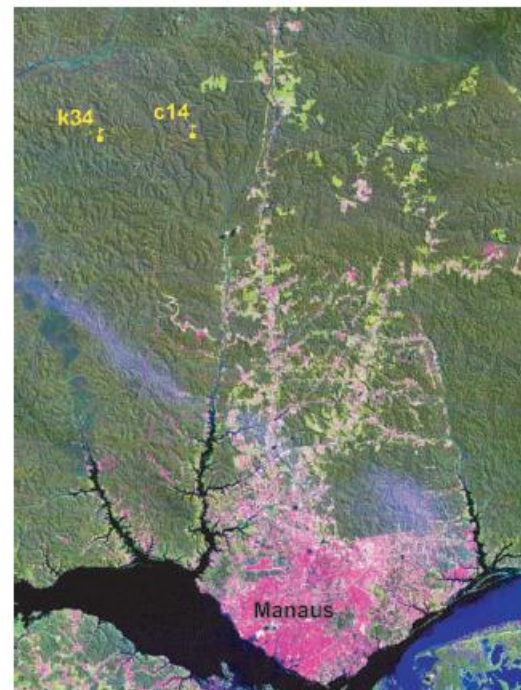
Vegetation source of both: water vapor and VOCs that makes up CCN



AEROCLIMA measurements in Manaus and Porto Velho

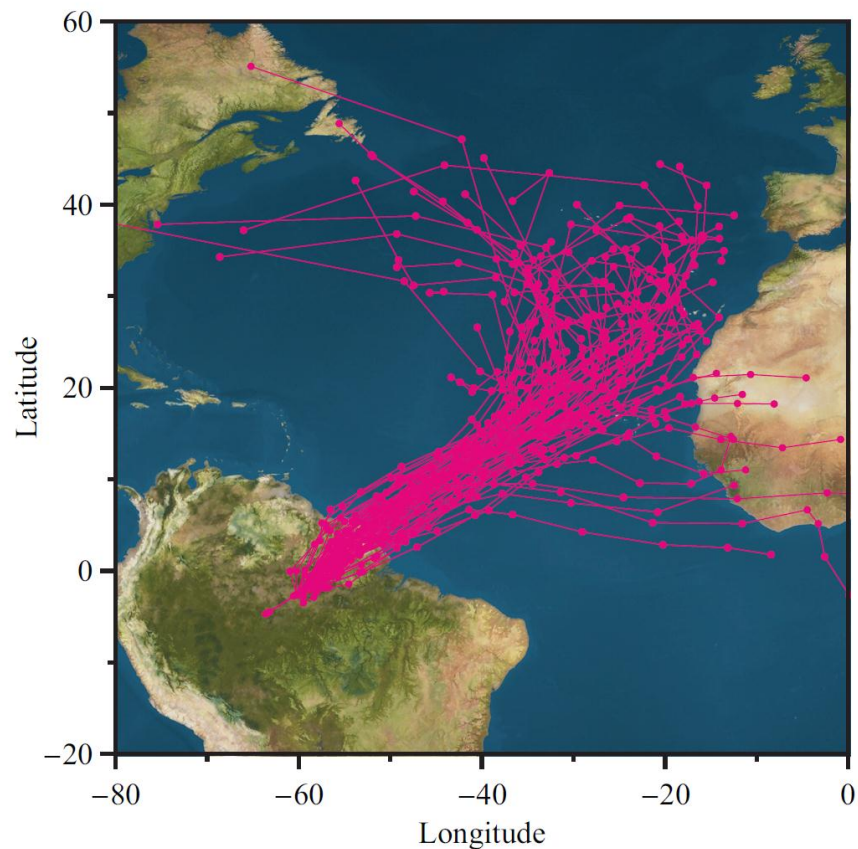
- Continuous aerosol analysis is being done with:
- SFU for fine and coarse mode aerosols with analysis for trace elements.
- Organic and Elemental Carbon and ionic composition;
- MOUDI for aerosol size distribution
- TSI 3-Lambda Neph for light scattering
- MAAP (Multi Angle Absorption Photometer) for 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, CO₂ with Picarro CVRD.
- Raman Lidar continuously up to 15 Km.
- Sun-photometry network (8 NASA AERONET instruments)
- Radiometers for visible and broadband radiation fluxes

- 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

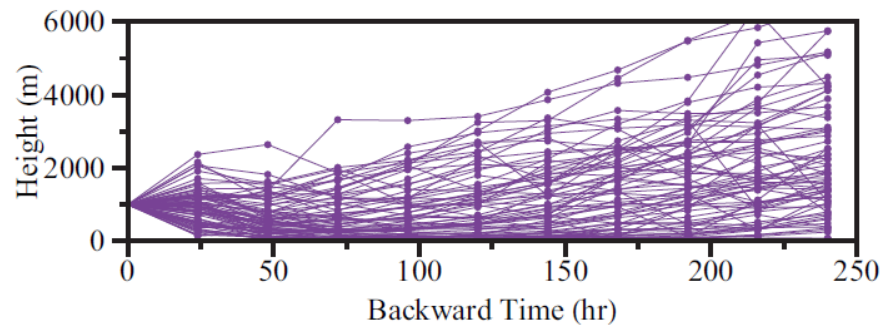
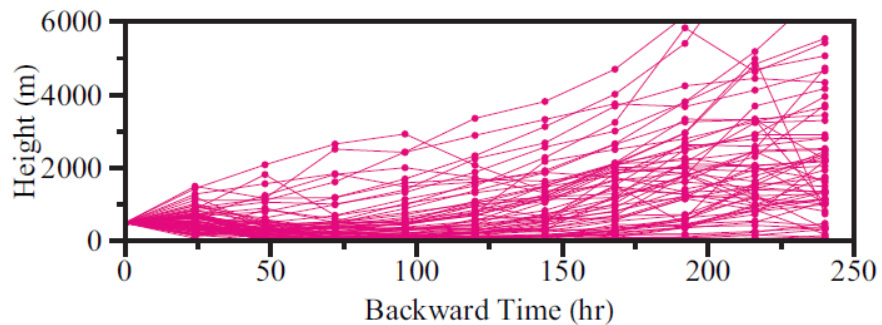
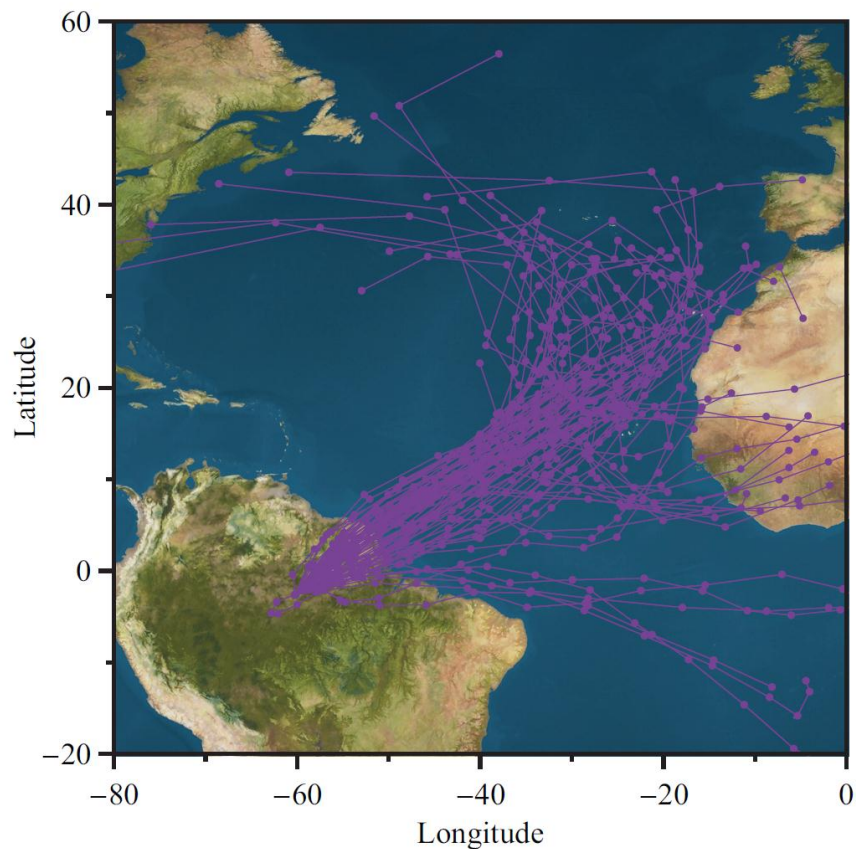


HYSPLIT air mass trajectories during for AEROCLIMA Manaus site

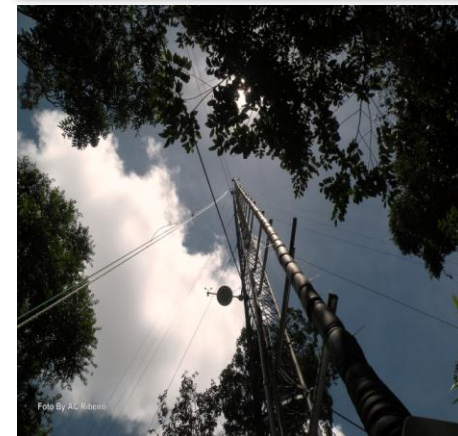
(a) 500 m



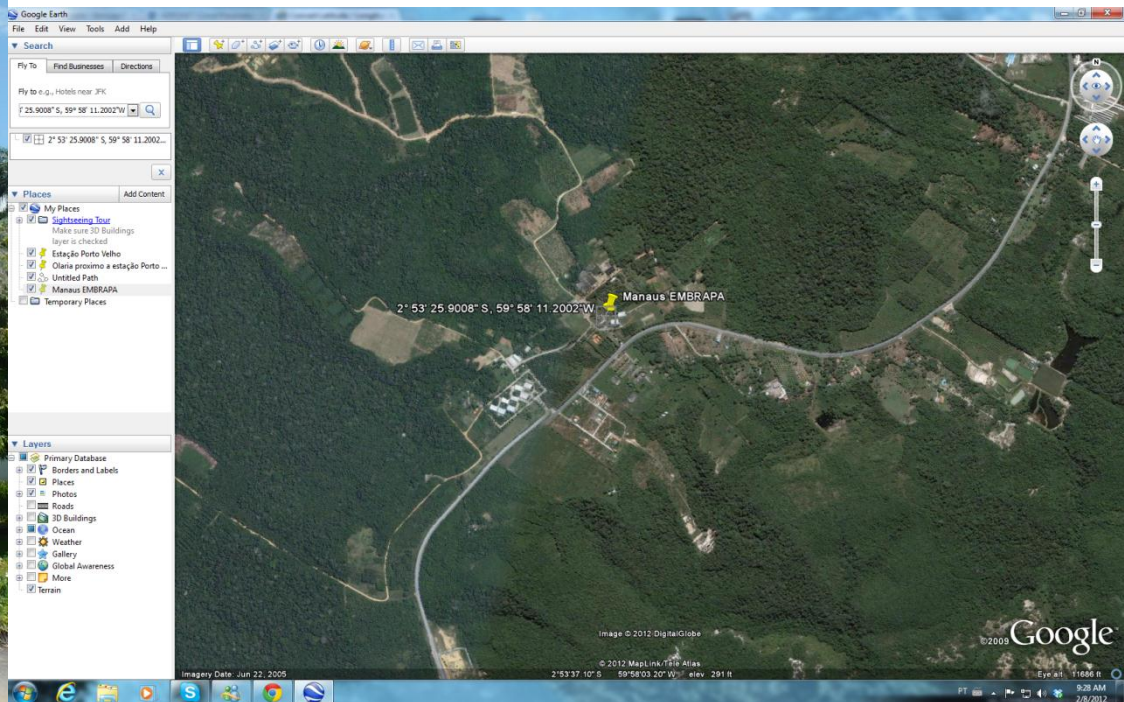
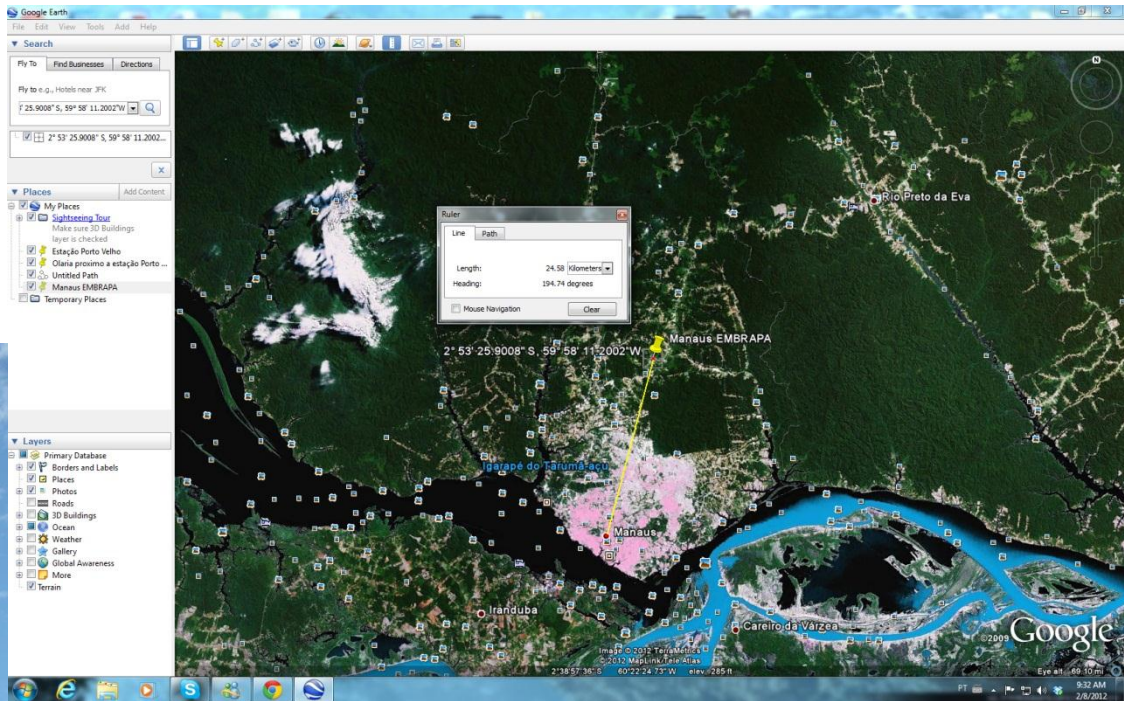
(b) 1000 m



Container with equipment powered by generators



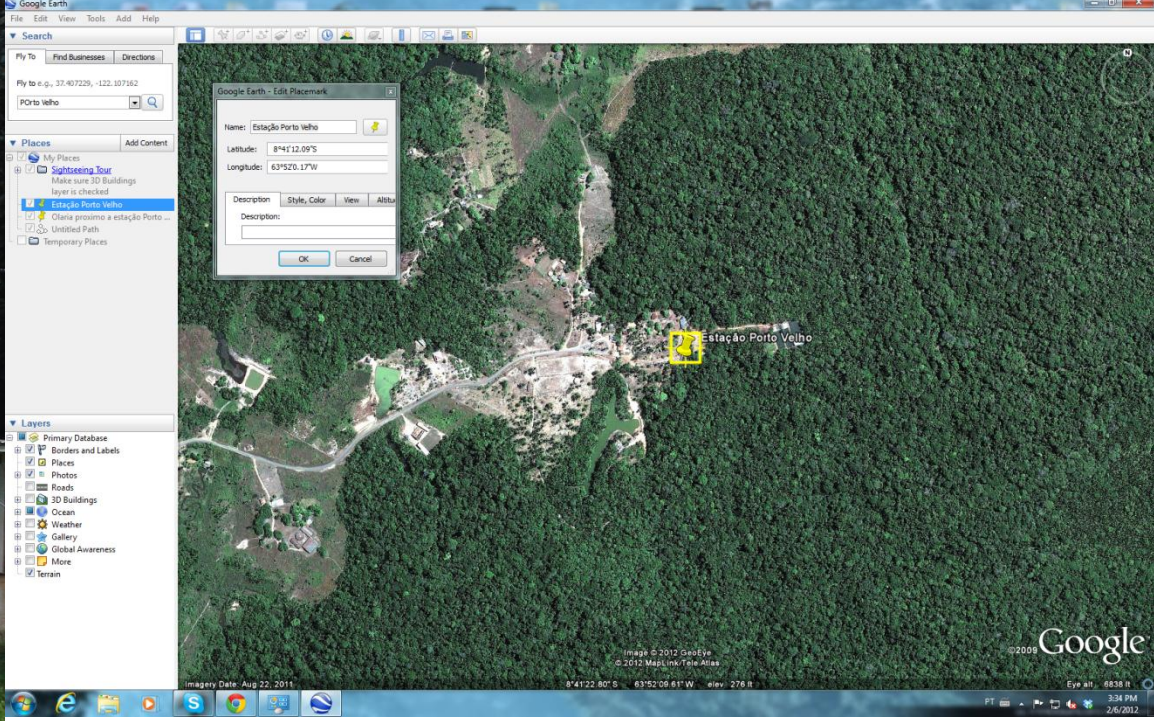
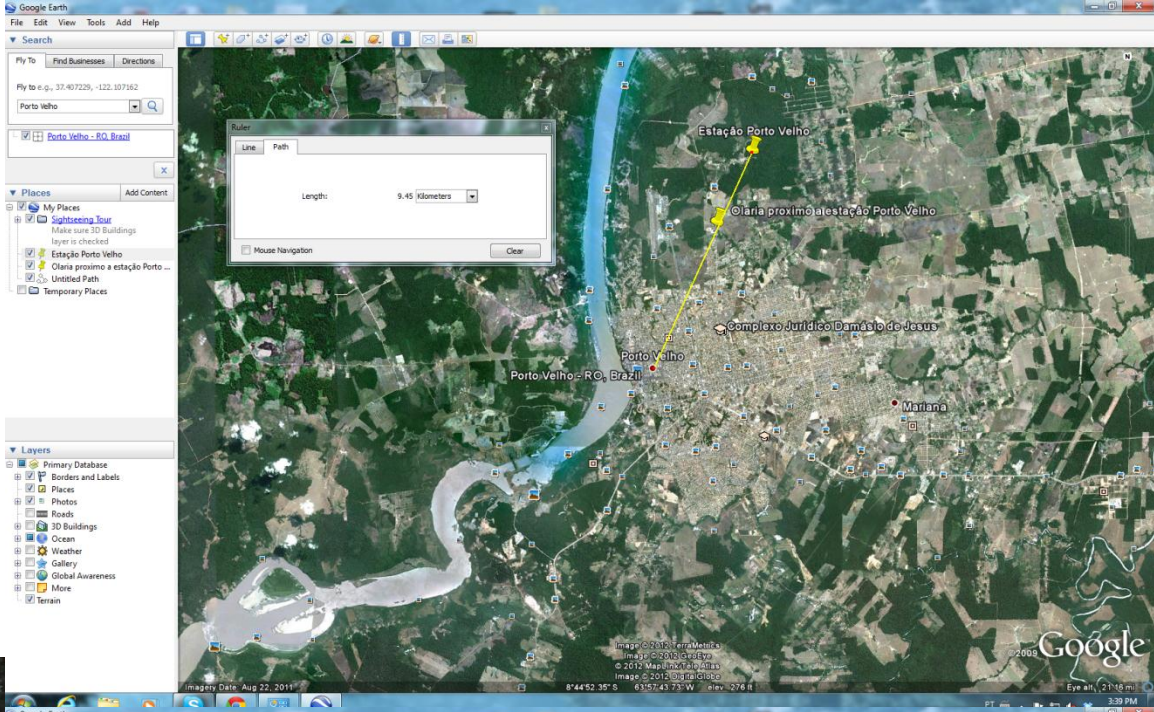
Manaus EMBRAPA AEROCLIMA site



Rondonia - Porto Velho aerosol and trace gases measurement site



Porto Velho AEROCLIMA site

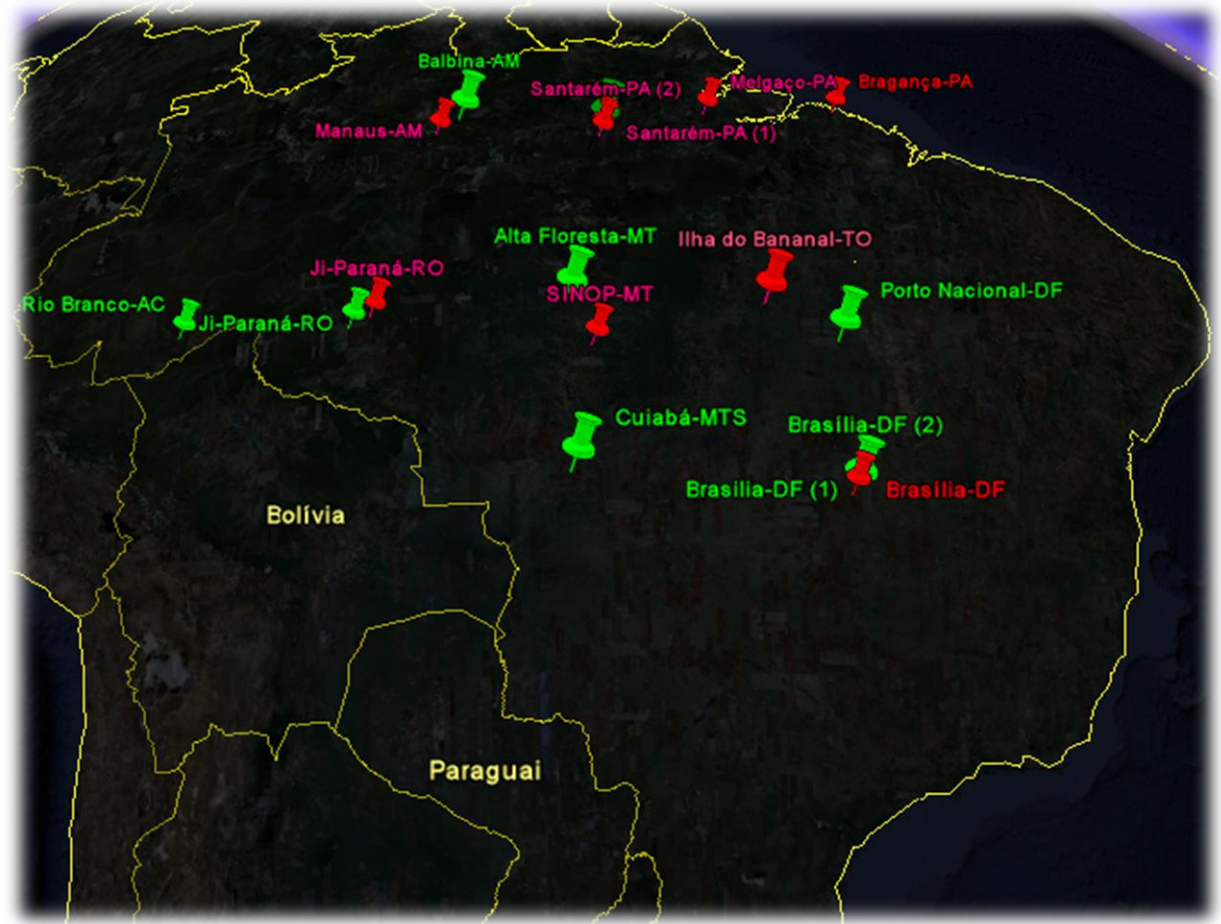
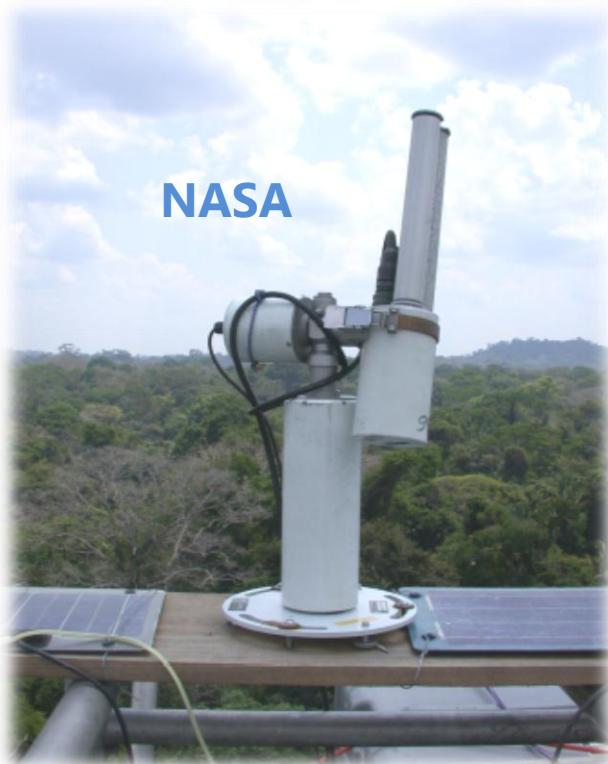


Medidas sendo realizadas em Porto Velho

- 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

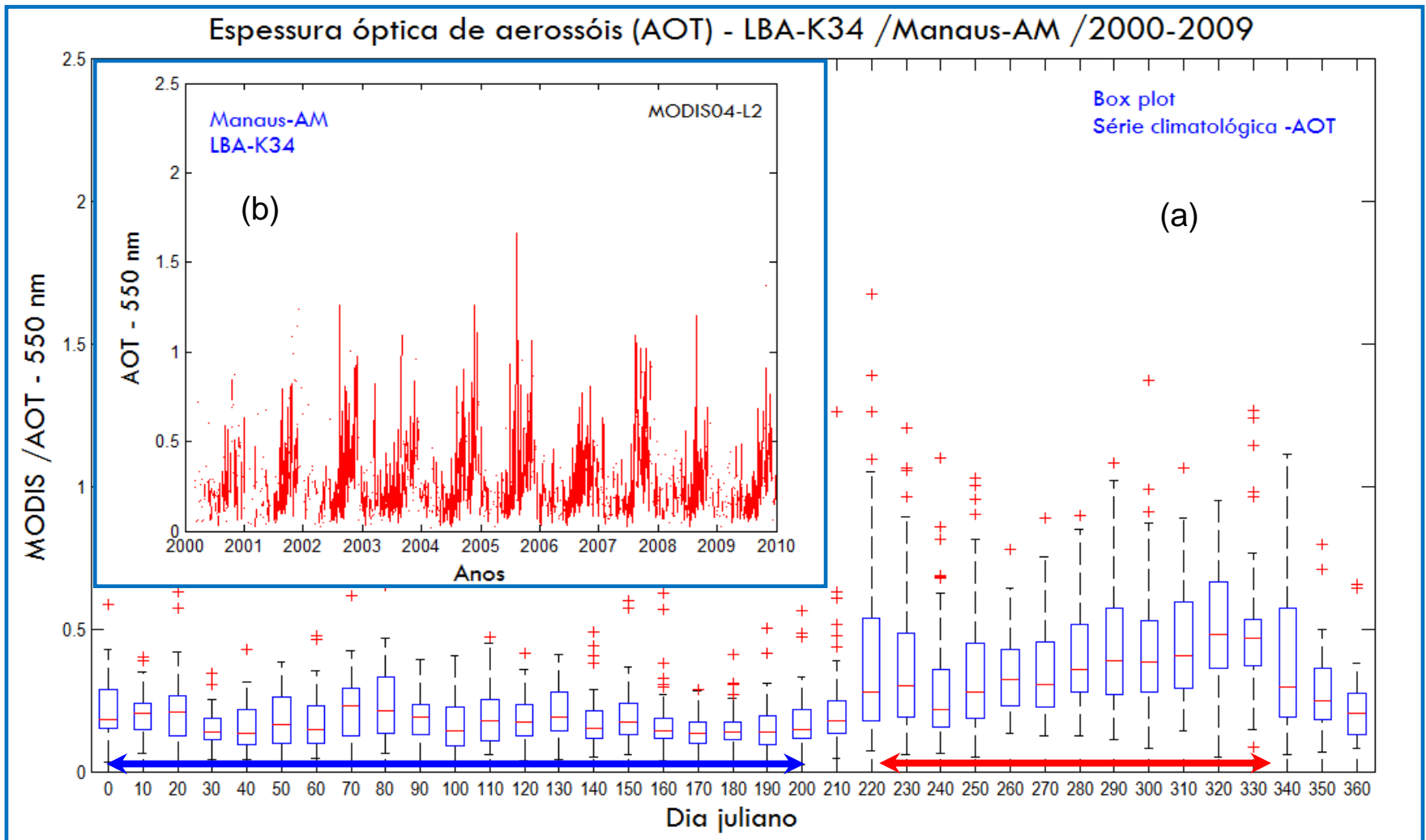


Fotômetros solares da rede AERONET (*Aerosol Robotic Network*): um sistema de monitoramento e caracterização de aerossóis mantidos pela NASA, a partir de uma rede de radiômetros solares operados na Amazônia e outras regiões do planeta.

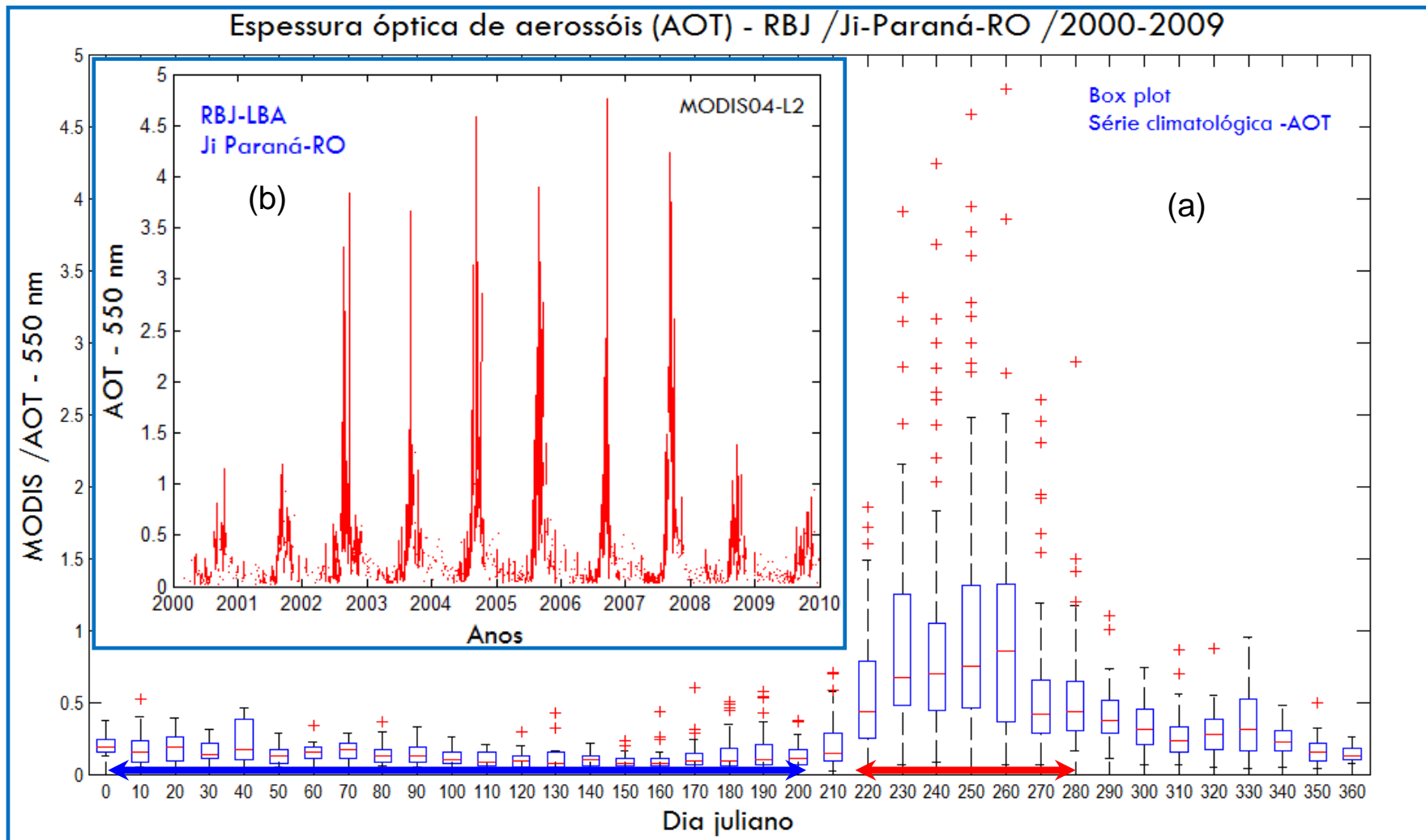


Medidas de espessura ótica de aerossóis (AOT) → (Comprimentos de onda: 340, 380, 440, 500, 670, 870, 940 e 1020 nanômetros)

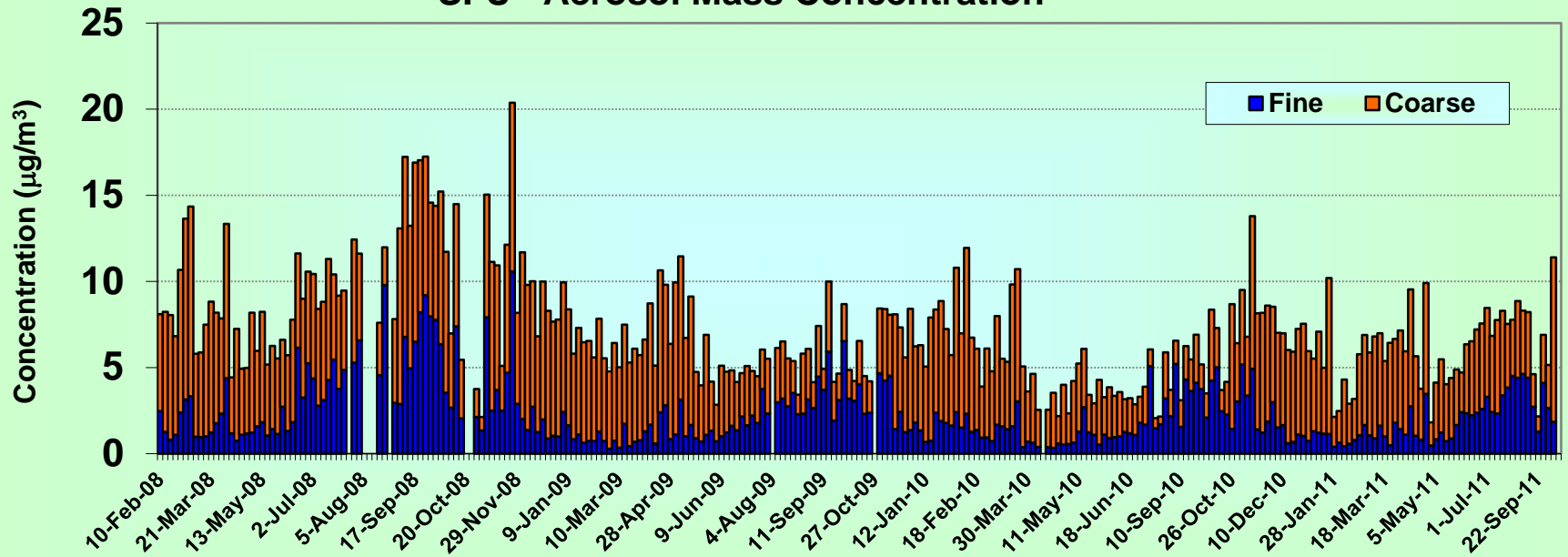
Aerosol optical thickness in Manaus



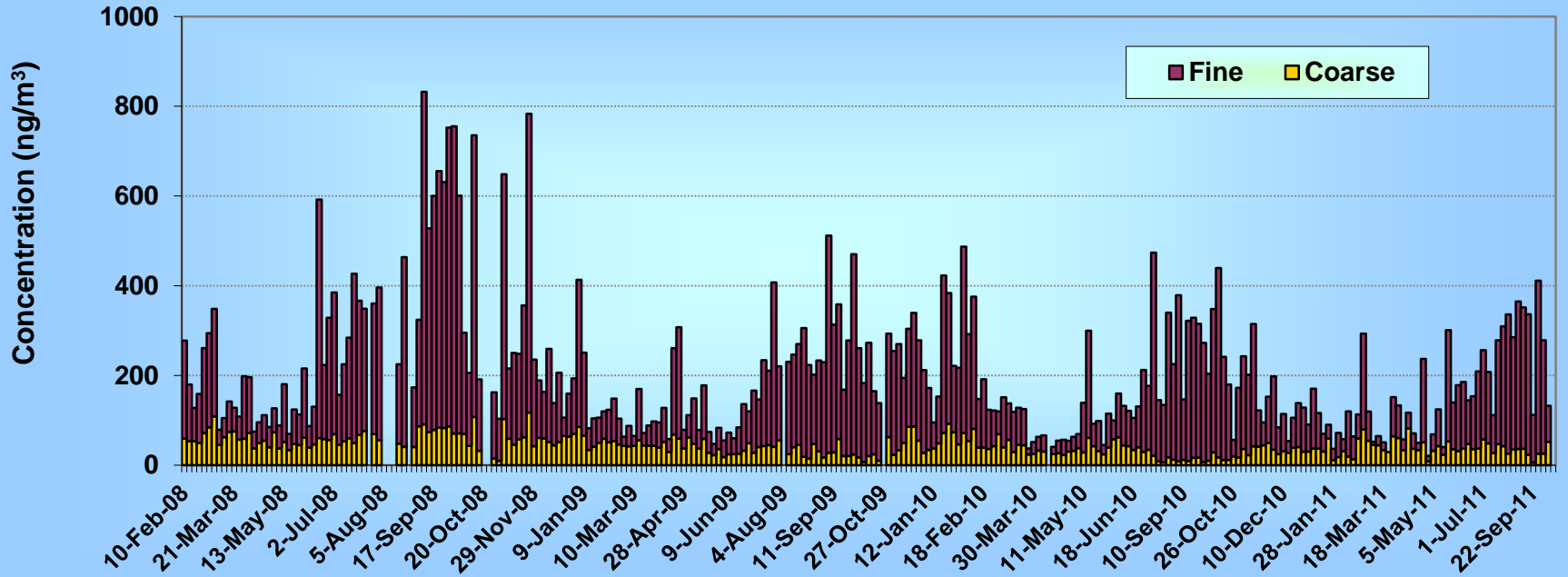
Aerosol optical thickness in Rondônia



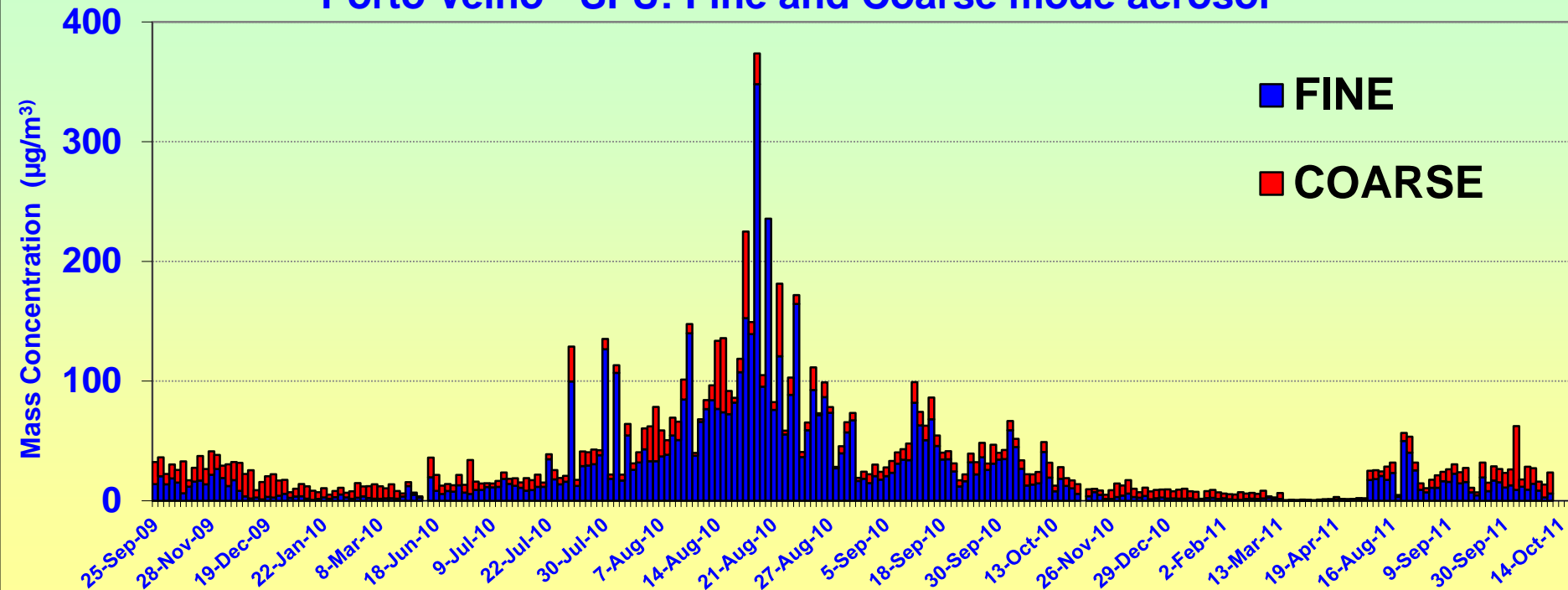
SFU - Aerosol Mass Concentration



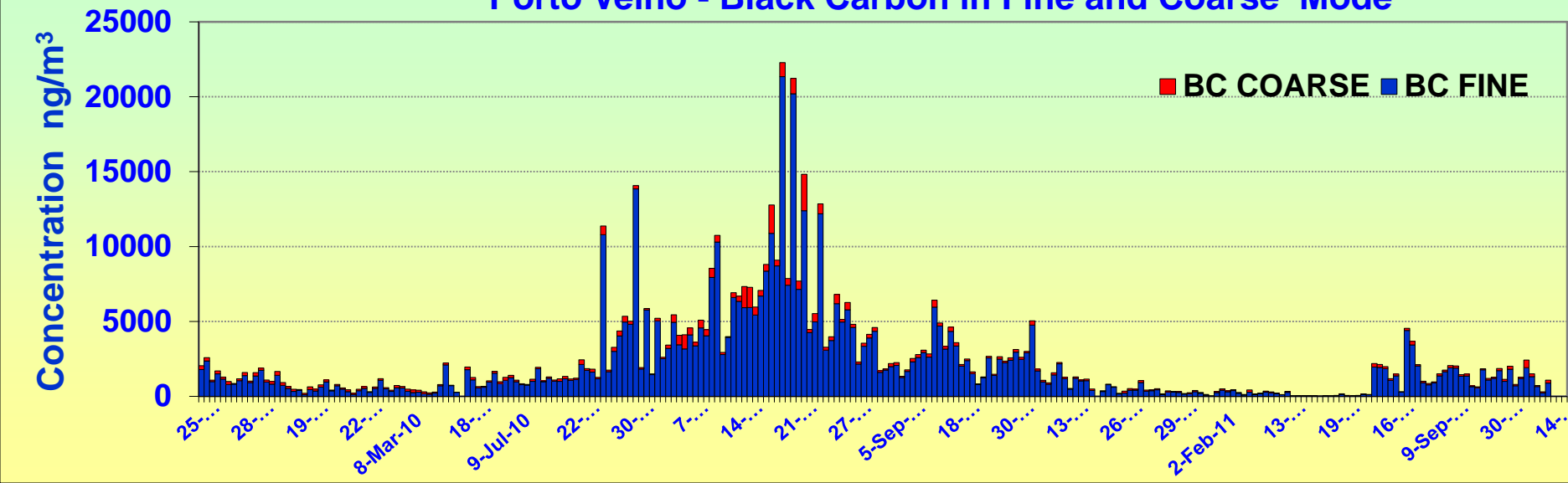
SFU - Black Carbon Concentration



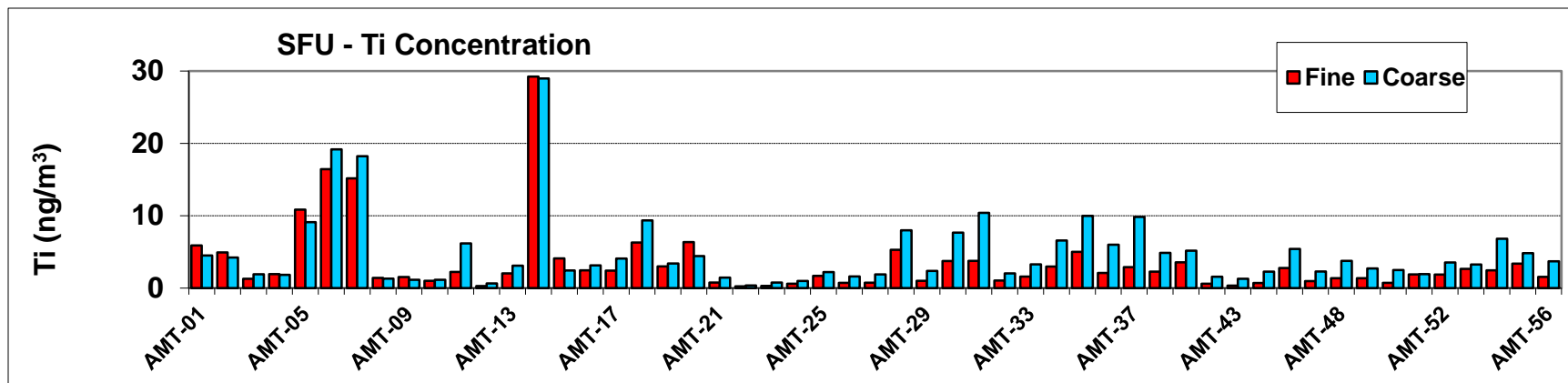
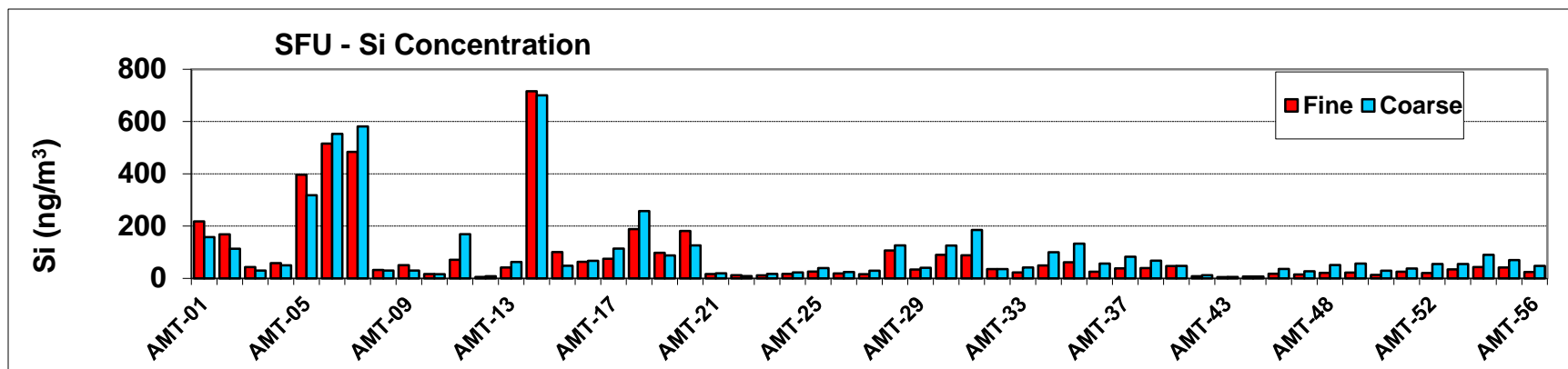
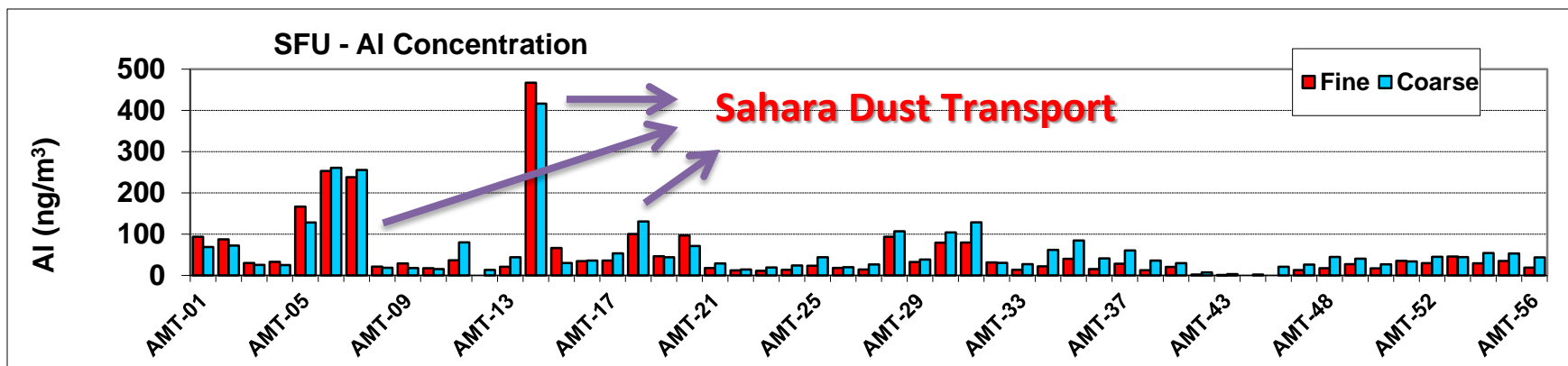
Porto Velho - SFU: Fine and Coarse mode aerosol



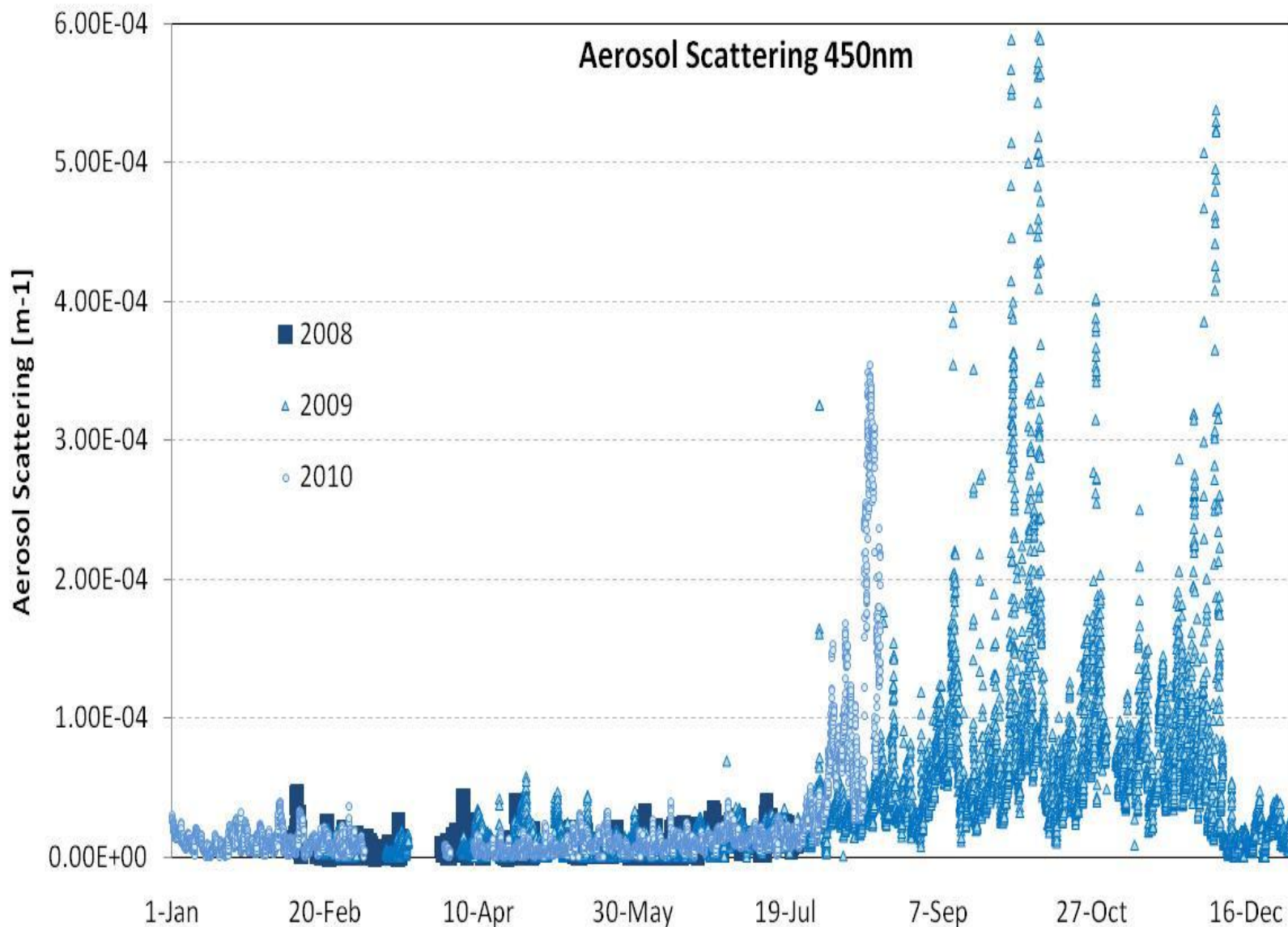
Porto Velho - Black Carbon in Fine and Coarse Mode



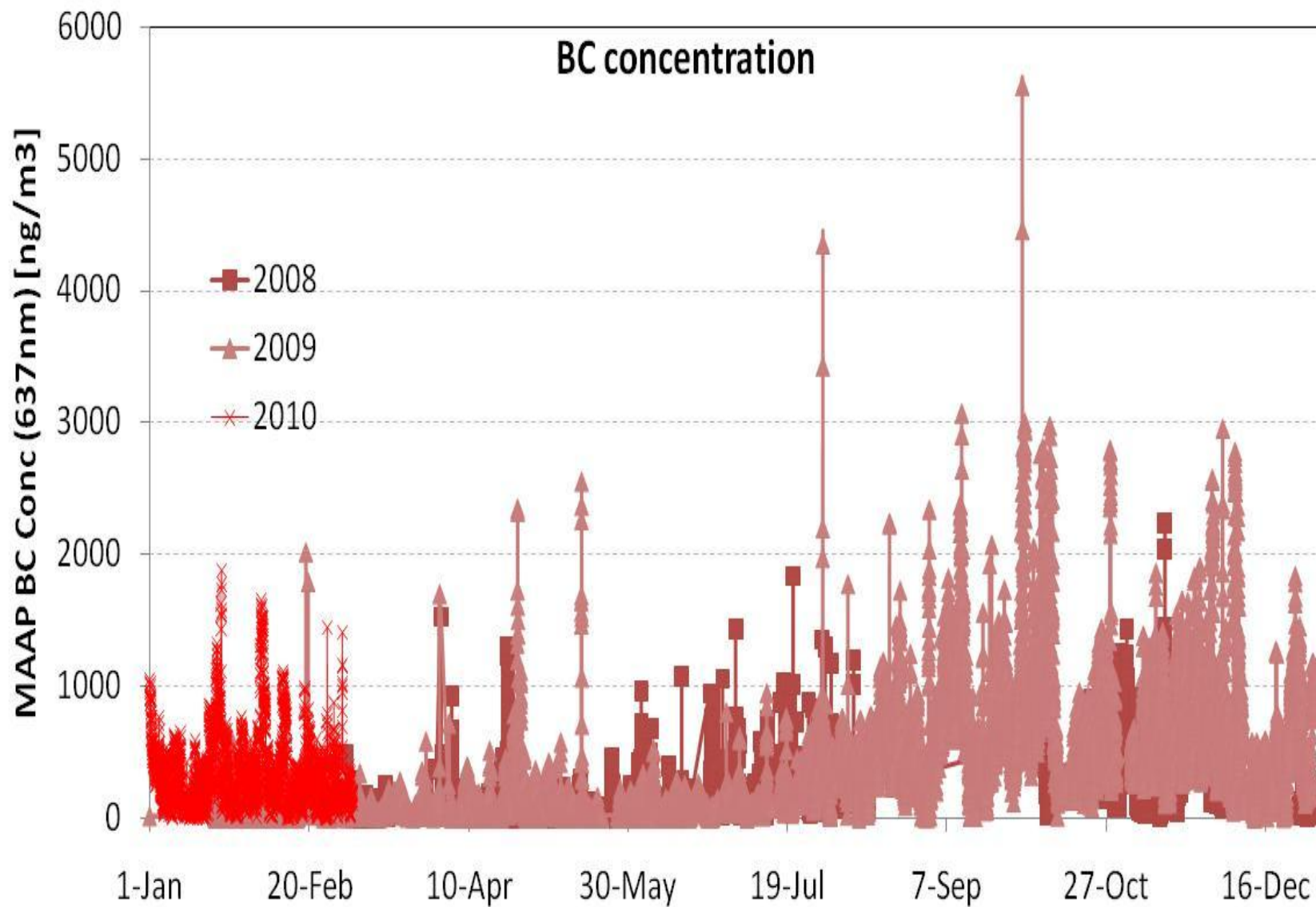
Al, Si and Ti elemental Concentration for fine and coarse mode aerosols Feb. to September

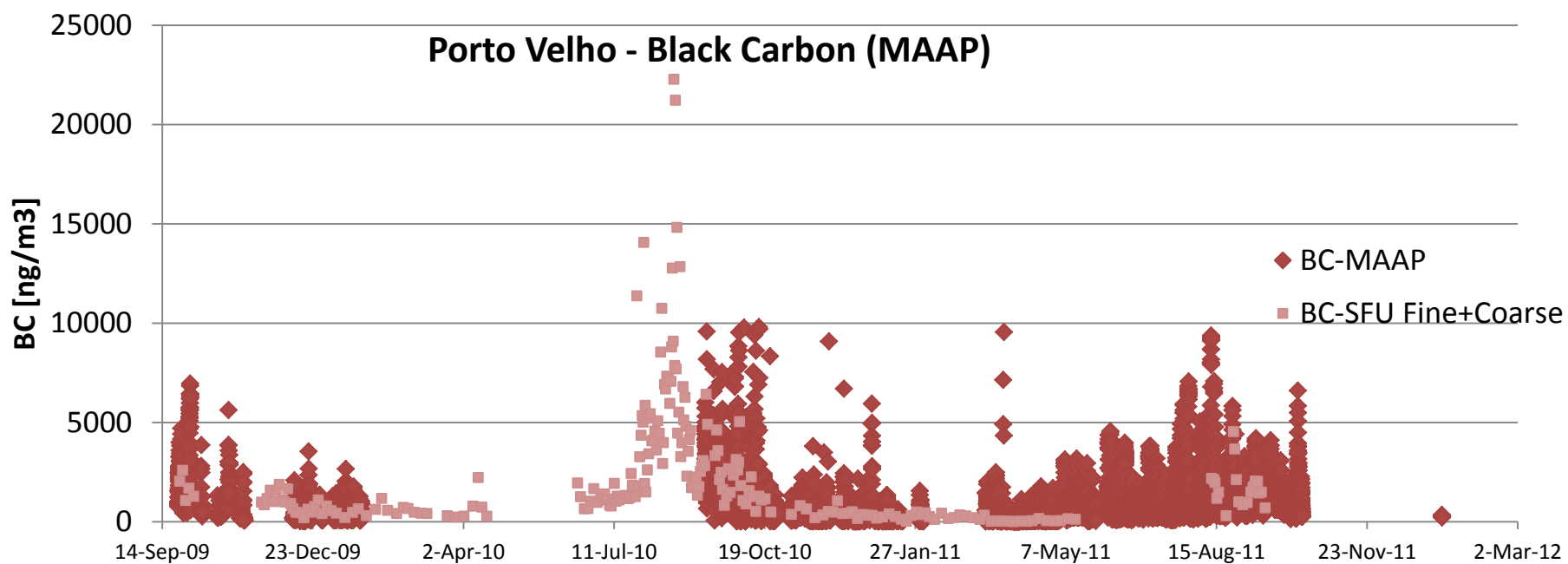
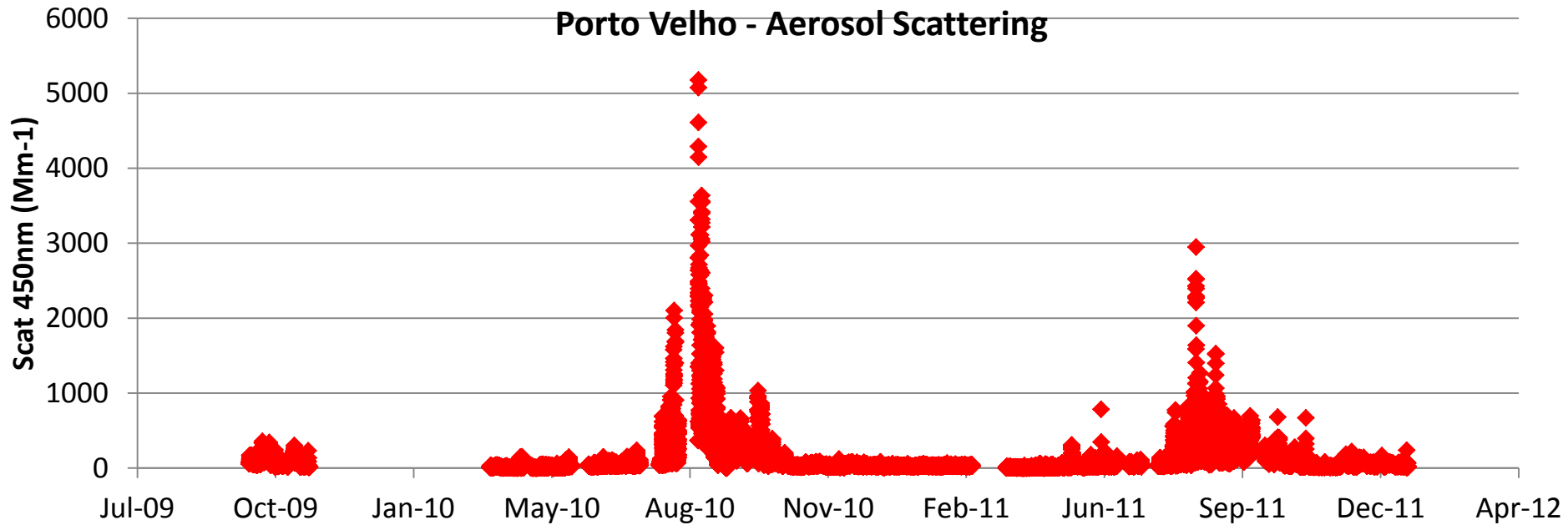


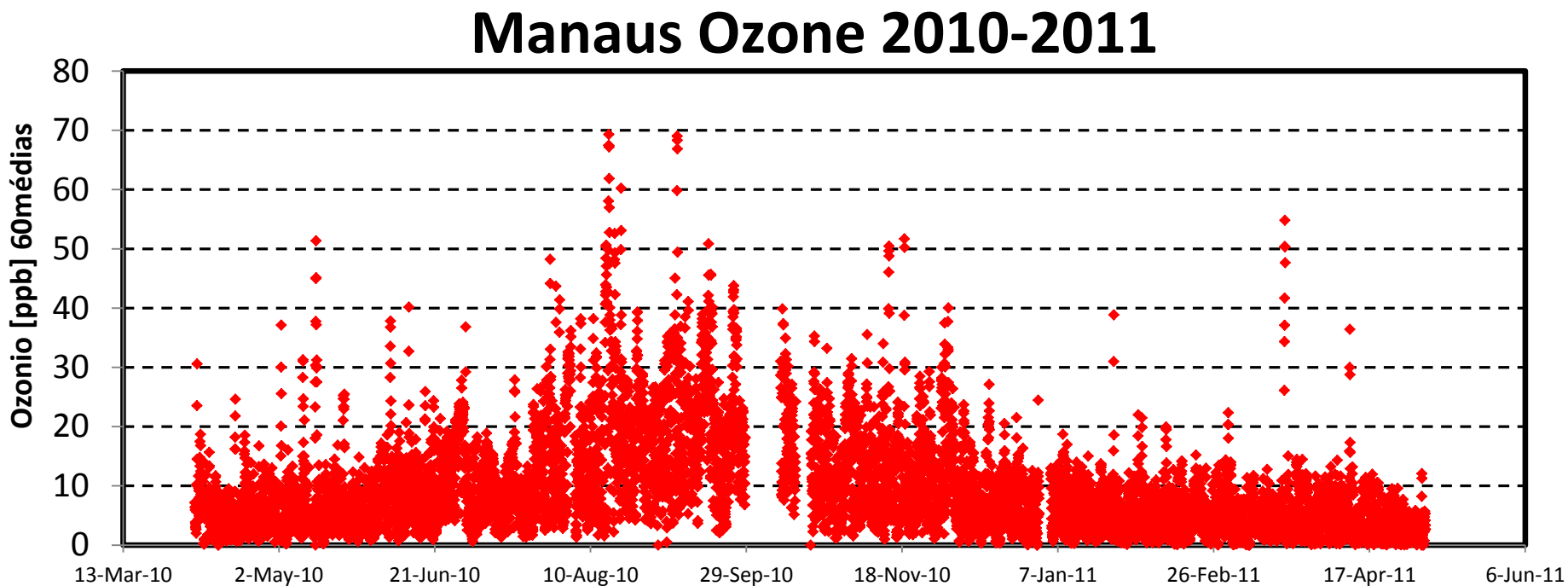
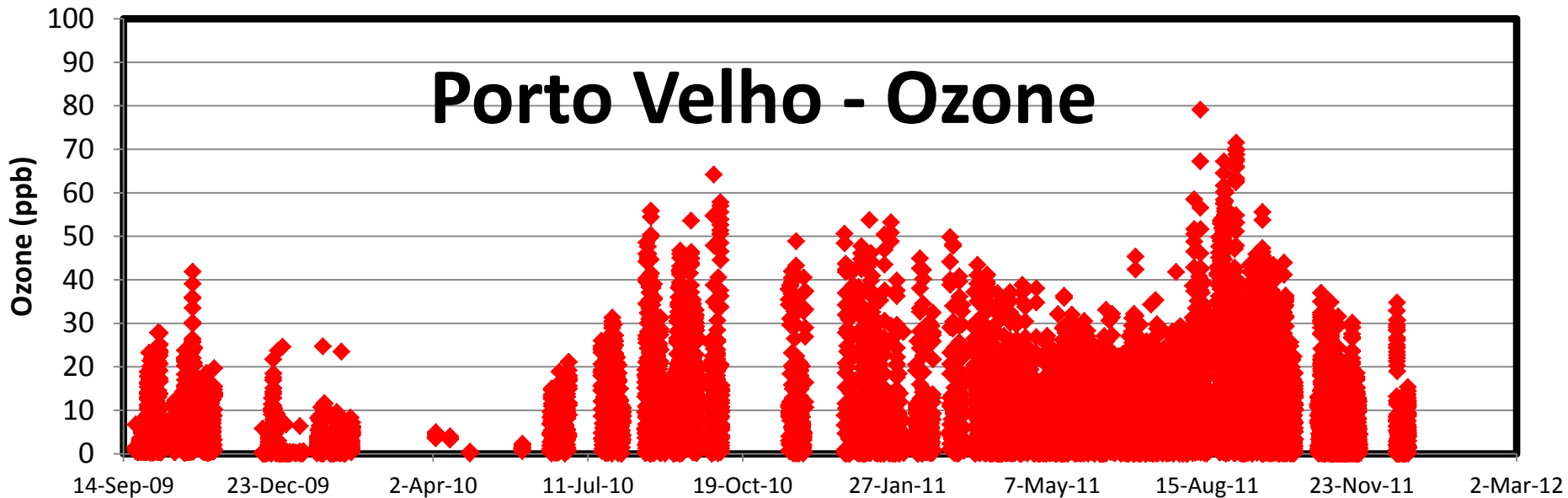
Manaus aerosol light scattering TSI Nephelometer 2008-2010



Manaus aerosol light absorption at 637 nm MAAP 2008-2010

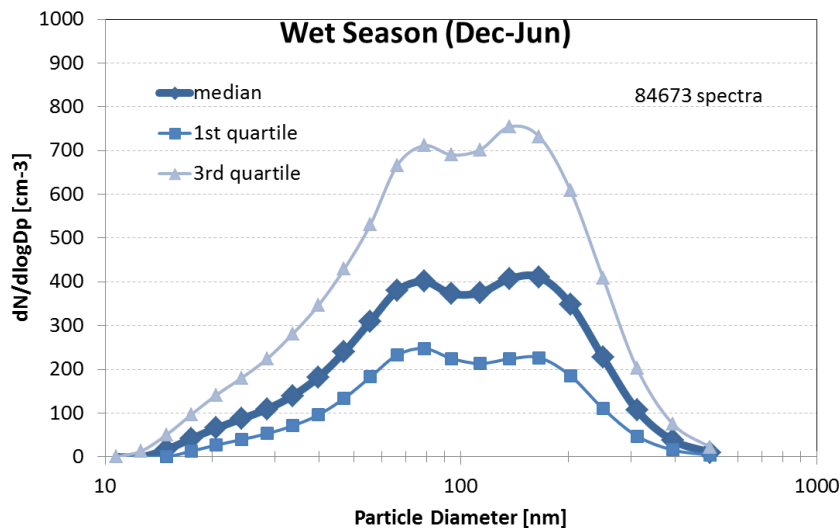




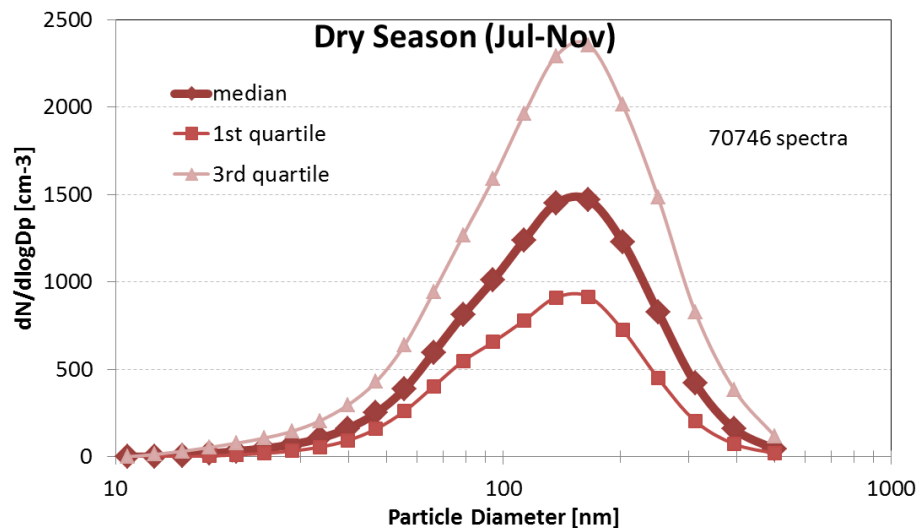


Amazonian aerosol size distributions 2008-2010

Wet season



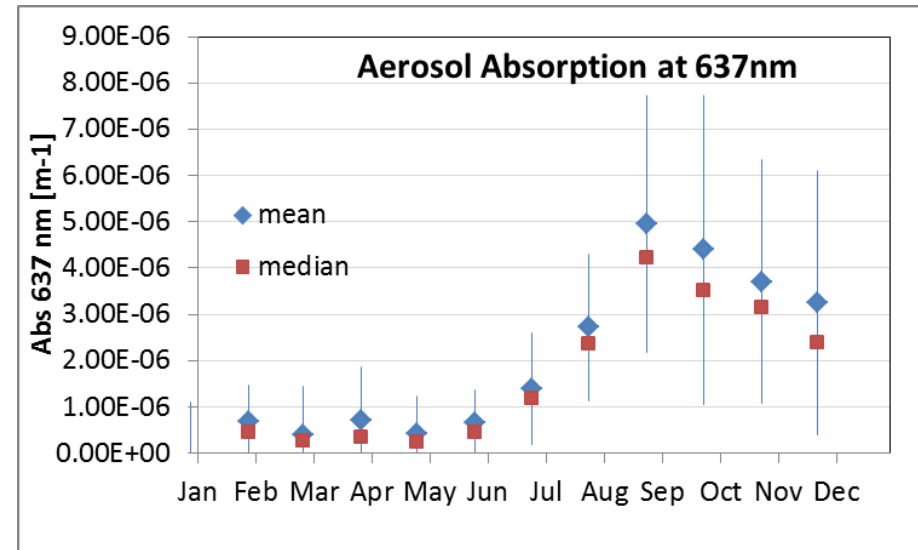
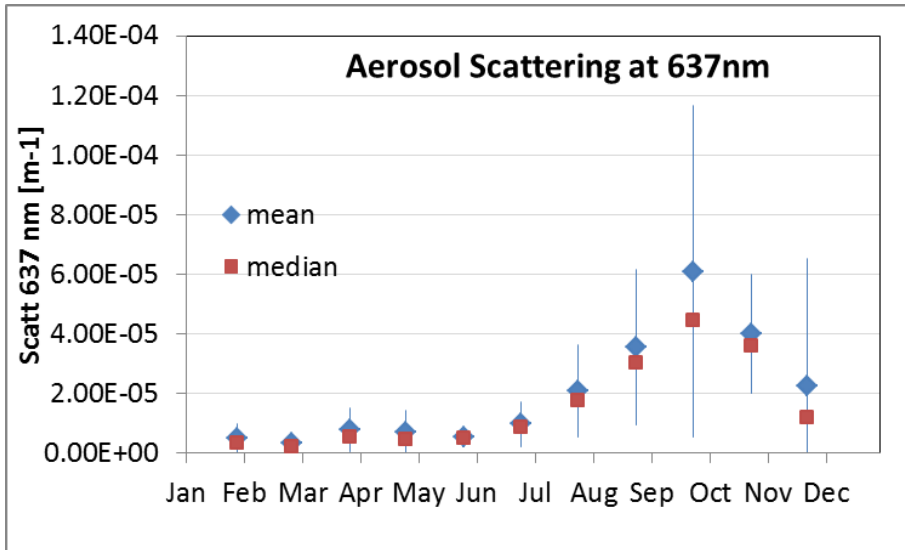
Dry season



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

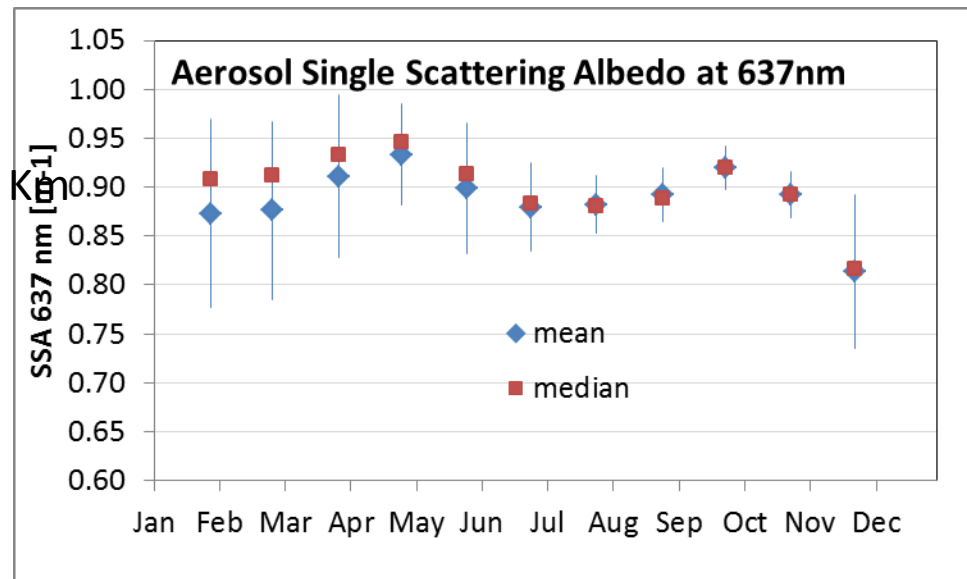
Monthly average optical properties



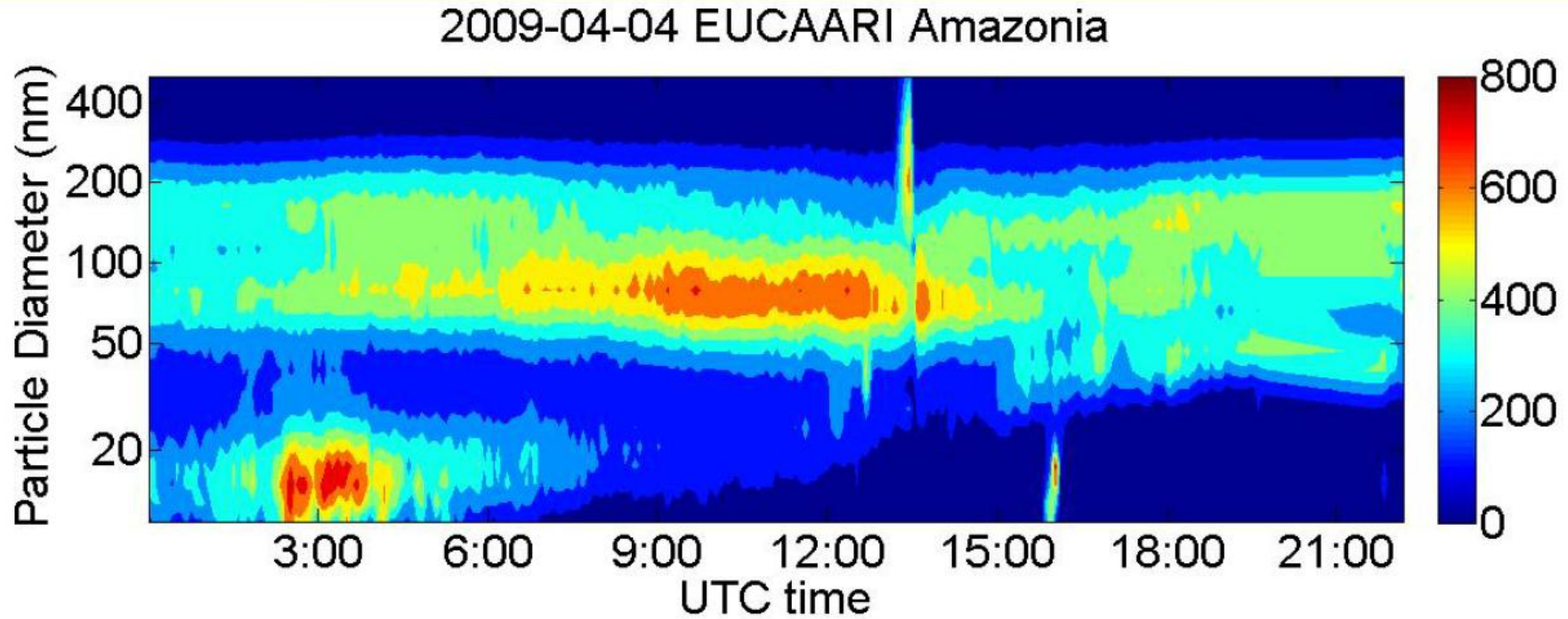
Single scattering albedo

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.

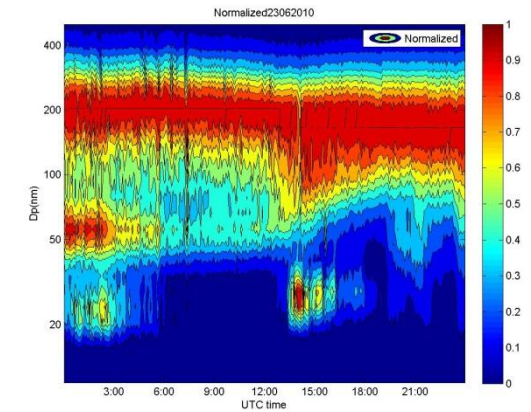
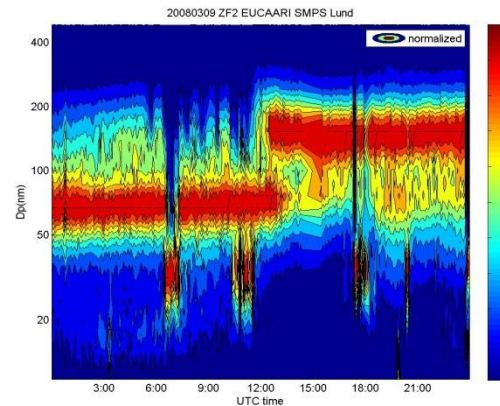
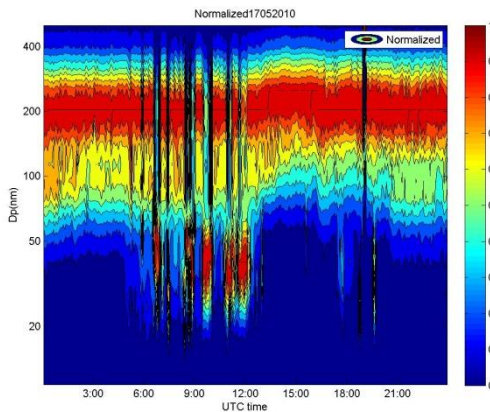
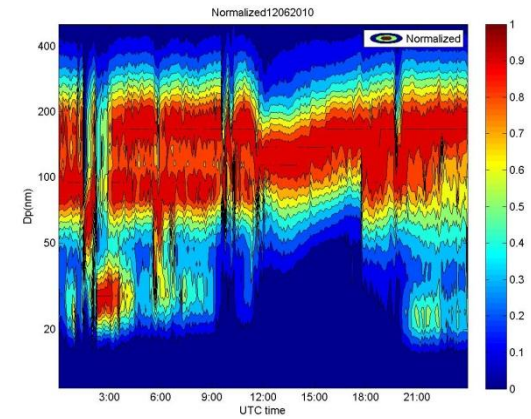
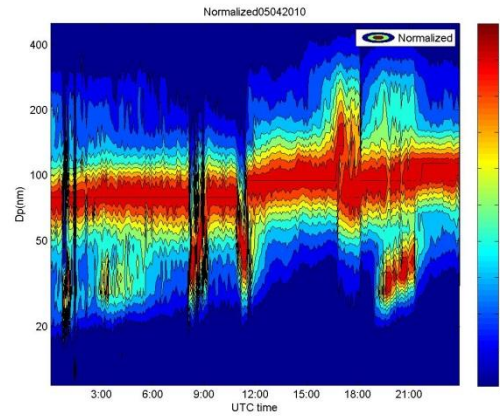
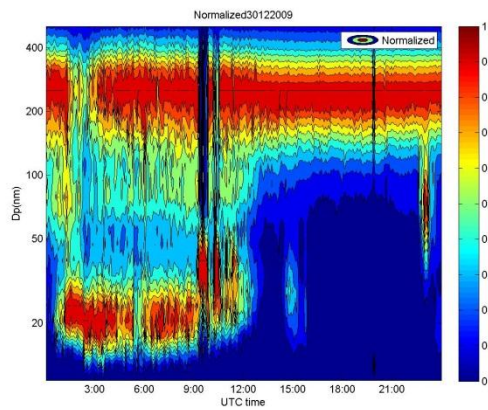


Aerosol size distributions measured in 2009 Apr 4th. There was a burst of ultrafine particles from 2:00 to 4:00 UTC time.

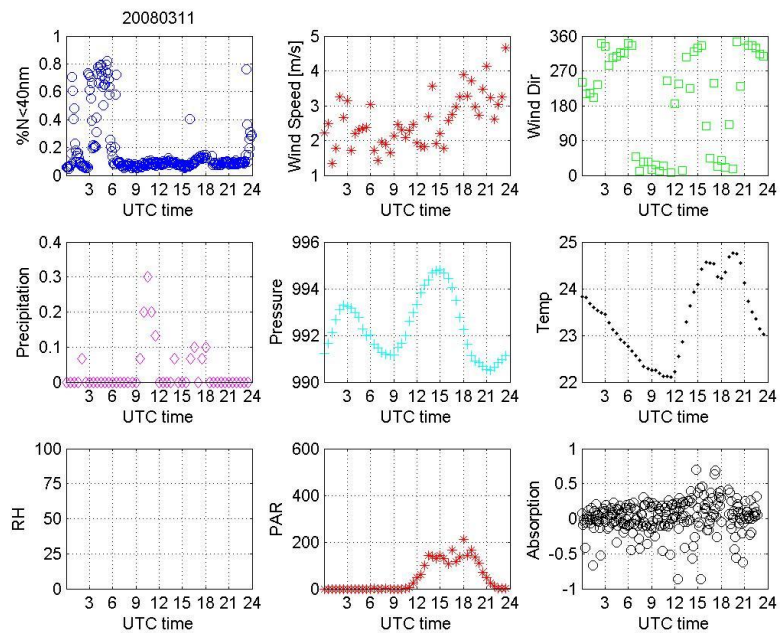
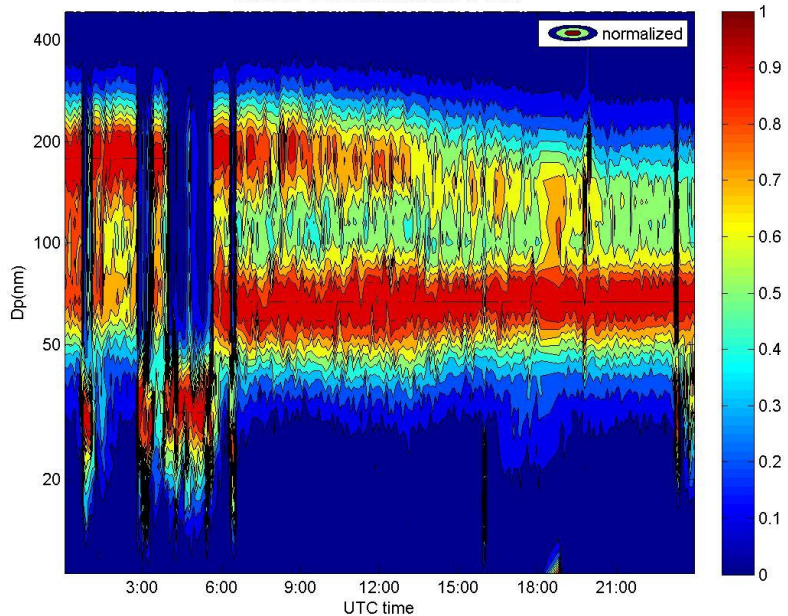
New particle formation and subsequent growth was seldom observed along two years of measurements. Nevertheless, in 70% of the days, bursts of particles with diameters in the range 10-40nm were detected. The events usually lasted from 20 to 120min, and the subsequent growth to larger sizes was not always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

Particle production at about 20 nm

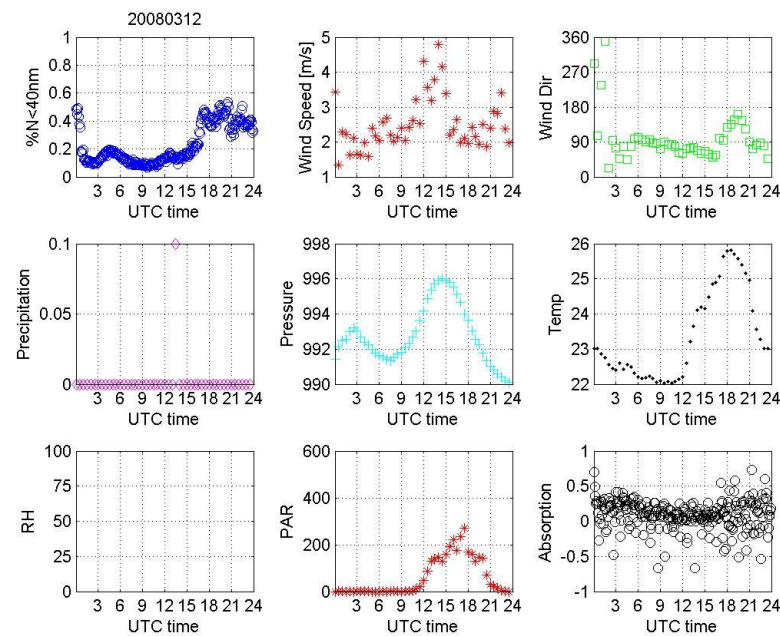
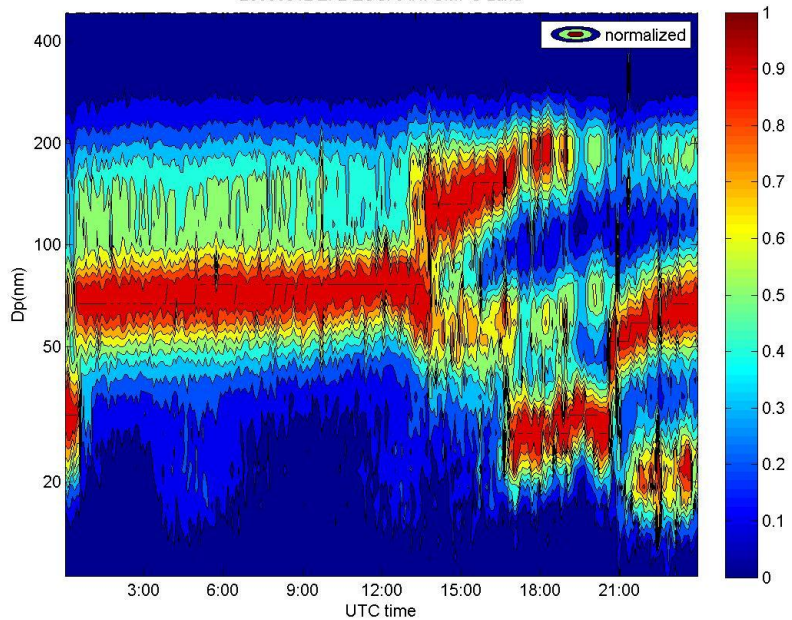
Which biological process is responsible for this new particle formation?



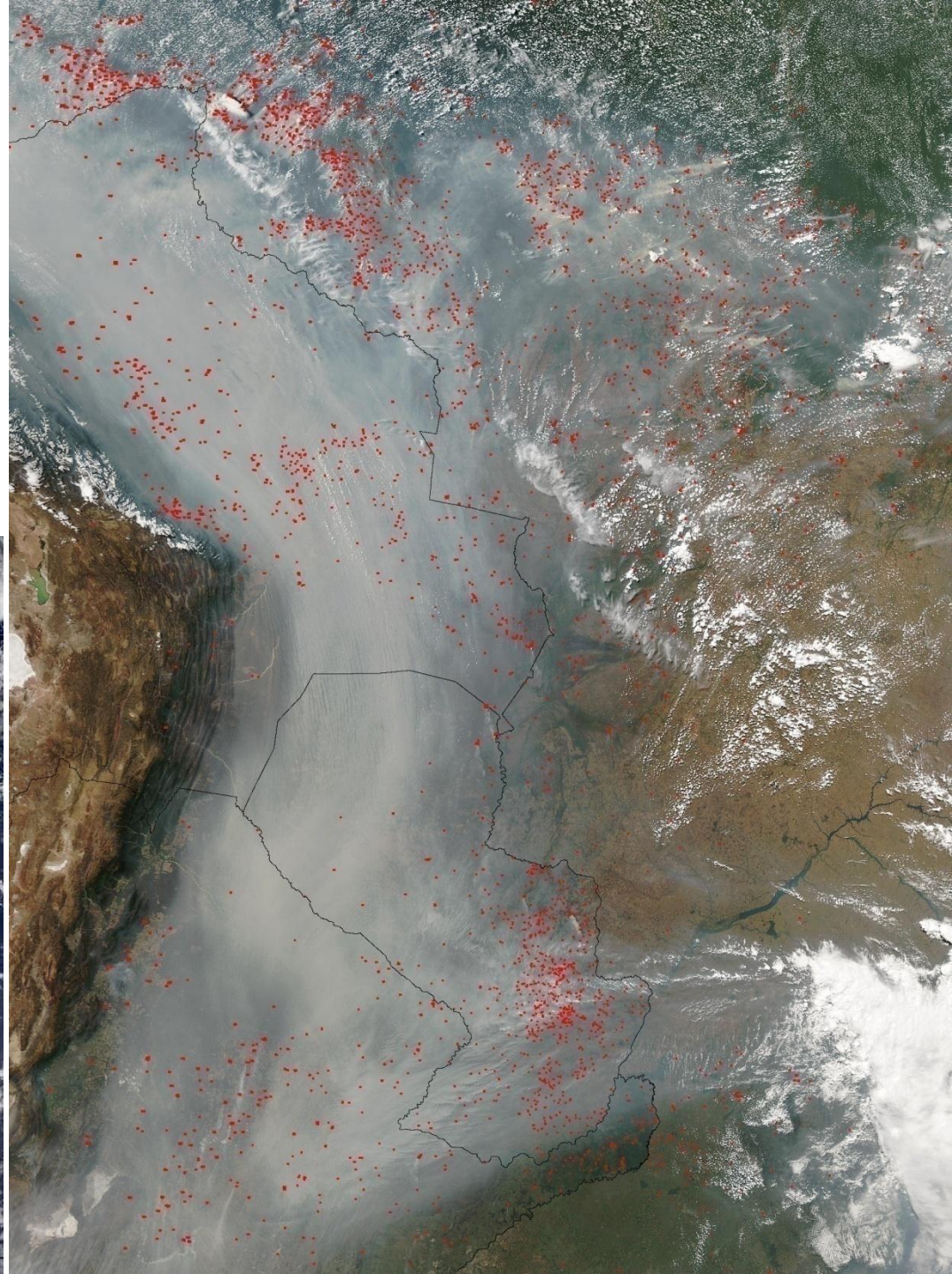
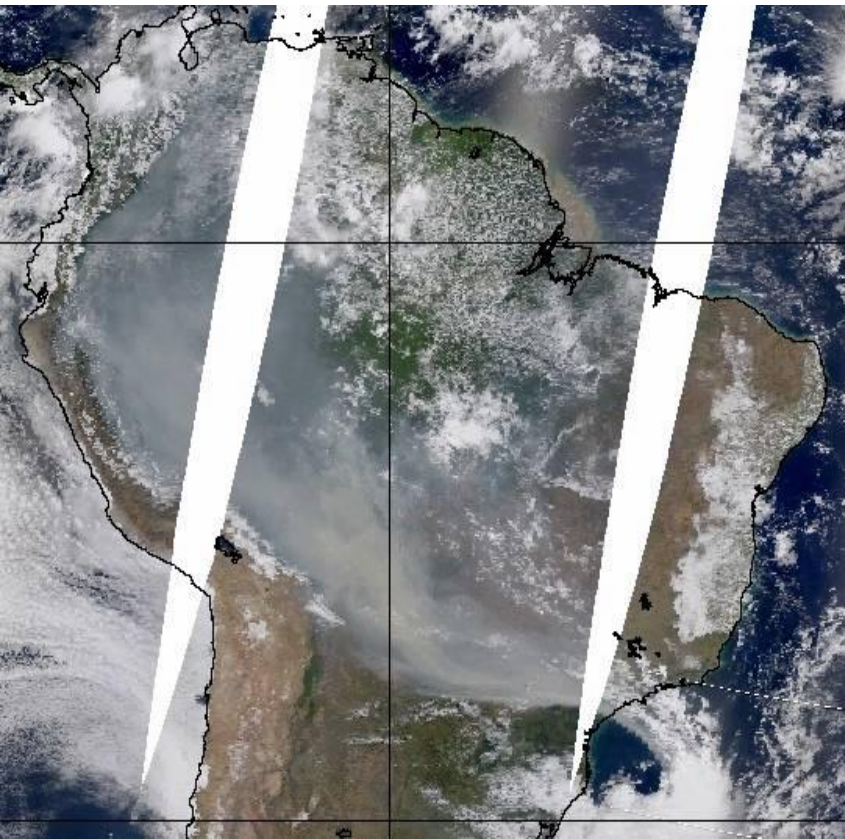
20080311 ZF2 EUCAARI SMPS Lund



20080312 ZF2 EUCAARI SMPS Lund



Large scale distribution of biomass burning aerosols in South America

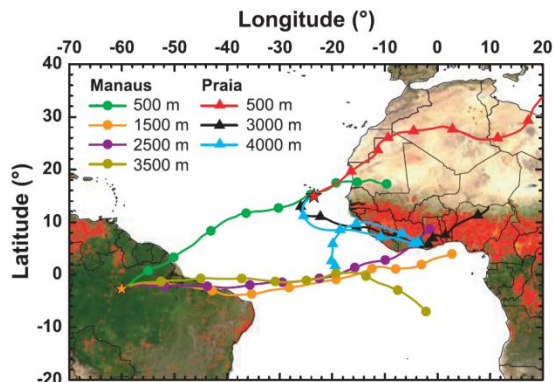


Raman Lidar observations of aerosols on Cape Verde and Manaus

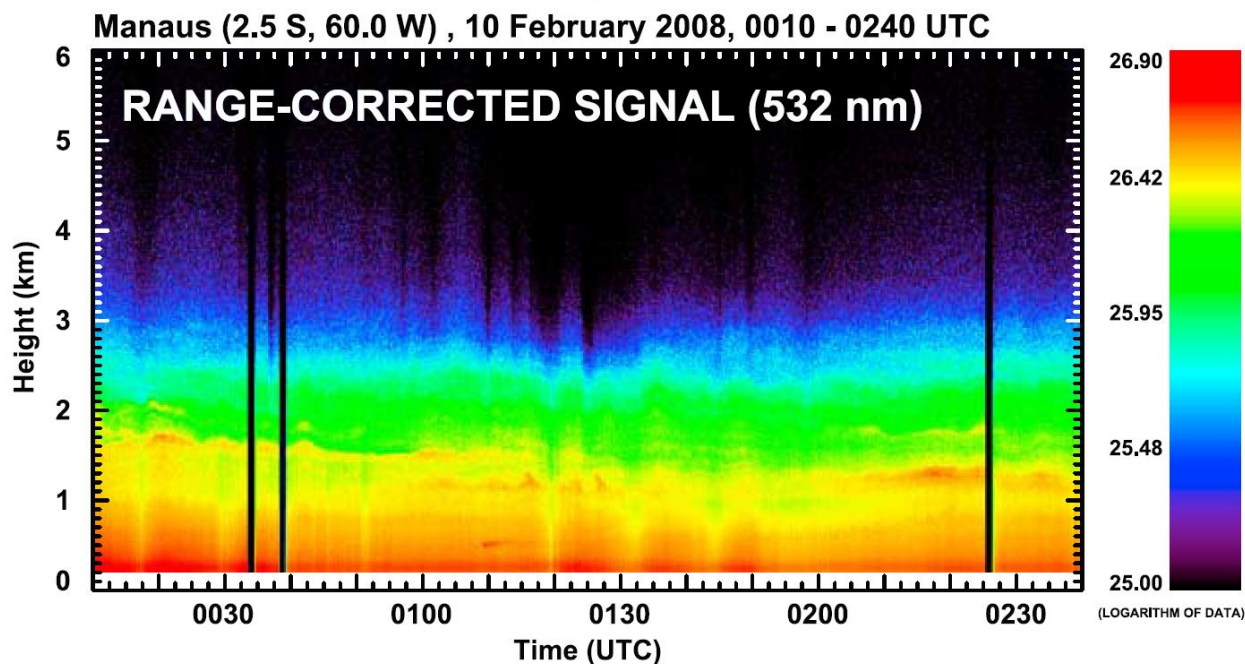
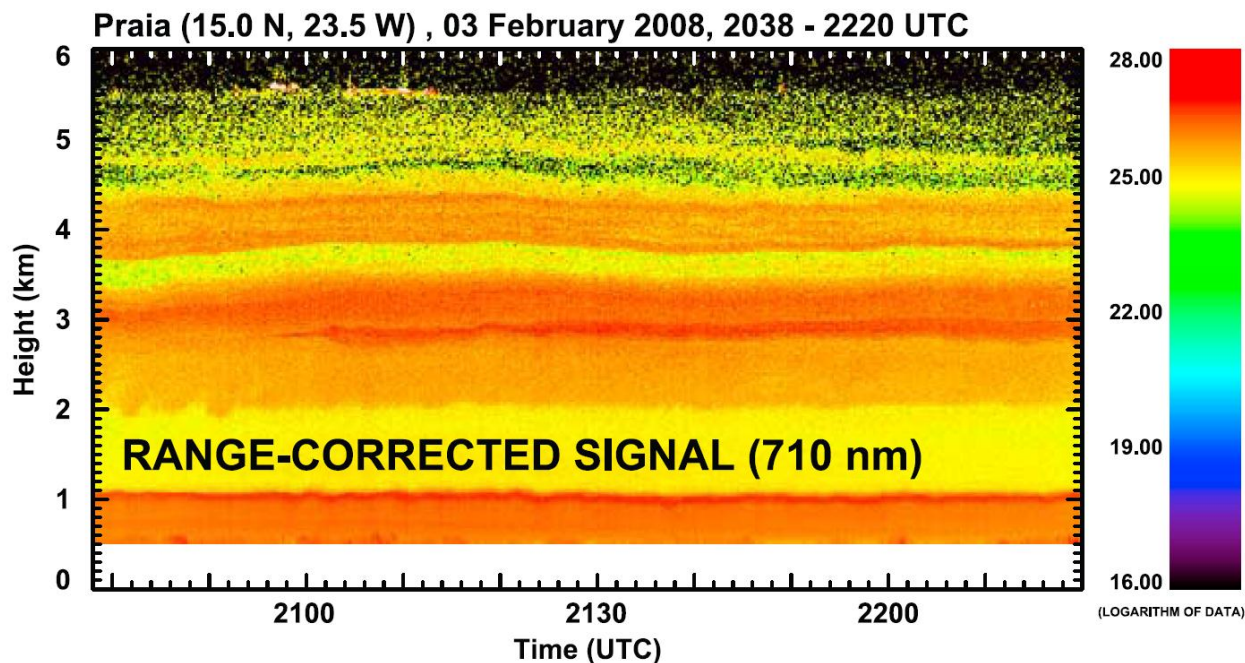
Range-corrected lidar signals

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)



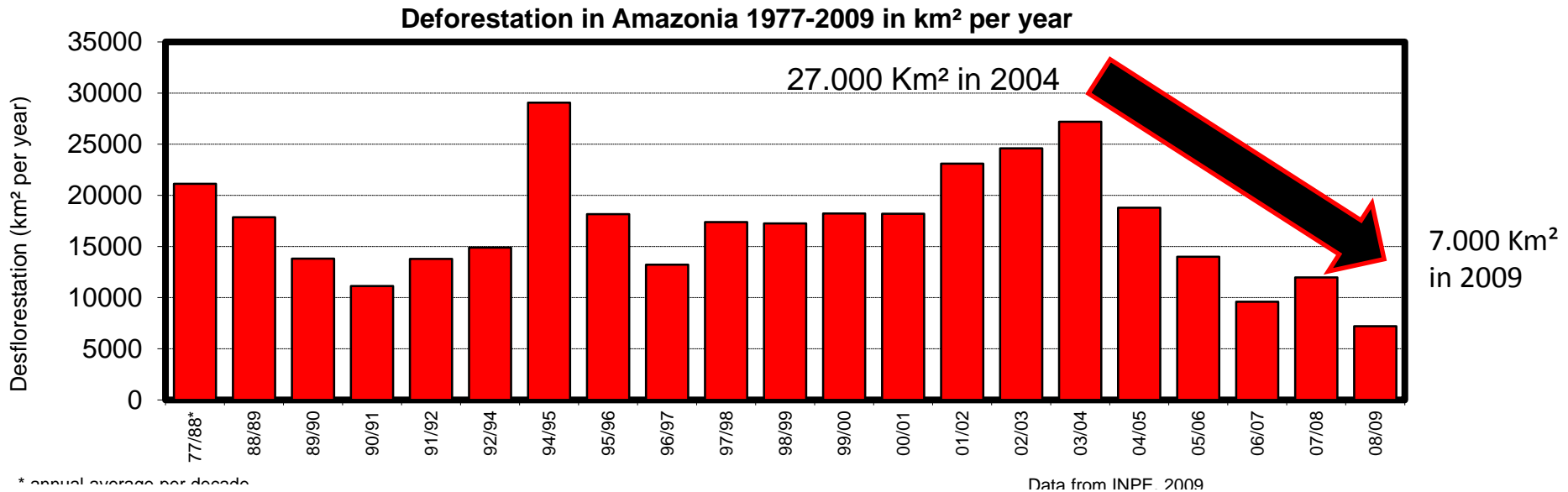
Ansmann et al., GRL 2009





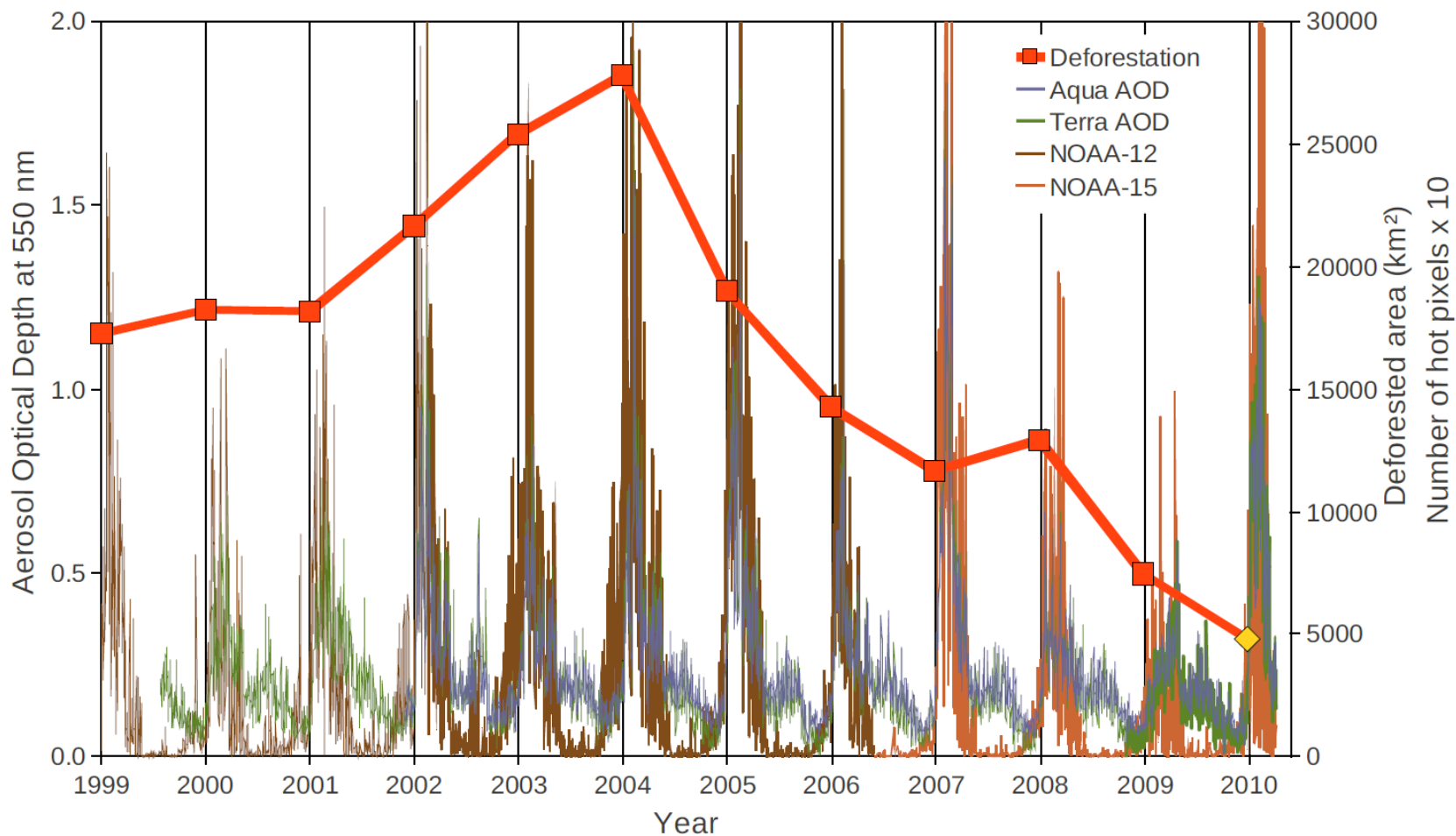
Deforestation was reduced from 27,000 Km² in 2004 to 7,000 Km² in 2009.

How much aerosols were reduced?



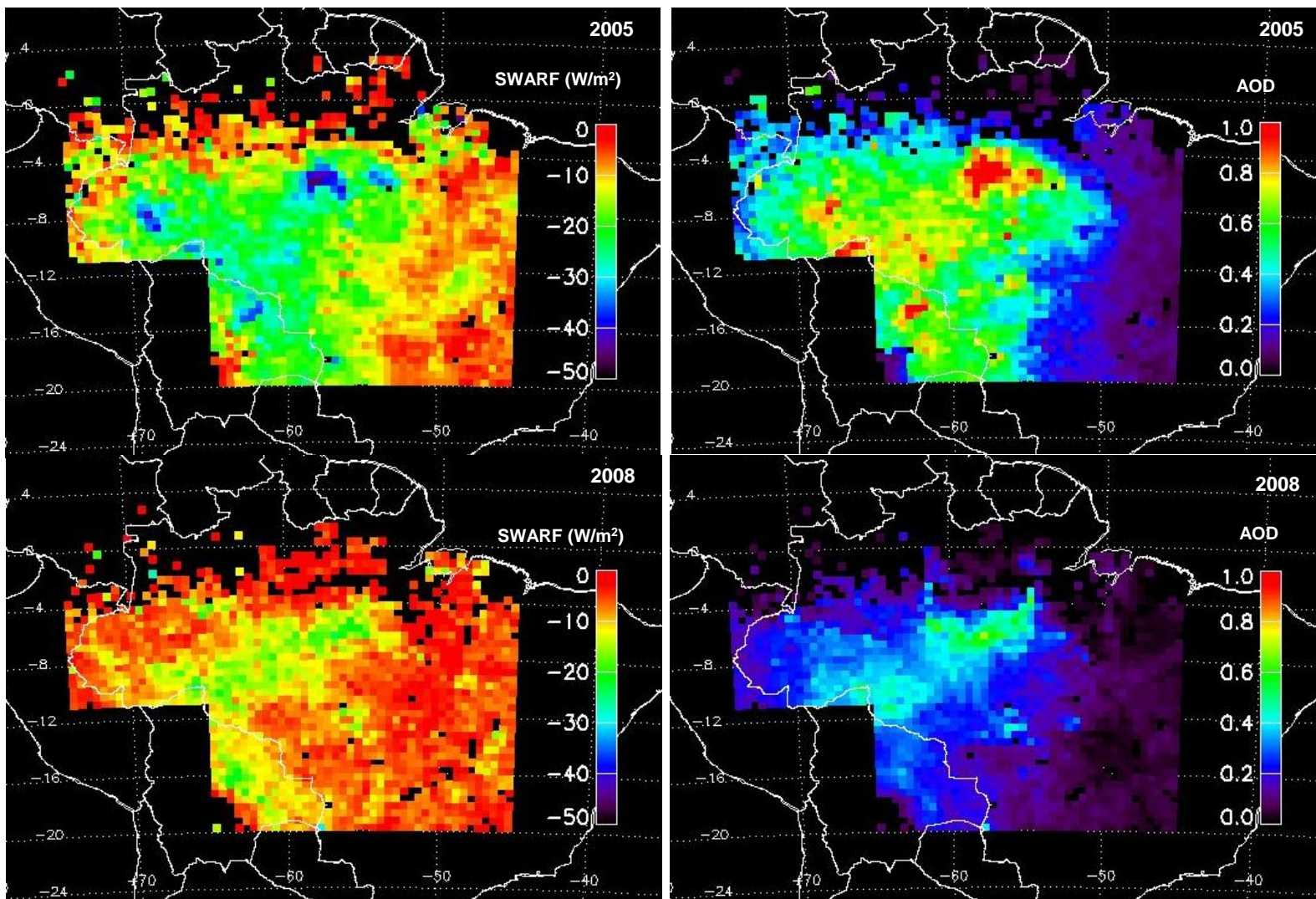
What public policies are needed to sustain this reduction?

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.

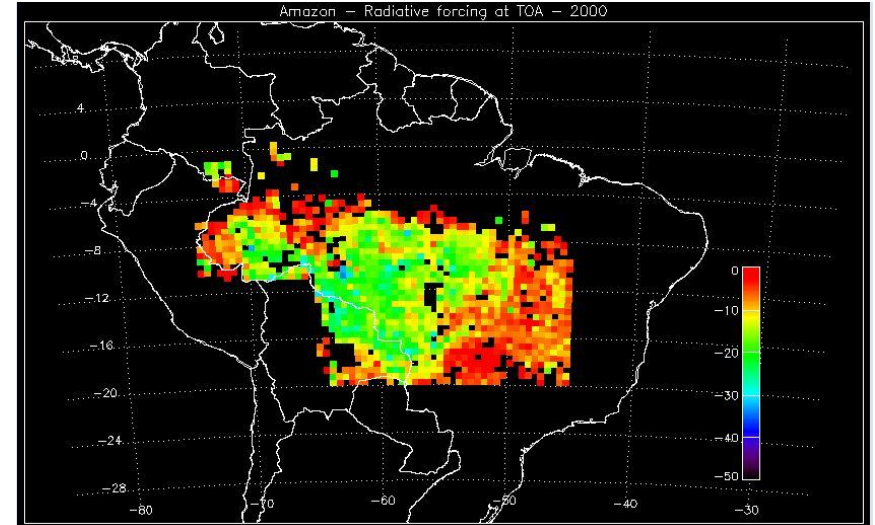
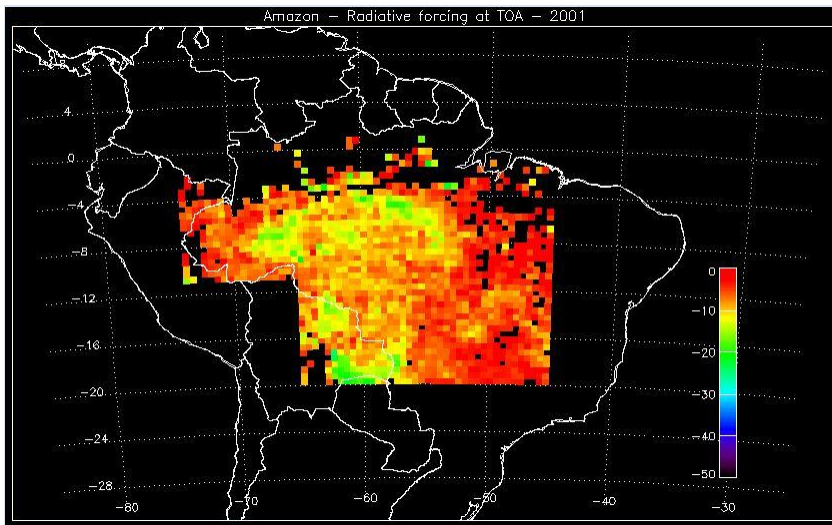
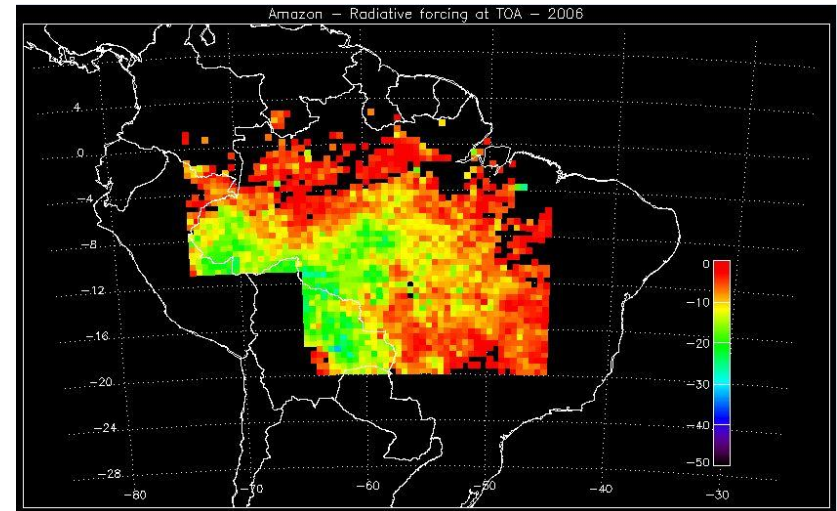
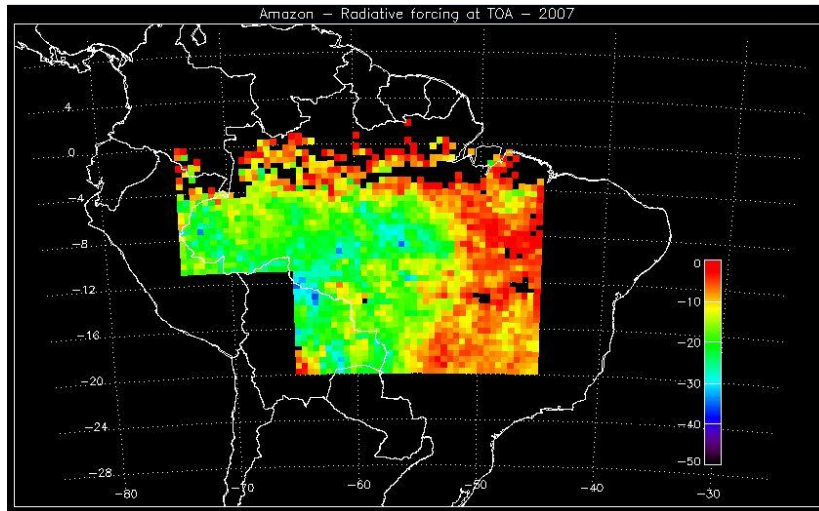
Examples of the spatial distribution of the SWARF at TOA



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



Clouds and rain are made of 3 basic ingredients:

Water Vapor

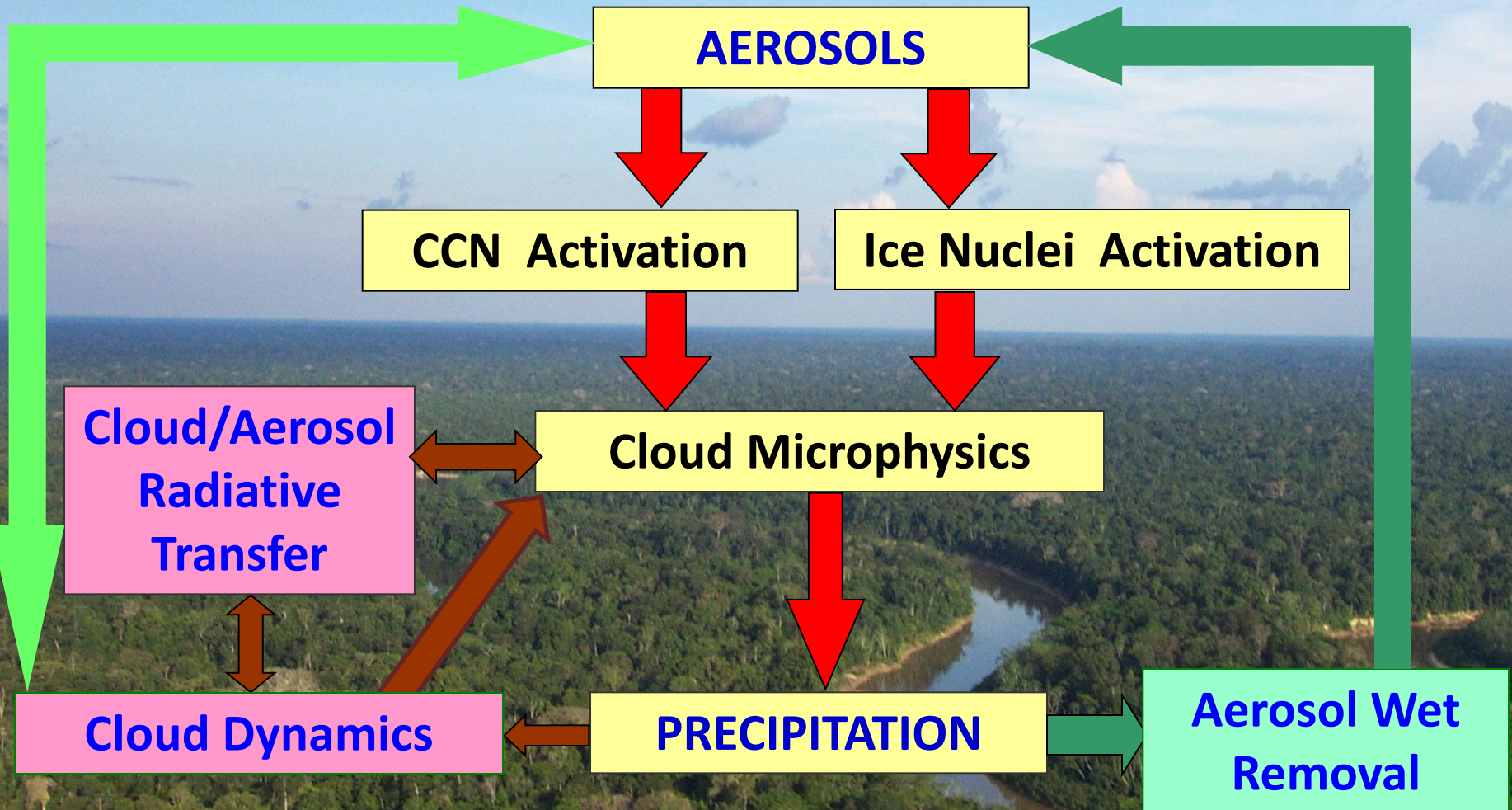
**Aerosol particle acting as a Cloud
Condensation Nuclei**

**Thermodynamic conditions of
the atmosphere**

Highly non-linear processes

Aerosol-cloud-precipitation feedbacks

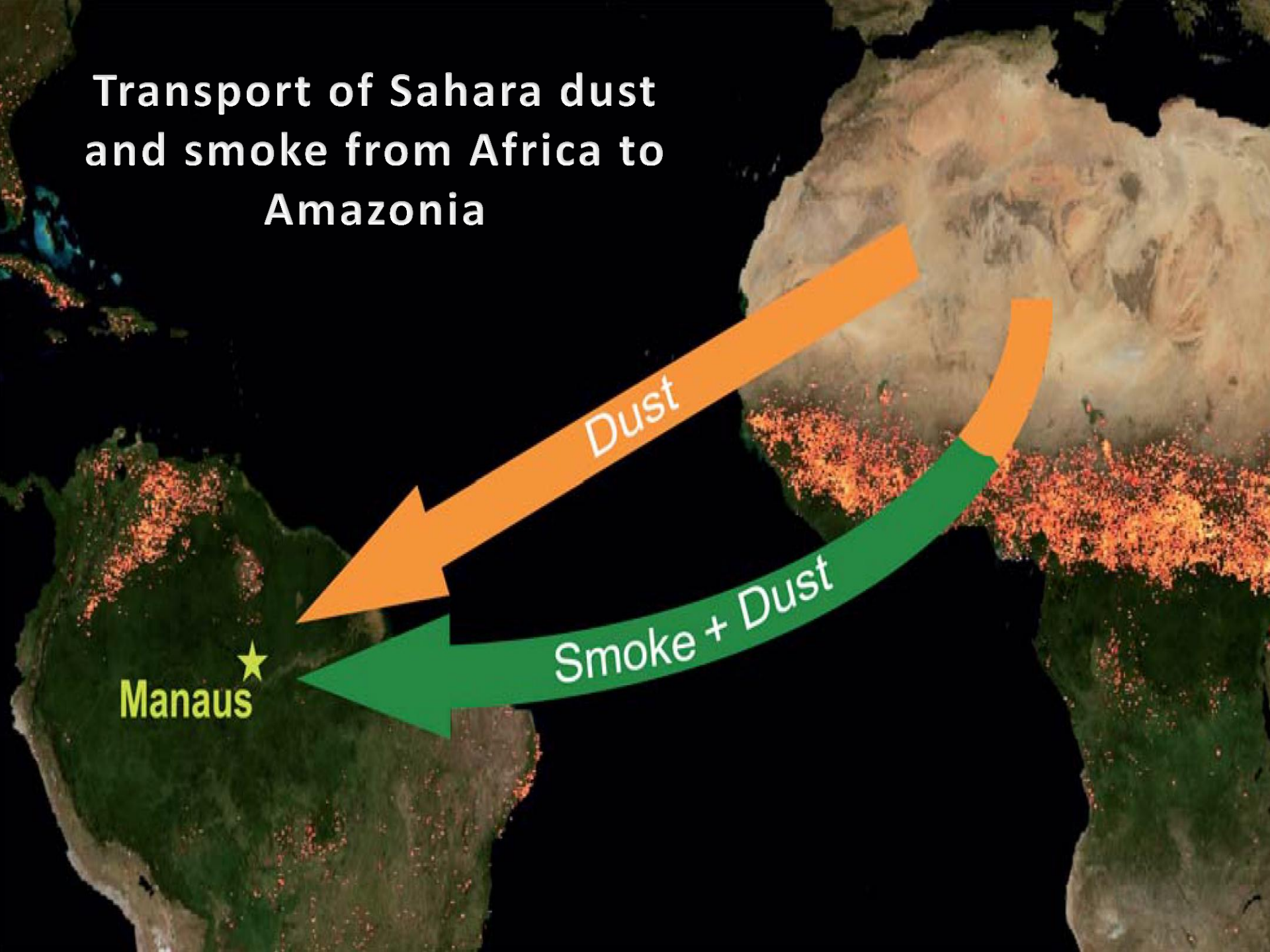
CCN = cloud condensation nuclei and IN = ice nuclei.



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.

Transport of Sahara dust and smoke from Africa to Amazonia



Dust

Smoke + Dust

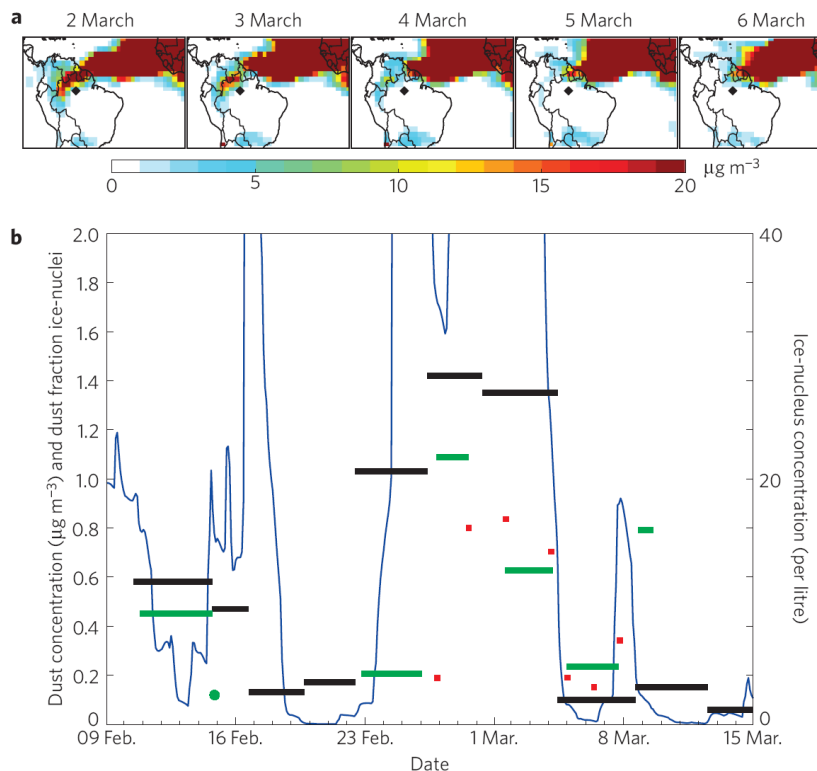
Manaus

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

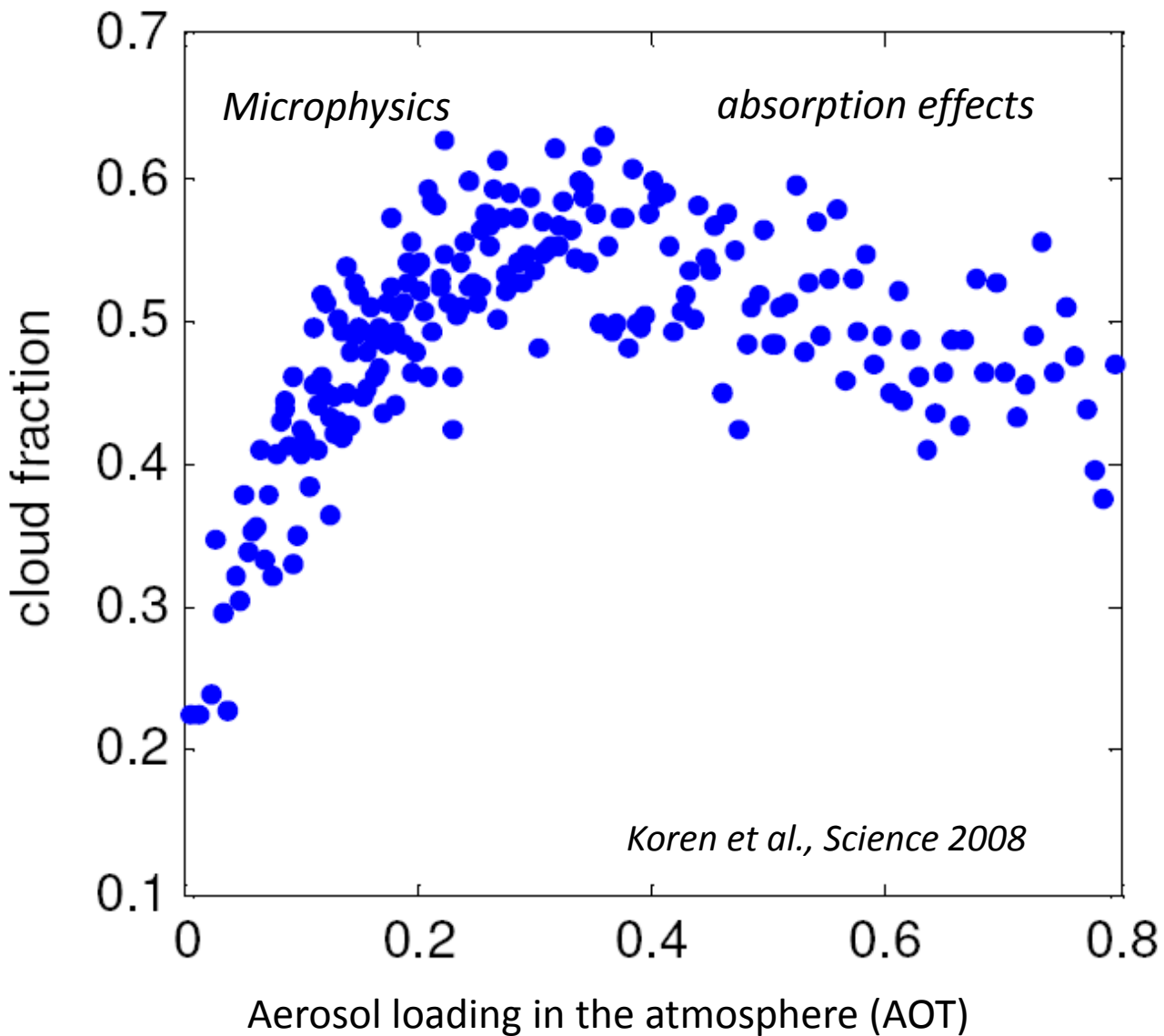
Anthony J. Prenni^{1*}, Markus D. Petters¹, Sonia M. Kreidenweis¹, Colette L. Heald¹, Scot T. Martin², Paulo Artaxo³, Rebecca M. Garland⁴, Adam G. Wollny⁴ and Ulrich Pöschl⁴

Ice nuclei from biogenic emissions and Sahara dust in Central Amazonia

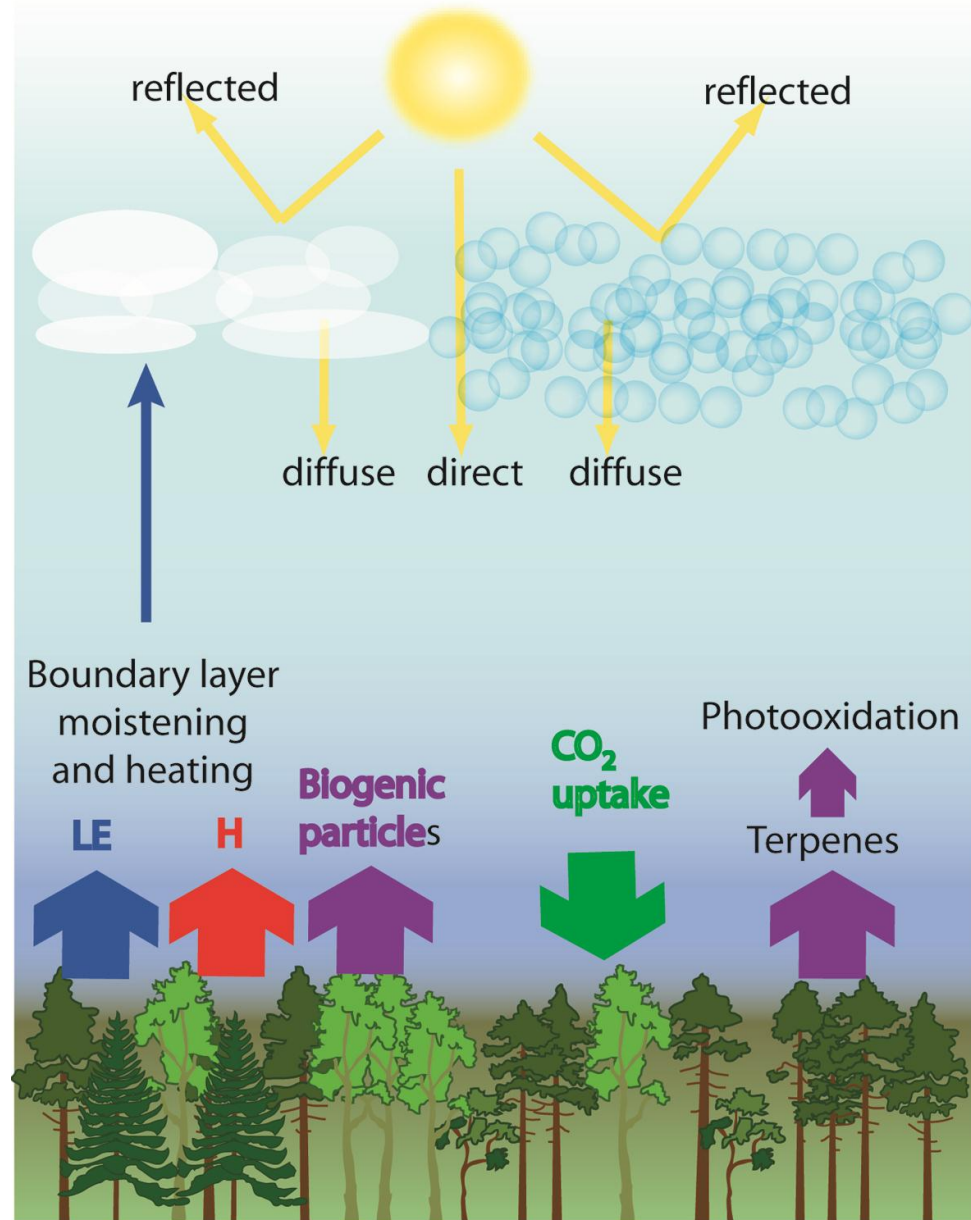
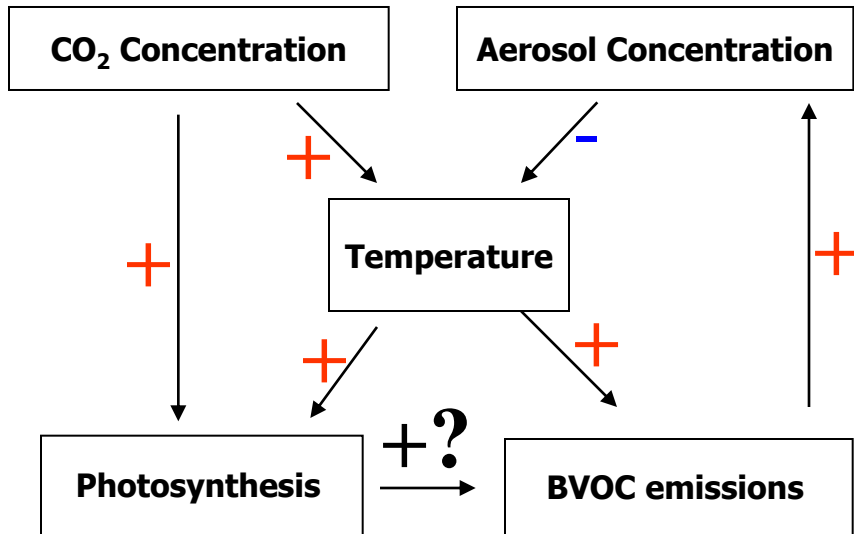
Dust relation to ice-nucleus measurements. Dust concentrations during AMAZE-08. a, GEOS-Chem simulated dust from 2–6 March at 18 UTC. The field site, shown as a black diamond, typically fell near the edge of the plumes. Fine-dust concentrations from PIXE measurements (black rectangles; $\mu\text{g}/\text{m}^3$, $d_p < 2\mu\text{m}$).



Relationships between cloud properties and aerosol loading in Amazonia

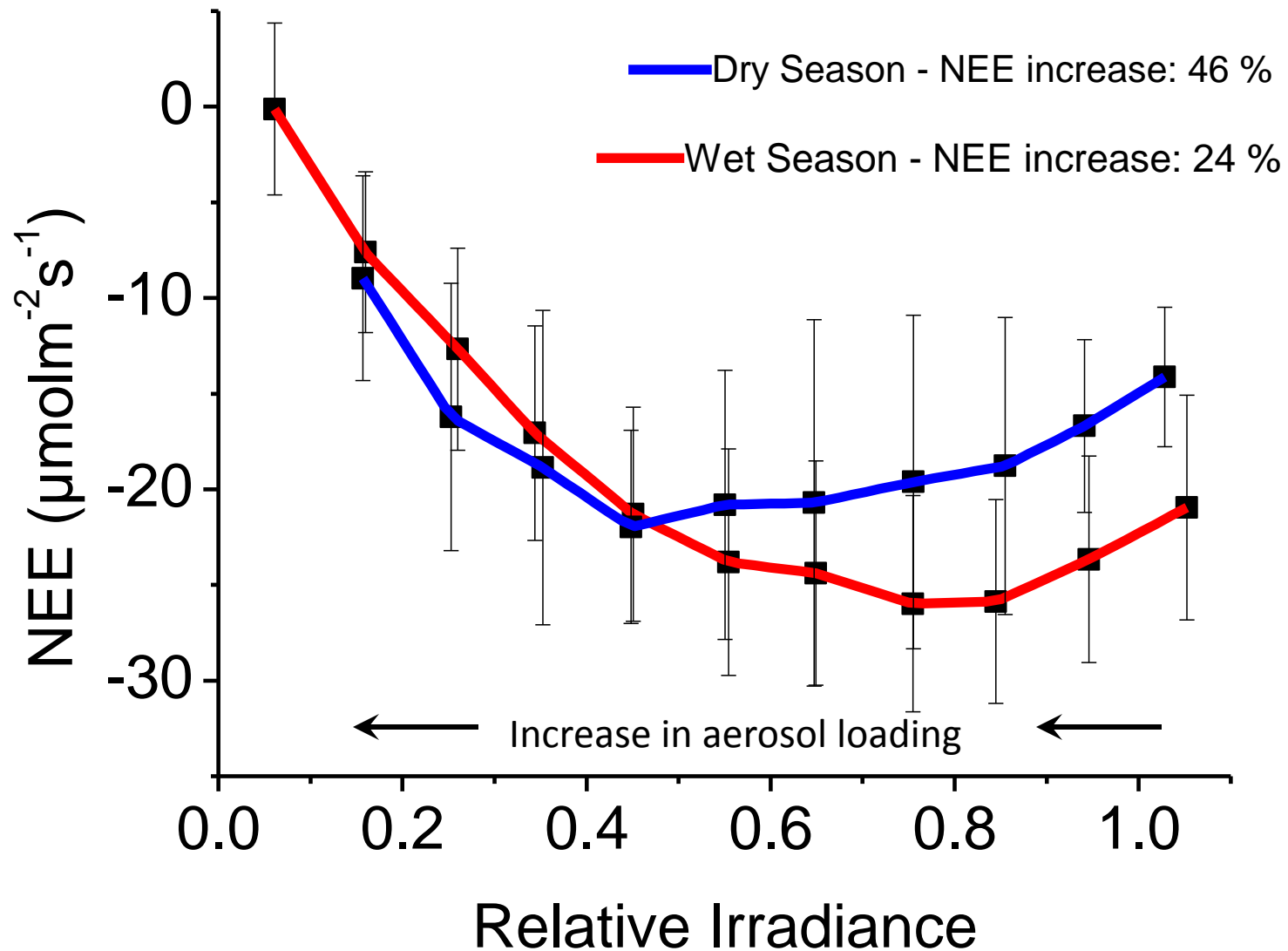


Aerosol effects on the Net Plant Productivity

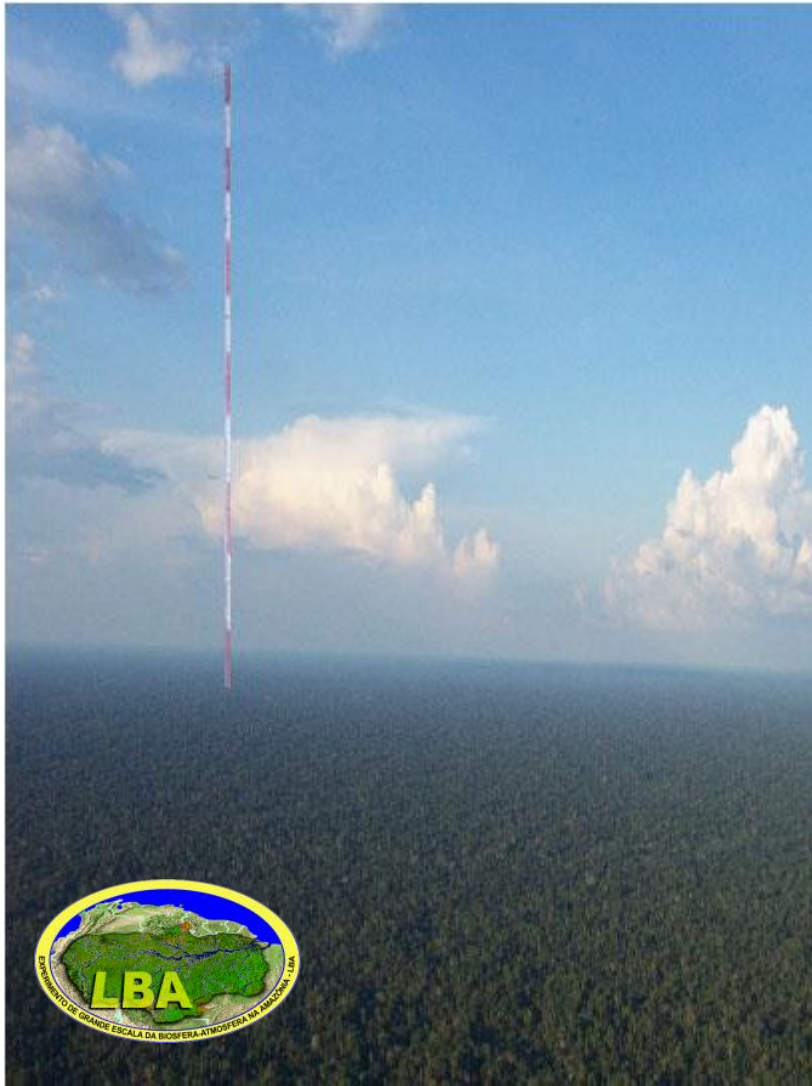


Strong aerosol effect on forest photosynthesis diffuse radiation have a large effect on CO₂ fluxes

Amazonia Rondonia Forest site 2000-2001



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.



Torre de
300 metros



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