Overview of the ACRF Deployment in the Amazon Basin

MegaCity Outflow in the Tropics: Manaus, Brazil

Presented by Scot Martin,
ASR Science Meeting, 29 March 2011

Statement of Motivation for *MegaCity Outflow in the Tropics: Manaus, Brazil*

The deployment site is situated such that it experiences the extremes of:

(i) a pristine atmosphere when the Manaus pollution plume meanders; and

(ii) heavy pollution and the interactions of that pollution with the natural environment when the plume regularly intersects the site.

The city of Manaus uses high-sulfur oil as its primary source of electricity. The city is also an industrial zone of several million people and has high emissions of soot.

Statement of Motivation for *MegaCity Outflow in the Tropics: Manaus, Brazil*

Cont'd

Particle number and mass concentrations are 10 to 100 times greater in the pollution plume compared to the times when pristine conditions prevail.

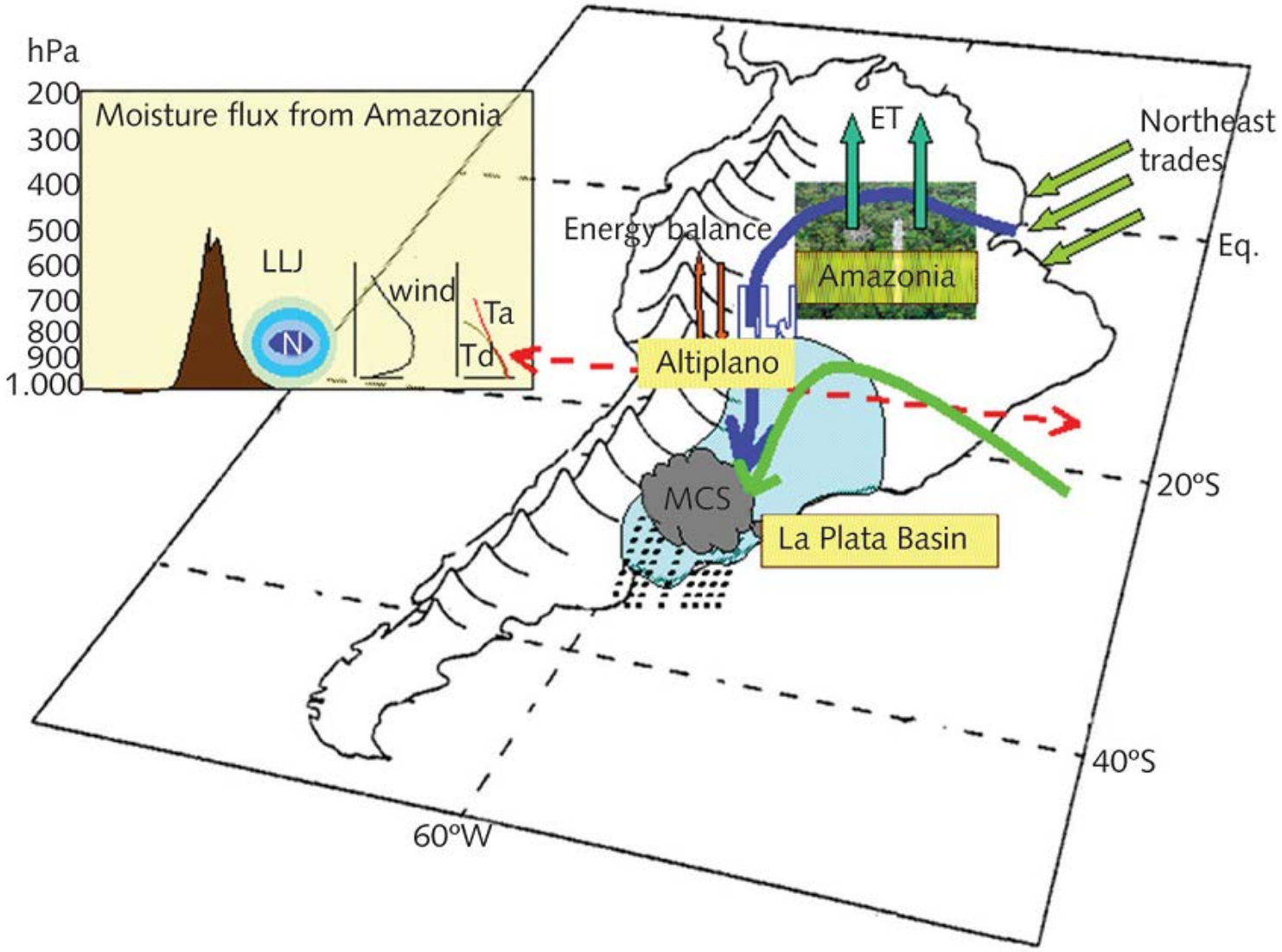
The deployment will enable the study of how aerosol and cloud life cycles, including cloud-aerosol-precipitation interactions, are influenced by pollutant outflow from a tropical megacity.

AMF Operations: Jan - Dec 2014 (Manacapuru)

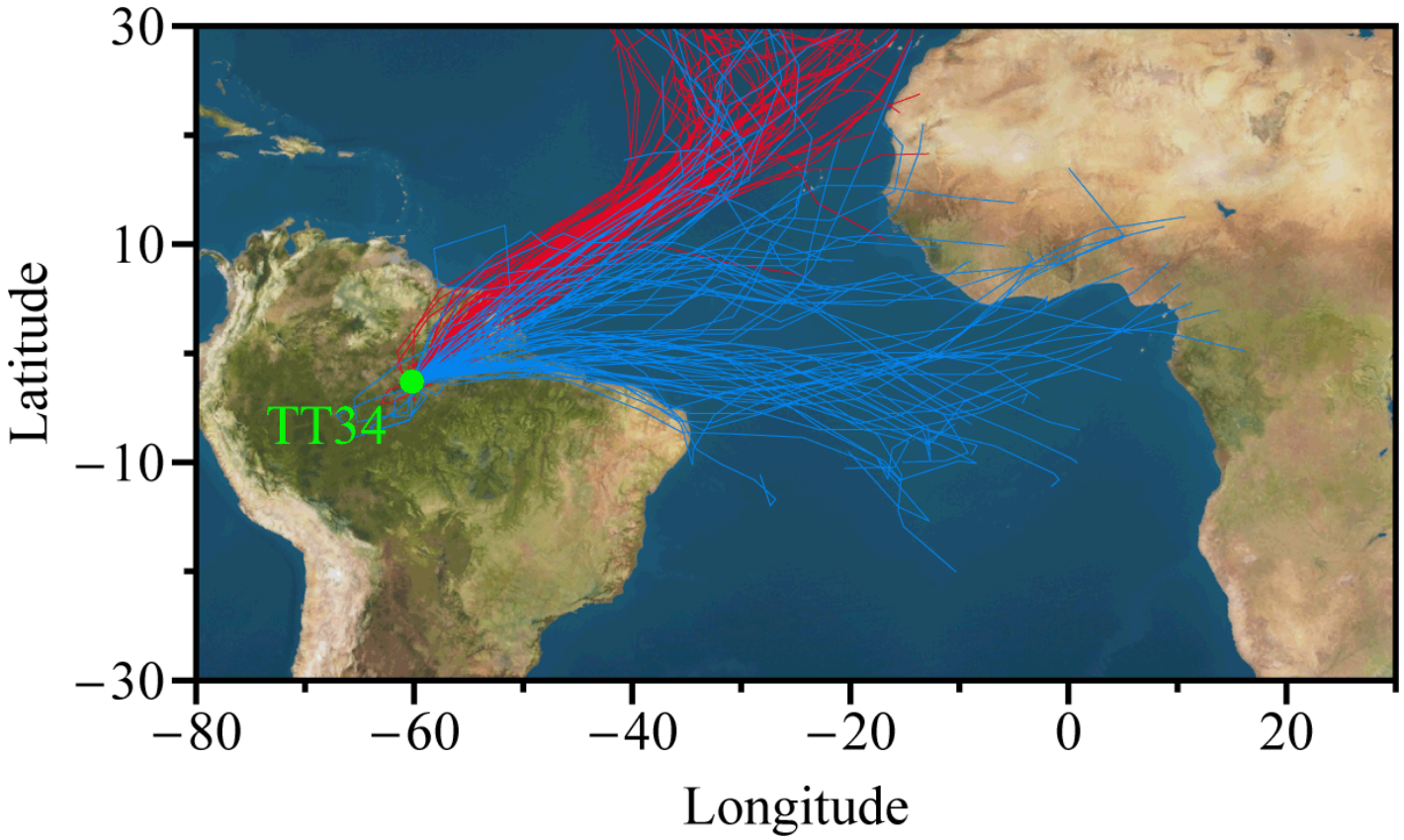
AAF Operations: Feb/Mar & Sep/Oct 2014 (Manaus)

A Brief Orientation to Mesoscale Features of the Amazon Basin

Prevailing Patterns of Wind, Water, and Energy Flows in the Amazon Basin



Ten-Day Back-Trajectories during AMAZE-08



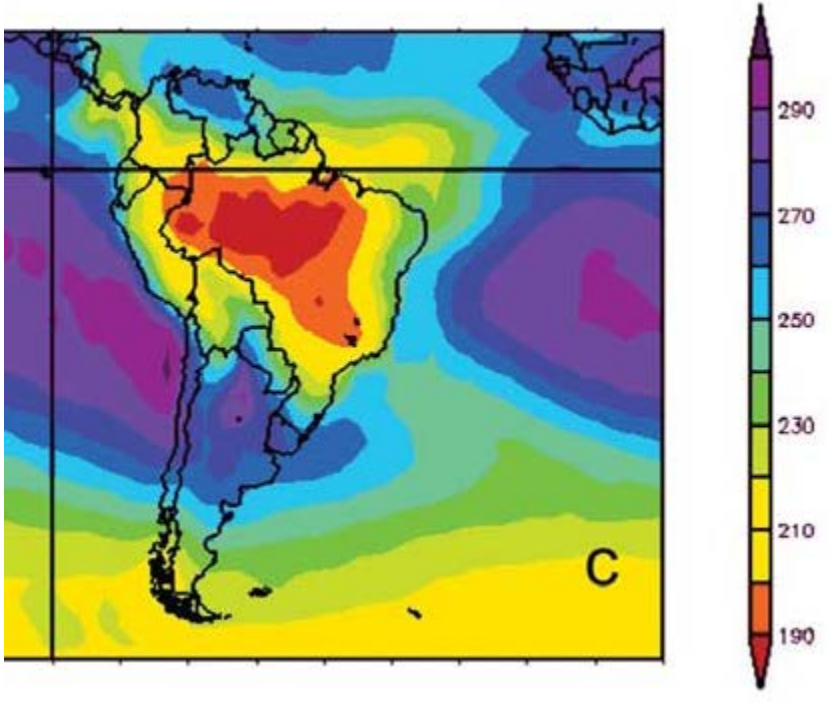
Red: 200 m
Blue: 4000 m

7 Feb - 14 Mar 2008

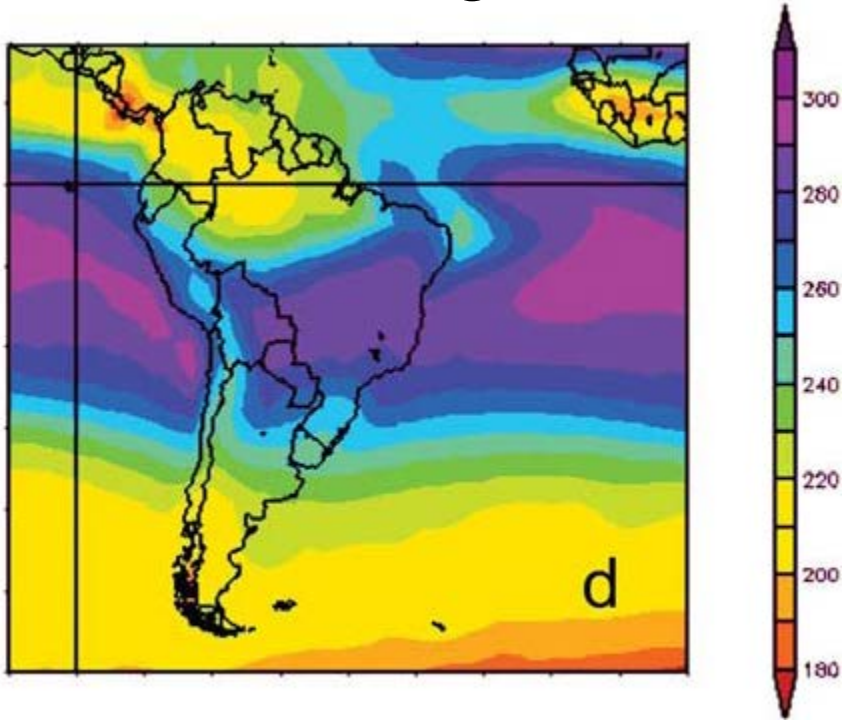
Source: Martin, S. T.; Andreae, M. O.; Althausen, D.; Artaxo, P.; Baars, H.; Borrmann, S.; Chen, Q.; Farmer, D. K.; Guenther, A.; Gunthe, S.; Jimenez, J. L.; Karl, T.; Longo, K.; Manzi, A.; Pauliquevis, T.; Petters, M.; Prenni, A.; Pöschl, U.; Rizzo, L. V.; Schneider, J.; Smith, J. N.; Swietlicki, E.; Tota, J.; Wang, J.; Wiedensohler, A.; Zorn, S. R., "An Overview of the Amazonian Aerosol Characterization Experiment 2008 (AMAZE-08)," *Atmos. Chem. Phys.* **2010**, *10*, 11415–11438.

Outgoing Longwave Radiation (W m^{-2})

Dec-Jan-Feb

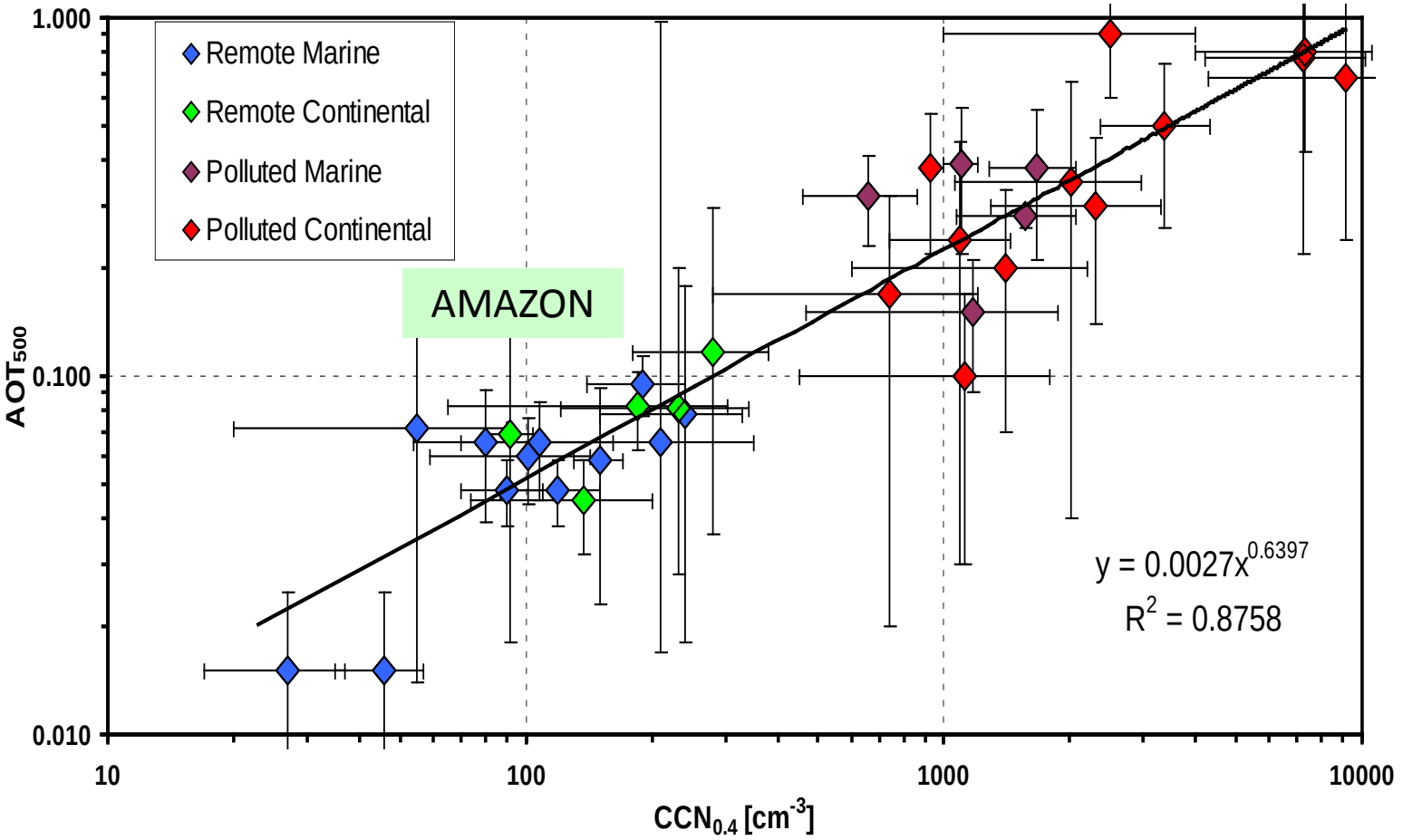


Jun-Jul-Aug



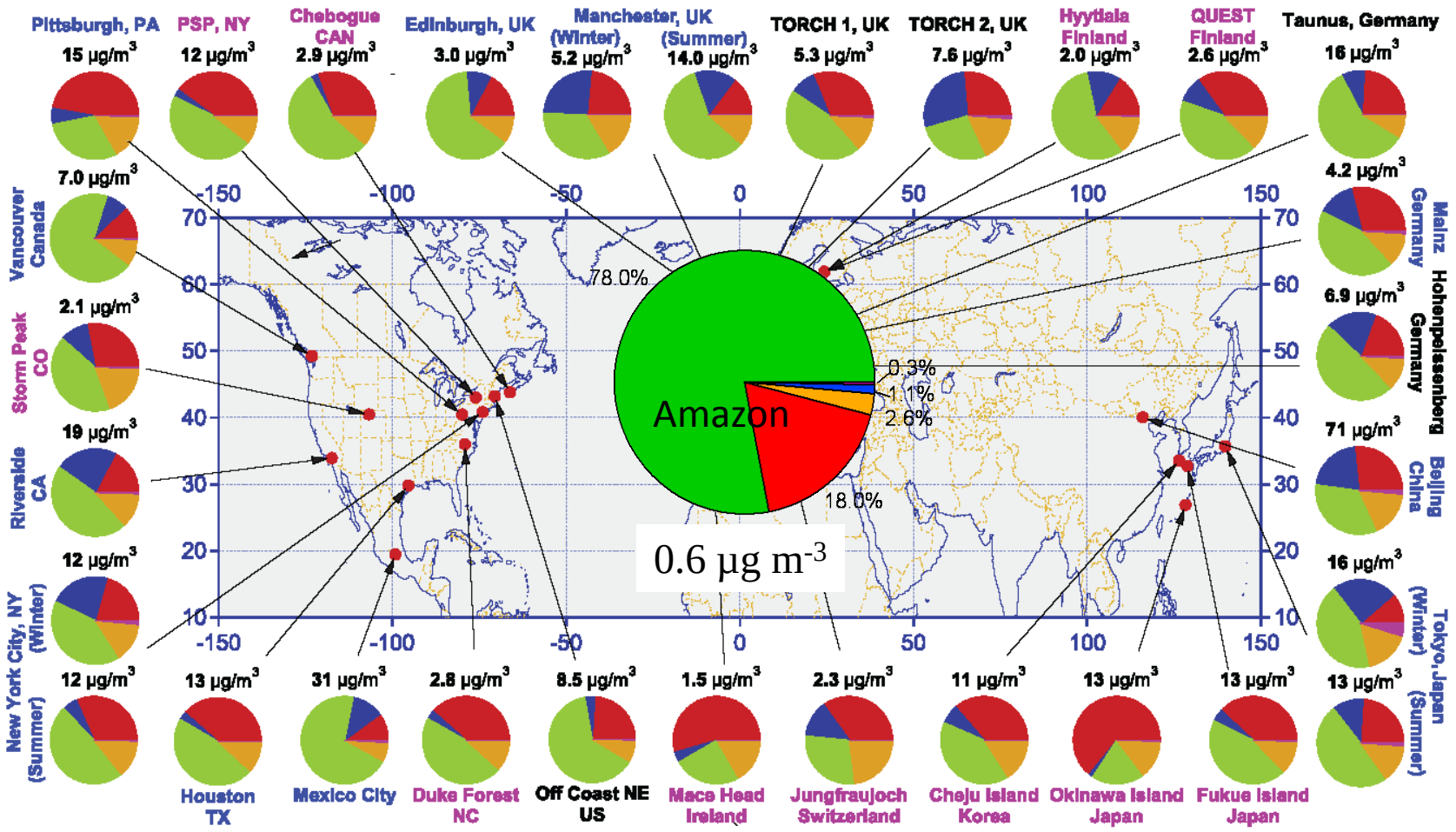
Source: Martin, S. T.; Andreae, M. O.; Artaxo, P.; Baumgardner, D.; Chen, Q.; Goldstein, A. H.; Guenther, A.; Heald, C. L.; Mayol-Bracero, O. L.; McMurry, P. H.; Pauliquevis, T.; Pöschl, U.; Prather, K. A.; Roberts, G. C.; Saleska, S. R.; Silva-Dias, M. A.; Spracklen, D. V.; Swietlicki, E.; Trebs, I., "Sources and Properties of Amazonian Aerosol Particles, " *Rev. Geophys.* **2010,** *48***,** RG2002**.**

Particle Chemistry & Physics, Circa 1750



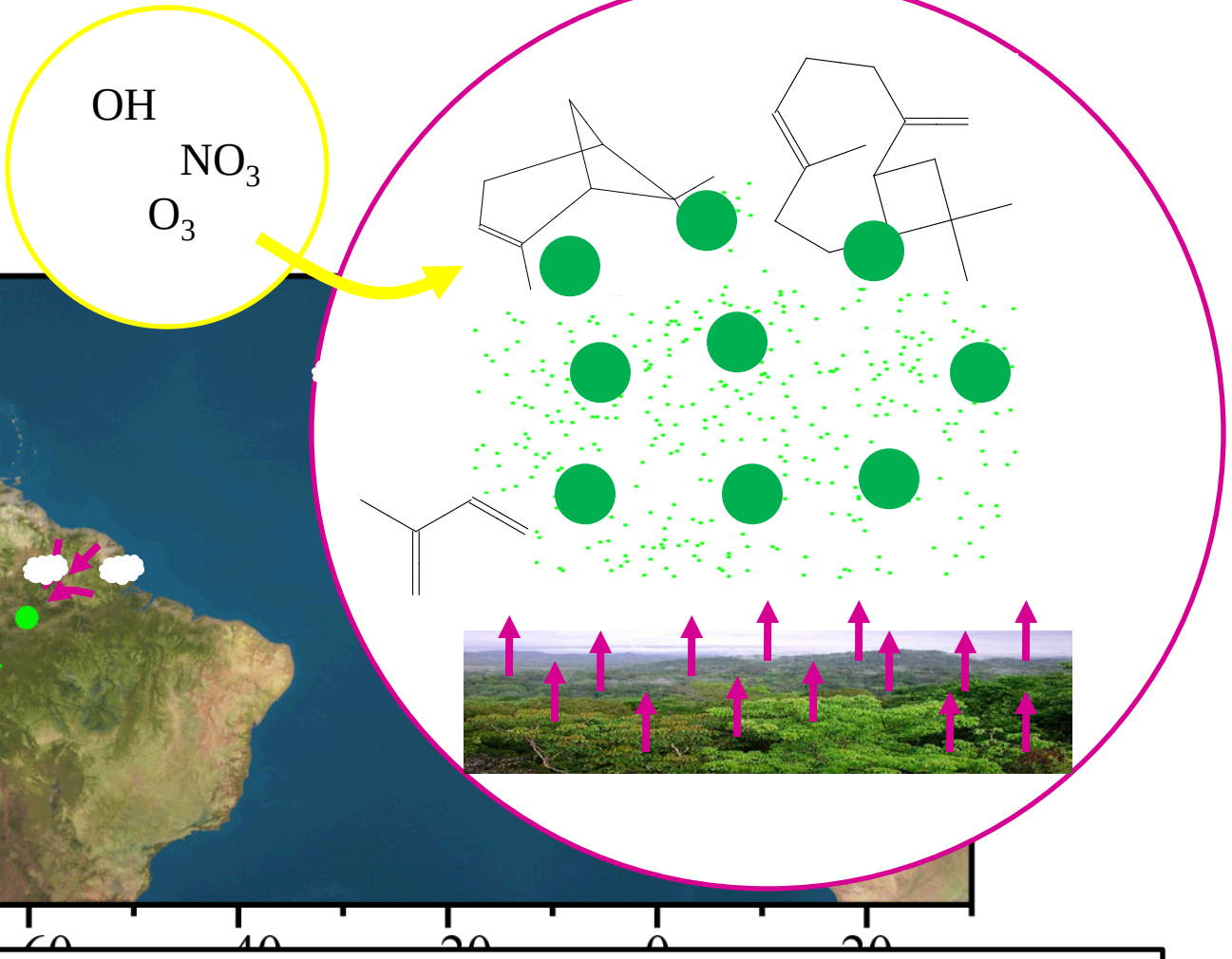
Adapted from Andreae, "Correlation between cloud condensation nuclei concentration and aerosol optical thickness in remote and polluted regions," *Atmos. Chem. Phys.*, **2009**, *9*, 543–556.

Amazon Particles Dominated by Organic Components

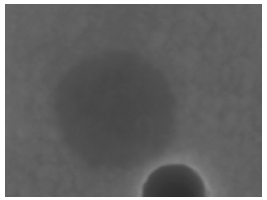


Adapted from Zhang et al., *Geophys. Res. Lett.*, 2007 and Chen et al. *Geophys. Res. Lett.*, **2009**, *36*, L20806.

AMAZE-08: *A Major Result*: Dominance of Secondary Organic Material in Submicron Particles



1. SEM



2. AMS

O:C of 0.4 to 0.5, consistent with chamber SOA particles

3. CCN

Measured CCN activity accurately predicted using $\kappa_{organic,SOA}$ from lab results

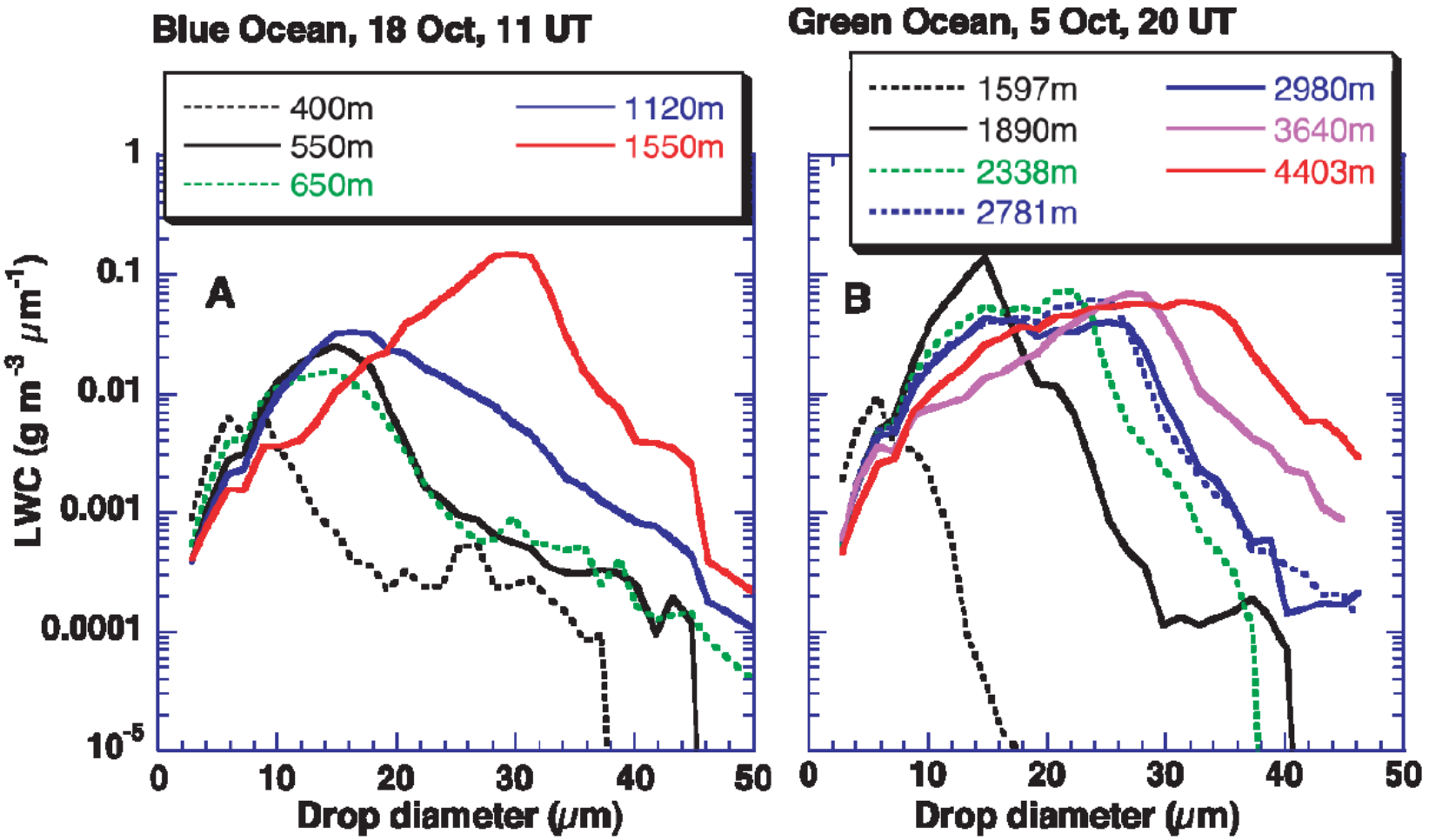
4. AMS

Similarity of measured mass spectra to those chamber SOA particles

5. AMS

Absence of features for PBAPs

Aspects of Cloud Development over this Continental Region are Similar to That over Oceans



Adapted from Andreae, M. O.; Rosenfeld, D.; Artaxo, P.; Costa, A. A.; Frank, G. P.; Longo, K. M.; Silva-Dias, M. A. F. *Science* **2004**, *303*, 1337.

Amazon Basin: Aerosol and water cycling over the pristine rainforest. SOA formed by photo-oxidation of volatile organic compounds (VOC) and PBA emitted from biota in the rainforest (serve as bi IN, which formation, deposition

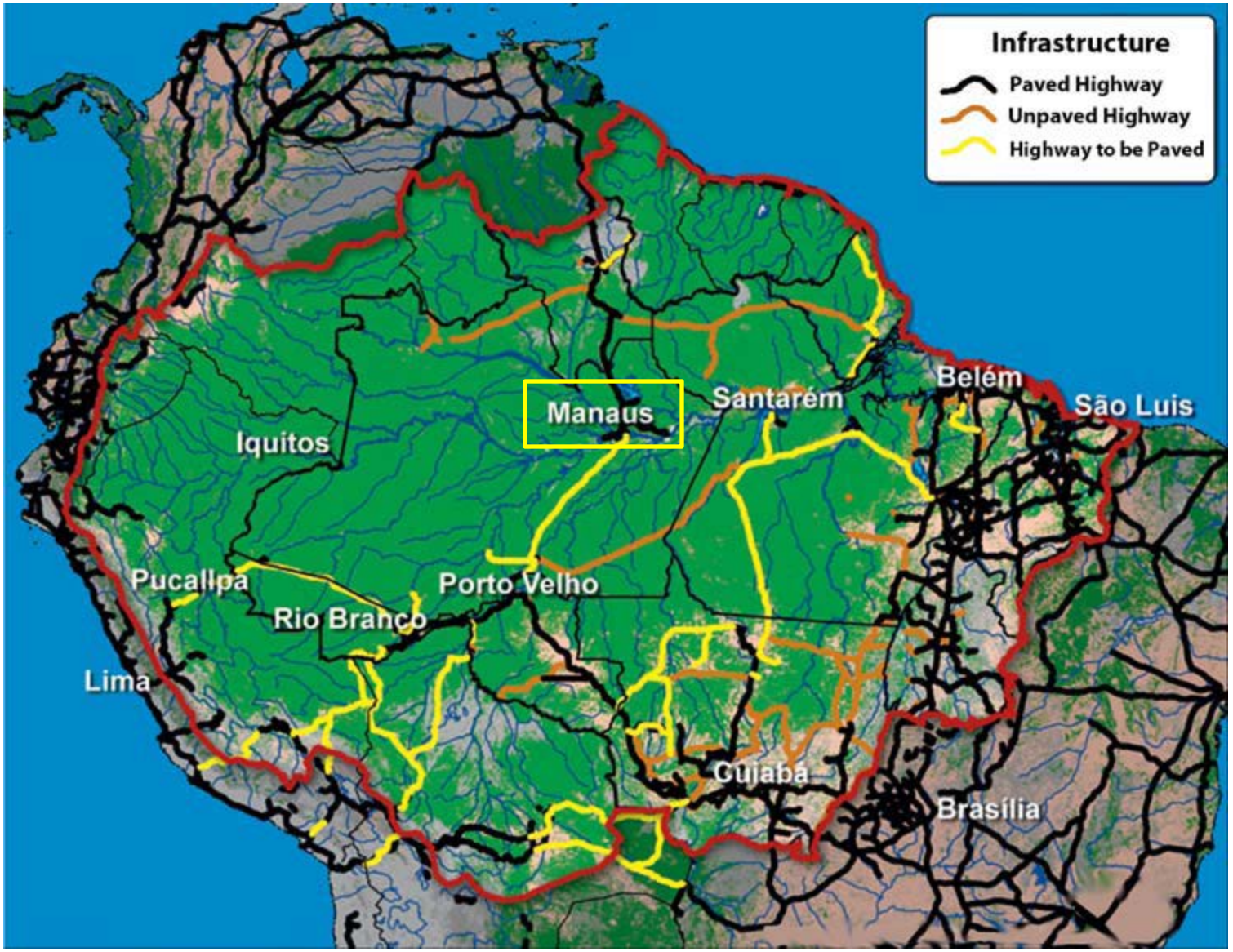
How will these aerosol and cloud life cycles, including cloud-aerosol-precipitation interactions, be influenced by pollutant outflow from the tropical megacity of Manaus?

U. Pöschl, S.T. M
J.A. Huffman, S
G. Helas, J.L. Ji
Mikhailov, T. Pa
Roldin, D. Rose
M. O. Andreae,
clouds and preci
329, 1513-1516.

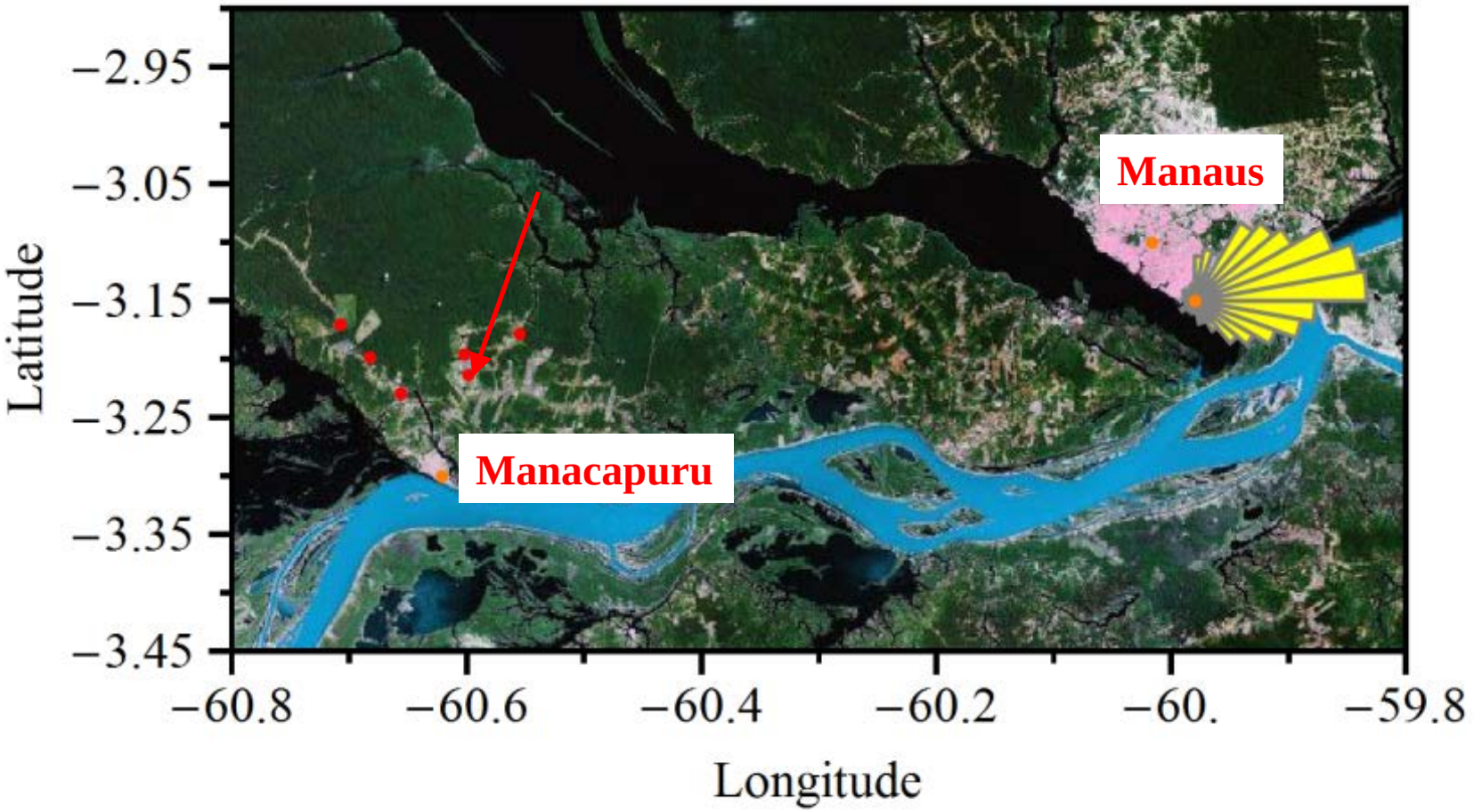
S.T. Martin, M.(
Baars, S. Borrm
S. Gunthe, J.L. J
Pauliquevis, M. Petters, A. Prenni, U. Poschl, L.V. Rizzo, J. Schneider, J.N. Smith, E. Swietlicki, J. Tota, J. Wang, A. Wiedensohler, S.R. Zorn, "An Overview of the Amazonian Aerosol Characterization Experiment 2008 (AMAZE-08)," *Atmospheric Chemistry Physics*, 2010, 10, 11415-11438.

ACRF Site Location

Site Location



Site Location: AAA Site Near Manacapuru
Large Pasture Site (LPS)



111 by 60.8 km represented by this box. Wind speeds at 1 km altitude are typically 10 to 30 kph.

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

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

Manaus Outflow Continues Across 60 km Forest

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

ACRF Instrumentation

ARM

CLIMATE RESEARCH FACILITY

The ARM Aerial Facility in Brazil

Beat Schmid, Technical Director

Pacific Northwest National Laboratory

Richland, WA

U.S. DEPARTMENT OF ENERGY | Office of Science

ARM Mobile Facility One - Typical Deployment

Van Cluster

AMF1-A1

AMF1-S4
(Workshop/spares & tools storage)

AMF1-A3
(GENSET)

AMF1-A2

Ka-W SACR

MAOS-A

MAOS-C

Instrument Field

SKYRAD

TSI/MFRSR Stand

RWP

BBSS Launcher

MWR

MWRP

MWR-HF

ECOR

MET/GNDRAD Tower

Revised March 2011

AMF1

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

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

MAOS

Mobile Aerosol Observing System (MAOS) – 2 x 20’ sea containers (MAOS-A & MAOS-C)

2 x full time post-docs (supplied by ARM)

Guest operational personnel (approx. 5)

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

Introduction to What is Already Known about Manaus Outflow

Atmos. Chem. Phys., 10, 9251–9282, 2010
www.atmos-chem-phys.net/10/9251/2010/
doi:10.5194/acp-10-9251-2010

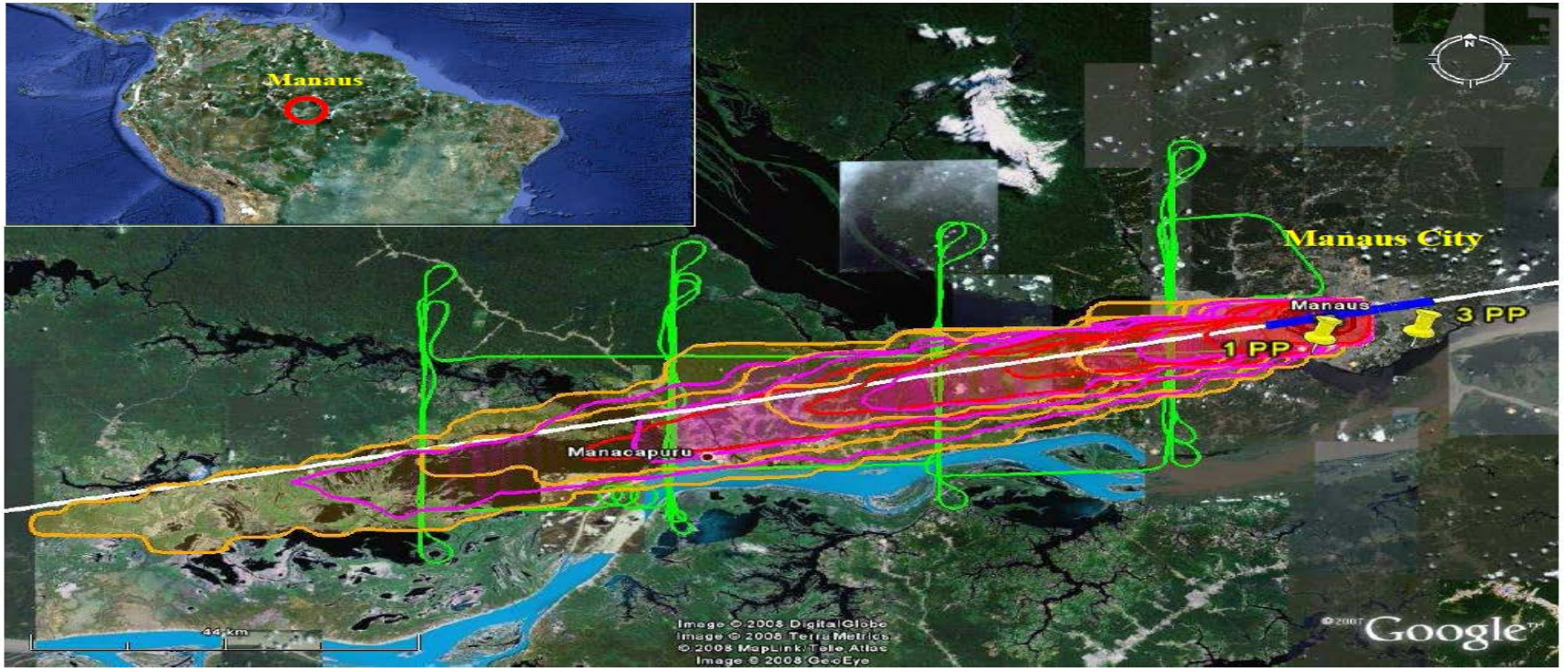
Atmospheric Chemistry and Physics

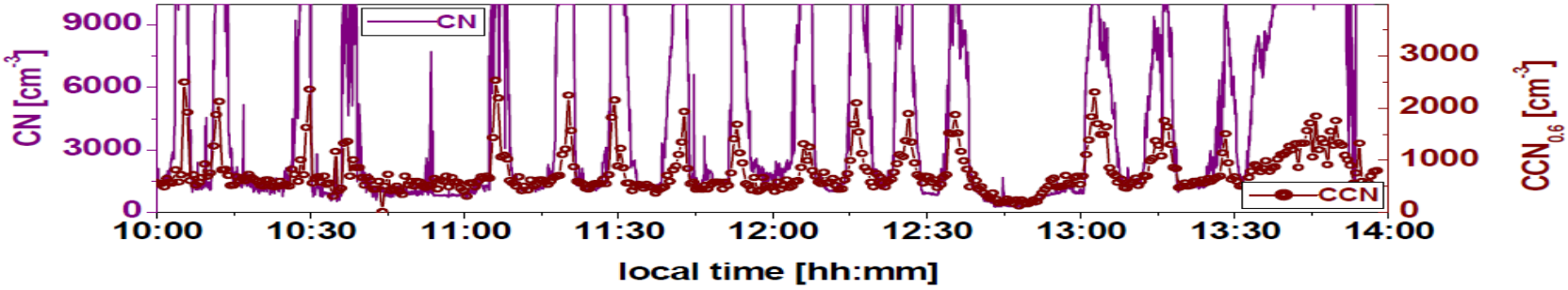
Impact of Manaus City on the Amazon Green Ocean atmosphere: ozone production, precursor sensitivity and aerosol load

U. Kuhn[1,*], L. Ganzeveld[2,], A. Thielmann[1,***], T. Dindorf[1], G. Schebeske[1], M. Welling[1], J. Sciare[1,****], G. Roberts[1,*****], F. X. Meixner[1,8], J. Kesselmeier[1], J. Lelieveld[2], O. Kolle[3], P. Ciccioli[4], J. Lloyd[5], J. Trentmann[6,******], P. Artaxo[7], and M. O. Andreae[1]**

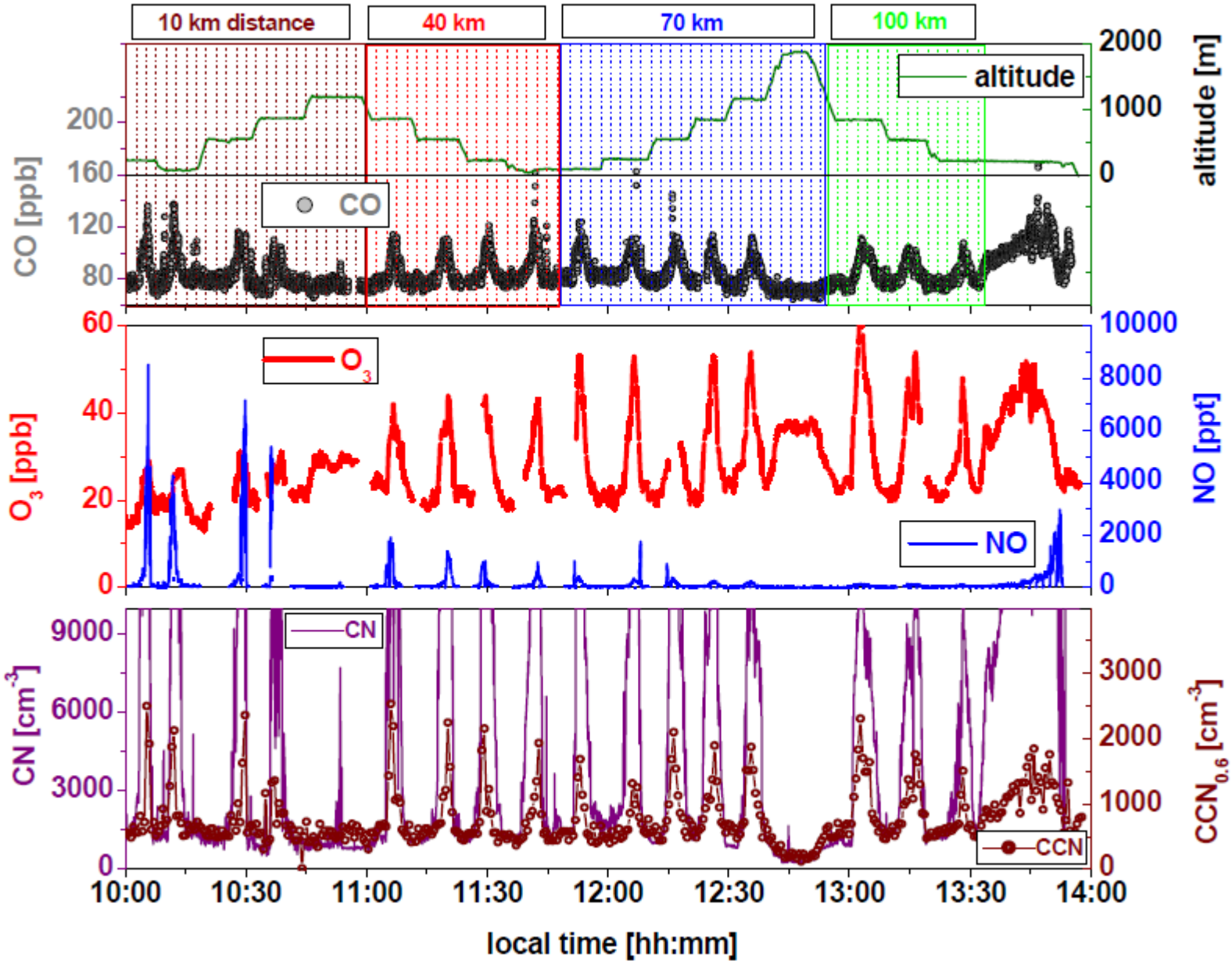
[1]Max Planck Institute for Chemistry, Biogeochemistry Dept., Mainz, Germany
[2]Max Planck Institute for Chemistry, Atmospheric Chemistry Dept., Mainz, Germany
[3]Max Planck Institute for Biogeochemistry, Jena, Germany

Interests for ACRF Deployment in Amazon Basin: Megacity Outflow in the Tropics: Climate and Pollution Effects





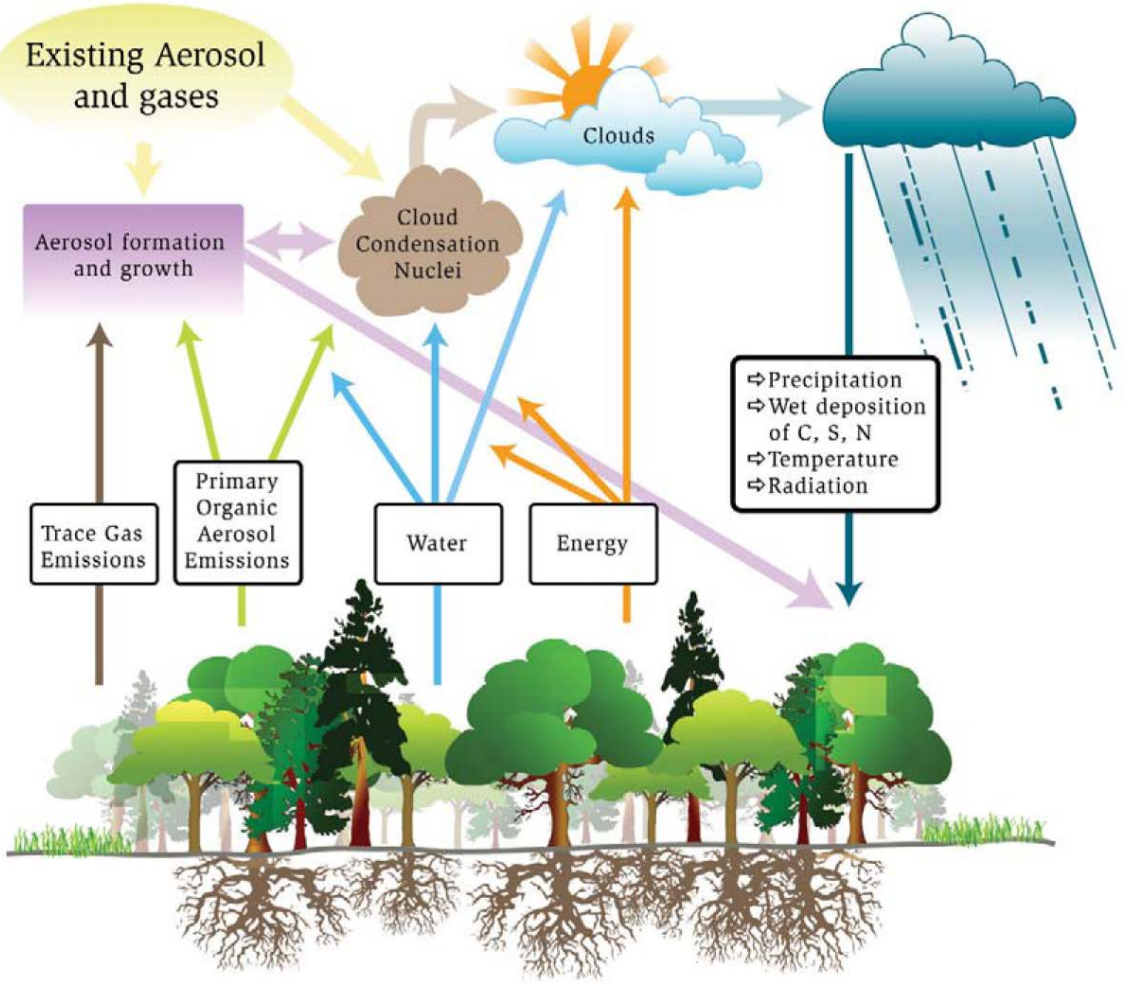
Reference: Kuhn, U.; Ganzeveld, L.; Thielmann, A.; Dindorf, T.; Welling, M.; Sciare, J.; Roberts, G.; Meixner, F. X.; Kesselmeier, J.; Lelieveld, J.; Ciccioli, P.; Kolle, O.; Lloyd, J.; Trentmann, J.; Artaxo, P.; Andreae, M. O., "Impact of Manaus City on the Amazon Green Ocean atmosphere: Ozone production,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


10 km distance
40 km
70 km
100 km
altitude
altitude [m]
CO
CO [ppb]
O3
O3 [ppb]
NO
NO [ppt]
CN
CN [cm-3]
CCN
CCN0.6 [cm-3]
local time [hh:mm]
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00

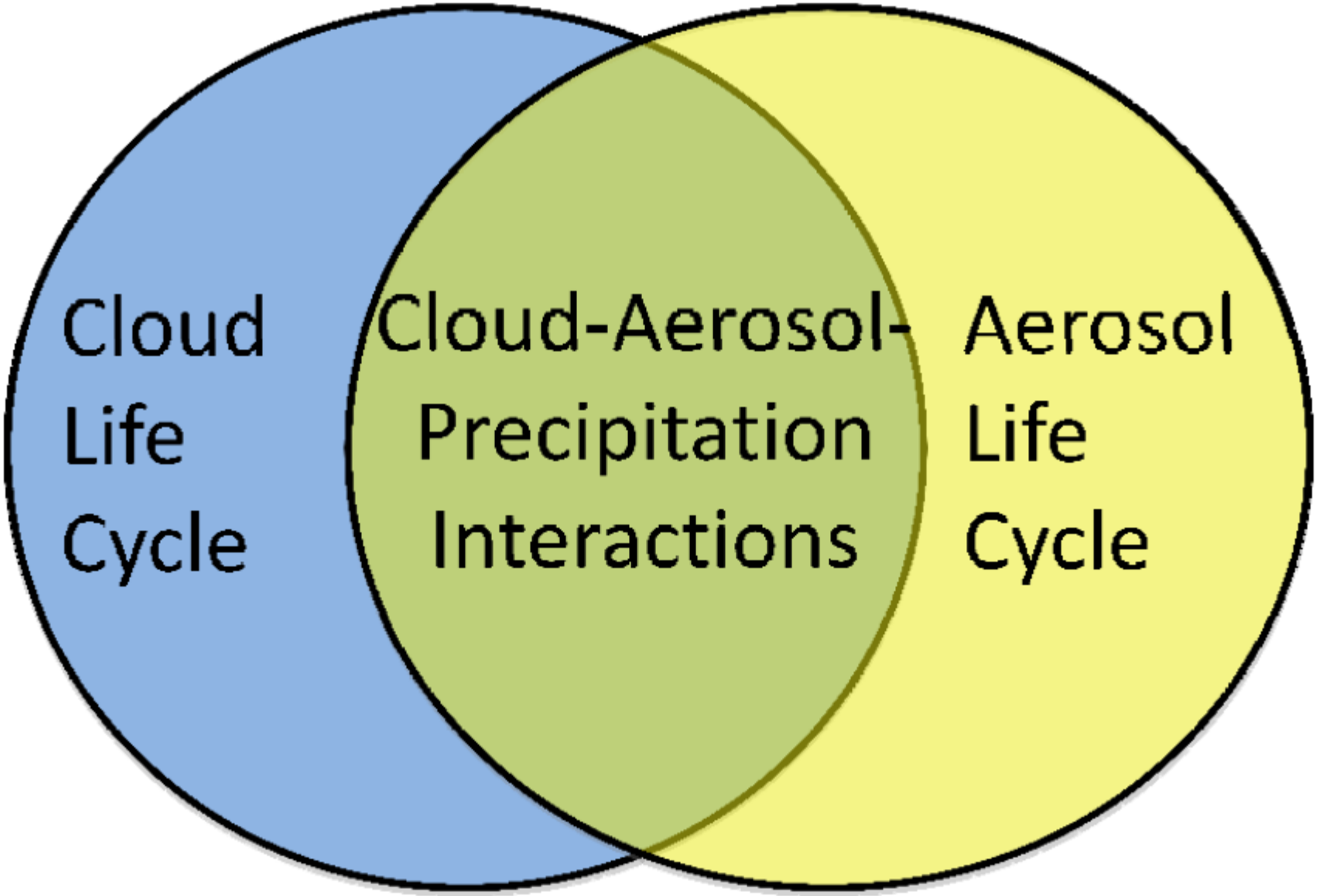
This is the most important slide of today's presentation: **Building Team**

What to Accomplish in Break Out Session: *Spinning Up Scientific Planning* ($$)

Aerosol Particles:
Coupling of Terrestrial Ecosystems and the Hydrologic Cycle
Energy and Water Exchange and Processing



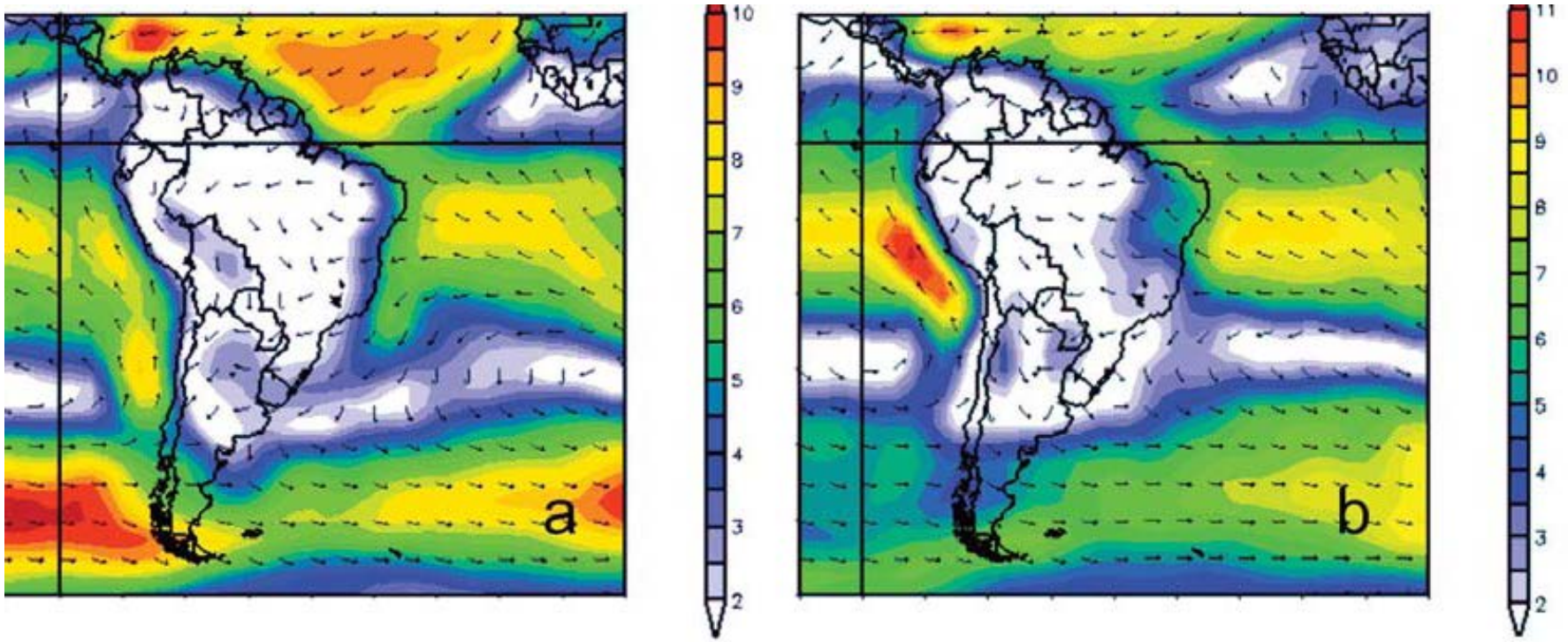
Adapted from Fig.1 of Barth et al., *BAMS*, *86*, 1738-1742, 2005.


Cloud
Life
Cycle
Cloud-Aerosol-
Precipitation
Interactions
Aerosol
Life
Cycle

Breakout session: ARM Climate Research Facility in the Amazon Basin Atmospheric System Research Science Team Meeting Tuesday, March 29, 1:30-3:30PM		
1:30-1:50	Overview of the ACRF deployment in the Amazon basin, including reports from recent scouting trips	Scot Martin
1:50-2:10	Background and scientific objectives: Aerosol Life Cycle	Jian Wang and Larry Kleinman
2:10-2:30	Background and scientific objectives: Cloud Life Cycle	Tom Ackerman and Mark Miller
2:30-2:50	Background and scientific objectives: Cloud-Aerosol-Precipitation Interactions	Graham Feingold and Jiwen Fan
2:50-3:30	Discussions, including further involvement of the scientific community and potential support from other agencies	

Join the google group:
http://groups.google.com/group/acrfmanaus2014

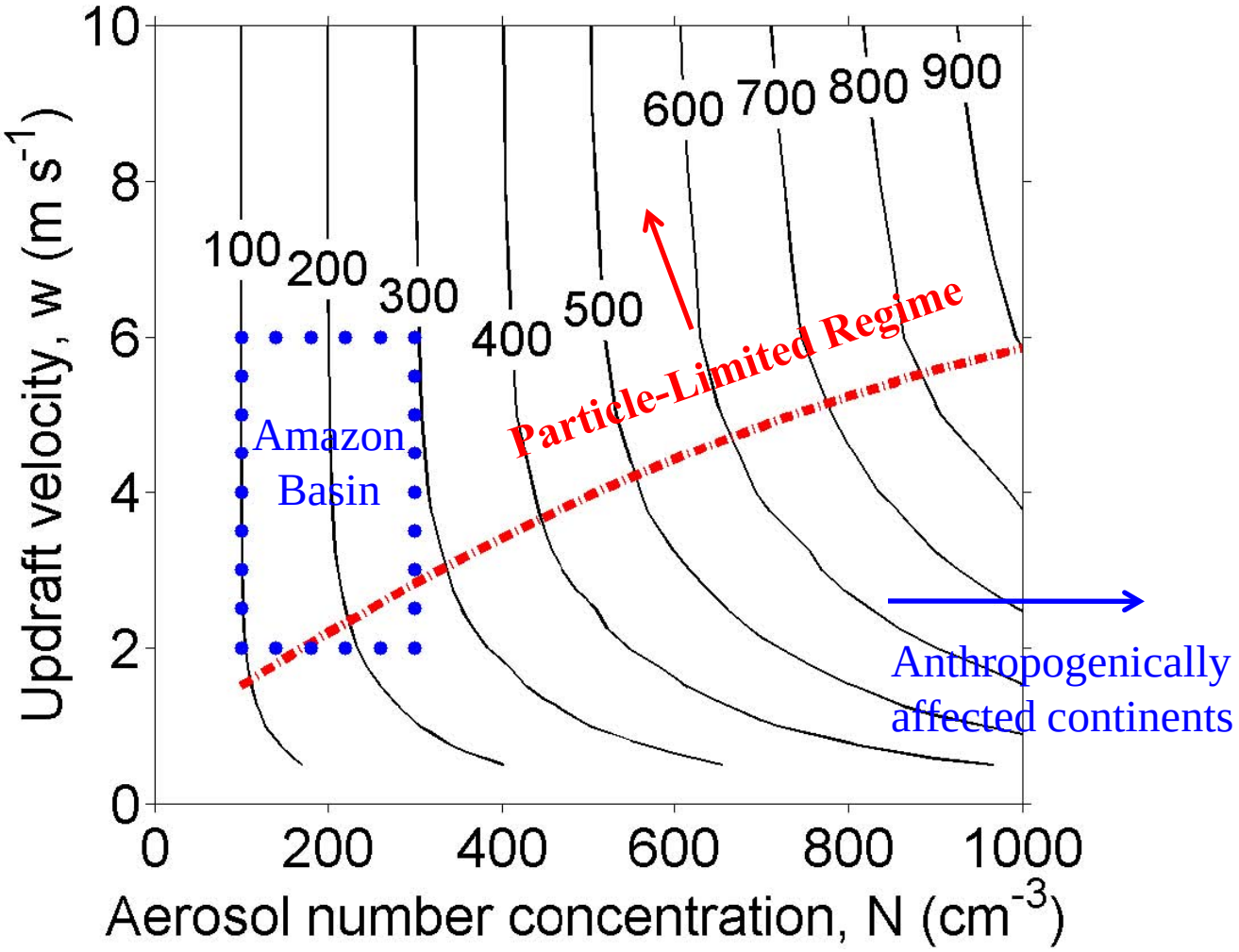
STOP



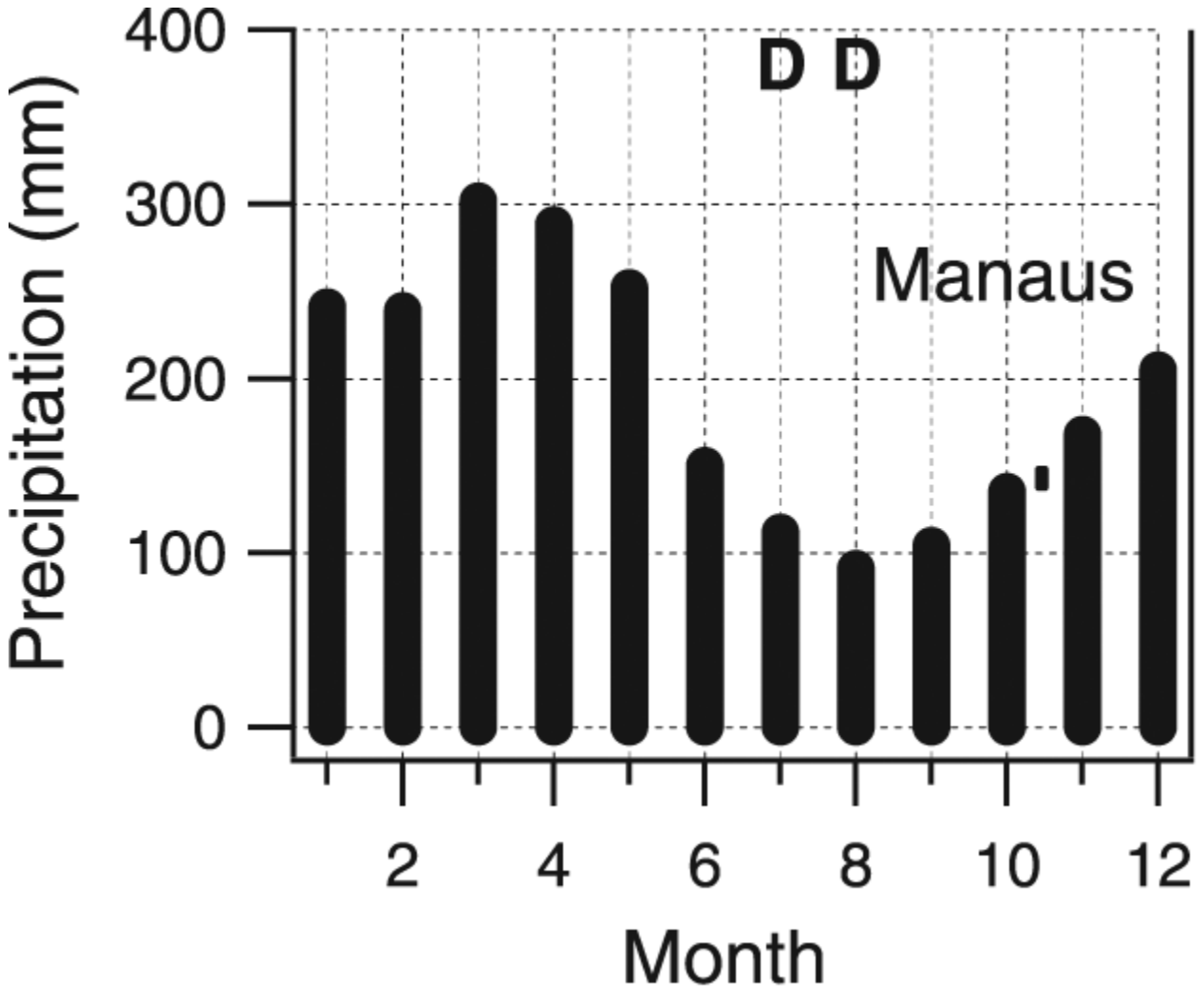
Source: Martin, S. T.; Andreae, M. O.; Artaxo, P.; Baumgardner, D.; Chen, Q.; Goldstein, A. H.; Guenther, A.; Heald, C. L.; Mayol-Bracero, O. L.; McMurry, P. H.; Pauliquevis, T.; Pöschl, U.; Prather, K. A.; Roberts, G. C.; Saleska, S. R.; Silva-Dias, M. A.; Spracklen, D. V.; Swietlicki, E.; Trebs, I., "Sources and Properties of Amazonian Aerosol Particles, " *Rev. Geophys.* **2010,** *48***,** RG2002**.**

Cloud Droplet Number Concentration (CDNC):

Sensitivity to Pollution in Pristine Regions



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


Precipitation (mm)
400
300
200
100
0
D D
Manaus
2
4
6
8
10
12
Month