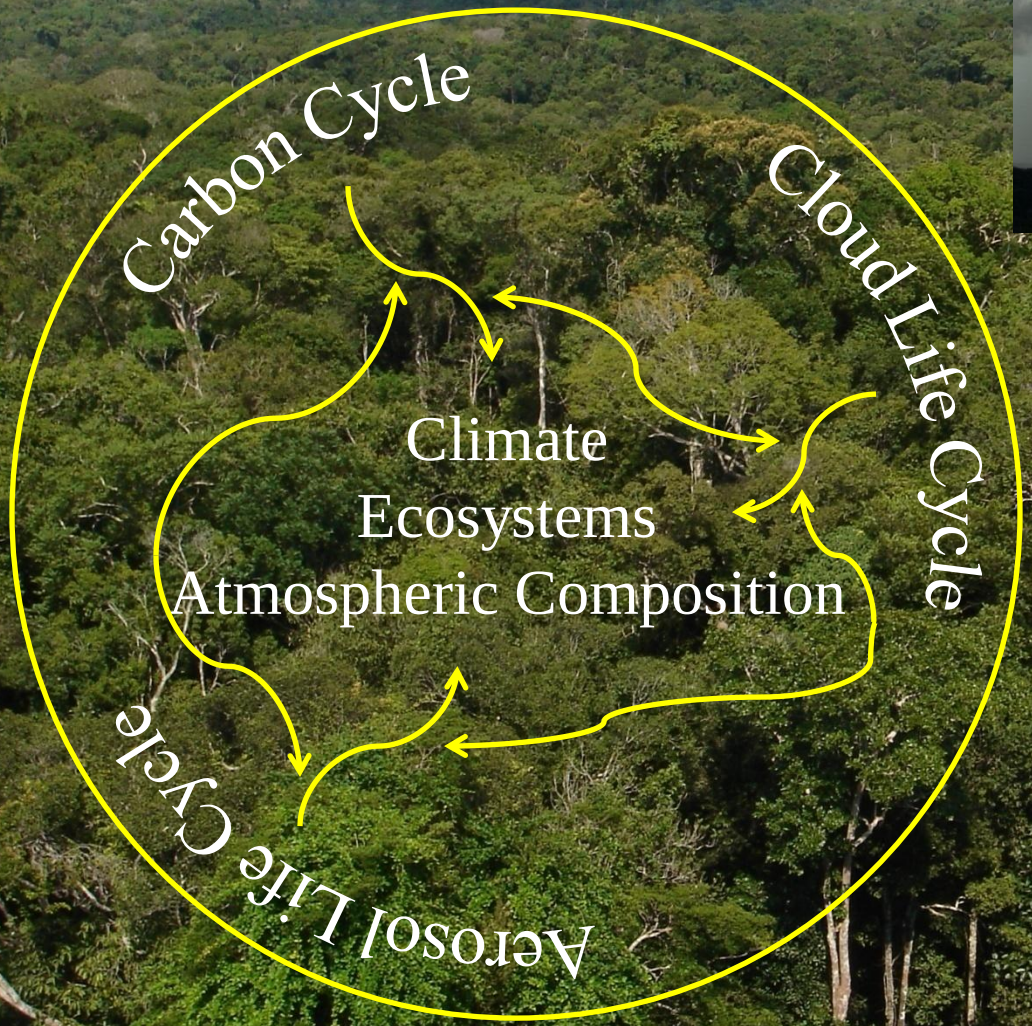
Observations and Modeling of the Green Ocean Amazon (GoAmazon2014/5)

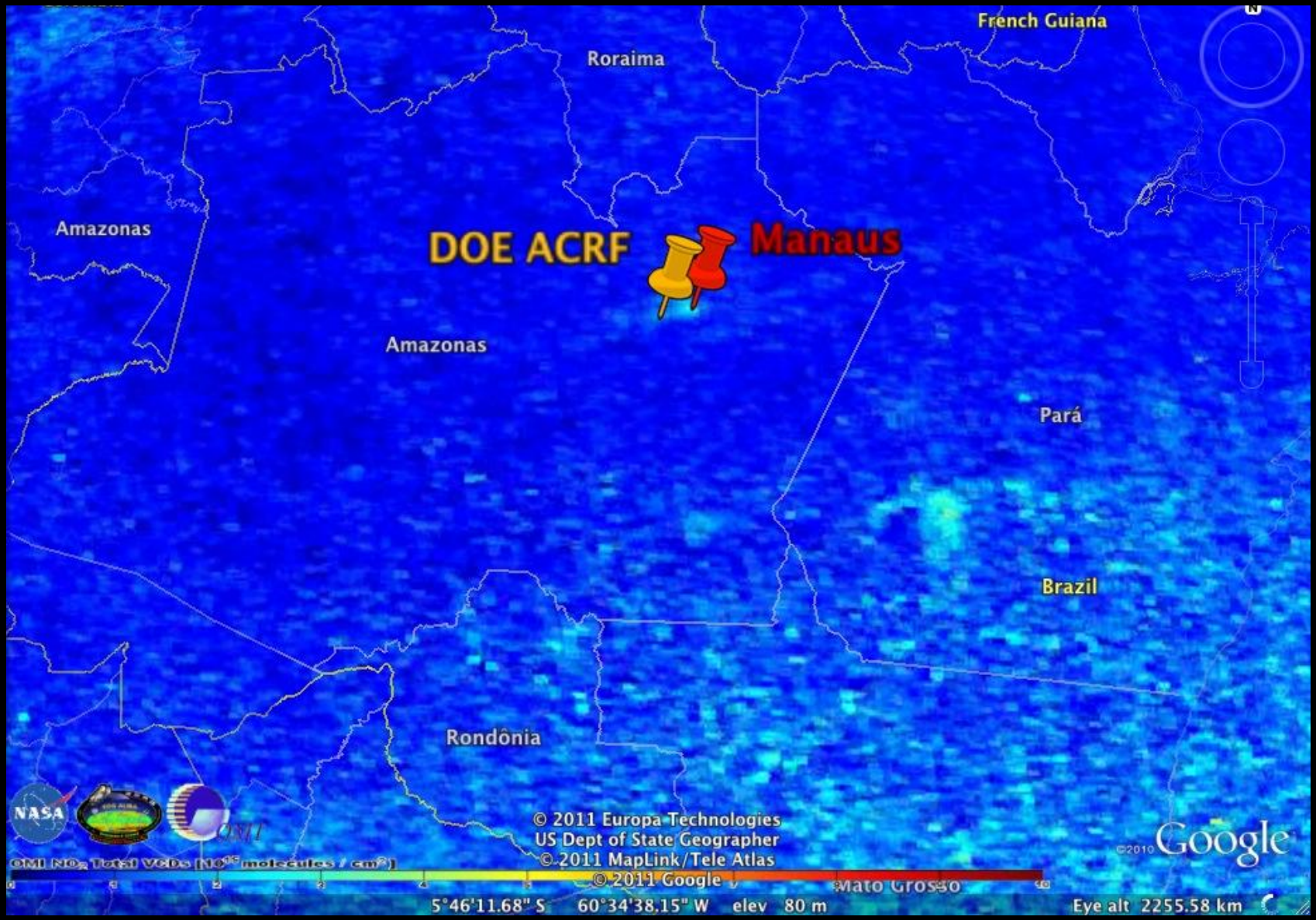


Presented by
Scot Martin (Harvard)
on behalf of Brazil
and USA partners

May 2013

CHUVA Meeting, USP, Brazil

NO_2 Outflow from Manaus in Aug 2010 observed by OMI



Acknowledgments: Jun Wang, Univ. Nebraska

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

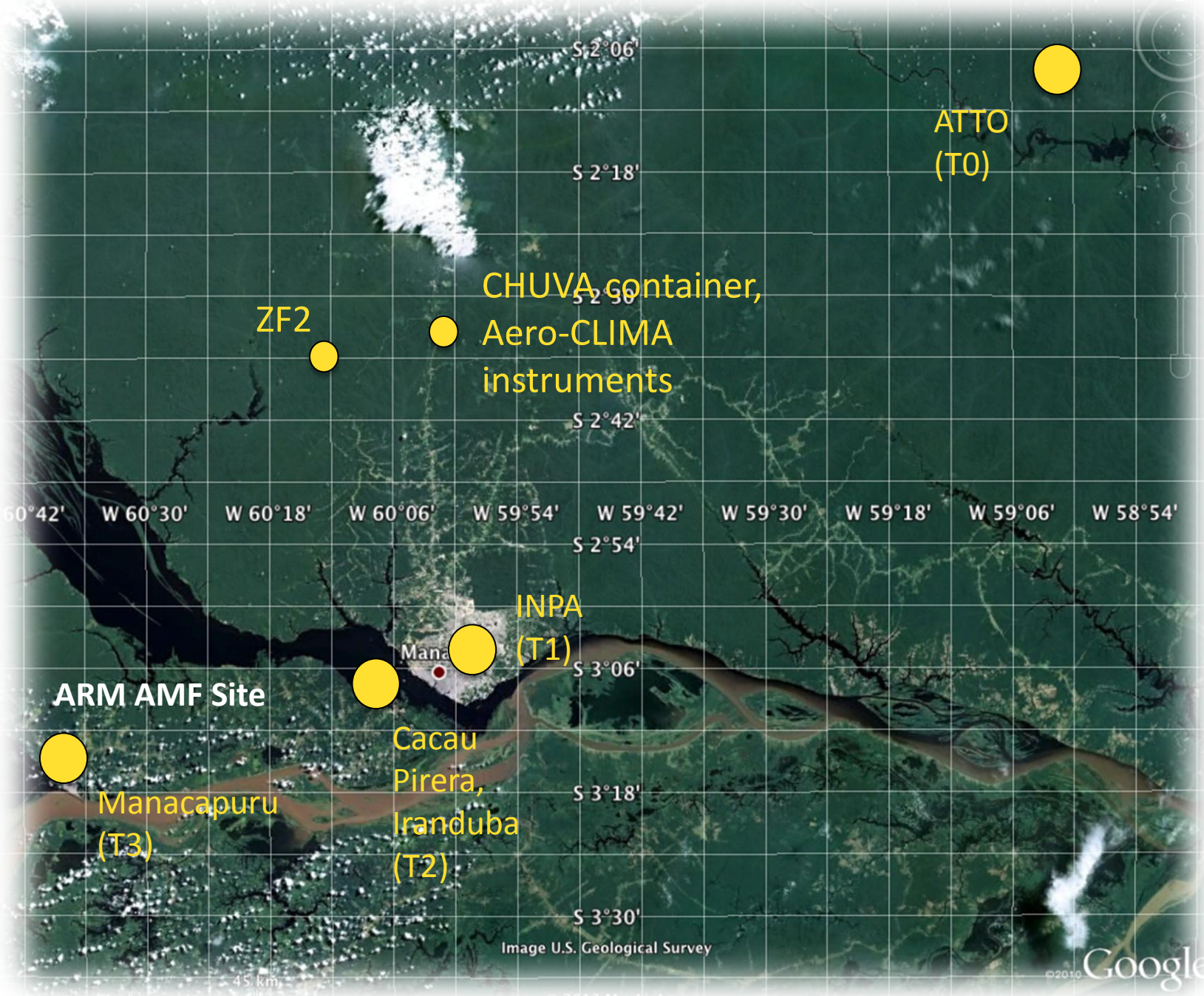
Hydropower

Oils of different grades

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

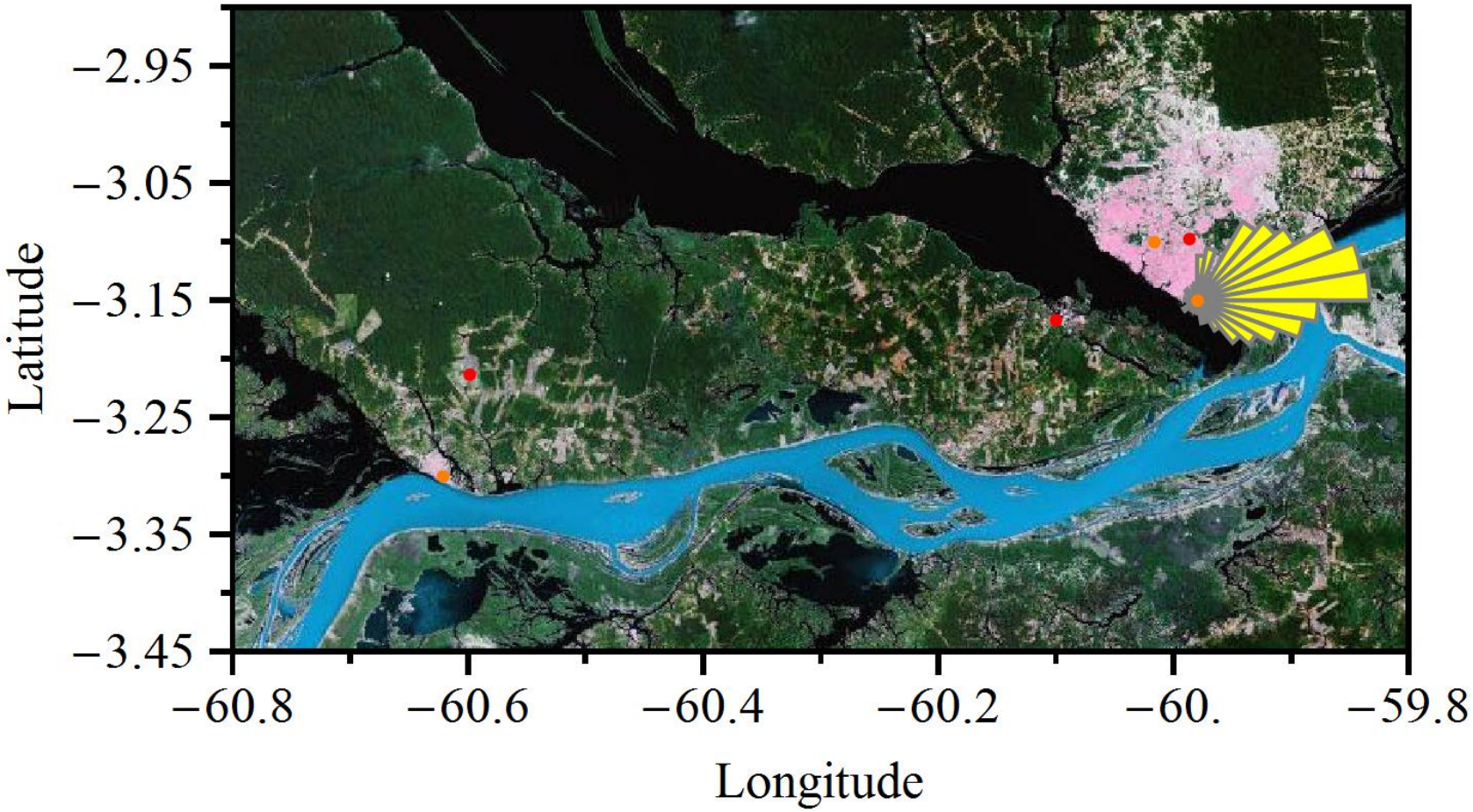
OCA-1 = Óleo Combustível com Alto teor de enxofre = Fuel Oil with High Sulfur

Acknowledgments: Rodrigo Souza, UEA



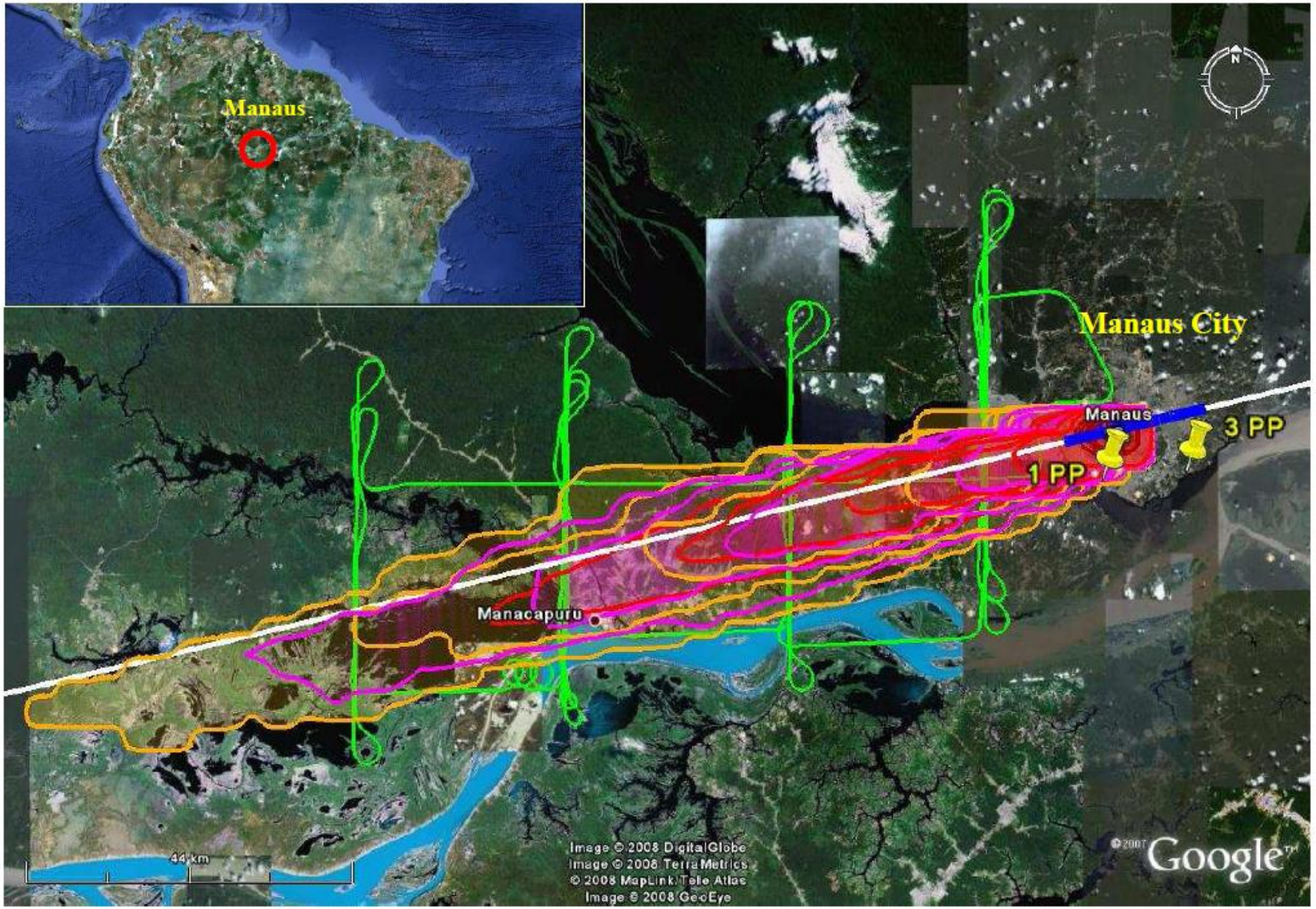
GoAmazon Site Locations

Downwind of Manaus

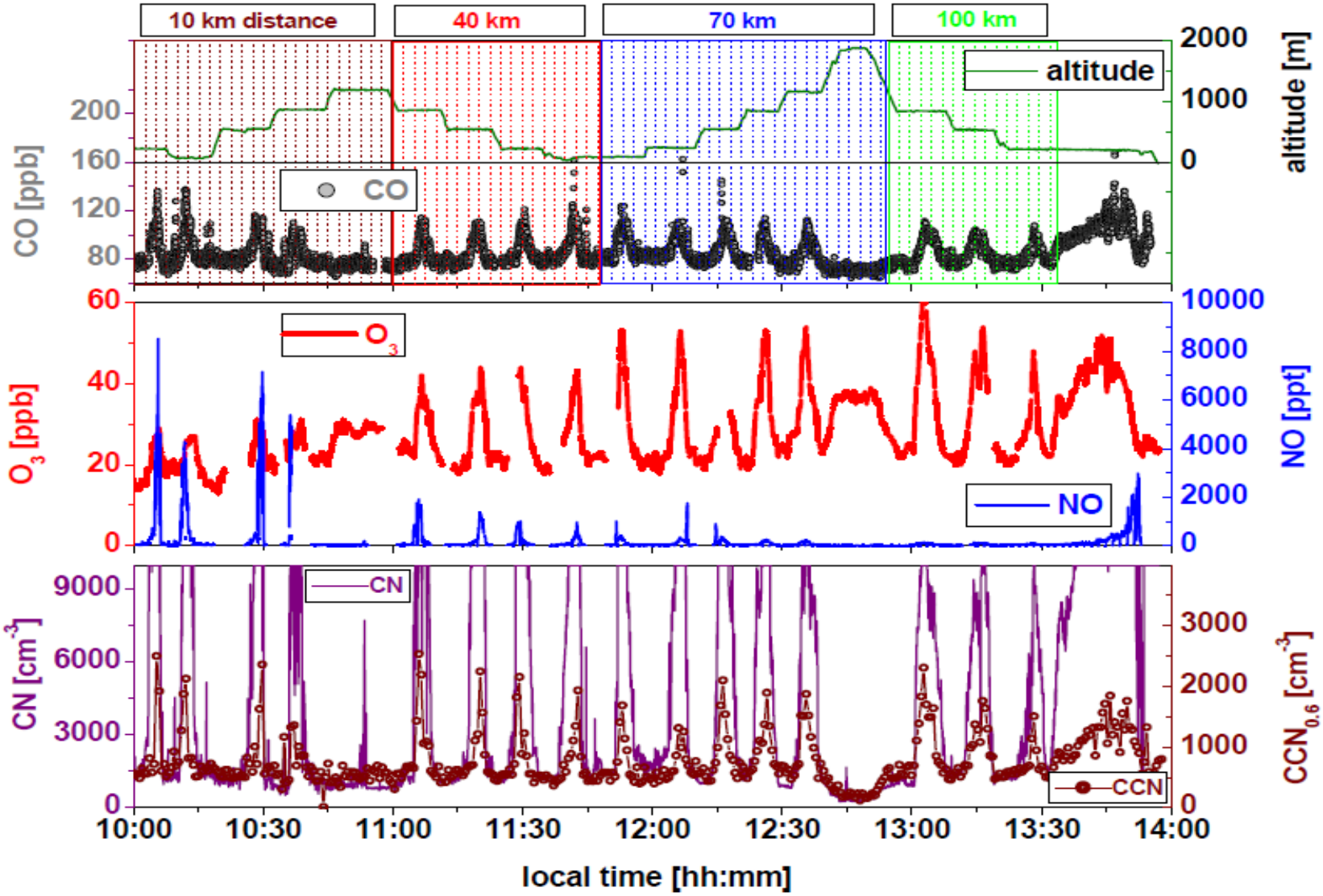


(−3.21328 ,	−60.5987)	DOE ARM ACRF	T3
(−3.16667 ,	−60.1)	TBD	T2
(−3.09722 ,	−59.9867)	INPA/UEA	T1
(−2.14663 ,	−59.005)	ATTO	T0
(−2.60908 ,	−60.2093)	K34	K34
(−2.59458 ,	−60.2093)	AMAZE08	TT34

- 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.



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.

Downwind of Manaus

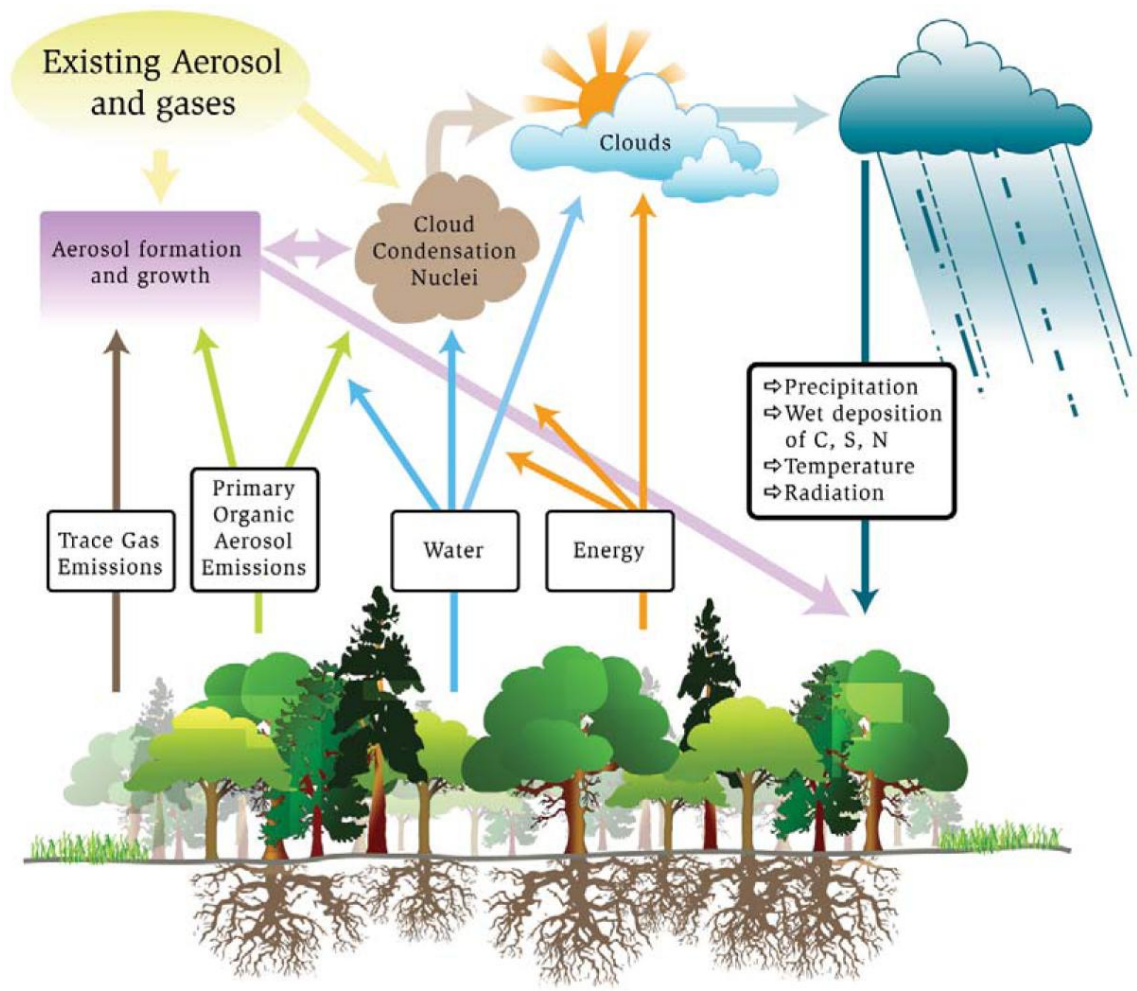
The deployment site is situated in the steady trade winds such that it experiences the extremes of:

(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.

Reminder: GoAmazon2014/5 Theme: What is the effect of pollution on… these cycles and the coupling among them?

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.

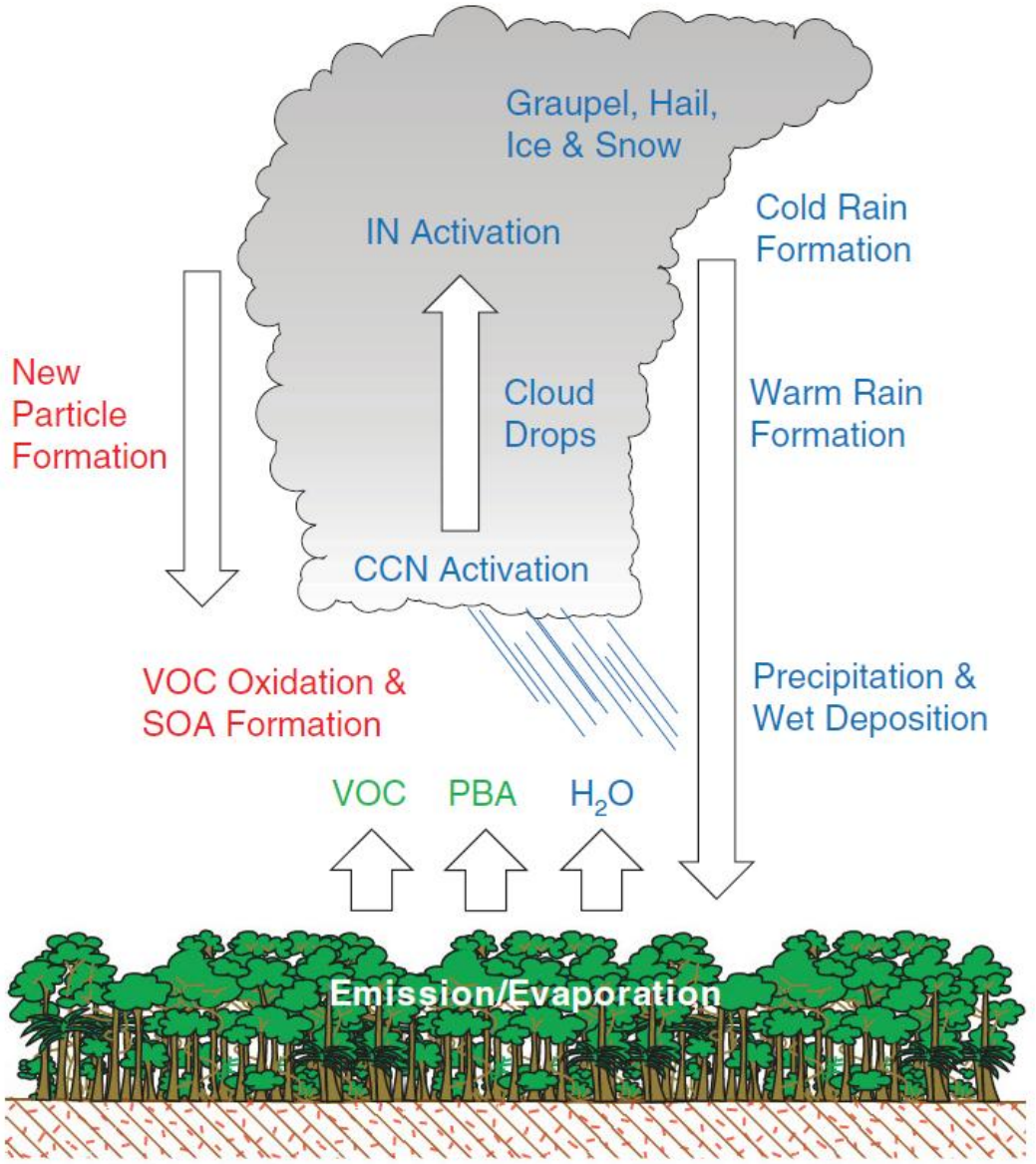


Source: Barth et al., "Coupling between Land Ecosystems and the Atmospheric Hydrologic Cycle through Biogenic Aerosol Particles," *BAMS, 86*, 1738-1742, 2005.

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?



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

Dates of GoAmazon2014/5

AMF Operations (T3 ground site)

- 1 January 2014 until 31 December 2015

AAF Operations (aircraft)

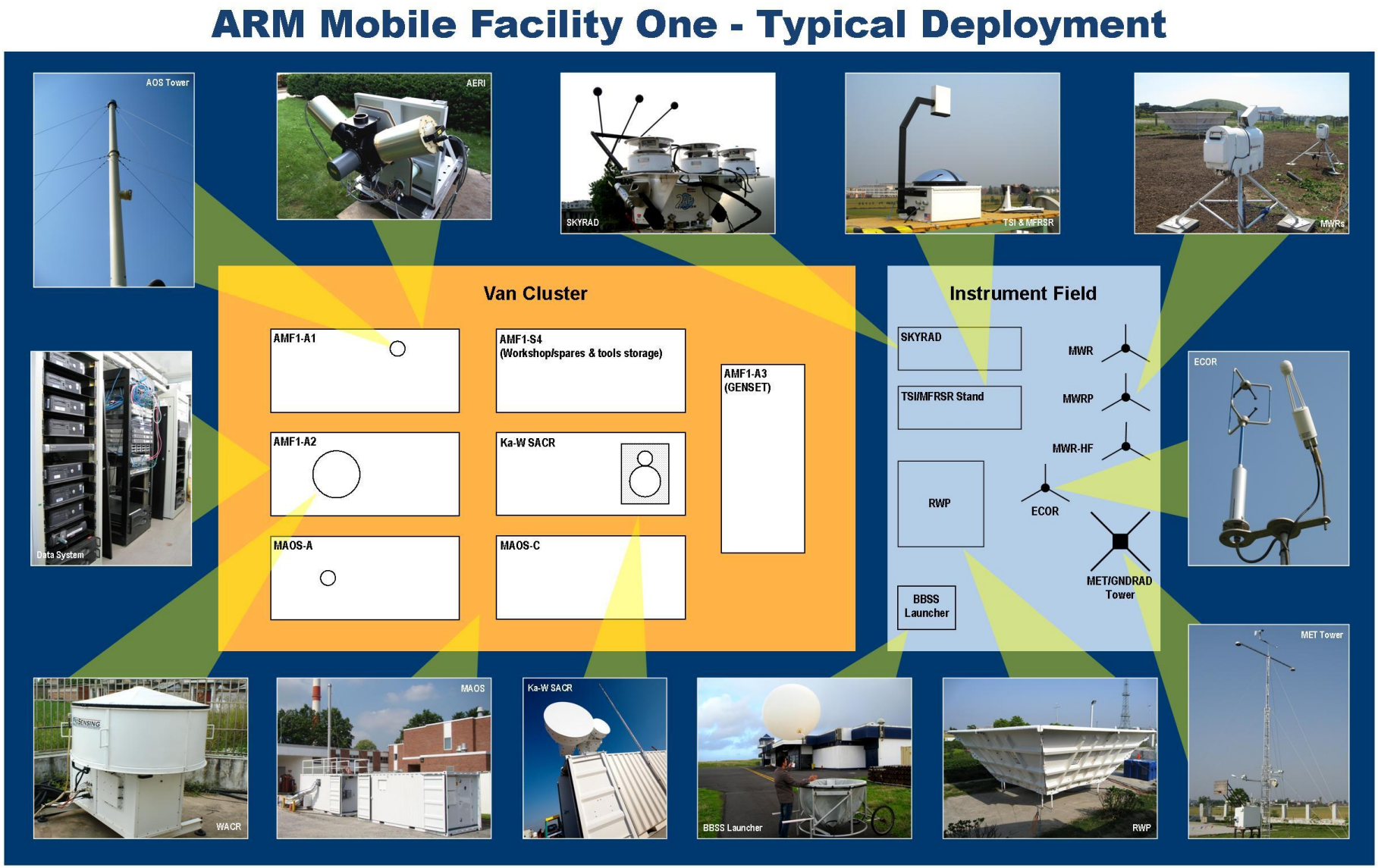
- 15 February until 26 March 2014 (wet season) (75 hrs)
- 1 September until 10 October 2014 (dry season) (75 hrs)

Aircraft operations correspond to the two *intensive operating periods* planned for the experiment.

December 2011: Fence and Weather Station

18 March 2013, T3

ARM Mobile Facility in Amazônia (AMFA) (Jan 2014)



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); technician + 2 x full time post-docs (supplied by ARM) ; Guest operational personnel (up to 5)

- SOnic Detection And Ranging (SODAR) System (1000 to 4000 Hz)
- Ultra-High Sensitivity Aerosol Spectrometer (enhanced) - Senum
- Dual Column Cloud Condensation Nuclei Counter (CCN) - Senum
- Single Particle Soot Photometer (SP2) - Sedlacek
- Scanning Mobility Particle Sizer (SMPS) - Kuang
- Photo-Acoustic Soot Spectrometer (PASS), 3 Wavelength –Dubey and Aiken
- Trace Gas Instrument System (Research-Grade) (CO, NO, NO_2, NO_y, O_3, SO_2) - Springston
- Particle Into Liquid Sampler-Ion Chromatography-Water Soluble Organic Carbon (PILS-IC-WSOC) - Watson and Lee
- Particle Soot Absorption Photometer (PSAP), 3 Wavelength – Springston
- Condensation Particle Counter (CPC), 10 nm to >3000 nm particle size range - Kuang
- Condensation Particle Counter (CPC), 2.5 nm to >3000 nm particle size range - Kuang
- Hygroscopic Tandem Differential Mobility Analyzer (HTDMA) - Senum
- Proton Transfer Mass Spectrometer (PTRMS) - Watson
- 7-Wavelength Aethelometer - Sedlacek
- Weather Transmitter (WXT-520) - Springston
- Aerosol Chemistry Speciation Monitor (ACSM) - Watson
- Ambient Nephelometer (3 wavelength) – Senum
- Controlled RH Nephelometer (3 wavelength) - Senum
- DMA-CCN – Wang
- HR-ToF-AMS – Alexander

“Intensive Airborne Research in Amazonia 2014” (IARA-2014)

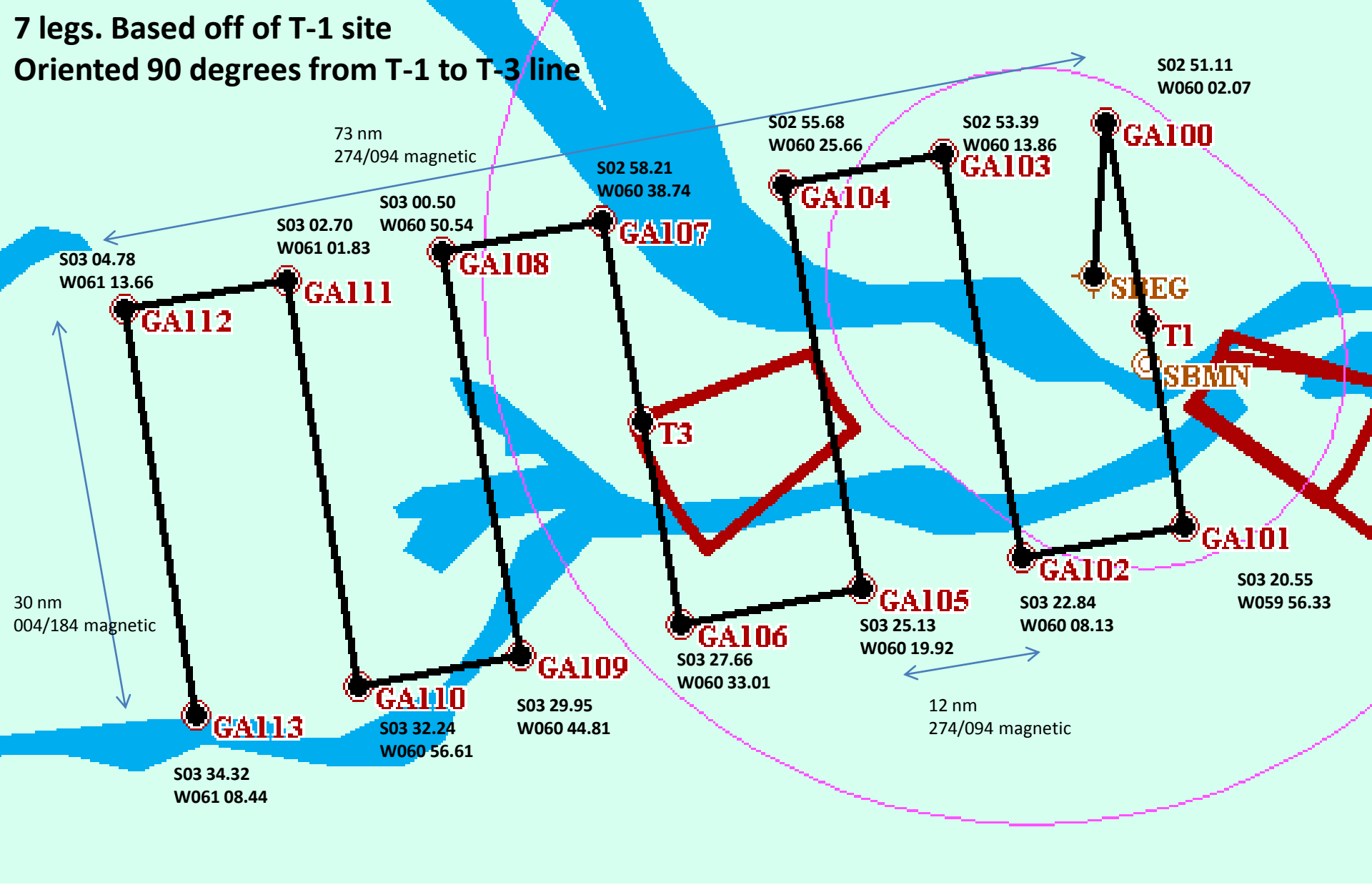
The ARM Aerial Facility (AAF) in Brazil

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		



IARA – Intensive Airborne Research in Amazonia

Flight Plan #7

1:35 to complete one pattern.

A white paper on

Effects of Anthropogenic Pollution on the Atmospheric Chemistry of the Tropical Rain Forest: *Intensive Operating Periods (IOPs) of GoAmazon2014*

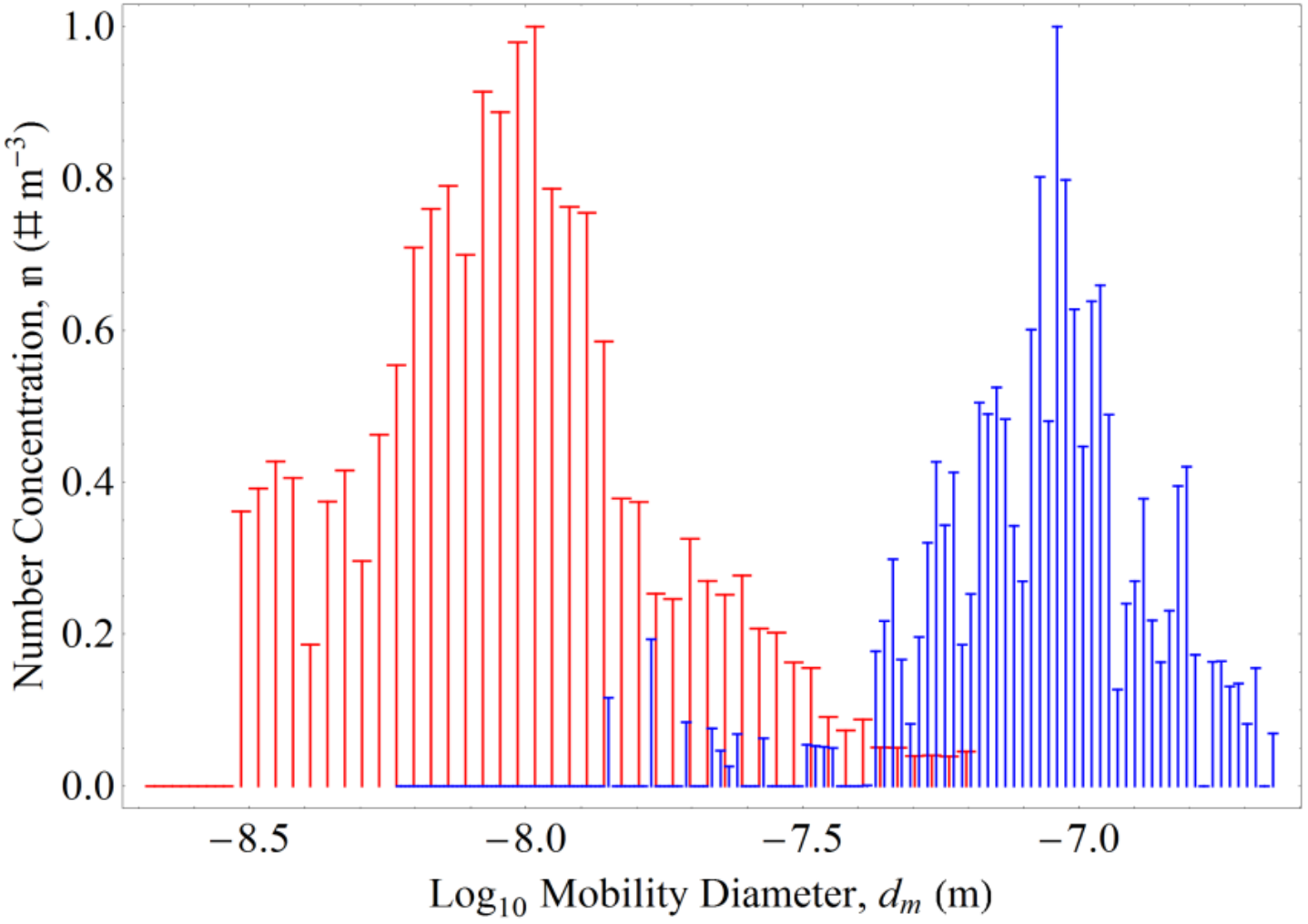
Meinrat O. Andreae, Paulo Artaxo, William Brune, Peter Buseck, Manvendra Dubey, Jiwen Fan, Delphine Farmer, Jerome Fast, Allen Goldstein, Alex Guenther, Jose Jimenez, Jürgen Kesselmeier, Frank Keutsch, Larry Kleinman, Karla Longo, Antonio Manzi, Scot Martin*, Luciana Rizzo, John Shilling, Rodrigo Souza, Julio Tota, Ivonne Trebs, Jian Wang*, Rodney Weber

*scot_martin@harvard.edu; jian@bnl.gov

Original: 29 August 2012. Updated: 05 March 2013

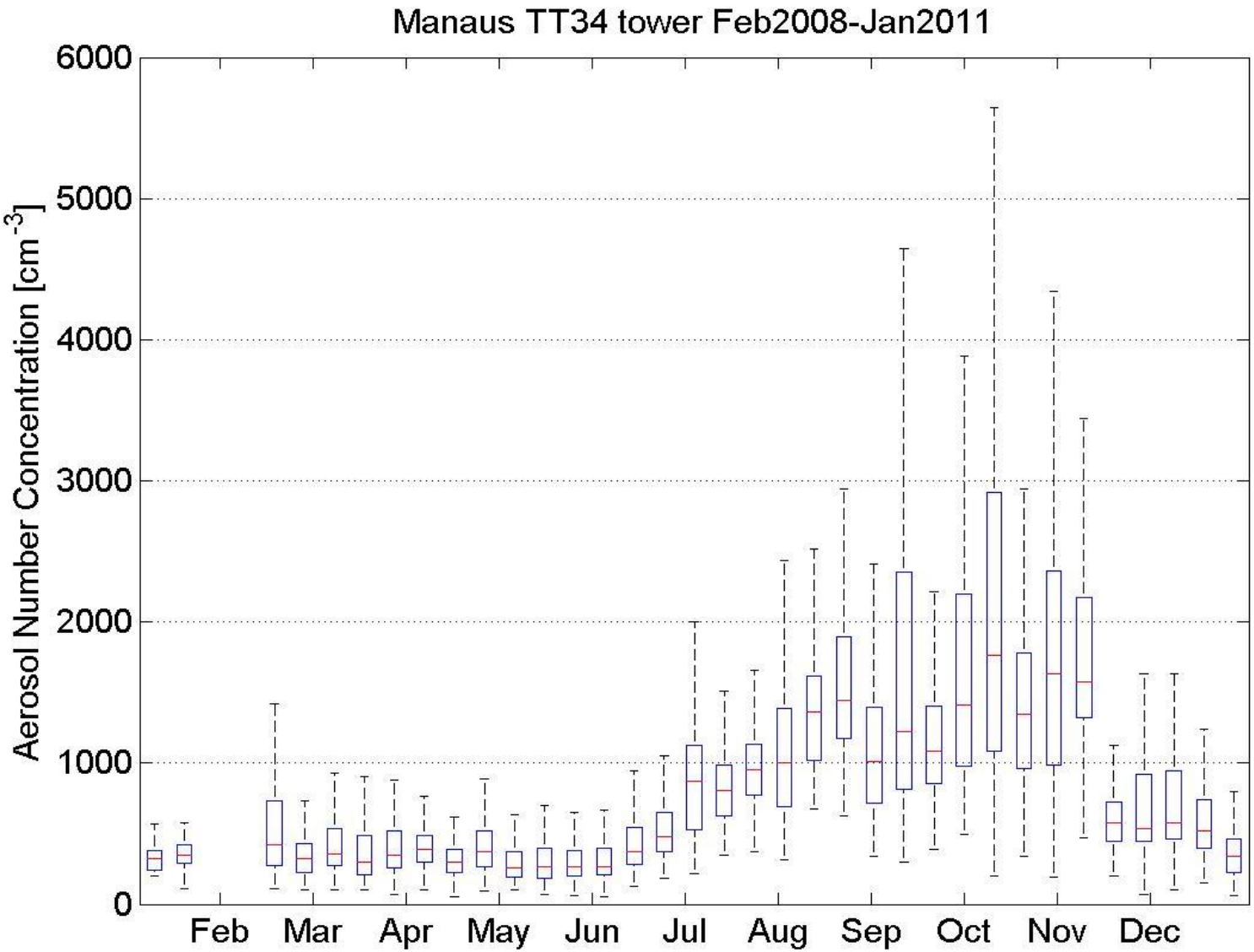
Two Brazil-side containers (FAPEAM) being outfitted with assistance from LANL

Normalized Size Distributions: *Polluted and Clean Conditions*



Source: S. Martin, J. Wang, R. Souza, P. Artaxo, Y. Ishida, J. Jimenez, private communication

Seasonal Particle Number Concentration



Source: Luciana Rizzo and Paulo Artaxo, private communication

Proposed NCAR facilities and timeline

<u>S-Pol radar</u>

Doppler, polarimetric measurements at

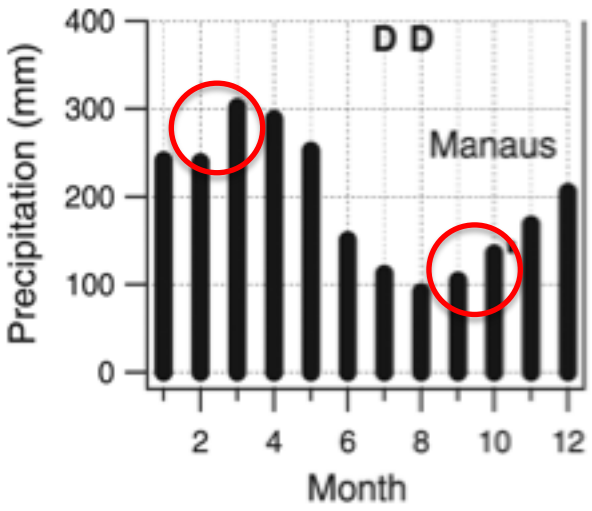
- S-band (10 cm, non-attenuating) and
- K_a-band (0.8 cm, heavily attenuating)

<u>2 Integrated Sounding Systems (ISS)</u>

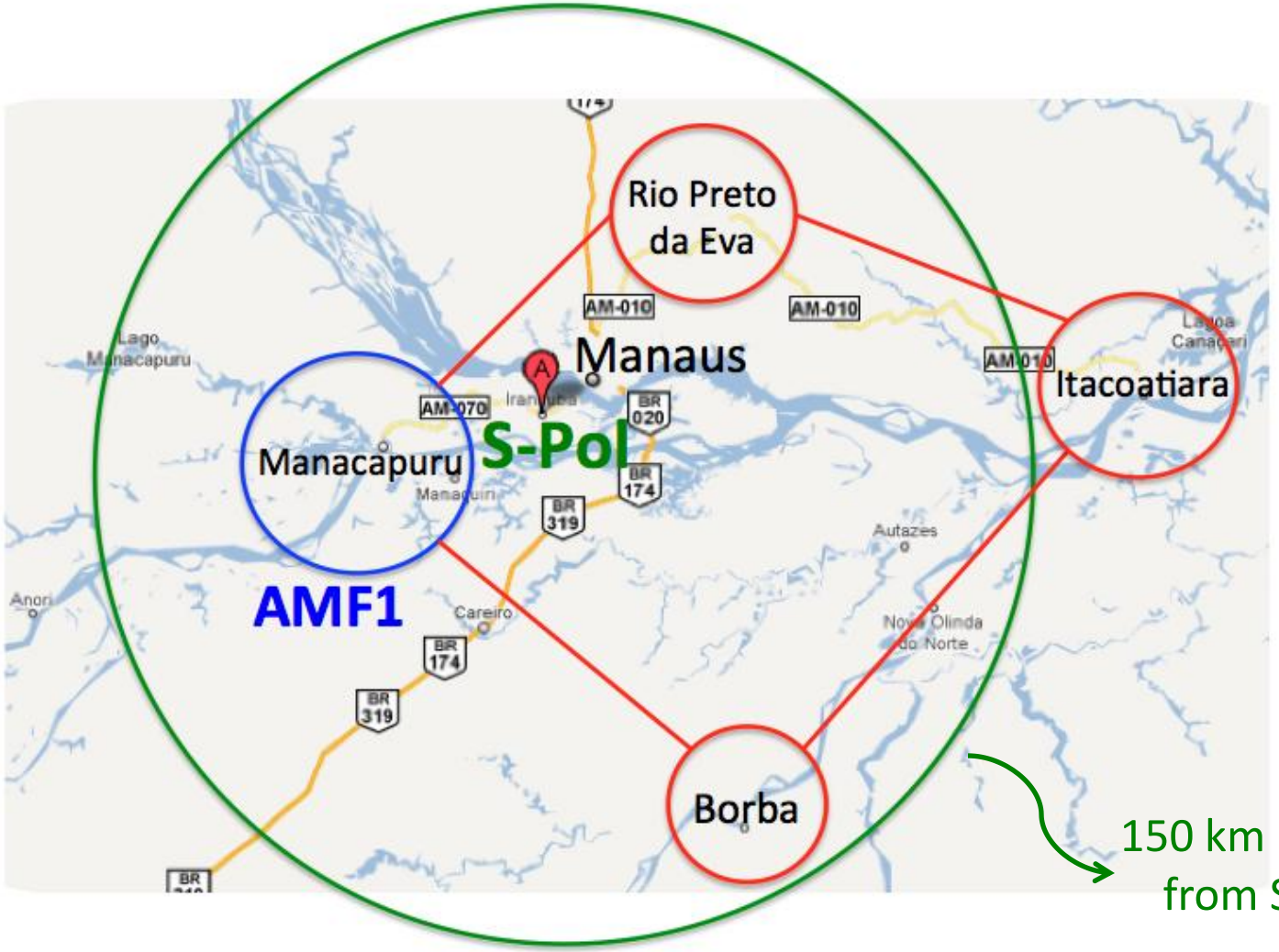
- GAUS radiosonde sounding system
  - 6/day launches
- Wind profiler/RASS
- Surface meteorology

<u>Deployment periods</u>

- IOP: Sep/Oct 2014 (transition season)
- IOP: Feb/Mar 2015 (wet season)



Potential S-Pol and sounding array sites



This network will provide more extensive observations of deep convection and the large-scale environment during GOAmazon.

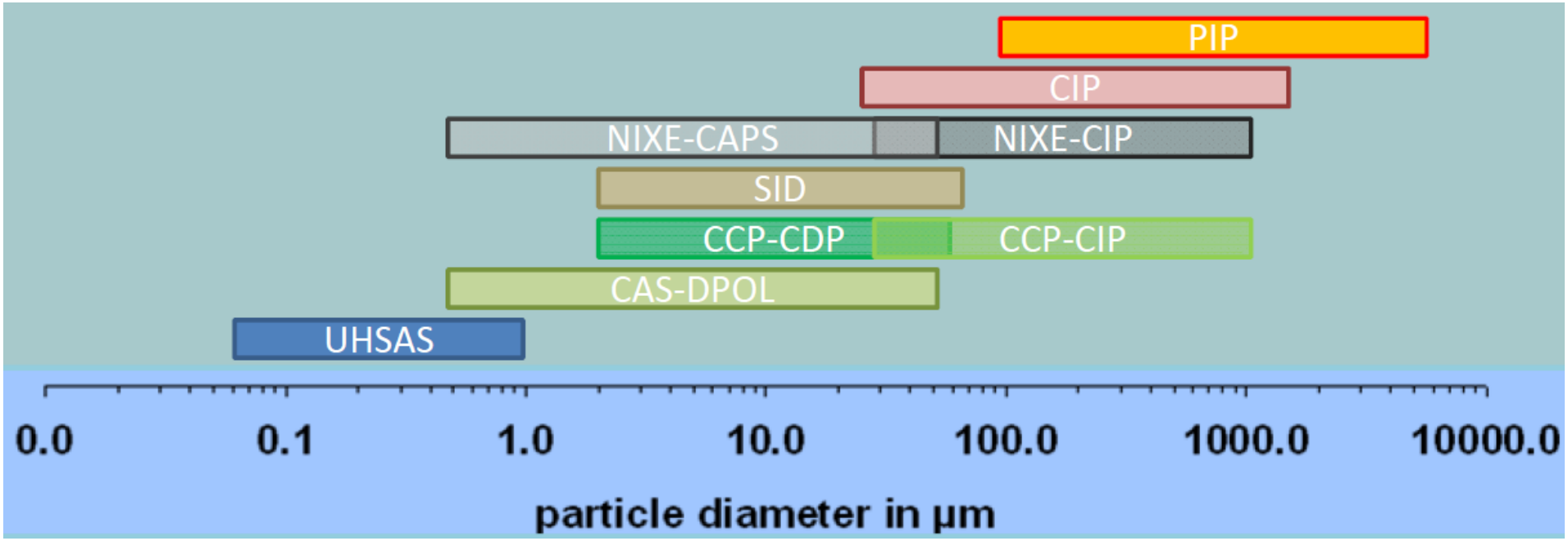
Aerosol, Cloud, Precipitation, and Radiation Interactions and Dynamics of Convective Cloud Systems (ACRIDICON)

Measurement Parameters and Techniques

- Aerosol particles: SD, BC, CCN, IN, Backscatter, Depol, Mixing State, Hygroscopicity
- Cloud particles/nuclei: SD, LWC, IWC
- Radiation/remote sensing: Spectral Radiometers, DOAS, LIDAR, LWP, IWP, RWP, SWP, GWP, humidity, and temperature profiles as well vertical hydrometeor classification.
- Precipitation/dynamics: RADAR
- Trace gases: CO, O3, SO2, NOx, NOy, PFC, CH2O NO2, HONO, BrO, IO, OIO, O2 und O4, H2O (Gas)
- Inlets: CVI, MAI, HASI (submicrometer and micrometer)
- Wing station probes:

Measurement Parameters and Techniques

Wing station probes



Mission Types

(1) Cloud Vertical Evolution (Cloud Profiling)

(2) Aerosol Processing (Inflow, Outflow)

(3) Satellite Validation (Cloud Products)

(4) Vertical Transport & Mixing (Artificial Tracer)

→ *Contrast of pristine and highly polluted conditions (in comparable thermodynamic environments)*

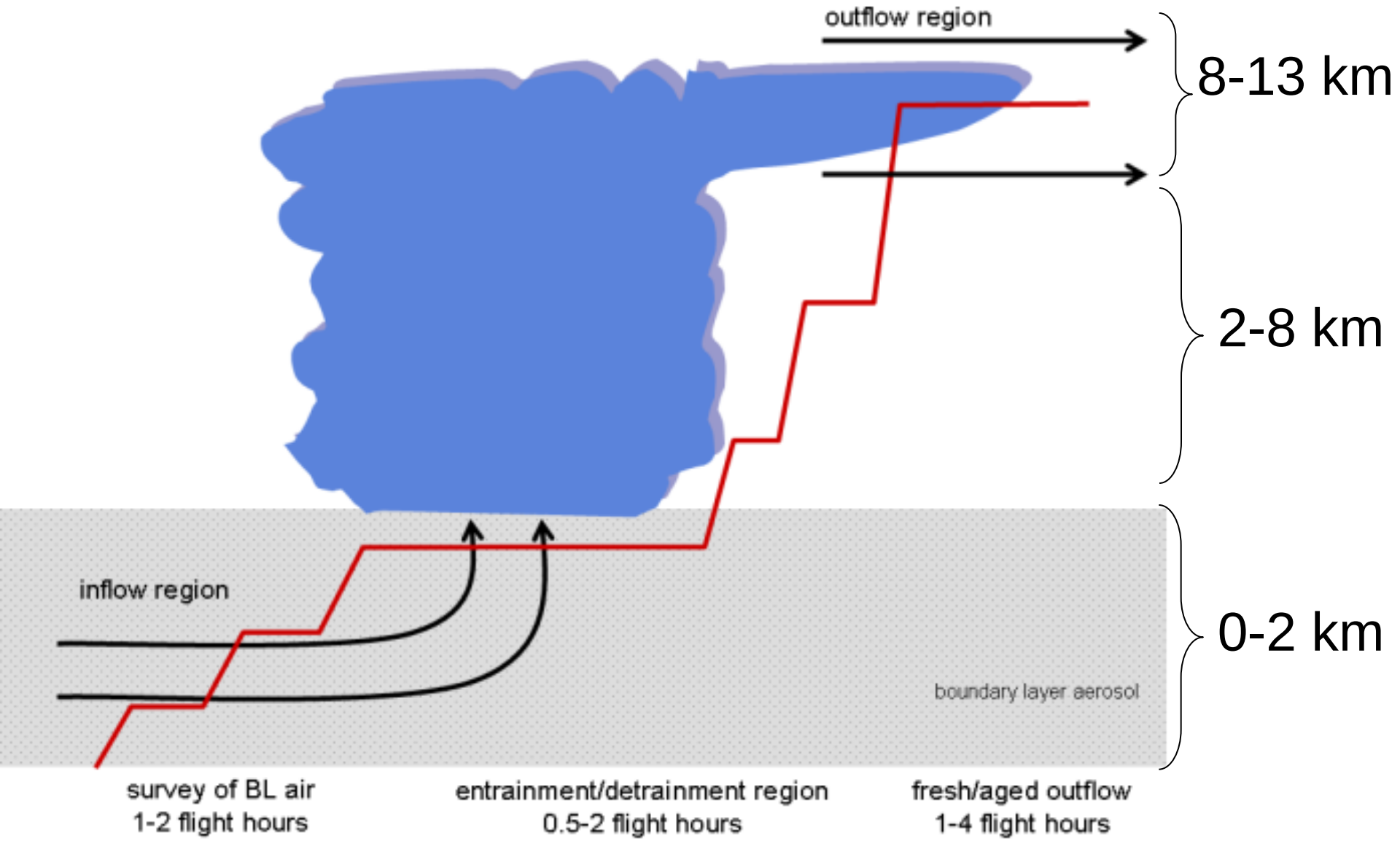
→ *Contrasting thermodynamic conditions (cloud base temperatures, humidity fields, wind shear)*

Mission Type 2: Aerosol Processing

Objectives:

- Characterize aerosol properties in the **inflow and outflow**.
- Quantify the **vertical redistribution** of aerosols.
- Study particle formation processes and the evolution of aerosol properties (size distributions, chemical processing) in the **fresh and ageing outflow** of convective cells.
- Assess the **cloud processing** of aerosol particles, in particular black carbon containing particles.

Mission Type 2: Aerosol Processing



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

Main research foci:

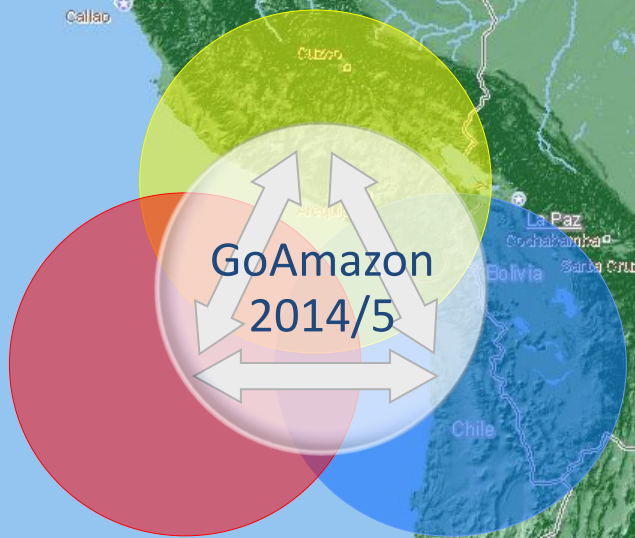
- The changing environment of Amazonia
- Environmental sustainability and the sustainability of current terrestrial and aquatic production systems
- Variability and changes in climatic and hydrologic systems – feedback, adaptation and mitigation

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;

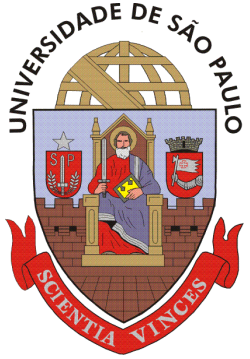
Blue: the social dimensions of environmental change and the dynamics of land cover change



Acknowledgments: Laszlo Nagy, INPA/LBA

Brazil-Side Organizations

- LBA - Large-Scale Biosphere Atmosphere Experiment, http://lba.inpa.gov.br/lba/
- INPA - National Institute for Amazonian Research, 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
- GPM-CHUVA (http://chuvaproject.cptec.inpe.br/portal/en/index.html)
- CsF - Ciencias Sem Fronteiras (http://www.cienciasemfronteiras.gov.br/)
- FAPEAM - Fundação de Amparo à Pesquisa do Estado do Amazonas (www.fapeam.am.gov.br)
- FAPESP - Fundação de Apoio à Pesquisa do Estado do São Paulo (www.fapesp.br)



Join this Google group to receive email from PI:

http://groups.google.com/group/GoAmazon2014

Websites:

DOE maintained: http://campaign.arm.gov/goamazon2014/. See there a workshop report of July 2011.

PI maintained: http://www.seas.harvard.edu/environmental-chemistry/GoAmazon2014/