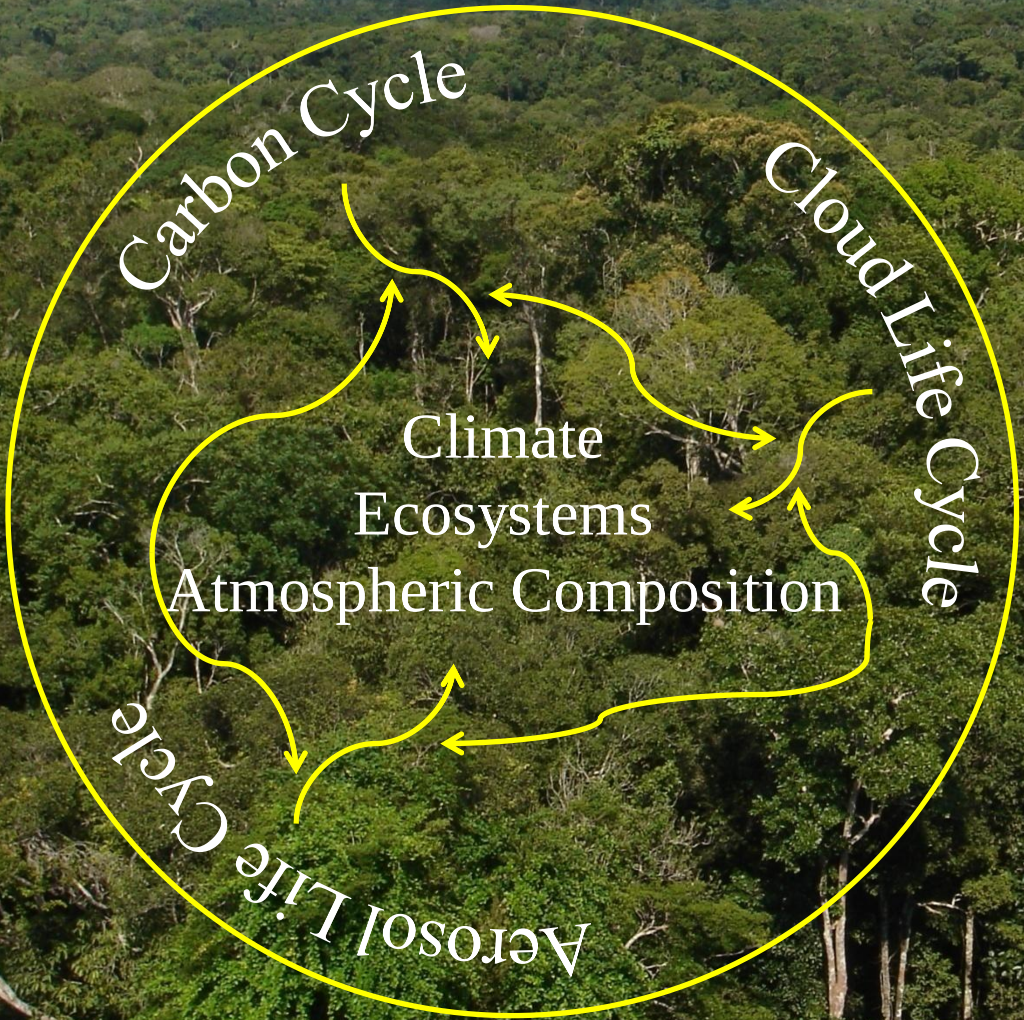
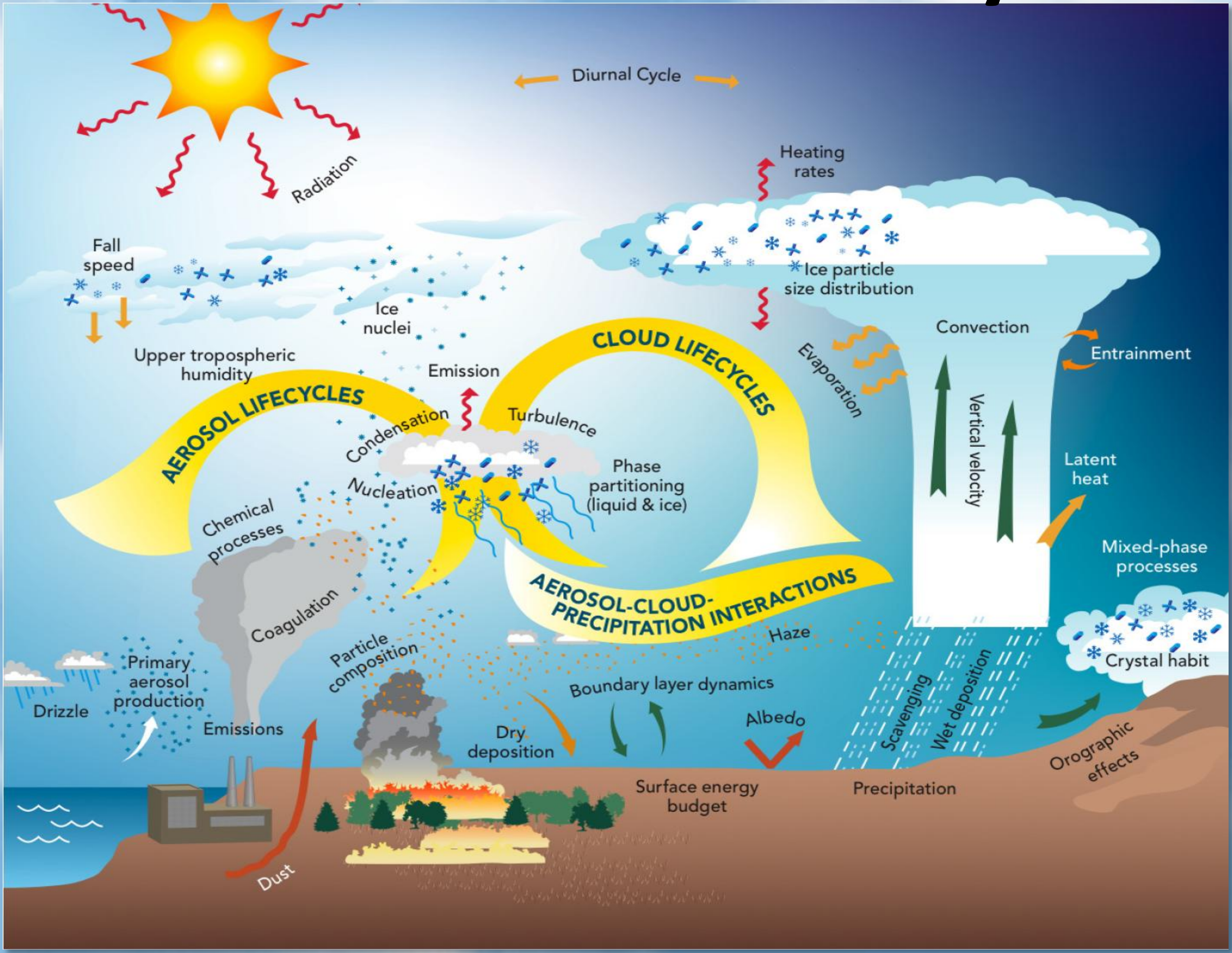
CHUVA Meeting, USP, Brazil

The Brazilian component of GoAmazon

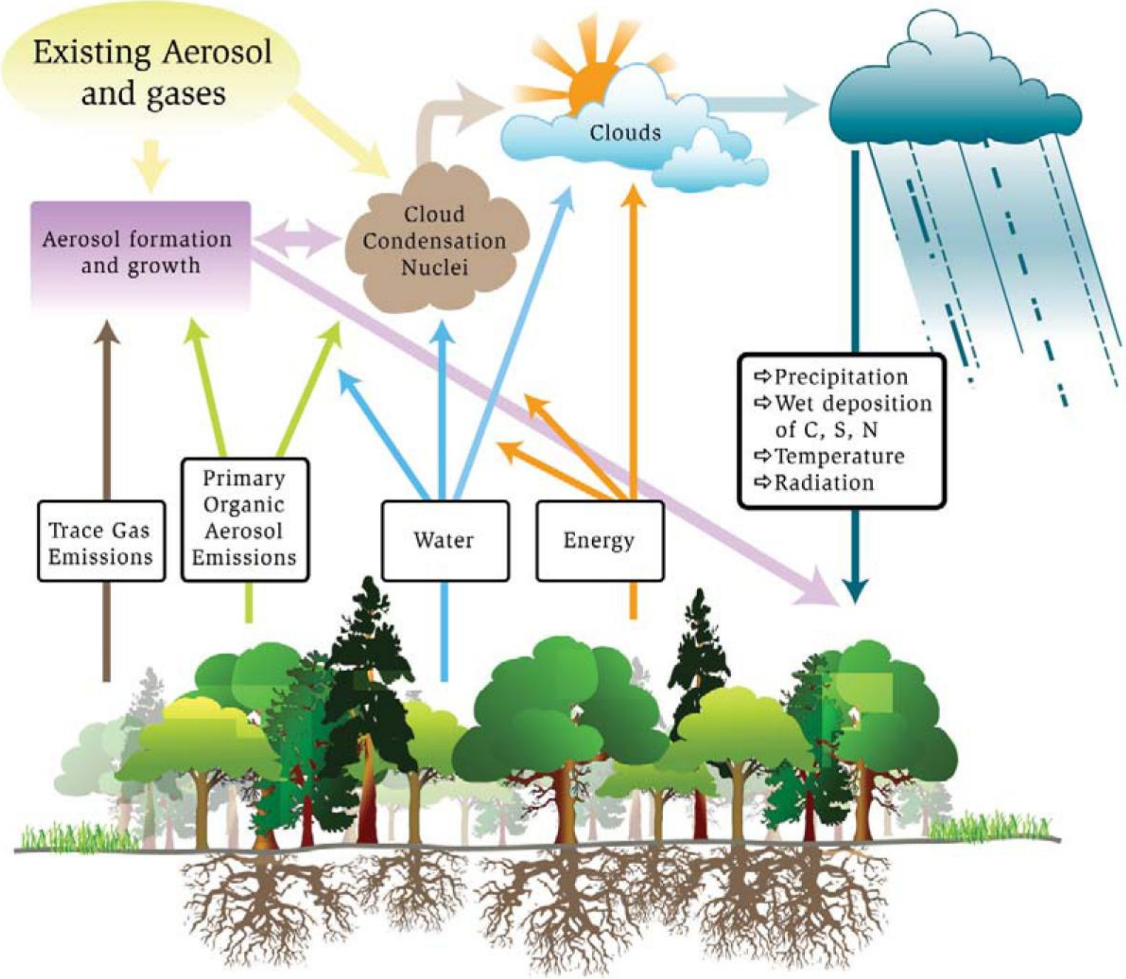
Paulo Artaxo, Maria Assunção Silva Dias, Luiz Augusto Machado, Gilberto Fisch, Rodrigo Souza and the Brazilian GoAmazon Science team



Aerosol and cloud lifecycles



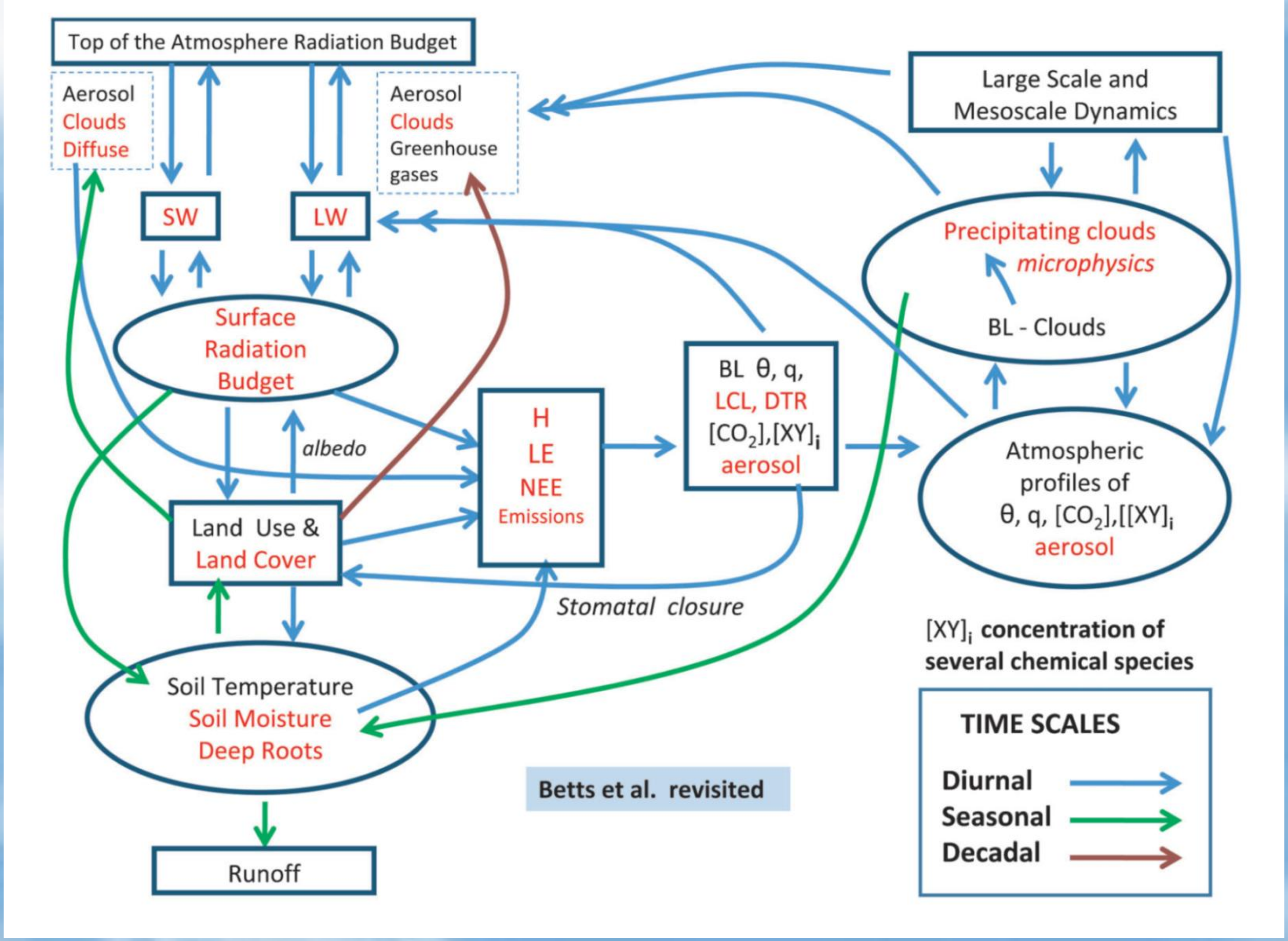
Amazon Basin has strong coupling between terrestrial ecosystem and the hydrologic cycle: The linkages among carbon cycle, aerosol life cycle, and cloud life cycle need to be understood and quantified.



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.

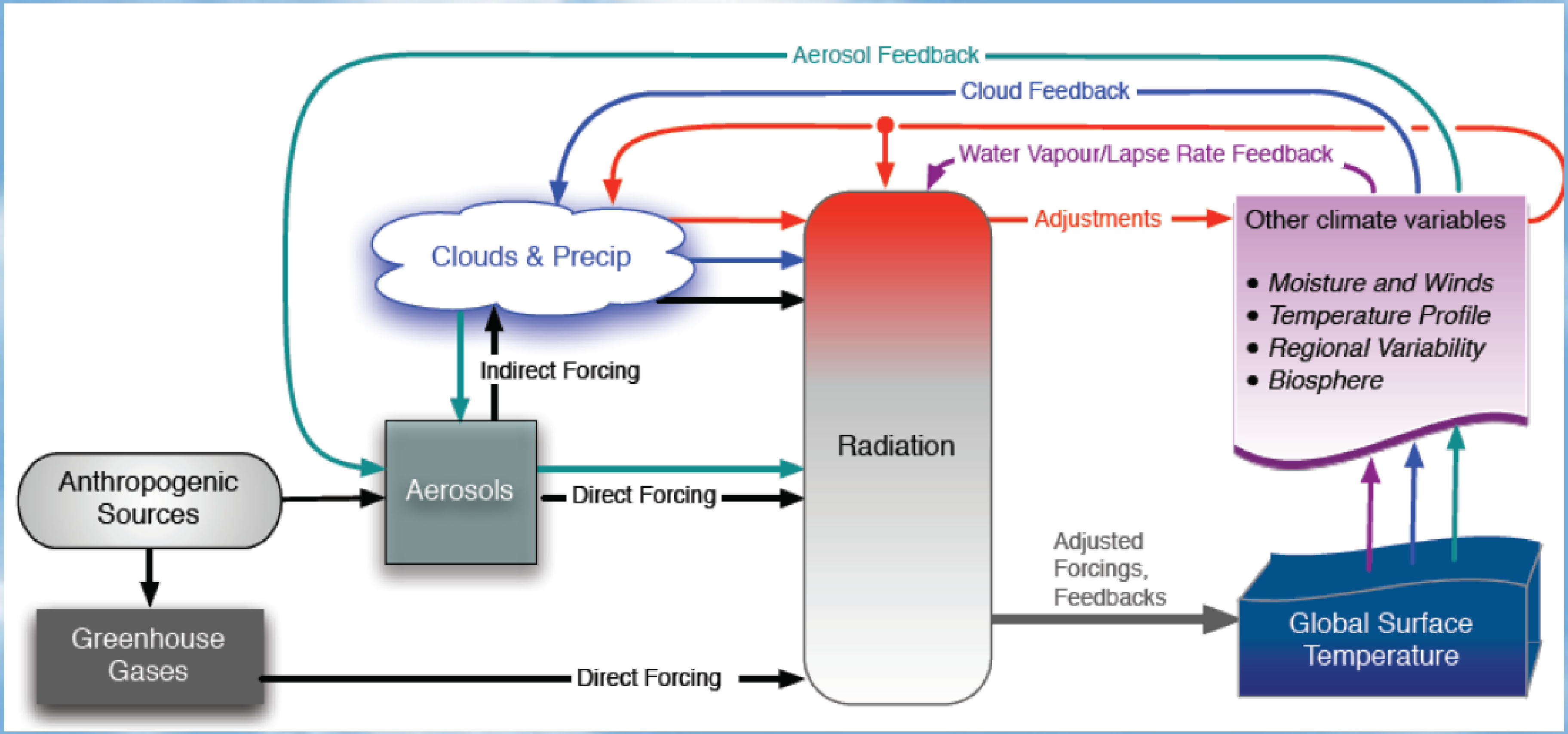
Schematic of land-surface-atmosphere interactions in Amazonia



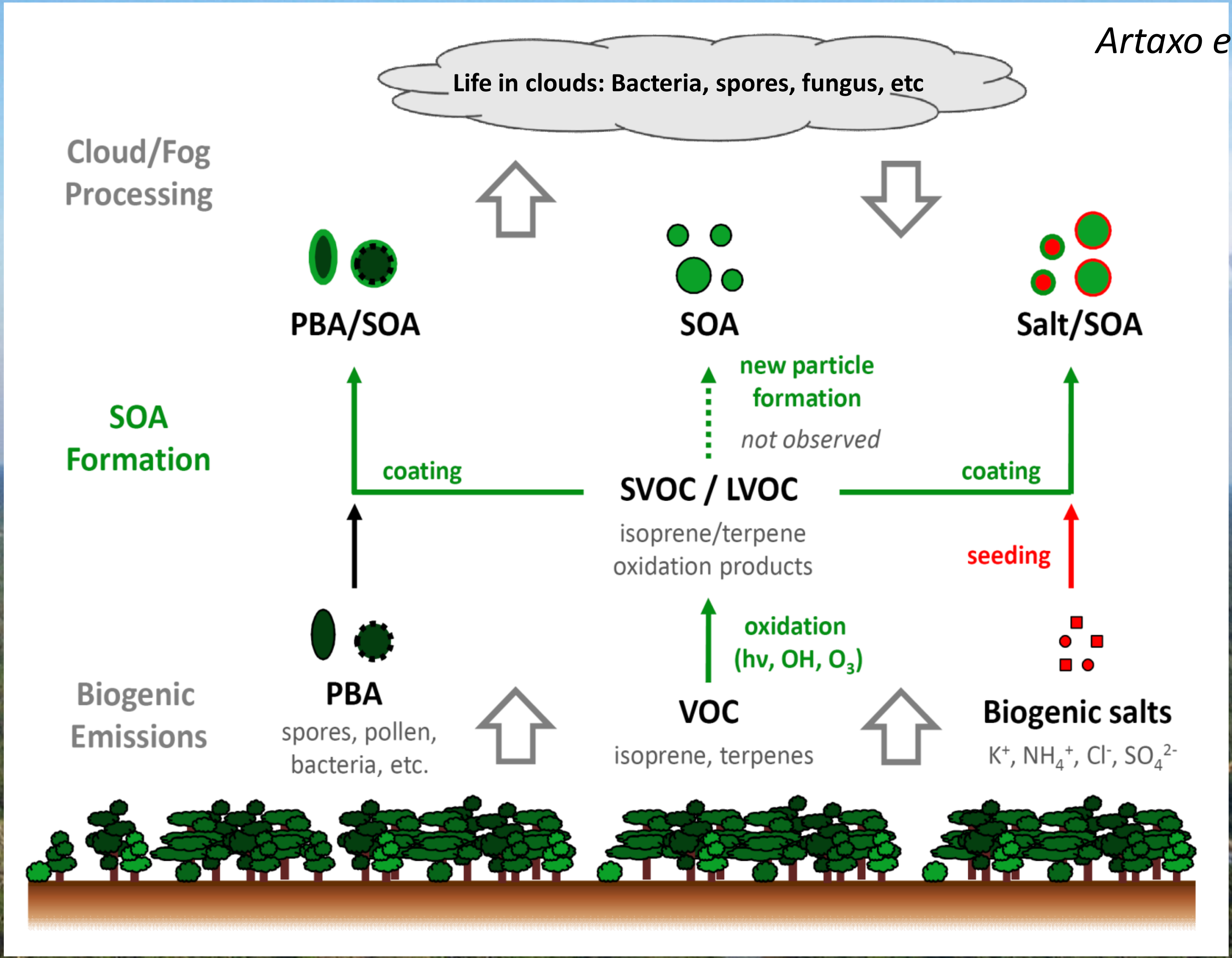
Meteorology, atmospheric chemistry, ecosystem function, radiation, etc. all very linked (Allan Betts et al. 2011)

Aerosols, radiation, clouds and greenhouse gases in the global climate system

The major uncertainties in the climate system

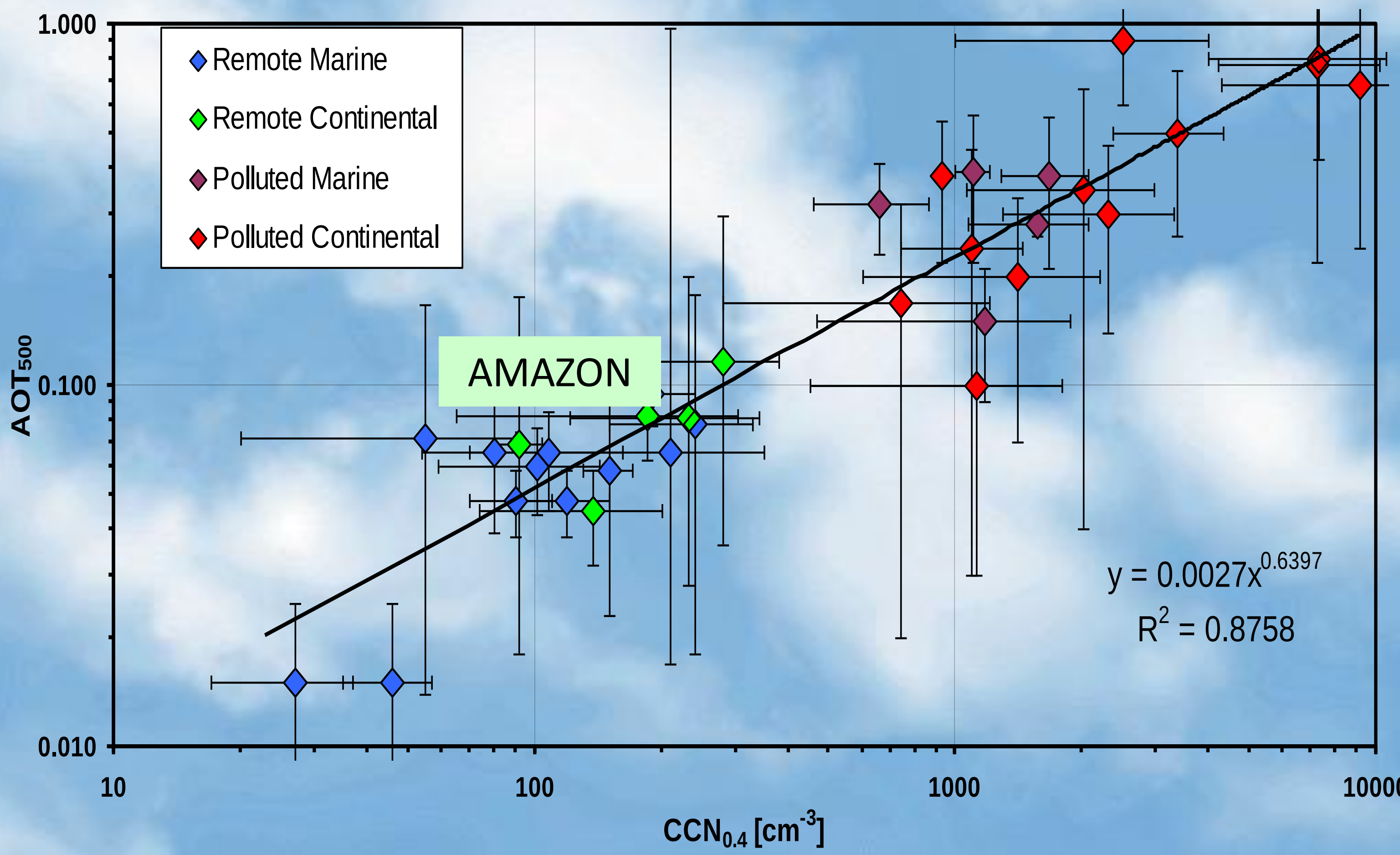


The biology of the forest partially controls the chemistry and physics of the atmosphere in Amazonia



Strong interactions between forest biology, physics and chemistry of the atmosphere

Particle Chemistry & Physics, Circa 1750



CCN concentrations and AOT over Amazonia are similar to the cleanest marine sites! (And representative of conditions pre-1750…)

Adapted from Andreae, ACP, **2009**, *9*, 543–556.

Primary Biological Aerosol Particles (PBAP)

PBAP Review Article

Despres et al. Tellus 2012

- History & Definition
- Particle Types
- Methods
- Concentration & Emission
- CCN & IN Activity
- **564 References**

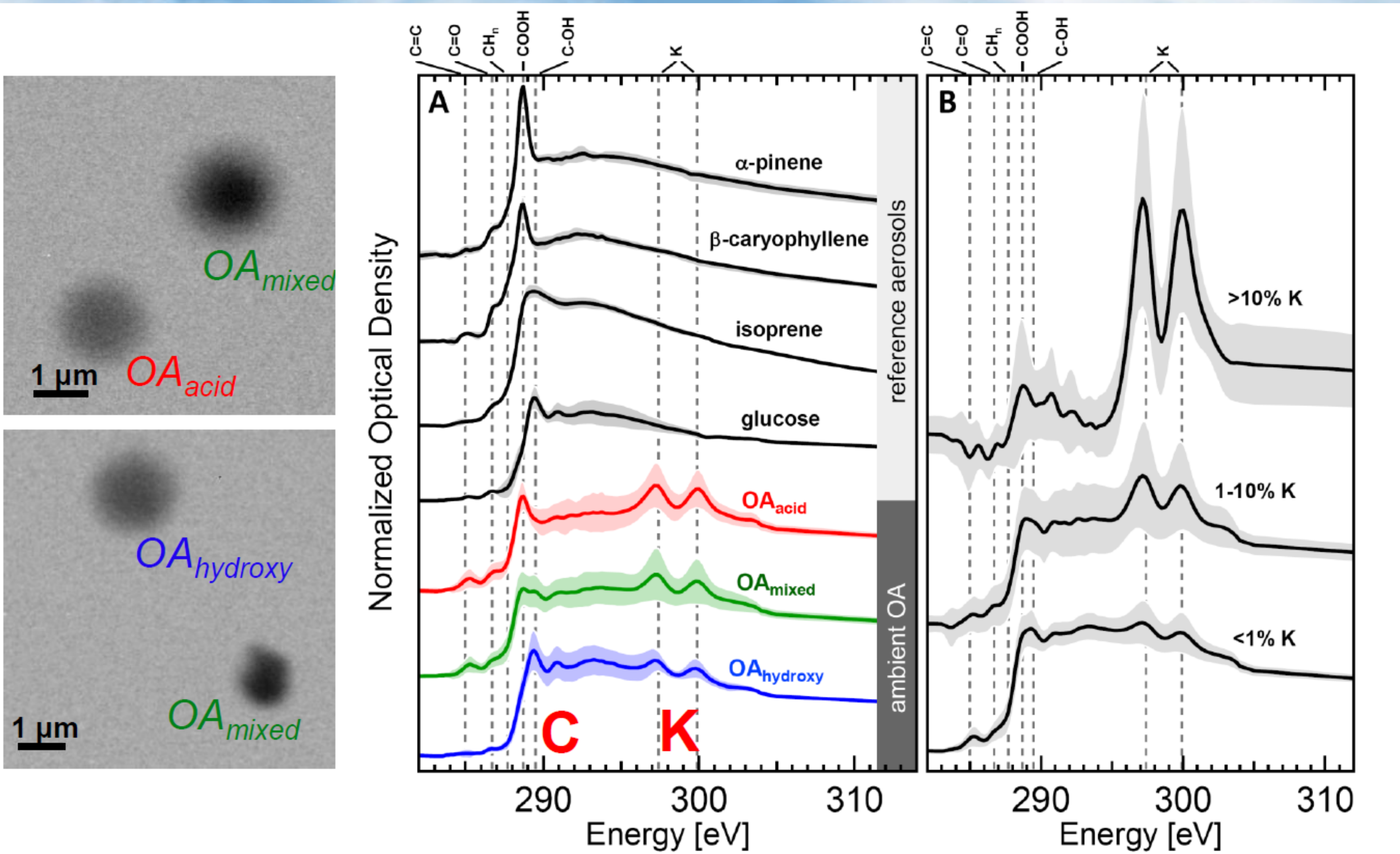
Table 1. Characteristic types of primary biological aerosol particles (PBAP)

Particle types	Examples
Biological organisms or dispersal units (dead or alive, isolated or aggregated)	Bacteria, fungi, protozoa, algae, spores, pollen, lichen, archaea, viruses, etc.
Solid fragments or excretions of biological organisms or dispersal units	Detritus, microbial fragments, plant debris/leaf litter, animal tissue and excrements, brochosomes, etc.

Table 4. Characteristic magnitudes of the number and mass concentrations of PBAP in air over vegetated regions

	Number concentration [m^{-3} air]	Mass concentration [$\mu g\ m^{-3}$]	Size range	References
Bacteria	$\sim 10^4$	~ 0.1	PM_{10}	Bauer et al. (2002a); Burrows et al. (2009a)
Plant debris (free cellulose)		~ 0.1–1	PM_{10}	Sánchez-Ochoa et al. (2007)
Viral particles	$\sim 10^4$	$\sim 10^{-3}$		This work, Sect. 2.4
Fungal spores	$\sim 10^3$–10^4	~ 0.1–1	TSP	Elbert et al. (2007); Fröhlich-Nowoisky et al. (2009)
Fungal hyphal fragments	$\sim 10^3$			Pady and Gregory (1963)
Pollen	~ 10 (up to $\sim 10^3$)	~ 1	TSP	Sofiev et al. (2006); Fröhlich-Nowoisky et al. (2009)
Algae	~ 100 (up to $\sim 10^3$)	$\sim 10^{-3}$		Reisser (2002)
Fern spores	~ 10 (up to $\sim 10^3$)	~ 1	TSP	Mücke and Lemmen (2008)

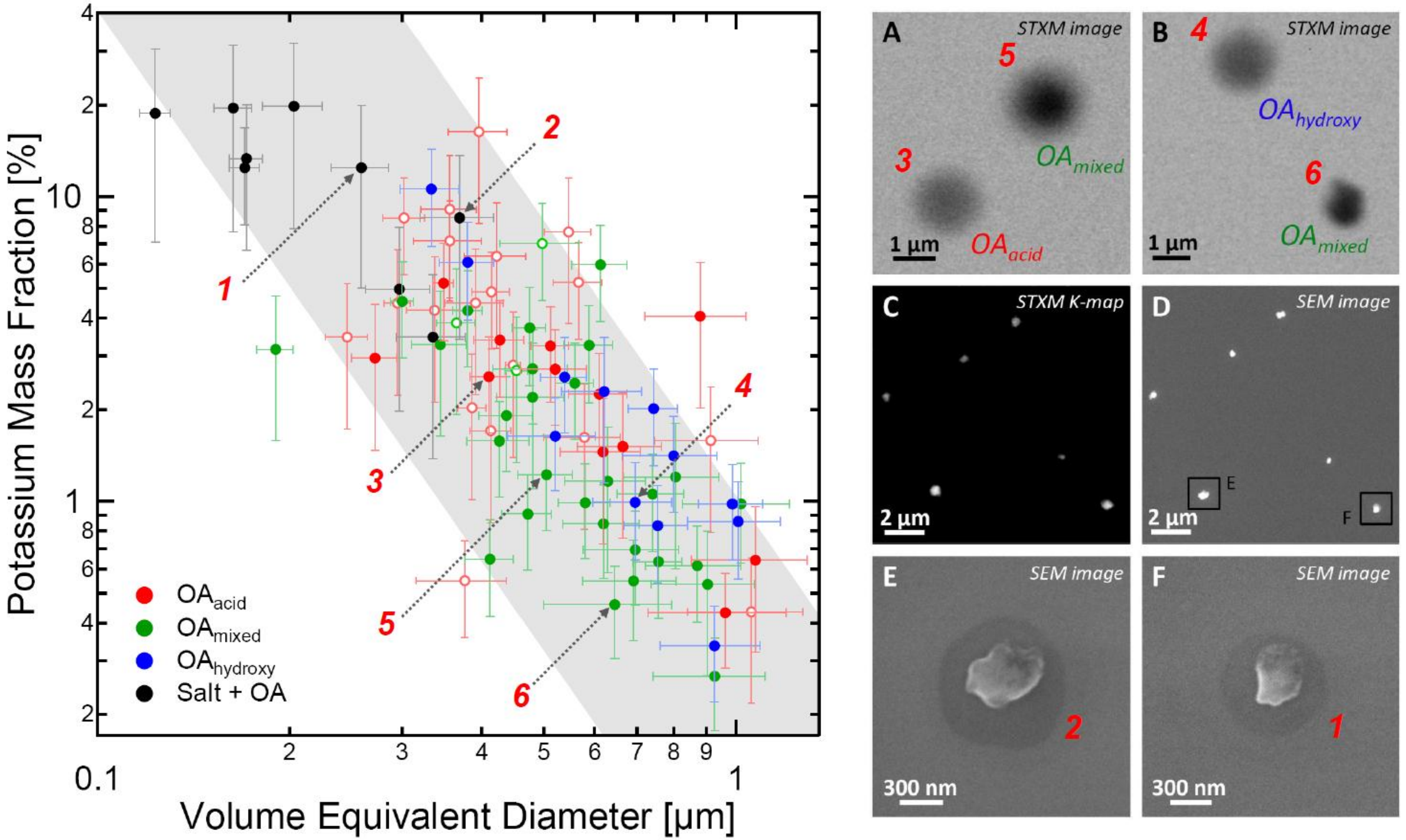
SOA Composition measured by STXM-NEXAFS



- STXM-NEXAFS: 3 SOA classes – acid (terpene), hydroxy (isoprene), mix
- potassium (K) in almost all SOA particles

Pöhlker Science 2012

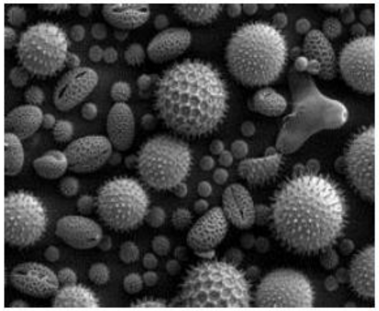
Potassium Salt Seeds very small particles



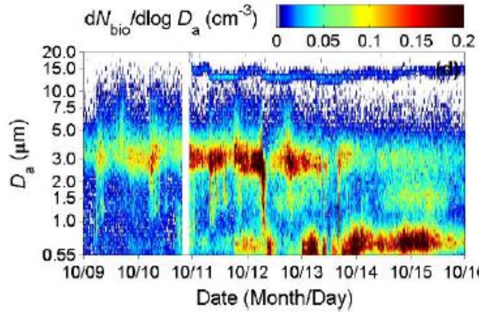
- Small potassium-rich salt particles with low organic content
- Dilution of primary potassium content upon SOA particle growth

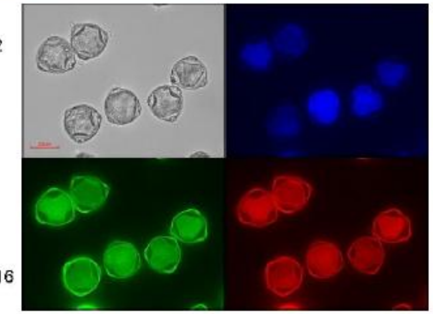
Pöhlker Science 2012

Life is in the air and it does interact with precipitation



DNA & Protein Analysis





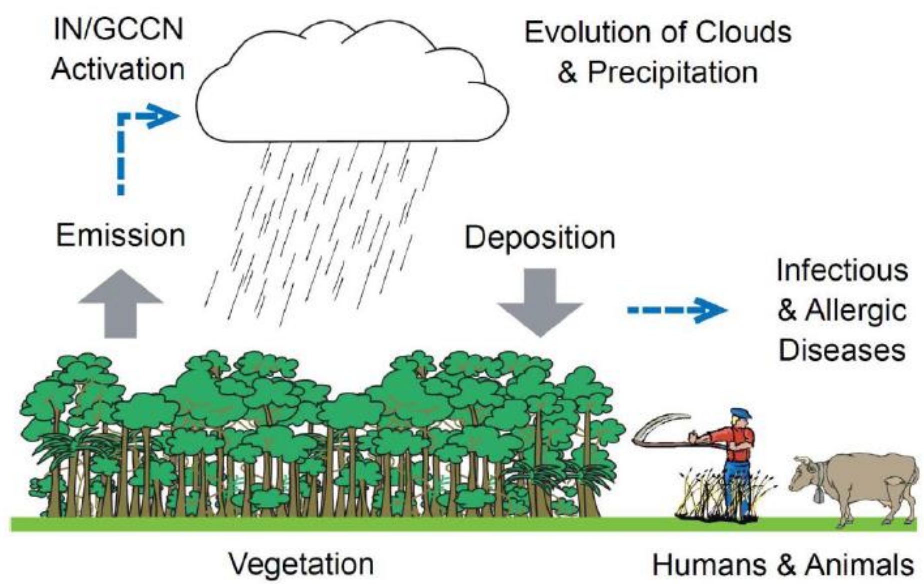
Fluorescence Spectroscopy & Microscopy

High abundance, diversity & emission fluxes of airborne fungi & bacteria:
~1 μg m^{-3}, ~10 L^{-1}, **~10^2 m^{-2} s^{-1}**, >10^3 species (urban PM)
Elbert ACP 2007, Fröhlich-Nowoisky PNAS 2009, Burrows ACP 2009, Huffman ACP 2010

Information: ~10 ng m^{-3} DNA
⇒ inhalation of ~1 μg/day ≡
~10^8 bacterial genomes/day
Despres BG 2007

Pathogens: permanent challenge
⇒ infectious & allergic diseases

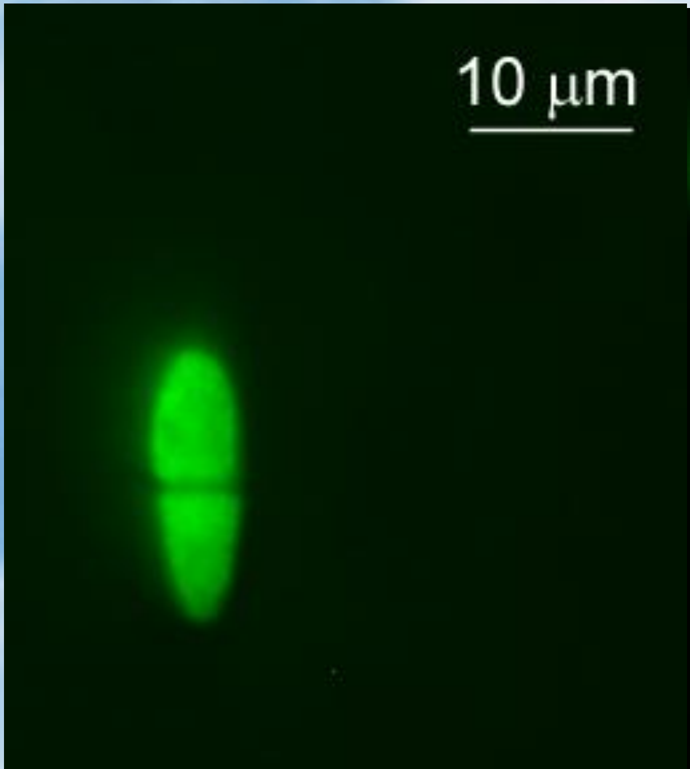
Cloud condensation & ice nuclei:
co-evolution of life & climate
⇒ bioprecipitation cycle
Sands J Hung Met Serv 1982

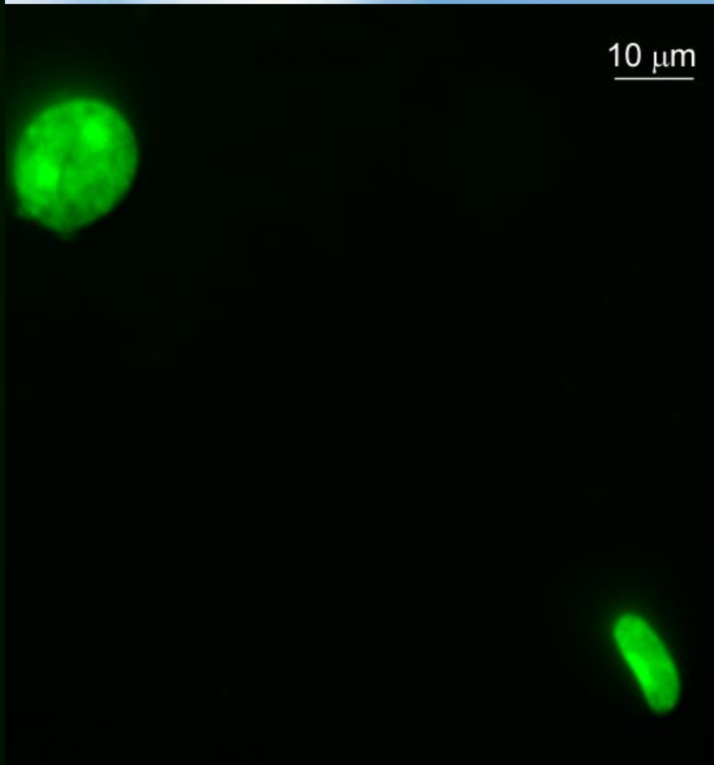


Species observed in cloud water.

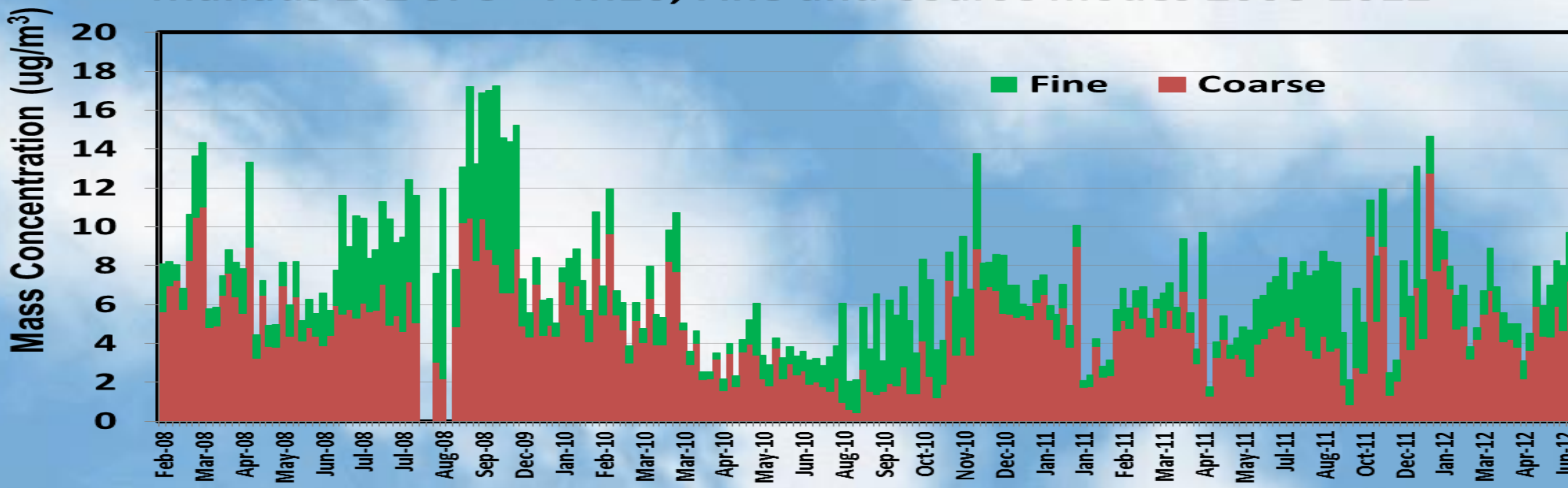
Average Cloudy Air Conc.	Convective Cumulus	Fair Weather Cumulus	Stratus[a]
Ammonium (nmol m^{-3})	74 (± 23)	18 (± 8)	450
Nitrate (nmol m^{-3})	83 (± 30)	16 (± 5)	320
DON (nmol m^{-3})	21 (± 9)	9 (± 4)	110
Bacteria Concentration (no. m^{-3})	2.5×10^5 (± 1.3×10^5)	3.3×10^5 (± 9.9×10^4)	N/A
Bacteria N (nmol m^{-3})	2.9×10^{-11}	3.9×10^{-11}	N/A
Sulfate (nmol m^{-3})	41 (± 22)	7 (± 3)	140
Calcium (nmol m^{-3})	53 (± 31)	10 (± 8)	120

- Algae/ Protozoa observed in cloud water samples
- Protozoa were alive and moving

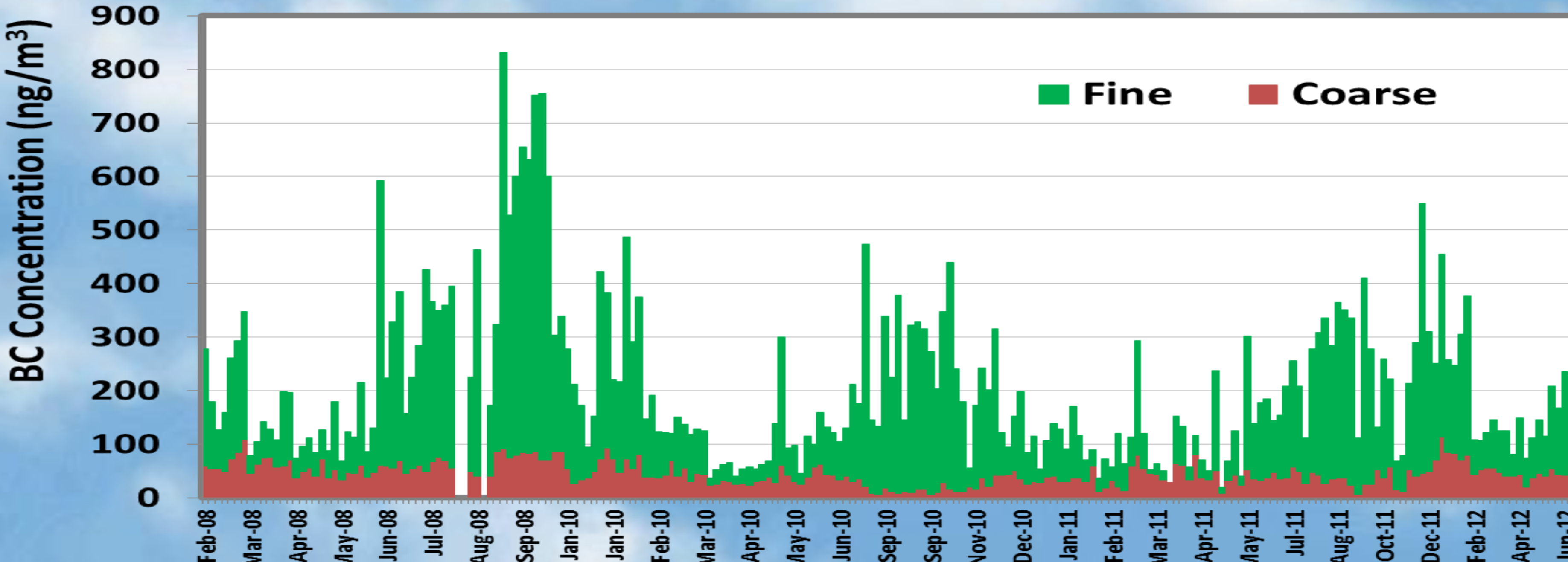




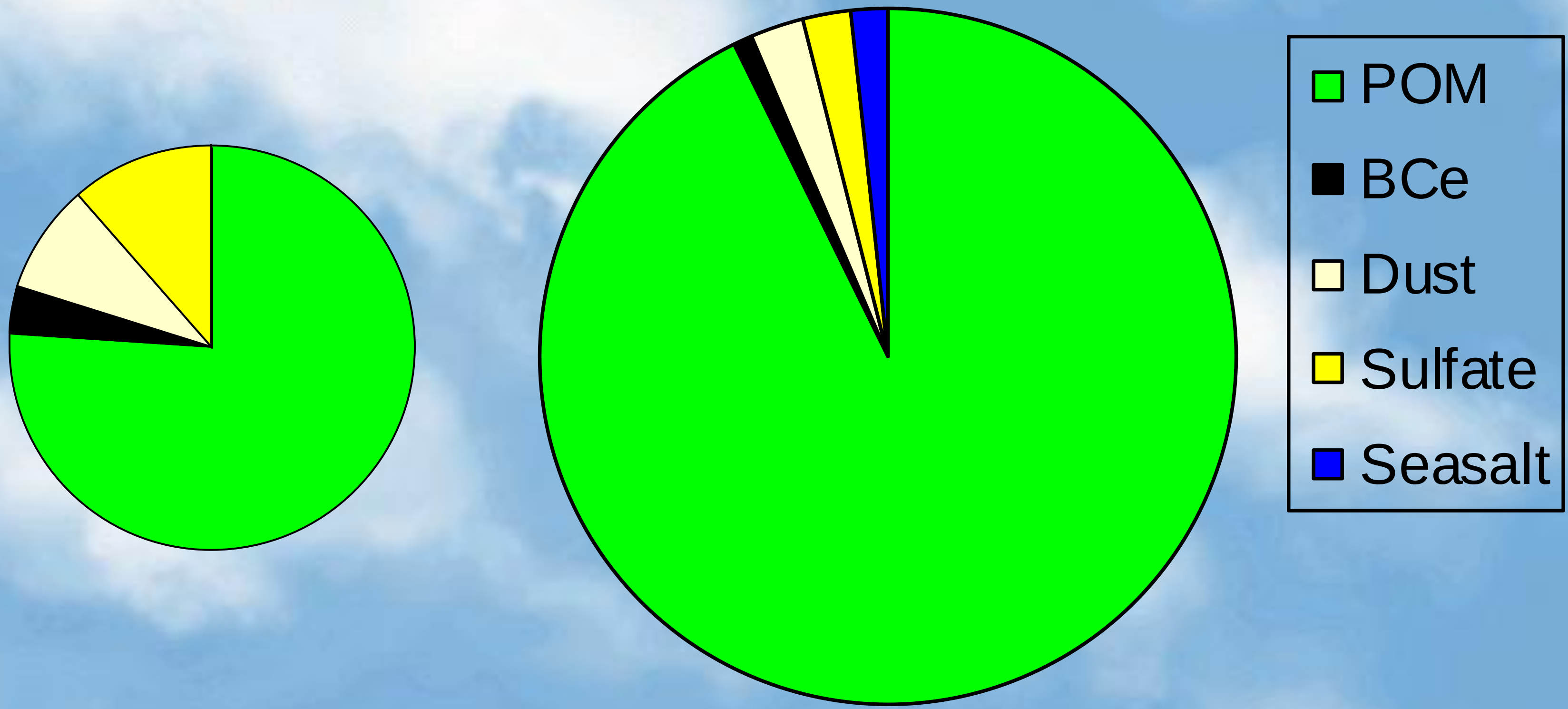
Manaus ZF2 SFU - PM10, Fine and Coarse modes 2008-2012



Manaus ZF2 Black Carbon - Fine and Coarse Mode 2008-2012



Aerosol composition in wet-season Amazonia

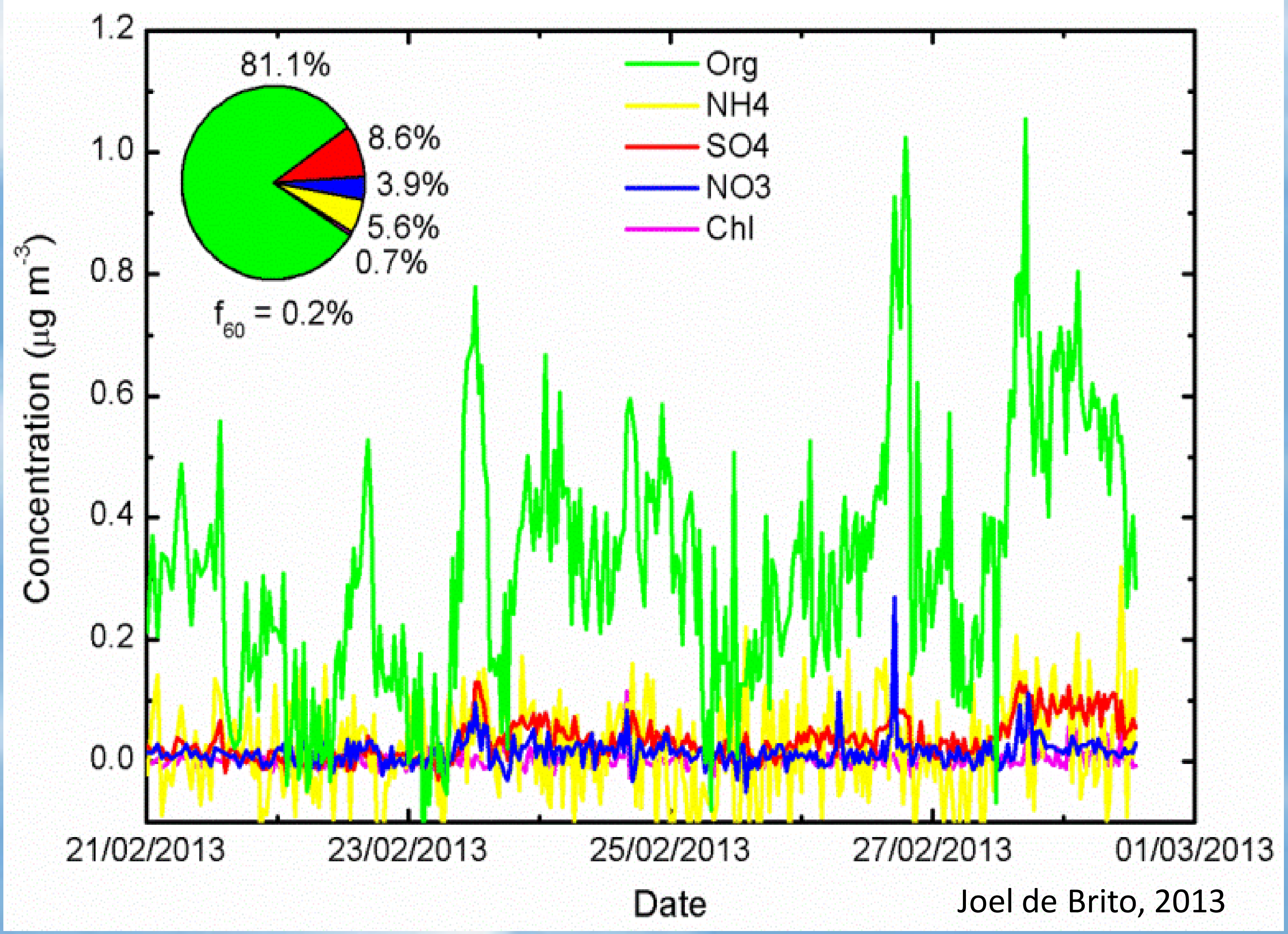


Fine Fraction
1.7 µg m^{-3}

Coarse Fraction
5.7 µg m^{-3}

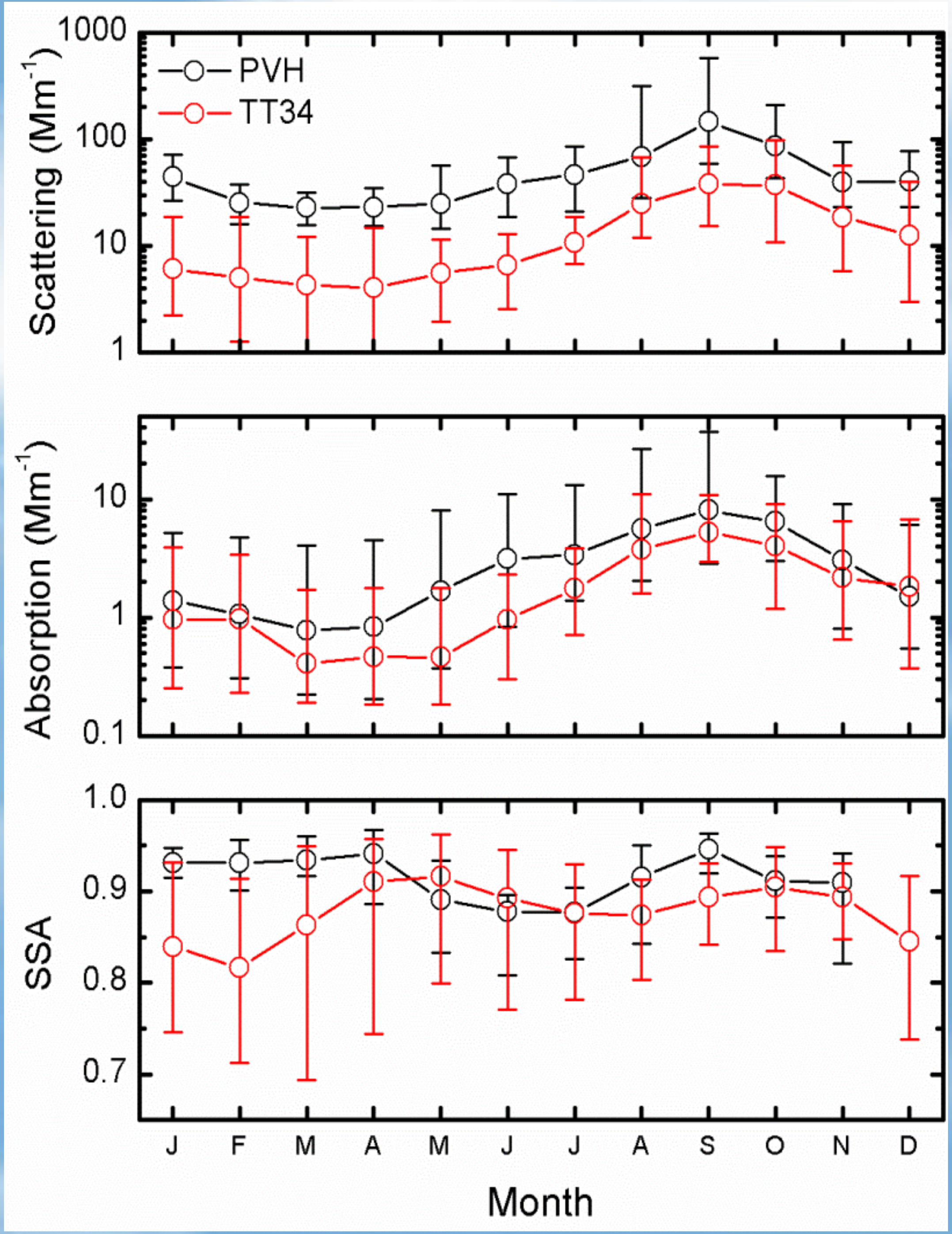
Martin et al., 2010

ZF2 ACSM 2013 wet season measurements

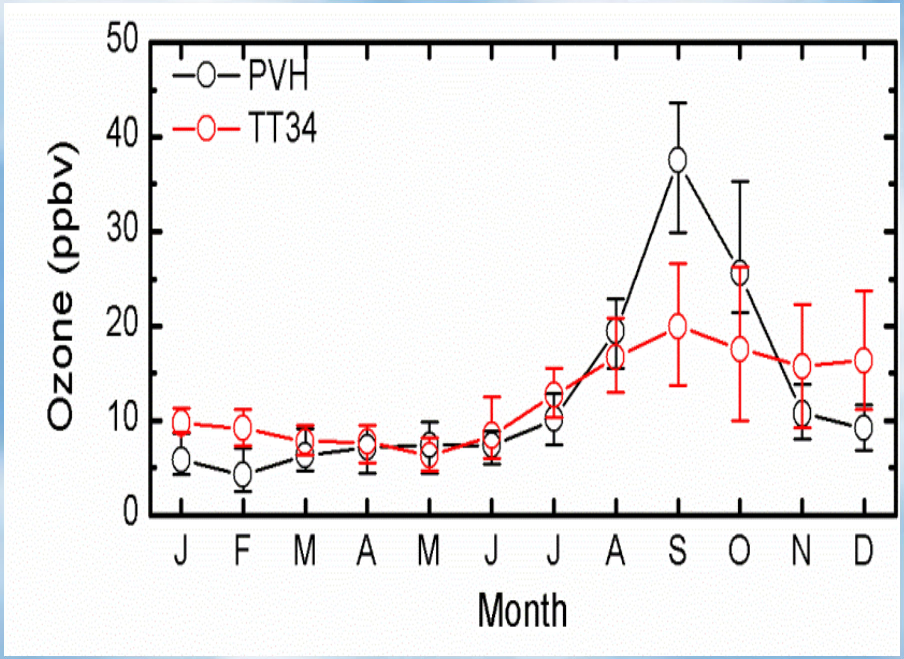


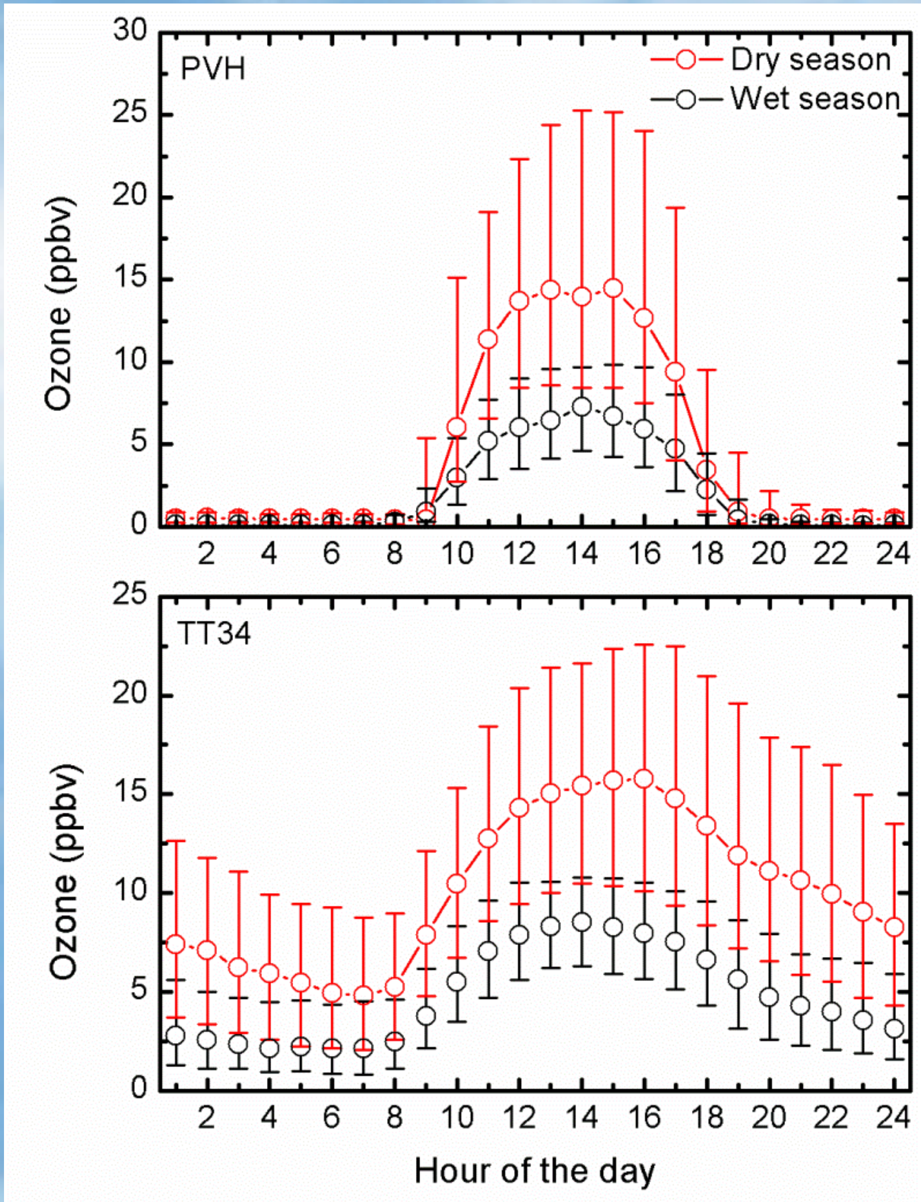
Monthly statistics (2009 – 2012) for light scattering coefficient σ_s at 637 nm and light absorption coefficient σ_a at 637 nm in Mm^{-1} for Porto Velho (PVH, in black) and central Amazonia (TT34, in red).

Single Scattering Albedo



Diurnal cycle of ozone mixing ratios in Porto Velho (PVH) and central Amazonia (TT34) for the dry and set seasons from 2009 to 2012.

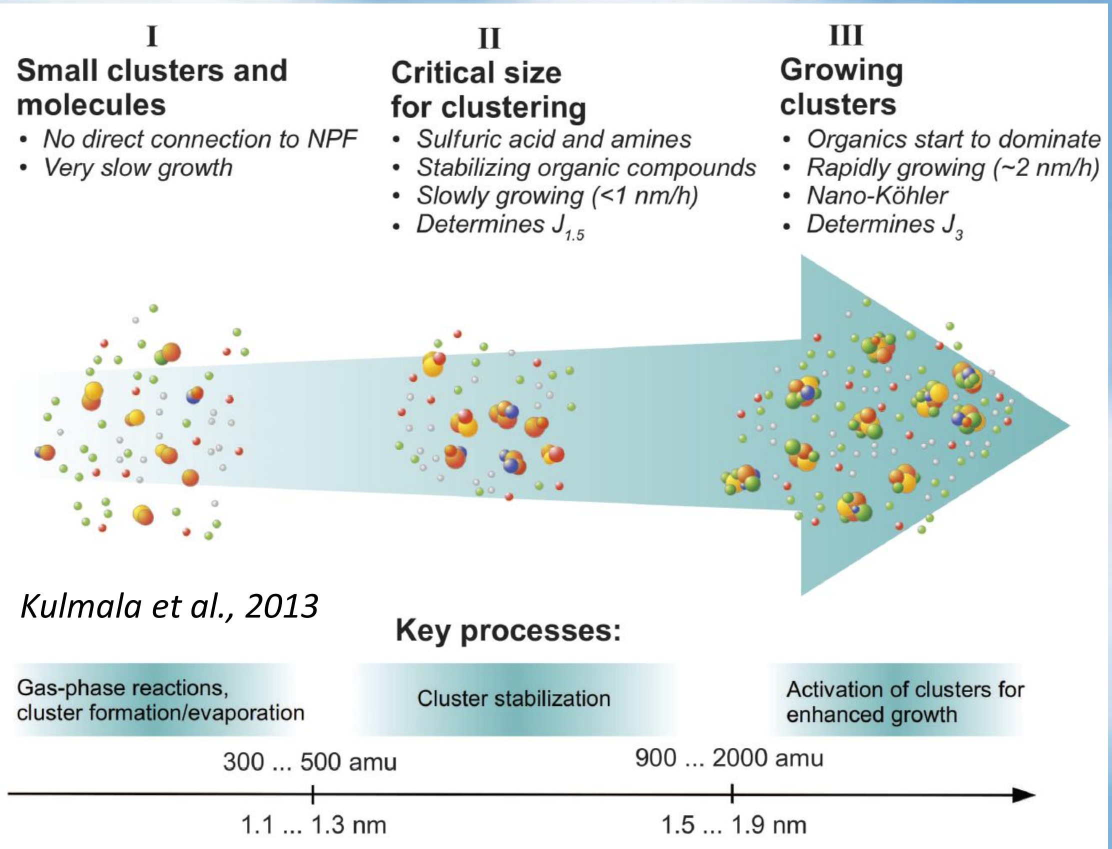




Seasonal variability

Circles represent median values, and bars represent 10 and 90 percentiles.

No new particle formation observed at surface under pristine conditions in Amazon



New particle formation: a two-step process:

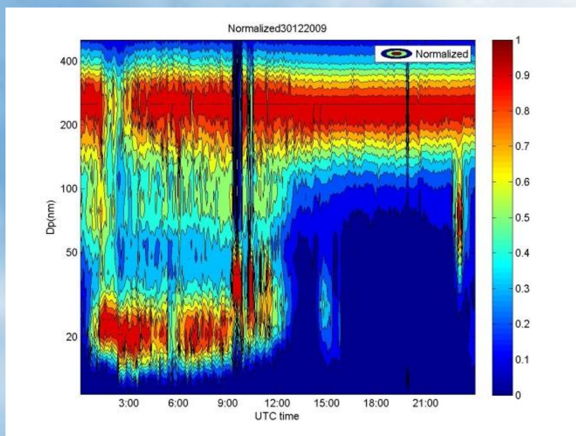
- **1st step: sulfuric acid and amines, ammonia, or organic vapor form stable clusters**
- **2nd step: organic vapor leads to enhance growth rate of the clusters to larger sizes.**

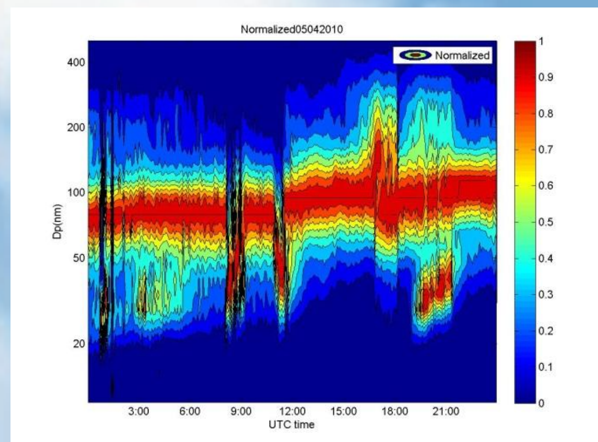
Why no new particle formation?

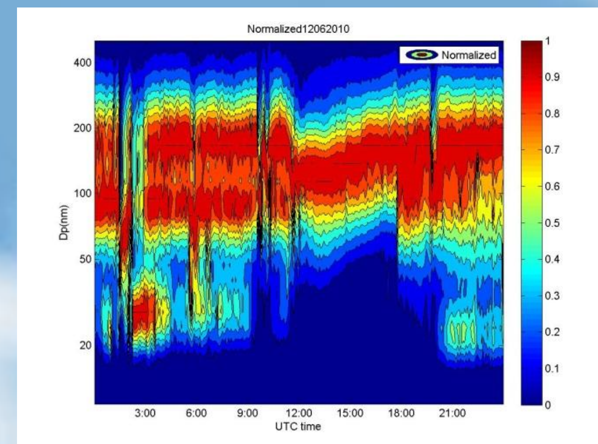
- **Low SO_2 concentration (20-30ppt) suggests the concentration of H_2SO_4 is low**
- **Organic concentration may be low for the growth of stable clusters.**

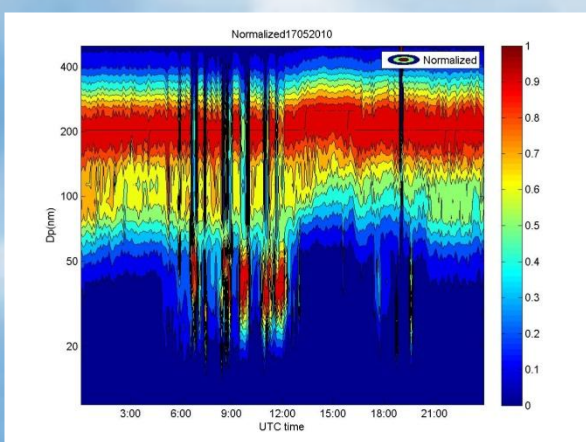
What is the impact of Manaus plume on NPF?

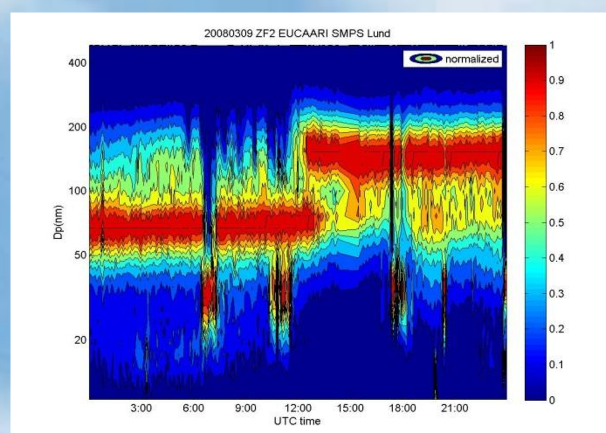
Particle bursts 20-30 nm at nighttime

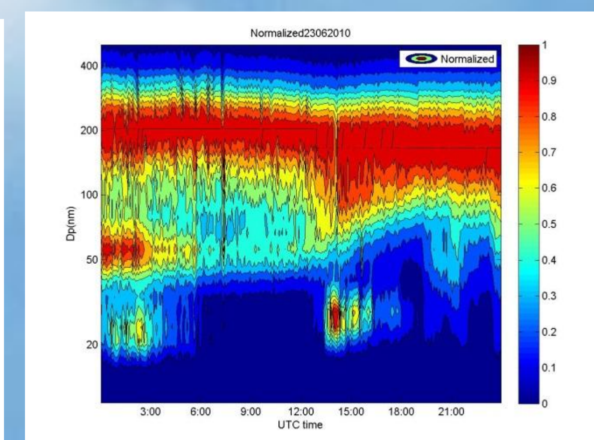






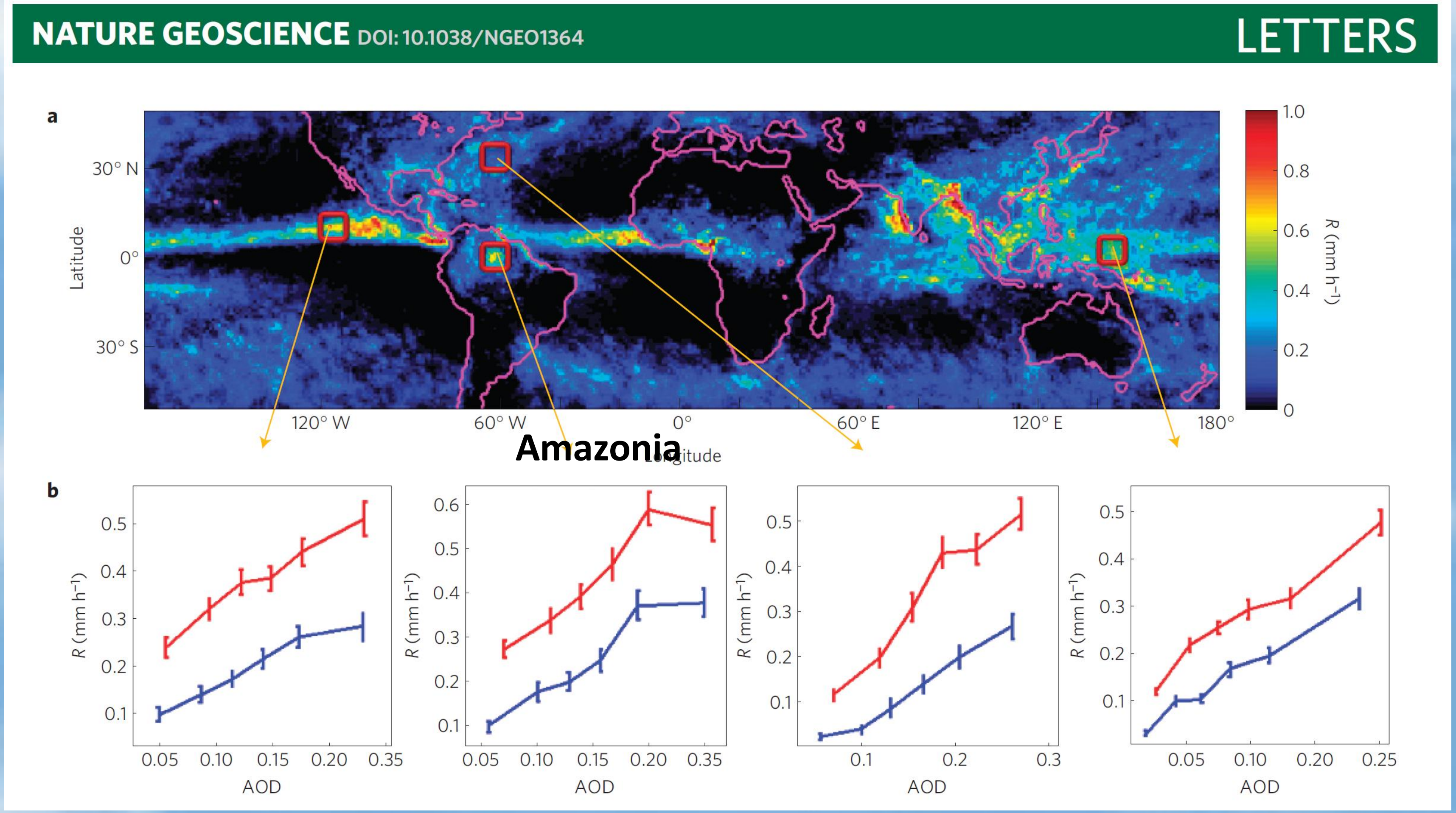




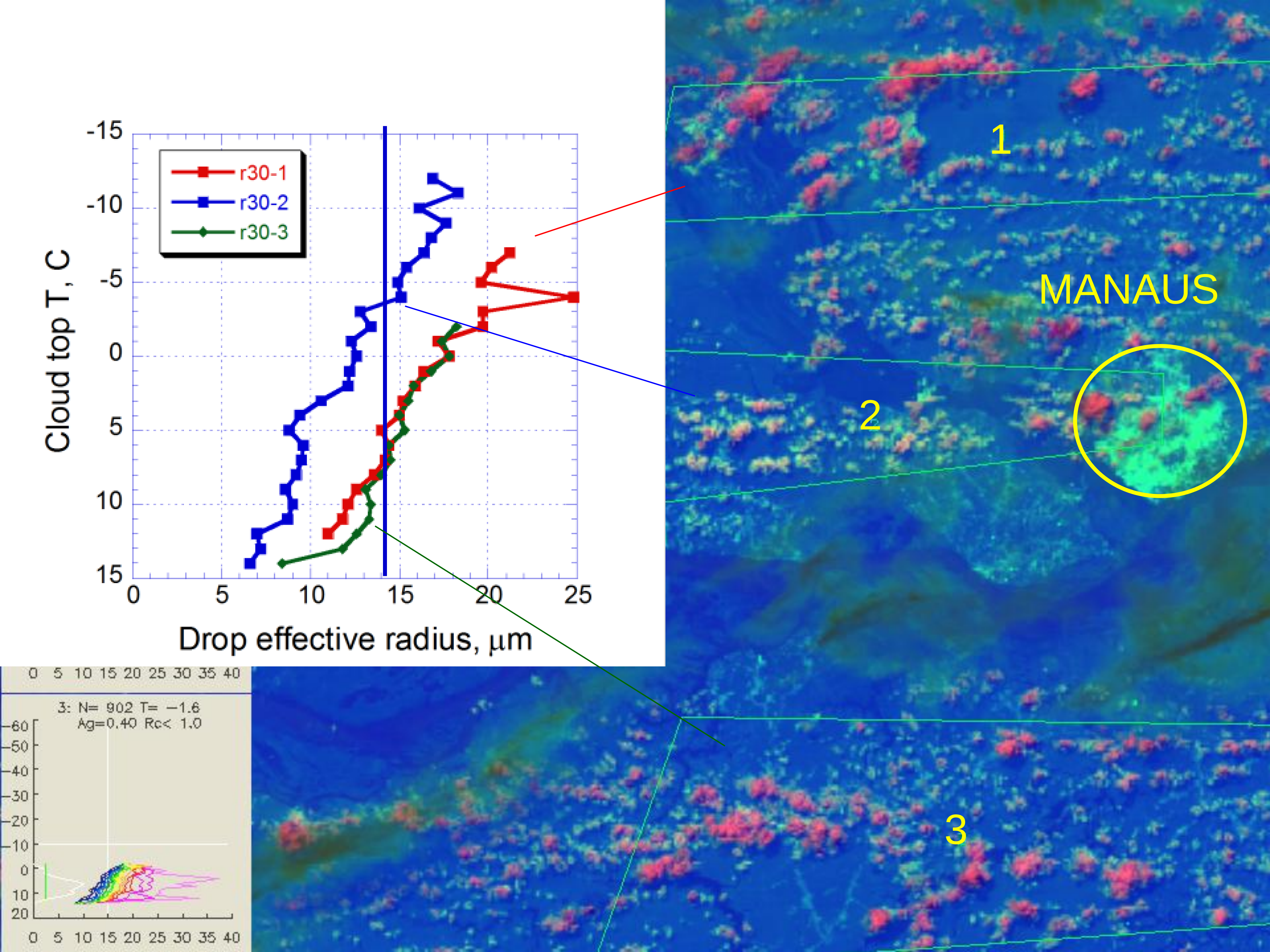


Luciana Rizzo et al., 2012

Rain rate (TRMM) versus Aerosol Optical Depth (MODIS)



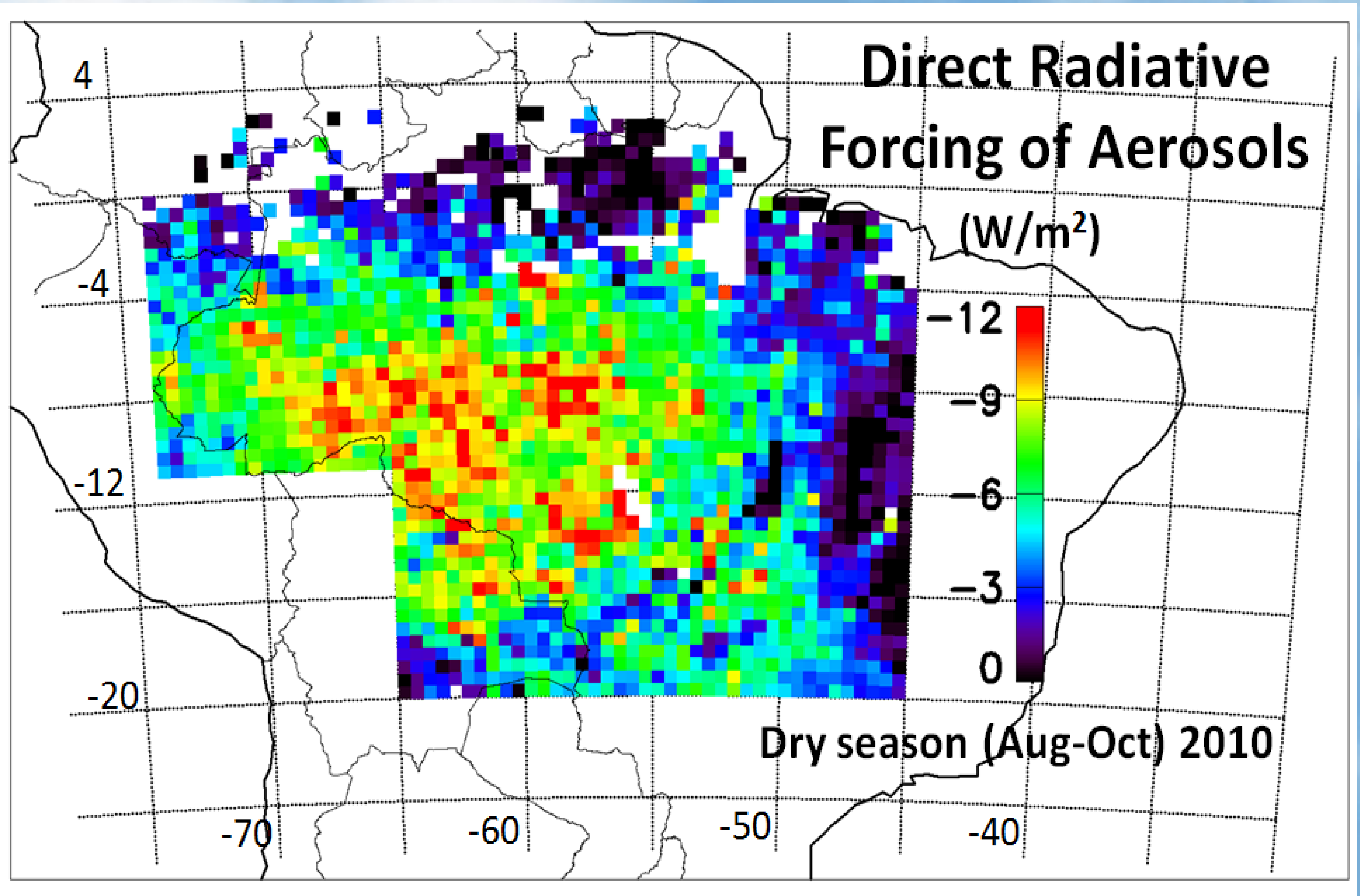
13:30 local-time map of rain rate (*R*) and the observed trend with aerosol loading in four selected regions. Period: July and August 2007. **b**, The average *R* values are plotted for six aerosol-loading sets (blue, including zero *R* grid squares; red, without zero *R* grid squares). Note the *R* intensification as a function of AOD in all cases. (Koren et al., Nature 2012)

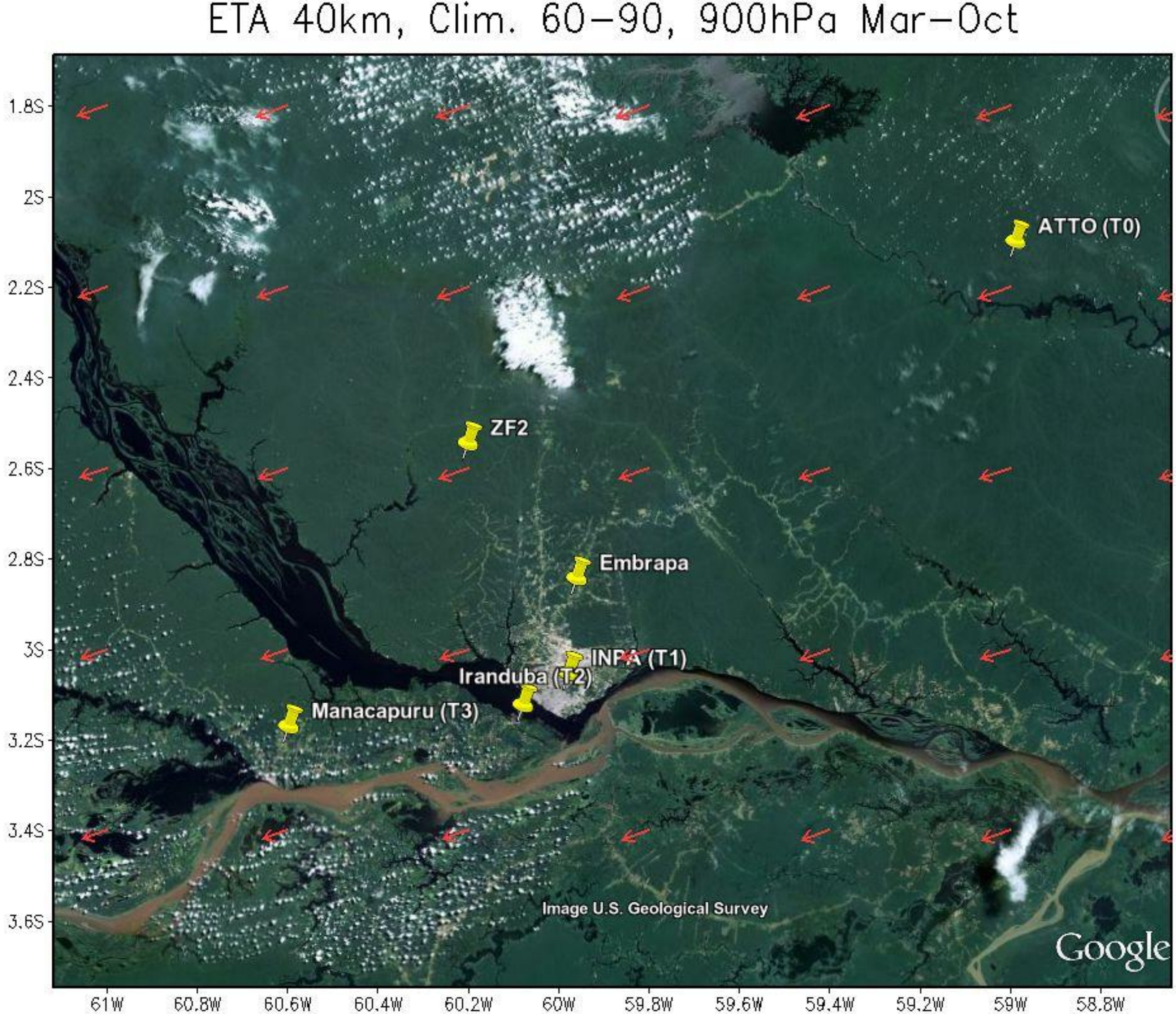


Cloud top T, C
Drop effective radius, μm
r30-1
r30-2
r30-3
-15
-10
-5
0
5
10
15
0
5
10
15
20
25
1
2
3
MANAUS
3: N= 902 T= −1.6
Ag=0.40 Rc< 1.0

Average spatial distribution of the direct radiative forcing (DRF) of biomass burning aerosols in Amazonia during the dry season of 2010

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




ETA 40km, Clim. 60-90, 900hPa Mar-Oct
1.8S
2S
2.2S
2.4S
2.6S
2.8S
3S
3.2S
3.4S
3.6S
61W
60.8W
60.6W
60.4W
60.2W
60W
59.8W
59.6W
59.4W
59.2W
59W
58.8W
ATTO (T0)
ZF2
Embrapa
INPA (T1)
Iranduba (T2)
Manacapuru (T3)
Image U.S. Geological Survey
Google


SITE_
Iranduba site
IRANDUBA CITY

Interactions of the Manaus plume across 60 km forest

Objectives based on these critical questions and issues are as follows:

Aerosol Life Cycle

1. Study process and interactions of the Manaus pollution plume with biogenic emissions of VOCs, especially the impact on the production of secondary organic aerosol (SOA) and the formation of new particles;

2. To measure the aging of biomass burning plumes and the subsequent formation of additional SOA;

3. The influence of anthropogenic emissions i.e., (a) the Manaus pollution plume and (b) biomass burning aerosols on aerosol microphysical, optical, CCN, as obtained by comparing the aerosol properties between pristine and anthropogenically influenced air masses; and

4. Determine the optical properties of aerosols from the interaction of the Manaus plume and the natural vegetation atmosphere and obtain the aerosol radiative forcing.

Cloud Life Cycle

5. Study the role of landscape heterogeneity (e. g., the urban area of Manaus or km-long scale of rivers) on the dynamics of convection and clouds;

6. The evolution of convective intensity from severe storms in the dry season to moderate storms in the wet season, and to consider how changes caused by local deforestation lead to similar transitions;

7. The transition from shallow to deep cumulus convection during the daily cycle of the Amazon Basin, with comparison and understanding to other ARM sites; and

8. Development of a knowledge base and test cases that will improve tropical cloud parameterizations in regional and global climate models (GCMs).

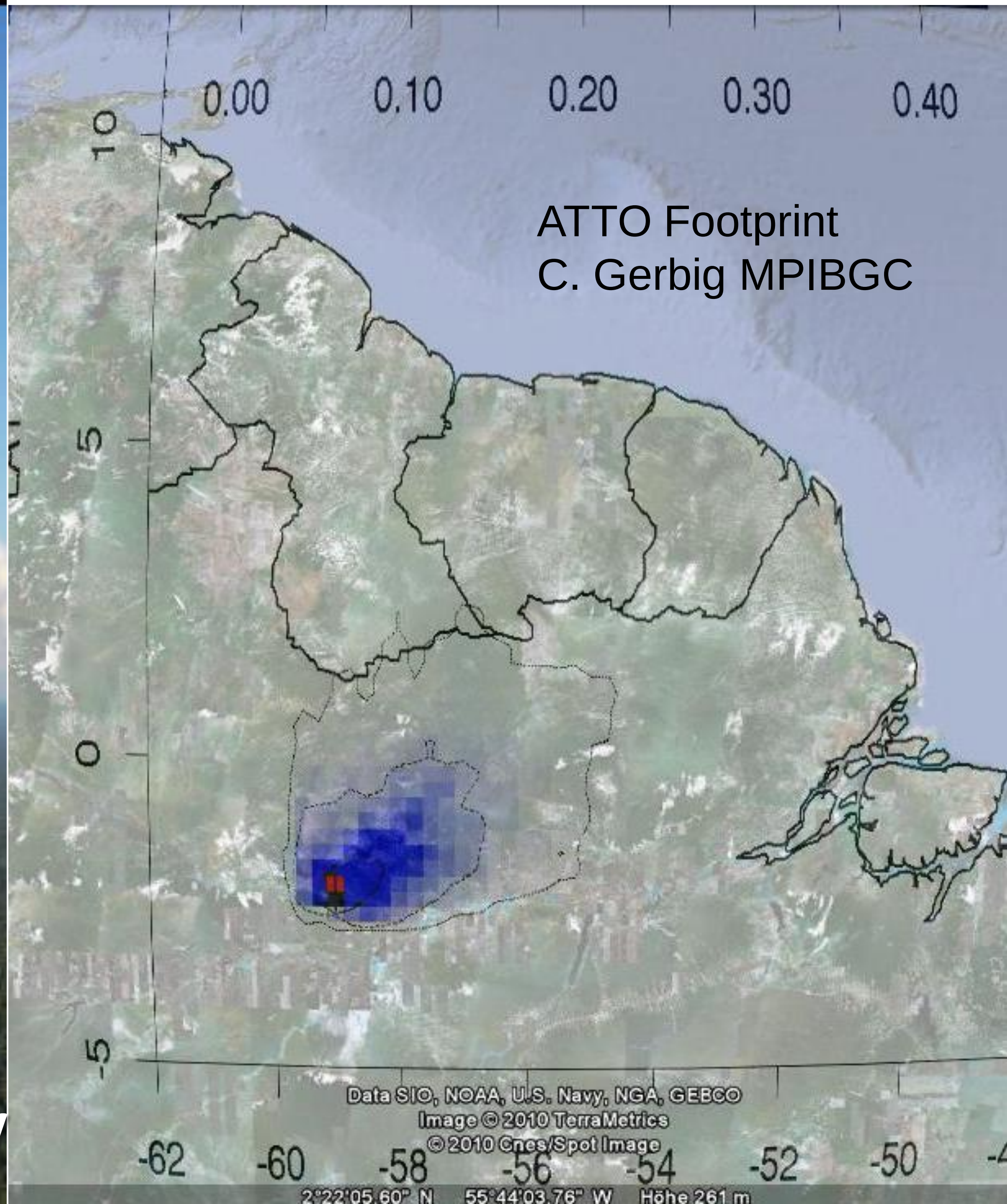
Cloud-Aerosol-Precipitation Interactions

9. Aerosol effects on scattered cumulus clouds, especially the aerosol radiative effect, with a special focus on the impact of biomass burning aerosols;

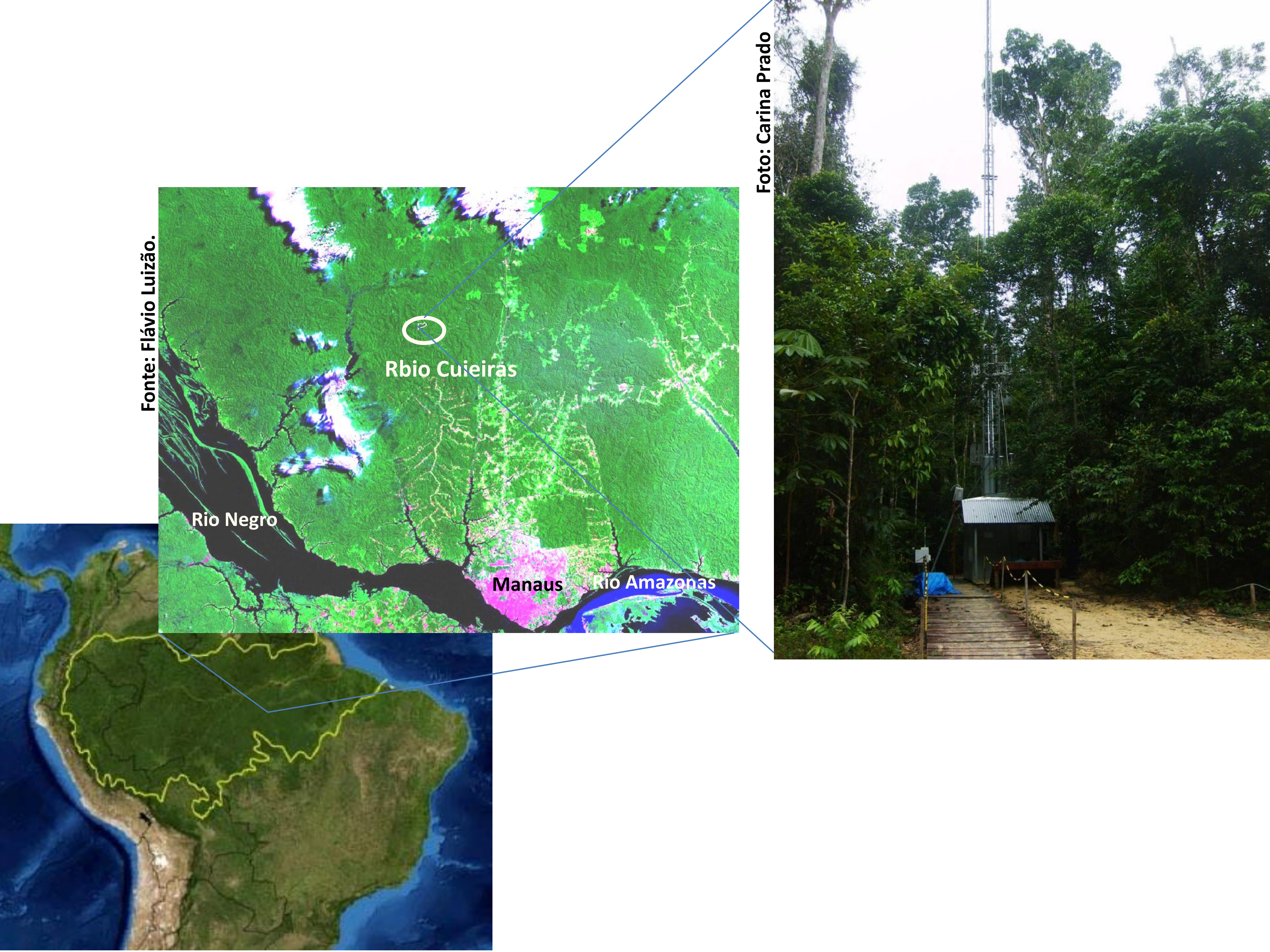
10. Aerosol effects on deep convective clouds, precipitation, and lightning under different aerosol and synoptic regimes, including the roles of aerosols in changing regional climate and atmospheric circulation; and

11. Improvement of parameterizations of aerosol-cloud interactions in the regional and global climate models

Amazonian Tall Tower Observatory
ATTO – 320 meters
Long term broad objectives observatory



ATTO site: Picture of the 85 meters tall tower at the left that is being used for aerosol and trace measurements and the proposed 320 tall tower under construction.


Rbio Cuieiras
Rio Negro
Manaus
Rio Amazonas
Fonte: Flávio Luizão.
Foto: Carina Prado

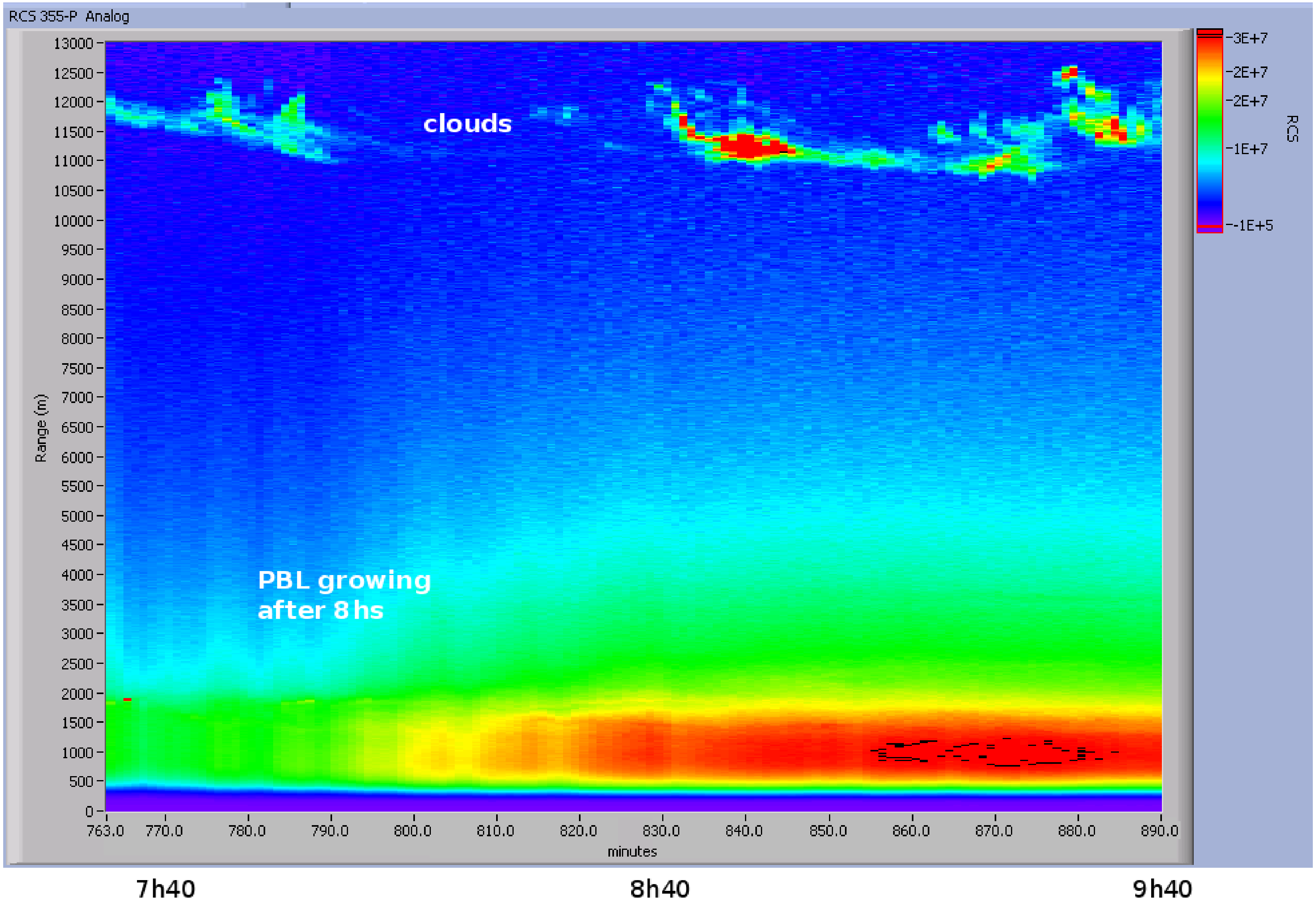
List of instruments at our upwind clouds site (EMB-Embrapa). Second column indicates instrument status. Third column shows if the downwind ARM site will have exactly the same instrument (=) or similar (DIF) instrumentation.

Instrument	EMB	ARM	Quantity Provided
UV Raman Lidar (Raymetrics)	1	DIF	Vertical profile of aerosol extinction and backscatter; night only: water vapor, lidar ratio
THIES Disdrometer	1	DIF	Raindrops size distribution (optical) at ground.
Multi Filter Radiometer (MFR)	1	=	Spectral shortwave radiation (direct and diffuse), optical depth of water vapor, ozone and clouds
Aeronet Sunphotometer	1	=	AOD, size distribution, phase function, water vapor, Angstrom coefficient, 7 wavelengths
Thermal infrared imager	1	DIF	Brightness temperature on cloud sides and cloud base
Thies Met station	1	DIF	P, T, RH, wind and radiation
Ceilometer (Jenoptix CHM15k)	2	DIF	Cloud base, Cloud amount, Penetration depth, Vertical visibility, Height of mixing layer
Micro Rain Radar (Metek MRR-2)	2	DIF	Vertical profile of reflectivity, raindrop size distribution and rain rate.
MP3000 Radiometer (Radiometrics)	3	=	Vertical profile of T, RH and liquid water of non-precipitating clouds
JOSS Disdrometer	3	=	Raindrops size distribution (acoustic) at ground.
PARSIVEL Disdrometer	3	DIF	Raindrops size distribution (optical) at ground.
Davis Met station	4	=	P, T, RH, wind and precipitation
GPS/GNSS + Vaisala Met station	4	=	Integrated Precipitable Water (IPW), P, T, RH

List of instruments to be acquired and operated within this FAPESP component, to be operated at Embrapa. Justification is included in the discussion above.

Instrument	ARM	Quantity Provided
Sky imager (YesInc TSI-880)	=	Cloud cover, Sun shine duration
Campbell CNR4-L Net Radiometer	=	up/down pyranometers and pyrgeometers for net short and thermal radiation
IRGA SON Integrated Gas Analyzer and Sonic Anemometer	DIF	latent and sensible heat fluxes

Raman Lidar: aerosols and water vapor up to 13 Km in Manaus

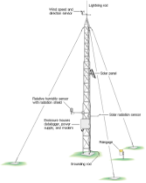


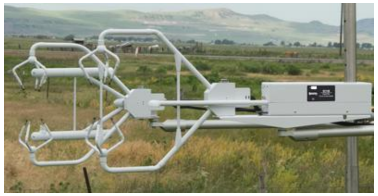
Henrique Barbosa, 2013

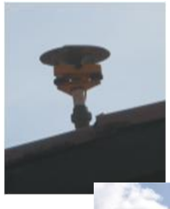
Instrumentation in GoAmazon 2014.

SELEX METEOR 50DX
X-Band DUAL POLAION RADAR

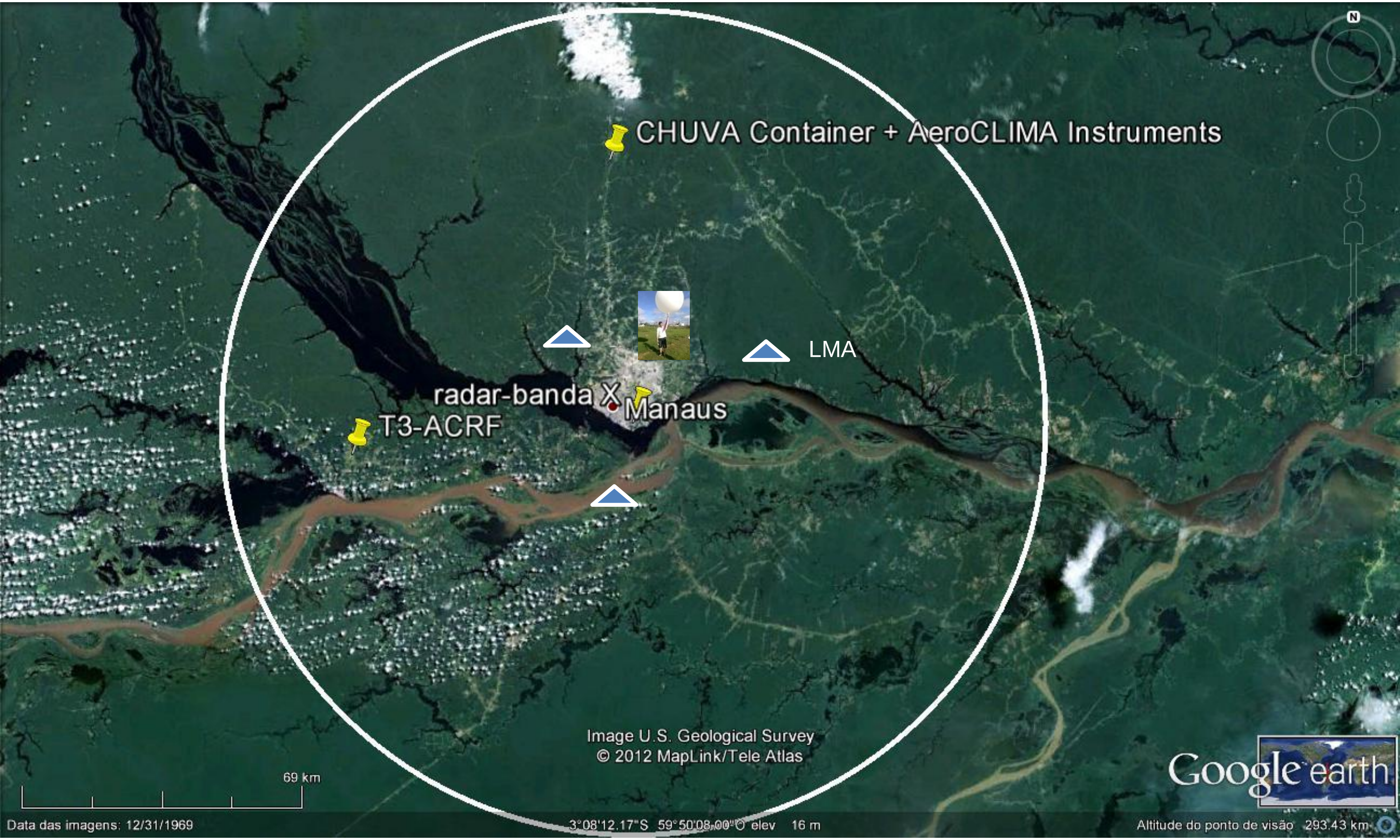
Multi Instrument Container and Networks





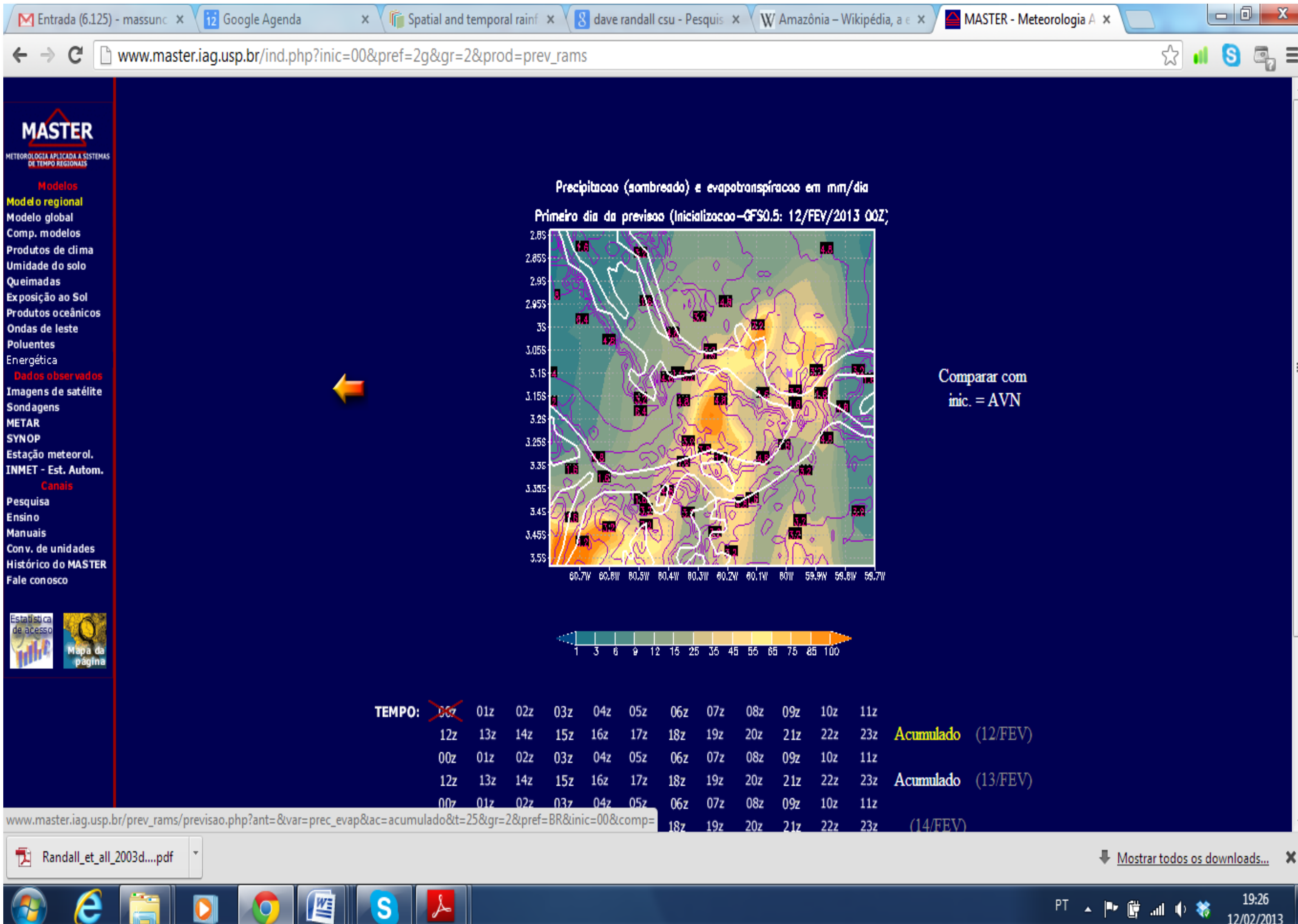


Proposal Locations



High resolution operational 2 km resolution regional forecast with BRAMS for the GOAMAZON.

http://www.master.iag.usp.br/ind.php?inic=00&pref=2g&gr=2&prod=prev_rams



Aircraft camapiagns

IARA - GoAmazon 2014

Activities related to Aerosol, Cloud, Precipitation, and Radiation Interactions and Dynamics of Convective Cloud Systems (ACRIDICON)

and CHUVA Project

Luiz.Machado@cptec.inpe.br


Thanks for the attention!!