Observations and Modeling of the Green Ocean Amazon 2014/15: CHUVA Field Campaign Report

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Executive Summary

The physical processes inside clouds are one of the most unknown components of weather and climate systems. A description of cloud processes through the use of standard meteorological parameters in numerical models has to be strongly improved to accurately describe the characteristics of hydrometeors, latent heating profiles, radiative balance, air entrainment, and cloud updrafts and downdrafts. Numerical models have been improved to run at higher spatial resolutions where it is necessary to explicitly describe these cloud processes. For instance, to analyze the effects of global warming in a given region it is necessary to perform simulations taking into account all of the cloud processes described above. Another important application that requires this knowledge is satellite precipitation estimation.

The analysis will be performed focusing on the microphysical evolution and cloud life cycle, different precipitation estimation algorithms, the development of thunderstorms and lightning formation, processes in the boundary layer, and cloud microphysical modeling. This project intends to extend the knowledge of these cloud processes to reduce the uncertainties in precipitation estimation, mainly from warm clouds, and, consequently, improve knowledge of the water and energy budget and cloud microphysics.

Acronyms and Abbreviations

AEB	Agencia Espacial Brasileira
ARM	Atmospheric Radiation Measurement
CHUVA	Cloud processes of the main precipitation systems in Brazil: A contribution to cloud resolving modeling and to the GPM
CTA	Centro Técnico Aeroespacial
DGG	Deutsche Forschungsgesellschaft
DLR	German Aerospace Center
FAPESP	Fundação de Apoio à Pesquisa do Estado de São Paulo
GoAmazon	Green Ocean Amazon 2014/15
GPM	Global Precipitation Measurement
HALO	High Altitude and Long Range
INPE	Instituto Nacional de Pesquisas Espaciais
LES	large-eddy simulation
SIPAM	Sistema de Proteção da Amazônia
UEA	Universidade Estadual do Amazonas
USP	Universidade de São Paulo
WSACR	W-band Scanning ARM Cloud Radar

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1.0 Background

As one of the Brazilian components of the GoAmazon 2014/15 field campaign, CHUVA is supported by FAPESP–Fundação de Amparo a Pesquisa do Estado de São Paulo, (grant number 2009/15235-8) and coordinated by INPE – Instituto Nacional de Pesquisas Espaciais. Meaning "rain" in Portuguese, CHUVA is the short name for the "Cloud processes of the main precipitation systems in Brazil: A contribution to cloud resolving modeling and to the GPM (Global Precipitation Measurement)." The CHUVA project has conducted five field campaigns since 2010. The sixth and last campaign was held in Manacapuru and Manaus from January to October 2014 as part of the GoAmazon 2014/15 campaign by the Atmospheric Radiation Measurement (ARM) Climate Research Facility, a U.S. Department of Energy Office of Science user facility sponsored by the Office of Biological and Environmental Research.

CHUVA's main scientific motivation is to contribute to the understanding of cloud processes, which represent one of the least understood components of the weather and climate system. The five CHUVA campaigns were designed to measure specific tropical weather regimes. The first two experiments, Alcântara and Fortaleza, in northeast Brazil focused on warm clouds. The third campaign, conducted in Belém, was dedicated to the large tropical squall lines that often form along the sea-breeze front. The fourth campaign was held in the Paraiba Valley of southeastern Brazil, a region with intense lightning activity. The fifth campaign was carried out at the end of 2012 in Santa Maria, southern Brazil, a region of very intense hailstorms associated with frequent mesoscale convective complexes. The last CHUVA campaign is a joint effort with the GoAmazon 2014/15 initiative.

The CHUVA project is headed by Dr. Luiz Machado (INPE), with Rachel Albrecht (Universidade de São Paulo [USP]), Carlos Morales (USP), Gilberto Fisch (Centro Técnico Aeroespacial [CTA]) and Maria Assunção Dias (USP) as co-scientists.

The ARM website for the CHUVA campaign is: http://www.arm.gov/campaigns/amf2014goamazon-chuva and the main CHUVA website is http://chuvaproject.cptec.inpe.br.

We acknowledge support from the Central Office of the Large Scale Biosphere Atmosphere Experiment in Amazonia (LBA), the Instituto Nacional de Pesquisas da Amazonia (INPA), the Instituto Nacional de Pesquisas Espaciais (INPE), the Agencia Espacial Brasileira (AEB), the Max Planck Society, the Deutsche Forschungsgesellschaft (DFG), and the German Aerospace Center (DLR). The work was conducted under 001030/2012-4, 001262/2012-2, and 00254/2013-9 of the Brazilian National Council for Scientific and Technological Development (CNPq).

2.0 Notable Events or Highlights

The main events of the campaign were the instrumented flights (Gulfstream 1 and HALO aircrafts) for which we prepared a special radar operation. Using the flight plans and coordinating with the pilots and scientists on board the airplanes, we were able to track meteorological systems close to the flight path with the radar. That way we produced a composed data set of radar and aircraft observations, as well as modeling outputs (large-eddy simulation [LES] and mesoscale) for those special cases.

3.0 Lessons Learned

We had three main issues during operation of the X-Band radar at the T3 site:

1. The high levels of relative humidity were a concern that the manufacturer of the equipment (Selex-Gematronik) did not predict, and caused a complete shutdown of the equipment. Since the X-Band waveguides are not sealed, operating the system for a long period in a moist environment caused the accumulation of moisture inside the guides, which lead to arcing and the failure of the magnetron (the "power source" of the radar). We had to wait a month for the magnetron to be released from customs because of an error in the documentation provided by the courier service contracted by Gematronik. These issues were discussed with the manufacturer, which now plans to improve the air conditioning unit and install dehumidifiers on systems deployed to moist regions. We also requested that the courier company in charge of the magnetron delivery be replaced, as this was the second time we had issues with that firm.

2. The generator that provided energy to the site in case of an electric power grid failure did not properly handle the total load of the site. This was did not affect all the equipment, but our radar needs a stable power source. The generator output varied almost 20% (sometimes a 220V phase had a -40V drop), which lead to the complete shutdown of the equipment in the case of a power grid failure. Since our radar was the only equipment that had that problem, it took some time to convince the site managers to replace the generator.

3. We also prepared our scan strategy to work together with the W-band Scanning ARM Cloud Radar (WSACR), so we could provide simultaneous observations. Unfortunately the WSACR did not work during the campaign, and we had to change our scanning procedures at the beginning of the campaign.

4.0 Results

Using the data obtained during the campaign, the researchers and their students are investigating the impact of aerosol and thermodynamics in the clouds life cycle, creating new parameterizations for numerical models, studying the characteristics of the boundary layer, and performing studies on cloud electrification and many other subjects. There are currently nine PhD students and two MSc students using the GoAmazon 2014/15/CHUVA data as their primary data sets for their theses and dissertations. The data gathered during the campaign will be analyzed for at least four years, if we combine all the ground instrumentation and the aircraft data.

5.0 Public Outreach

During the CHUVA campaign a series of news stories (TV, newspapers, and websites) were produced about the scientific developments and achievements of the campaign. All the news regarding the CHUVA project can be found on the CHUVA website.

Also, as part of an educational component of the project, a series of training courses were offered in partnership with the SIPAM (Sistema de Proteção da Amazônia) and the UEA (Universidade Estadual do Amazonas). The CHUVA researchers taught classes on Cloud Microphysics, Radar Meteorology, Instrumentation, Numerical Modeling, and related subjects.

6.0 "Observations and Modeling of the Green Ocean Amazon 2014/15: CHUVA" Publications

We are still preparing the articles to be submitted on the major publications, as well as presentations that are already approved on the AGU and AMS conferences, to be held in San Francisco and New Orleans respectively. Also there will be an international conference on the CHUVA/ACRIDICON project to be hosted in Ilhabela/Brazil in February 2016.

We have prepared daily weather reports and flight reports during the campaign, all reports are available in the CHUVA web site for each campaign.

7.0 References

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