Tropical Cloud Process and Sensitivities to Environmental Conditions

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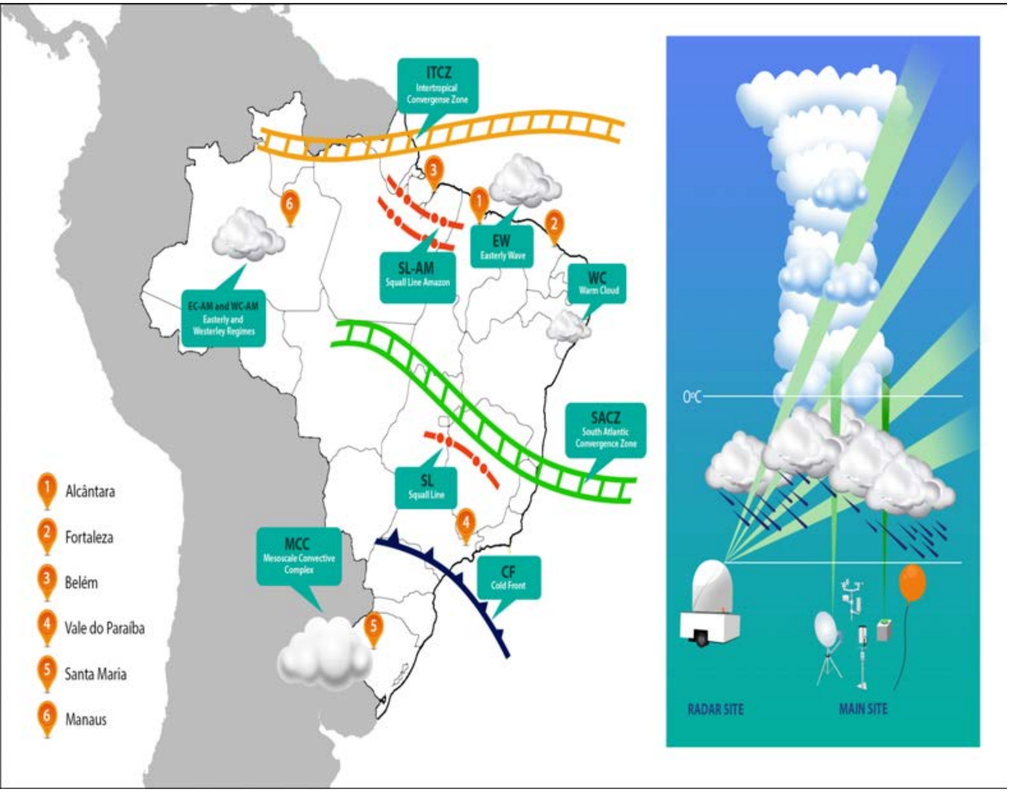
Outline



Cloud-Precipitation-Aerosol Interaction: Some results from GoAmazon – ACRIDICON-CHUVA

Aerosol- Effects

Microphysics

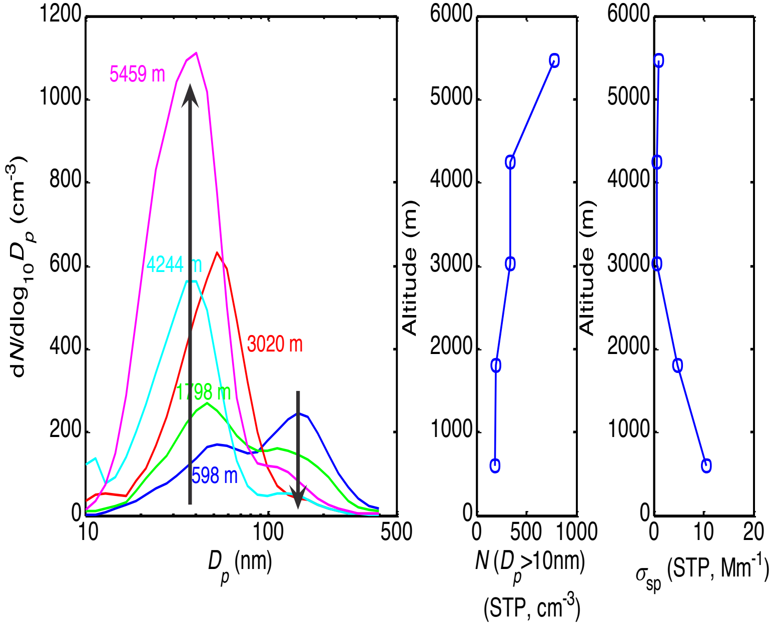
Gamma Space

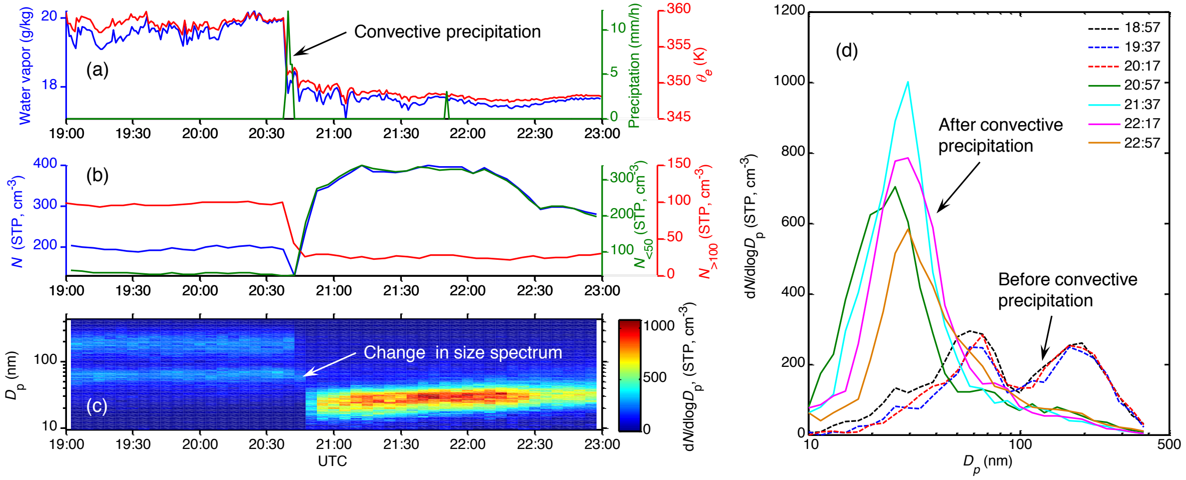
GOAMAZON 2014-2015

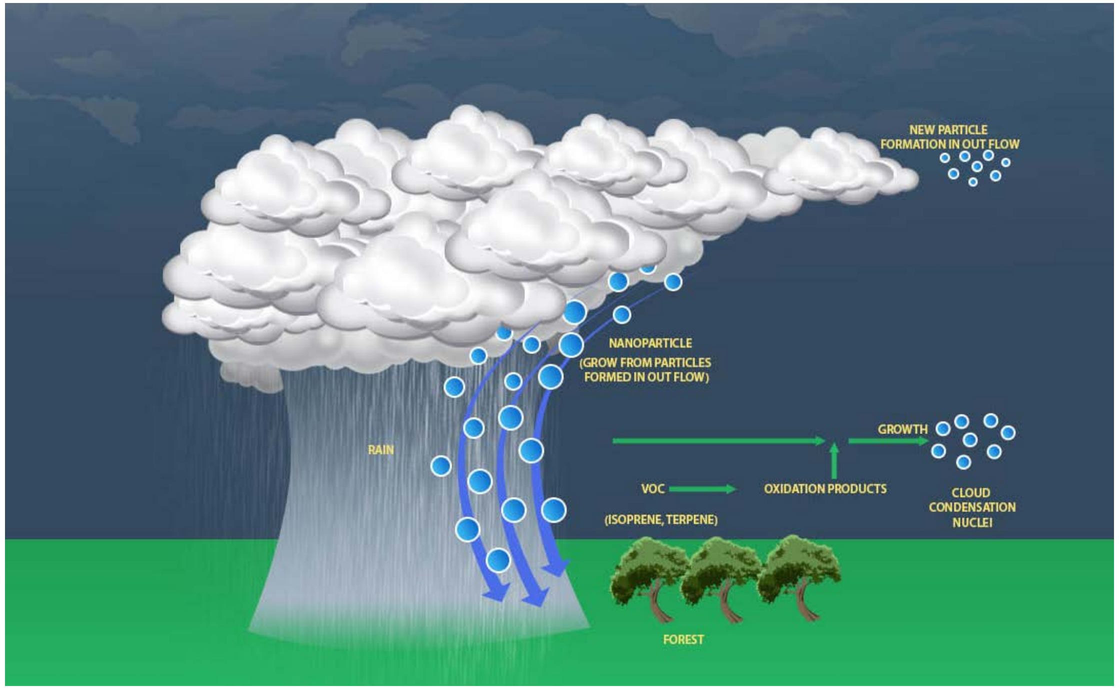
GoAmazon – ACRIDICON-CHUVA

ACRIDICON - CHUVA Manaus 2014

PROJETO CHUVA







Deep convections sustain aerosol concentration in Amazon atmosphere by *Jian Wang, Radovan Krejci, Scott Giangrande, Chongai Kuang, Hanna E. Manninen, Henrique M. J. Barbosa, Joel Brito, Jennifer Comstock, Mira Krüger, Jost Lavric, Karla Longo, Antonio O. Manzi, Fan Mei, Christopher Pöhlker, Beat Schmid, Rodrigo A. F. Souza, Steven Springston, Jason Tomlinson, David Walter, Daniela Wimmer, Jim Smith, Markku Kulmala, Luiz A. T. Machado, Paulo Artaxo, Meinrat Andreae, Scot Martin, Tuukka Petaja –* ***Nature 2016***

Transverse Transects of Urban Plume

500 m
11 AM local
13 March 2014

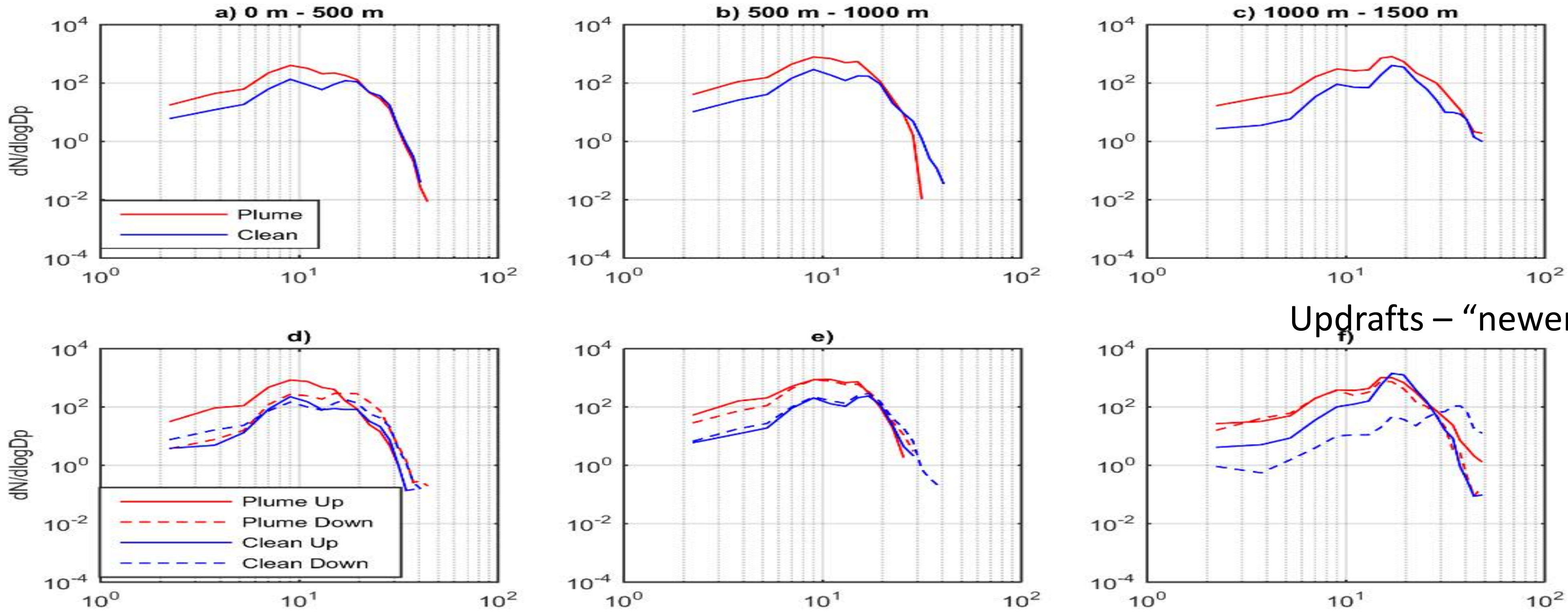
Rain

CDNC

CCN

CN

Wet Season - Nearly the same Thermodynamics Characteristics

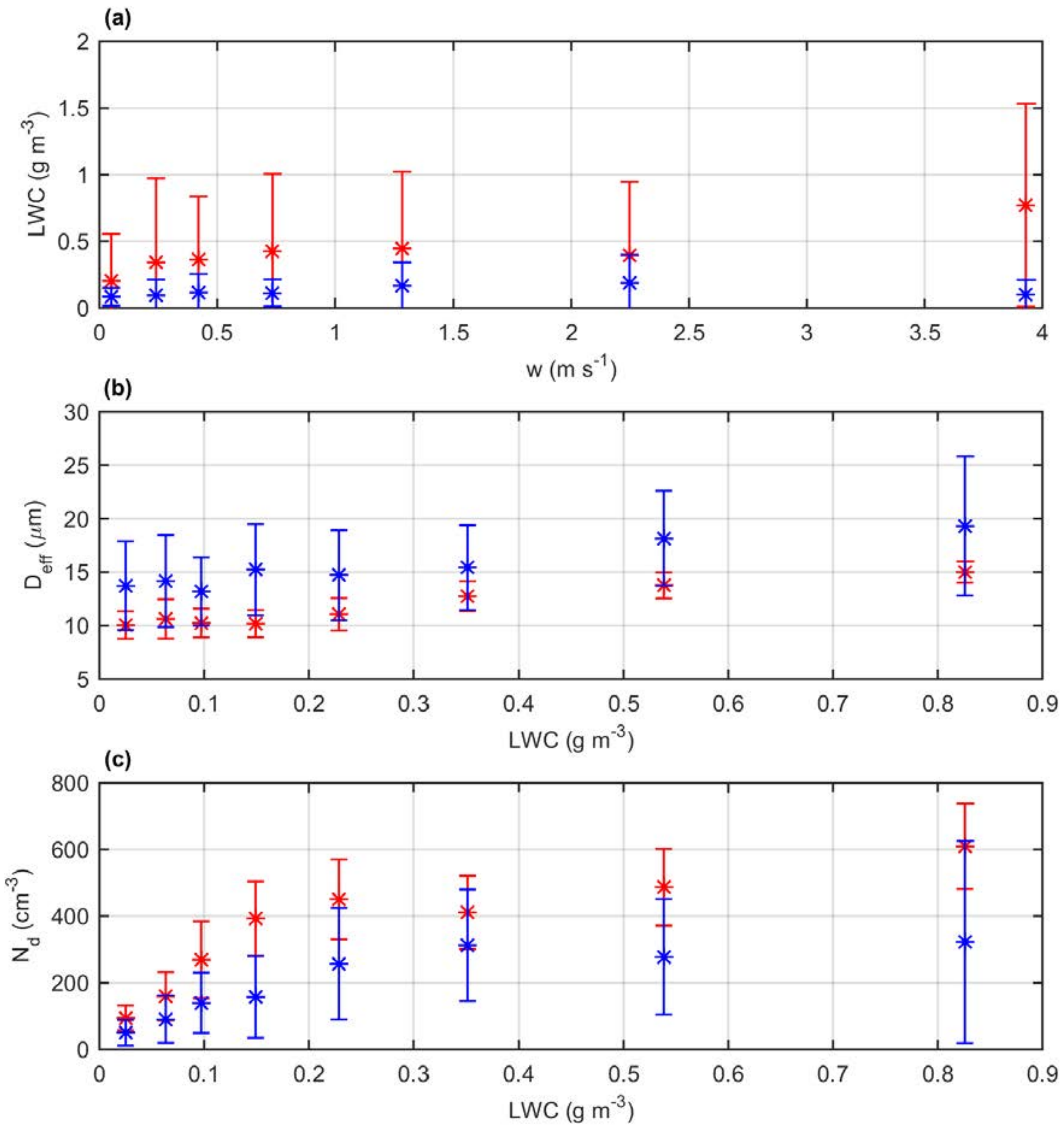


Updrafts – “newer droplets”

Downdrafts – “more processed”

DSDs for plume (red) or clean (blue) conditions as a function of altitude. Graphs a)-c) shows the mean DSDs in absolute number concentrations (cm^{-3}). d)-f) shows the mean DSDs for up- (*w*>1.5 m/s) and downdraft (*w*<-1.5 m/s) regions in cm^{-3}

Manaus’ pollution plume impacts on cloud microphysical properties. Micael A. Cecchini[1], Luiz A.T. Machado[1], Jennifer M. Comstock[2], Fan Mei[2], John Schiling[2], Jian Wang[2], Jiwen Fan[2], Jason M. Tomlinson[2], Beat Schmid[2], Scot T. Martin[3]; Atmos. Chem. Phys. 2016



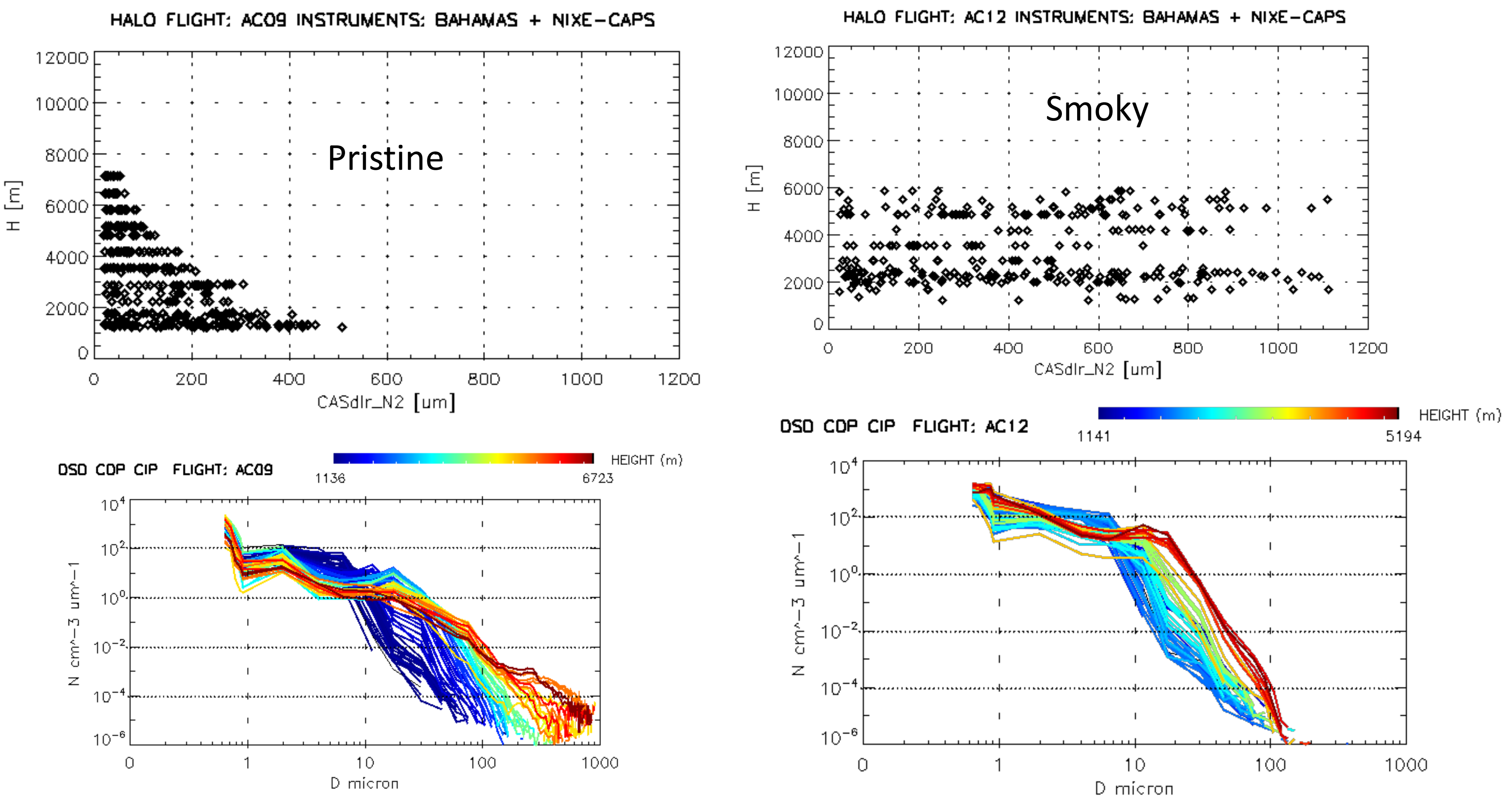
w

Effect of pollution on bulk water amount

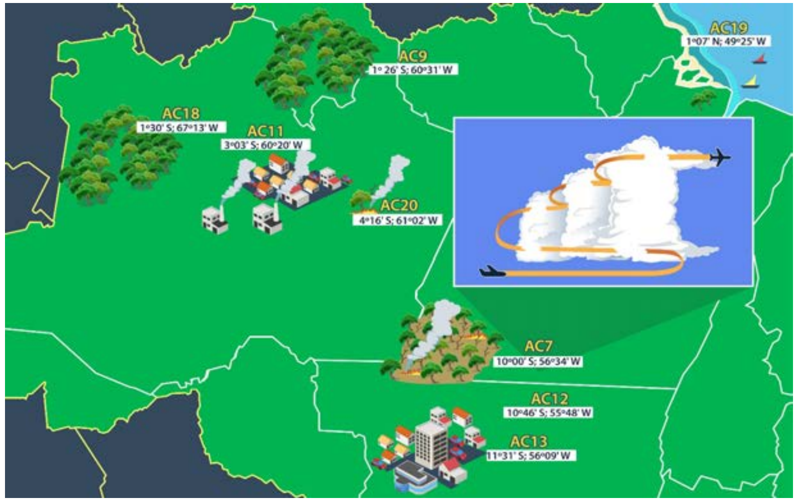
LWC

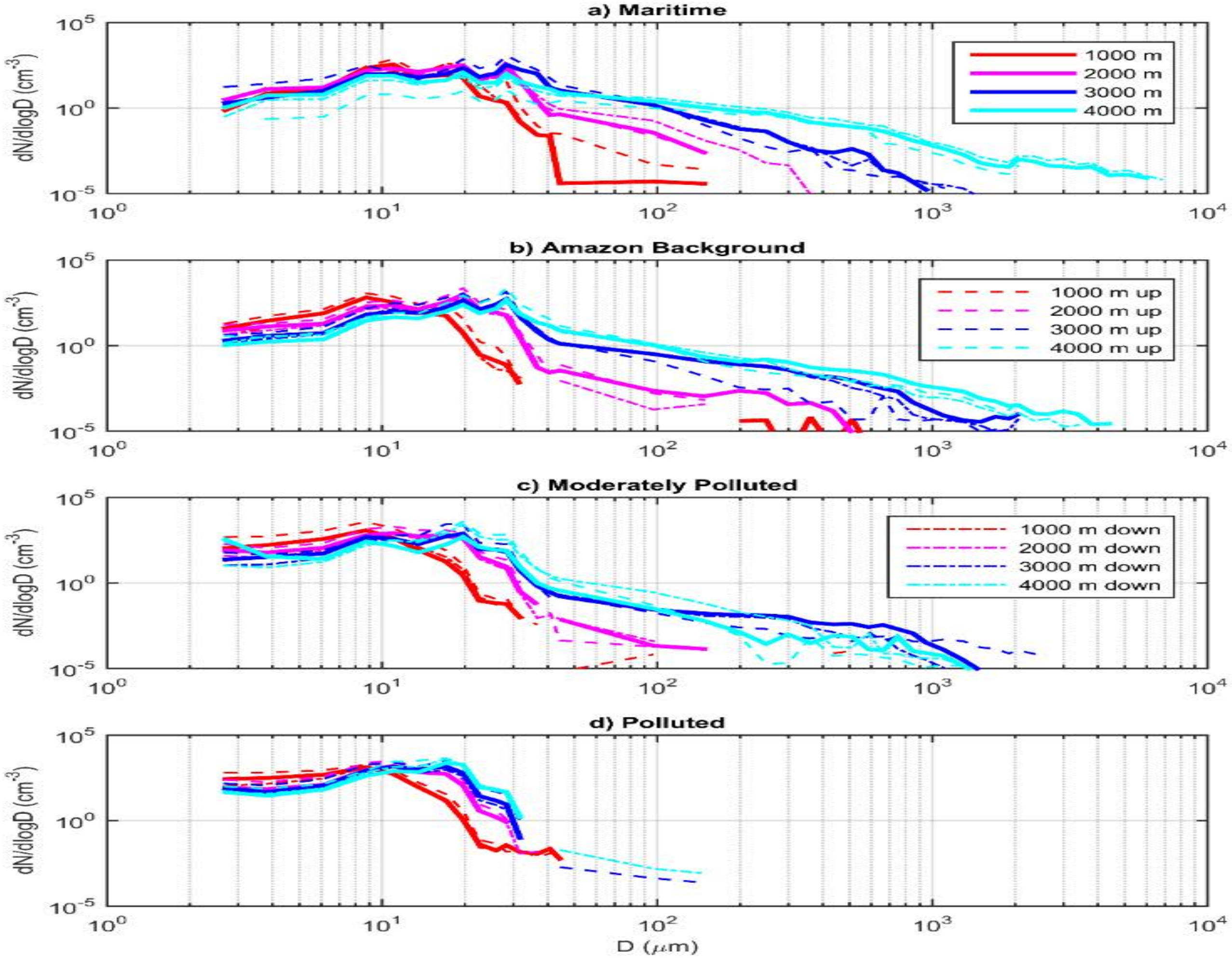
Water vapor competition

LWC



The ACRIDICON–CHUVA campaign to study tropical deep convective clouds and precipitation using the new German research aircraft HALO by Manfred Wendisch, Ulrich P¨oschl, Meinrat O. Andreae , Luiz A. T. Machado , Rachel Albrecht, Hans Schlager k, Daniel Rosenfeld et al. - Bulletin of American Met. Soc. 2016





Sensitivities of Amazonian clouds to aerosols and updraft speed. Micael A. Cecchini[1], Luiz A. T. Machado[1], Meinrat O. Andreae[2,12], Scot T. Martin[3], Rachel I. Albrecht[4], Paulo Artaxo[5], Henrique M. J. Barbosa[5], Stephan Borrmann[2,6], Daniel Fütterer[7], Tina Jurkat[7], Christoph Mahnke[2,6], Andreas Minikin[8], Sergej Molleker[6], Mira L. Pöhlker[2], Ulrich Pöschl[2], Daniel Rosenfeld[9], Christiane Voigt[6,7], Bernadett Weinzierl[7,10], Manfred Wendisch. Atmos. Chem. Phys. Disc. 2017

Rainfall and Cloud Microphysics as Function of the Aerosol

Several Halo Cloud Profiles
(AC 7,8,9,11,12,13,14,18,19,20)
Only bellow melting layer

$$dlnD_0 \propto \left.\frac{dlnD_0}{dlnCN}\right|_{w,H} + \left.\frac{dlnD_0}{dlnw}\right|_{CN,H} + \left.\frac{dlnD_0}{dlnH}\right|_{CN,w}$$

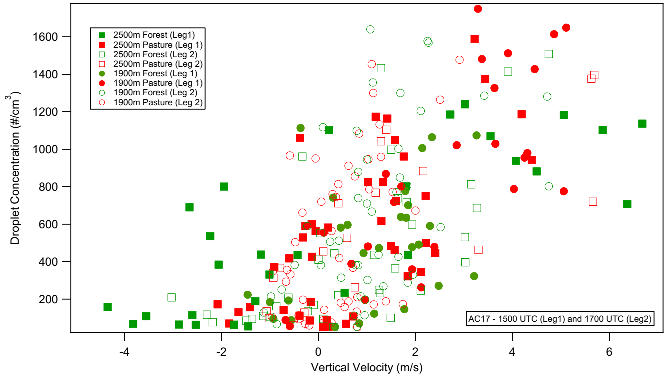
Cloud Droplet Concentration — Cloud Droplet Diameter

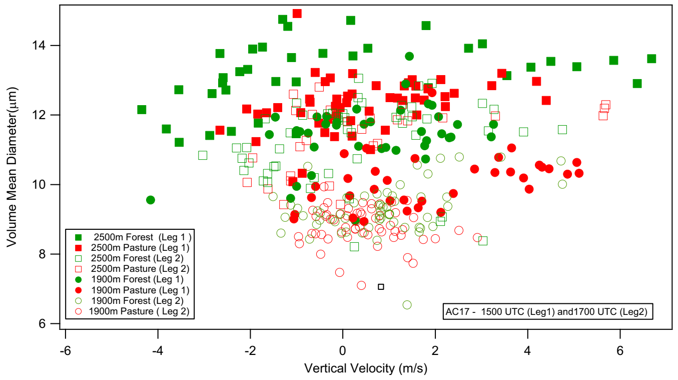
	$\overline{S_{N_d}}$ (Cloud Droplet Concentration)	$\overline{S_{D_{eff}}}$ (Cloud Droplet Diameter)
N_a (Aerosol Concentration)	0.83 ± 0.21 R^2 = 0.91	-0.26 ± 0.074 R^2 = 0.89
w (Vertical Motion)	0.43 ± 0.28 R^2 = 0.81	0.03 ± 0.05 R^2 = 0.46
H (Height inside the cloud)	-0.14 ± 0.16 R^2 = 0.38	0.27 ± 0.05 R^2 = 0.93

Vertical bars indicate which variables are considered constant in the derivatives.

The first term on the right hand side represents the variations observed in the mean volumetric diameter due to changes in Aerosol Concentration with similar w and H conditions.

As the derivatives are considered under the natural logarithm, the results are normalized and can be directly quantitatively compared.





HALO Flight AC17 Forest – Deforested areas – same level nearly same time. Cloud droplet concentration and diameter as function the vertical velocity at different Height

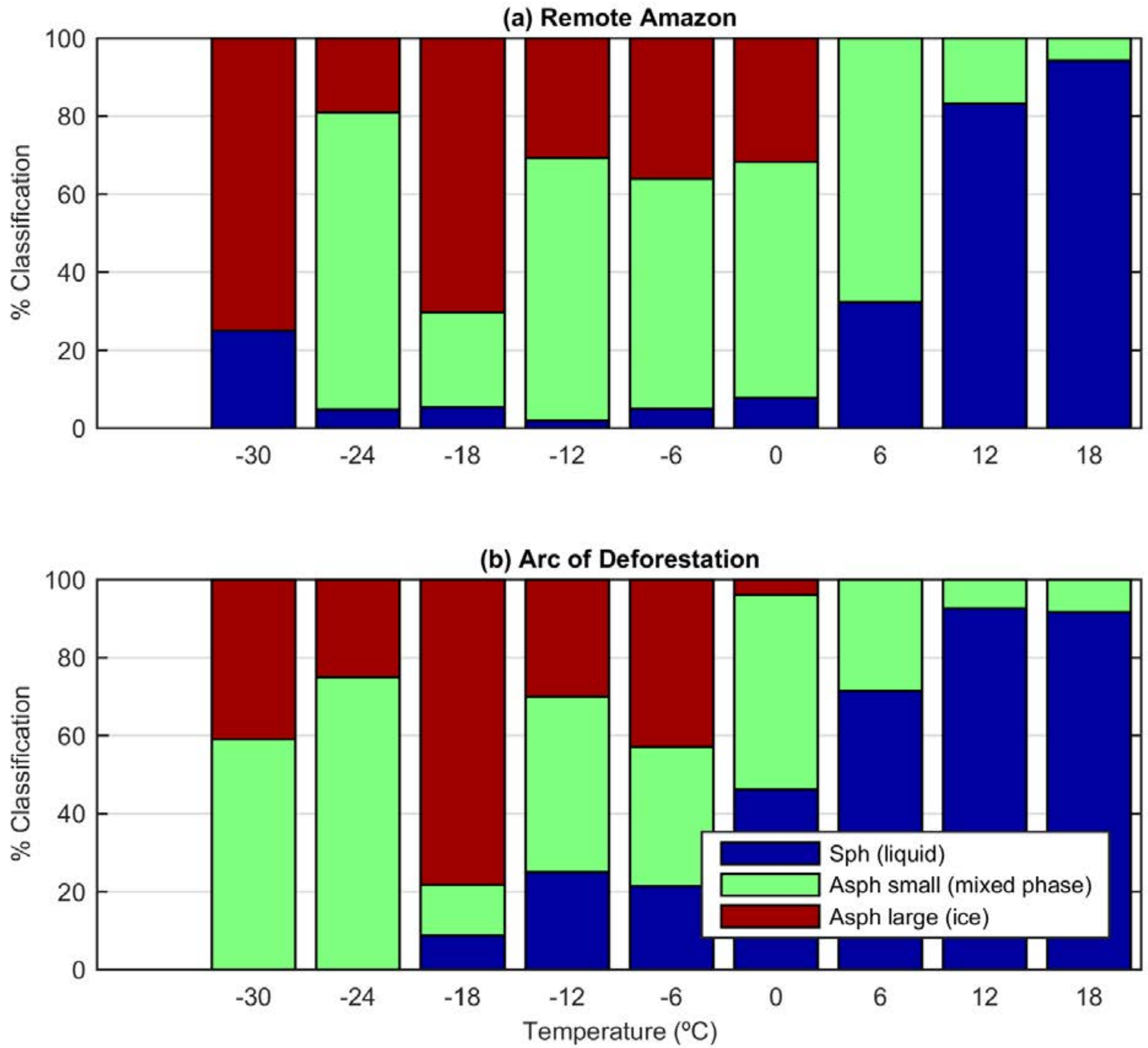
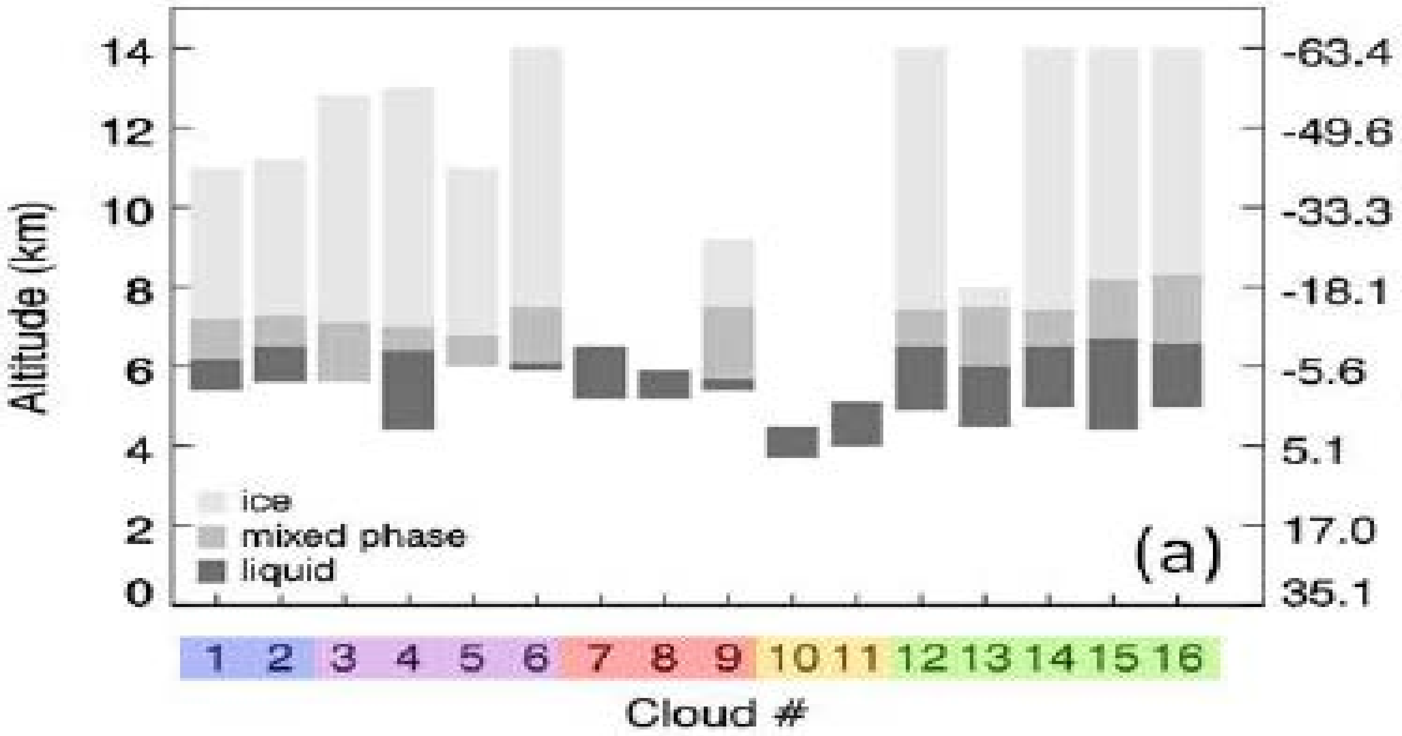
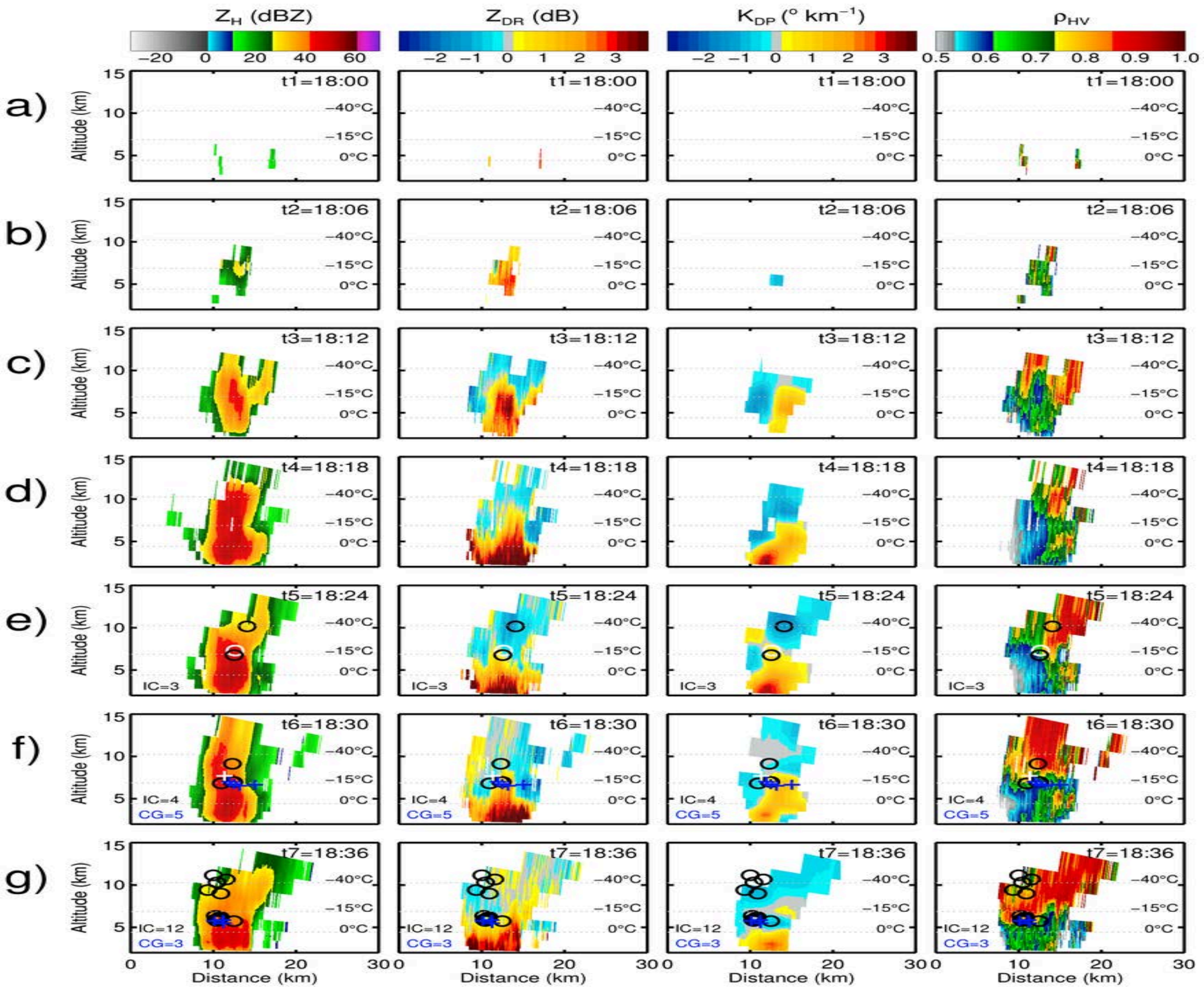
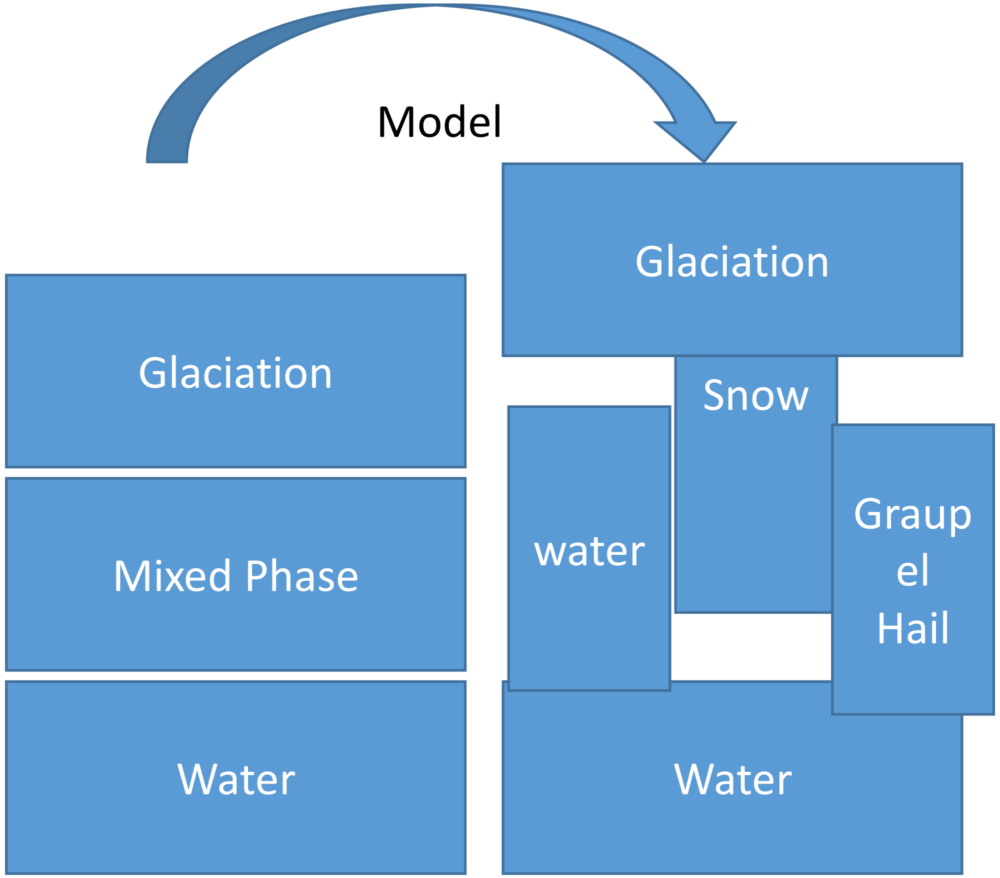


Illustration of microphysical processes in Amazonian deep convective clouds in the Gamma phase space: Introduction and potential applications. Micael A. Cecchini[1], Luiz A. T. Machado[1], Manfred Wendisch[2], Anja Costa[3], Martina Krämer[3], Meinrat O. Andreae[4,5], Armin Afchine[3], Rachel I. Albrecht[6], Paulo Artaxo[7], Stephan Borrmann[4,8], Daniel Fütterer[9], Thomas Klimach[4], Christoph Mahnke[4,8], Scot T. Martin[10], Andreas Minikin[11], Sergej Molleker[8], Lianet H. Pardo[1], Christopher Pöhlker[4], Mira L. Pöhlker[4], Ulrich Pöschl[4], Daniel Rosenfeld[12], Bernadett Weinzierl. Atmosp. Chem. Phys. Discussion., 2017.

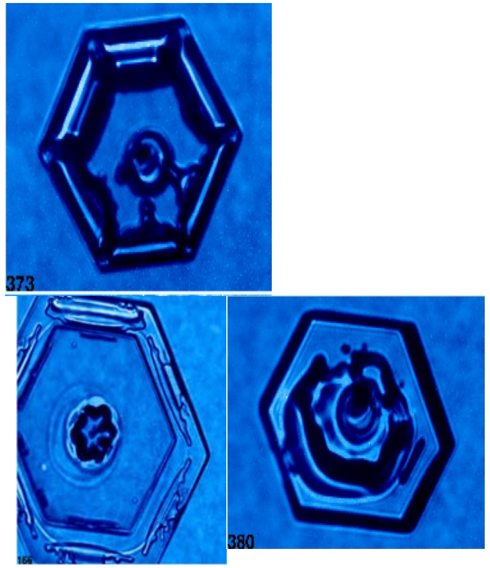


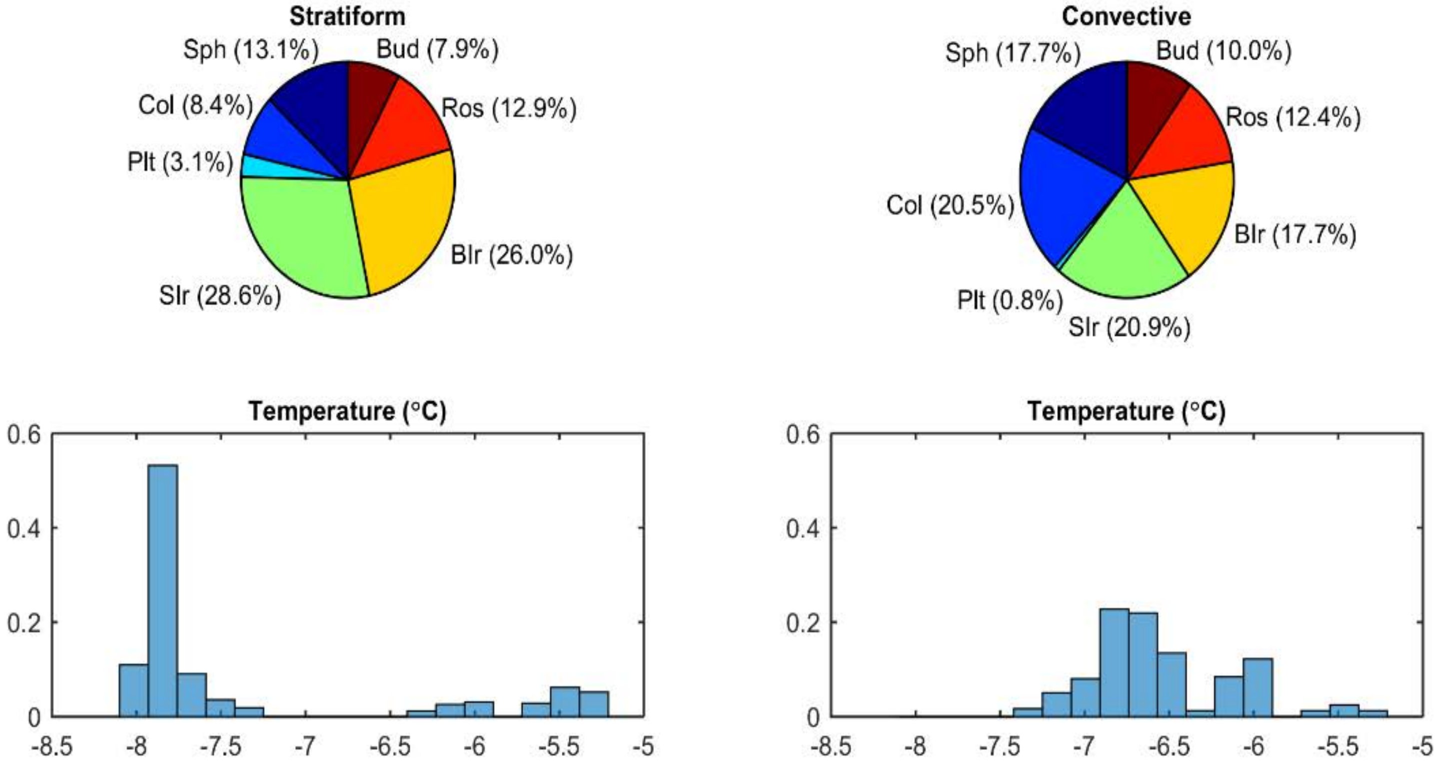
Vertical distribution of the phase state of particles in tropical deep-convective clouds as derived from cloud-side reflected solar radiation measurements. Evelyn Jäkel1, Manfred Wendisch1, Trismono C. Krisna1, Florian Ewald2,3, Tobias Kölling2, Tina Jurkat3, Christiane Voigt3, Micael A. Cecchini4, Luiz A. T. Machado, Armin Afchine5, Anja Costa5, Martina Krämer5, Meinrat O. Andreae6,7, Ulrich Pöschl6, Daniel Rosenfeld8, and Tianle Yuan. ACPD 2017

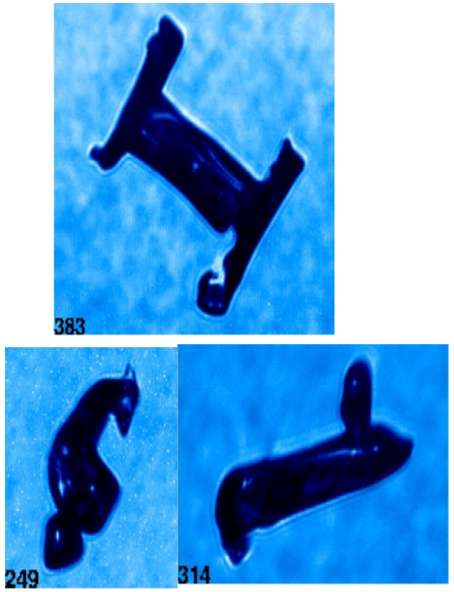




Electrification Life Cycle of Incipient Thunderstorms by Mattos, Enrique V., Luiz. A. T. Machado, Earle R. Williams, Steven J. Goodman, Richard J. Blakeslee, Jeffrey Bailey.. Journal Geoph. Res., 2017.







Frequency of occurrence of different ice crystals types for stratiform and convective clouds near Manaus. Histograms show the respective dispersion of the temperature of the measurements. Crystal types considered are: 1) Sph: spheroids, 2) Col: columns, 3) Plt: plates, 4) Sir: small irregular (<200µm), 5) BIr: big irregular (>200µm), 6) Ros: rosette and 7) Bud: budding rosette.

You may also want to include some of the actual images of the crystals that were observed under diferente conditions.

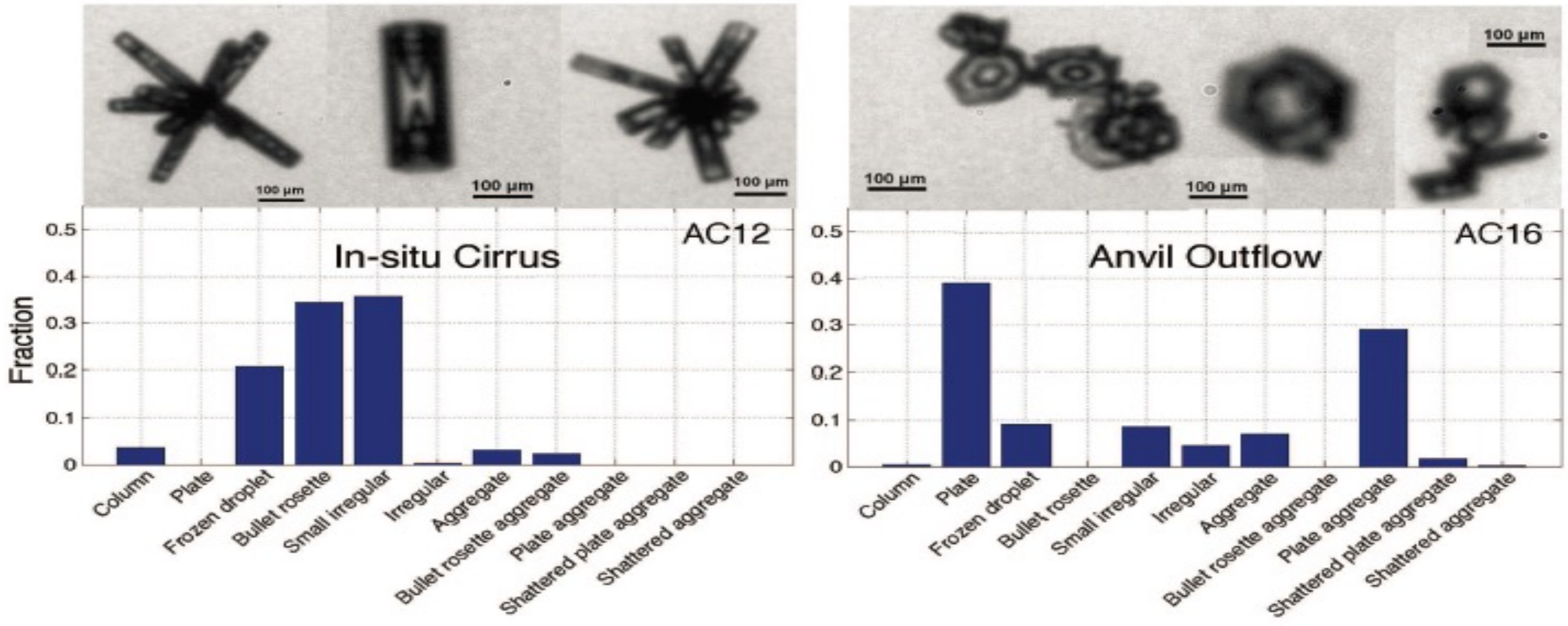


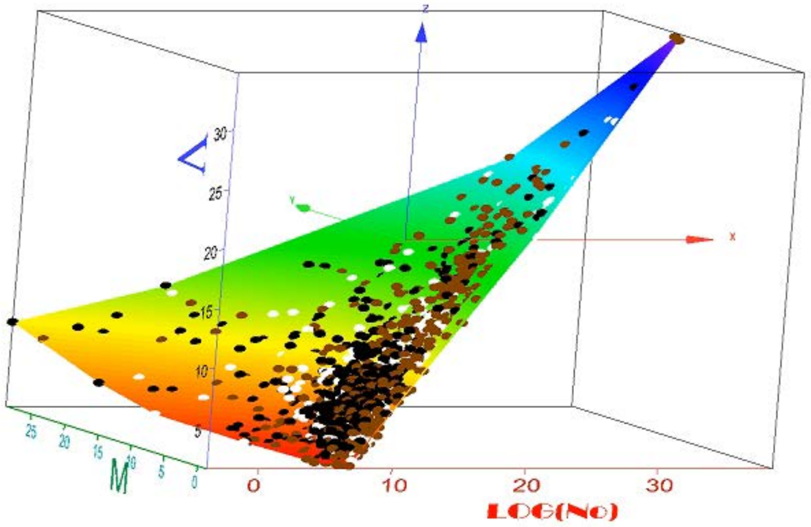
FIG. 14. Statistical analysis of the ice microphysical properties of ambient in–situ cirrus sampled during flight AC12 and of an anvil outflow of a tropical convective system sampled during flight AC16. The analysis is based on stereoscopic images taken by the PHIPS–HALO probe, which was newly developed for HALO.

The ACRIDICON–CHUVA campaign to study tropical deep convective clouds and precipitation using the new German research aircraft HALO by Manfred Wendisch, Ulrich P¨oschl, Meinrat O. Andreae , Luiz A. T. Machado , Rachel Albrecht, Hans Schlager k, Daniel Rosenfeld et al. - Bulletin of American Met. Soc. 2016

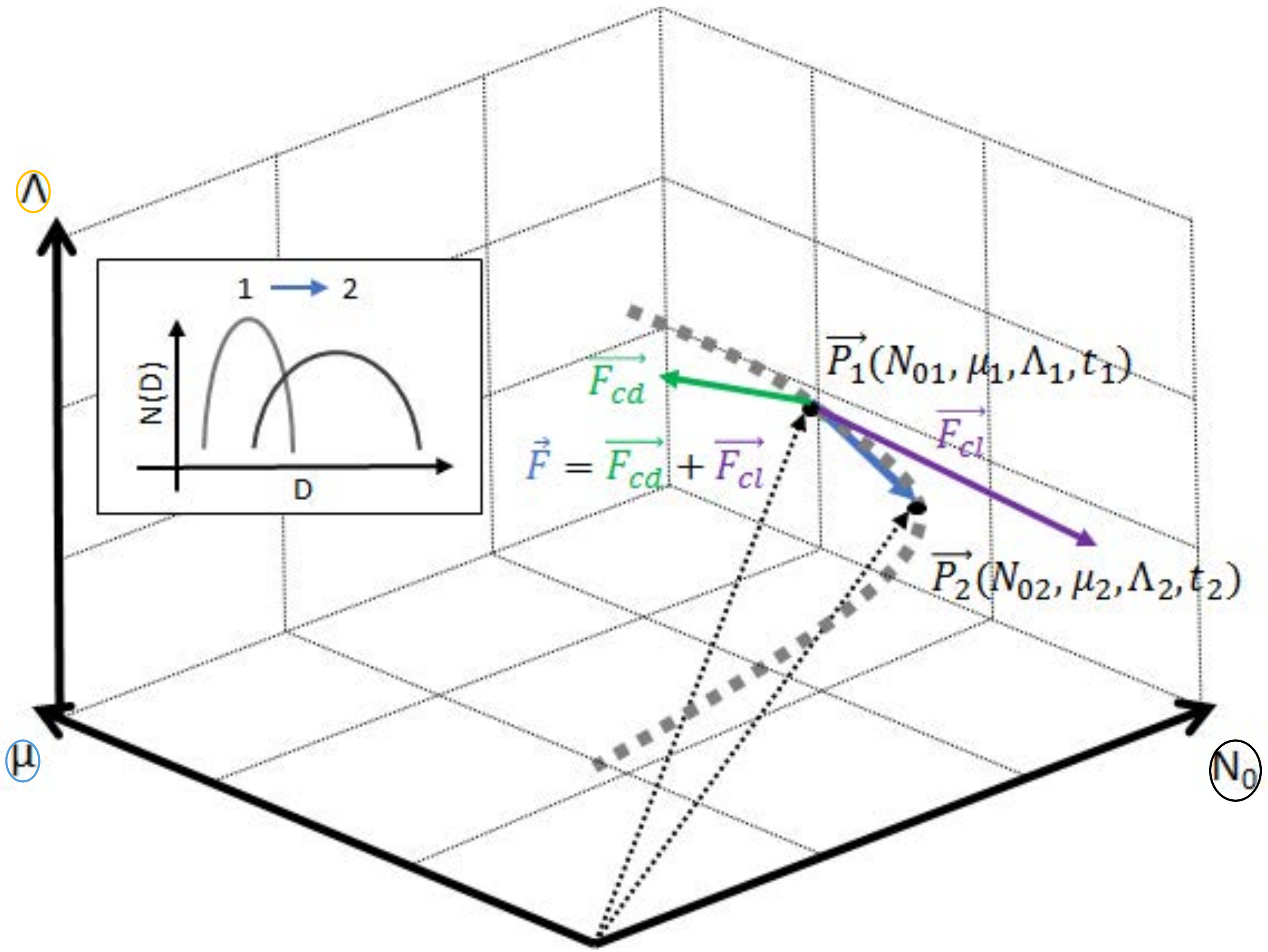
Droplet Size Distribution (DSD)

Gamma Distirbution

$$N(D) = N_o D^{\mu} \exp(-\Lambda D),$$



The CHUVA Project – how does convection vary across Brazil? By L. Machado, Silva Dias, Albrecht, Morales, Fisch, Vila et al., 2014 – Bull. Amer. Met. Soc.



$$N(D) = N_0 D^{\mu} \exp(-\Lambda D)$$

$\overrightarrow{F_{cd}}$ induces DSD narrowing:

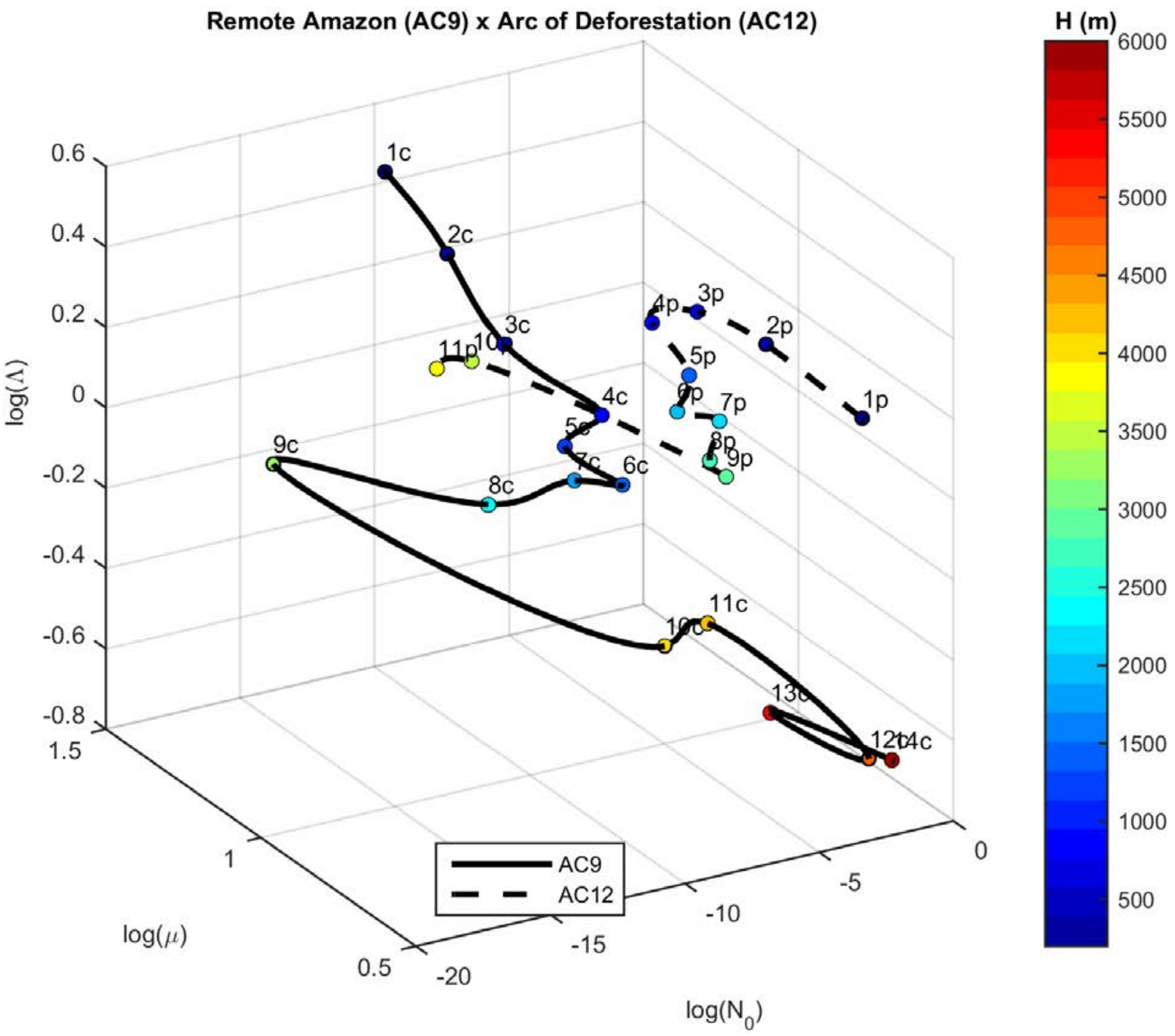
- Higher Λ, μ; Lower N_0 (no new droplet formation)

$\overrightarrow{F_{cl}}$ induces DSD widening:

- Lower Λ, μ; Higher N_0

$\overrightarrow{F_{cd}}$ and $\overrightarrow{F_{cl}}$ affected by:

- CCN number, size distribution
- w (or SS)
- $\overrightarrow{P_1}$



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Summary

Data Available – (processed) 2014-2015 GoAmazon. Futures Campaigns long term Observations

The 325-meter-high Amazon Tall Tower Observatory, a stairway to heavenly air.

ATMOSPHERIC PHYSICS

A pristine Amazon's last stand

Laboratory in the sky will sample some of the last unspoiled air on the planet

By Lizzie Wade

allow scientists to sample air as close to

enough to Manaus to get there and back in a single day. The chosen location is 150 kilometers northeast—and, vitally, upwind—of the city, allowing scientists to reach the site in about 6 hours by car and boat. For the most part, the only air that reaches the tower travels from the Atlantic Ocean over 1500 kilometers of undisturbed rainforest.

One feature that sets the Amazon's pristine air apart is a dearth of aerosols—the

ATTO – Amazon Tall Tower Observatory 2017 – 2037?

2018

RELAMPAGO: Remote sensing of Electrification, Lightning, And Meso-scale/micro-scale Processes with Adaptive Ground Observations

CACTI: Cloud, Aerosol, and Complex Terrain Interactions