INTERACTIONS BETWEEN URBAN AND FOREST EMISSIONS IN MANAUS, AMAZONIA: THE BRAZILIAN COMPONENT OF GOAMAZON

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Figure 1. Tiwa GoAmazon station in September 2014

The GoAmazon experiment seeks to understand how traces gases, aerosol particles and cloud life cycles are influenced by pollutant outflow from Manaus in the Amazonian tropical rainforest. We are quantifying the susceptibility to cloud-aerosol-precipitation interactions and the feedbacks among biosphere and atmosphere functioning under the influence of human activities. Manaus is a major urban center with 2 million people with large vehicular and power plant emissions, surrounded by hundreds of kilometers of tropical forests with large emissions of Volatile Organic Compounds (VOC). The reactions of the urban emissions with the natural background forest emissions produces secondary organic aerosol (SOA), ozone and other compounds that influences the Amazonian ecosystem functioning and this interaction is important to regional and global climate change assessments. A set of detailed aerosol, trace gases and cloud measurements are being performed over six different sampling sites, followed by detailed meteorological transport studies. A large set of measurements will be performed: aerosol optical measurements with spectral light scattering and absorption, aerosol size distribution, aerosol composition for organic and inorganic components, CCN (Cloud Condensation Nuclei), aerosol optical depth, radiation balance, atmospheric vertical thermo-dynamic structure among many other measurements. Four aerosol mass spectrometers will be deployed to measure organic and inorganic aerosol in several locations. Raman Lidar will measure the vertical distribution of aerosols and water vapor up to 12 Km. Trace gases measurements such as O_3, CO, CO_2, CH_4, SO_2 and detailed VOCs characterization will also be performed. Measurements of cloud properties, including cloud cover fraction, droplet size distribution, precipitation, water vapor and others, will be combined with cloud and precipitation radars for a regional assessment of the complex cloud-aerosol-precipitation relationship. Two aircraft experiments in the dry and wet seasons will look at the large scale impact in clouds, aerosols and trace gases. High resolution BRAMS regional modeling will be performed daily with 2 km resolution with full aerosol and trace gas chemistry. Cloud modeling will integrate aerosol, CCN, water vapor and thermodynamic conditions for a variety of conditions. The GoAmazon measurements and modeling framework will provide a dataset vital to constrain tropical forest model parameterizations for organic aerosols, cloud and convection schemes, coupled to the radiation balance. The analysis will also provide insights into how the Amazonian ecosystem is perturbed by pollution and how they influence climate regionally and globally.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

It was observed remarkable influence of the urban plume of Manaus in the chemistry and physics of the atmosphere downwind of the GoAmazon experimental area. Ozone concentrations are naturally low in Amazonia, with values of around 10 ppb (parts per billion) at mid-day. Under the influence of the Manaus plume and also long range biomass burning emissions, ozone concentrations went of up to 70-80 ppb. The aerosol particle composition is very different from natural conditions, with a much less oxidized component. Black carbon concentrations that are also naturally low in Amazonia shows enhancement of factor of 10 under the influence of the Manaus plume, which impacts strongly on the radiation balance. Carbon monoxide under natural biogenic condition is about 100 ppb, but when impacted can reach 1000 ppb, a similar increase as observed with SO_2 concentrations. The oxidizing capacity of the atmosphere is much higher downwind of the Manaus plume, observed trough the oxidation products of isoprene, a naturally emitted VOC in Amazonia. Aerosol size distribution shows a much higher amount of nanoparticles that can grow to form CCN (Cloud Condensation Nuclei) and directly influence cloud formation and precipitation patterns. The large aerosol concentration increases the diffuse light radiation, affecting the photosynthetic rate of the natural forest hundreds of kilometers far from the emissions. Lidar measurements can separate the Manaus plume from the long range transport biomass burning aerosols, that reach 3 km altitude, at the cloud base, directly influencing cloud formation and development. Aircraft measurements shows that the impact of the Manaus pollution plume extends over 200 Km downwind of the urban area. With the high altitude HALO airplane (18 Km) in the experiment, it was observed cloud outflow of aerosols and trace gases in the top of convective clouds. The aircraft measurements also shows significant processing of aerosol particles within clouds and a large reduction of cloud droplet sizes with increasing aerosol and cloud condensation nuclei atmospheric loading. This influences precipitation efficiency and alters the hydrological cycle in Amazonia. Modeling analysis will look at the influence of the particles on precipitation to the outside boundaries of Amazonia.

Figure 2. Aerial view of the GoAmazon T3 site

MAIN PUBLICATIONS

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