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ACONVEX: A NEW SITE IN CENTRAL AMAZONIA DEDICATED TO LONG-TERM CLOUD PROPERTIES OBSERVATIONS: DESCRIPTION, FIRST RESULTS AND FUTURE PERSPECTIVES

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Partner Institutions

UNIFESP – Universidade Federal de São Paulo 1933

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MOTIVATION is to address the following questions:

"HOW CLOUDS WILL BEHAVE IN A WARMER PLANET?"

- Perhaps it is the most tricking question in global change;
- Clouds constitute the largest uncertainty in the climate system.
- There are solid reasons why our knowledge of clouds and their processes is very limited (Heitzenberger and Charlson, 2009).

"HOW TO ESTIMATE GLOBAL CHANGES IN CLOUD FEATURES WITHOUT AN "UNPERTURBED CLOUD" REFERENCE?"

- There is a need to establish a baseline of what we can stand for natural clouds, nad its formation without anthropogenic influence;
- Few places in the world resembles the atmosphere before industrial era: Amazonia (during wet season, Antartida, remote oceanic areas (Andreae, 2007).
- ACONVEX (Aerosols, Clouds and cONVction EXperiment) will provide cloud data for decades, yielding a climatological perspective of what unperturbed clouds are in a tropical environment.

ANTHROPOGENIC FACTOR PERTURBING CLOUDS

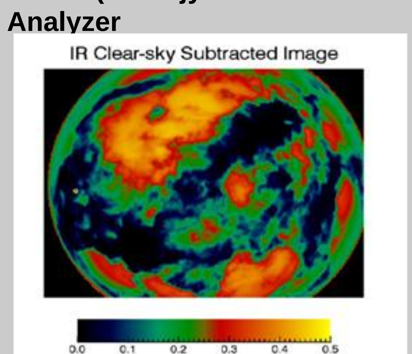
CLOUD TYPE	PERTURBATION	POTENCIAL MECHANISM
Contrails	+Albedo	Water vapor and anthropogenic CCN/IN[1]
Contrails	Daily termal amplitude	Changes in air traffic after Sept 11t[2]
Ship Tracks	+Albedo	Water vapor anthropogenic CCN[3]
Continental Stratocumulus	+Albedo	Anthropogenic CCN[4]
Continental Stratocumulus	Cloud Top Temperature	Anthropogenic CCN[5]
Continental Stratocumulus	+Albedo	Anthropogenic CCN[6]
Stratocumulus (global) at PBL	+Albedo	Anthropogenic CCN[7]
Continental precipitating clouds	-Precipitation	Anthropogenic CCN[8]
Continental deep convection	+Freezing level	Anthropogenic CCN[9]
Continental shallow clouds	+Precipitation	CCN or IN seeding[10]
Continental shallow clouds	+ Cloudiness	Change in surfasse fluxes due to landuse change[11]
PBL oceanic clouds	$-R_{eff}$	Anthropogenic CCN[12]
Stratocumulus at PBL	-LWC	Anthropogenic soot[13]
Cloud formation	+Atmospheric warming	GHG[14]
Global Cloud Cover	+Cloudiness	Cosmic rays, ions, anthropogenic CCN[15]
Regional Weather	+- Sinoptic systems	Release ou redirecting of anthropogenic energy[16]

[1] Scorer 1955; Meerkötter et al. 1999, [2] Travis et al. 2002, [3] Twomey 1974; Coakley et al. 1987, [4] Twomey 1974; Krüger and Graßl 2002, [5] Devasthale et al. 2005, [6] Albrecht 1989; Rosenfeld 1999; Rosenfeld 2000, [7] Twomey 1974; Nakajima et al. 2003; Sekiguchi et al. 2003, [8] Bell et al. 2008, [9] Andreae et al. 2004, [10] Garstang et al. 2004, [11] Pitman et al. 1999; Ray et al. 2003, [12] Twomey 1974; Albrecht 1989; Han et al. 1994, [13] Ackerman et al. 2000, [14] Douville et al. 2002; Wetherald and Manabe 2002, [15] Marsh and Svensmark 2000, [16] Hoffman 2002

Adapted from Heitzenberger and Charlson, 2009

Experimental:

ACONVEX site is located at 2.890738S, 59.970347W, as shon in the satellite picture. Central Amazonia, where the site is, is a region where cloud formation occurs most of time (specially during the wet season) without any significant influence of the the anthropogenic factors cited above. CENTRAL AMAZONIA was choosen because all meteorological systems that influence weather in Amazonia exert influence at least once in an year at Central Amazonia: 1) Local Convection; 2) Squall Lines; 3) Cold Fronts; among others.

Operating	Quantity observed	About to be installed
Multiangle Absorption Photometer (MAAP)	Absorption Coefficient	
Eddy covariance system – Campbell	Latent and sensible heat flux	ASIVA (All Skjy Infrared Visible Analyzer
Radiometer– Radiometrics	Vertical profile of T, RH and liquid water	
Nephelometer – Aurora	Scattering coefficient (3 lambdas)	
Met. Station – Gill	T, V, U, Precip	
Micro rain radar – Metek	Vertical profile of raindrop Size Distribution	
Ceilômetro – Jenoptiks	Cloud base and top heights (up to three layers	
Met. Station – Thies	T, V, U, Radiation	
Disdrometer – Thies	Size distribution of rain drops at ground level	
Met. Station – Davis	T, V, q, Precip	
GNSS Receiver – Trimble	Integrated Water Vapor	New GNSS (IWV)
MFR - Multi filter shadow band radiometer –	Total and diffuse hemispheric radiation in 7 lambdas	New Ceilometer (VAISALA)
Sun photometer – Cimel	AOT in 5 lambdas	
UV Raman LIDAR – Raymetrics	Vertical profile of aerosols (24 hs) and water vapor (night only)	

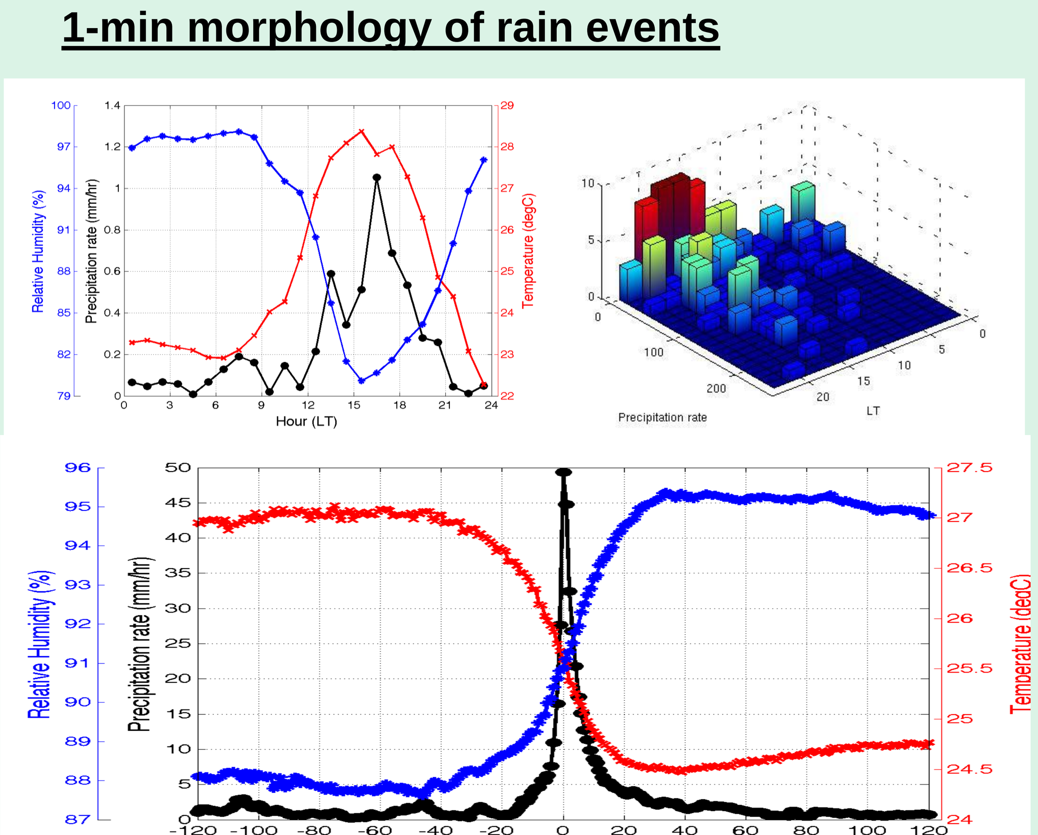
Scientific approach

Cloud Type	Important parameters	Instrument related	Scientific issues to be addressed
Low clouds (fair weather cumulus, Stratus)	Cloud fraction	ASIVA; GOES satellite; Ceilometer	Cloud Radiative Forcing; Area/perimeter ratio: connected to entrainment
	Liquid water Content (vertical profile)	Microwave radiometer	Characterize the evolution of shallow convection before shallow to deep conversion, and relate it to microphysics and macrophysics observations.
	Diurnal cycle of shallow convection	ASIVA	
	Cloud base height , PBL height	Lidar; ASIVA	
	Cloud top height	Ceilometer; Satélite GOES	
	Cloud layer thickness	Ceilometer	
	Rain rate (warm clouds)	Vertical Pointing Radar	Allows inferring coalescence efficiency in warm clouds, relating time evolution of effective radii with macrophysical parameters of clouds, e.g: vertical thickness, among others.
	Size distribution of rain droplets (vertical profile)	Vertical Pointing Radar	
	Size distribution of rain droplets at surface	Disdrometer	
	Radiation (spectral) difuse and direct	MFR, CIMEL	Cloud Radiative Forcing, associated with cloud cover measurements.
	Cloud Optical Thickness	ASIVA	
	Water vapor	GPS/GNSS (24hs, column integrated) Lidar (night, vertical profile)	Associate water vapor availability with shallow clouds formation (cloud cover, CAPE, CINE, diurnal cycle, and moment of *shallow to deep convection* transition)
Multiplayer clouds (cumulunimbus)	Cloud base height	Lidar; Ceilometer	Associate physical thickness with LWC, water vapor convergence, and precipitation rate, just below cloud and at surface. Cloud Optical Thickness obtained with ASIVA can be compared with Cloud Top Temperature and total water content at MODIS (AQUA satellite) passing.
	Cloud top height	GOES Satellite	
	Liquid water Content (vertical profile)	Microwave radiometer	
	Atmospheric column integrated water vapor	GPS/GNSS	
	Cloud Optical Thickness	ASIVA	
	Rain rate (at cloud base)	Vertical Pointing Radar	Microphysical quantities of precipitation associated with deep convection. It has to be related with previous shallow convection evolution
	Size distribution of rain droplets (vertical profile at cloud base)	Vertical Pointing Radar	
	Size distribution of rain droplets at surface	Disdrometer	
	Rain rate	Met station	

Site location

RESULTS OF OBSERVATIONS FOR SELECTED PERIODS OF 2011, 2012 and 2013.

1-min morphology of rain events

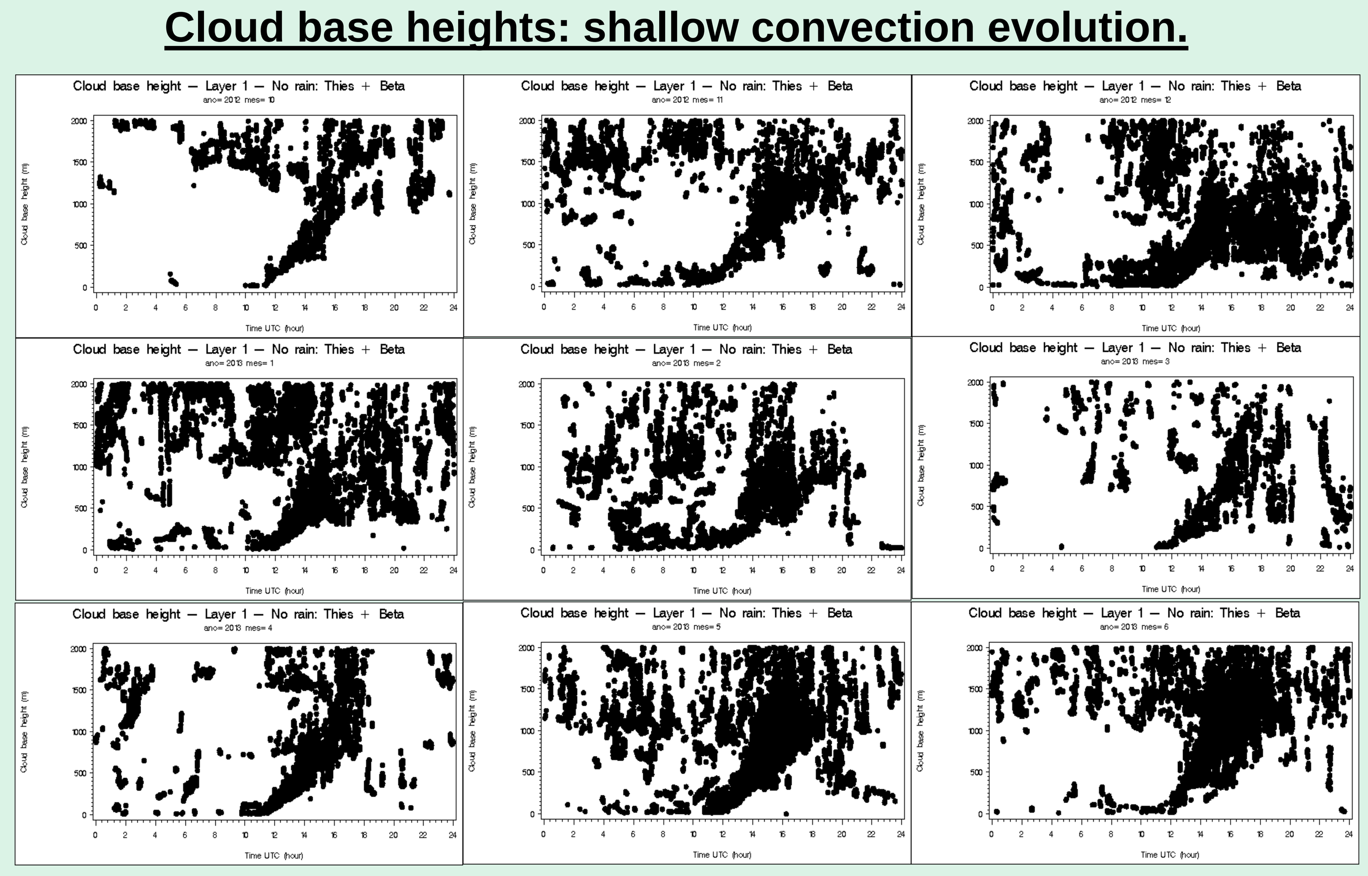


Left-top figure shows mean T, RH and precipitation for all observations. It is clear that there is a preferable time, in the afternoon, to the occurrence of rain events. Right-top figure shows a histogram of rain events resolved by maximum precipitation rate, local time and frequencies. Clearly the most intense precipitation happens around 16h (LT).

Bottom figure is the same as upper left but only around rain events. Center time is the moment of maximum precipitation, and data are shown for +- 2 hr of rain events. This is the MEAN, typical rain event at Amazonia: maximum precipitation rate ~ 50 mm/hr; intensities increase very fast 5 minutes before the peak, and last for 12 minutes until reach the pre-rain intensity. Mean volume is 10 mm. Intensive rain average volume (between -5 and + 12 min) comprises to 7.8 mm.

The remarkable fact is the existence of a time scale for rain events. Another time scale was also observed for IWV.

Cloud base heights: shallow convection evolution.



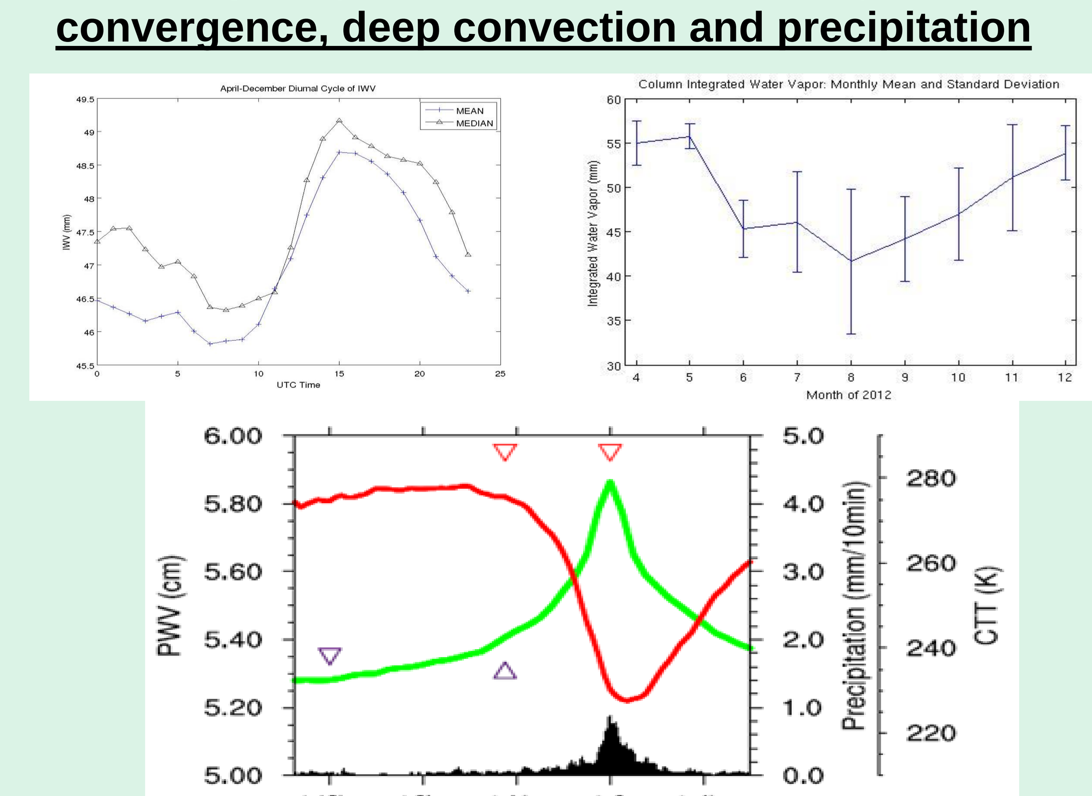
Plots above show the mean monthly diurnal cycle of cloud base heights observed with a Ceilometer. Height shown above correspond to the first cloud layer that the instrument see.

The most important feature above is the gradual increase of cloud base heights from ~ 100 m (before sunrise) to 1000m-1500m at12LT (16UTC). It is strongly connected to the evolution of Planetary Boundary Layer and the establishment of a shallow cumulus field. One of the goals of this proposal is to investigate the relationship of this field of fair weather cumulus with the diurnal cycle of precipitation. Actually, numerical models based on cumulus parameterization lack the ability to make rain occur in the correct time (see figures at left). This fail is due to the impossibility of such models, that run with 10 km (in the best case), while fair weather cumulus size is ~ 0.5 – 2.0 km.

Fair weather cumulus are important because they 1) transport humidity from lower to mid levels of the atmosphere, and 2) Reduce available shortwave radiation, thus slowing convection and postponing deep convection.

This is na open question until now, and we hope that our observation contribute to understand it better.

Water vapor dynamics: diurnal/annual cycle; WV convergence, deep convection and precipitation



Clouds are formed when air humidity reaches saturation. In convective areas it is usually associated to water vapor convergence. Adams et al (2012) showed that deep convection is strongly associated with a sudden peak in IWV.

Bottom figure shows mean values (for 2011) of the following quantities: Cloud Top Temperature (CTT, in red, from GOES); IWV (derived using a TRIMBLE/GNSS sensor) and precipitation. The two triangles show critical moments where IWV starts to increase: 8hs and 4hs before the deep convection/rain event. It means that the rain event actually started to be constructed several hours before its moment.

Top figures show (for April-December of 2012) the diurnal and annual cycle of IWV. Differences between days (and also months) are significantly high (not shown), but the shape of the daily cycle curve is reasonably the same for an entire 24 hours period.

CONCLUSION: Results are very preliminar, but it is possible to see that once the site is fully operational it will provide, in a climatological time scale, valuable information with respect to clouds and precipitation features in na almost pristine location, and a baseline data set for natural clouds in tropical areas.

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