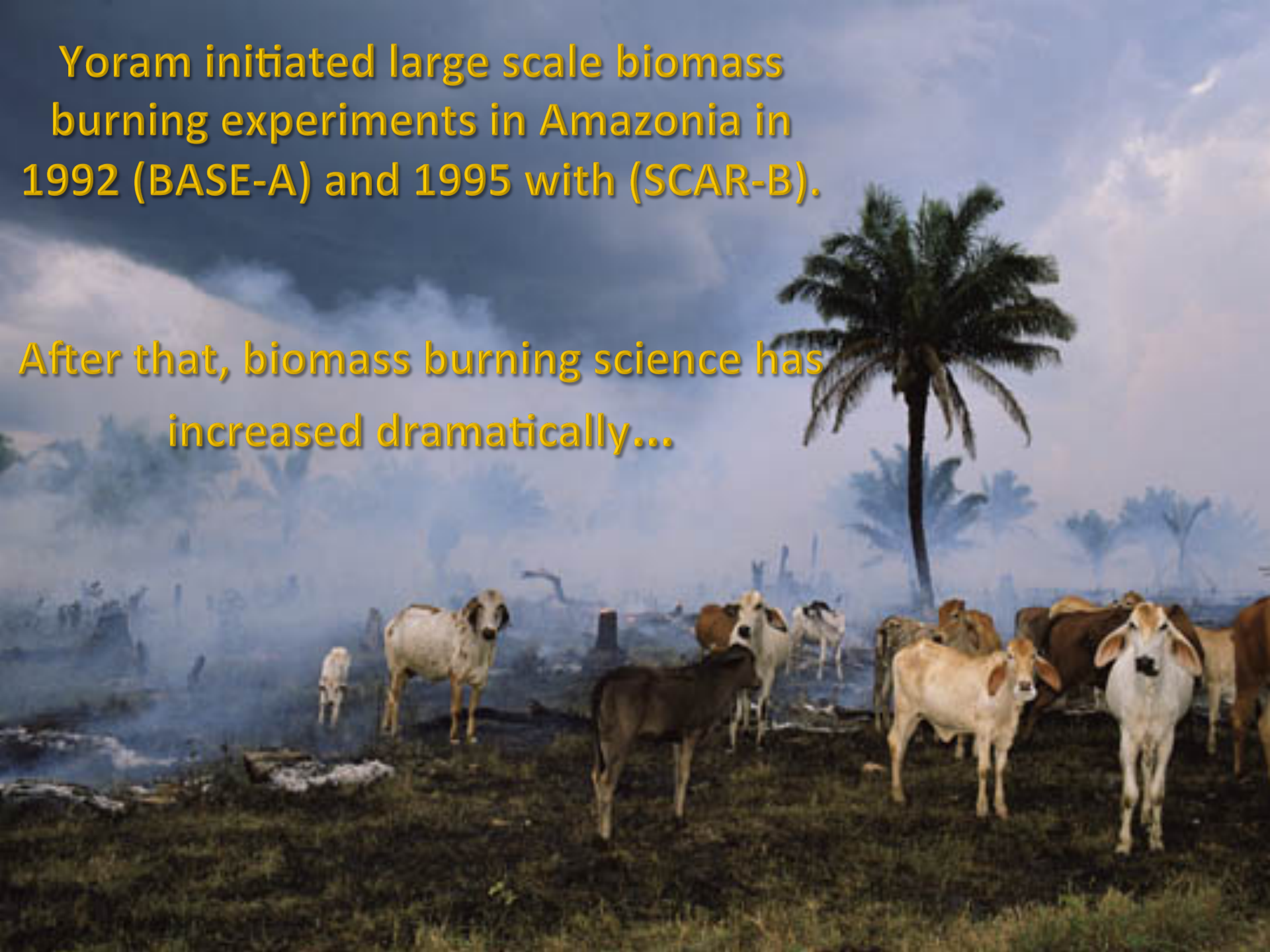
10th Aniversary Yoram Kaufman Memorial Symposium
NASA Goddard June 22, 2016

Legacy of Yoram on Amazonian Research

Paulo Artaxo, Henrique Barbosa, Vanderlei Martins and others
University of Sao Paulo, Brazil.

Trademarks:
Creativity,
innovation and
partnership !!!
Yoram Kaufman


Yoram initiated large scale biomass burning experiments in Amazonia in 1992 (BASE-A) and 1995 with (SCAR-B).
After that, biomass burning science has increased dramatically...

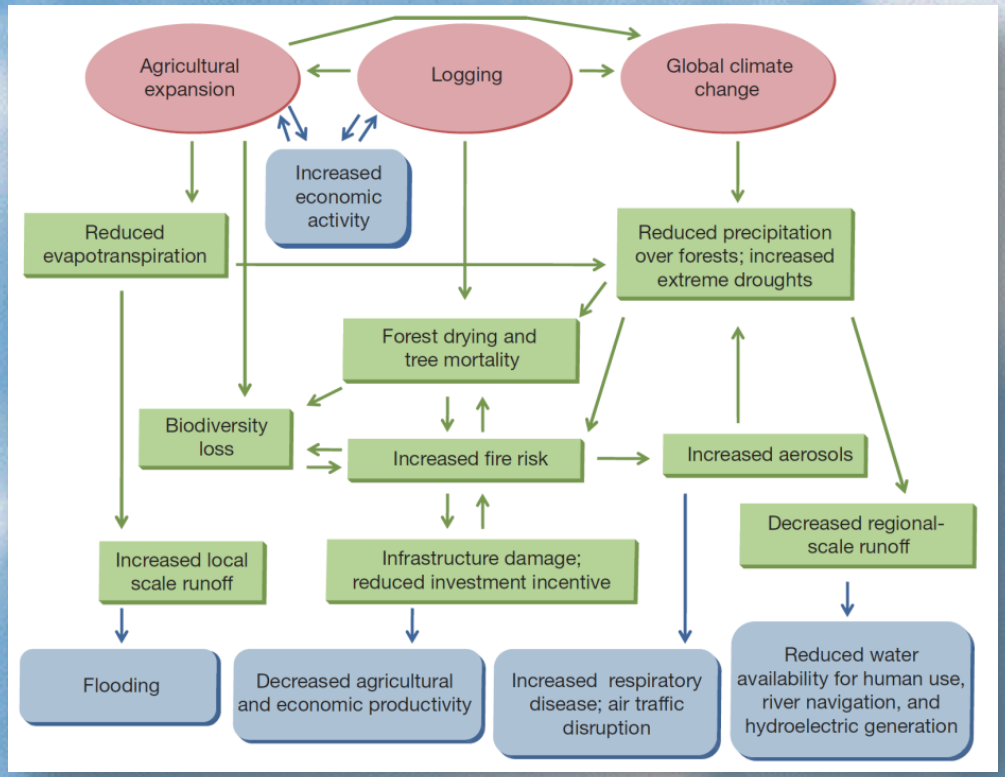
REVIEW

doi:10.1038/nature10717

The Amazon basin in transition

Eric A. Davidson[1], Alessandro C. de Araújo[2,3], Paulo Artaxo[4], Jennifer K. Balch[1,5], I. Foster Brown[1,6], Mercedes M. C. Bustamante[7], Michael T. Coe[1], Ruth S. DeFries[8], Michael Keller[9,10], Marcos Longo[11], J. William Munger[11], Wilfrid Schroeder[12], Britaldo S. Soares-Filho[13], Carlos M. Souza Jr[14] & Steven C. Wofsy[11]

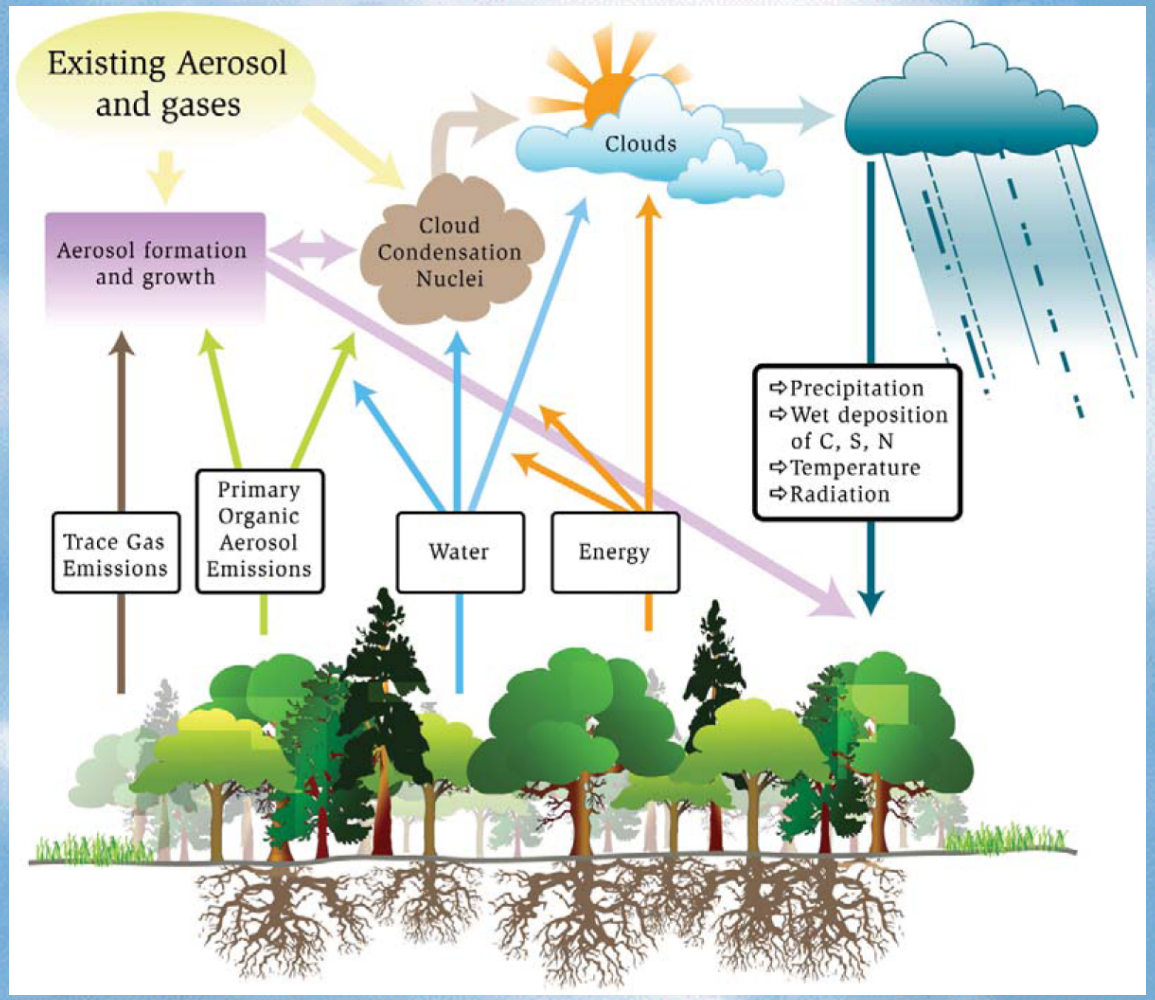
Agriculture expansion and climate variability are critical ingredients on Amazonian transition. Energy balance and hydrological cycles changes are already observed in Amazonia.



Interactions between land use change and climate change are major drivers for changes in Amazonia.

Naturally, the Amazon forest interacts strongly with the atmosphere and climate. There are strong and complex links between the forest biology, and the physics and chemistry of the atmosphere

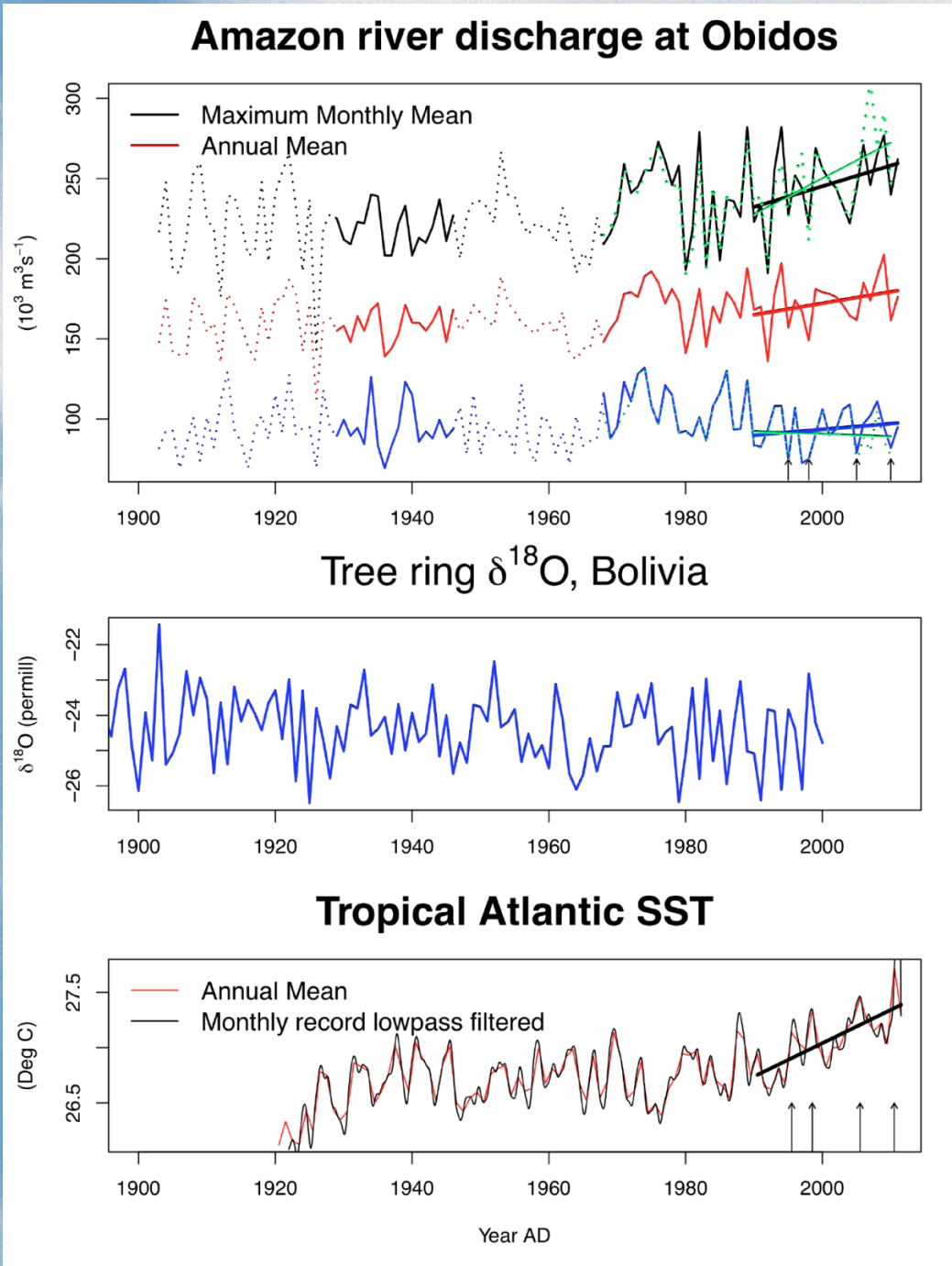
Natural System



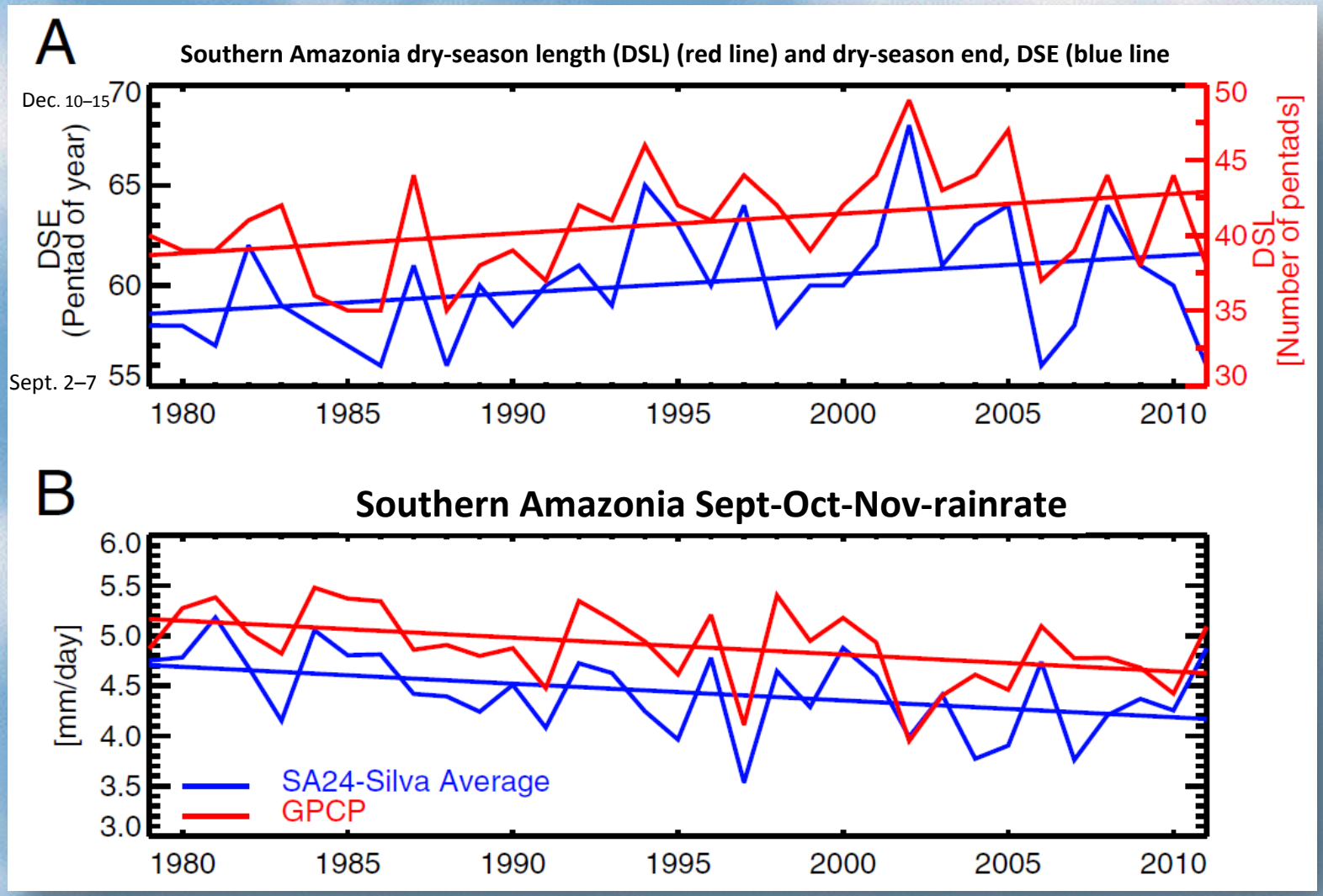
The Transition

Is the Amazonian hydrological cycle intensifying?

Maximum monthly, annual mean and minimum monthly mean Amazon river discharge at Óbidos and in green maximum and minimum daily mean river discharge, (b) $\delta^{18}O$ in precipitation in Bolivia derived from tree rings (Brienen et al. 2012) and (c) tropical Atlantic sea surface temperature from Extended reconstructed sea surface temperature) (Gloor et al. 2013).



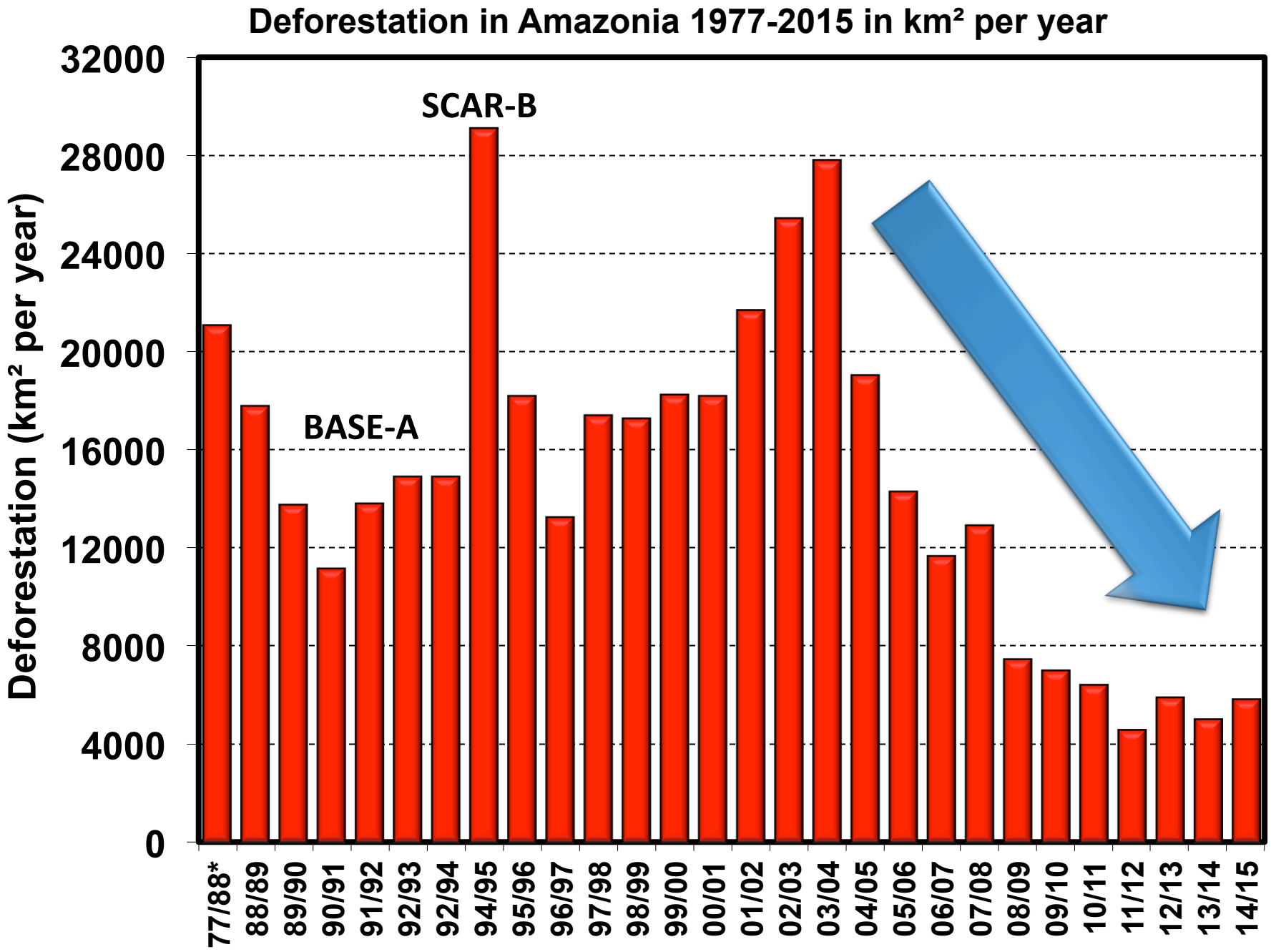
Dry season length is increasing in Amazonia



(A) Annual time series of the dry-season length (DSL) (red line) and dry-season end, DSE (blue line) dates derived from the PM daily rainfall data over the southern Amazonian domain show a decrease of DSL due to a delay of DSE. The unit is pentad (5 d). On the left axis, the 55th pentad corresponds to September 2–7 of the calendar date and the 70th pentad corresponds to December 10–15. (B) Time series of austral spring seasonal rainfall over southern Amazonia derived from the PM and GPCP datasets show decrease of rainfall consistent with the delay of DSE shown in (A). Trends are significant at $P < 5\%$.

Rong Fu, PNAS 2013

Land use change in Amazonia


Deforestation in Amazonia 1977-2015 in km² per year
Deforestation (km² per year)
32000
28000
24000
20000
16000
12000
8000
4000
0
SCAR-B
BASE-A
77/88*
88/89
89/90
90/91
91/92
92/93
92/94
94/95
95/96
96/97
97/98
98/99
99/00
00/01
01/02
02/03
03/04
04/05
05/06
06/07
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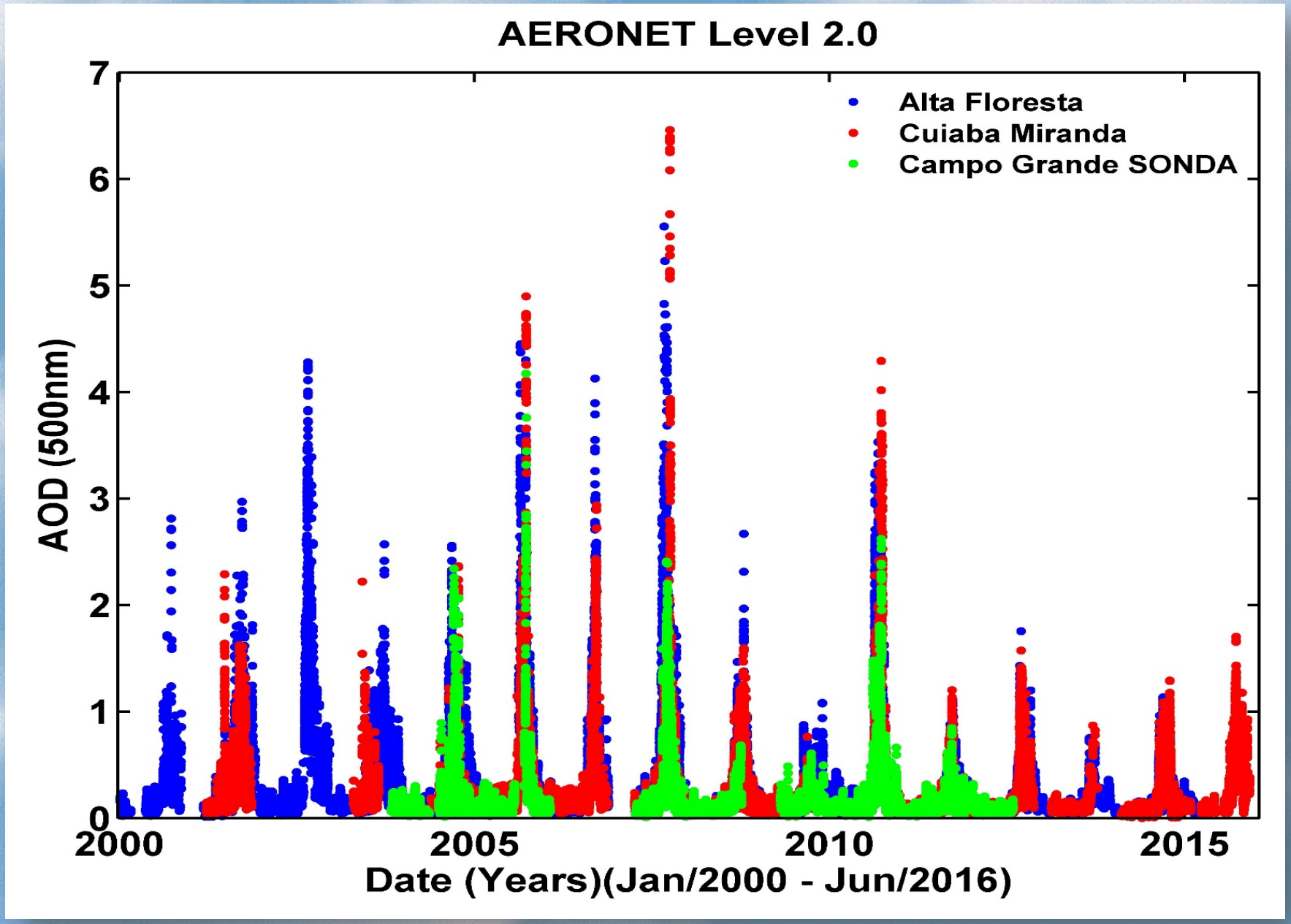
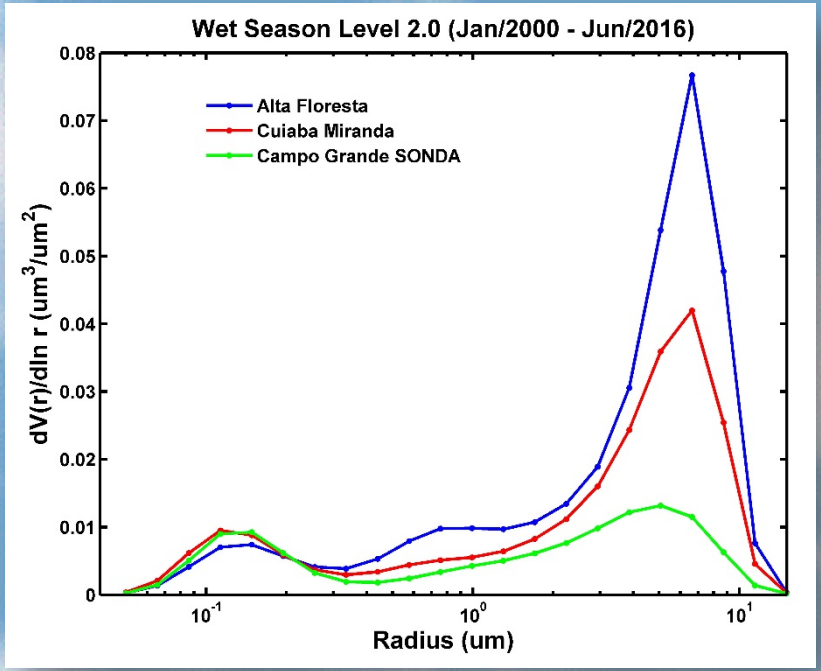
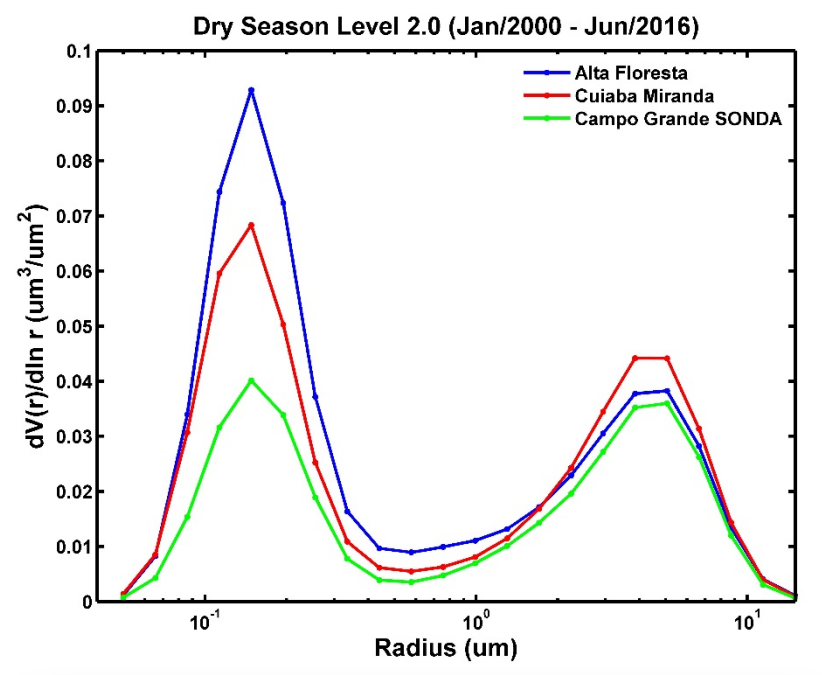
11/12
12/13
13/14
14/15

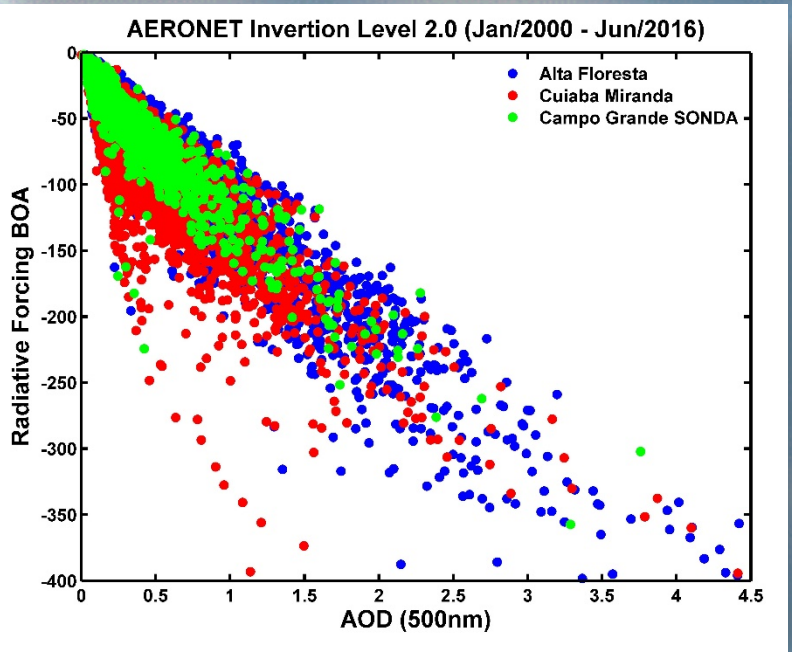
AERONET 16 years of AOD over several sites in Amazonia







AERONET: 16 years of continuous good quality data for several sites in Amazonia, thanks to Yoram, Brent, Joel Schafer and others



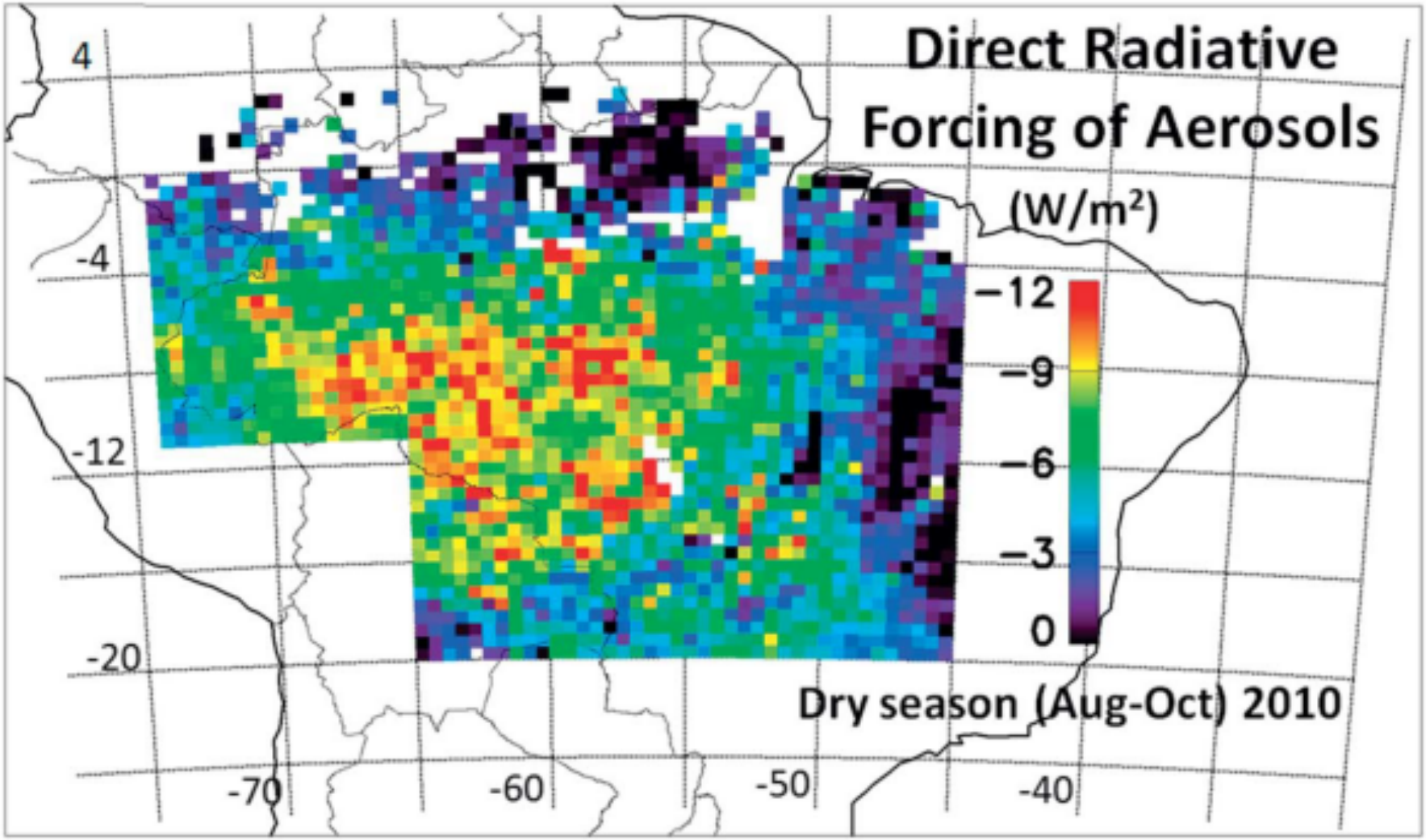
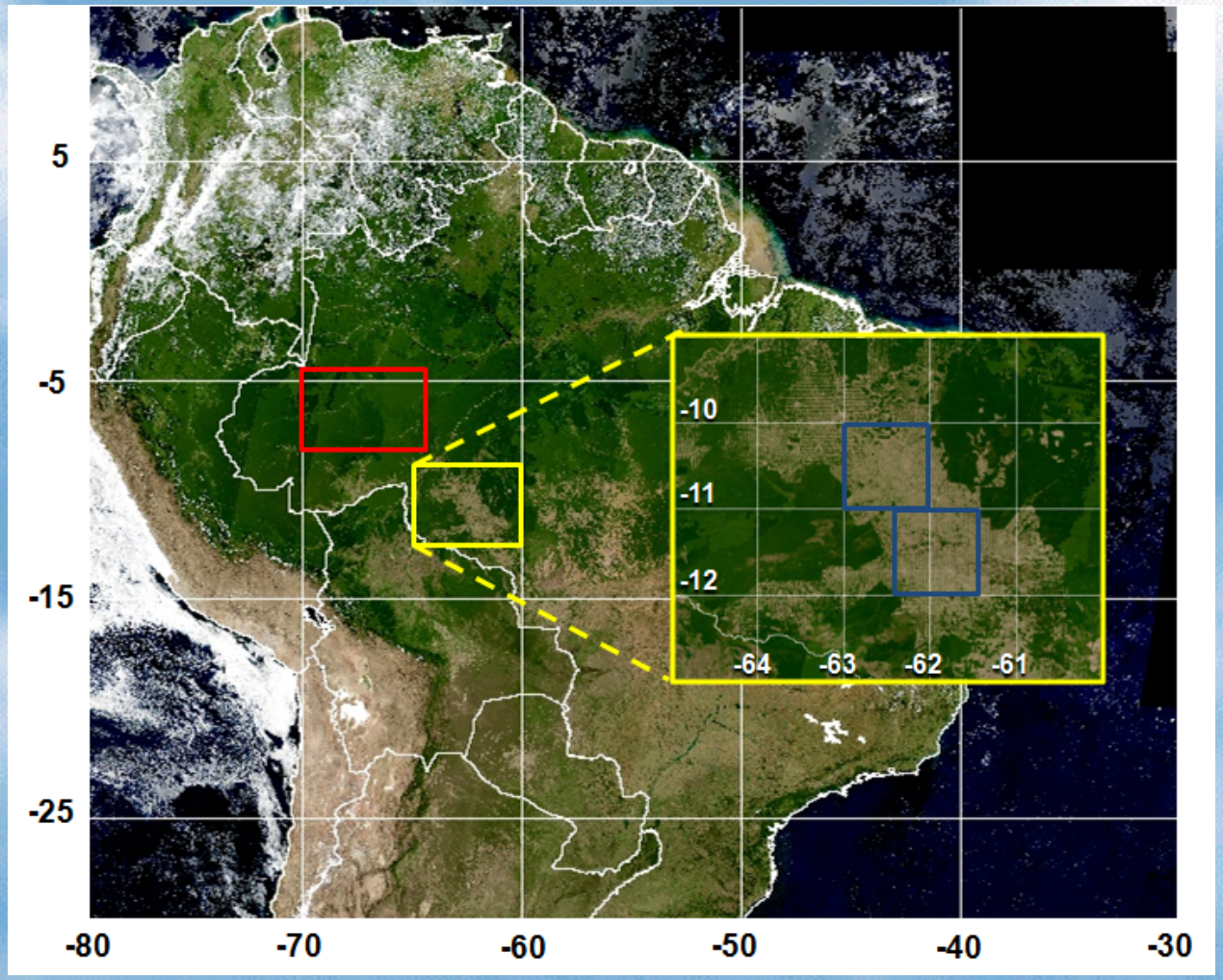


Fig. 18 Average spatial distribution of the direct radiative forcing (DRF) of biomass burning aerosols in Amazonia during the dry season (August to October) of 2010. Forcing derived from calculations using a combination of MODIS and CERES sensors data. During this three-month period, the daily-average radiative forcing of aerosols for the whole area was on average -5.3 ± 0.1 W m^{-2}.

Elisa Sena, 2011



Land-use change radiative forcing. Forested areas are selected in red and deforested areas are selected in blue.

Mean Diurnal Radiative Forcing due to change in surface albedo: -8.0 ± 0.9 W/m^2

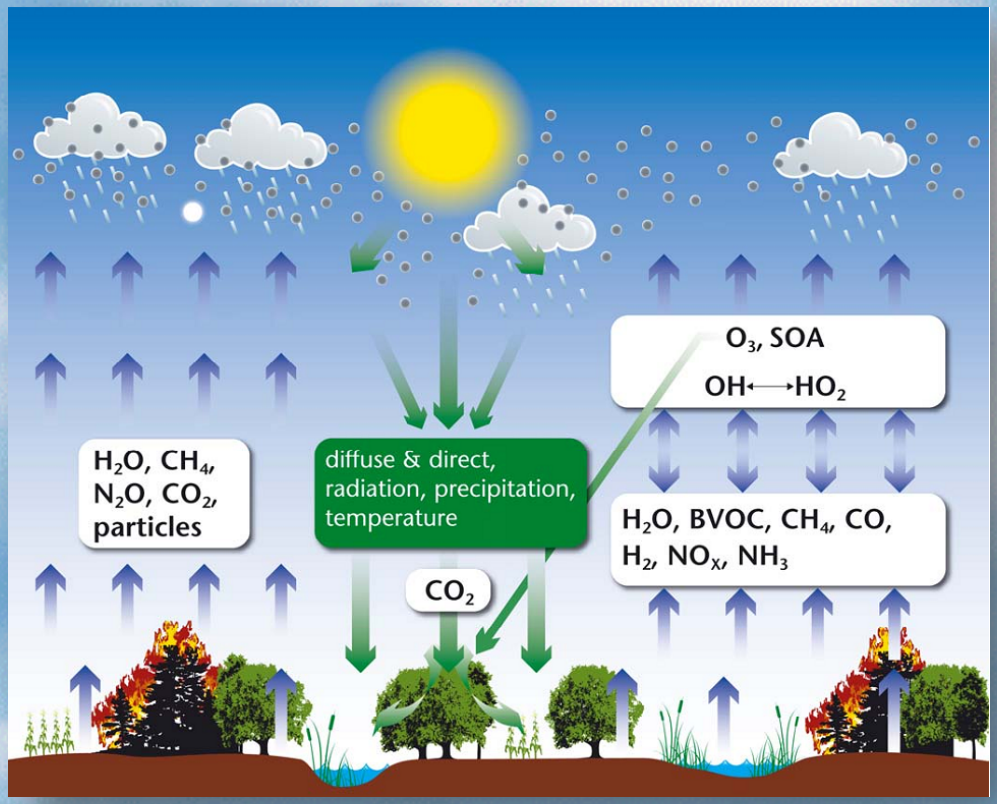
Mean Diurnal Aerosol Forcing Efficiency:

Forest: -22.5 + 1.4 W/m^2

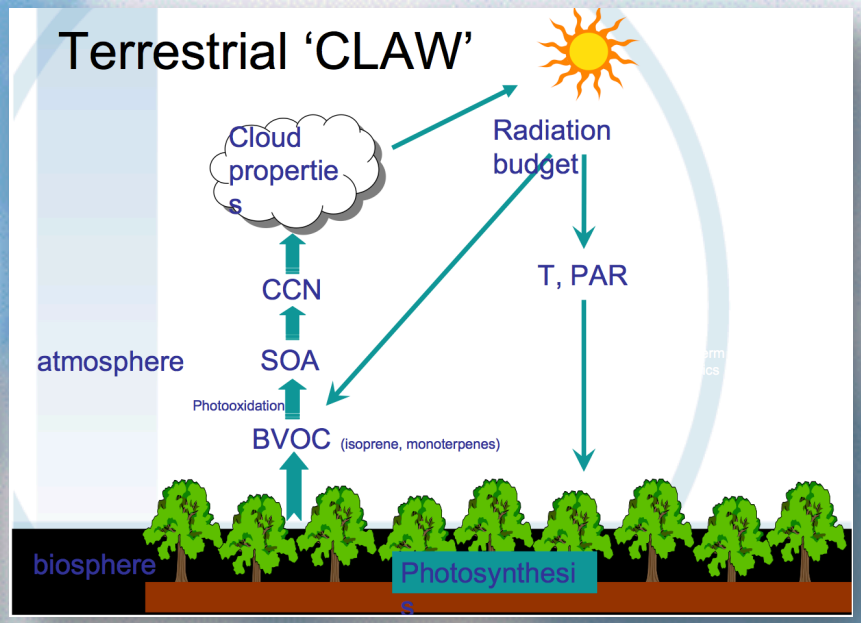
Cerrado: -16.6 ± 1.7 W/m^2

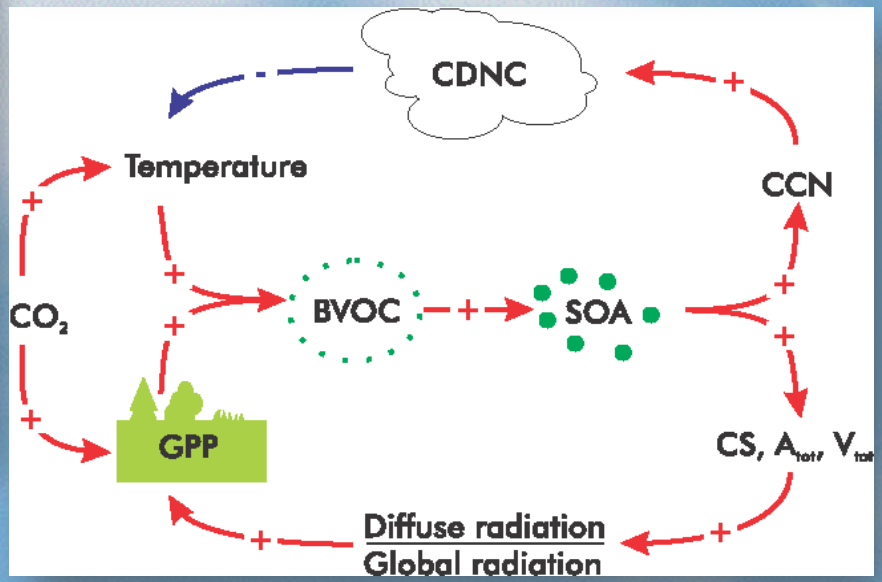
Elisa Sena, 2011

Conceptual overview of terrestrial carbon cycle – chemistry – climate interactions



Arneth et al., 2011

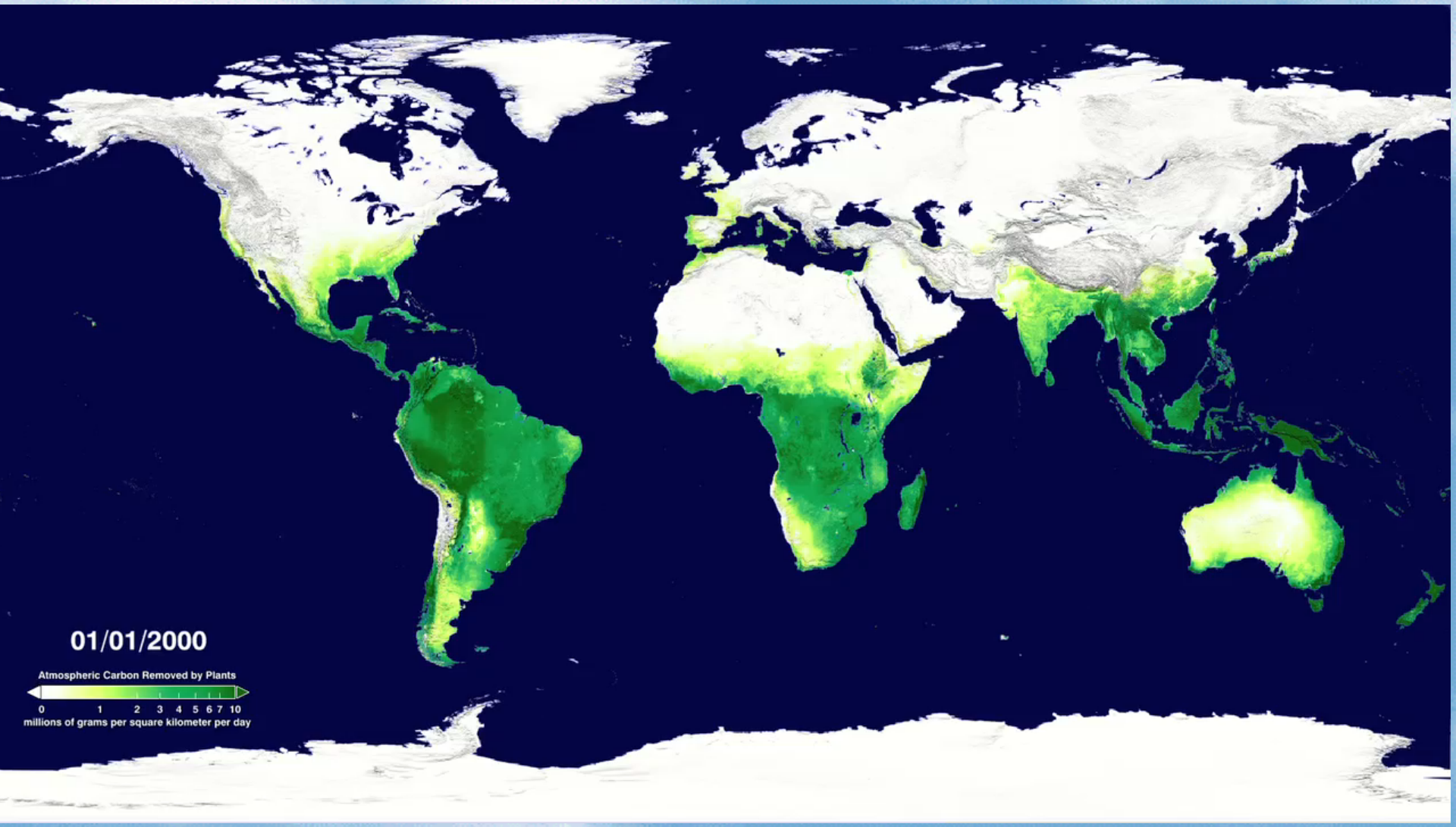




Kulmala et al, 2013

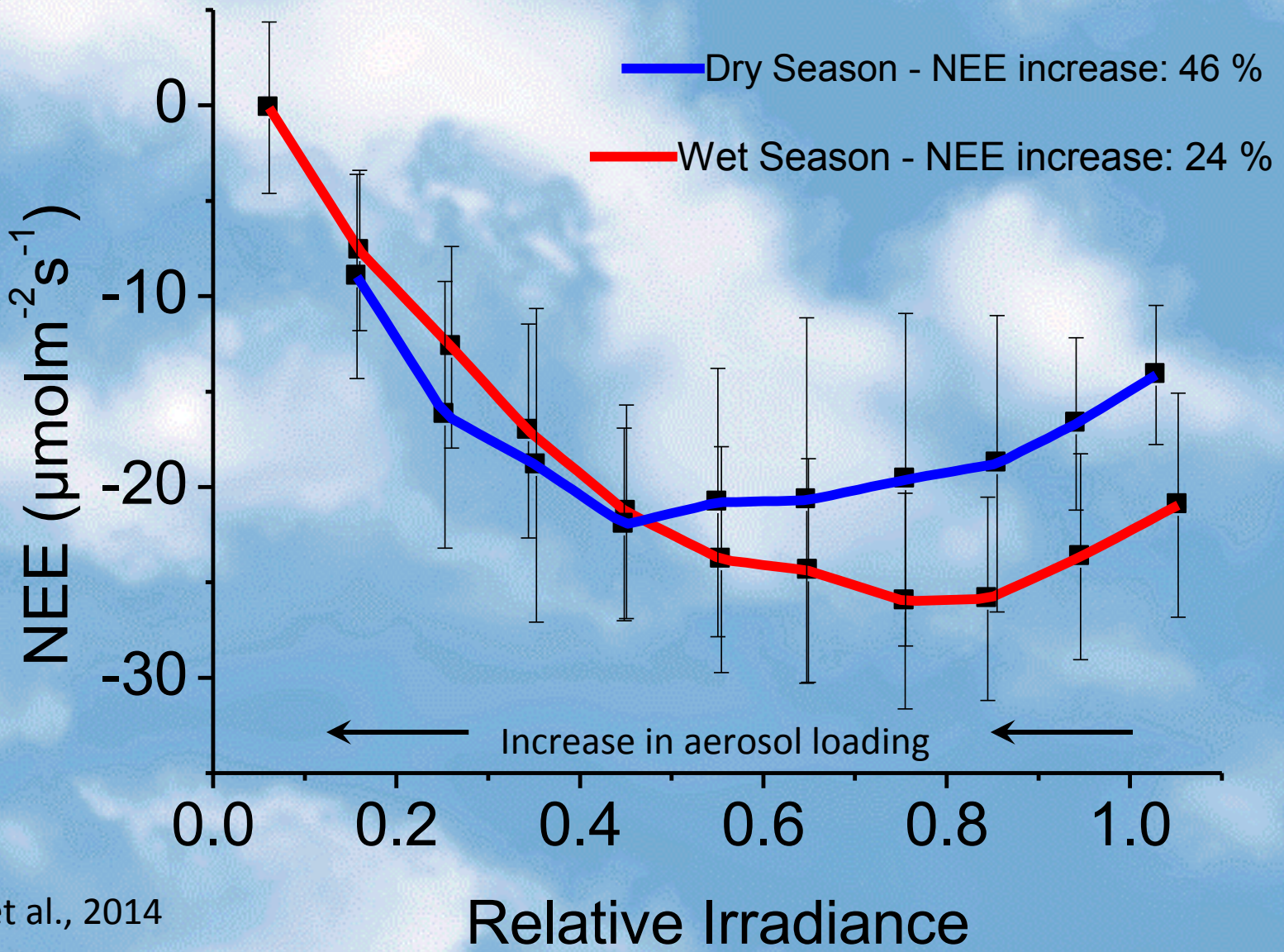
HOW MUCH CARBON DO PLANTS TAKE FROM THE ATMOSPHERE?

MODIS gross primary productivity (GPP) estimation from NDVI 2000-2010



Strong effects of aerosols on carbon uptake in Amazonia

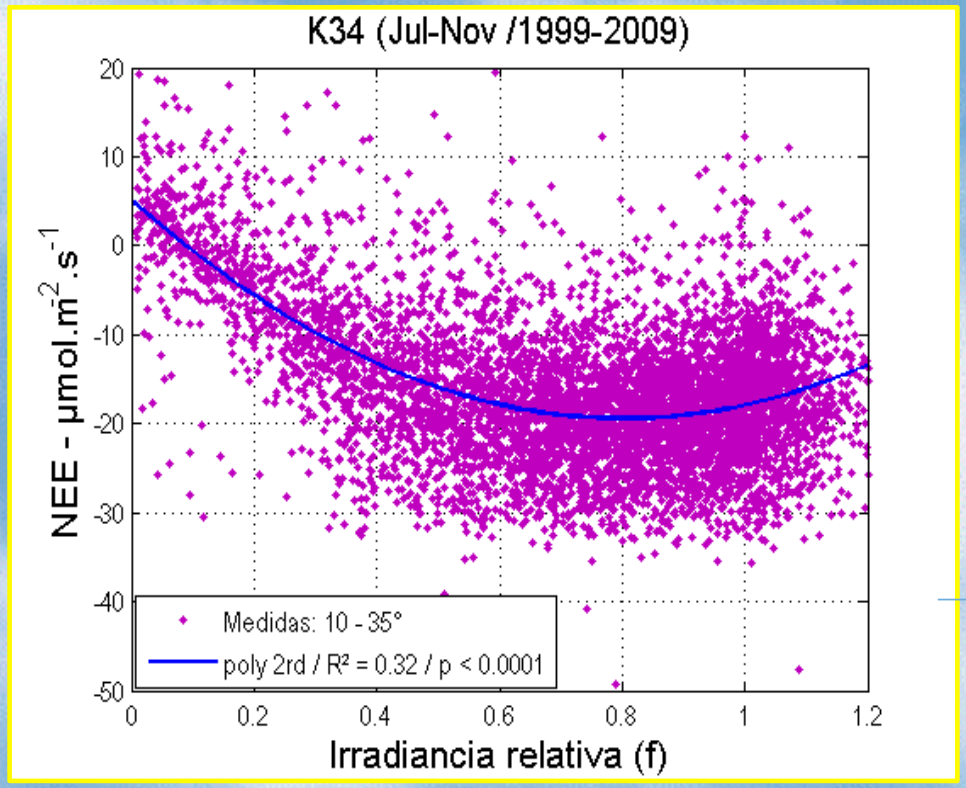
Amazonia Rondonia Forest site 2000-2001



Cirino et al., 2014

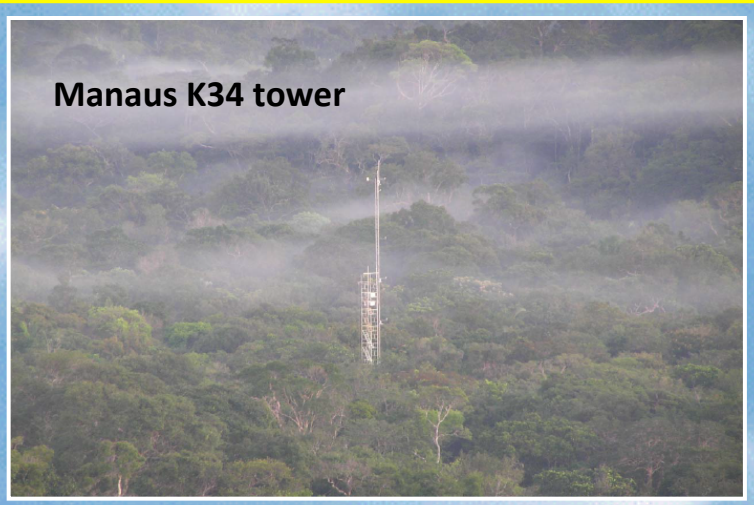
Aerosols effects on NEE – Manaus and Rondonia

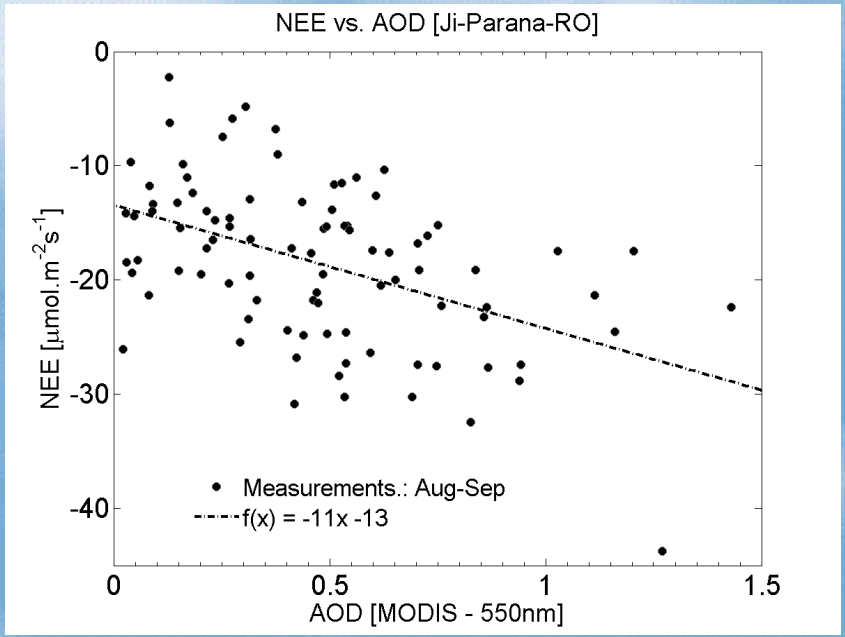
(Glauber Cirino, INPA, 2013)



f max: ~ 0,80

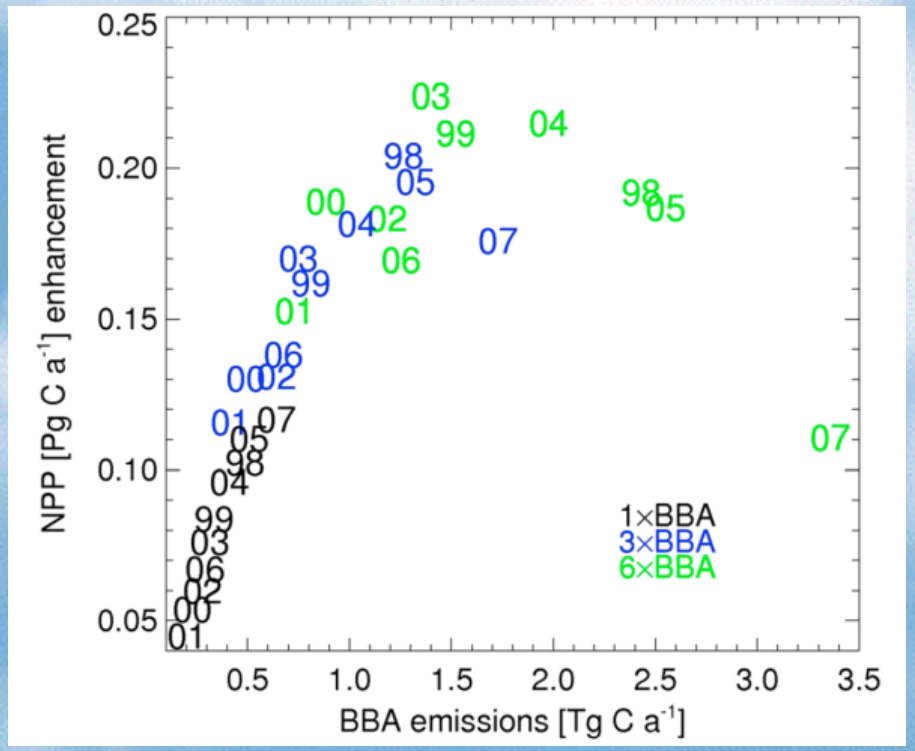
NEE (max): ~ -20 µmol/m²s
AOT: ~ 0,5



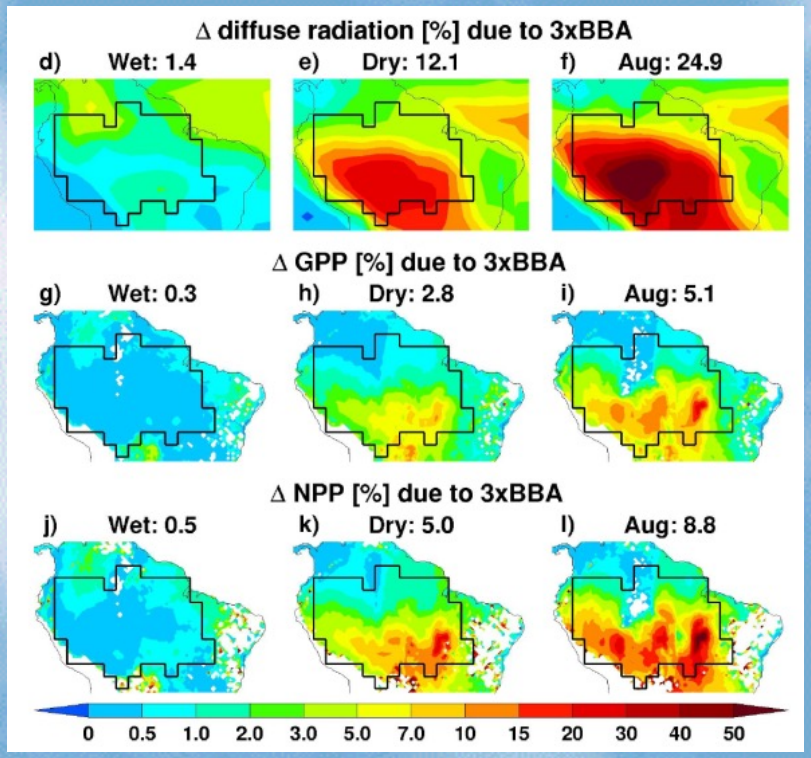


Fires increase Amazon forest productivity through increases in diffuse radiation

Rap et al., 2015



Amazon basin annual mean NPP enhancement caused by BBA as a function of BBA emissions (black: standard BBA emissions; blue: 3 × BBA emissions; and green: 6 × BBA emissions), for each year during

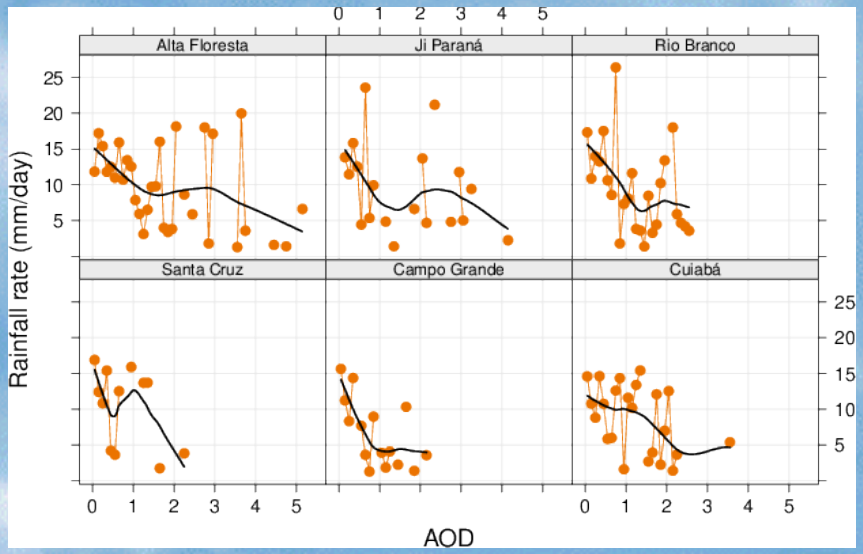


Modeled 1998–2007 mean percentage changes in (a–c) diffuse radiation, (g–i) GPP, and (j–l) NPP during the wet (defined here as December to May) season, dry (June to November) season, and August due to BBA emissions.

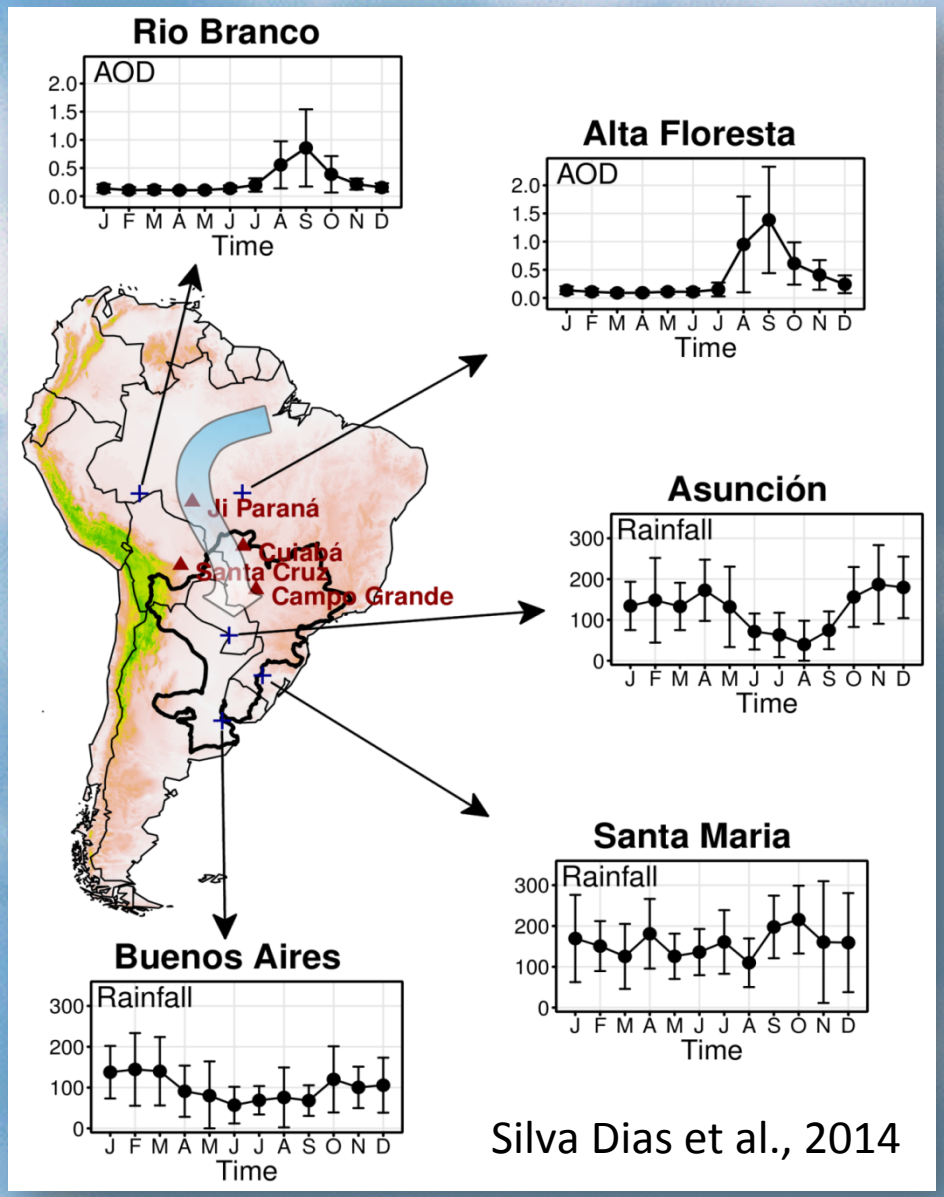
Relationship between aerosols and precipitation in the La Plata Basin

AERONET (Aerosols) + TRMM (Precipitation) + BRAMS (simulations)

Reduction in precipitation with increase in aerosols



BRAMS: Simulations with cloud microphysics confirm the measurements



Silva Dias et al., 2014

Overview of South American Biomass Burning Analysis (SAMBBA) field experiment

[Brazil, Sept – Oct 2012]

Ben Johnson[1], Jim Haywood[1,5], Karla Longo[2], Hugh Coe[3], Paulo Artaxo[4], Saulo Freitas[2], William Morgan[3], and Kate Szpek[1]

[1] Met Office, UK
[2] National Institute for Space Research (INPE), Brazil
[3] University of Manchester, UK
[4] University of Sao Paulo, Brazil
[5]University of Exeter

SAMBBA Broad science drivers

- Quantify biomass burning emissions from S. America
- Increase understand of atmospheric processes associated with BB (aerosols, chemistry, plumes, transport).
- Assess the impacts of BB on climate, weather, air quality, biosphere.
- Evaluation & development of models
- Validation of remote sensing observations: Fire products (FRP), aerosol retrievals, etc.

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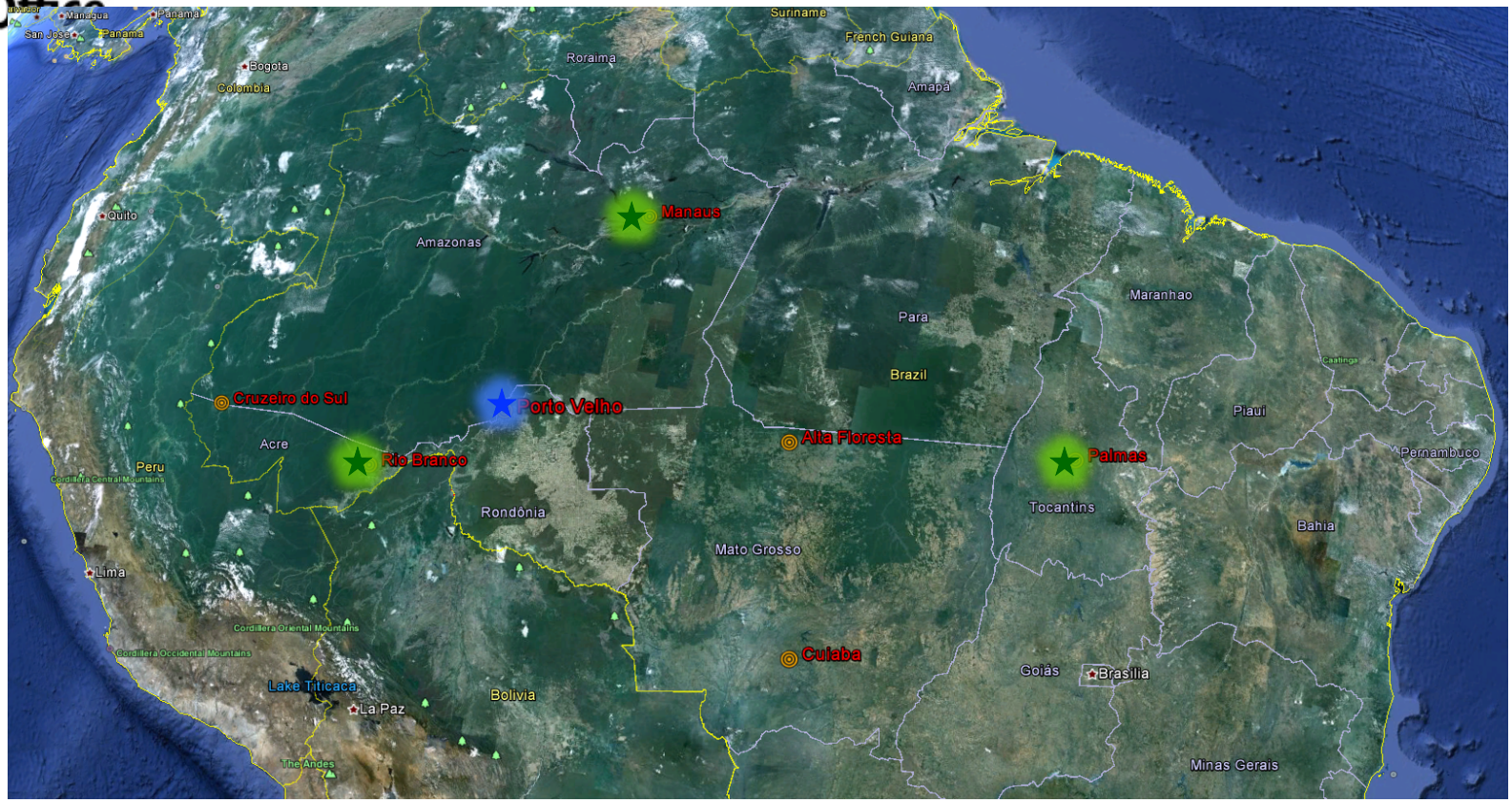
FAAM BAe146 aircraft

(Facility for Airborne Atmospheric Measurements)

SAMBBA operating region



★ Re-fuel / overnight stop
★ Permanent base

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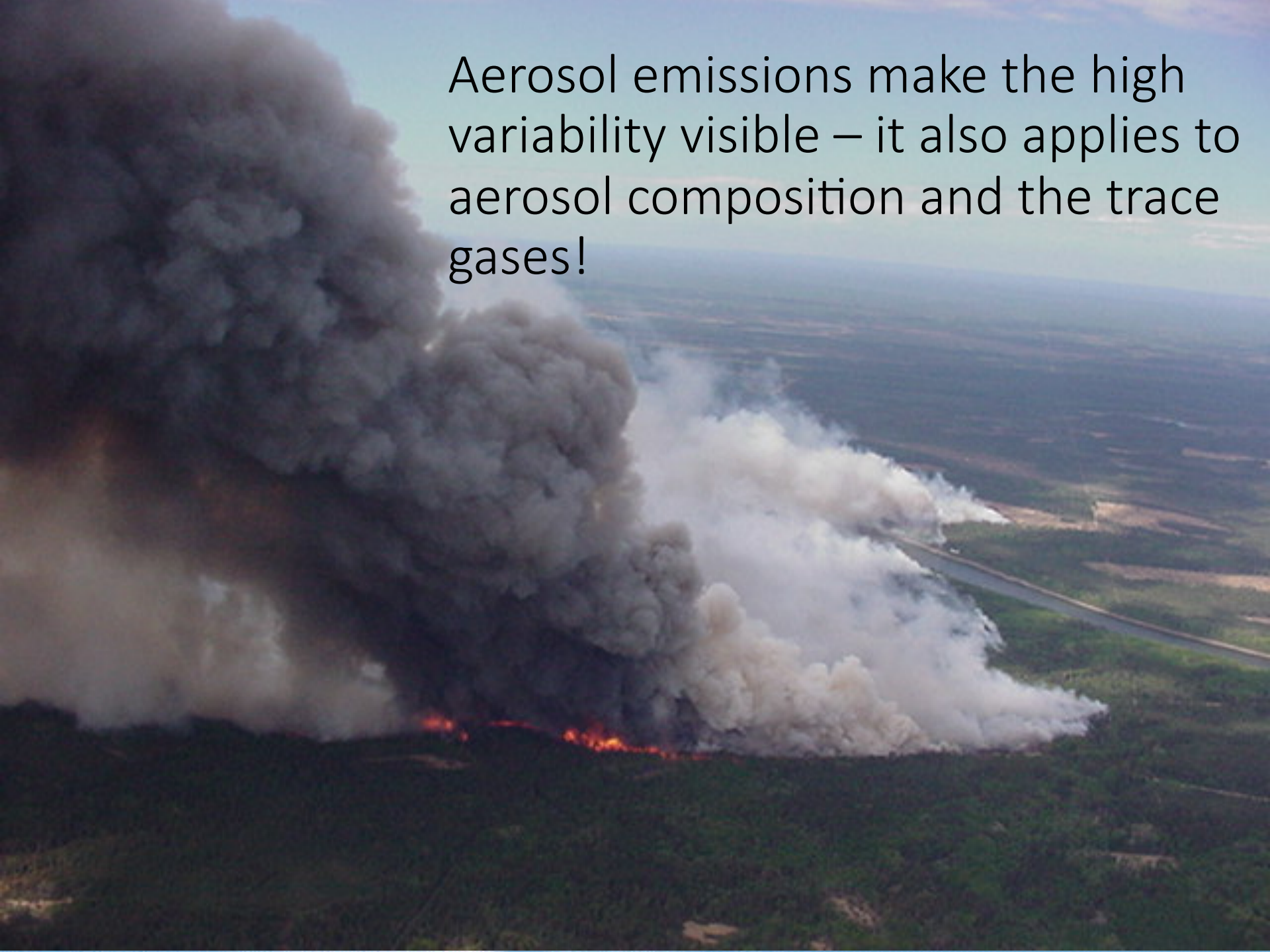

Aerosol emissions make the high variability visible – it also applies to aerosol composition and the trace gases!

25 years after SCAR-B: Biomass burning emissions

	GFED3/4	FINN1.0/1.5	GFAS1.0/1.2
Method	MODIS Burned Area	MODIS TAP	MODIS FRP
Spatial	0.5°, 0.25°	1 km^2	0.5°, 0.25°
Temporal	daily 2003 – 2011 2003 – 2014	daily 2002 – 2012 2002 – 2015	daily 2001 – 2013 2001 – now
OC (Tg/yr)	17.6	23	18.2
BC (Tg/yr)	2.2	2.2	2.0
Ref	van der Werf et al., 2010	Wiedinmyer et al., 2011	Kaiser et al., 2012

Injection heights: distributed emissions over six ecosystem-dependent altitudes between surface and 6 km.

Good agreement between observed and modelled AOD was gained only after scaling up GFED3 emissions by a factor of 2.0 for HadGEM3 with GLOMAP-mode.

AGU PUBLICATIONS

Geophysical Research Letters

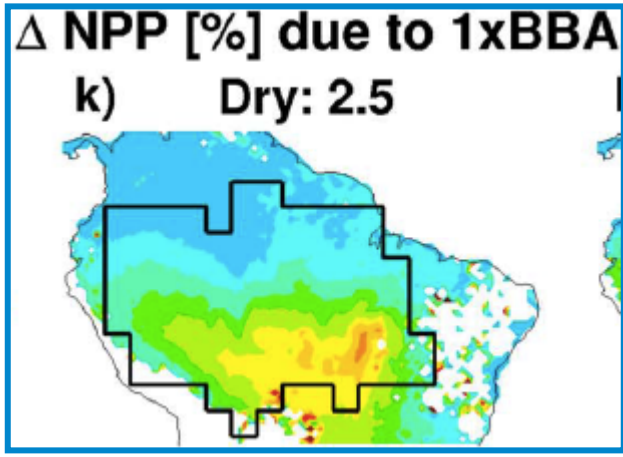
RESEARCH LETTER
10.1002/2015GL063719

Key Points:
- First estimate of diffuse radiation fertilization due to Amazon BBA

Fires increase Amazon forest productivity through increases in diffuse radiation

A. Rap[1], D. V. Spracklen[1], L. Mercado[2,3], C. L. Reddington[1], J. M. Haywood[4], R. J. Ellis[3], O. L. Phillips[5], P. Artaxo[6], D. Bonal[7], N. Restrepo Coupe[8], and N. Butt[9]

- First estimate of diffuse radiation fertilization due to Amazon BBA.
- BBA increases Amazon basin annual mean **diffuse radiation by 3.4–6.8%** and **NPP by 1.4–2.8%**.
- Effect offsets 33–65% of the annual regional carbon emissions from BBA.
- Estimate 30–60 Tg C a^{-1} of NPP enhancement is within woody tissue → accounts for **8–16% of the observed carbon sink** across mature Amazonian forests.



LETTERS
PUBLISHED ONLINE: 16 SEPTEMBER 2015 | DOI: 10.1038/NGEO2535
nature geoscience

Air quality and human health improvements from reductions in deforestation-related fire in Brazil

C. L. Reddington[1], E. W. Butt[1], D. A. Ridley[2], P. Artaxo[3], W. T. Morgan[4], H. Coe[4] and D. V. Spracklen[1]*

- Analysed satellite & AERONET AOD over southwest Brazil and Bolivia for dry season (from 2001 to 2012).
- Observed dry season AODs strongly correlated with declining deforestation rate.
- Simulated dry season PM2.5 declined by ~30% in the region.

⇒Reduction in PM2.5 may be preventing roughly 1,700 premature adult deaths annually across South America.

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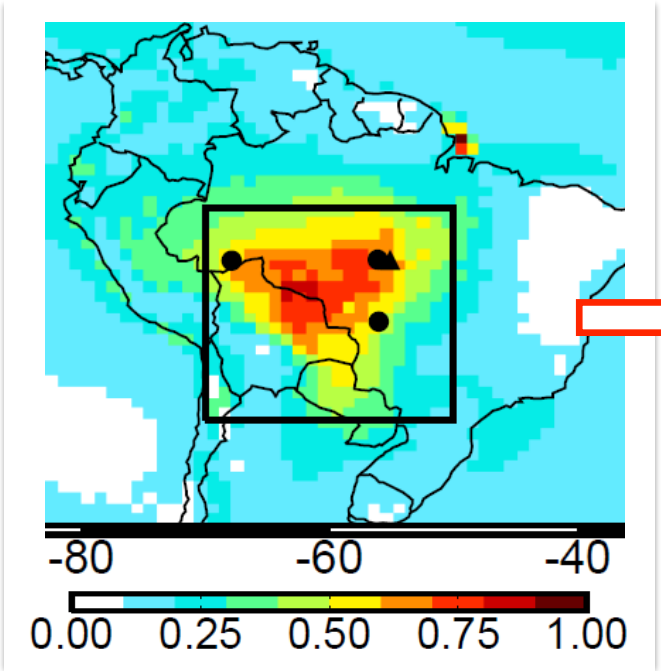
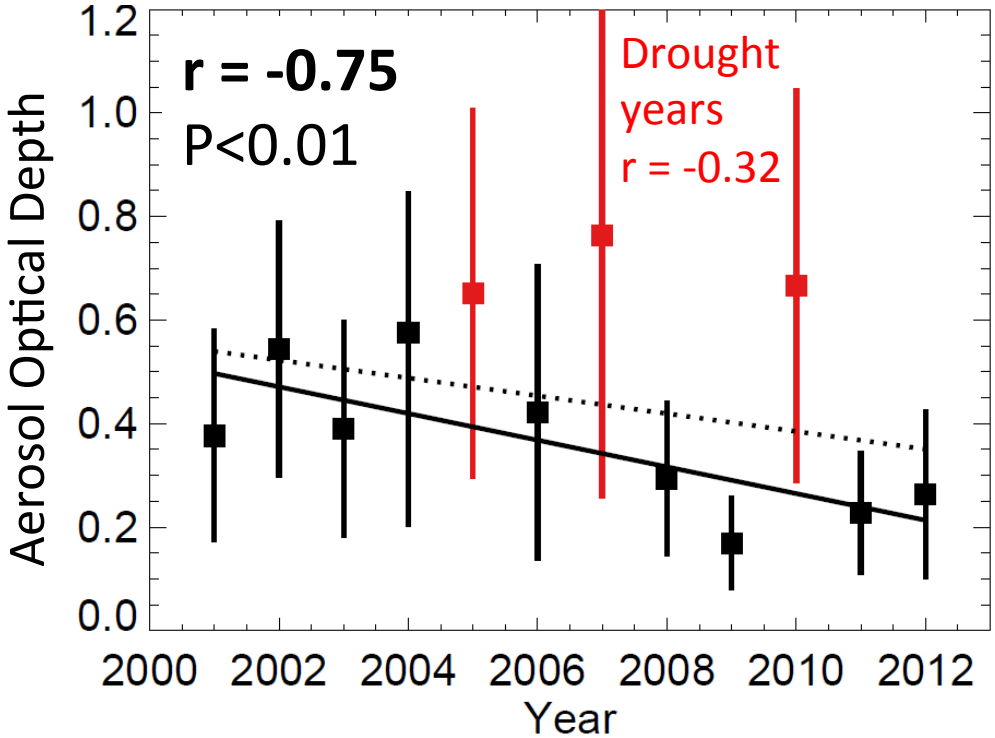


Dry season mean AOD retrieved by MODIS



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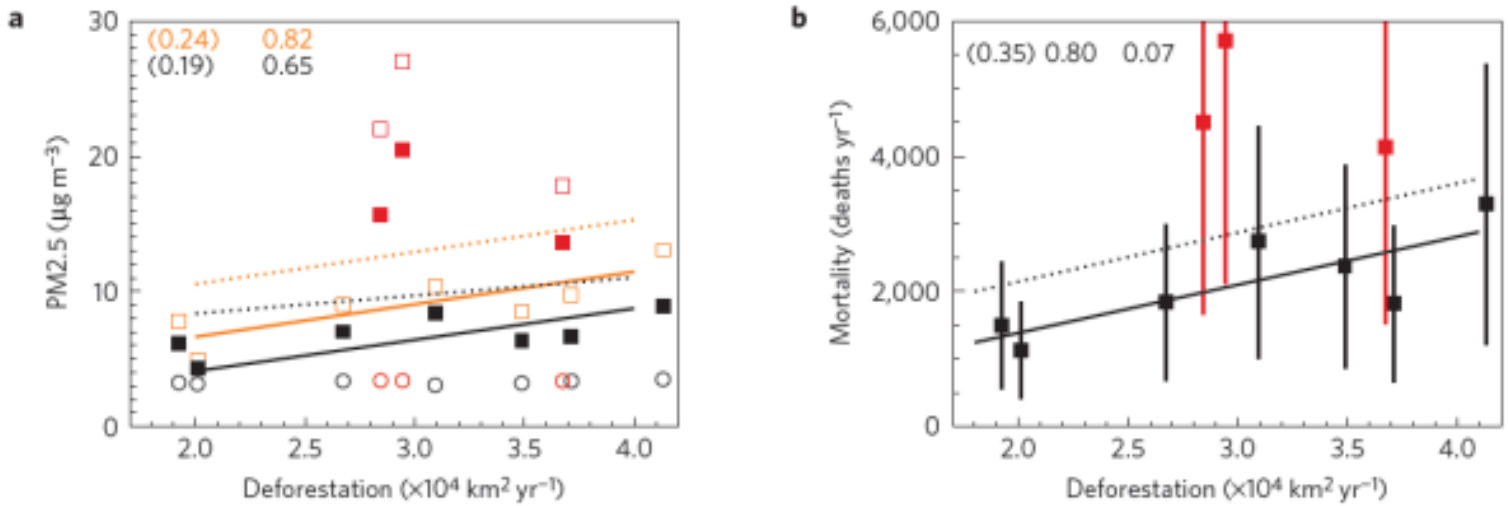


Relationship of simulated PM2.5 and premature mortality against Brazil's deforestation rates.

Using particulate matter concentration response functions from the epidemiological literature, we estimate that this reduction in particulate matter may be preventing roughly 1,700 premature adult deaths annually across South America.

Ozone and carbon uptake in Amazonia in the dry season

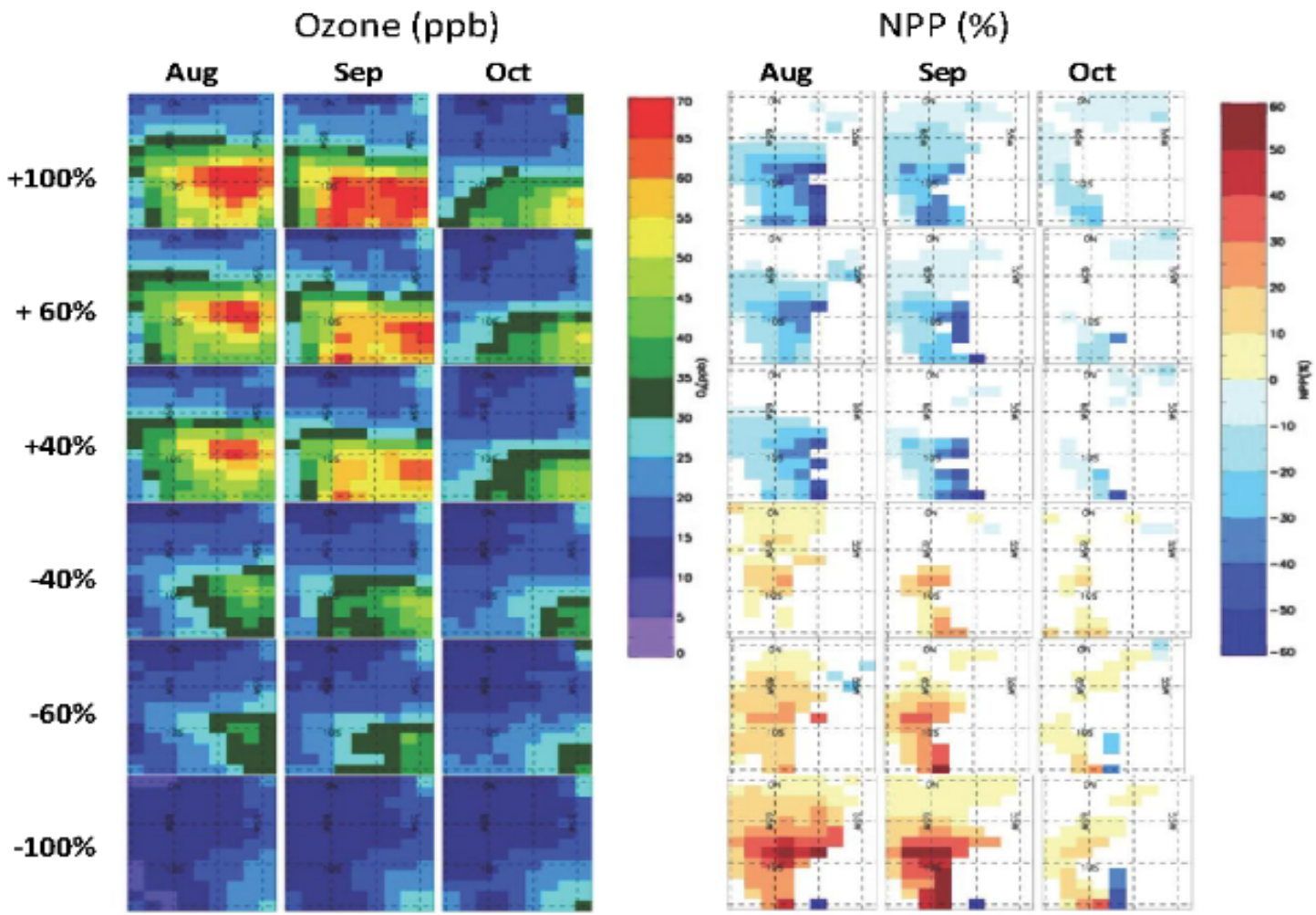
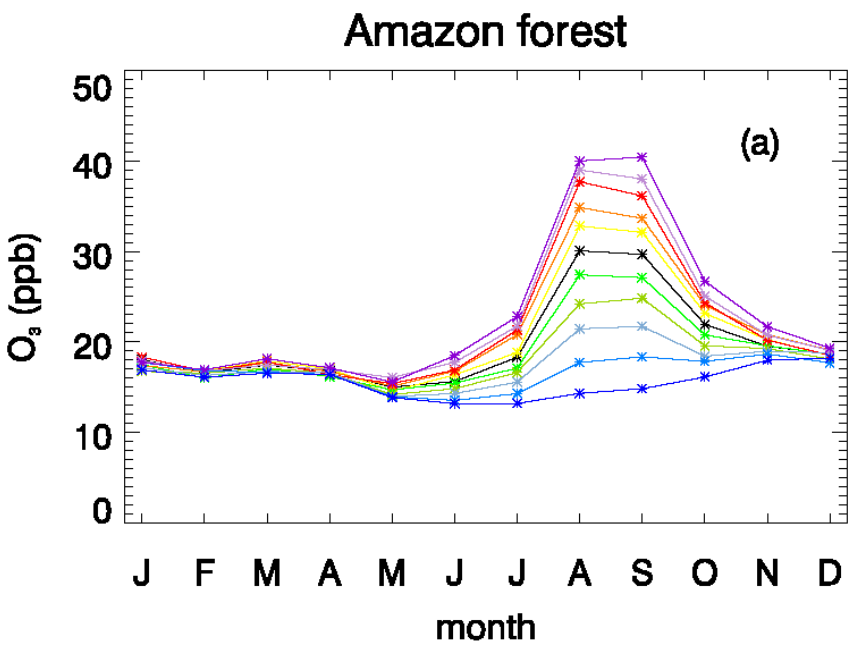
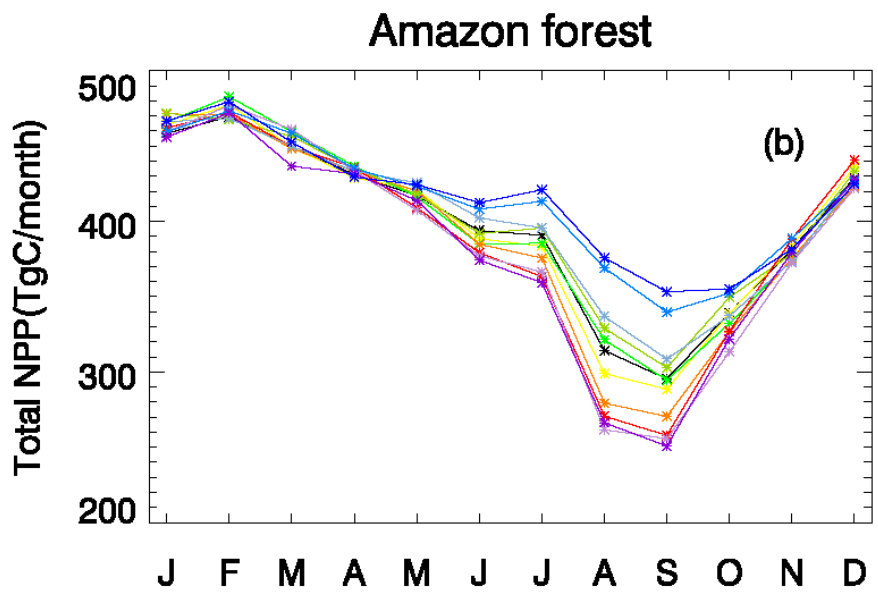


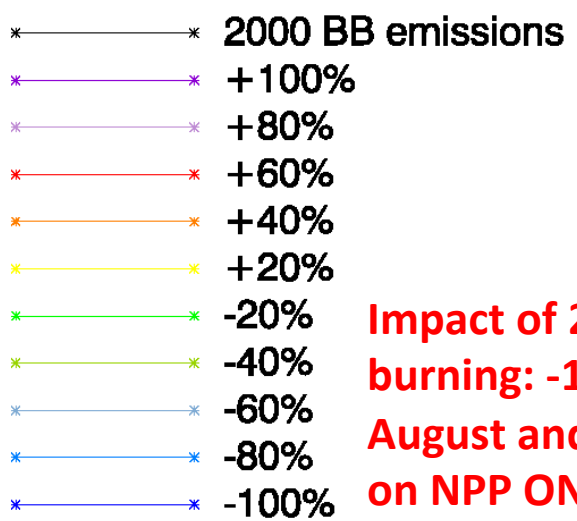
Figure 6. From the left: simulated variation in surface O_3 mixing ratios and NPP over the region of analysis for the months of Aug September and October.

Ozone exposure reduces carbon uptake at the same order of magnitude as emissions from deforestation. Potentially doubling the impact of biomass burning on the carbon cycle

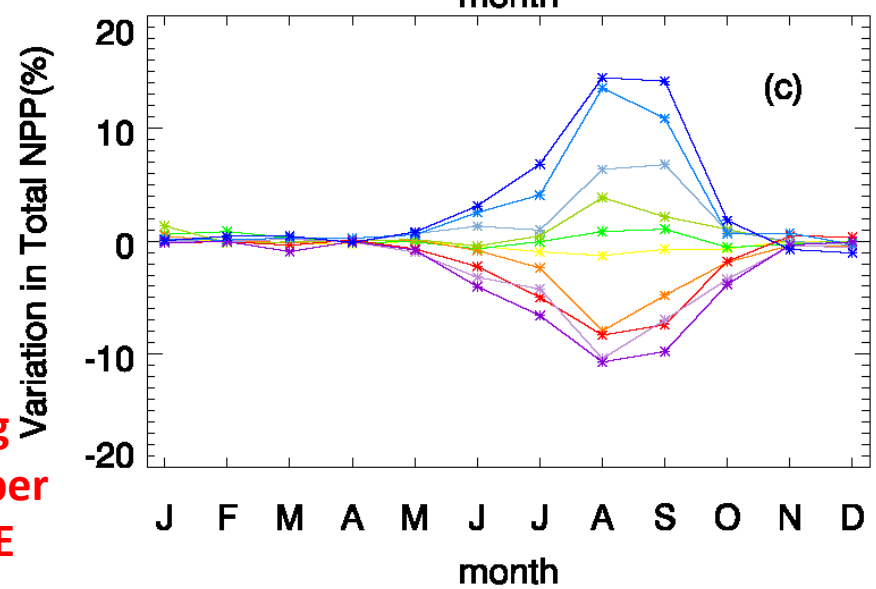
Sensitivity study of the impacts of ozone concentrations on ozone concentrations and NPP







Impact of 2015 burning: -15% during August and September on NPP ON AVERAGE



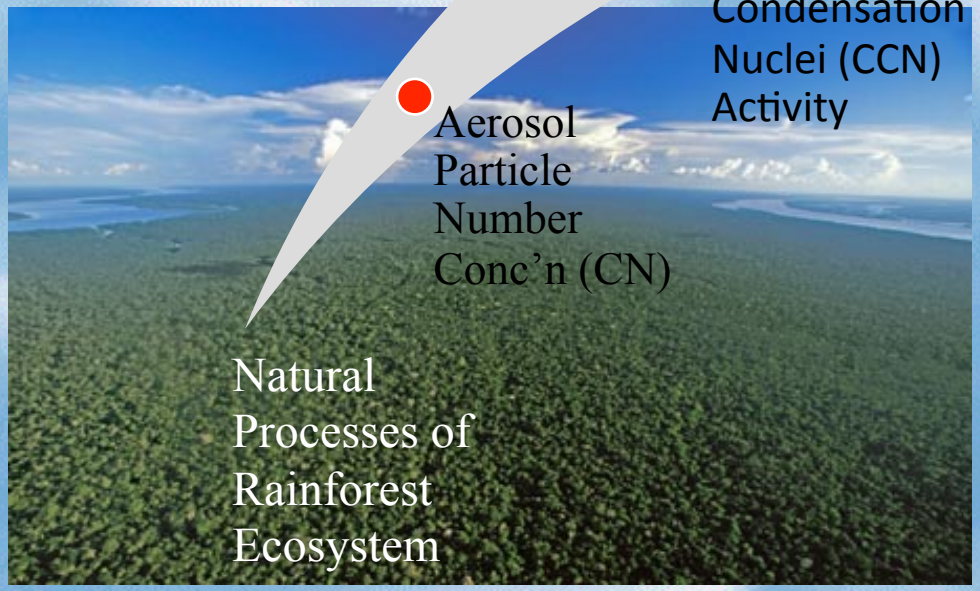
GoAmazon2014/15 Experiment

The central idea...

Manaus is a city of 2 million people surrounded by just forest in a radius of 1.500 Km. UNIQUE situation.

The aim of the GoAmazon 2014/15 experiment is to analyze how the emissions of pollutants of the city of Manaus interacts with the Amazonian natural biogenic emissions from the forest and how are the impacts on the climate over the forest and ecosystem functioning.

How particles are formed from the interactions of forest biogenic VOCs with urban emissions?



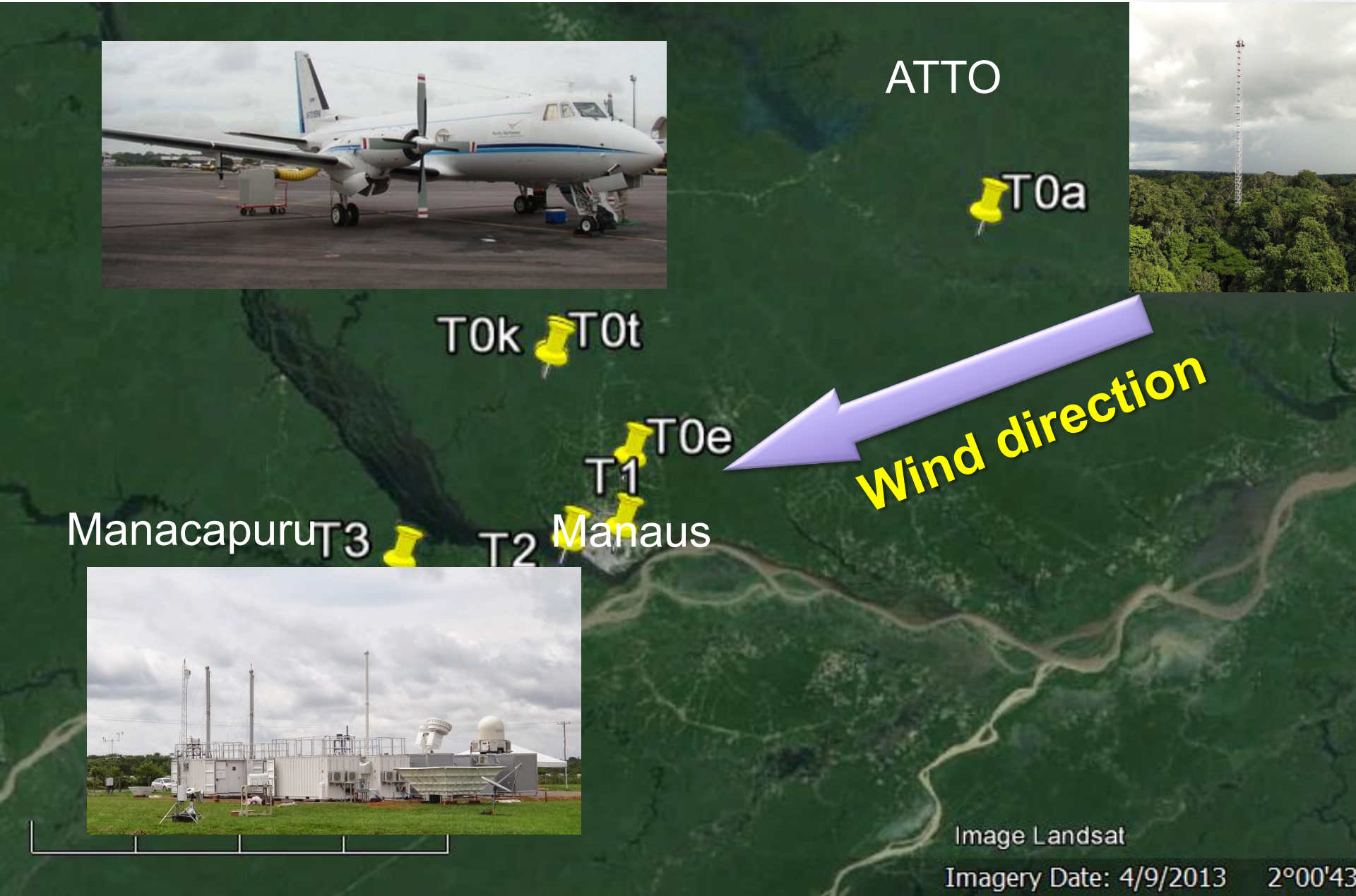
Aerosol Particle Number Conc'n (CN)

Aerosol Particle Cloud Condensation Nuclei (CCN) Activity

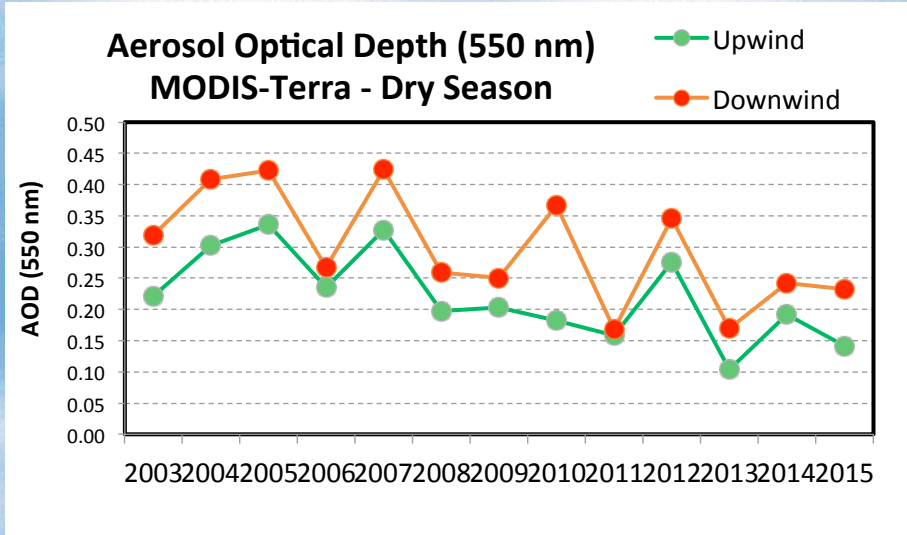
Cloud Droplet Number Concentration (CDNC)

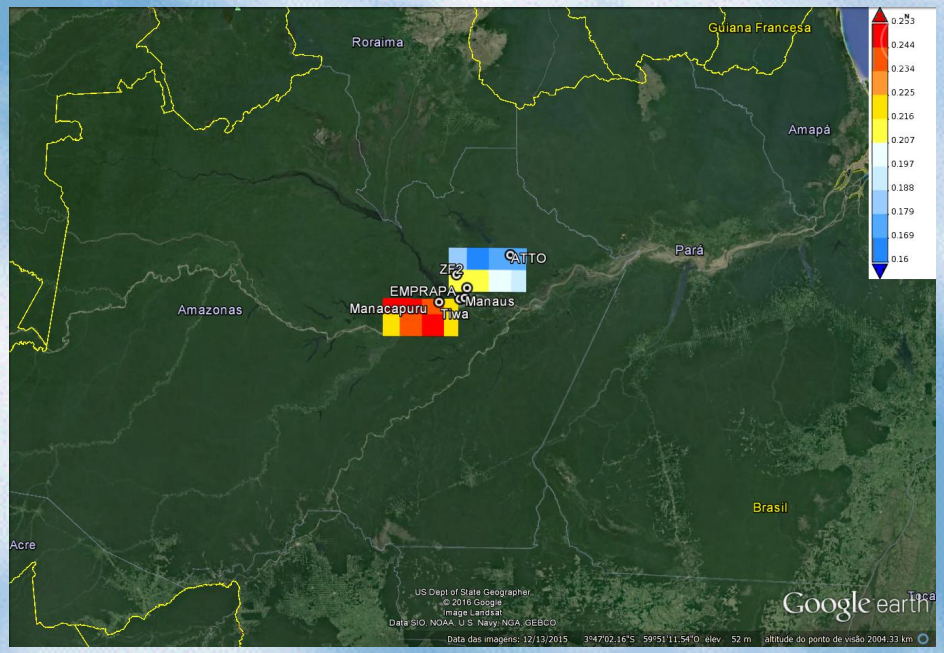
Lightning Strikes

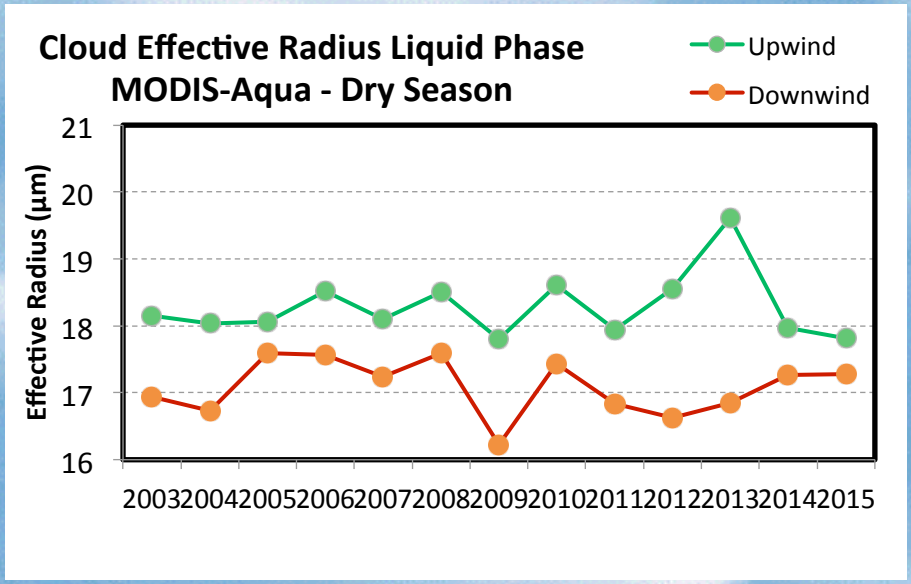
Seven measuring sampling sites in Central Amazonia

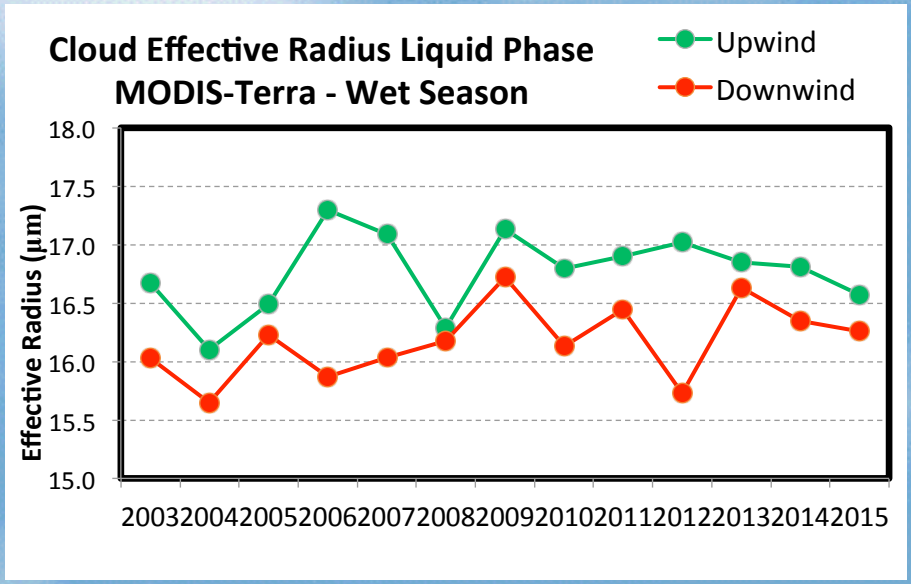


12 years of remote sensing of aerosols and clouds



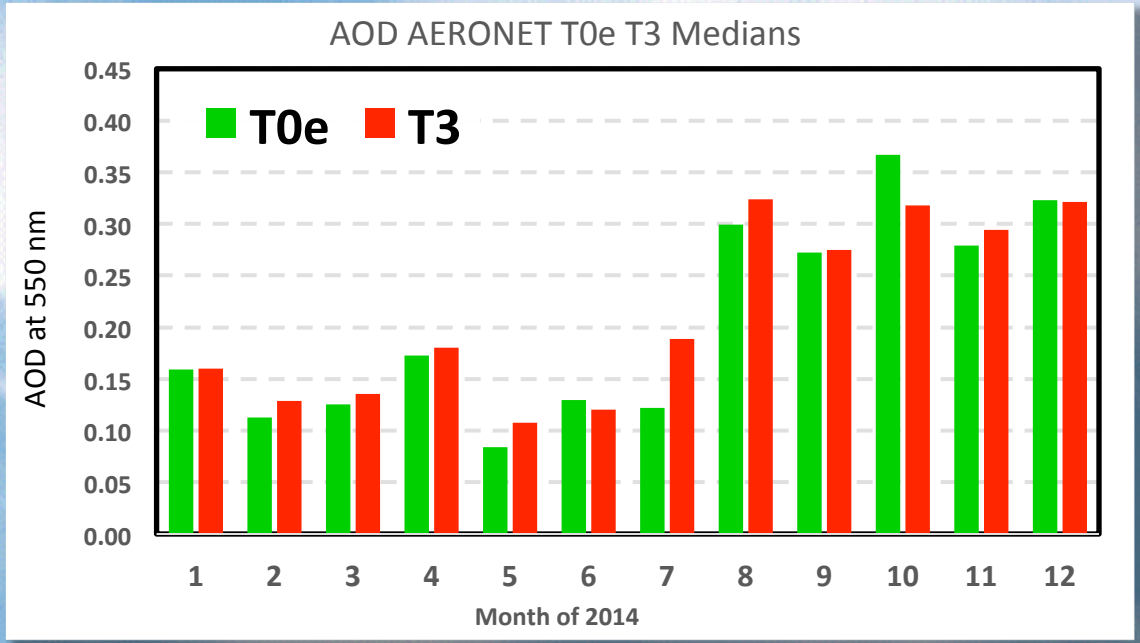




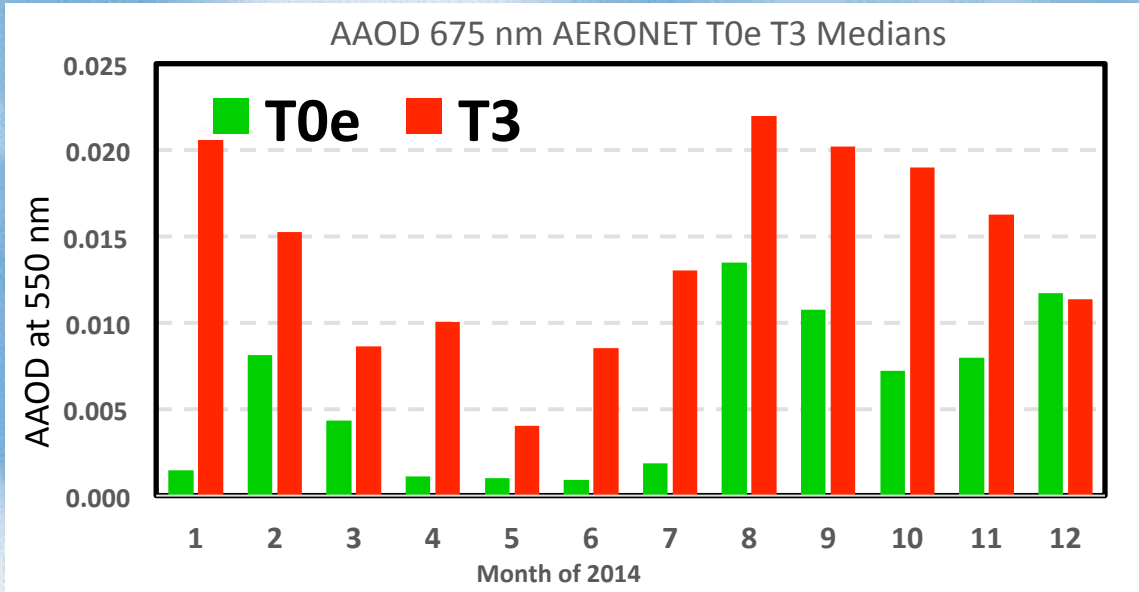


AERONET Aerosol optical depth before and after Manaus plume

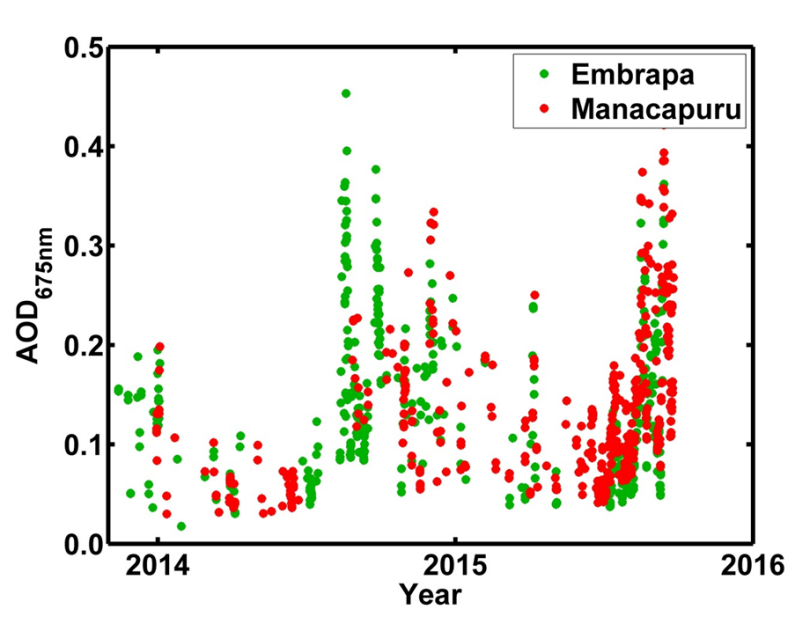
Aerosol optical depth of T0e versus T3: <u>Where are Manaus emissions</u>?

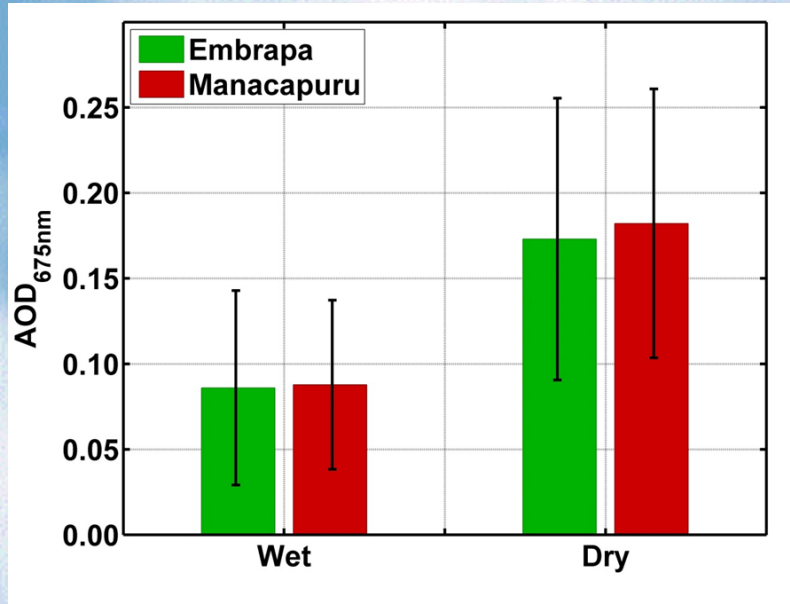


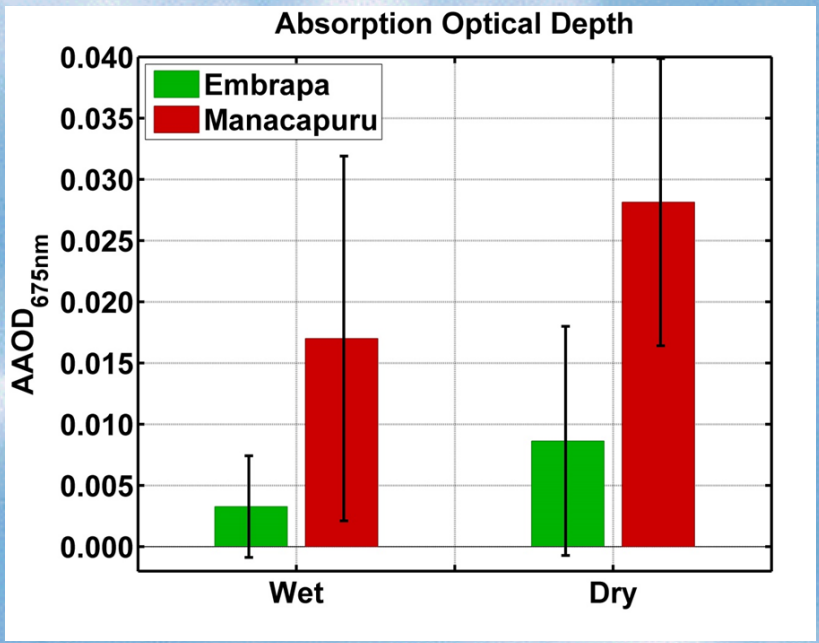
<u>Absorption</u> aerosol optical depth : Strong difference between T0e and T3

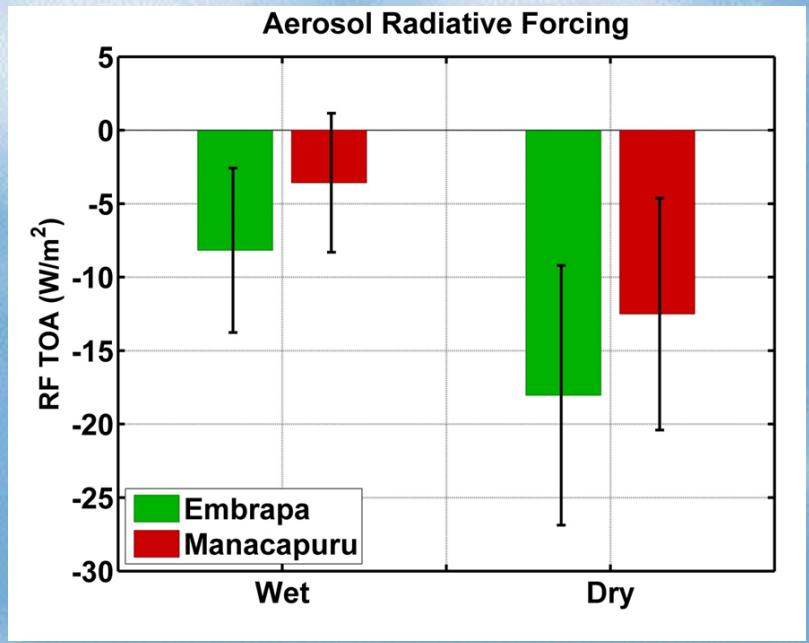


T0e -T3: AOD, Absorption AOD and radiative forcing

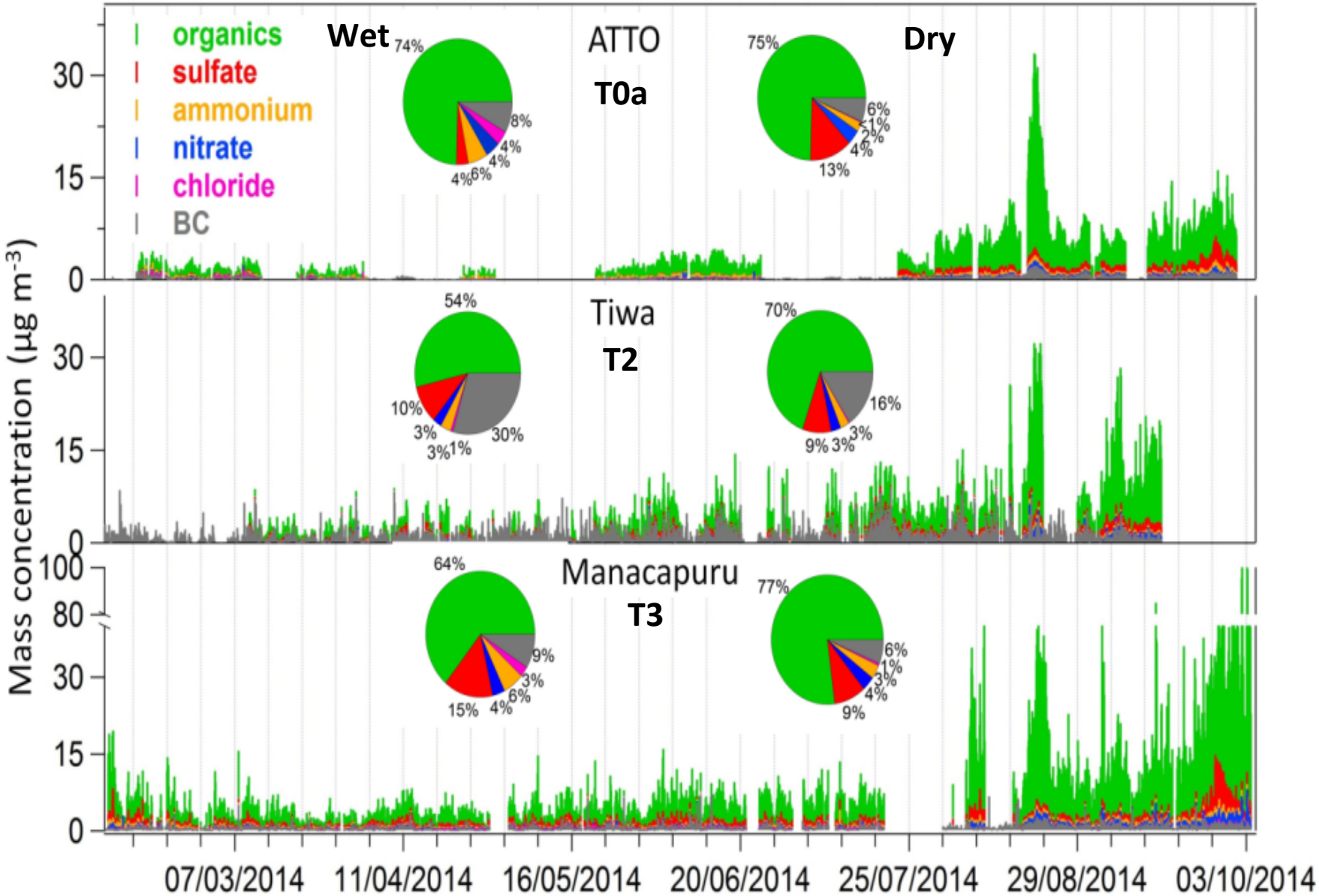






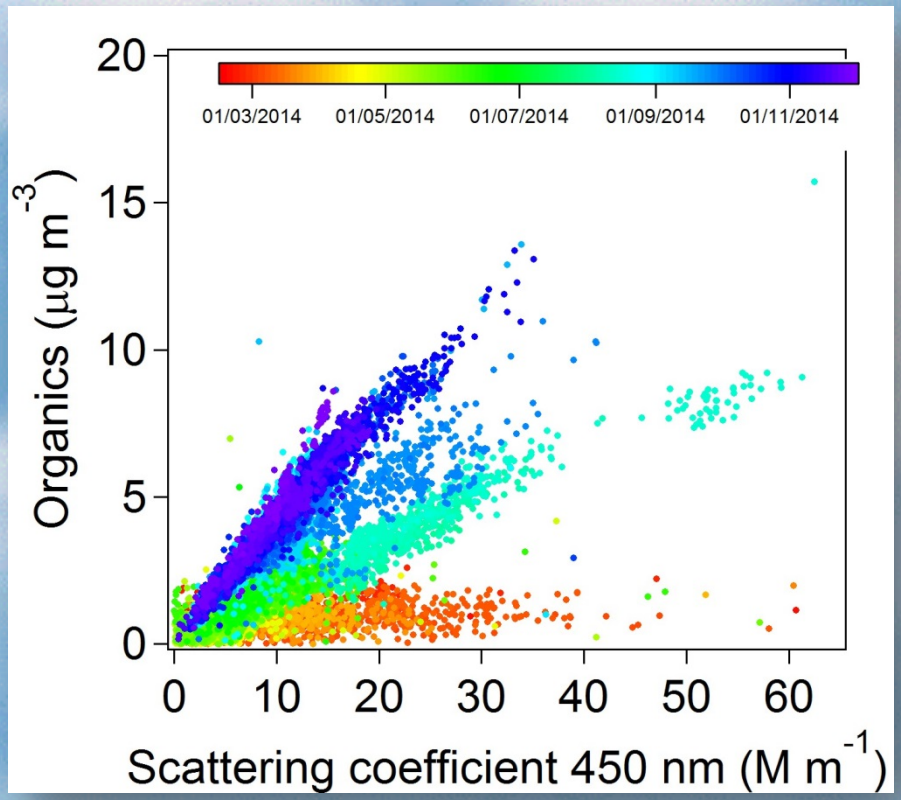


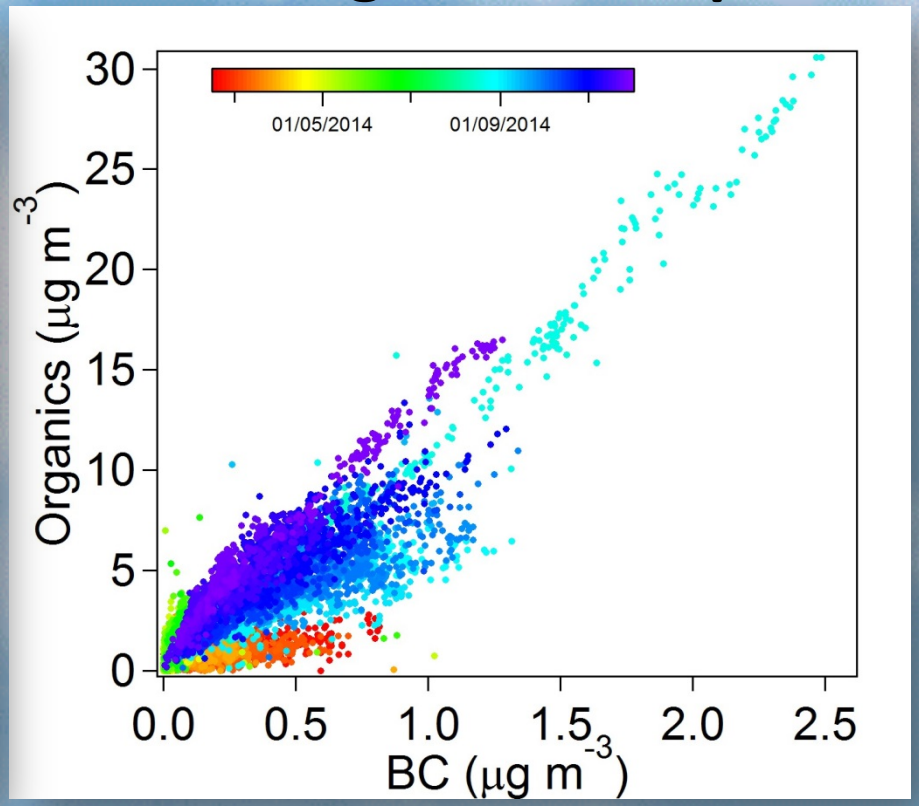
Organic aerosols from ATTO to Tiwa and Manacapuru (with BC)



What drives light scattering and absorption for PM1?

T0a ATTO - Organics versus light scattering and absorption

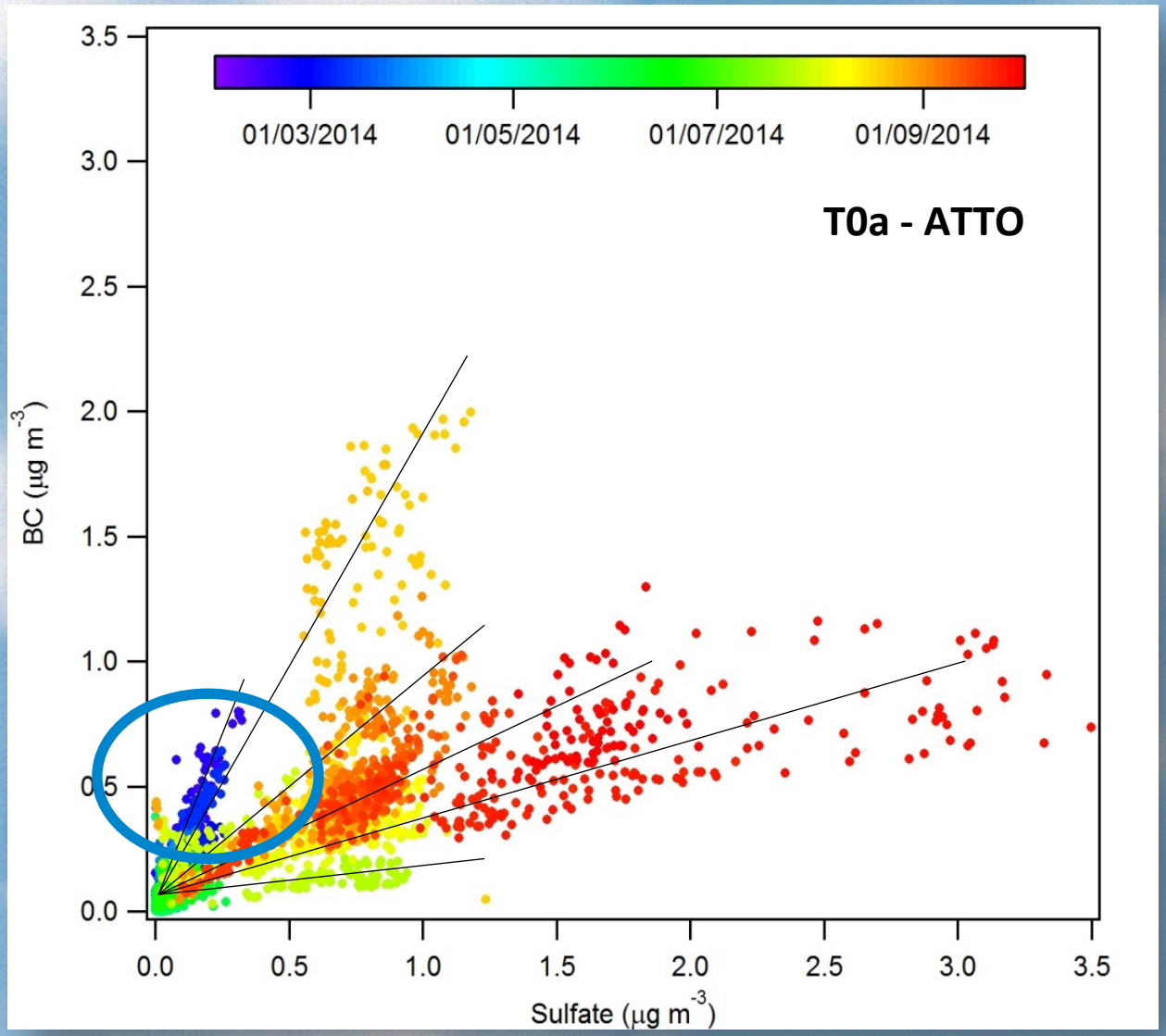




The organics made up to 76% of the fine particles and when investigated as a function of the scattering coefficient (σ_{450}) different patterns (with different slopes) were observed over time. BC also shows different patterns but less pronounced

Sulfate is related to BC, but with various ratios

Different sources, modulated by different Long range transport processes



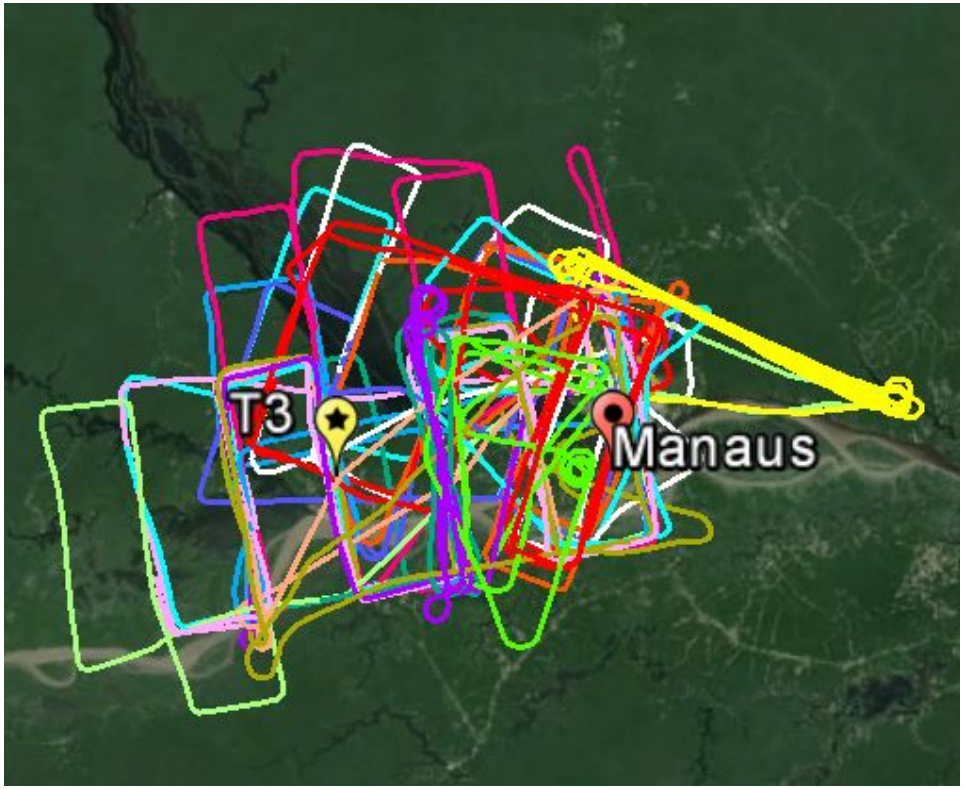
BC from Africa wet season

G5 HALO plane - "High Altitude and Long Range Research Aircraft" at the "ACRIDICON: Aerosol, Cloud, Precipitation, and Radiation Interactions and Dynamics of CONvective Cloud Systems".

"Intensive Airborne Research in Amazonia 2014" (IARA-2014)

G-1 Flight Paths during GoAmazon

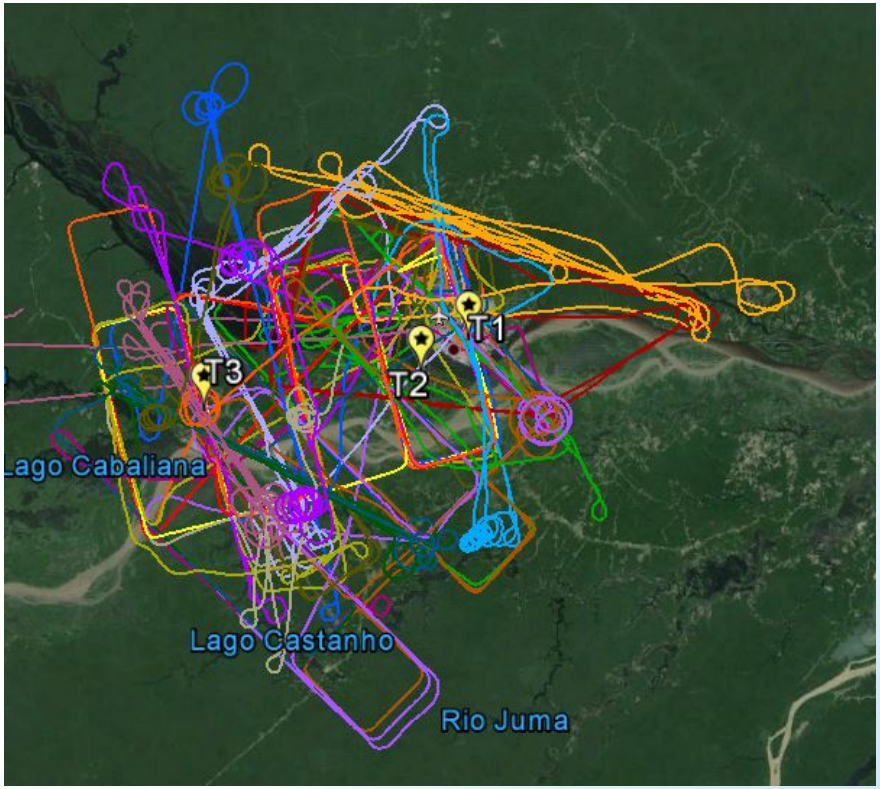
Phase 1 (Wet season)



16 flights – 42.8 hours

Feb 15th - March 26st , 2014

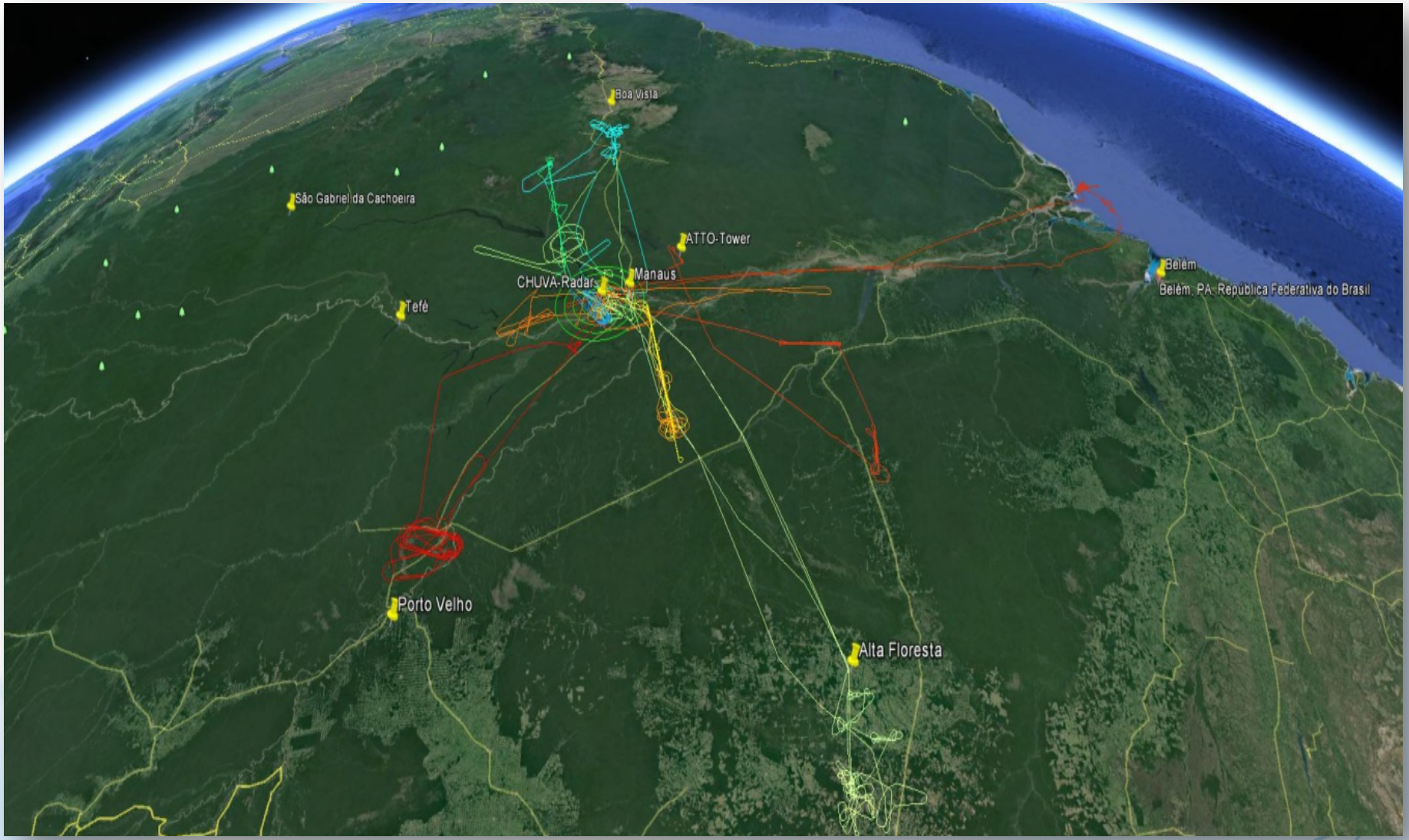
Phase 2 (dry season)



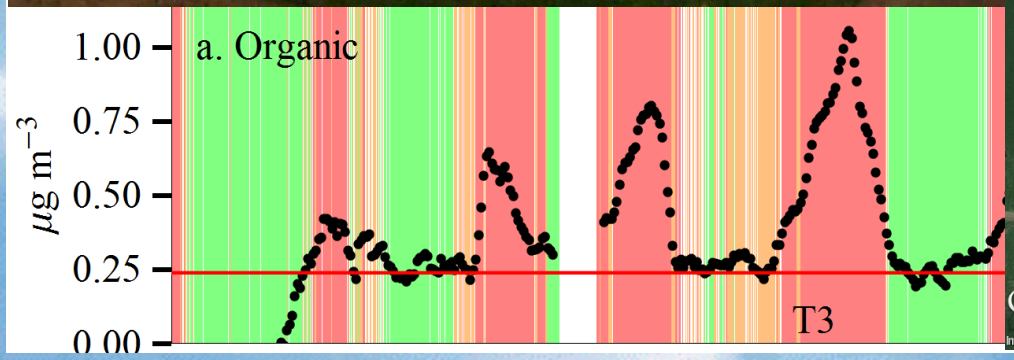
19 flights – 53.7 hours

Sep 1st - Oct 10th , 2014

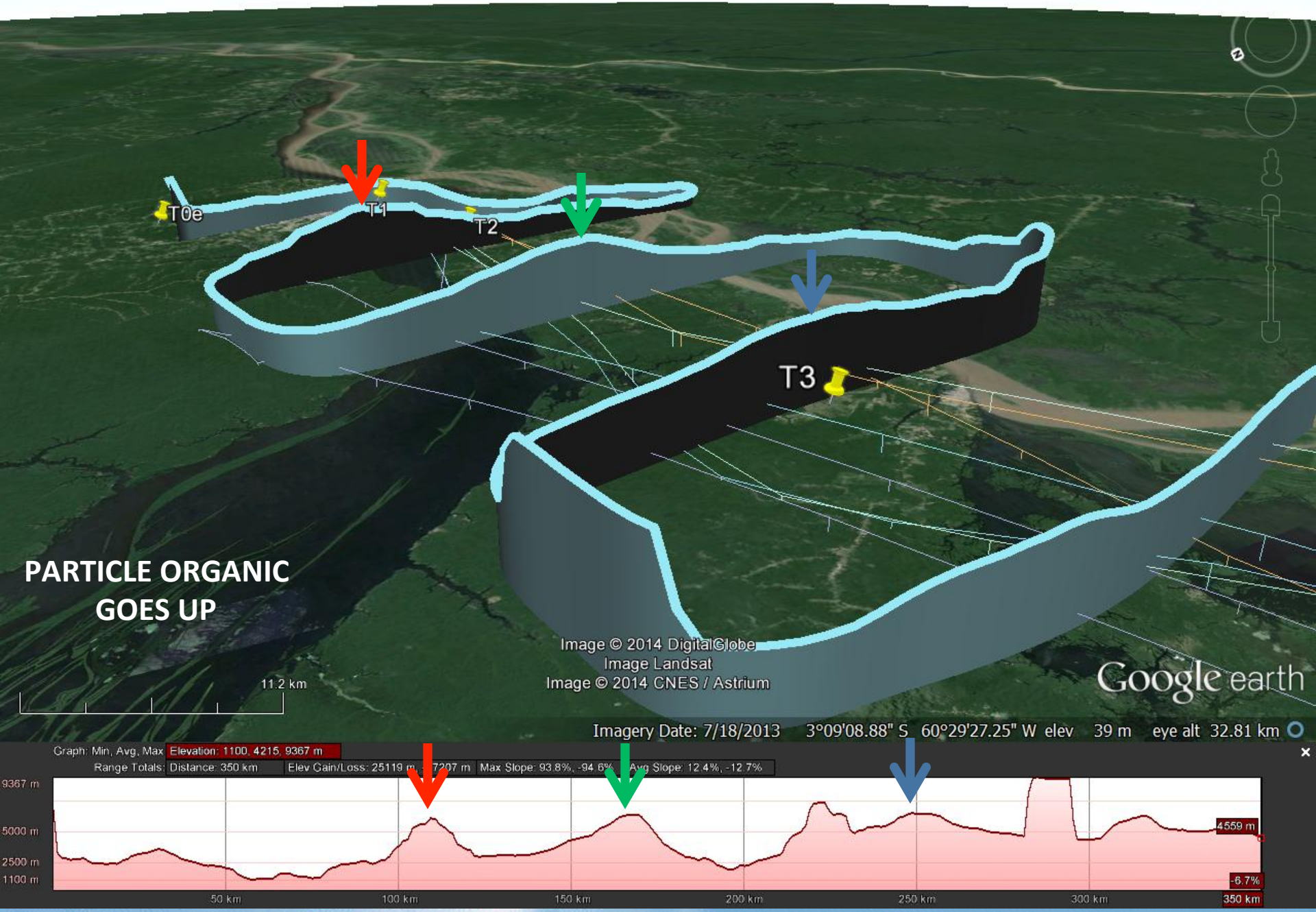
ACRIDICON Flights G5-HALO plane dry seaso



G-1 Flight Paths during GoAmazon

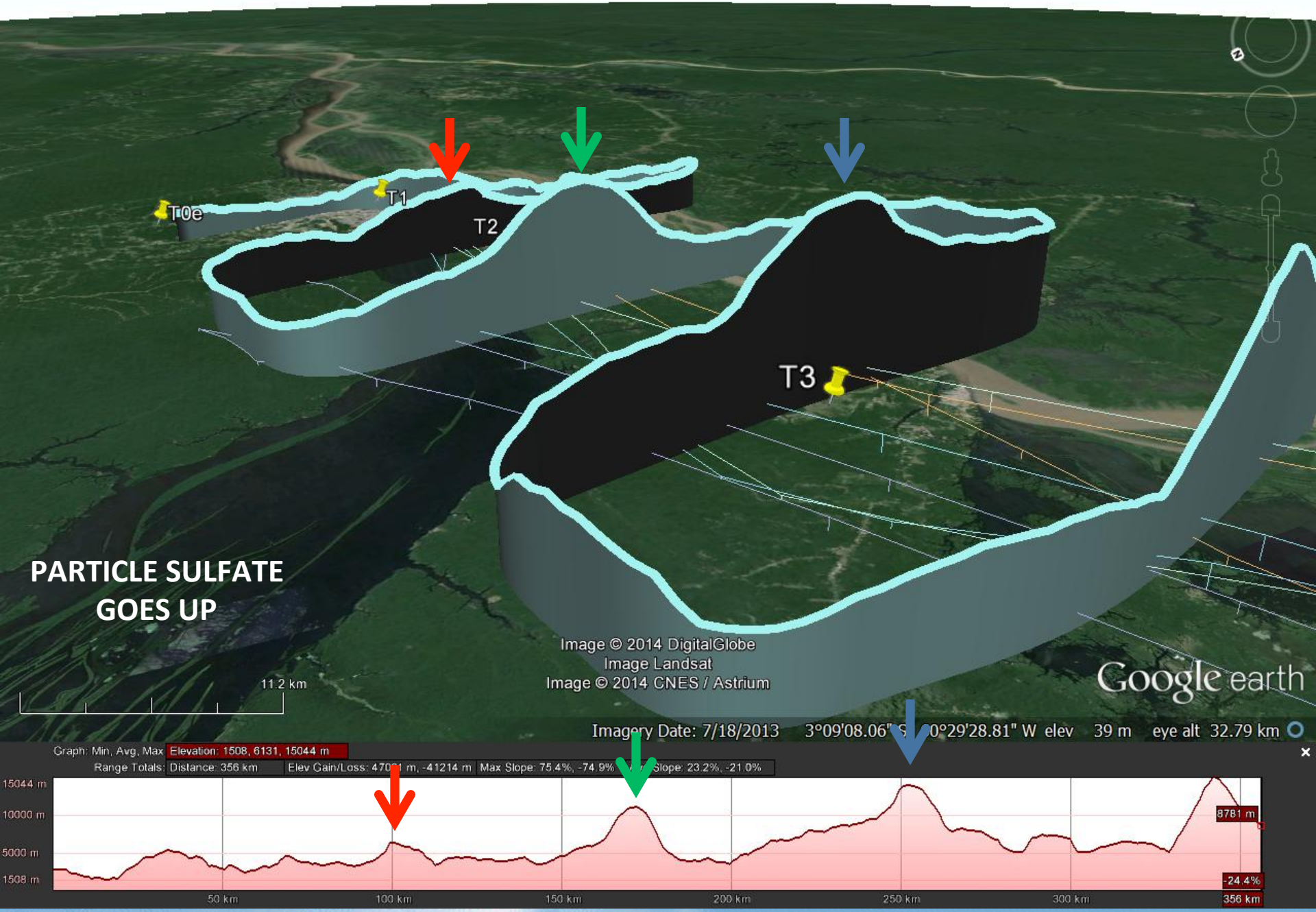


PARTICLE ORGANIC, GoAmazon2014/5, IOP1, 17 March 2014, 16:24 to 17:31



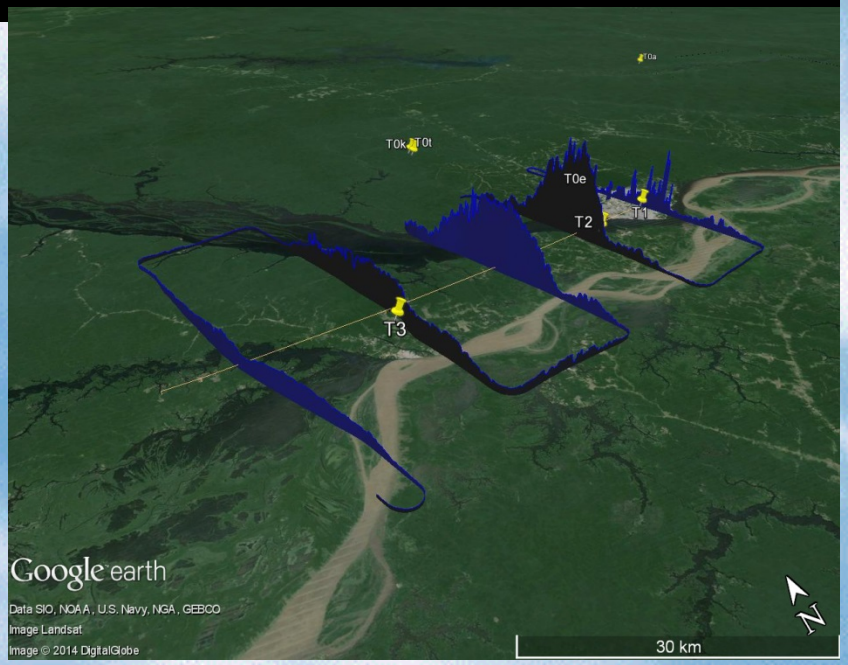
Slide prepared by Scot Martin

PARTICLE SULFATE, GoAmazon2014/5, IOP1, 17 March 2014, 16:24 to 17:31

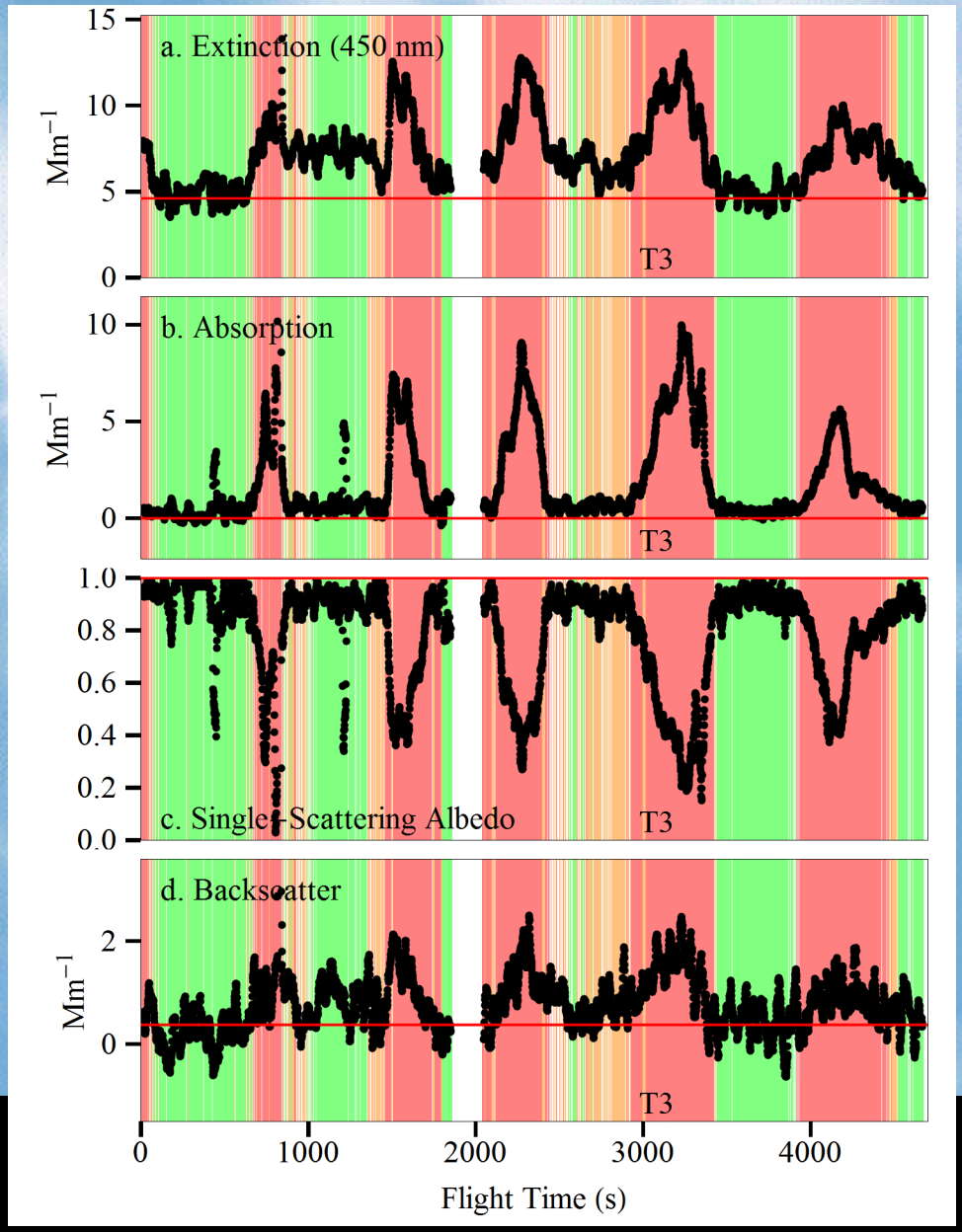


Slide prepared by Scot Martin

Optical Properties

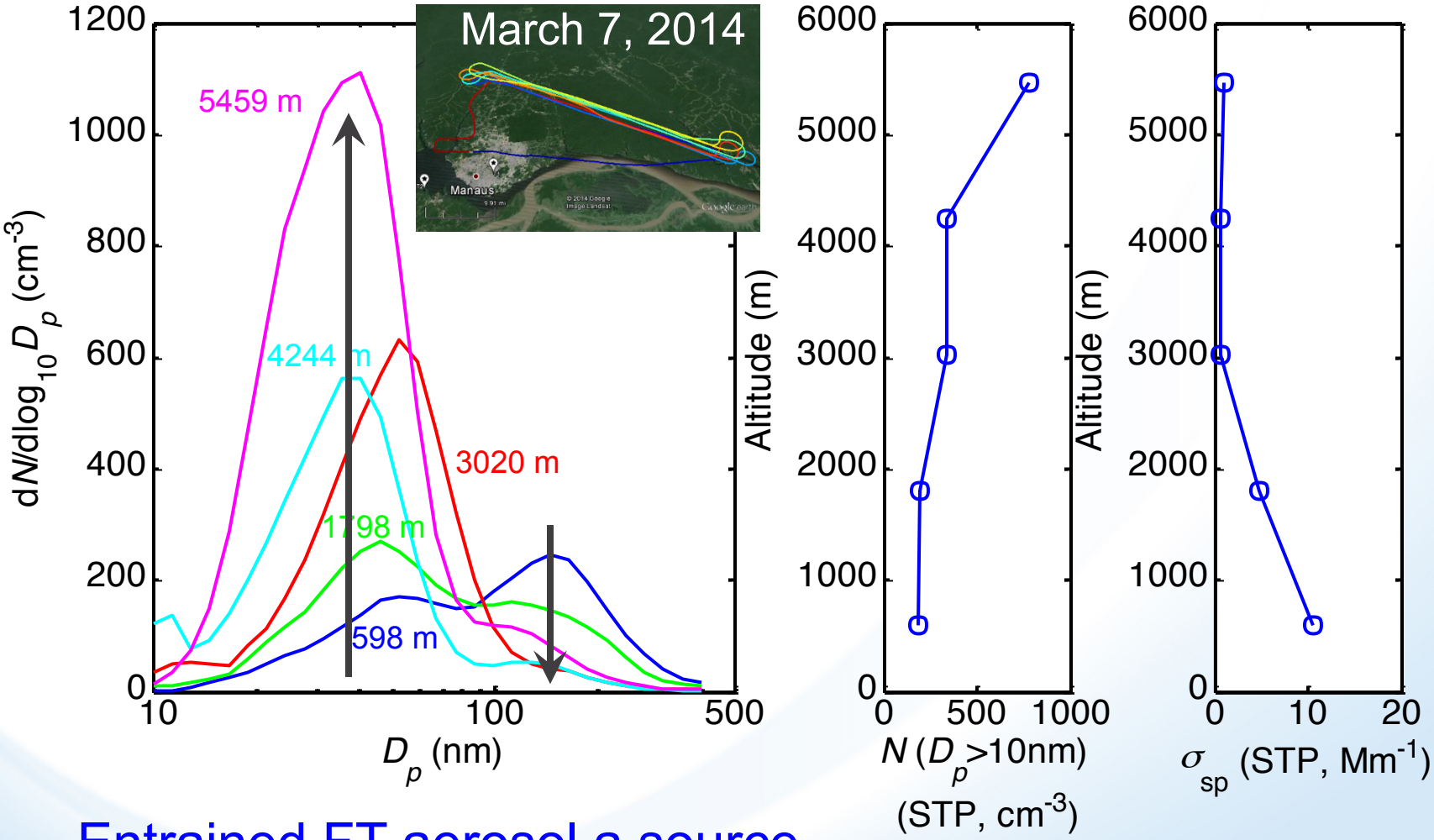


500 m, 11 AM local, 13 March 2014



Data Source: Duli Chand, IARA Experiment, DOE AAF G1 Platform

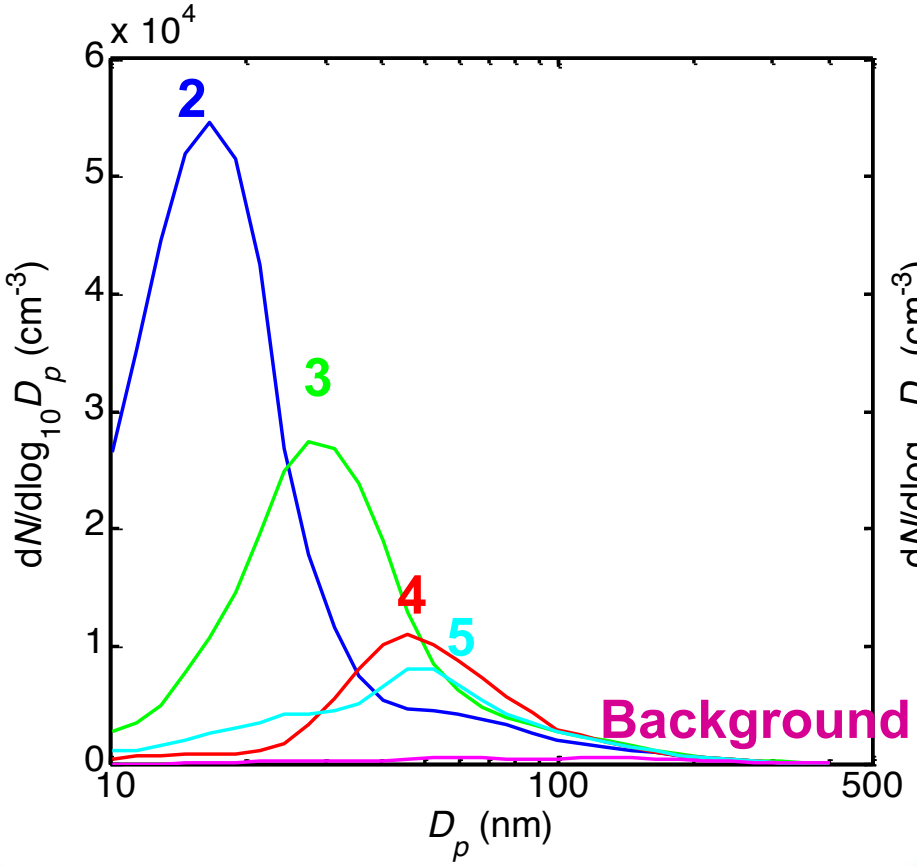
Vertical profile of particle size distribution under pristine condition during wet season

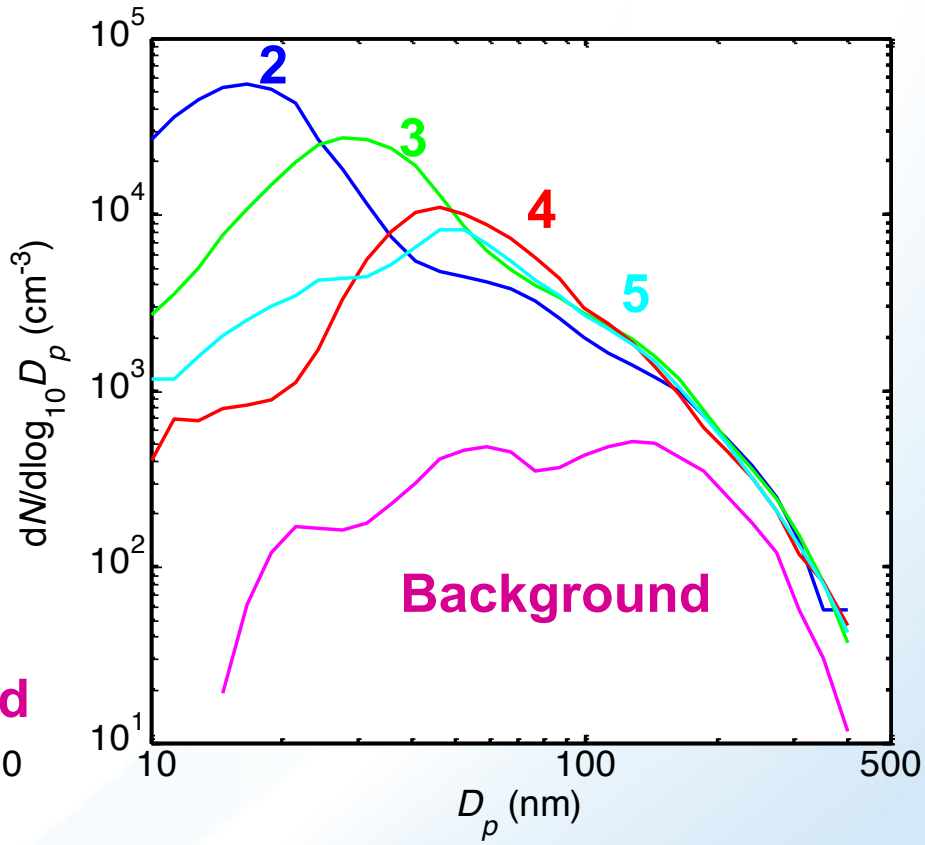


Entrained FT aerosol a source of particle number in BL?

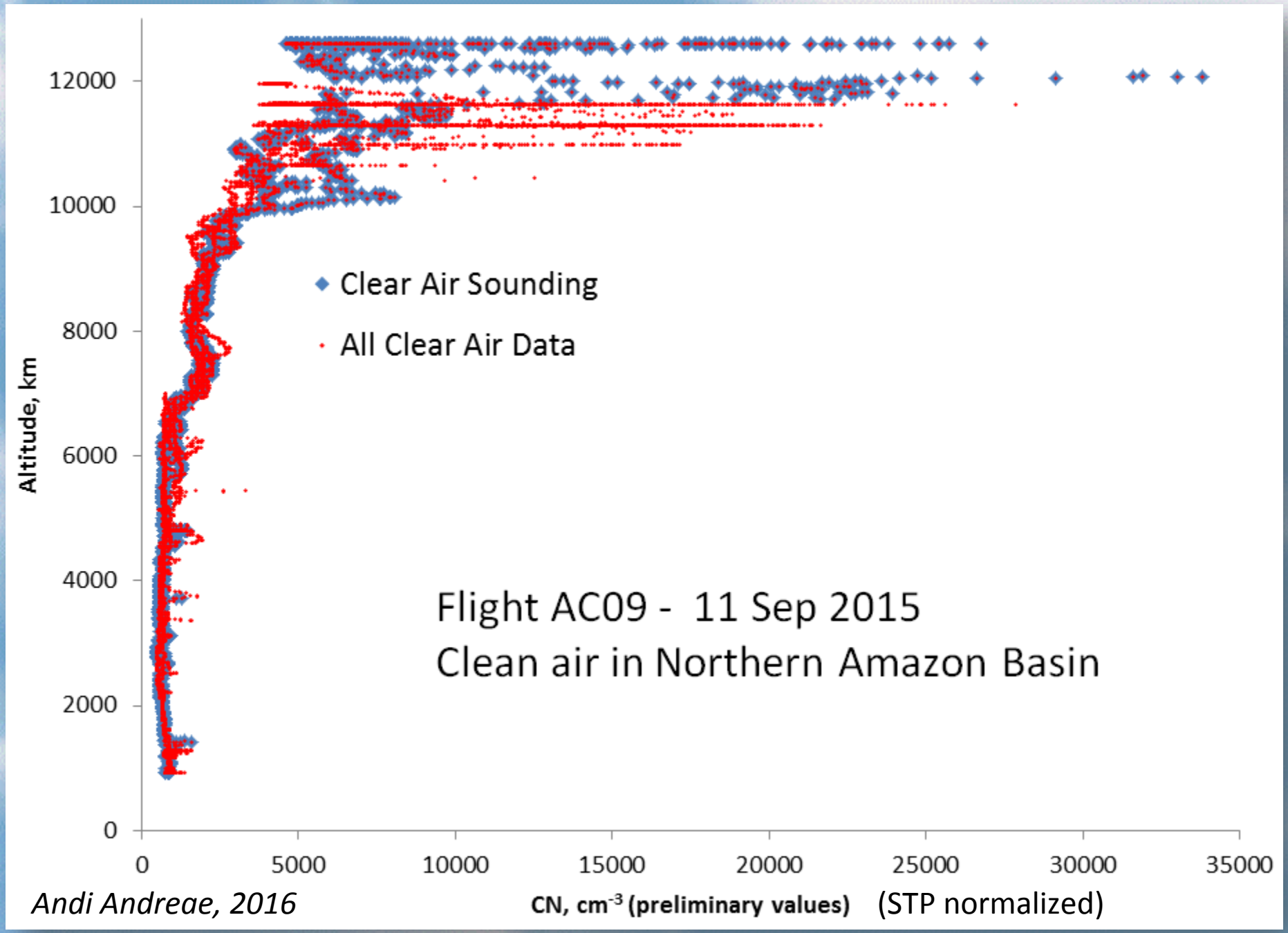
(Jian Wang, BNL)

Evolution of aerosol size distribution in Manaus plume (March 13, 2014, Wet season)

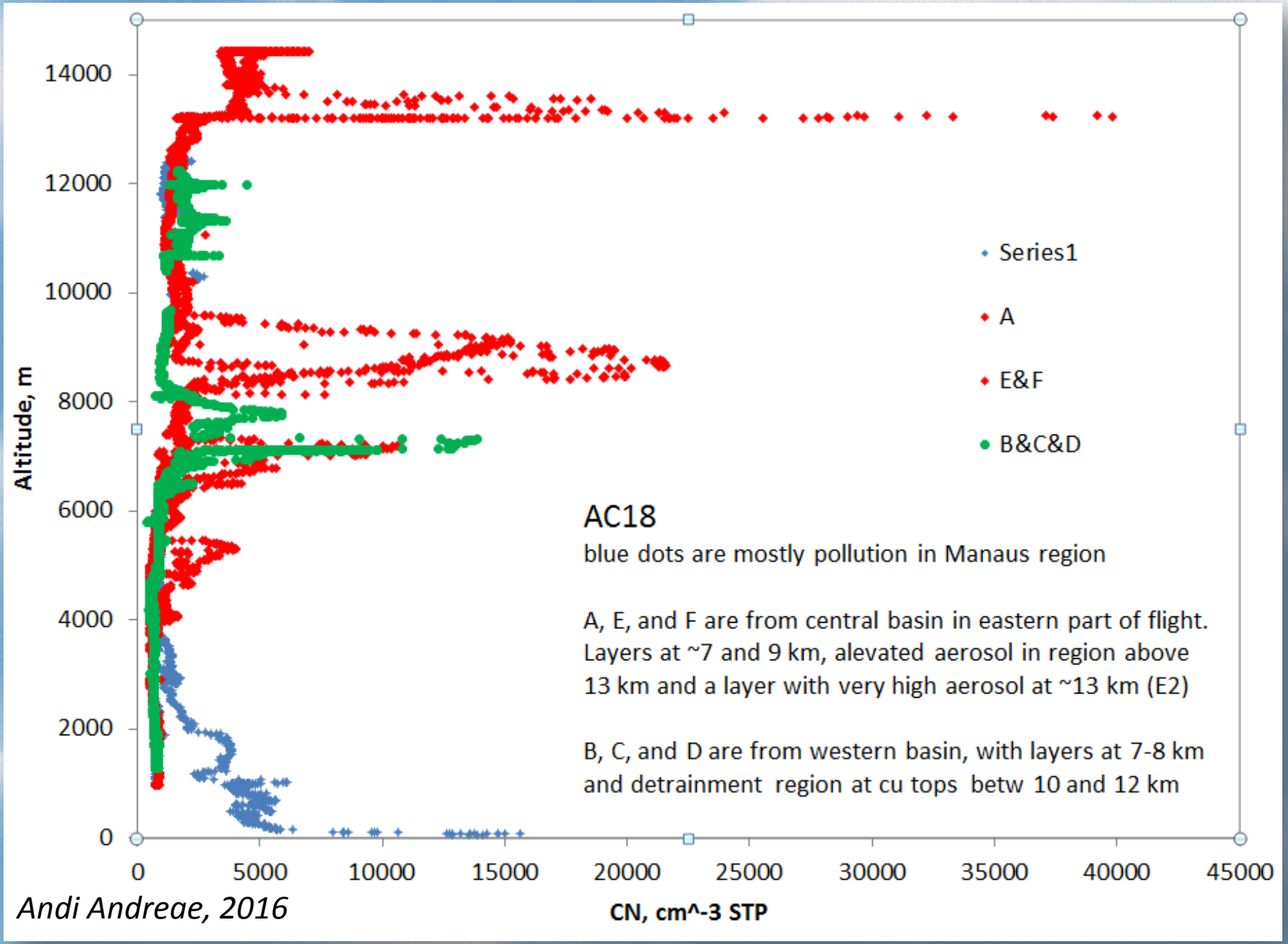




Growth of particles inside Manaus plume due to condensation of secondary species.

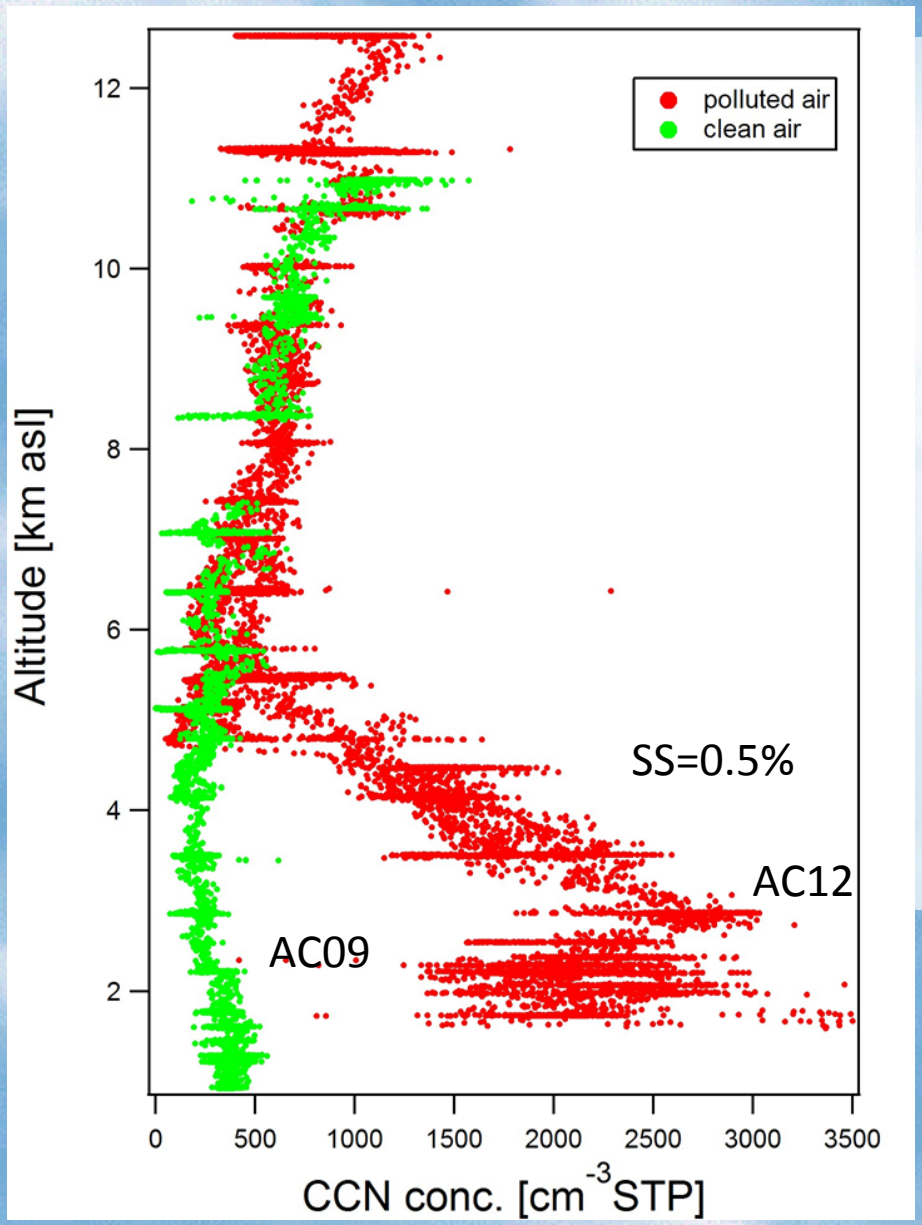


Andi Andreae, 2016



Andi Andreae, 2016

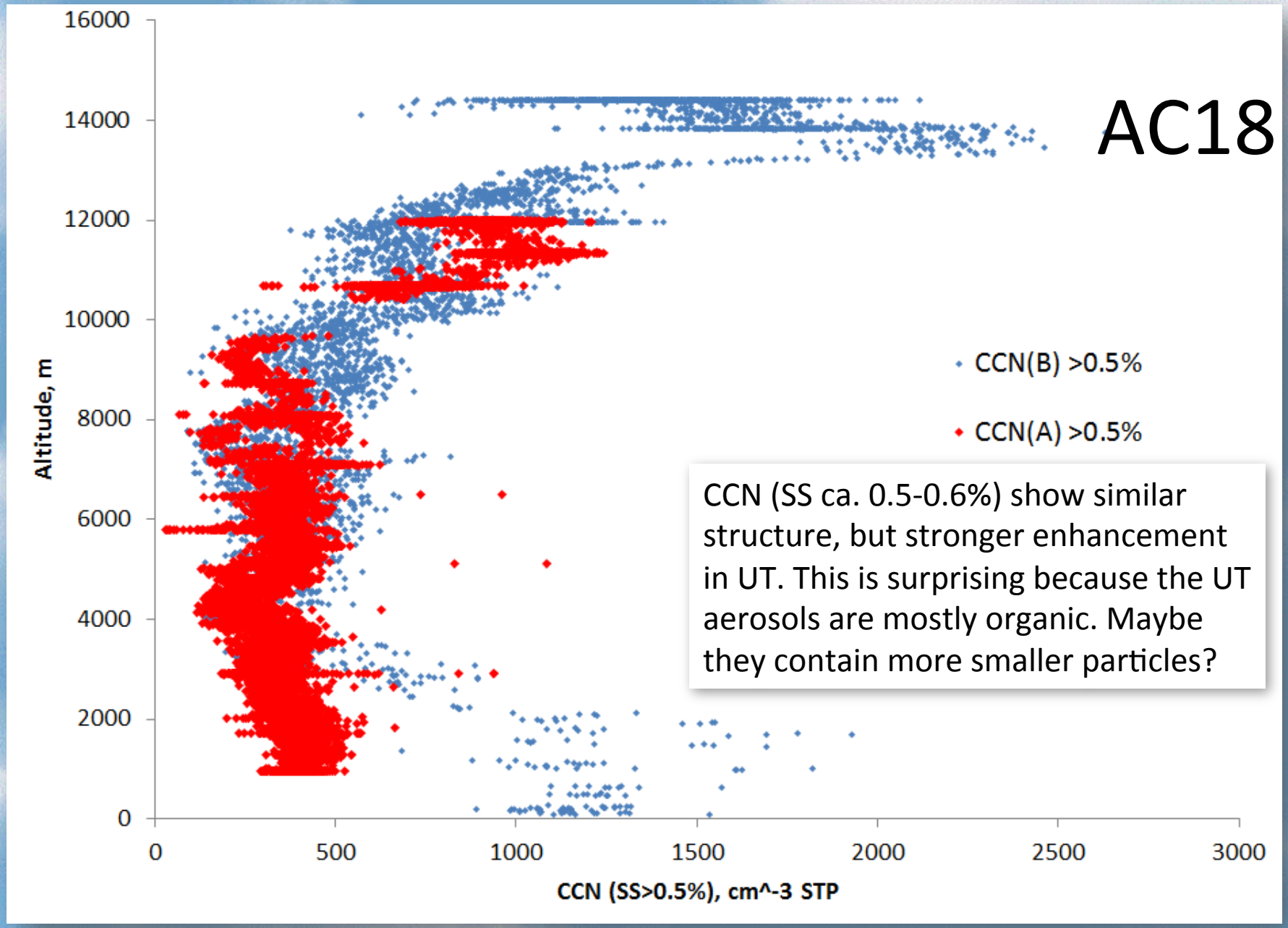
CCN Enhancement



CCN are also enhanced in UT, but not as strongly as CN: smaller particles and/or less hygroscopic

Enhancements in UT similar over clean area and polluted area: Aerosol is not result of pollution, but likely product of particle production from clean BL air – BVOC oxidation products

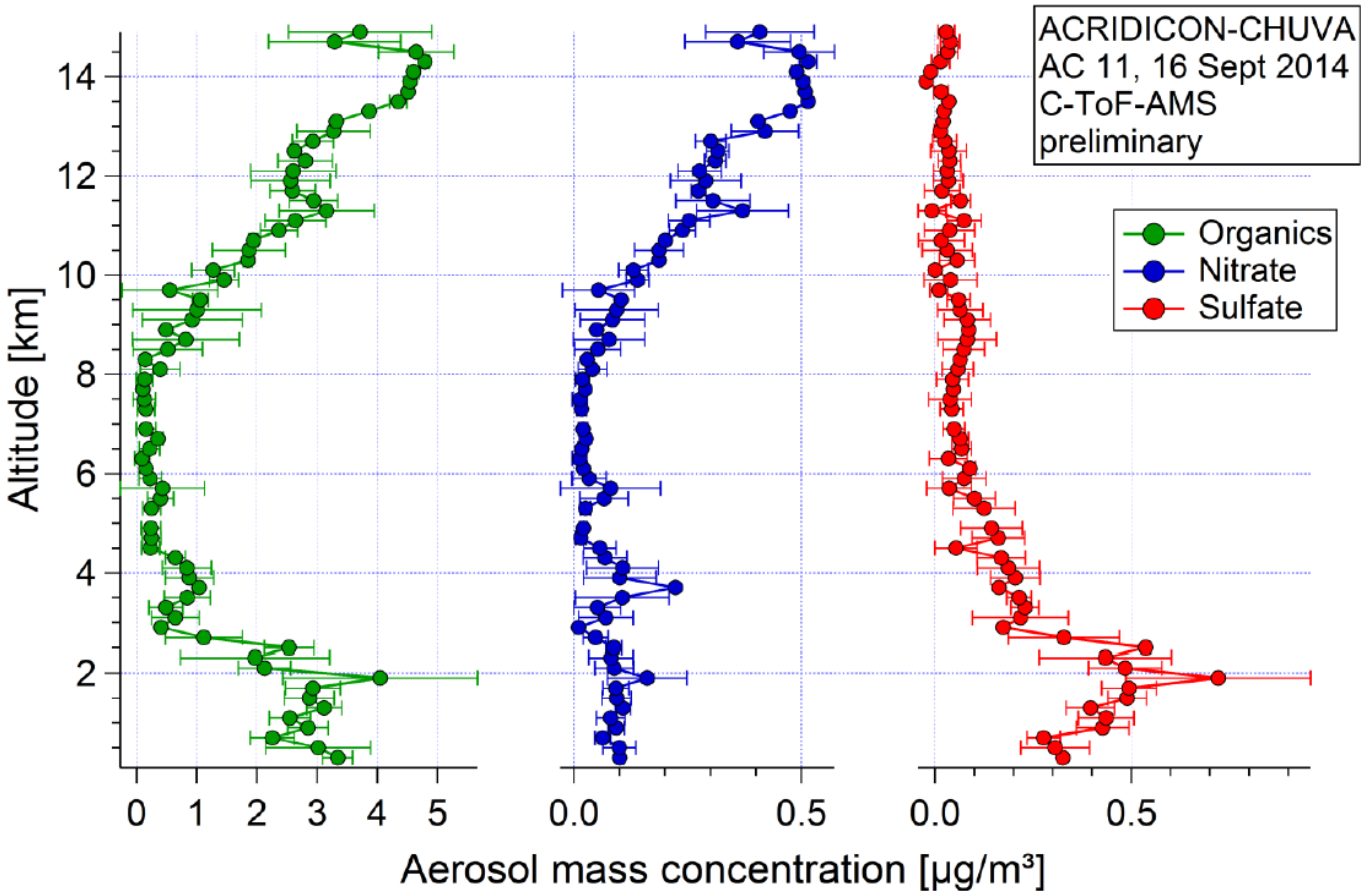
Andi Andreae, Mira Pöhlker, *2016*



CCN (SS ca. 0.5-0.6%) show similar structure, but stronger enhancement in UT. This is surprising because the UT aerosols are mostly organic. Maybe they contain more smaller particles?

Andi Andreae, 2016

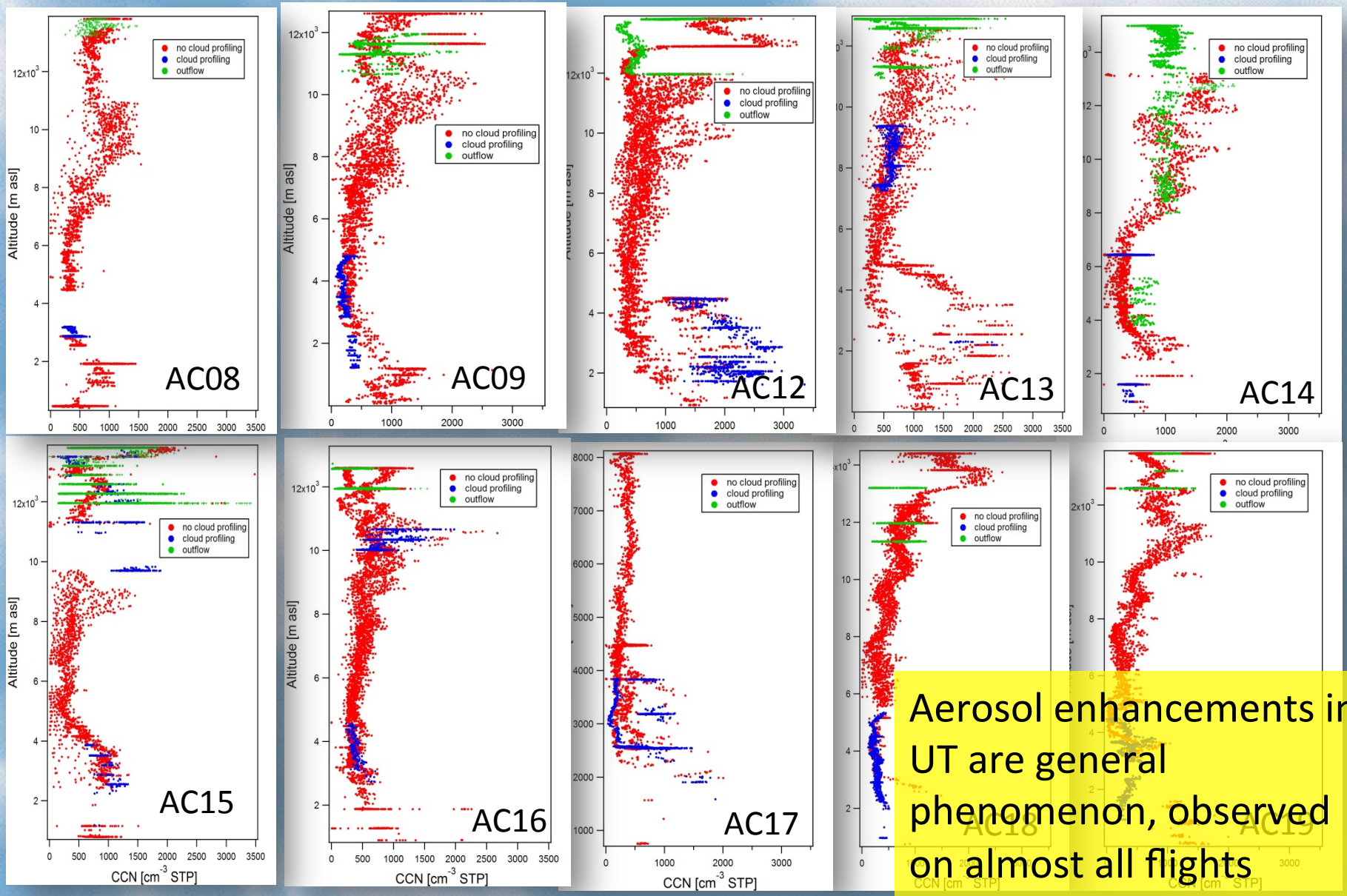
Aerosol composition: Organics and nitrates. No sulfates



Andi Andreae, 2016

MAX-PLANCK-GESELLSCHAFT

CCN vertical Profiles HALO ACRIDICON-CHUVA campaign Sep. 2014



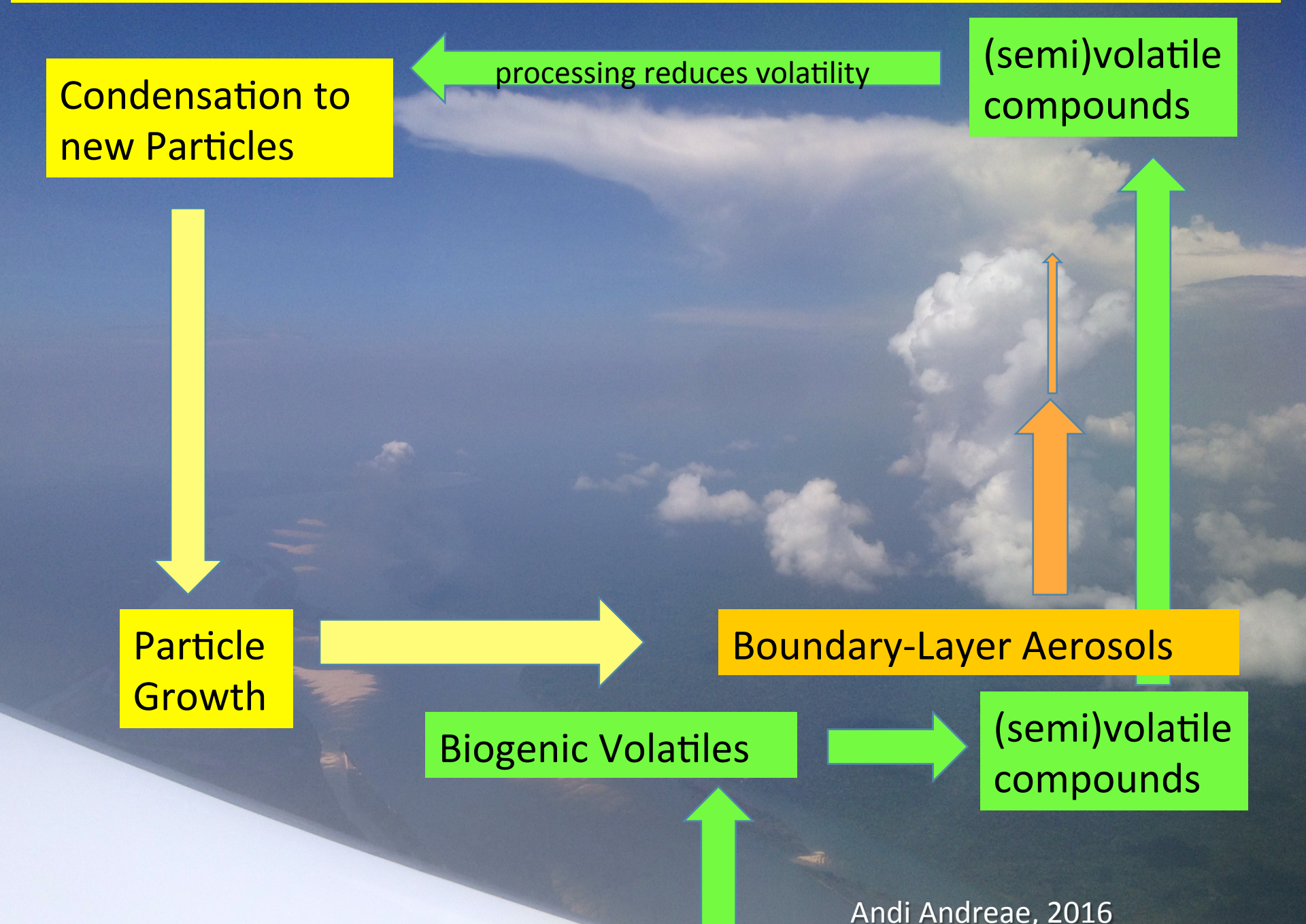
Aerosol enhancements in UT are general phenomenon, observed on almost all flights

- enhanced CCN conc. at high altitude is observed in most of the flights (S~0.5%)

S~0.5% @ HASI

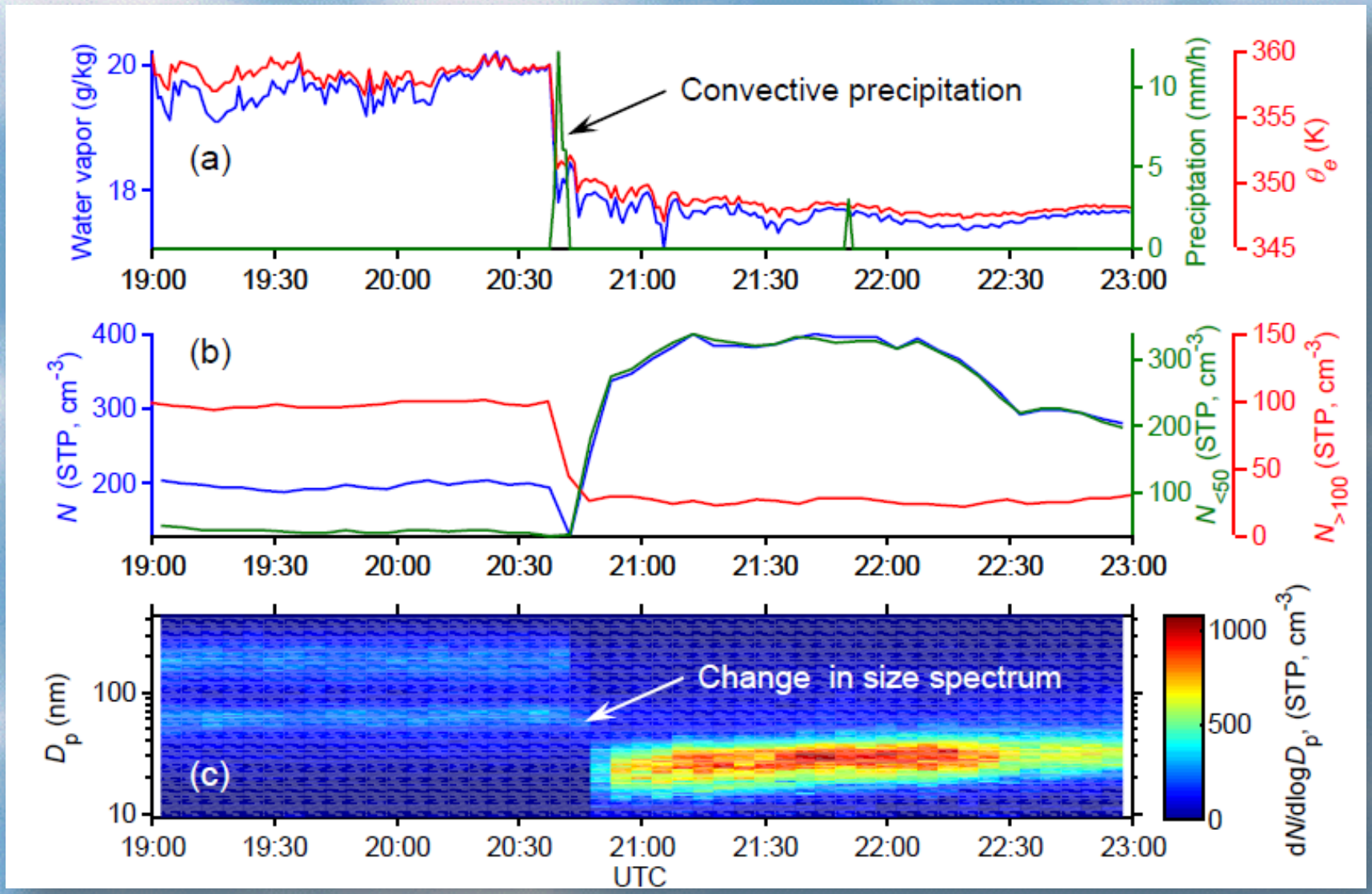
Slide from Andi Andreae and Mira Kruger

Biogenic organic aerosol formation at low H_2SO_4 happens in UT!



Andi Andreae, 2016

Convective precipitation brings these particles down to the surface

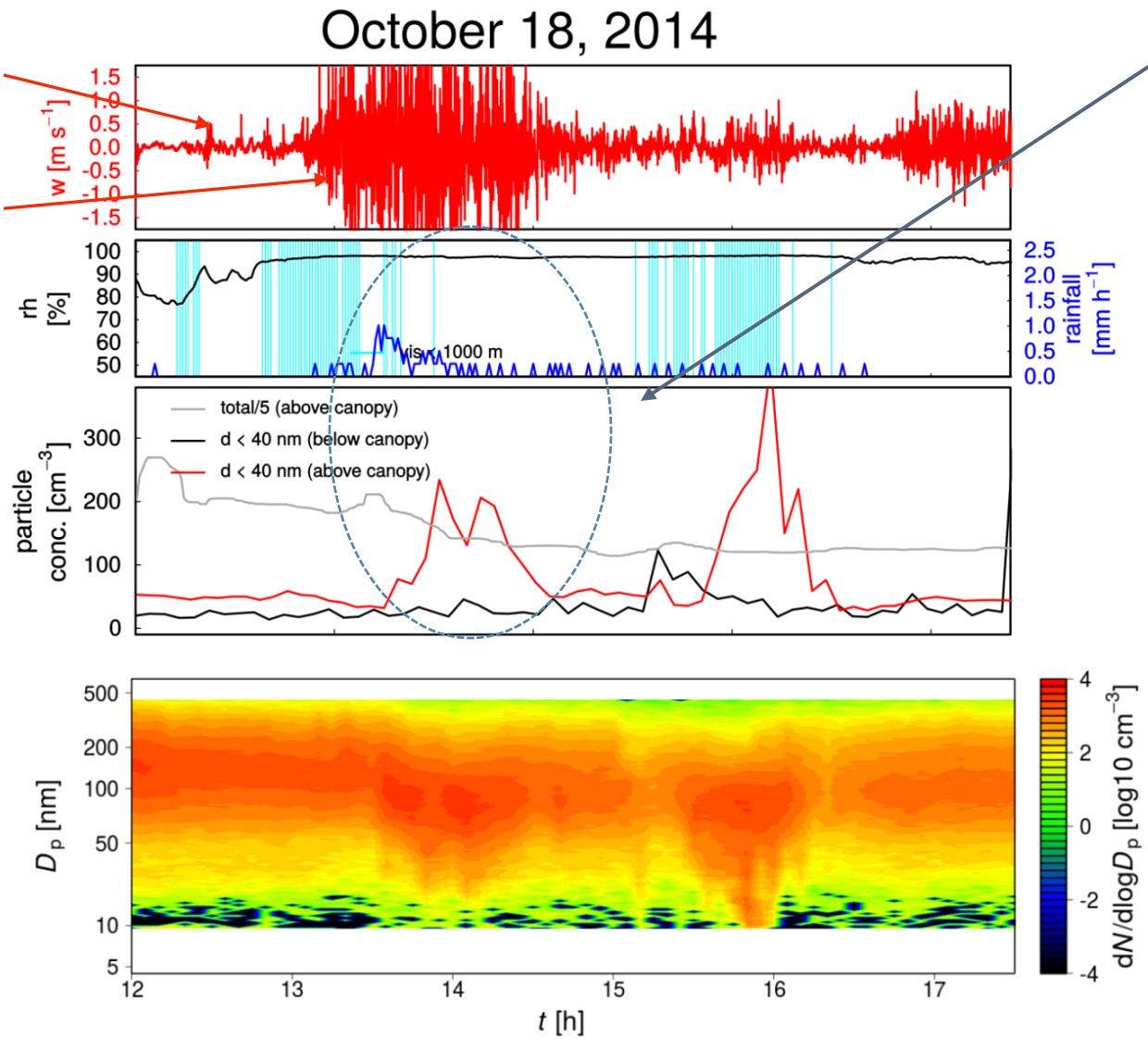


Wang et al. (2016, under review)

Rain-Related Downdrafts of Particles

very calm conditions vs. ±1.5 m/s

intense vertical transport upon strong rain

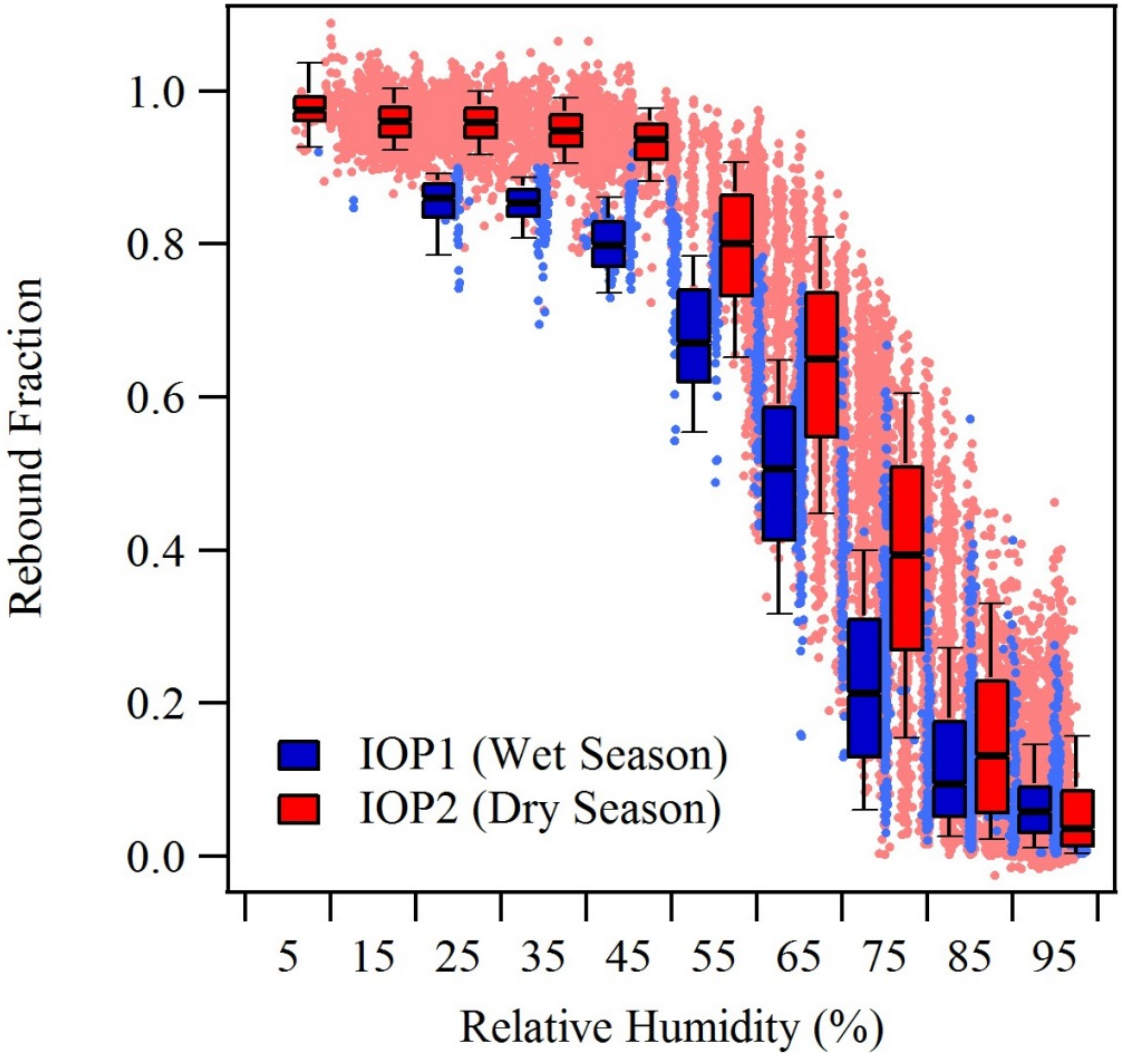


- Frequently observed scenario
- Rain-related injection of fine particles into boundary layer
- Nucleation/Aitken mode particle likely from outflow of convective clouds

Wang et al. 2016, submitted; Ditas et al., 2016, in prep.

Amazonia: Liquid Organic Particulate Matter

Aerosols are part of the liquid atmosphere (not the solid one)…



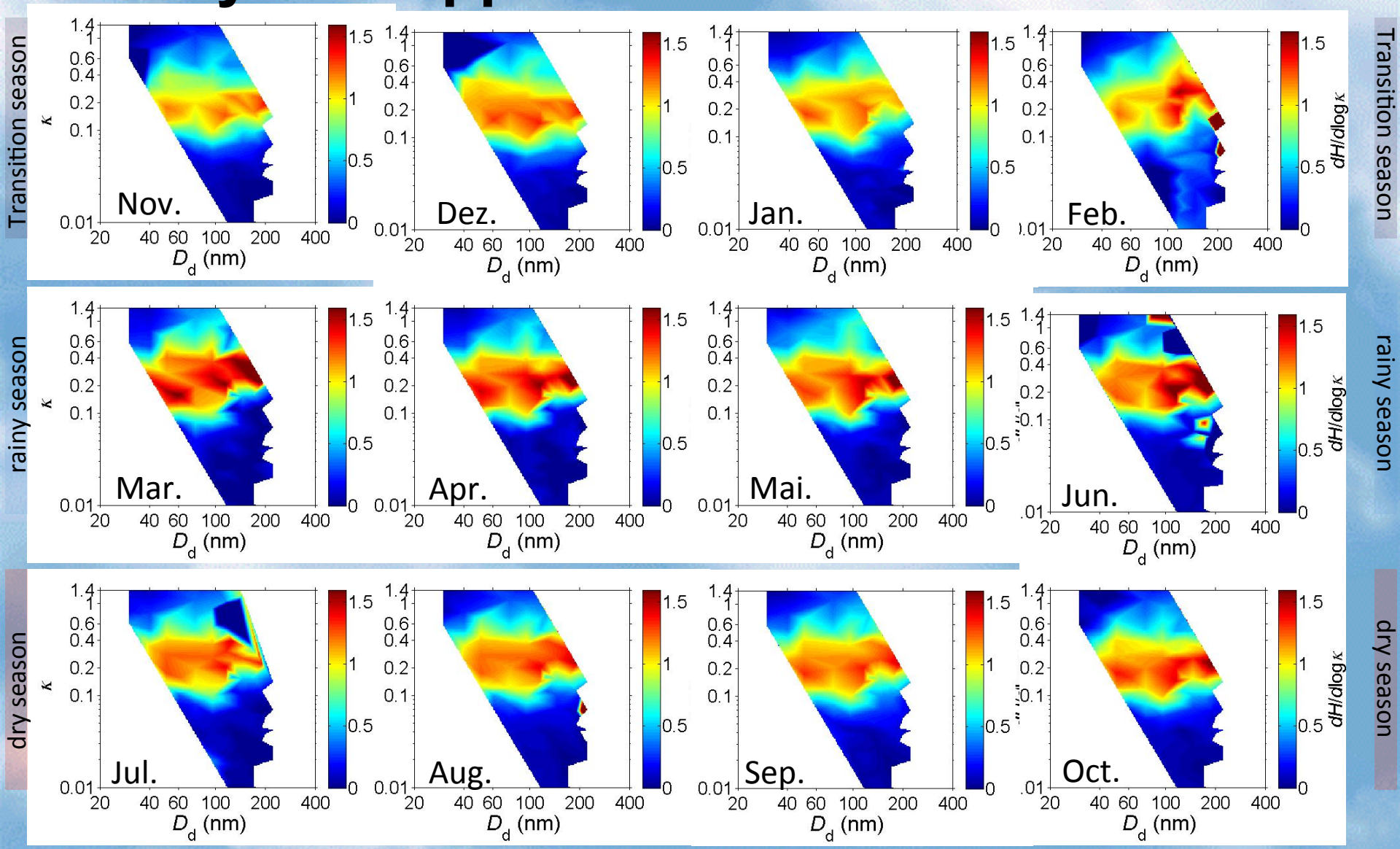
nature geoscience LETTERS
PUBLISHED ONLINE: 7 DECEMBER 2015 | DOI: 10.1038/NGEO2599

Sub-micrometre particulate matter is primarily in liquid form over Amazon rainforest

Adam P. Bateman[1], Zhaoheng Gong[1], Pengfei Liu[1], Bruno Sato[2], Glauber Cirino[3], Yue Zhang[1], Paulo Artaxo[4], Allan K. Bertram[5], Antonio O. Manzi[3], Luciana V. Rizzo[6], Rodrigo A. F. Souza[7], Rahul A. Zaveri[8] and Scot T. Martin[1,9]*

Adam Bateman (2016)

One year Kappa distribution at ATTO Site



- Somewhat enhanced values in the rainy season. *From Mira Kruger and H. Barbosa*
- the dominant kappa value is around **<u>0.2</u>**, with larger values for larger diameters

Thanks, Yoram, for the creative inspiration. Not very many people makes the difference…

Yoram was one of these people…

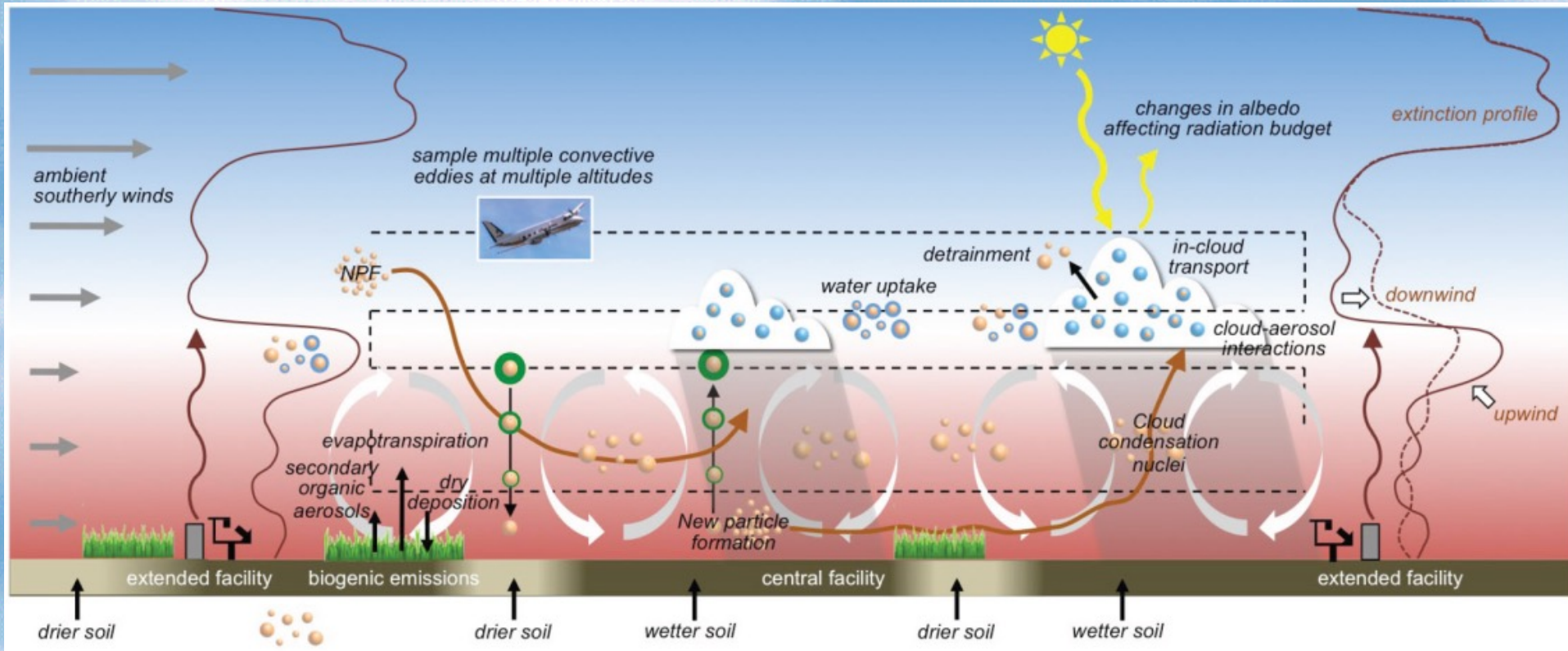
Lesson learned: When we all go, we will not be remembered by our papers, but by our quality as a human beings.
Yoram is remembered for that…

Thanks for the attention!!

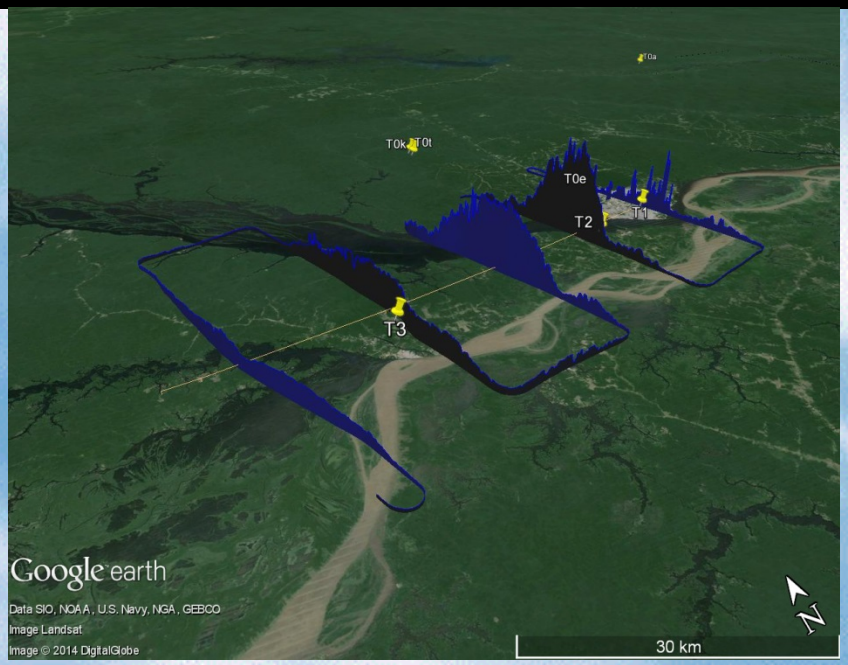
We can see a complex mixture of sources, transformation and meteorological effects that mix forest biology with the chemistry and physics of the atmosphere

GoAmazon is providing a fantastic data set to study key atmospheric process in tropical regions…

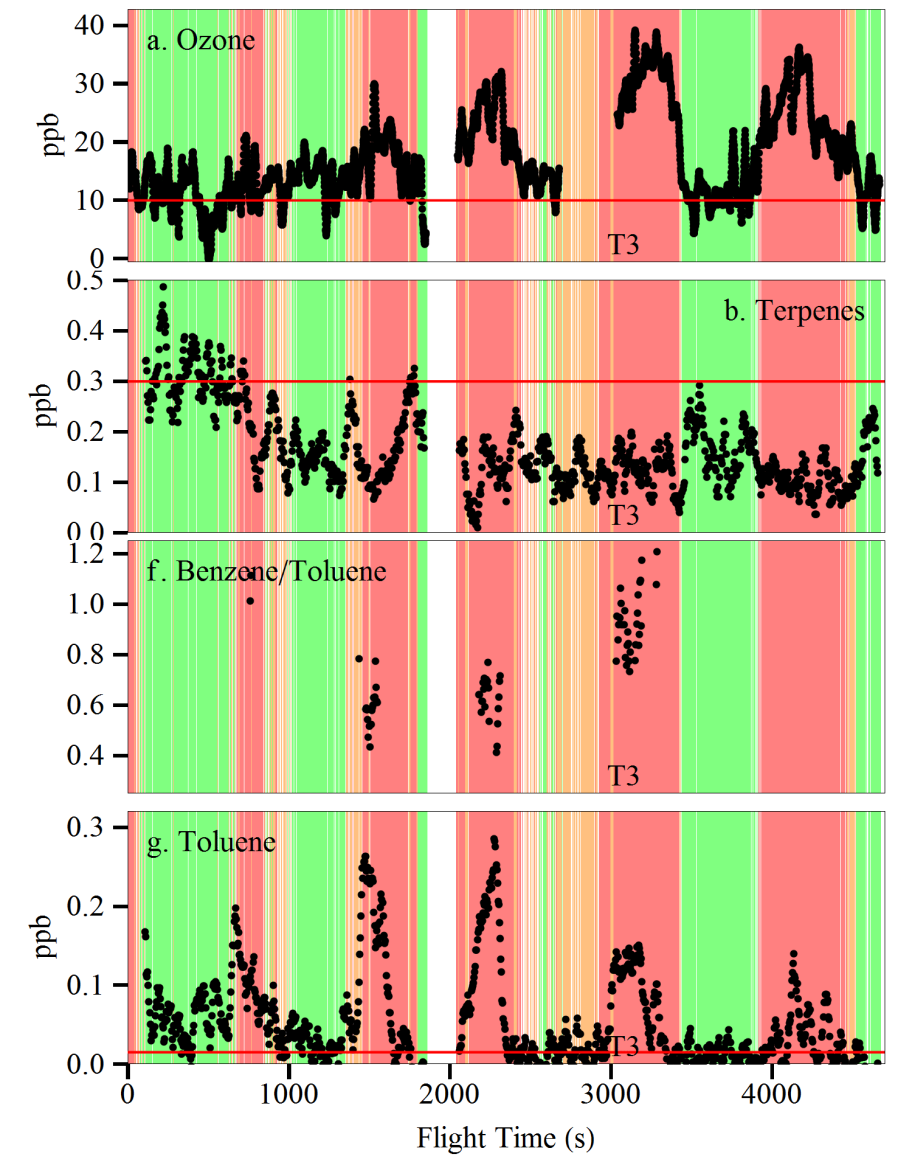
Thanks for the attention!!


ambient
southerly winds
sample multiple convective
eddies at multiple altitudes
changes in albedo
affecting radiation budget
extinction profile
NPF
detrainment
in-cloud
transport
water uptake
downwind
cloud-aerosol
interactions
upwind
evapotranspiration
secondary
organic
aerosols
dry
deposition
Cloud
condensation
nuclei
New particle
formation
extended facility
biogenic emissions
central facility
extended facility
drier soil
drier soil
wetter soil
drier soil
wetter soil

Ozone, Terpenes and Toluene Concentrations

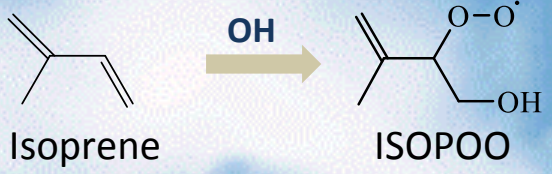


500 m, 11 AM local, 13 March 2014



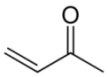
Data Source: John Shilling, IARA Experiment, DOE AAF G1 Platform

Isoprene Photochemistry in Transition?

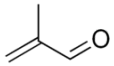


NO

methyl vinyl ketone (MVK, C_4H_6O)



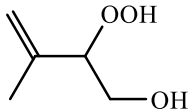
methacrolein (MACR, C_4H_6O)



…

HO_2

ISOPOOHs ($C_5H_{10}O_3$)



…

Isomerization

Products

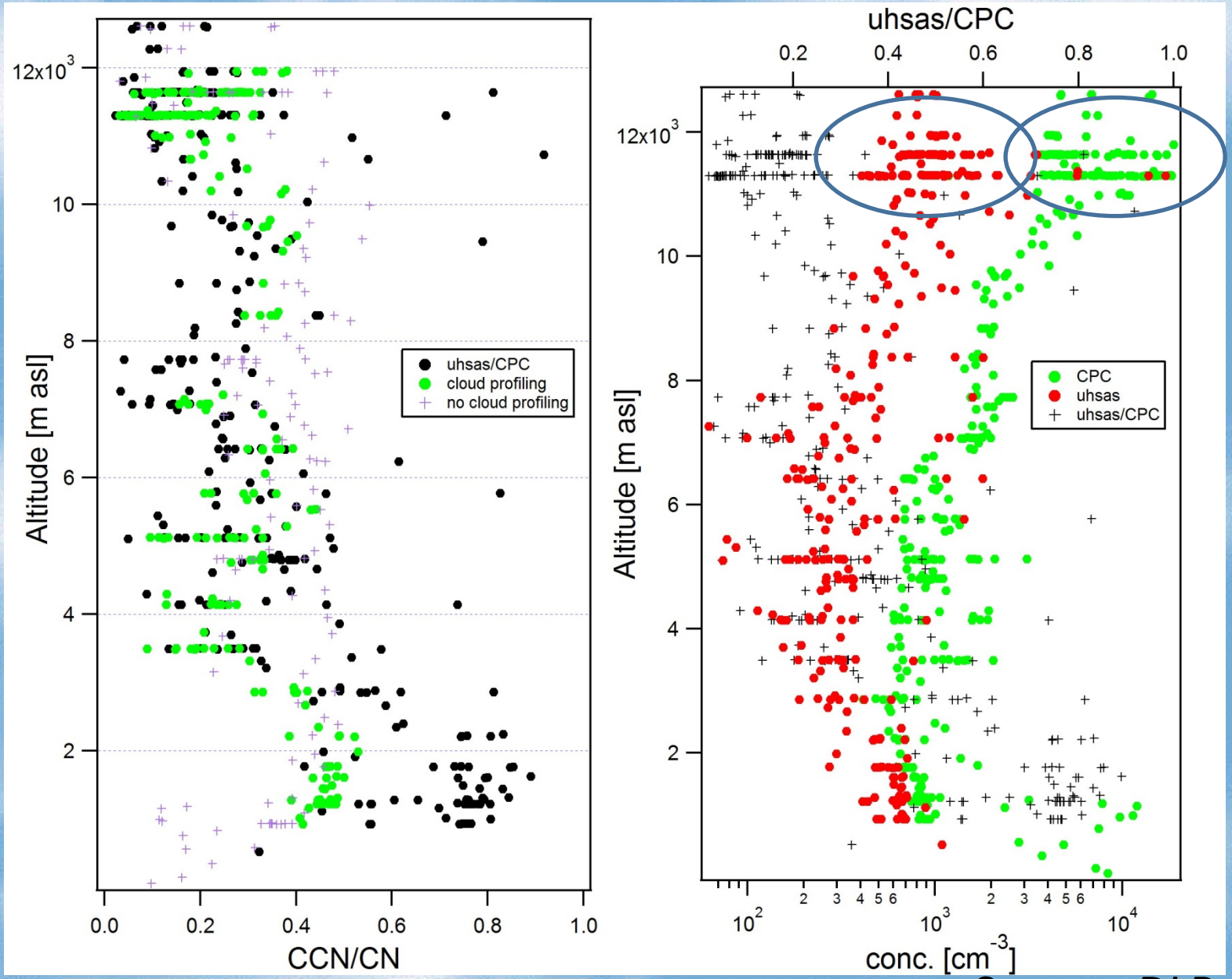
RO_2

Products

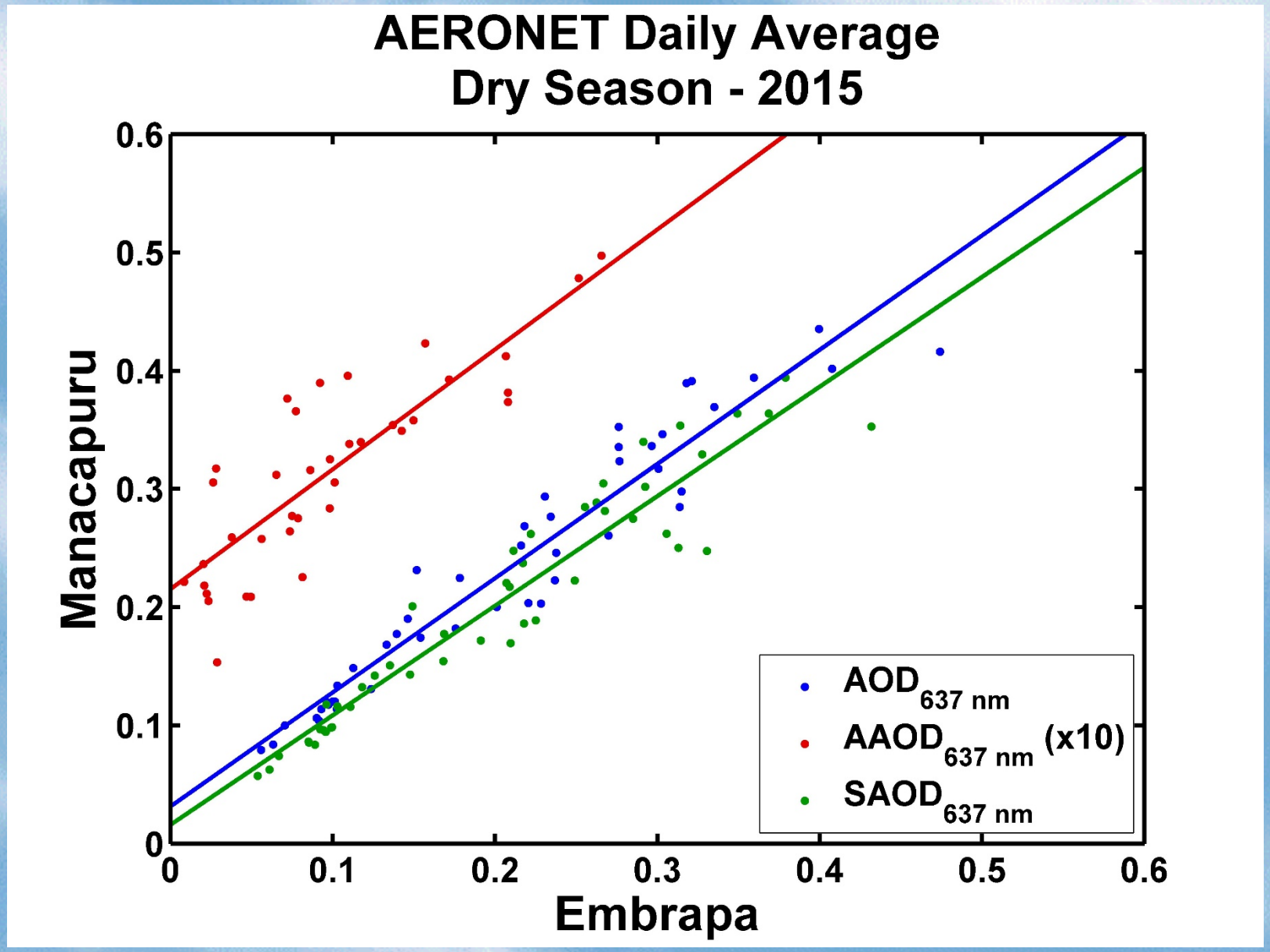
(Tuazon et al., 1990; Paulot et al., 2009; Surratt et al., 2010; Crounse et al., 2011, Peeters et al., 2009; 2010; 2014; Fuchs et al., 2013…)

HALO ACRIDICON-CHUVA campaign Sep. 2014

F- AC09

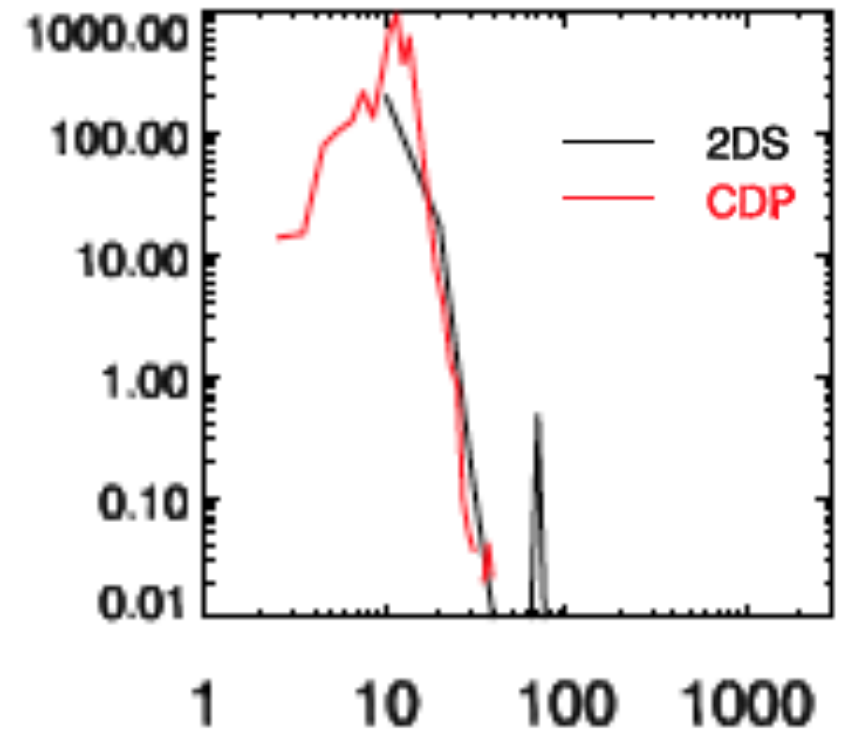


Source: DLR, LMU

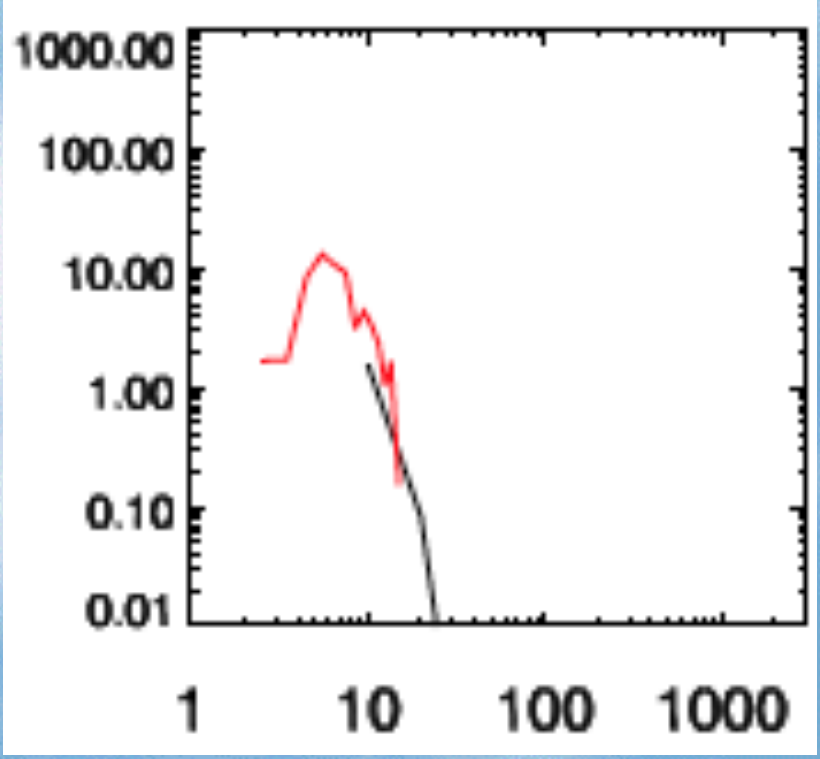

AERONET Daily Average
Dry Season - 2015
Manacapuru
Embrapa
0
0.1
0.2
0.3
0.4
0.5
0.6
AOD 637 nm
AAOD 637 nm (x10)
SAOD 637 nm

G1 Cloud droplet number concentrations

Cloud influenced by plume



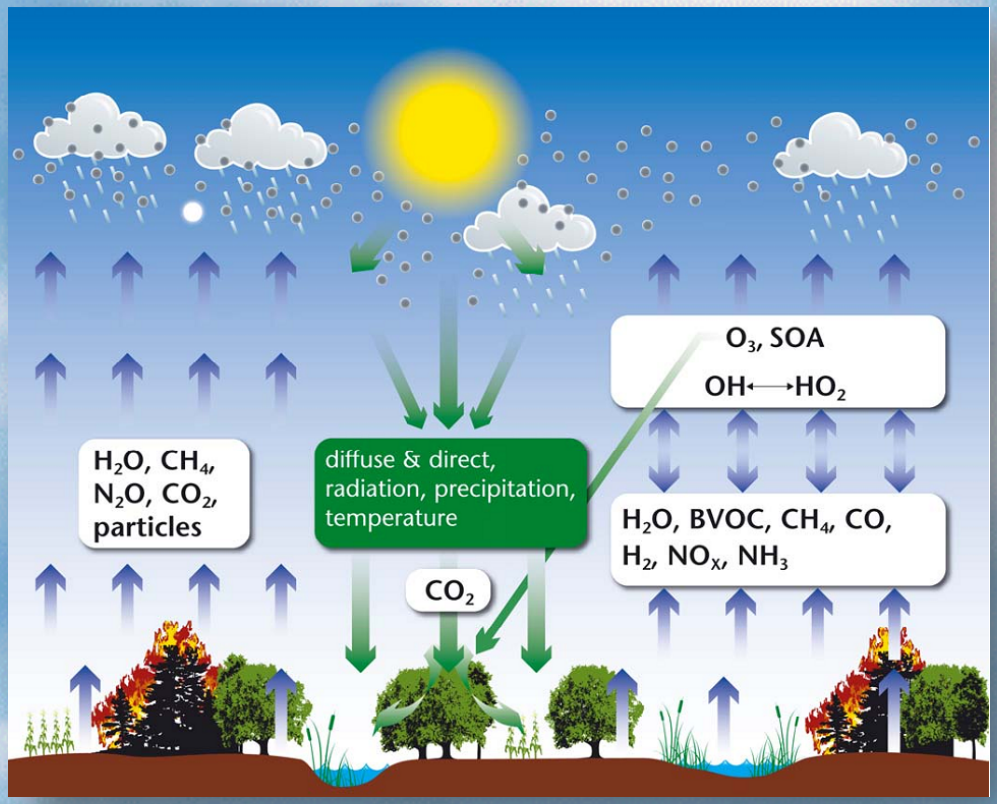
Cloud outside plume



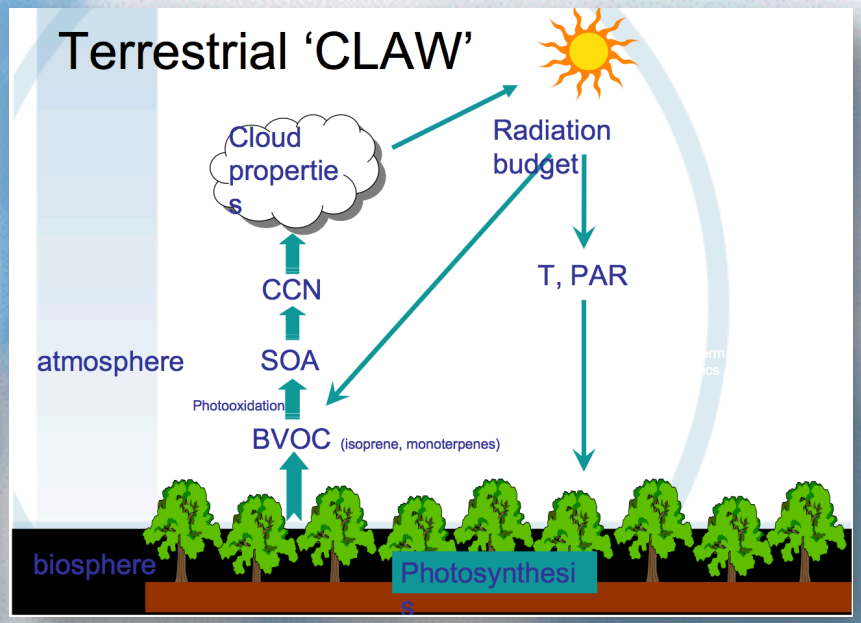
Cloud droplet number concentrations **(CDNC)** are greatly increased in the pollution plume compared to the natural conditions outside of the plume, as observed by the G1 aircraft.

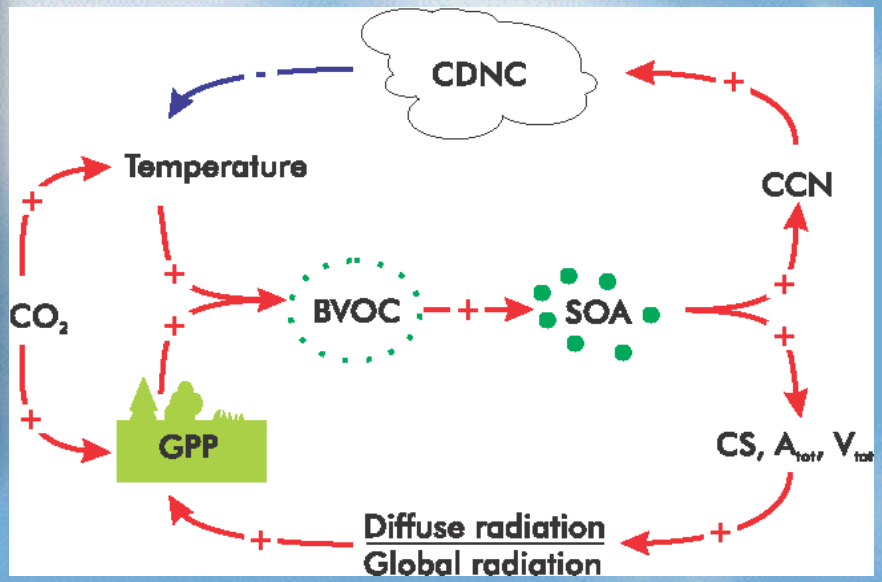
Slide prepared by Jiwen Fan, PNNL, IARA experiment, DOE AAF G1 platform.

Conceptual overview of terrestrial carbon cycle – chemistry – climate interactions



Arneth et al., 2011

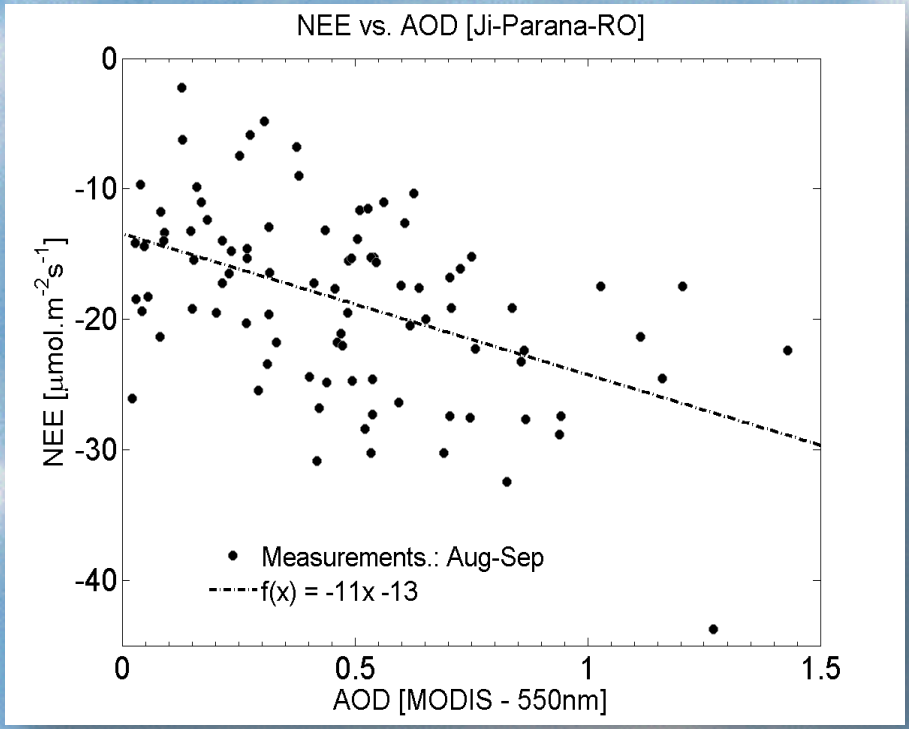


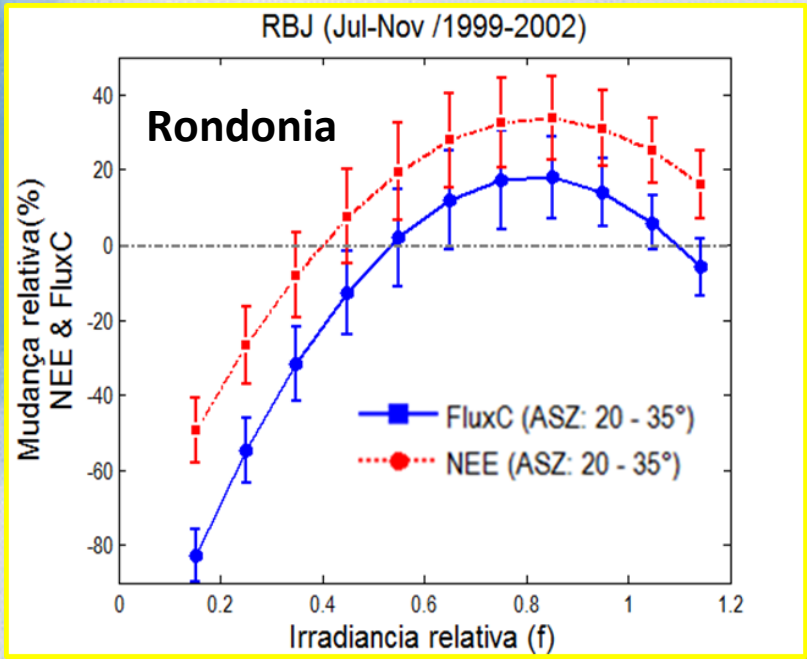


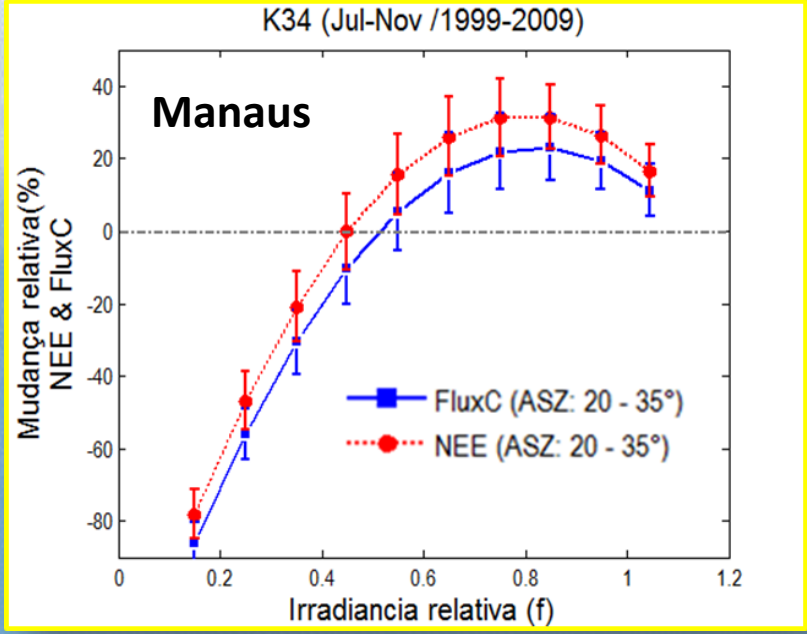
Kulmala et al, 2013

Effects of aerosol particles on carbon uptake by the forest: Diffuse radiation plays a major role

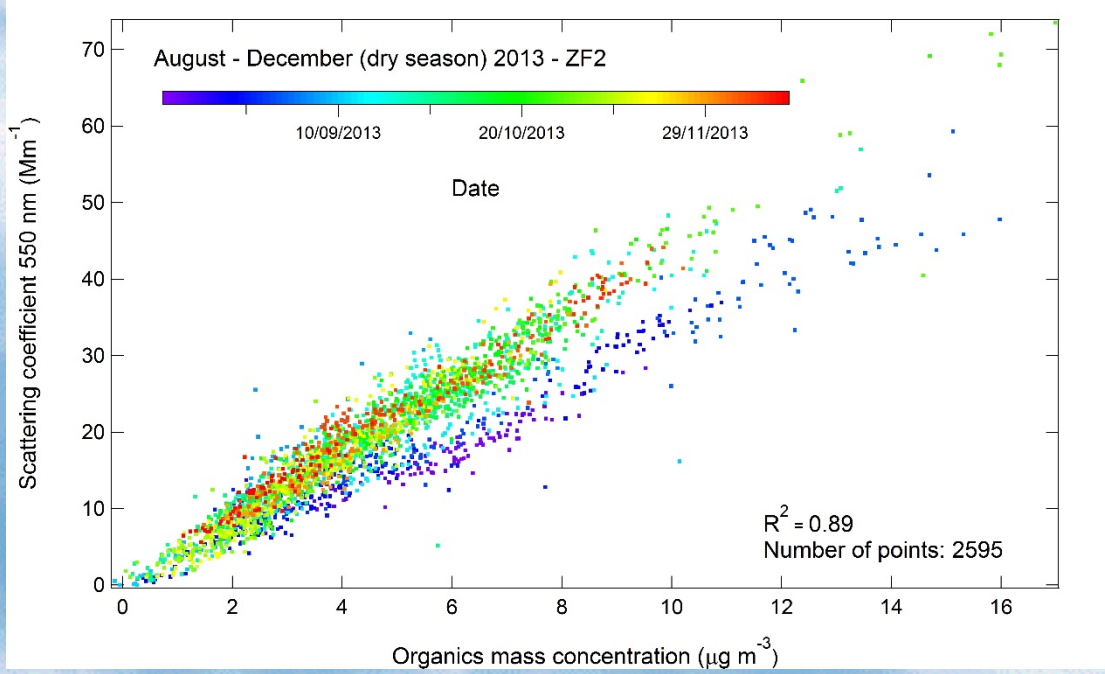
(Glauber Cirino, 2014)

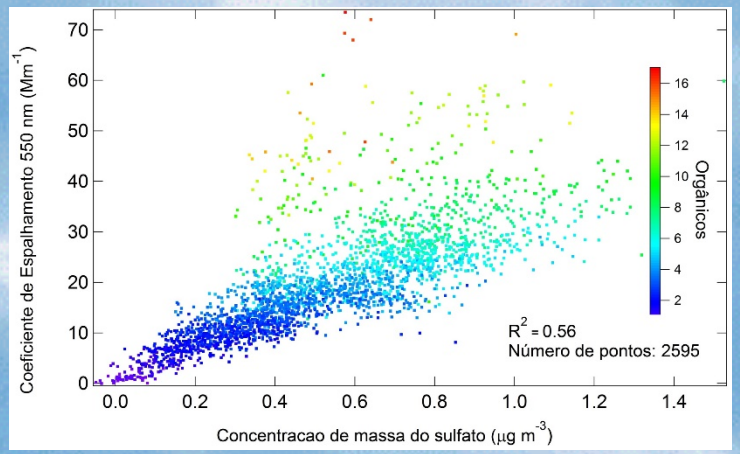


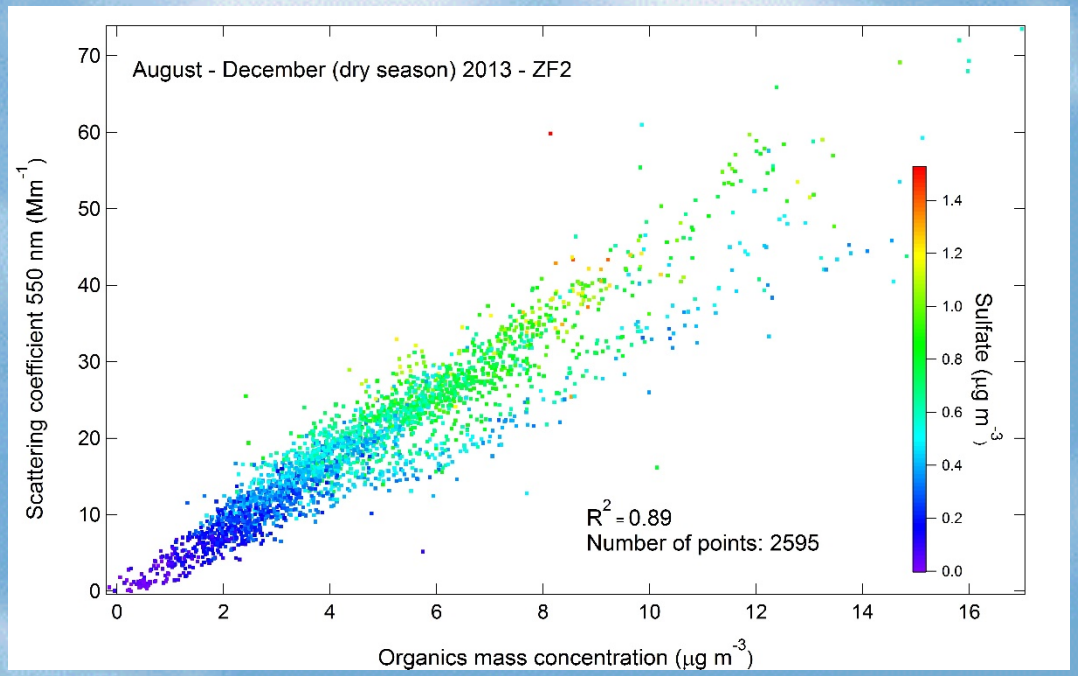




T0z: Scattering versus organics

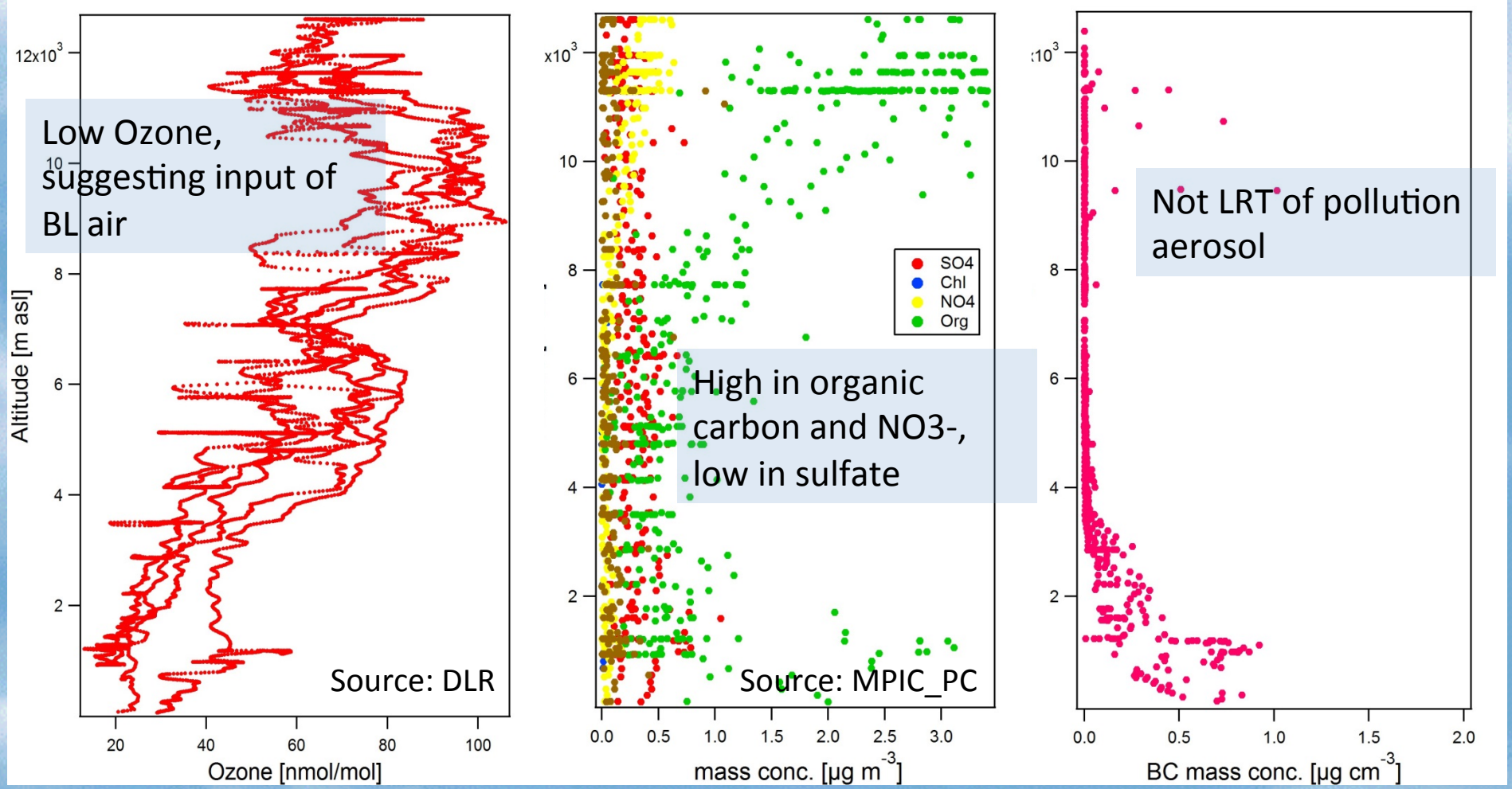






HALO ACRIDICON-CHUVA campaign Sep. 2014

AC09



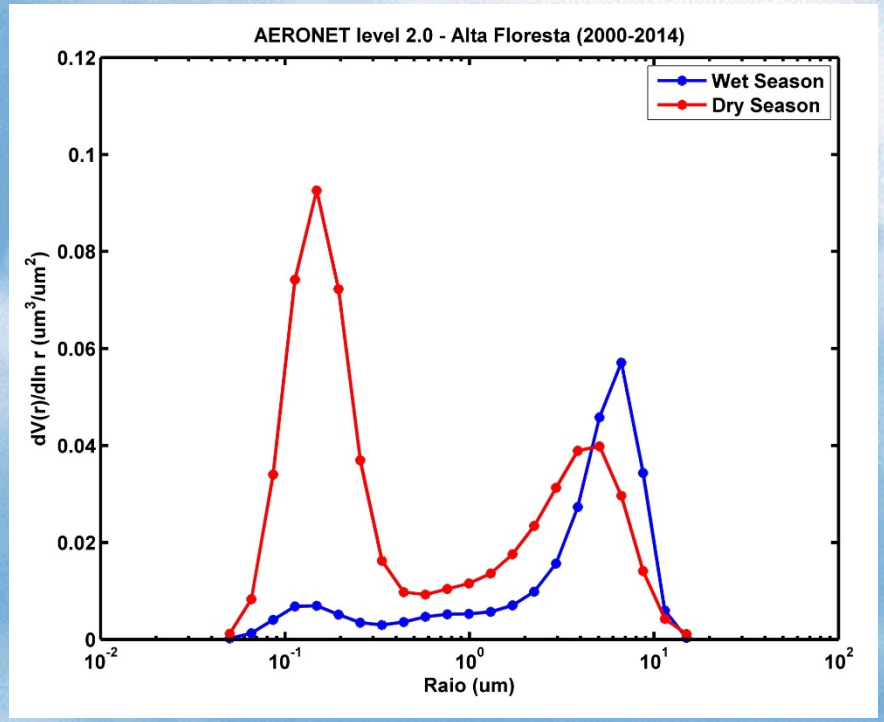
- BC from SP-2 and AMS at the HASI Inlet

Slide from Andi Andreae

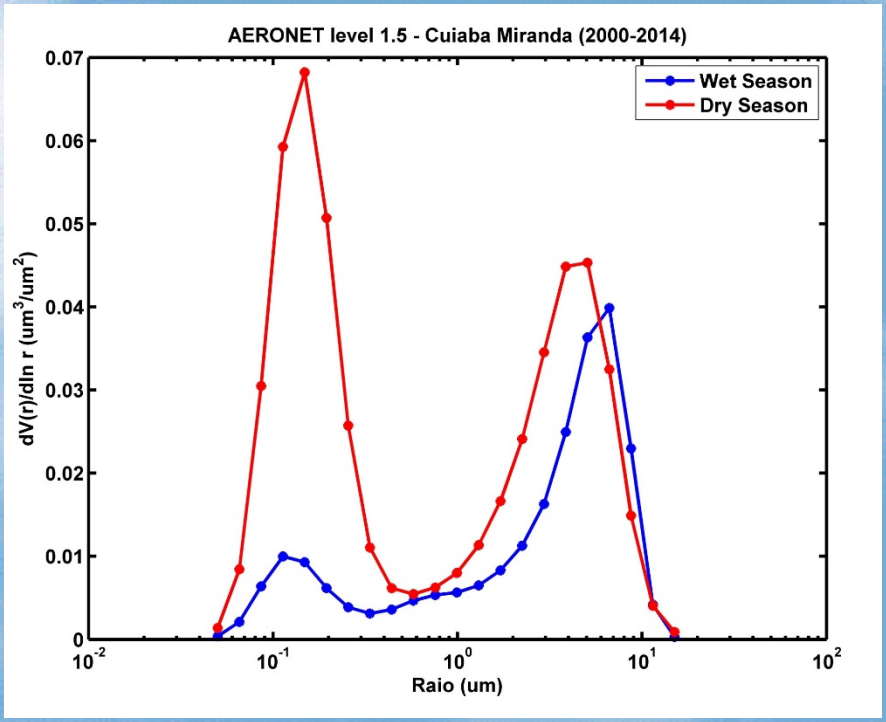
ATTO Tower: Permanent observatory at 325 meters height

Consistent aerosol size distribution over 14 years

Alta Floresta 2000-2014

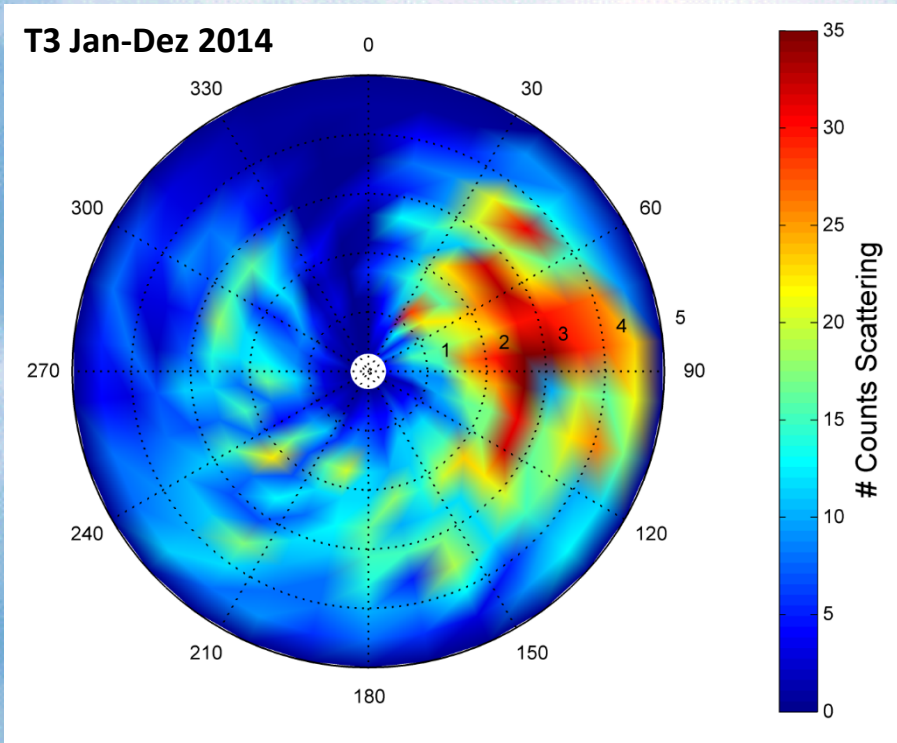


Cuiabá 2000-2014

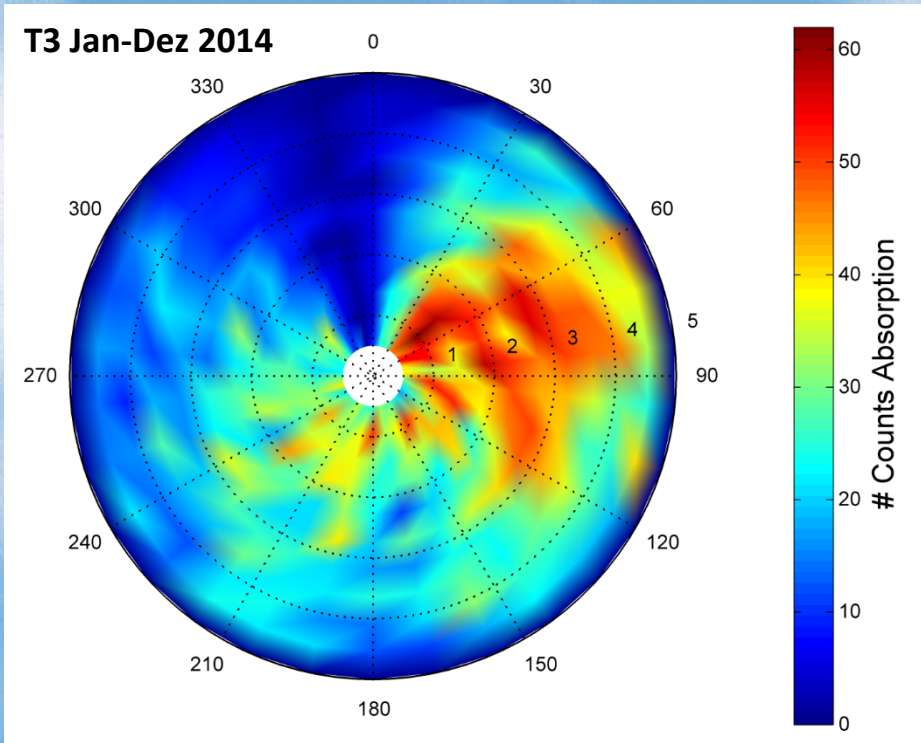


P.S.: Thanks to Brent, Joel and Fernando

T3 – Light Scattering versus wind direction and speed



T3 – Light Absorption versus wind direction and speed

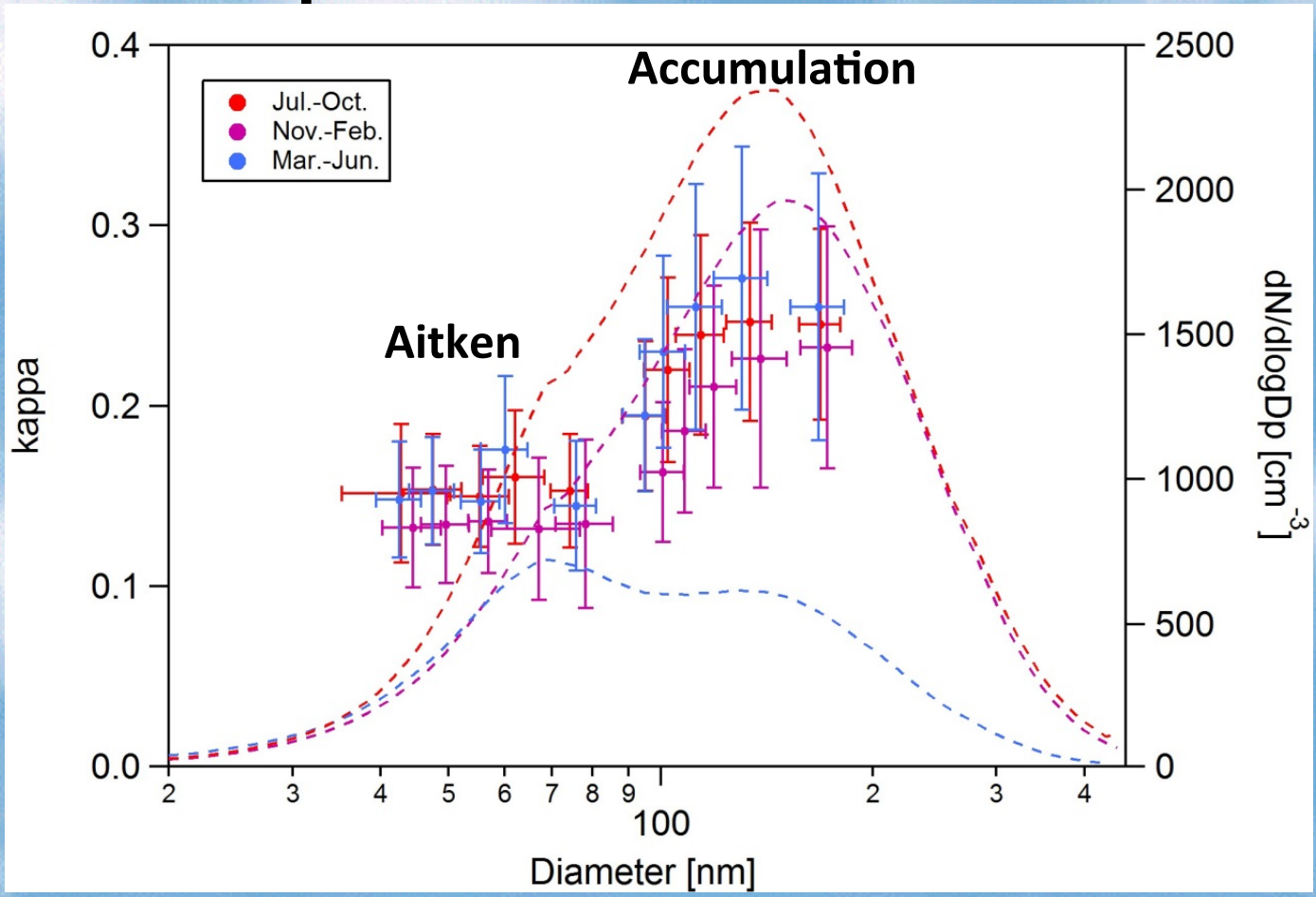


Higher scattering and absorption observed from Manaus wind direction and at low wind speeds

Plots from Glauber Cirino

G5 HALO plane - “High Altitude and Long Range Research Aircraft” at the “ACRIDICON: Aerosol, Cloud, Precipitation, and Radiation Interactions and Dynamics of CONvective Cloud Systems”.

T0-ATTO Hygroscopicity parameter kappa vs. midpoint activation diameter

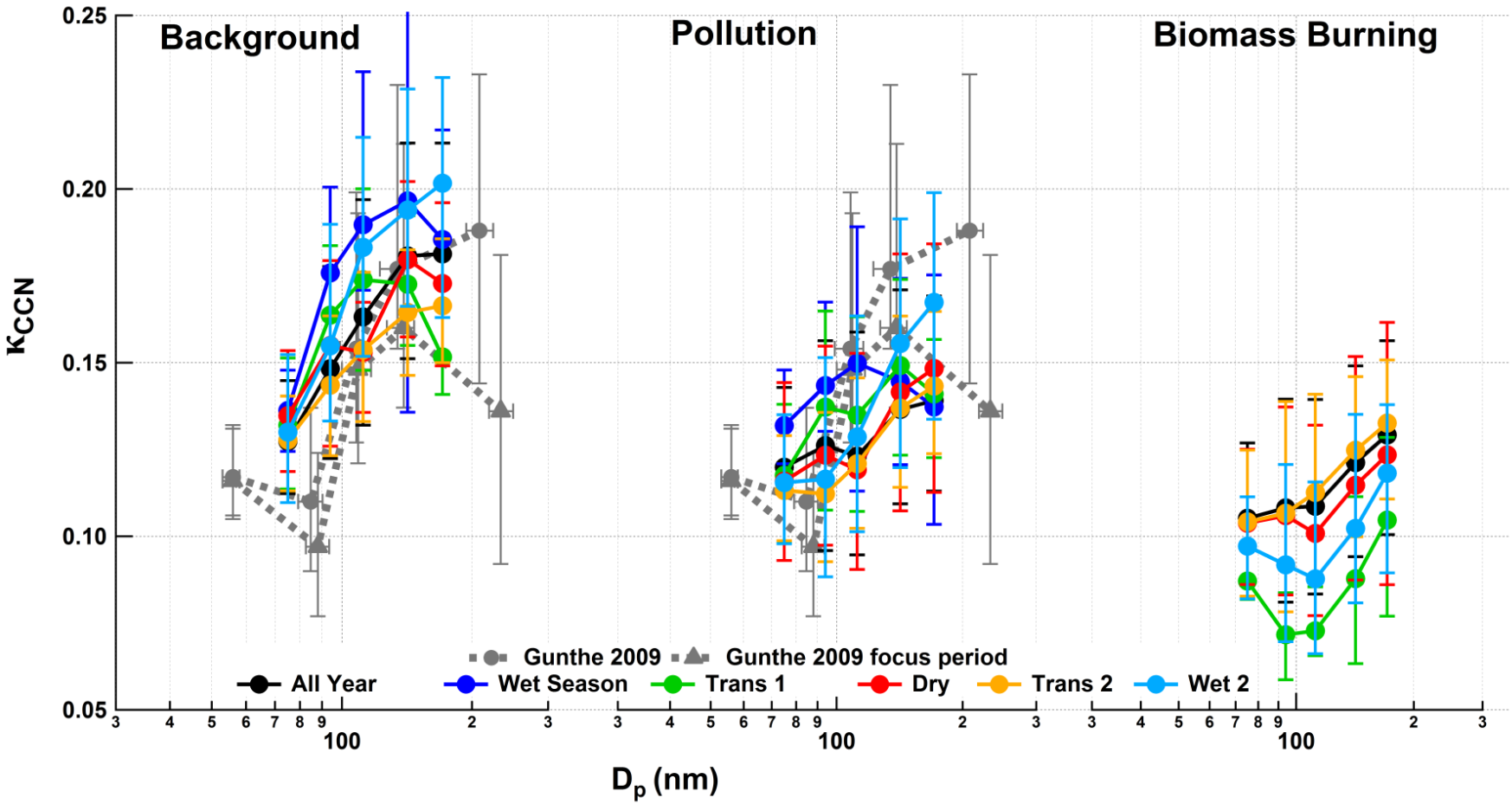


- highest kappa values and lowest particle in the rainy season
- the different kappa value between Aitken mode and accumulation mode results from different composition of the two modes.

From Mira Kruger and H. Barbosa

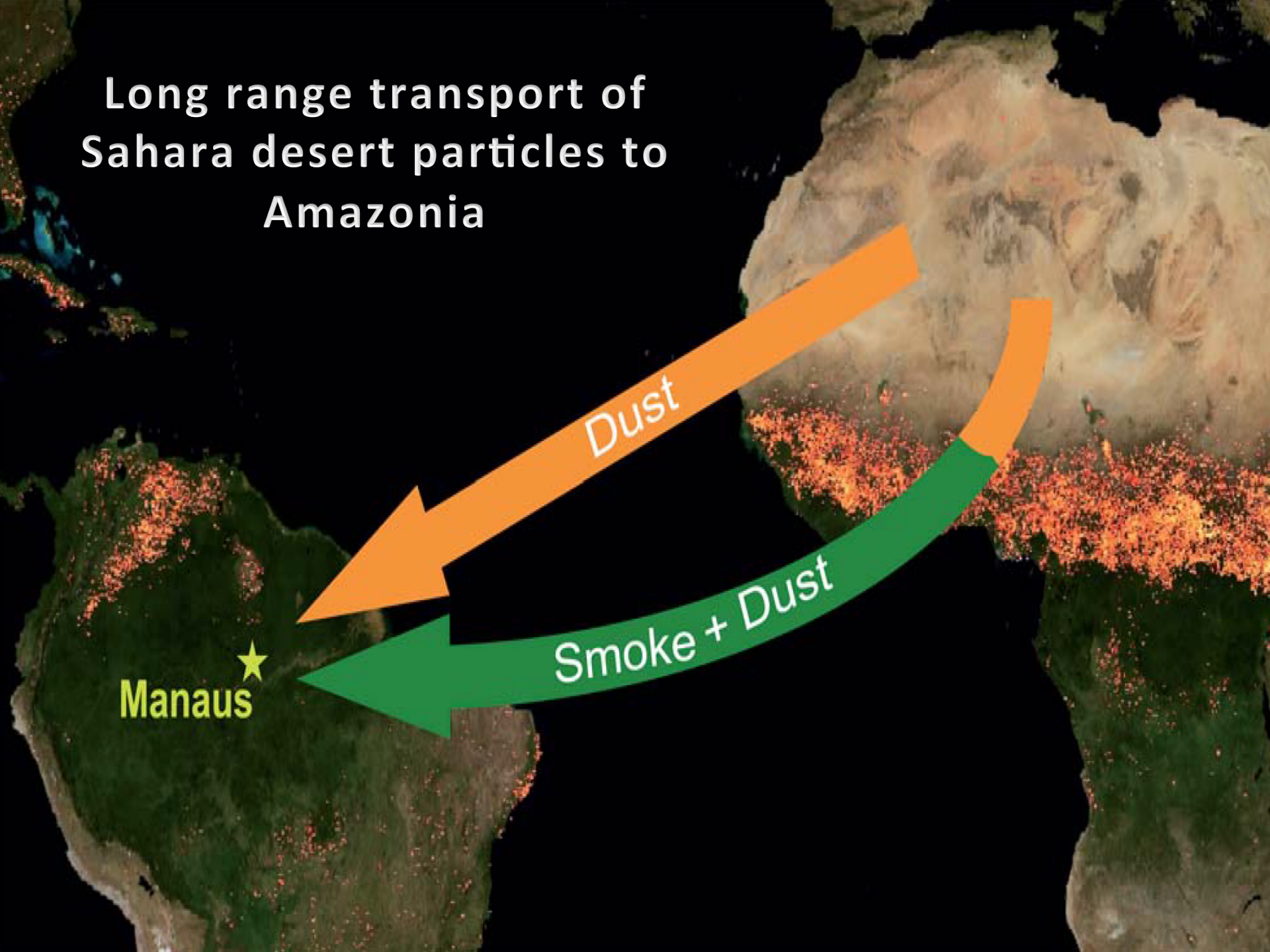
One year of CCN Measurements at T3

Larger Kappa Values Correspond to Greater CCN Activity of Individual Particles

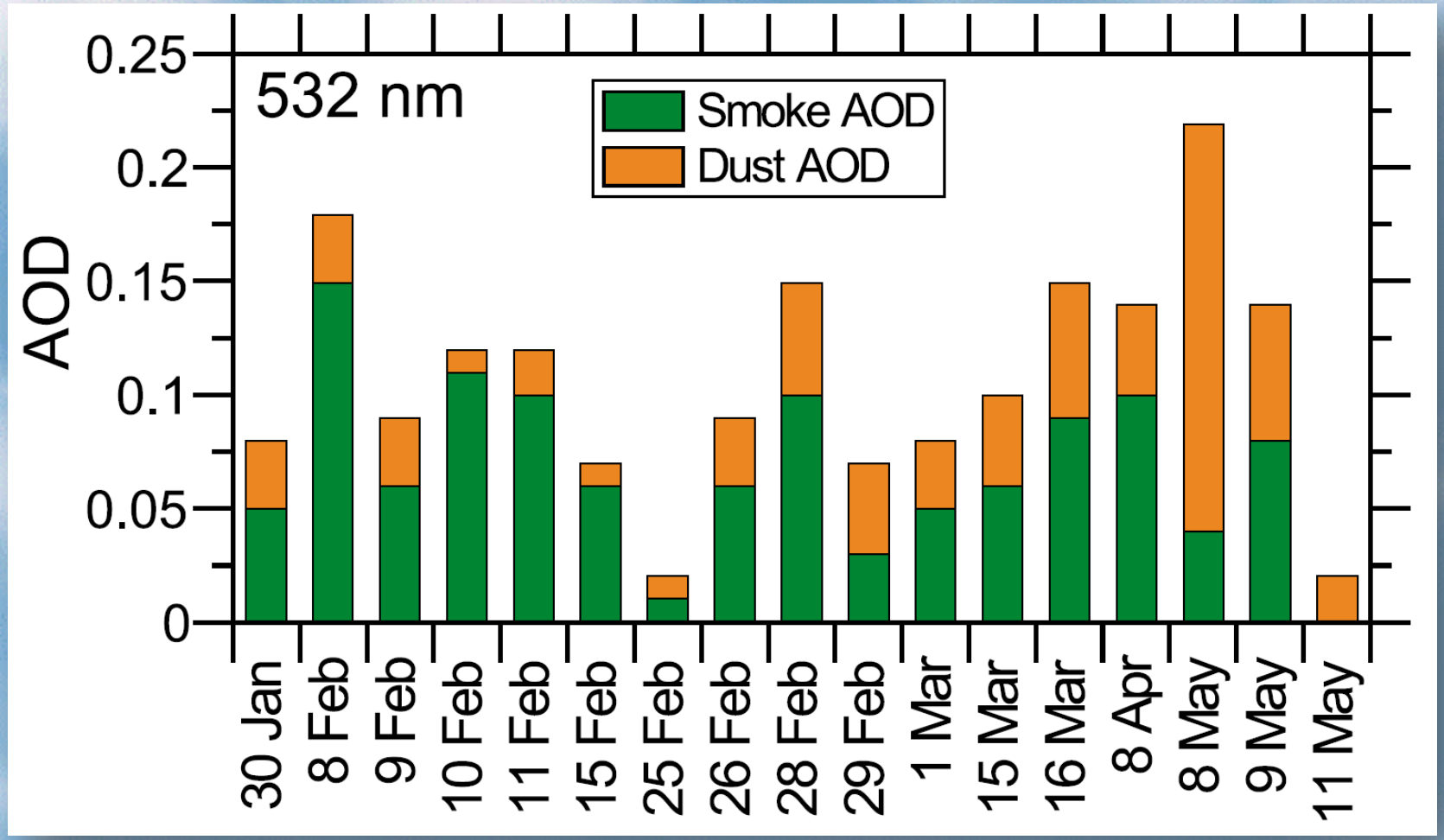


Data Source: R. Thalman, J. Wang, et al., BNL.

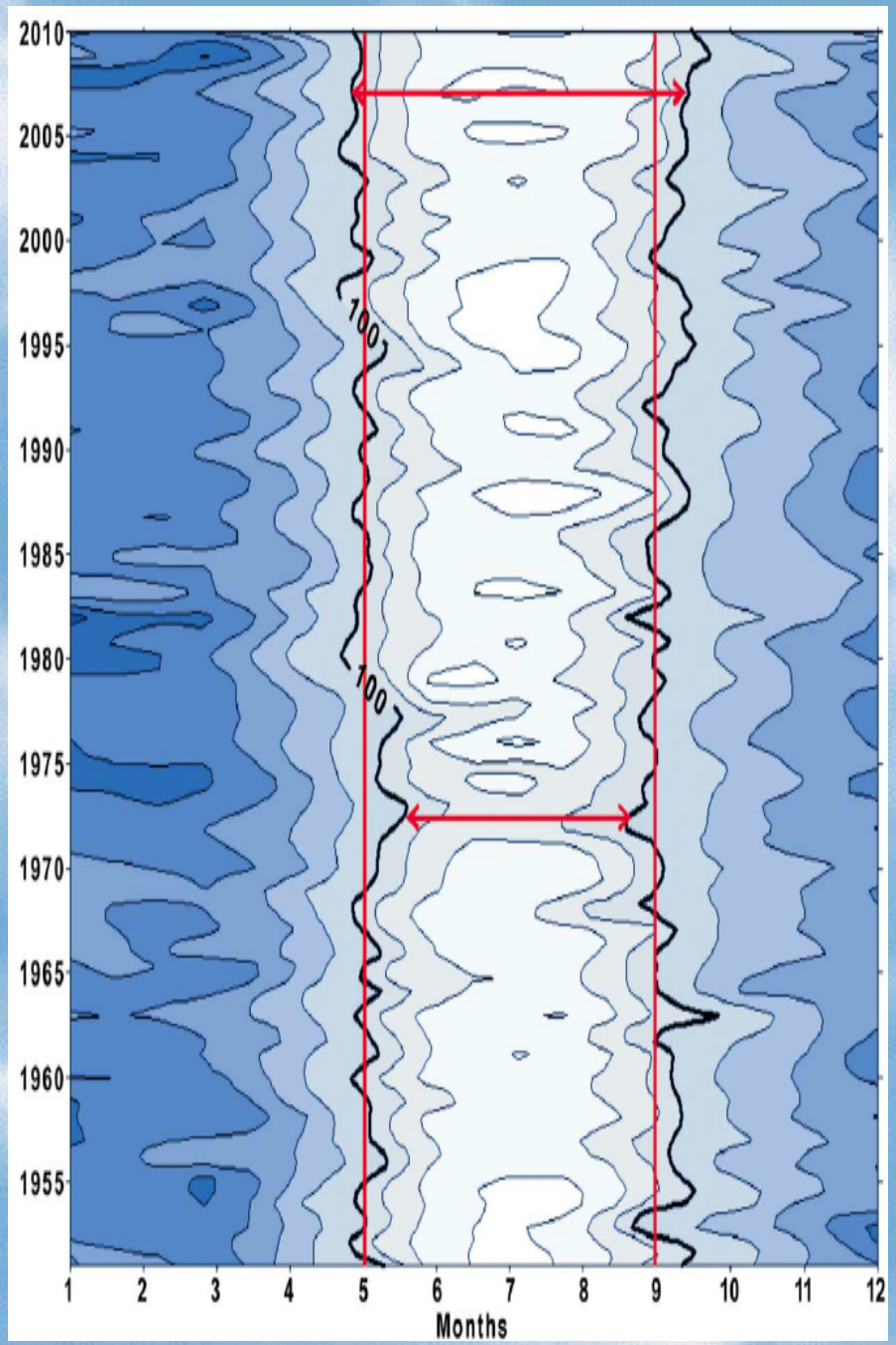
Long range transport of Sahara desert particles to Amazonia



African aerosol in central Amazonia



Smoke and dust AOD indicating the advection of African aerosol toward Amazonia (Baars, 2011).



Hovmoller diagram of monthly rainfall from 1951 to 2010 for southern Amazonia.

Units are in mm/month. The 100 mm/month isohyet is marked in bold and is an indicator of dry season.

The onset of the Amazon rainy season shows a large temporal and spatial variability, delays on the data of the onset may have strong impacts on local agriculture, hydroelectric power generation as well as on the hydrology of large rivers.

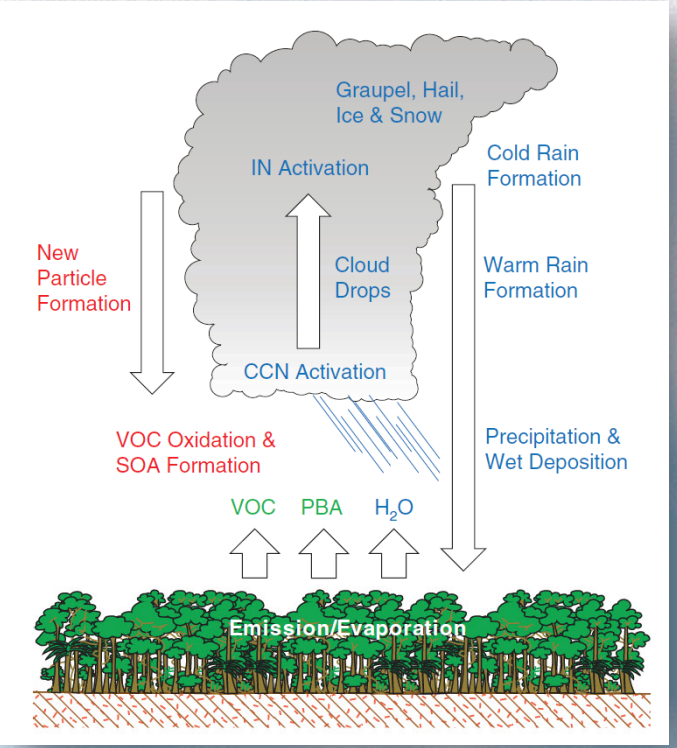
Two “once-on-a-century” droughts occurred in 2005 and 2010, and it was shown that on those events the rainy season started later than normal, and also that on the last 10 years the dry season has increased in length by about one month.

Marengo et al., 2011

How external (Biomass Burning, Sahara dust, pollution) and internal emissions (primary organic aerosol particles and SOA) interact chemically and physically altering aerosol and cloud properties.

2 years continuous measurements at seven ground based stations and two aircraft flying dry and wet seasons

Pöschl, et al., *Science*, 2010



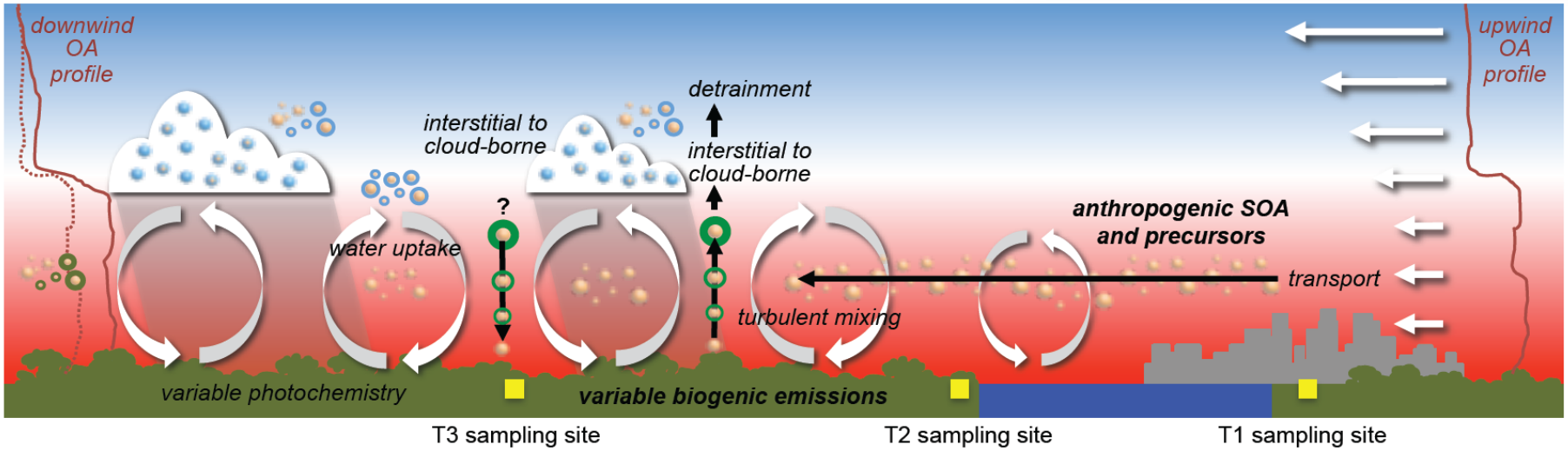
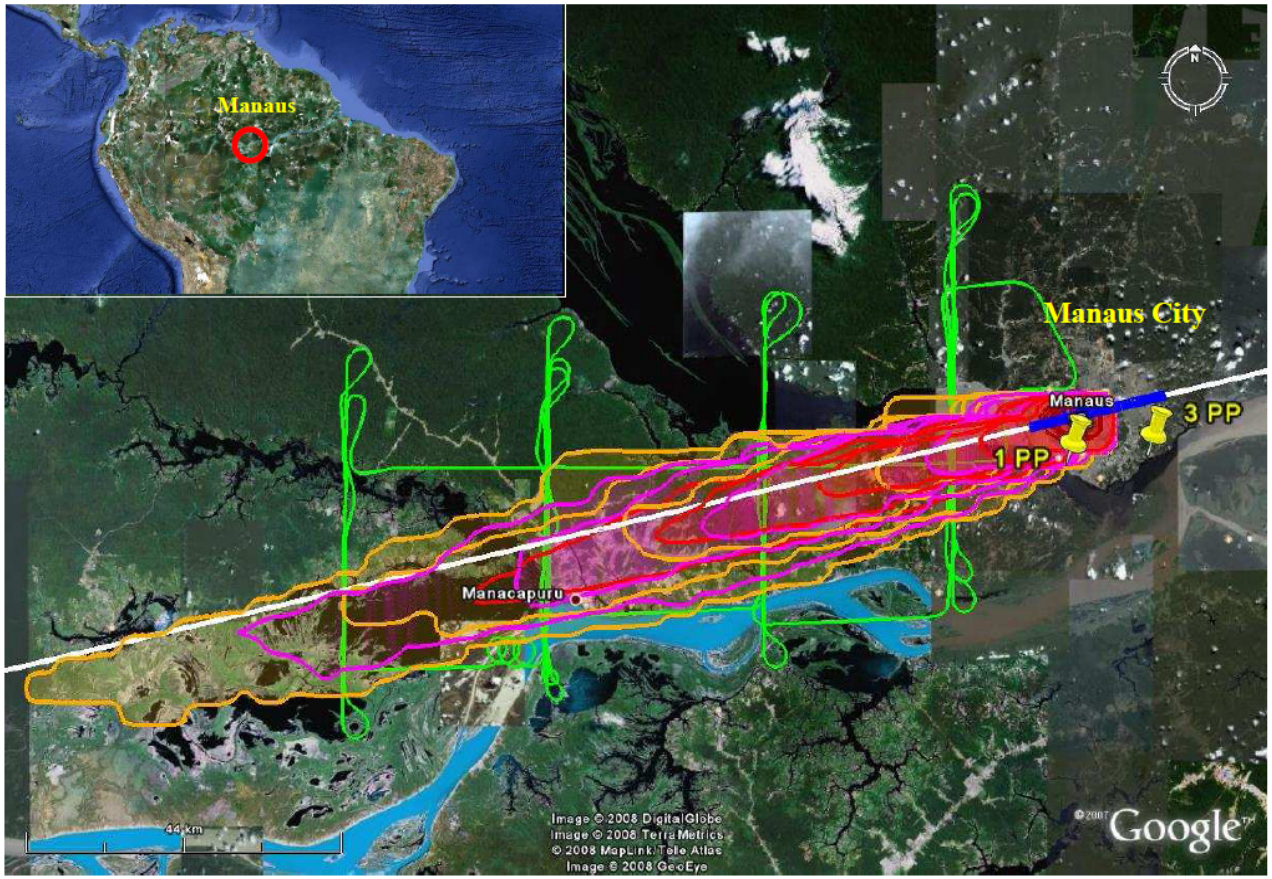


Image Source: Jerome Fast

GoAmazon Experiment 2014-2015

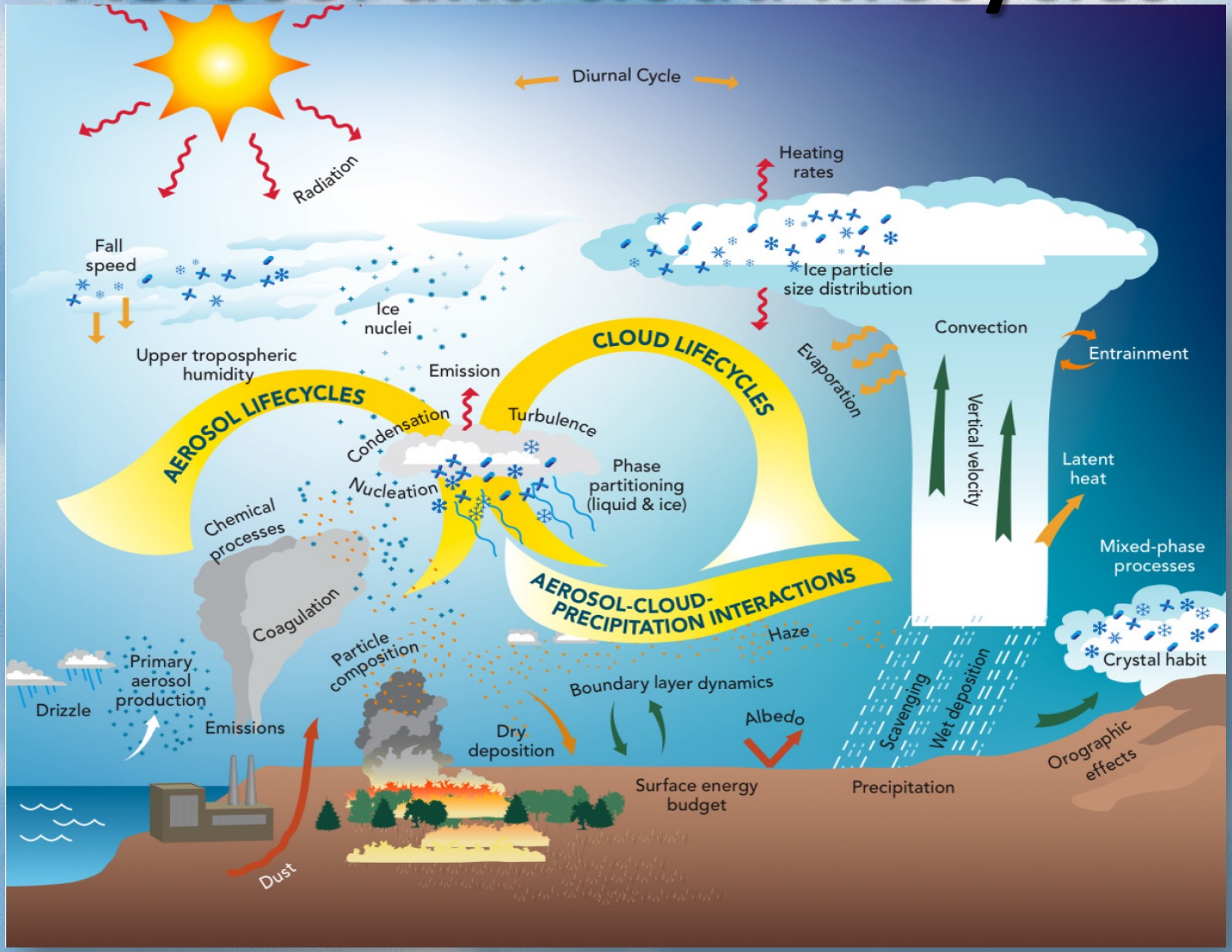
4 ground sites (before at and after Manaus plume)

DoE G1 plane and the German G5 HALO plane for large scale

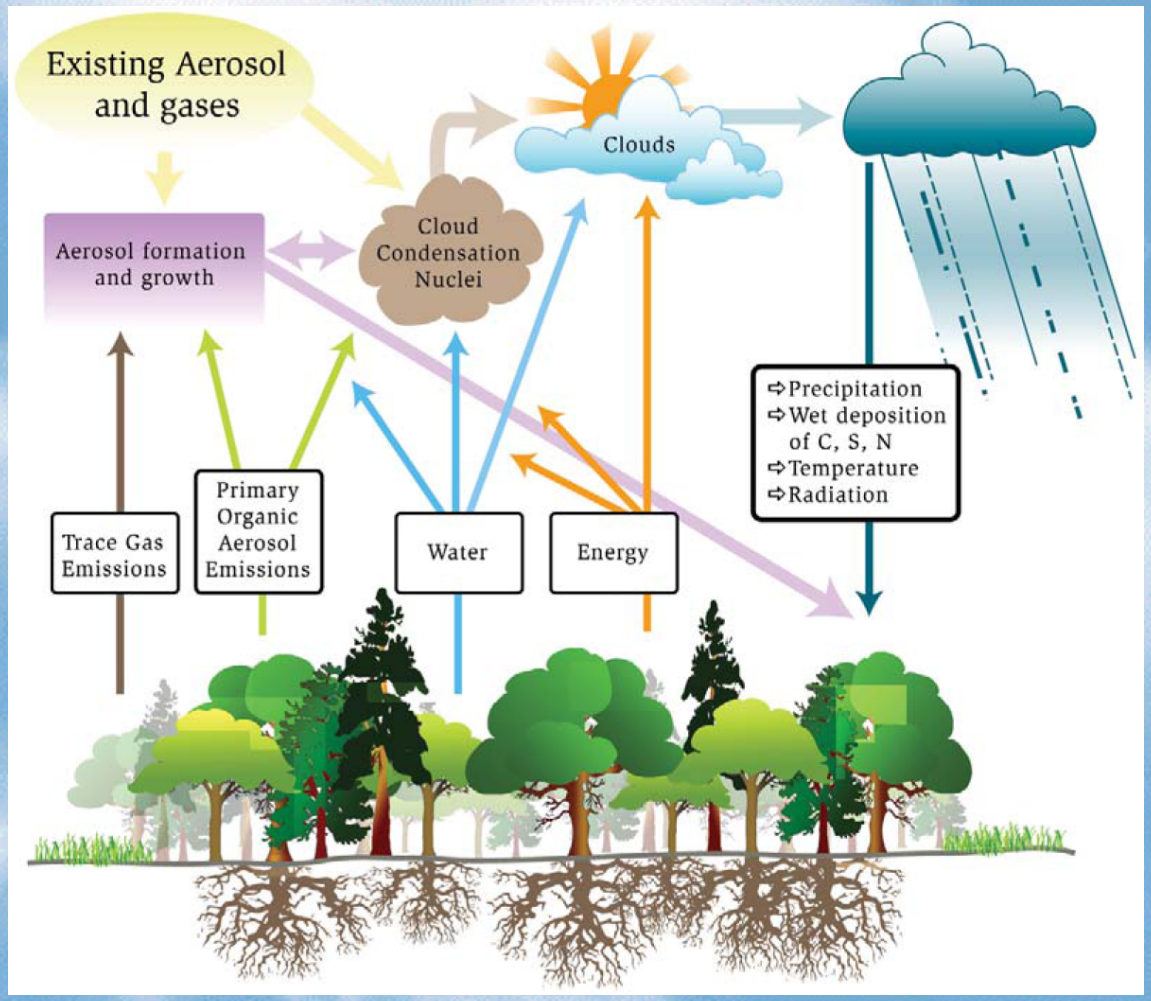


Study of the interactions of the urban plume of Manaus with the forest, producing secondary organic aerosols, ozone and others

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.

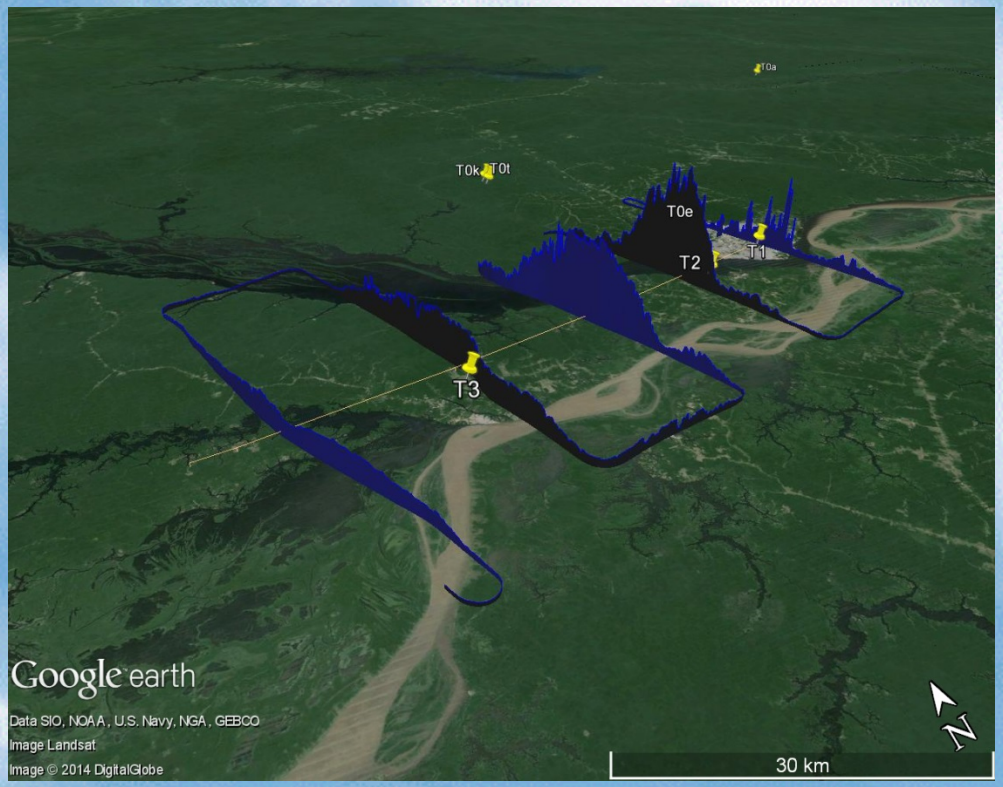


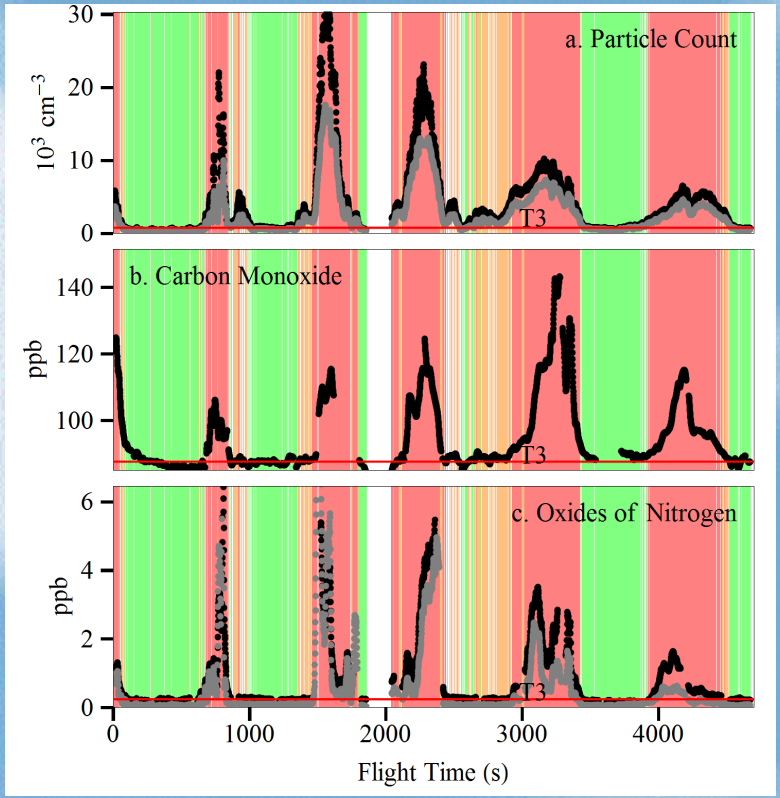
Source: Barth et al., "Coupling between Land Ecosystems and the Atmospheric Hydrologic Cycle through Biogenic Aerosol Particles," *BAMS*, *86*, 1738-1742, 2005.

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.

Transverse Transects of Urban Plume

500 m, 11 AM local, 13 March 2014

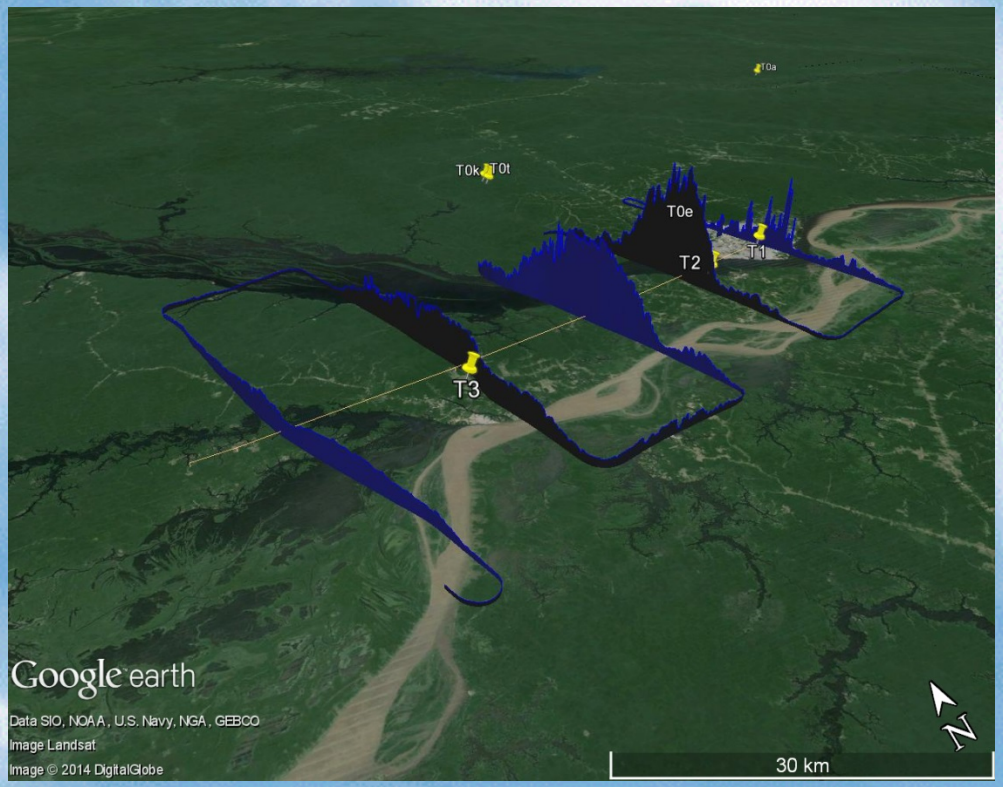


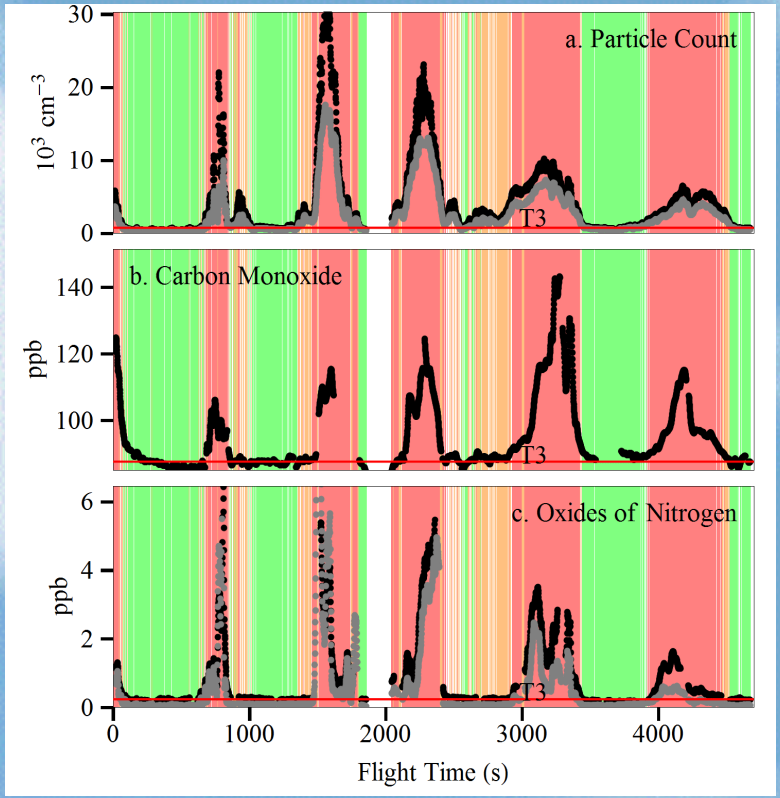


Data Source: Mei Fan, Stephen Springston, IARA Experiment, DOE AAF G1 Platform

Transverse Transects of Urban Plume

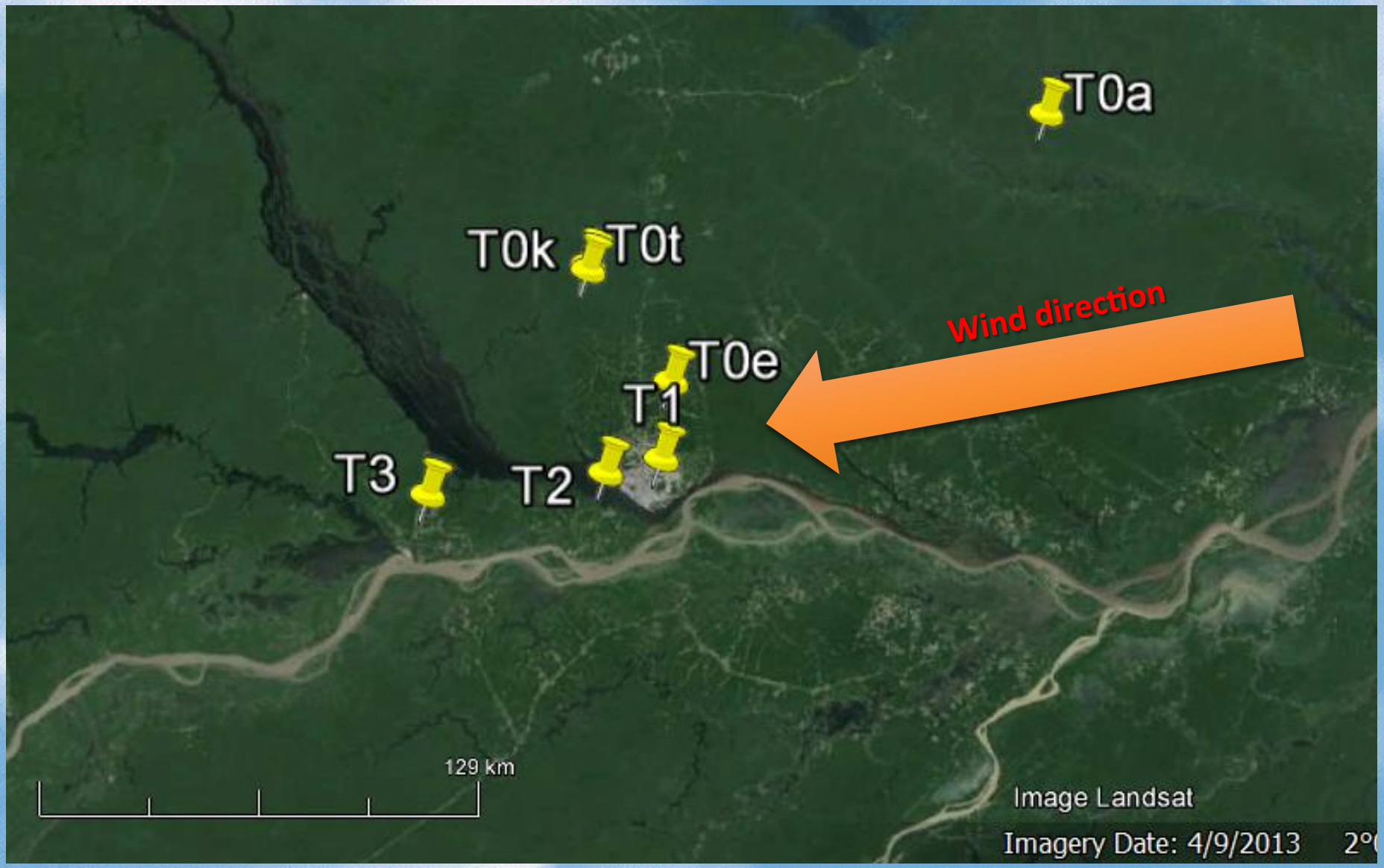
500 m, 11 AM local, 13 March 2014



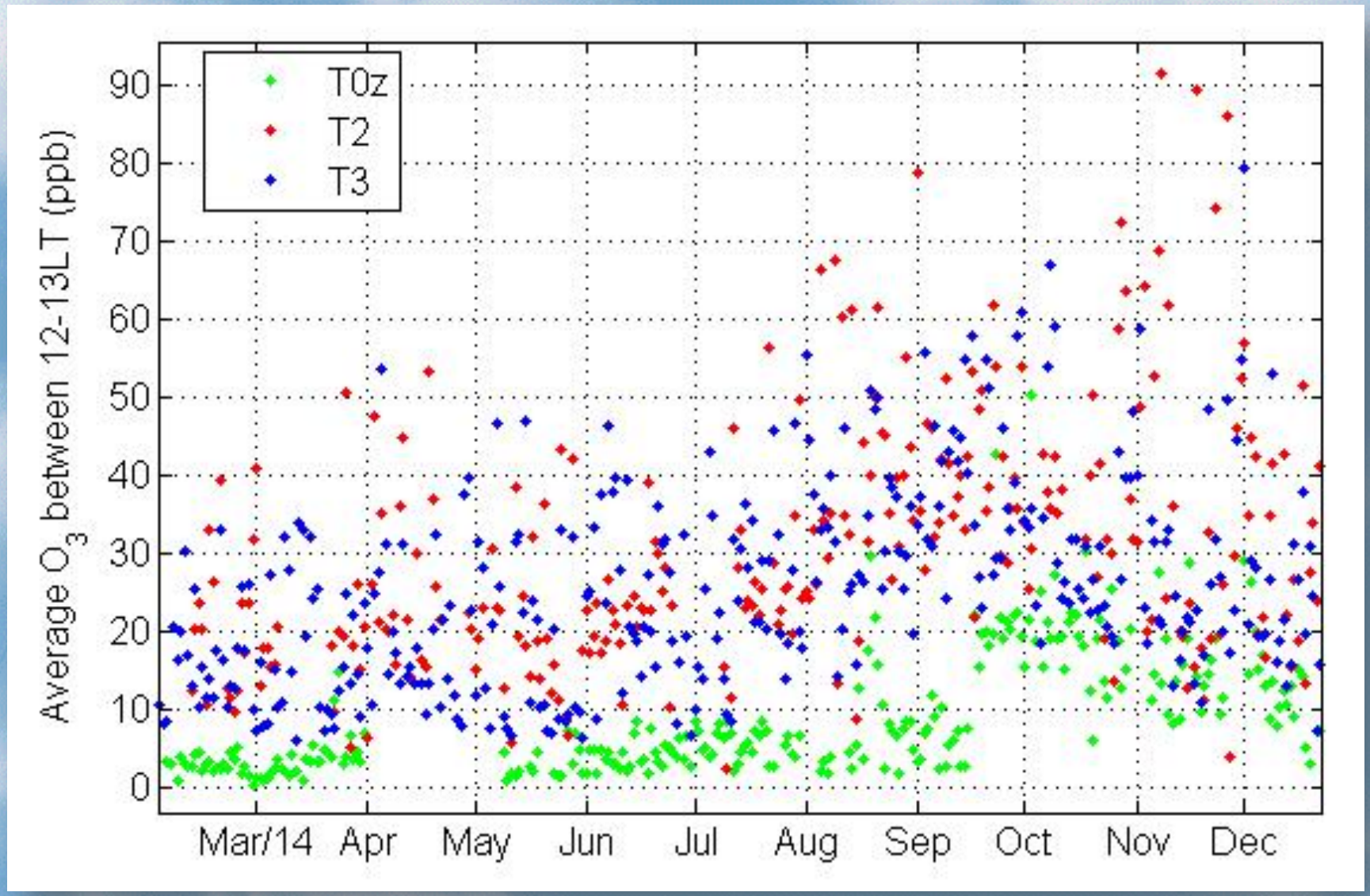


Data Sources: Mei Fan, Stephen Springston, IARA Experiment, DOE AAF G1 Platform

Simple question: How do atmospheric composition looks like at **T3** compared to **T0a**, **T0z** and **T2**?



The problem: Ozone at mid day 12:00-13:00 LT for each site



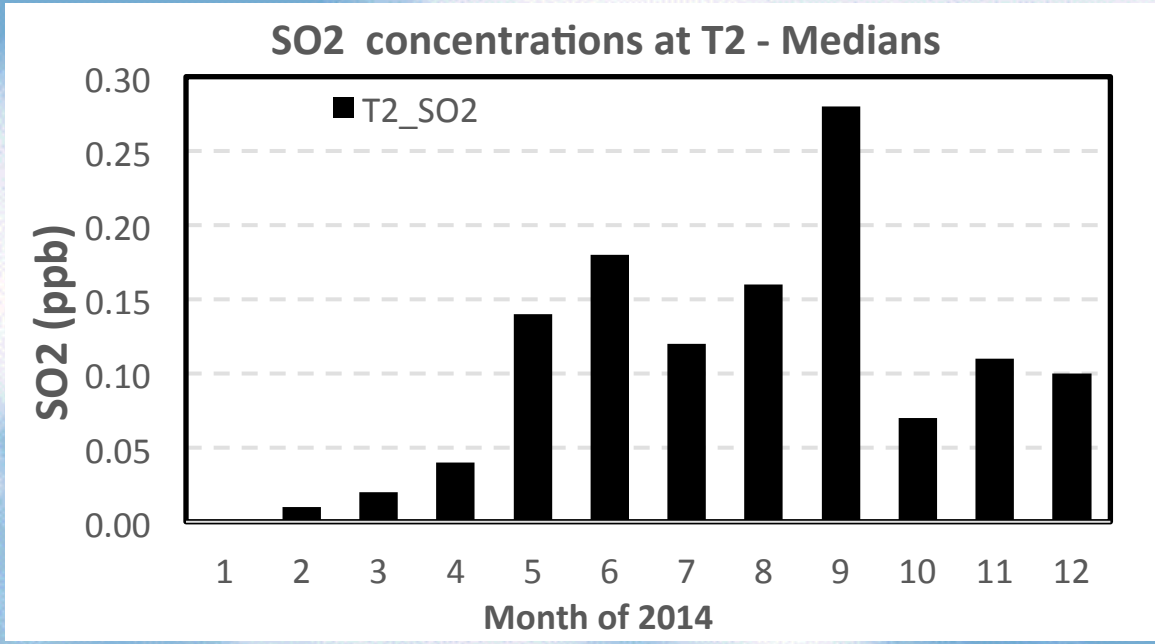
Is O_3 higher at T3 compared to T2? Lower? When?

Simple Method: comparing MEDIANS of MONTHLY values for each site
Example: Carbon Monoxide - CO

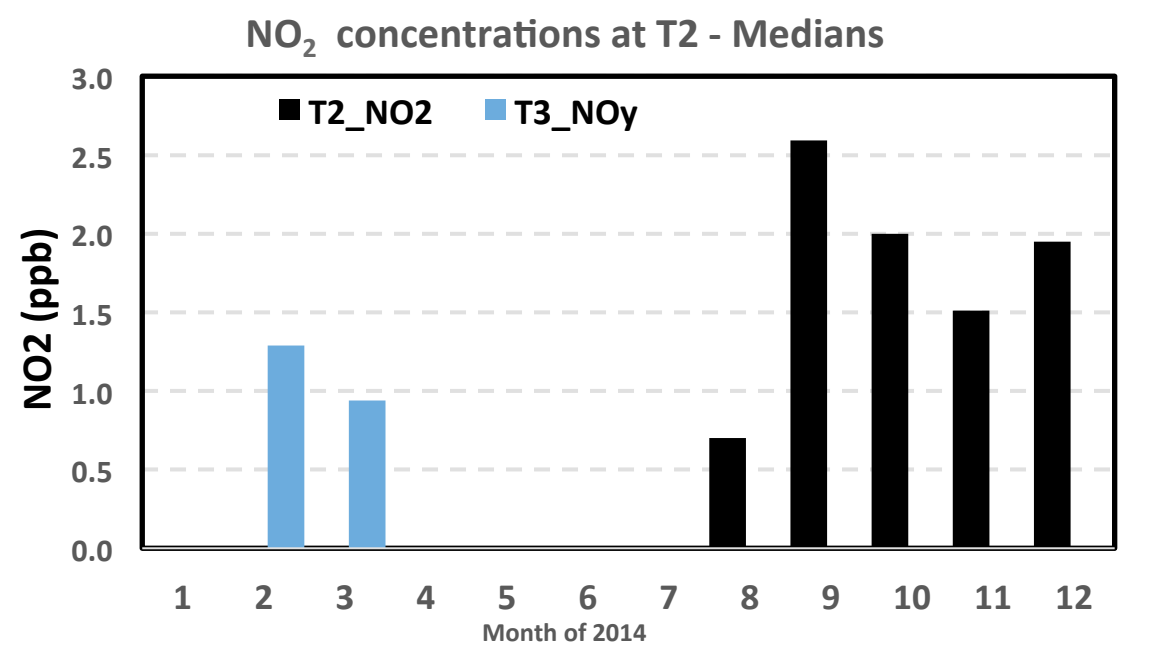
T0z_CO ppb						T2_CO_ppb						T3_CO_ppb				
T0z	T0z	T0z	T0z	T0z		T2	T2	T2	T2	T2		T3	T3	T3	T3	T3
Month	Mean	Median	StDev	%Coverage		Month	Mean	Median	StDev	%Coverage		Month	Mean	Median	StDev	%Coverage
1	203	**135**	0	0.0		1	155	**148**	40	4.1		1	139	**128**	59	10.6
2				0.0		2	151	**139**	45	89.2		2	124	**121**	19	33.3
3				0.0		3	150	**136**	47	74.4		3	125	**123**	19	34.7
4				0.0		4	130	**116**	48	51.1		4	124	**117**	29	34.7
5	113	**112**	9	80.7		5	129	**111**	58	91.7		5	107	**102**	22	34.7
6	118	**117**	10	99.8		6	150	**128**	65	93.0		6	117	**114**	27	34.7
7	126	**125**	15	98.2		7	152	**132**	52	99.5		7	127	**124**	24	34.7
8	181	**152**	78	99.0		8	222	**186**	114	80.9		8	158	**148**	49	19.0
9	165	**160**	22	98.0		9	218	**191**	82	89.5		9	209	**186**	91	32.3
10	168	**165**	29	86.8		10	190	**175**	57	94.5		10	202	**175**	96	31.3
11	168	**163**	25	82.9		11	213	**191**	77	98.8		11	183	**171**	52	99.3
12	190	**184**	45	98.3		12	211	**198**	59	91.3		12	174	**167**	42	99.3

Issues:
Different instruments, different calibrations;
Instrument down for a while
Duplicate measurements at each site (CO at T3 with at least 3 instruments) (BC: 5 instruments)
Need to do the medians with Level 3 data

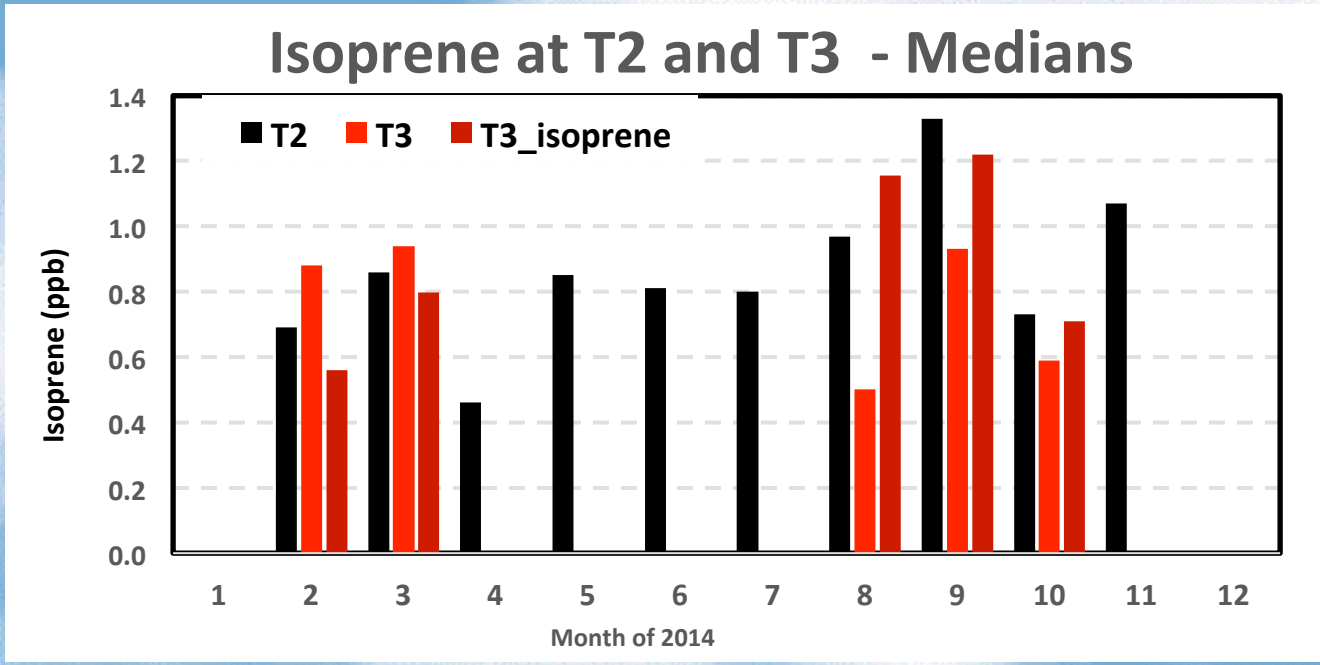
SO_2 higher in the dry season because of biomass burning emissions? Or less deposition in the dry season? Or change in trajectories?



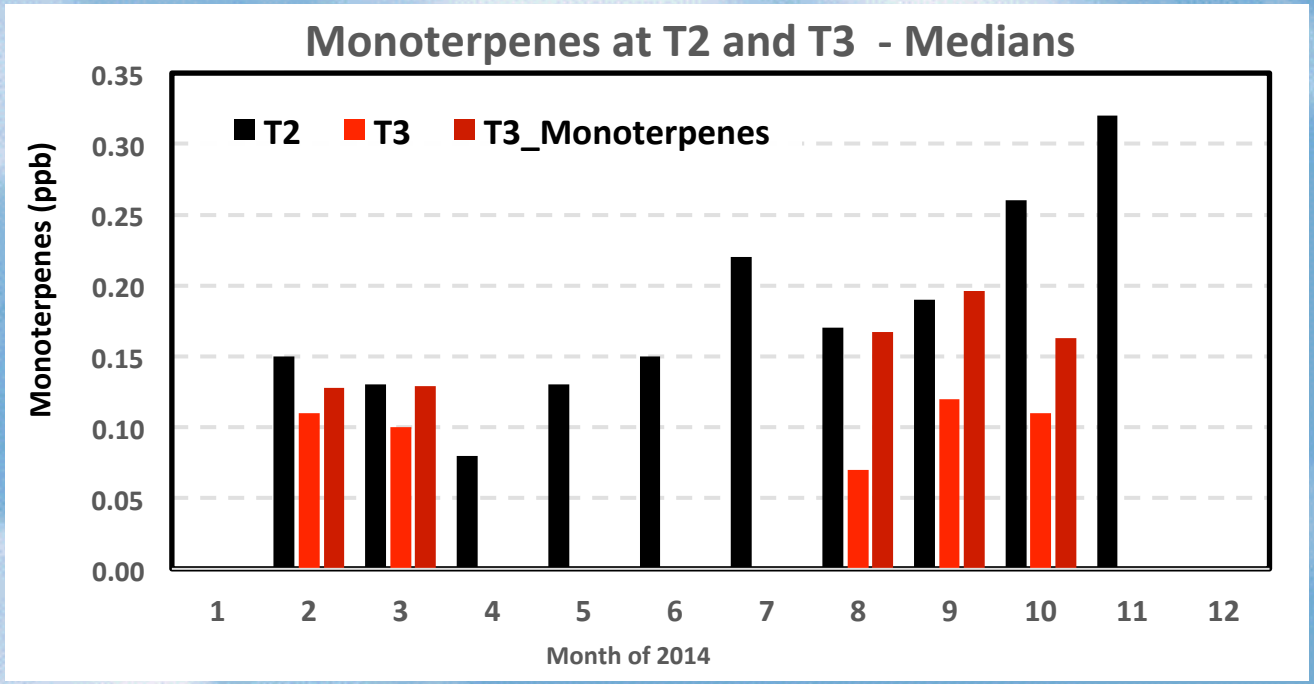
NO_y and NO_2



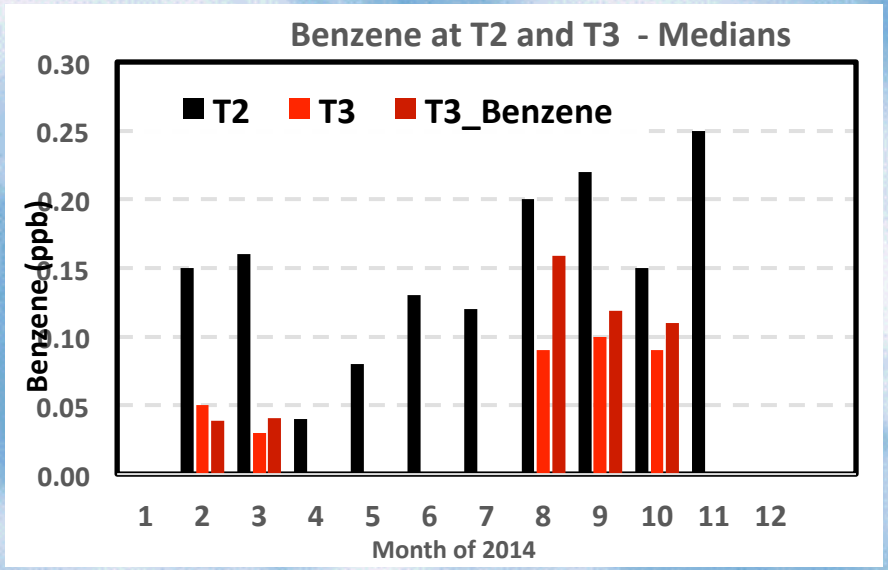
PTR-MS measurements

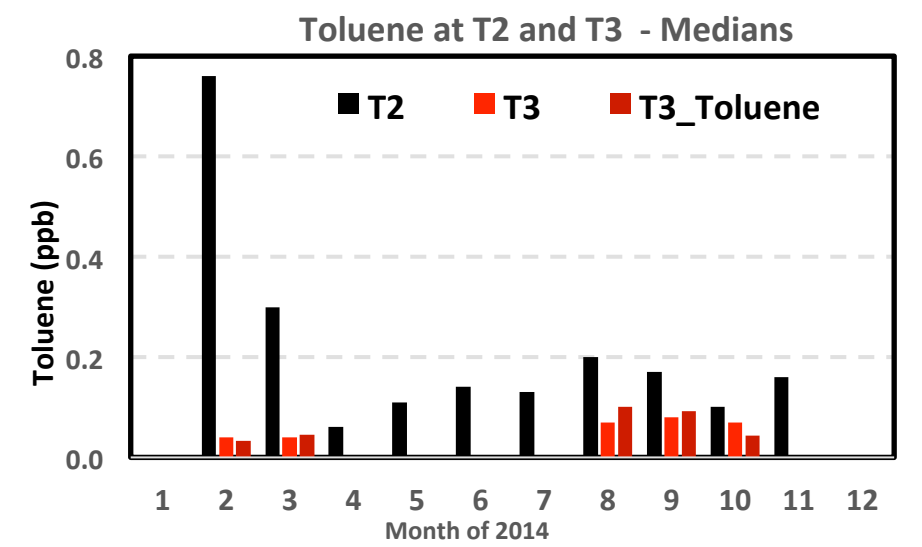


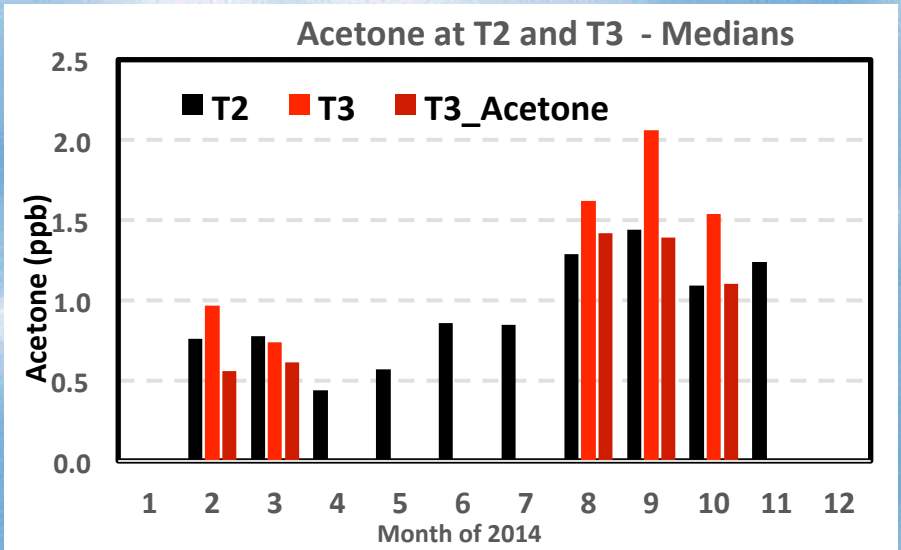
Excellent consistency between T2 and T3 and between the several instruments

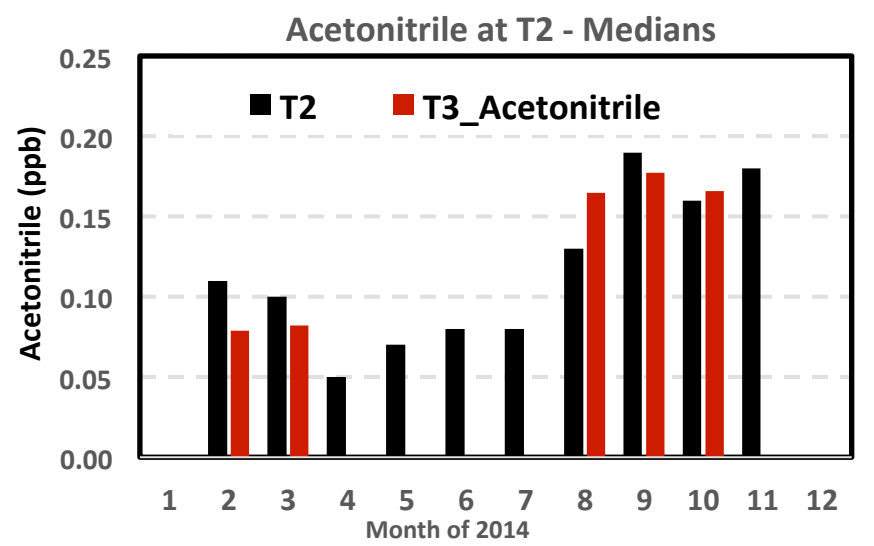


PTR-MS comparison: Benzene, Toluene Acetone and Acetonitrile

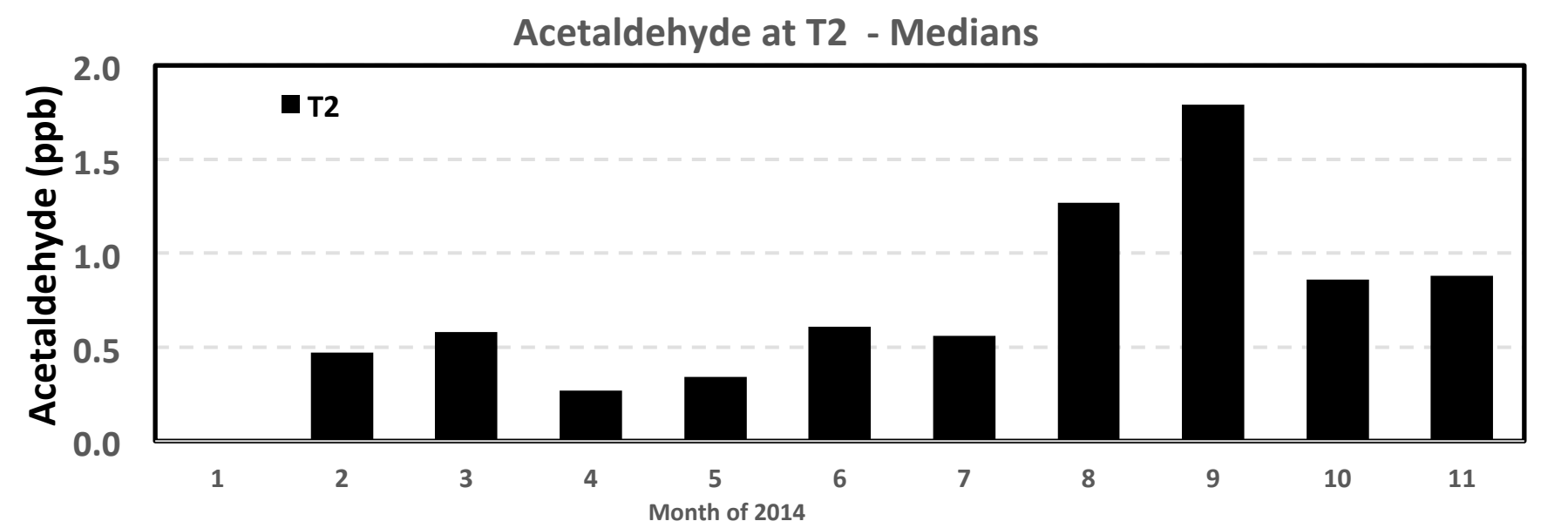


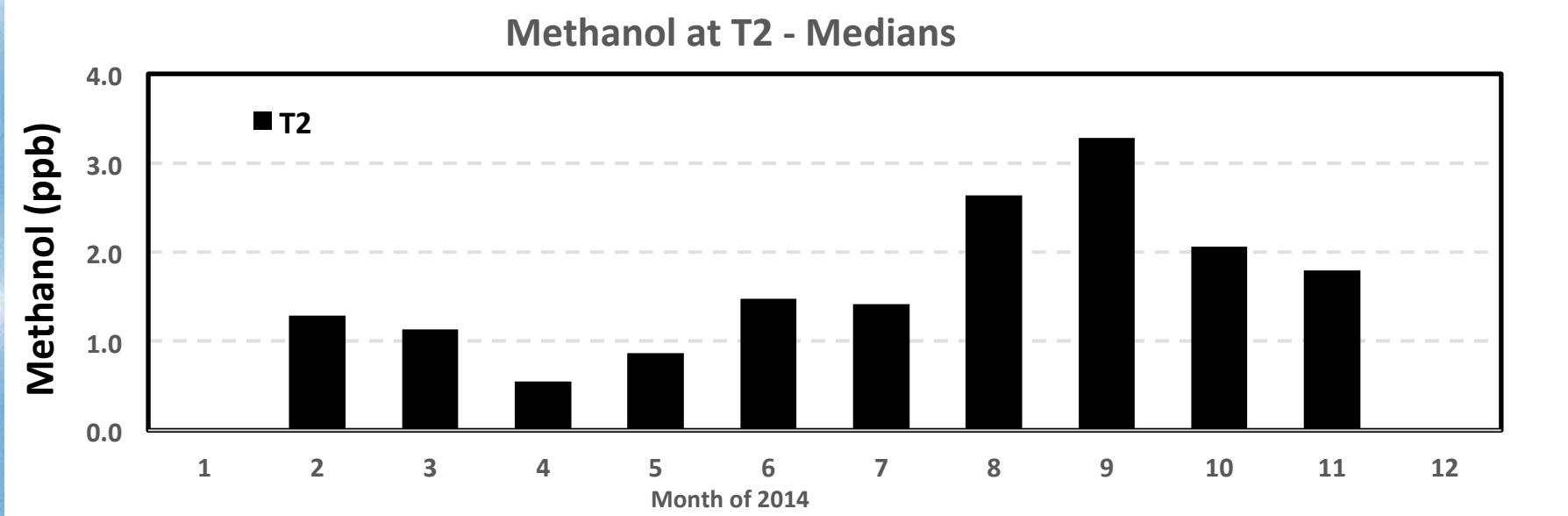




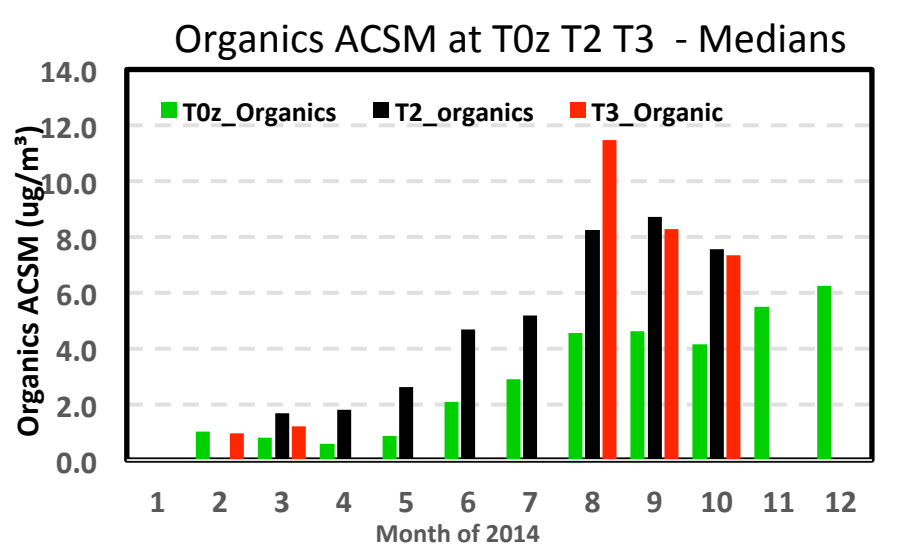


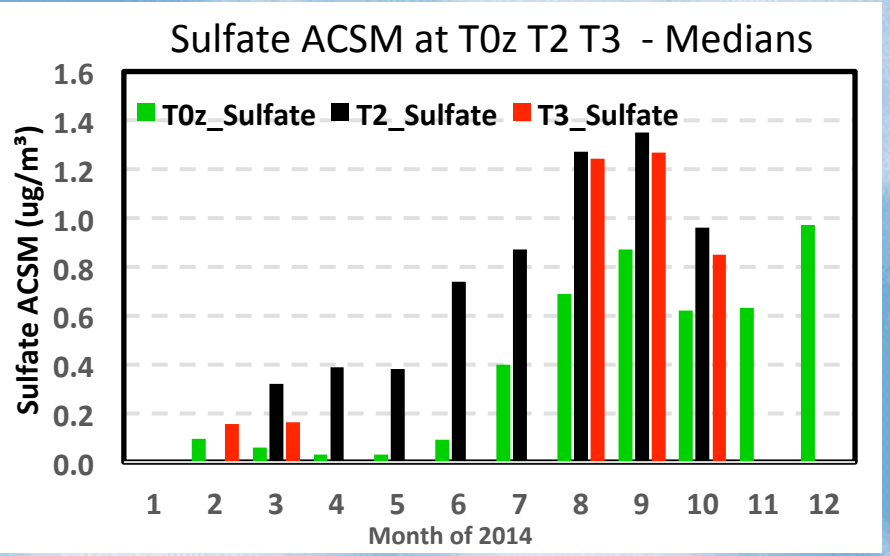
PTR-MS at T2: Acetaldehyde and Methanol

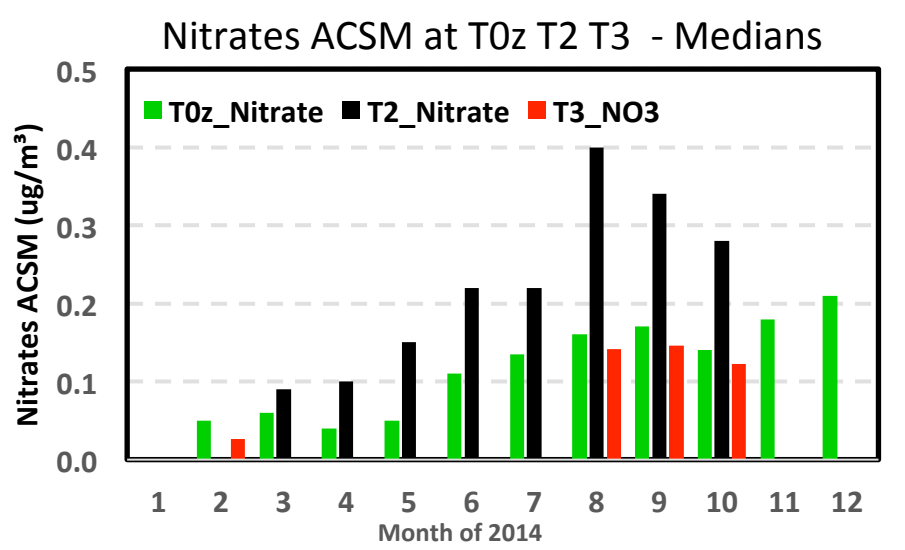


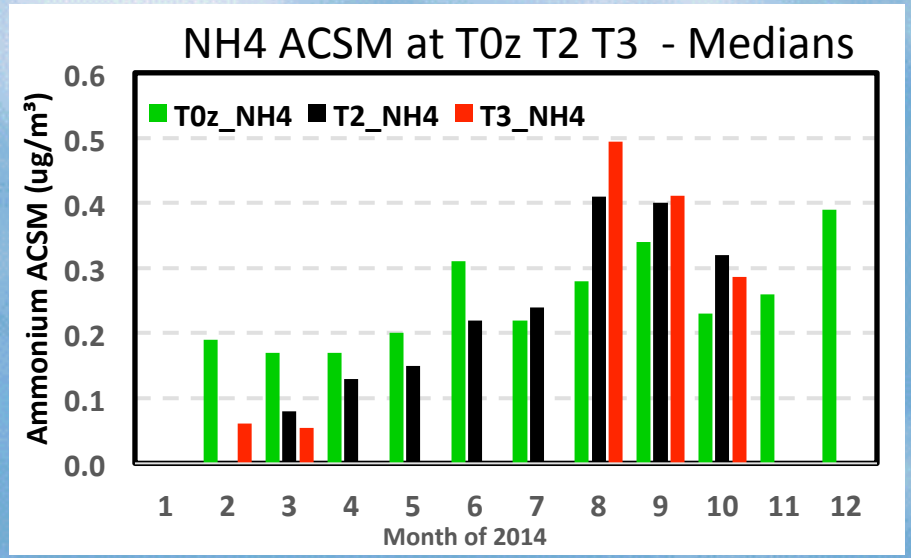


ACSM and AMS: Organics, Sulfate, Nitrates and NH4





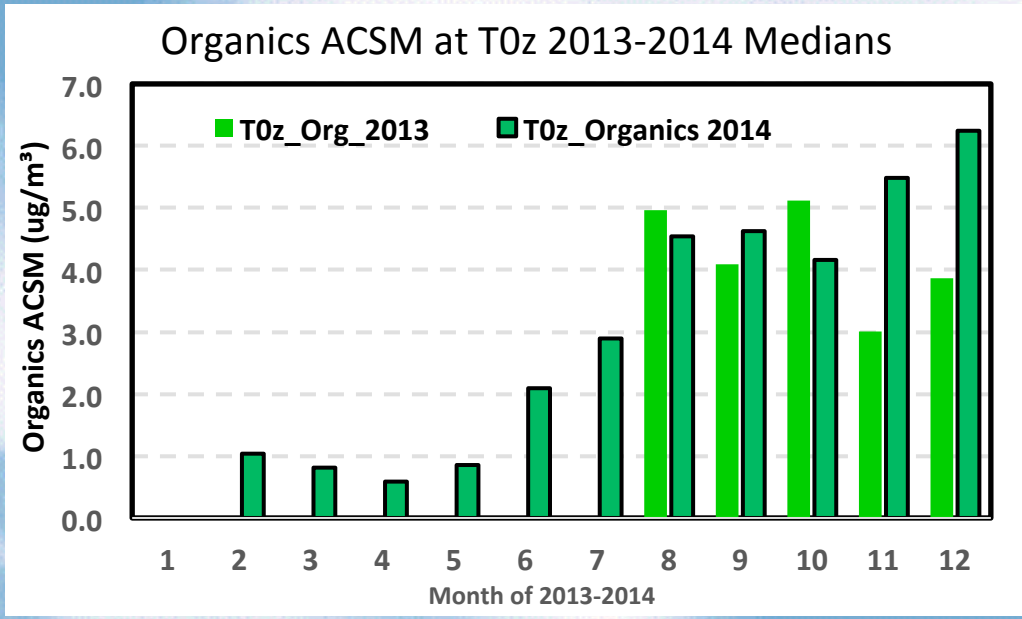


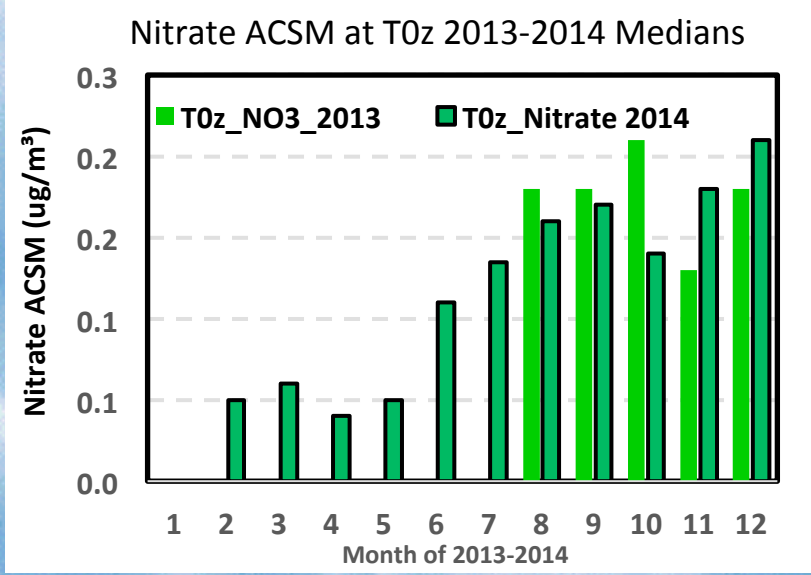


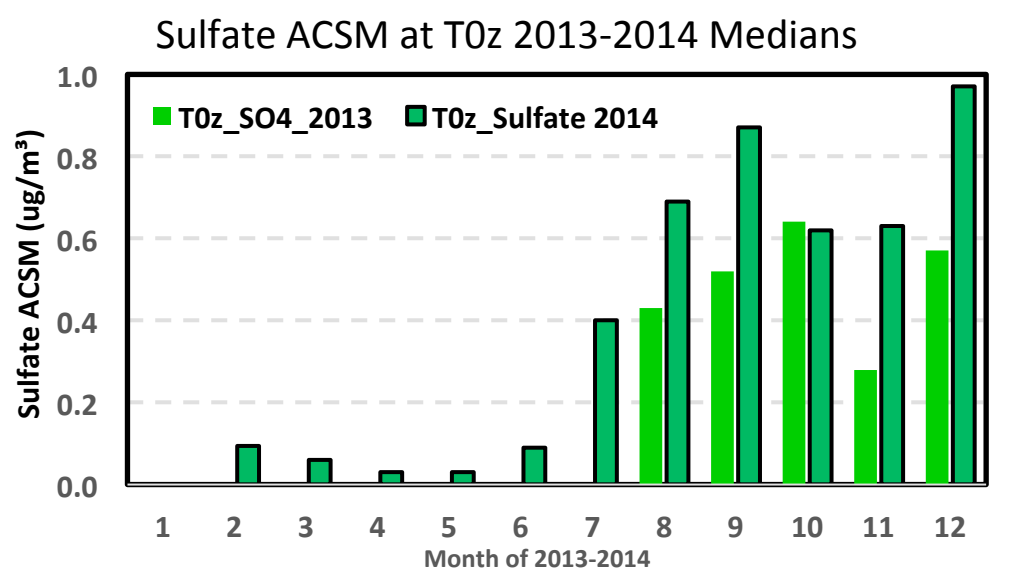
SO4, Organics: very similar T2 and T3: No aerosol formation? No evidence of pasture NH4

ACSM T0z: 2013 versus 2014

Very similar concentrations for 2013 and 2014, also similar seasonality

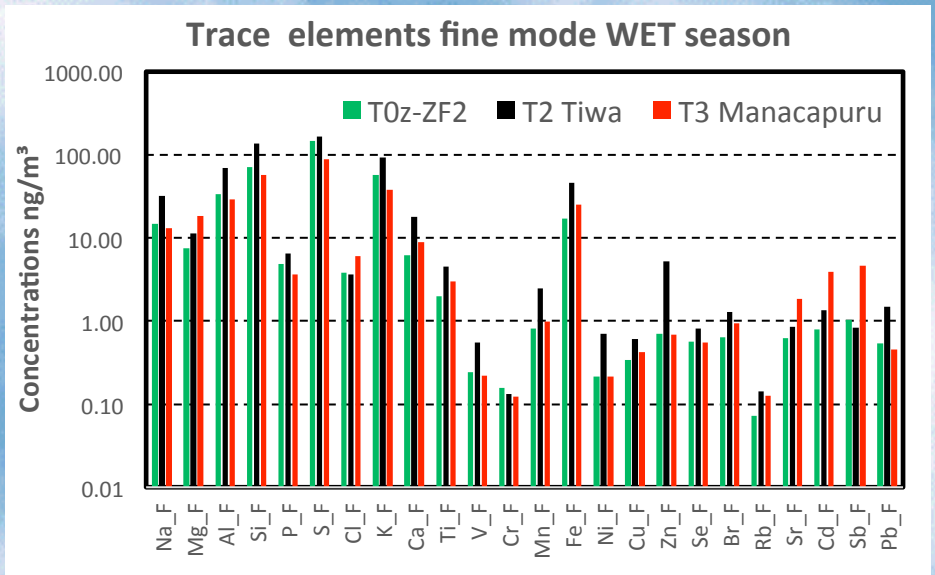


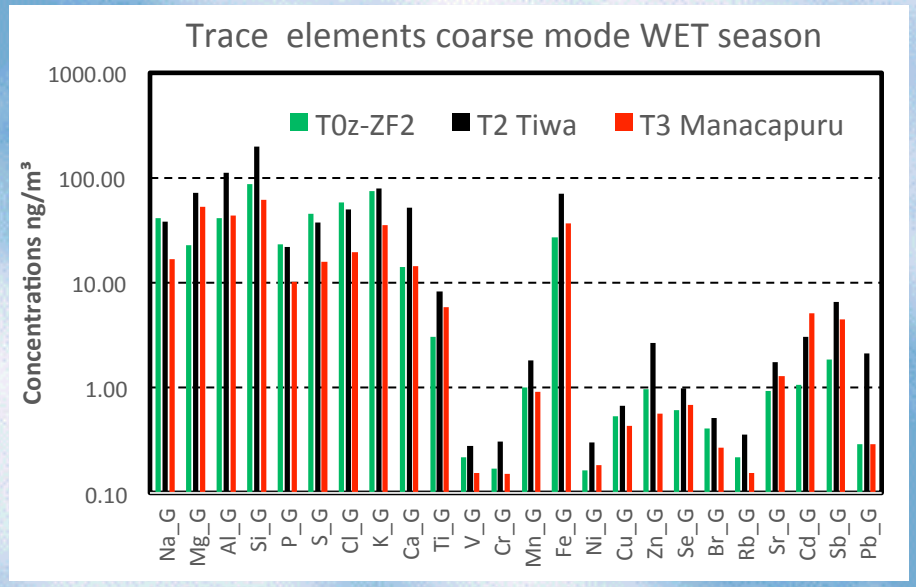


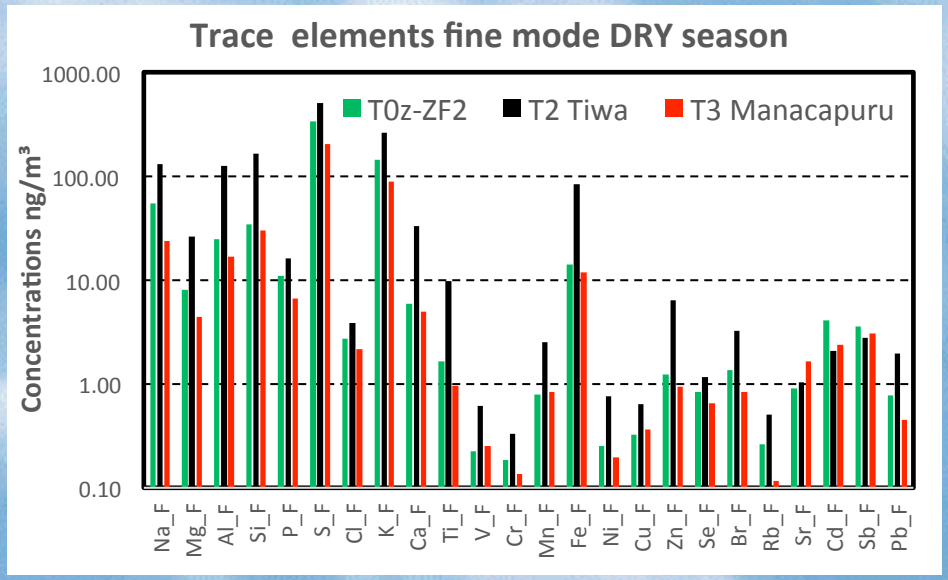


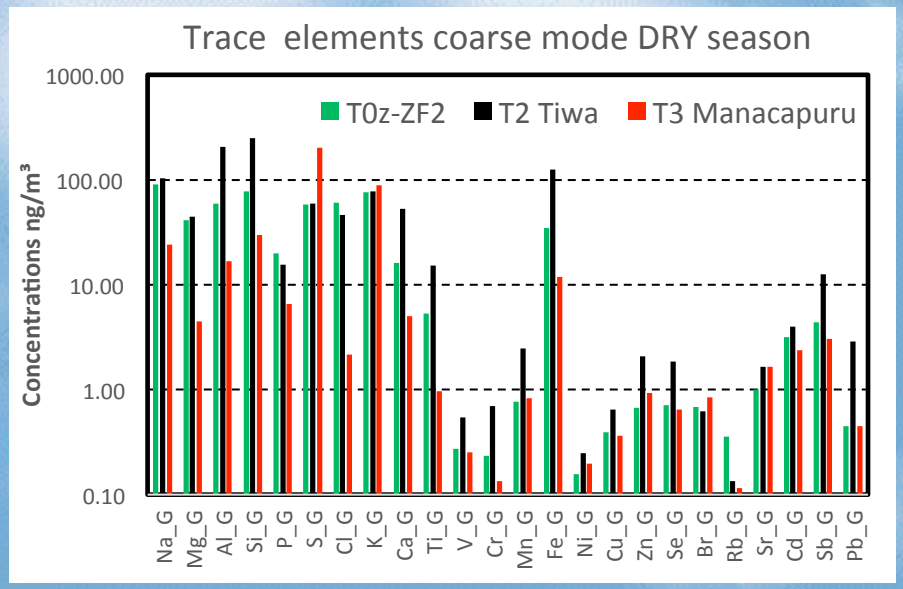
See poster of Rafael Stern

Trace elements for the 3 sites at wet and dry seasons









T3 and T0 very similar also in elemental composition for both fine and coarse mode

Brazil-USA-sponsored contributions:

- DOE-FAPESP-FAPEAM (ASR, RGCM, TES): 6 projects

USA-sponsored contributions:

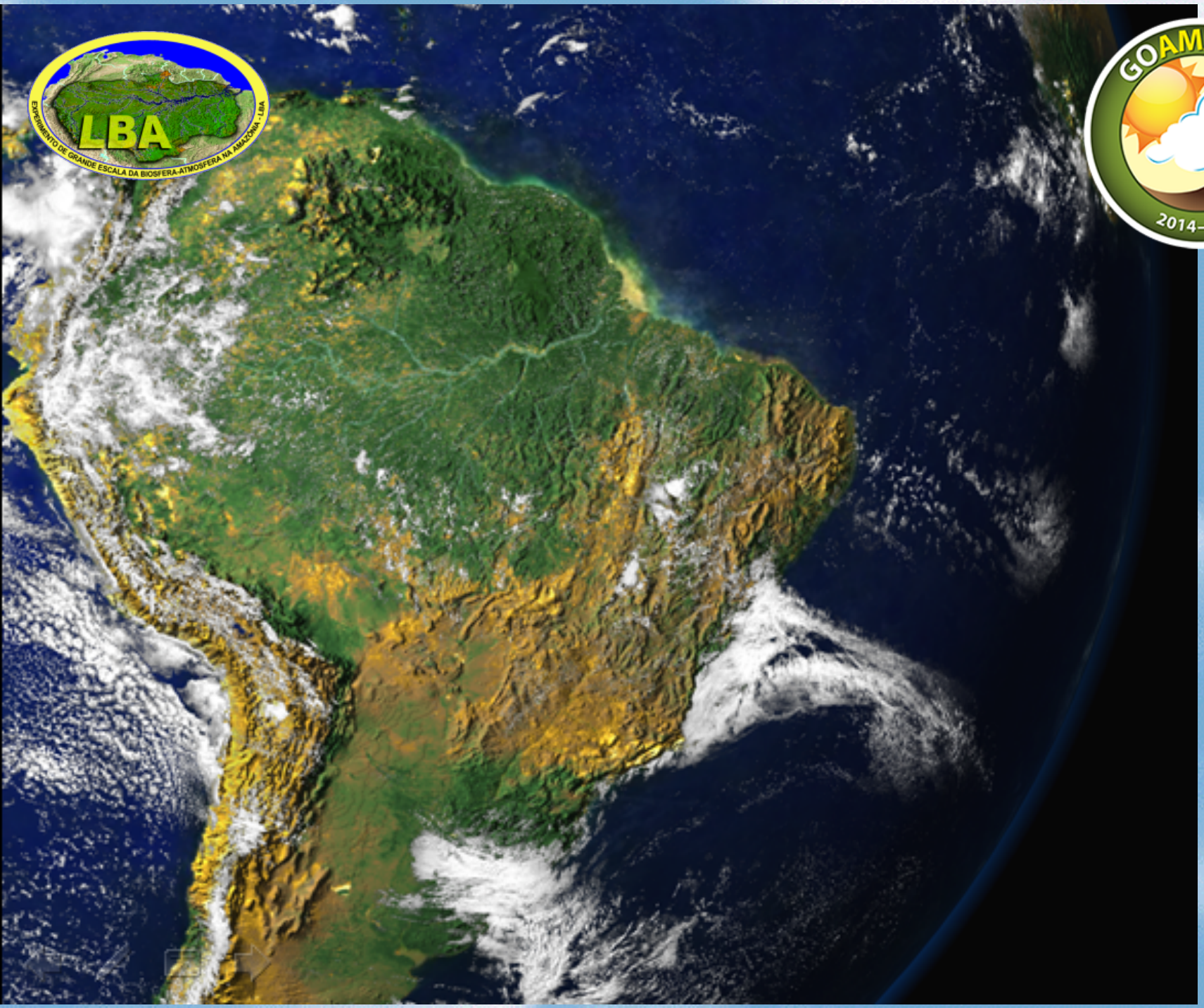
- DOE ARM (T3), DOE AAF (G1), DOE EMSL (HR-TOF-AMS), DOE ARM (DMA-CCN), DOE TES (GECO)
- NSF Atmospheric Chemistry: 2 projects
- PNNL and BNL SFA's

Additional Brazil-sponsored contributions:

- CHUVA
- Aeroclima
- CsF
- LBA

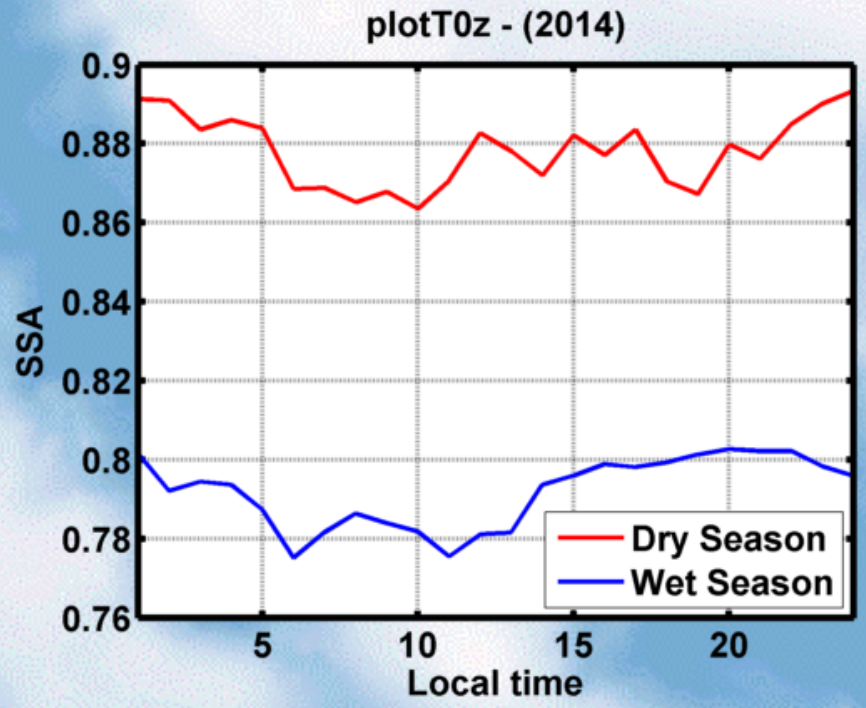
Other international contributions:

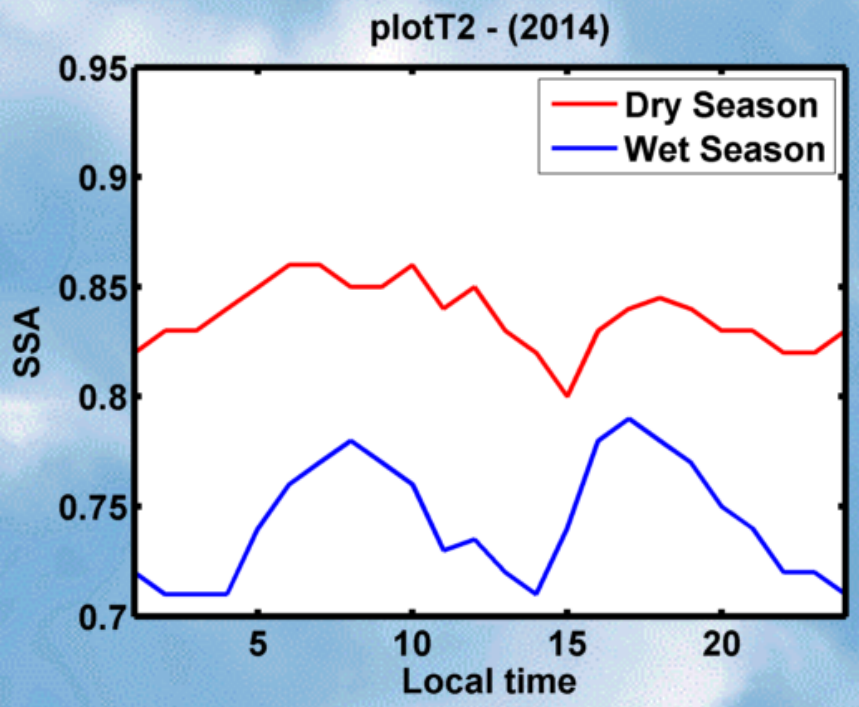
- ACRIDICON
- ATTO

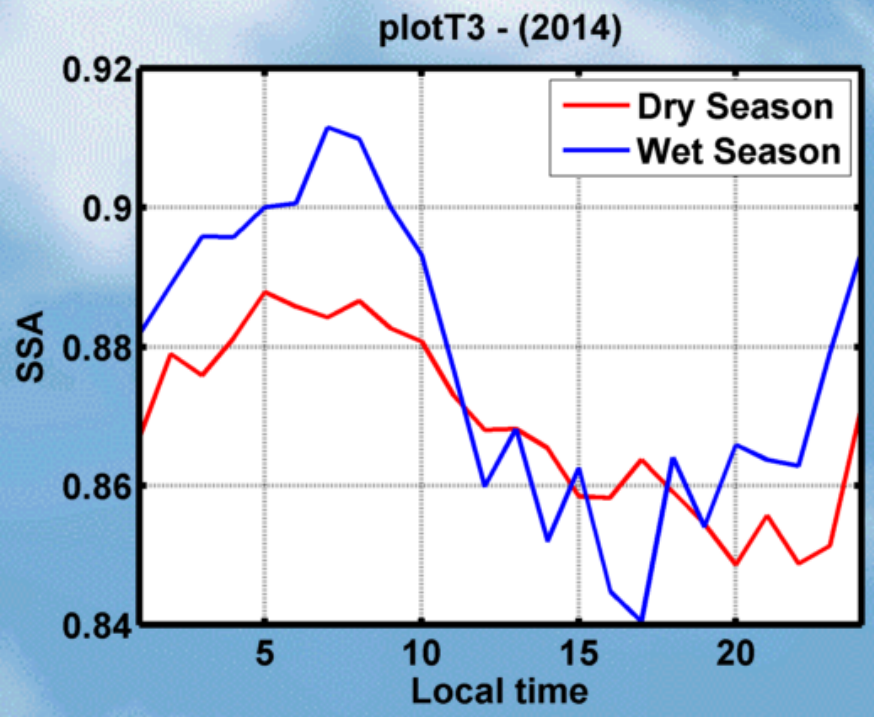

LBA
EXPERIMENTO DE GRANDE ESCALA DA BIOSFERA-ATMOSFERA NA AMAZONIA - LBA
GOAMAZON
2014–2015

Thank you!

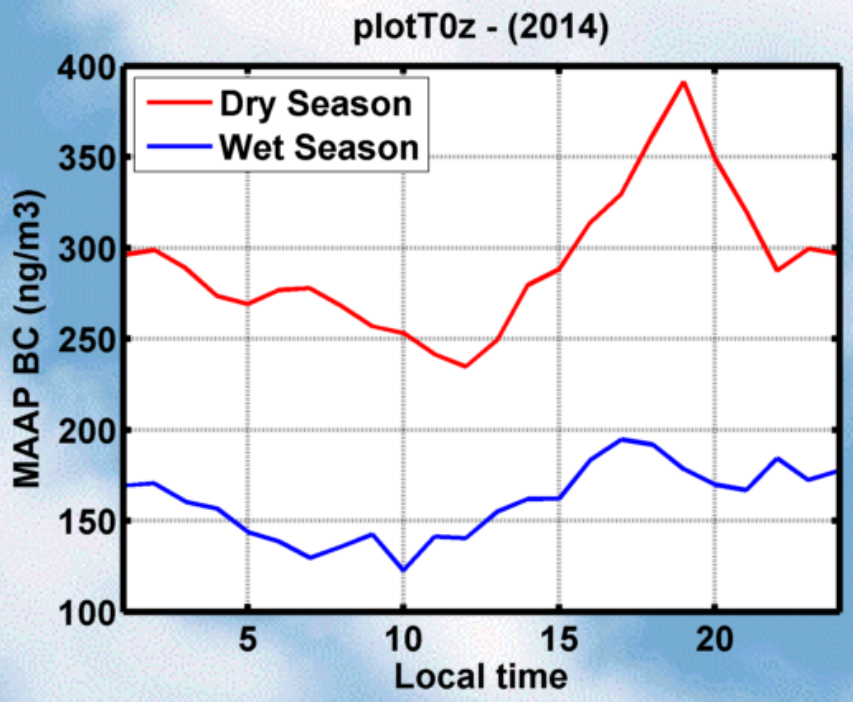
SSA Diurnal Variability for each site and season

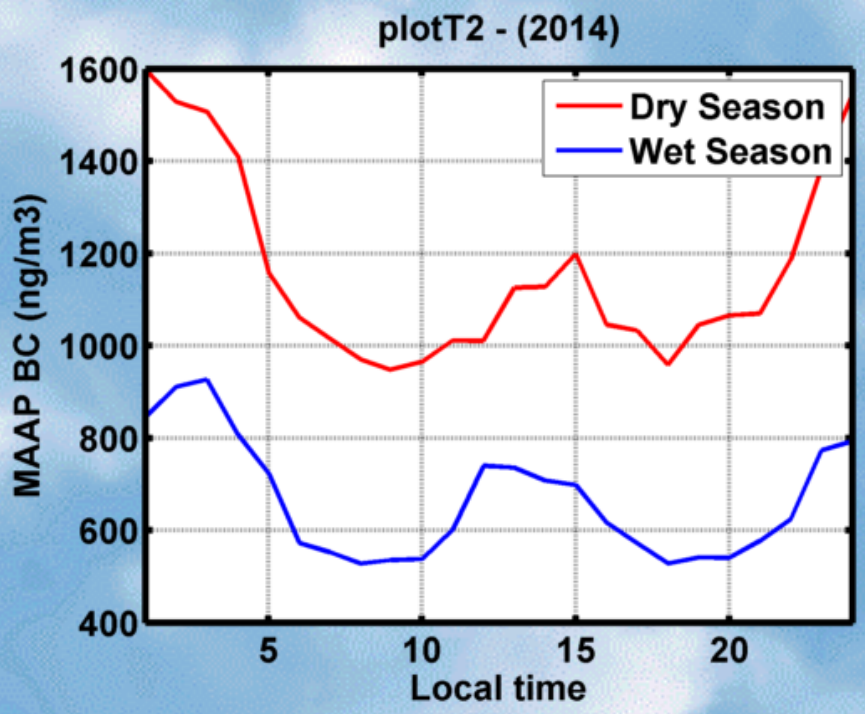


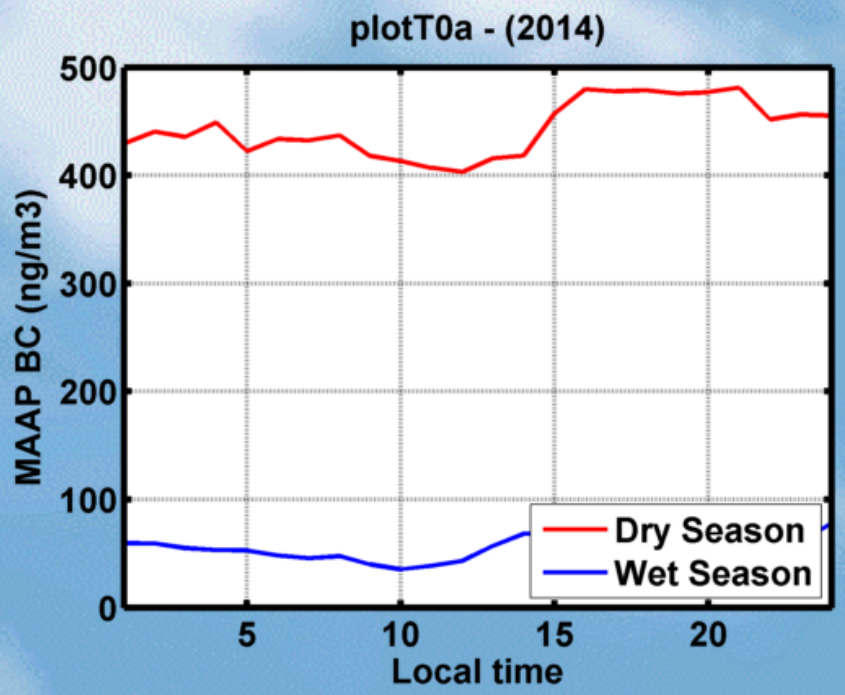




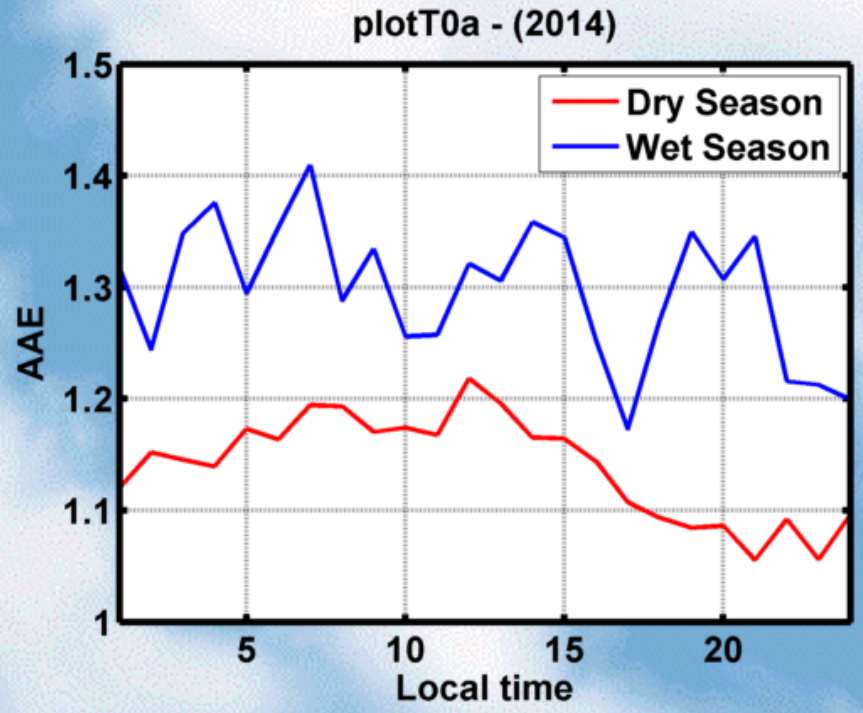
Black Carbon Diurnal Variability for each site and season

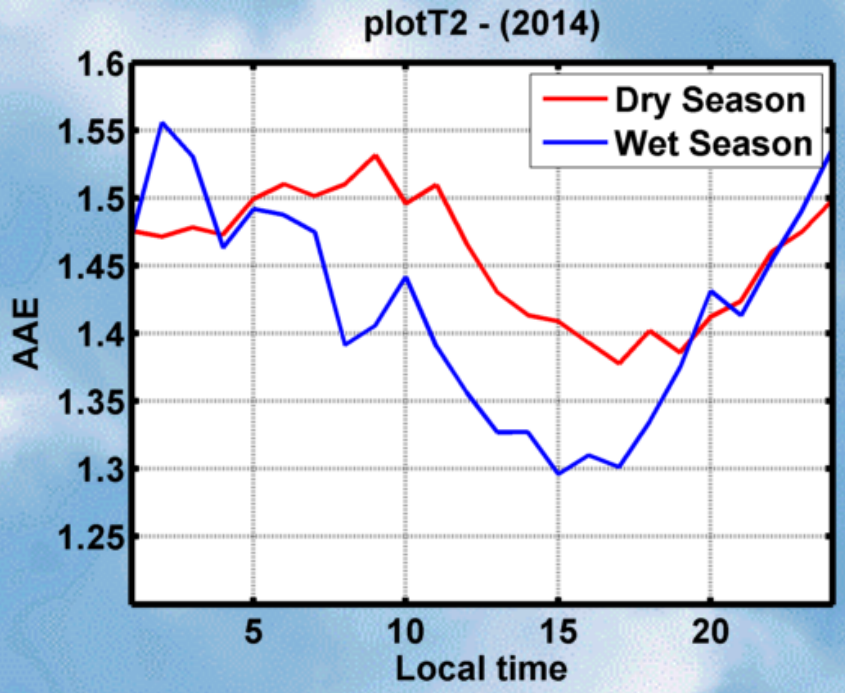


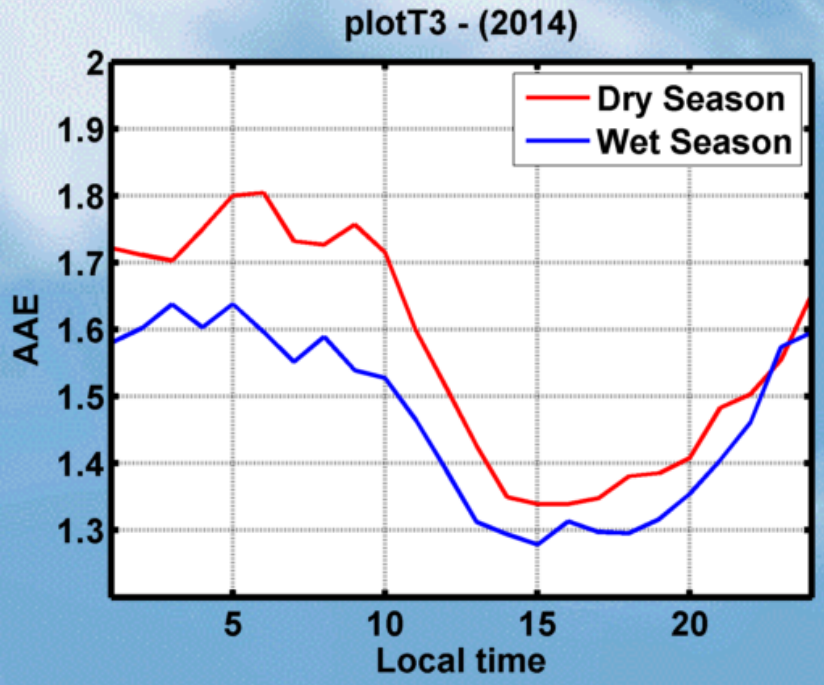




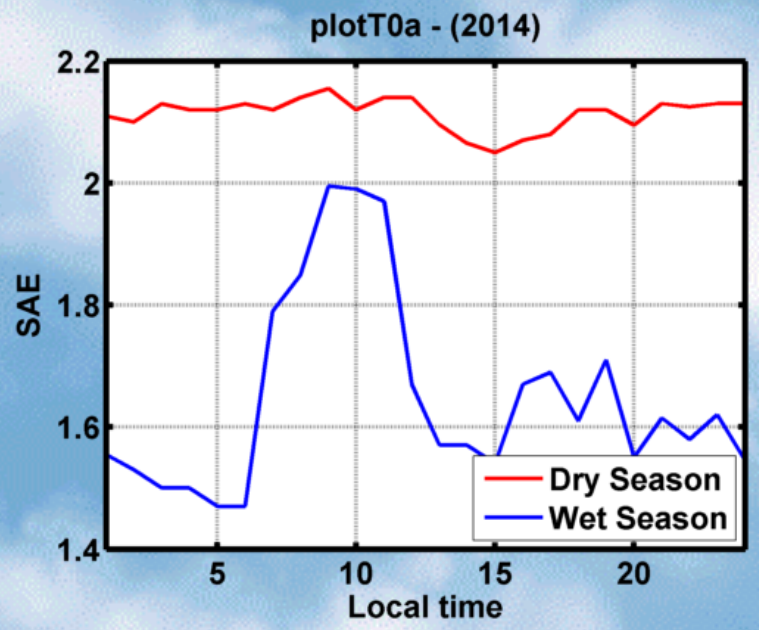
AAE – Absorption Angstrom Exponent Diurnal Variability for each site and season

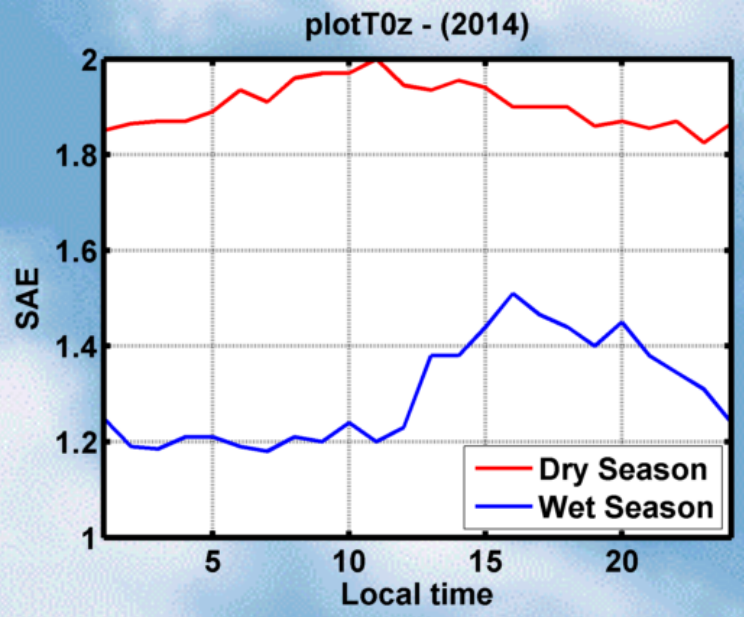


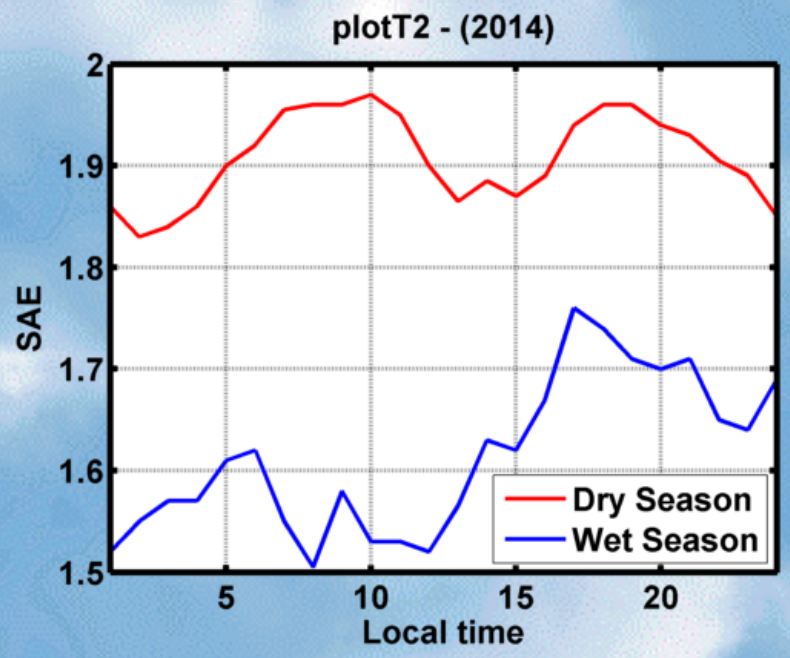


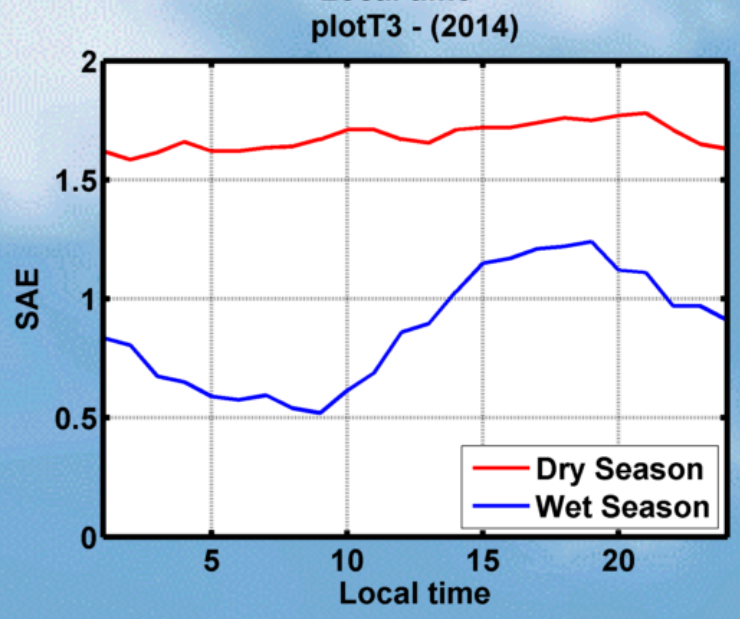


SAE Scattering Angstrom Exponent

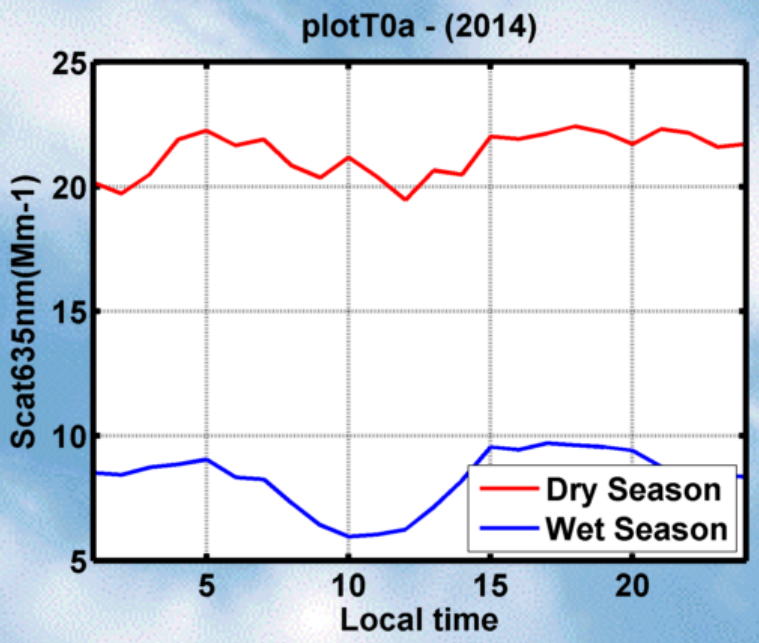


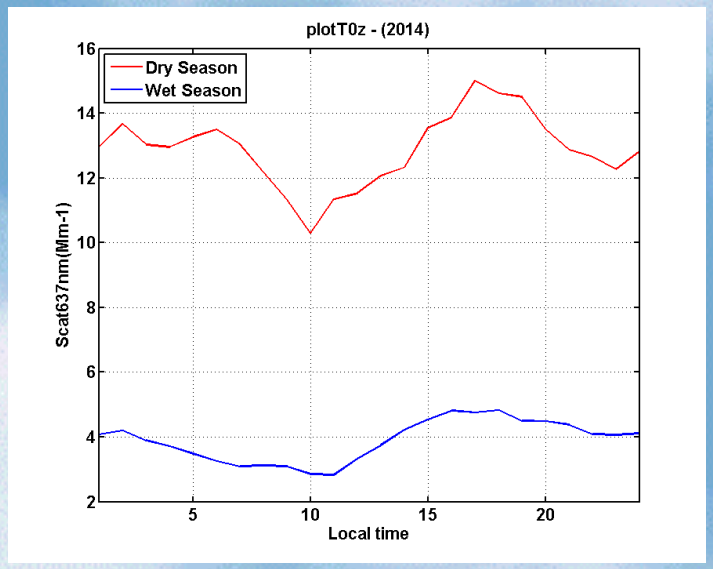


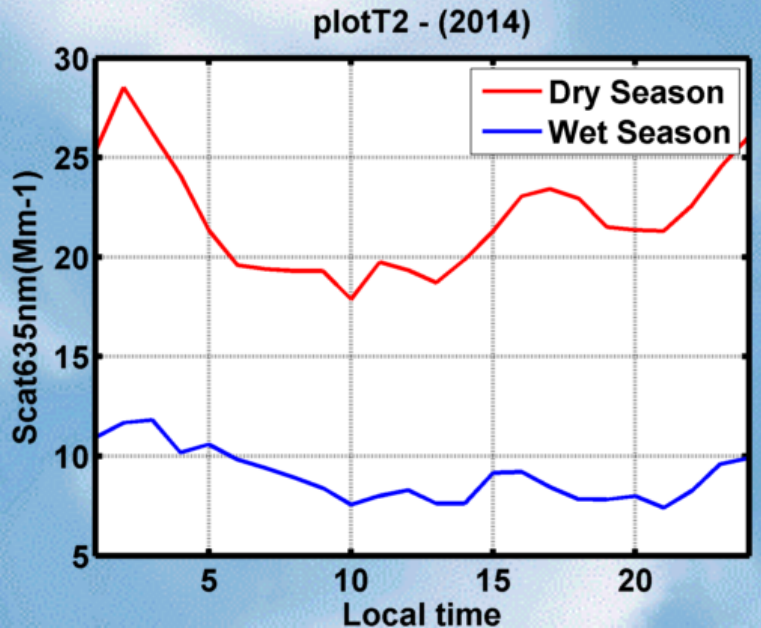


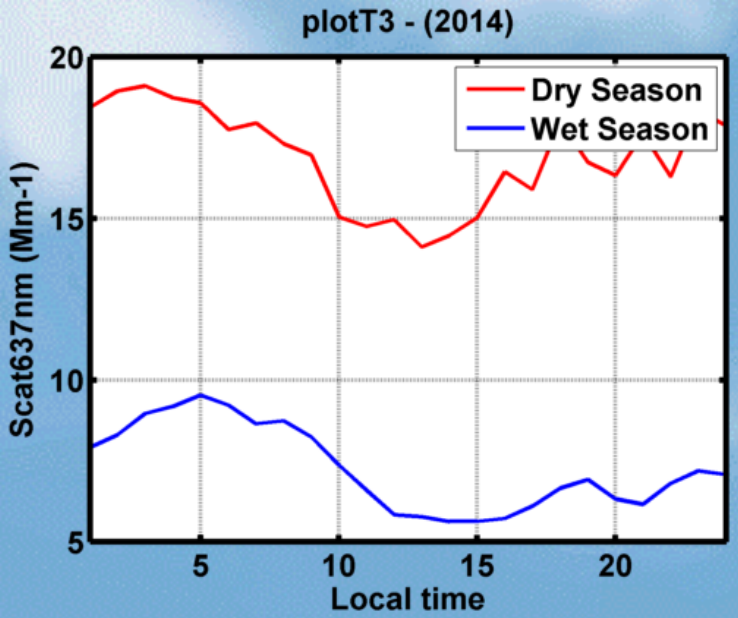


Scattering coefficient at 635 nm



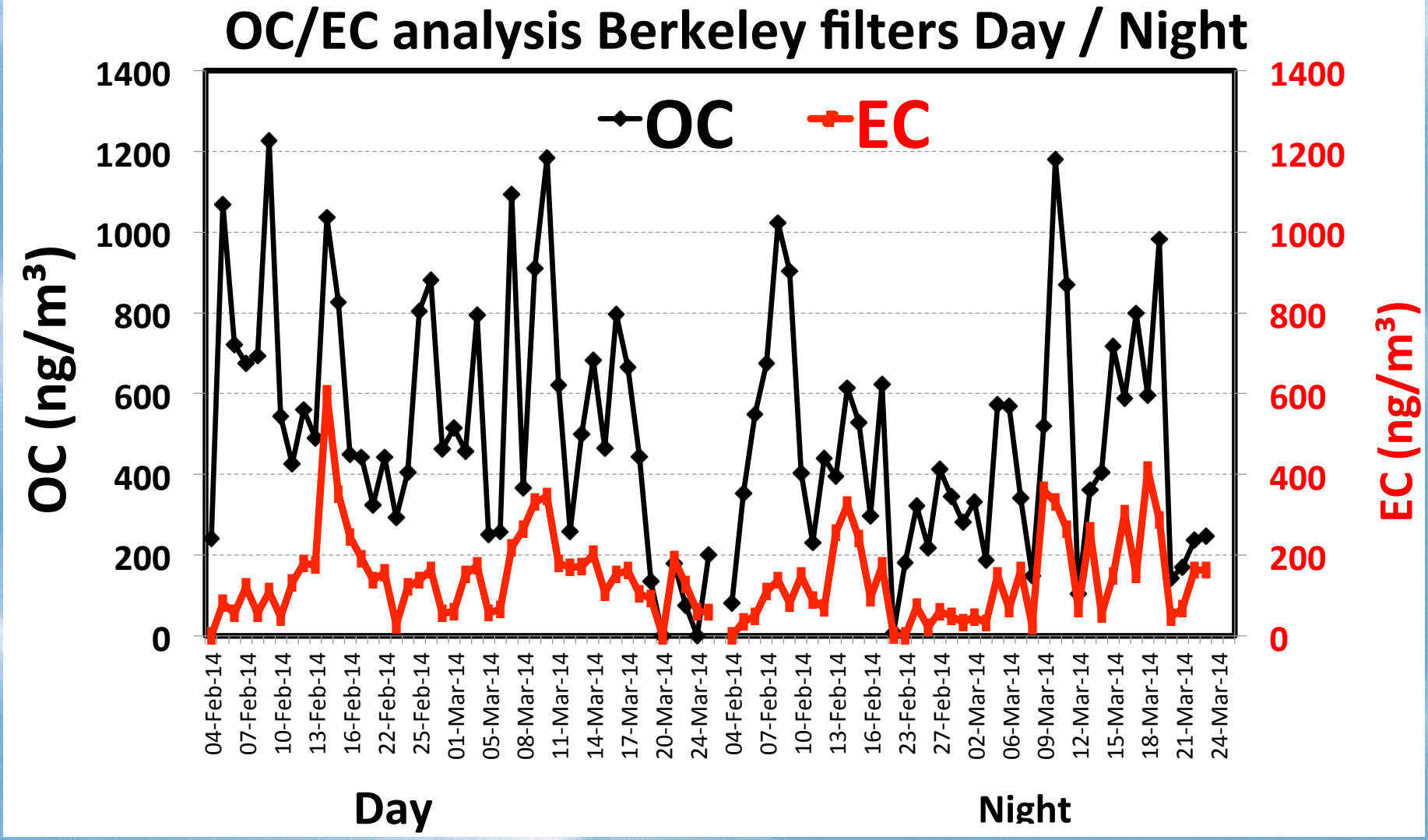




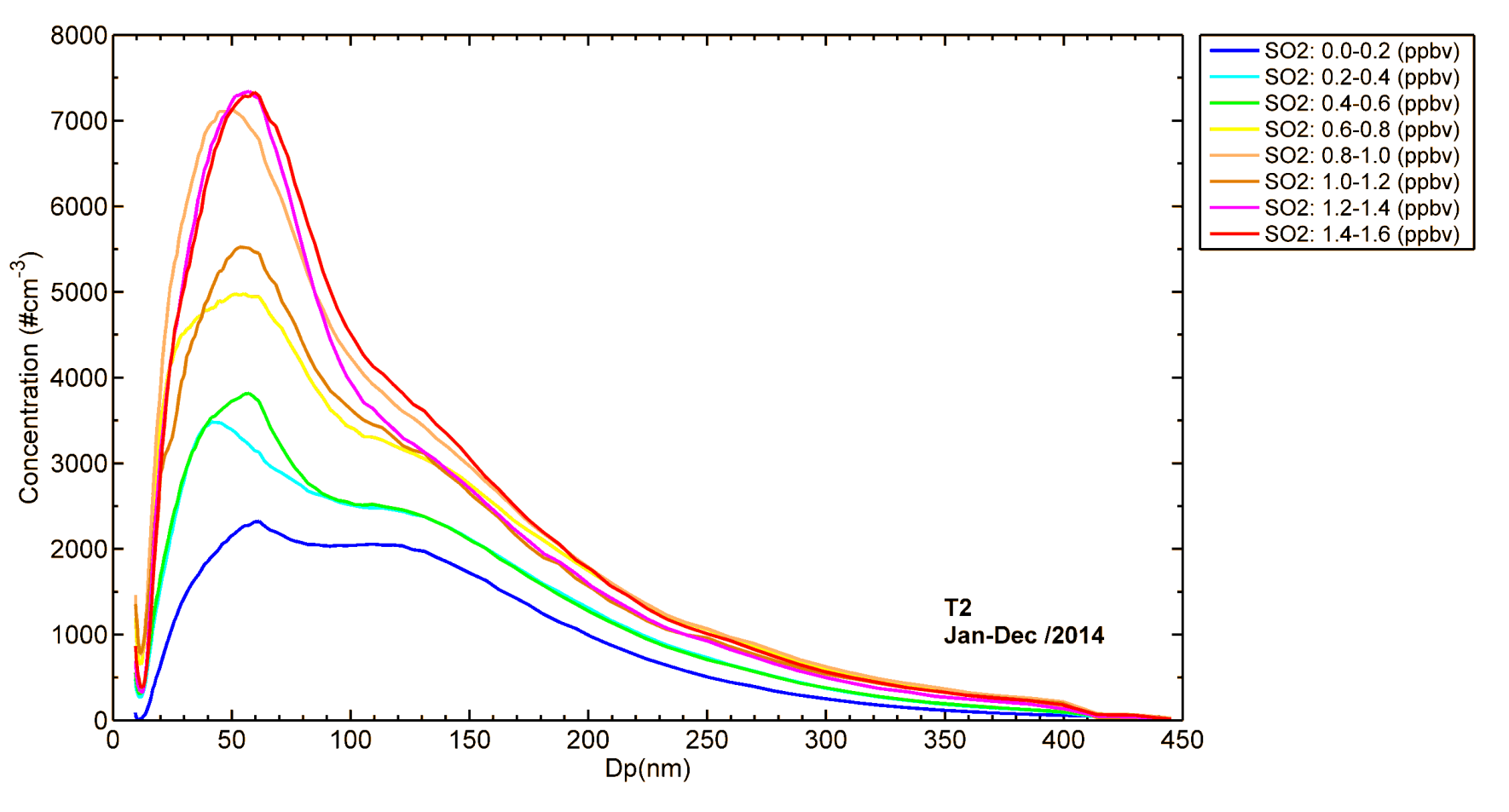


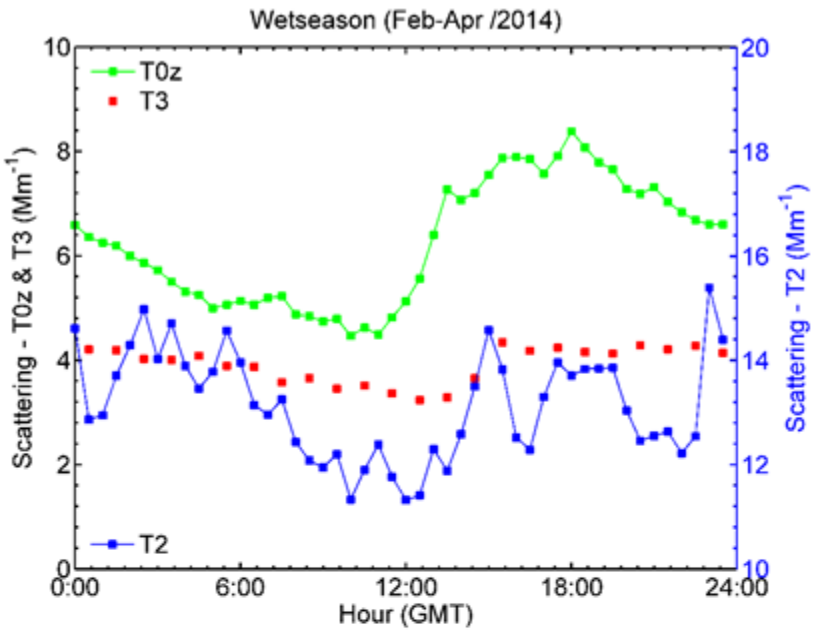
Filters OC/EC analysis: a changing story…

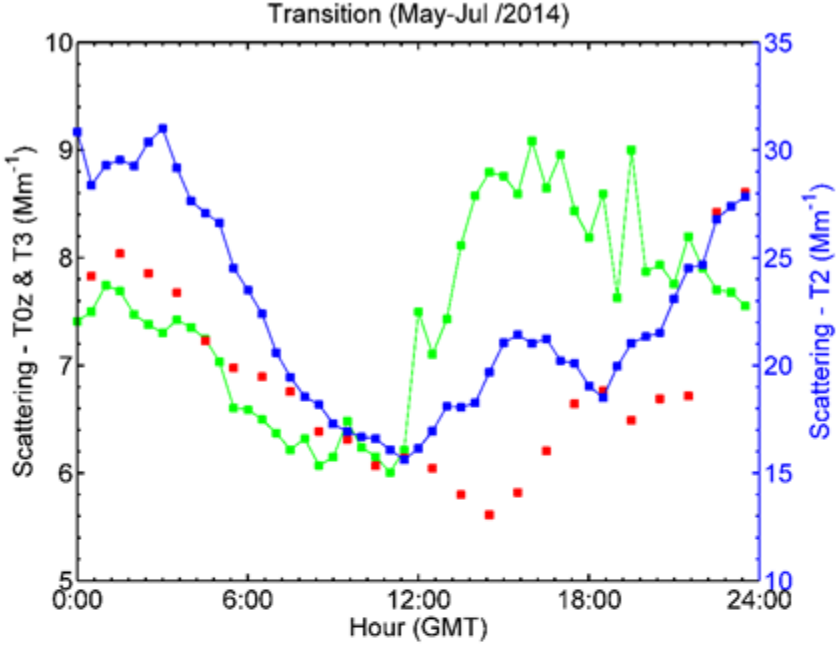
Analysis by
Andrea Arana and Ana L. Loureiro

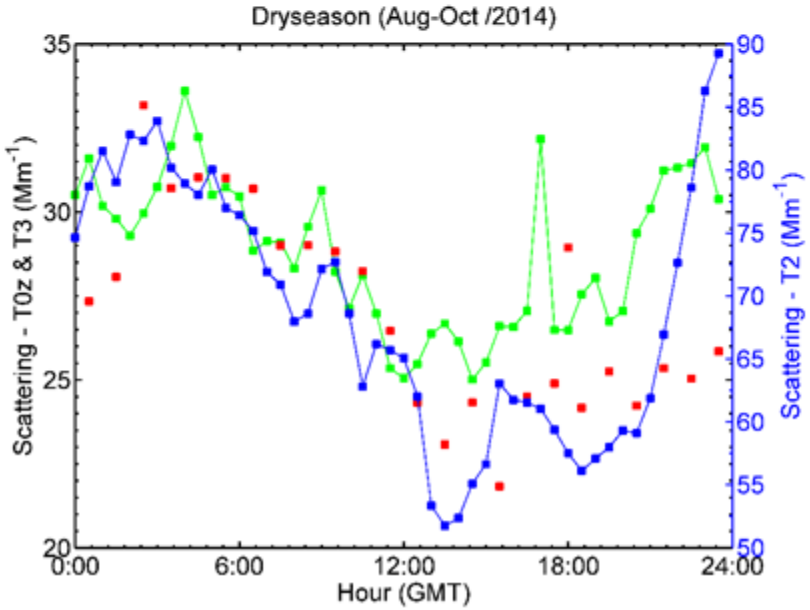


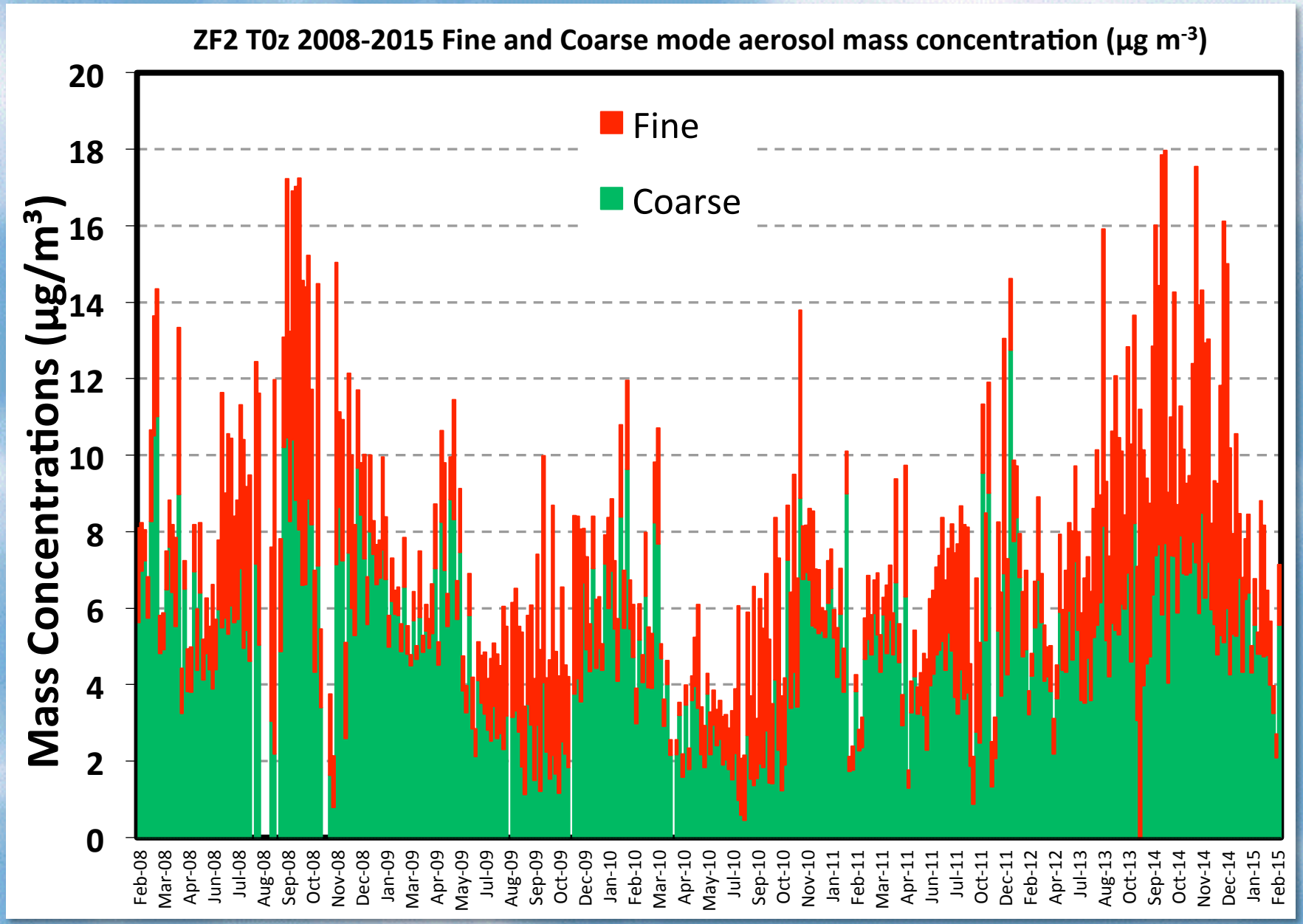
T2: Jan-Dec 2014 - Aerosol size distribution and SO_2 concentration



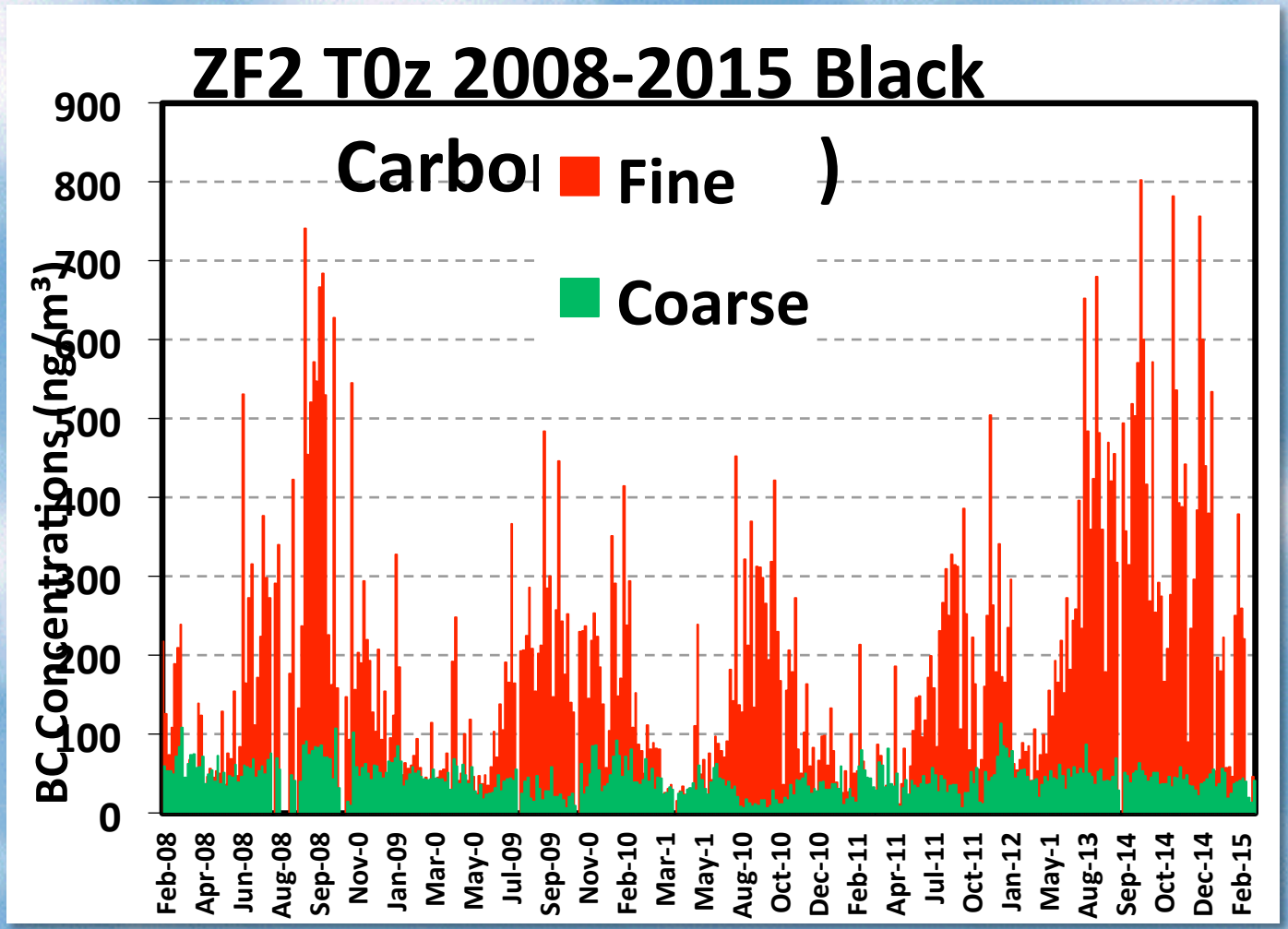

Wetseason (Feb-Apr /2014)
T0z
T3
T2
Scattering - T0z & T3 (Mm-1)
Scattering - T2 (Mm-1)
Hour (GMT)
0:00
6:00
12:00
18:00
24:00


Transition (May-Jul /2014)
Scattering - T0z & T3 (Mm-1)
Scattering - T2 (Mm-1)
Hour (GMT)
0:00
6:00
12:00
18:00
24:00


Dryseason (Aug-Oct /2014)
Scattering - T0z & T3 (Mm-1)
Scattering - T2 (Mm-1)
Hour (GMT)
0:00
6:00
12:00
18:00
24:00

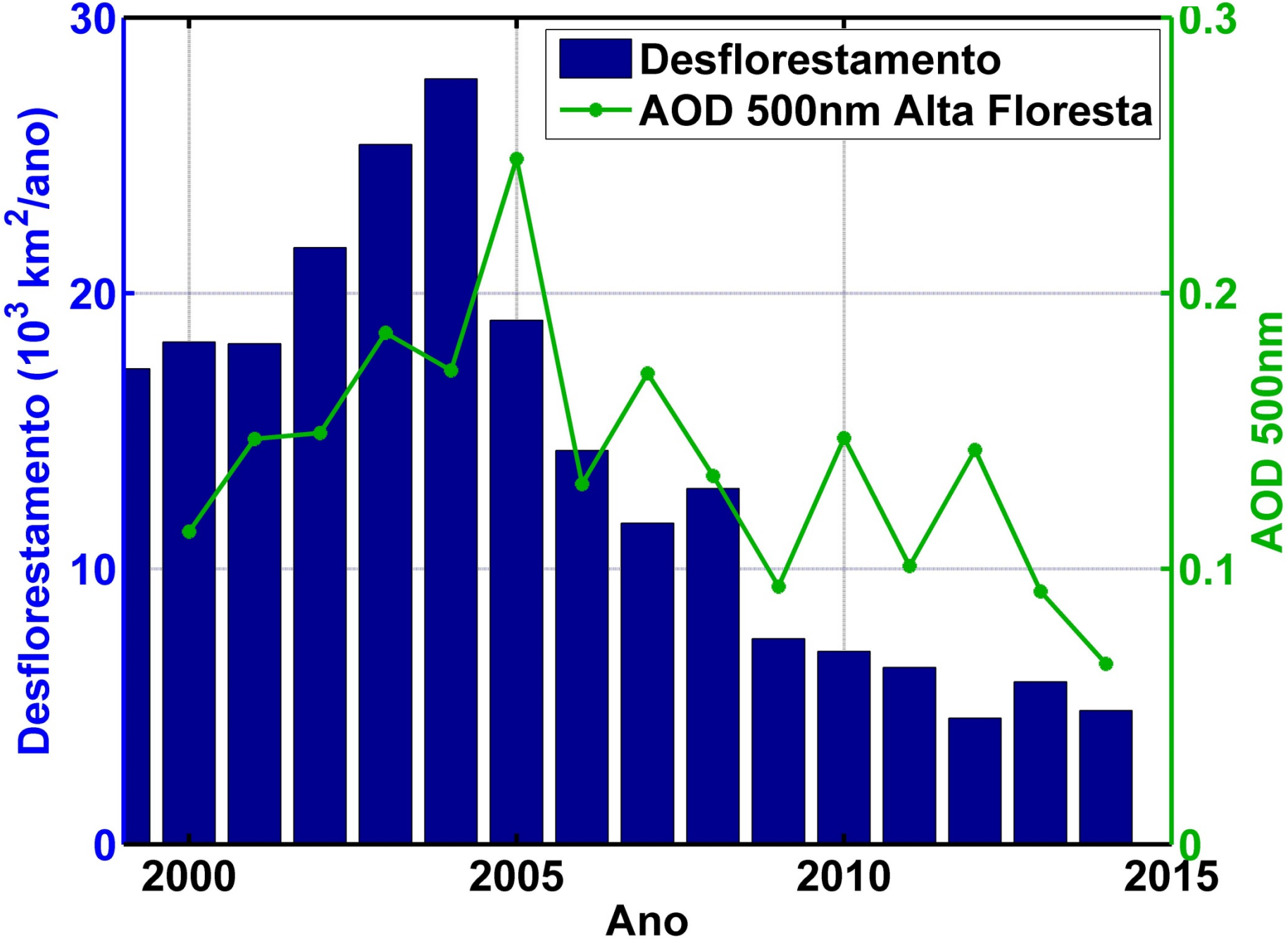


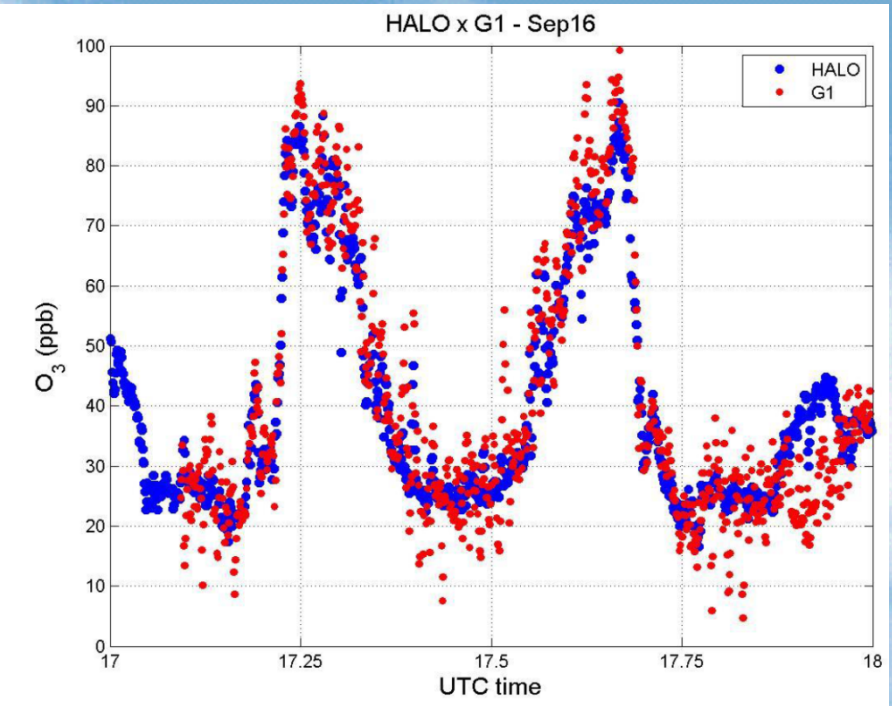
Compilation by Andrea Arana

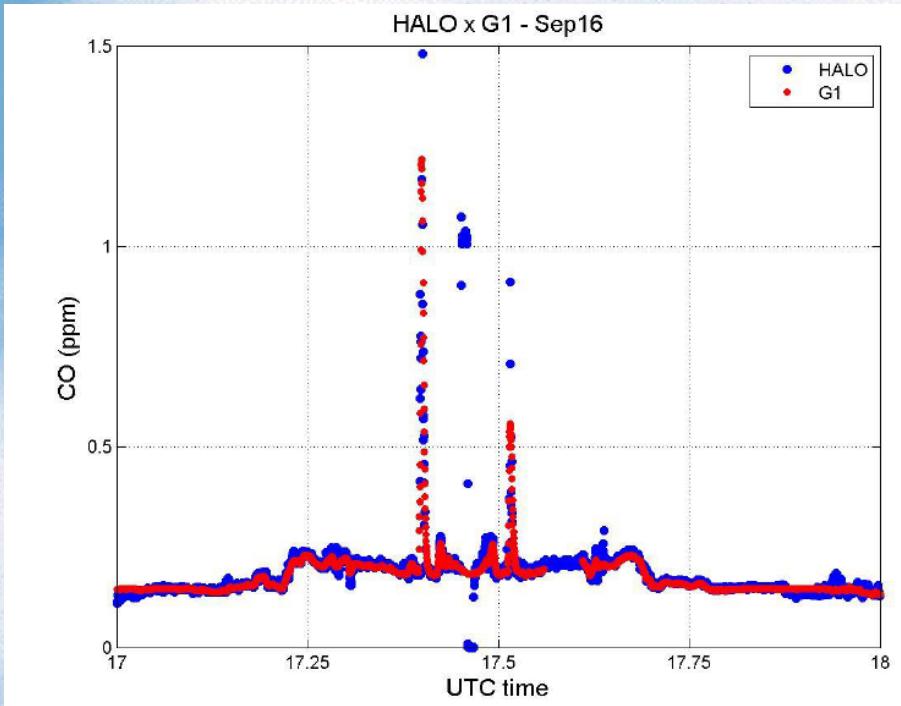


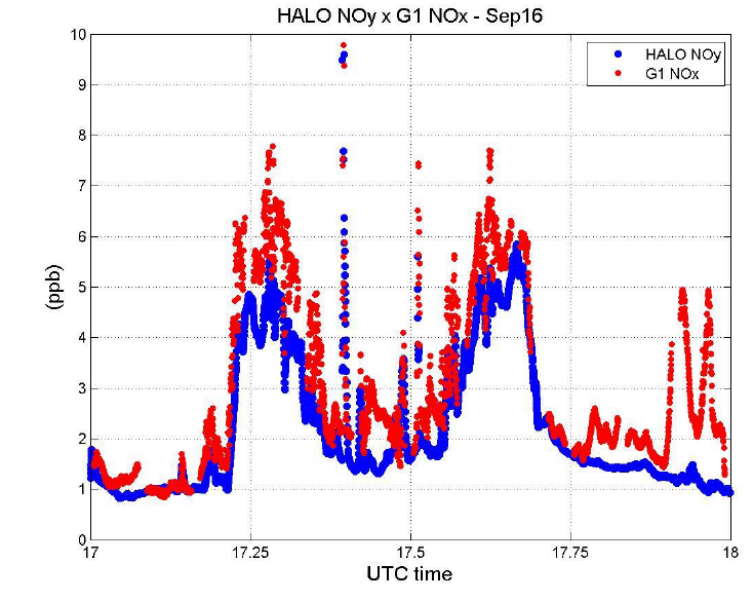
Compilation by Andrea Arana

AOD and deforestation in Amazonia 2000-2015









It was expected that HALO NOy > G1 NOx