GOAmazon2014/15

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Co-Sponsors: US Department of Energy (DOE), Amazon Research Foundation (FAPEAM), and São Paulo Research Foundation (FAPESP)

Web: http://campaign.arm.gov/goamazon2014/

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Location: Central Amazon to the west of the city of Manaus. The main site, T3, is that of GOAMAZON2014/15 (3.21°S, 60.60°W), which is to the north of Manacapuru. The auxiliary site, T2, (3.17°S, 60.0 °W) is nearby Iranduba.

Current Status: Pre-experiment planning and coordination are ongoing and a small subset of the instrumentation that will be deployed as part of GOAmazon2014 is already operational at T3 Manaus, Brazil.

Overview

The GOAMAZON2014/15 campaign seeks to understand how aerosol and cloud life cycles are influenced by pollutant outflow from a large industrial city in the tropical rain forest, particularly the susceptibility to cloud-aerosol-precipitation interactions and the feedbacks among biosphere and atmosphere functioning and human activities.

Scientific Objectives

- quantify interactions in the tropics of an urban pollution plume with biogenic volatile organic compounds, especially the impact on the production of secondary organic aerosol, the formation of new particles, and biogenic emissions of aerosols and their precursors

- explore the influence of anthropogenic activities in the tropics on aerosol microphysical, optical, cloud condensation nuclei, and ice nuclei properties

- determine the role of the daily evolution of shallow to deep convection on the evolution and dynamics of convective cloud systems, with comparison and understanding between tropical environments

- observe the evolution of storms over tropical rain forest from (i) severe in the dry season to (ii) large but less intense in the wet season

- investigate aerosol effects on convective clouds and precipitation, including the roles of aerosols in changing regional climate and atmospheric circulation and the effects of aerosols on tropical precipitation for clean and polluted situations

- stimulate data driven improvement and evaluation of parameterizations of cloud and aerosol interactions, as used in the climate models

The theme uniting these scientific objectives is the development of a data driven knowledge base for predicting how the present day functioning of energy, carbon, and chemical flows in the tropical rain forest might change, both due to external forcing on Amazonia from global climate change and internal forcing from past and projected demographic changes in Amazonia. The ultimate goal is to estimate future changes in direct and indirect radiative forcing, energy distributions, regional climate, ecosystem functioning, and feedbacks to global climate. In this regard, the presented objectives are representative, and further definition and broadening can be expected as the science team spins up prior to deployment.

Experiment Specifics

Manaus, a city of two million people and growing rapidly, is an isolated, highly polluted urban area (Figure 1) within the otherwise pristine Amazon Basin. The city has been a free trade zone since the 1960s, and this status was recently renewed for another 50 years by the Brazilian government. As a result, it is an industrial manufacturing city with one of the highest per capita incomes in Brazil.

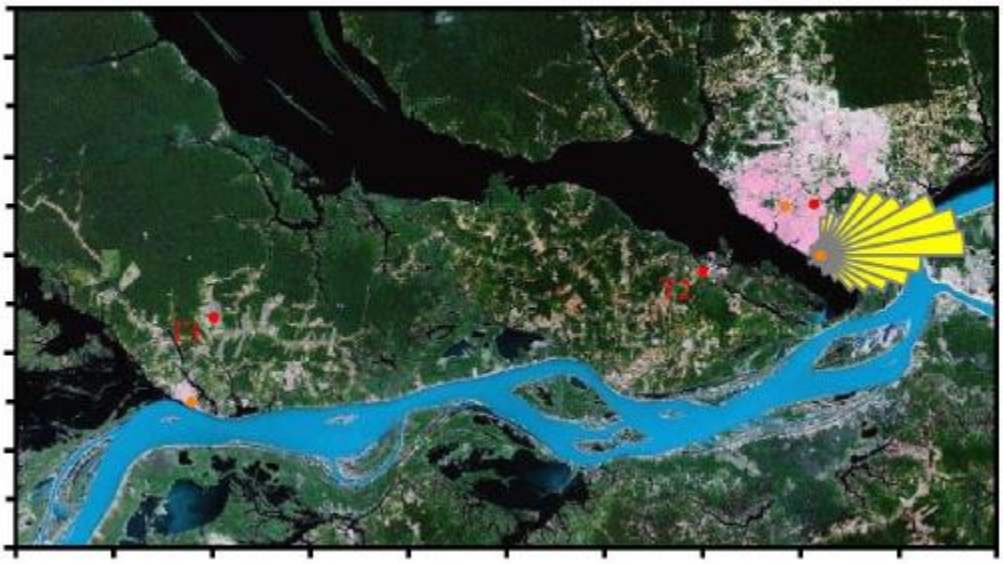

Figure 1. Map depicting the central Amazon to the west of the city of Manaus. The main research site,T3, (-3.21°S,-60.60 °W) is to the north of Manacapuru. The auxiliary site, T2, (-3.17°S,-60.0°W) is near Iranduba. The yellow sectional chart shows the frequency of wind direction at 1 km for one year's data.

As a consequence of this industrial and other economic activity (e.g., the city's electricity is produced in large part by burning high sulfur fuel oil), there are high pollution levels in the plume. The width of the urban plume is about 20–25 km, resembling the dimension of the city itself, with little downwind spreading (i.e., there is distinct clean air on both sides of the pollution plume [Figure 2]). The plume from the city has high concentrations of SO_2, NOx, and soot, among other pollutants. Measurements in the plume show very strong formation of photochemical pollution, e.g., a threefold increase in ozone mixing ratios within the atmospheric boundary layer occur within a 100-km travel distance downwind of Manaus while peak NO concentrations of >10 ppb near Manaus drop precipitously with travel distance. Particle number and mass concentrations are 10 to 100 times greater in the pollution plume compared to the times when pristine conditions prevail.

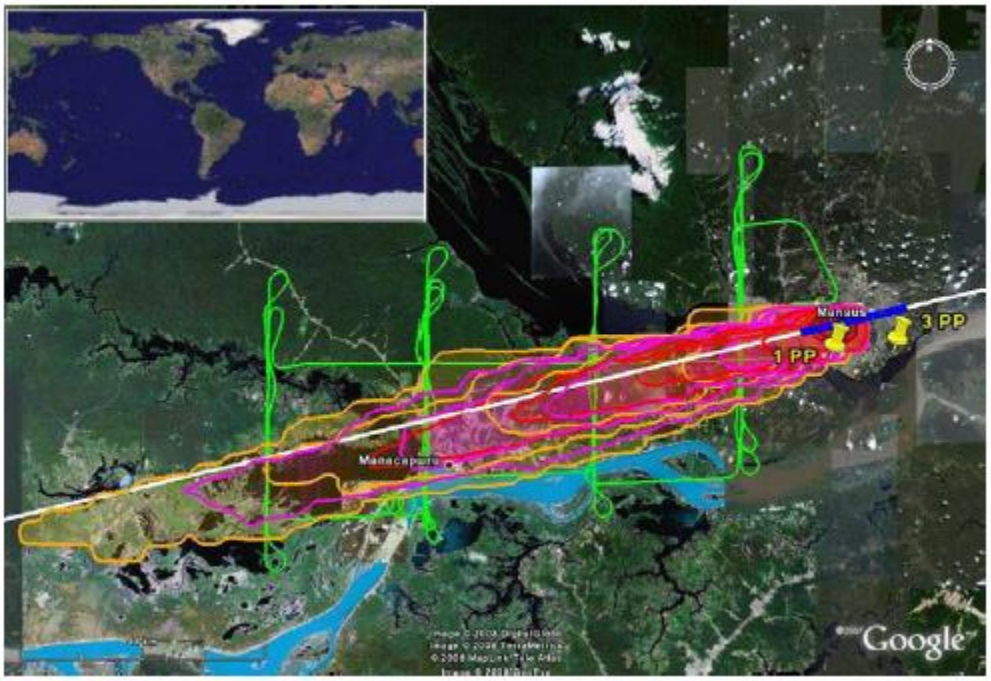

Figure 2. Land cover image with an overlay of a flight pattern on 19 July 2001 from 10:00–14:00 (local time) that samples the Manaus plume. Flight track global positioning system data are shown in green line. The output of a HYSPLIT dispersion model run from the Manaus plume is indicated by the red/orange contour lines. The two yellow pins indicate the locations of power plants (3 PP, 560 MW capacity; 1 PP, 125 MW). GOAMAZON site T3 is slightly north of Manacapuru. Figure is adapted from Kuhn et al. (2010).

The Atmospheric Radiation Measurement (ARM) program Mobile Facility #1 (AMF1) will be deployed in two locations downwind of Manaus, Brazil in support of GOAmazon2014/15. These two sites are designated as T3 and T2 in the GOAmazon2014/15 Science Plan. Site T3 is designated as the primary AMF1 deployment location because it will contain the remote sensors that measure properties of the atmospheric column. Aerosol Observing Systems (AOS) will be deployed at T2 and T3 allowing the instruments at site T2 to sample the plume closer to Manaus and the primary site (T3) to observe the plume as a later stage. Measurements at sites T2 and T3 can be roughly subdivided into three classifications: (1) surface meteorology and fluxes, (2) boundary layer aerosol properties, and (3) atmospheric profiling.

Standard meteorological variables such as pressure, temperature, humidity, and winds are measured every few seconds and the turbulent fluxes of sensible and latent heats measured using eddy correlation and a frequency of 30 Hz. Both sites will be equipped with a state-of-the-art radiation measurement system that collects narrowband and broadband shortwave (SW) irradiances and dissects the radiation field into its diffuse and direct components. Details of the spectral composition of downwelling radiation are measured with high resolution SW and LW spectrometers.

Boundary layer aerosol properties measured by the AOS systems at both sites include cloud nucleating and radiative properties. Site T3 contains a full array of trace gas and aerosol chemistry measurements in including mass spectrometry.

Atmospheric profiling is accomplished at site T3 using a variety of passive and active remote sensors. Temperature and moisture profiles in the boundary layer are measured every few seconds with a twelve-channel profiling Microwave Radiometer and constrained by four radiosonde launches per day. To supplement these profiles, total integrated cloud liquid water and integrated water vapor are measured using multiple three-channel microwave radiometers. Unparalleled measurements of boundary layer cloud structure are available from three cloud sensing radars, two that scan and one that is positioned in zenith at all times, and a variety of additional active remote sensors (Doppler lidar, Micropulse Lidar, and Wind Profiler).

A Gulfstream-1 research aircraft operated by the US DOE during two Intensive Operations Periods (IOPs) during February 15-March 26 2014 and September 1-October 10 2014 (representing the wet and transition seasons, respectively) will be used in vertical profiles to an altitude of 5 to 6 km to determine changes to gases and particles within the detrainment levels of shallow cumulus clouds, to investigate properties of polluted layers, and to characterize cloud dynamics, thermodynamics, and microphysics.

Collaborative projects include CHUVA, a Brazilian program that has the main objectives of studying cloud and precipitation processes throughout Brazil and validating their retrieval from GPM, an international satellite constellation with a planned launch date in early 2014, and ACRIDICON, a German program with the goal to quantify aerosol-cloud-precipitation interactions and their effects in convective cloud systems using aircraft observations, indirect measurements and numerical simulations. Additional GOAmazon resources will likely become available after decisions are made on a recent joint solicitation by DOE, FAPESP, and FAPEAM. The DOE call encompasses three branches of the Office of Biological and Environmental Research (BER), namely, Atmospheric System Research (ASR), Regional and Global Climate Modeling (RGCM), and Terrestrial Ecosystem Sciences (TES). Interactions between the process-oriented ASR and TES and the climate model-oriented RGCM is likely of strong interest to PSMI. Other planned modeling efforts include operational forecasting during the field deployments and CRM runs of case studies during the IOPs.

Difficulties in Experimental Execution and Plan

Not Applicable

Data Sharing

Data collected with AMF1 and by its collaborating affiliates will be shared between ASR/ARM and INPA/LBA (National Institute for Research in Amazonia / Large Scale Biosphere-Atmosphere Experiment in Amazonia). All data collected by the AMF will be available online, typically within 24 hours. A full description of this data archive is found at http://www.archive.arm.gov/armlogin/login.jsp. In addition, the ARM archive distributes numerical output from several models and satellite data from selected satellites for each AMF deployment. A list of archived data is found at http://www.arm.gov/xdc. Data from the G1 will be available as soon as quality control procedures are complete.

Coordination

Cooperation between the US Department of Energy and the Brazilian science and funding infrastructure has been exceptional. An early container with basic meteorological instrumentation was successfully shipped to Brazil and deployed at the T3 site May of this year and Brazilian instruments have since been added. Aircraft permissions for both the DOE G1 and the German HALO are still ongoing and have taken more effort, but seem to be progressing well.