

MODIFICATIONS BY ANTHROPOGENIC POLLUTION OF THE NATURAL ATMOSPHERIC CHEMISTRY AND PARTICLE MICROPHYSICS OF THE TROPICAL RAINFOREST DURING THE GOAMAZON INTENSIVE OPERATING PERIODS (IOPS)

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FAPESP # 2013/50510-5 | Term: Jan 2014 to Dec 2016

Brazil - USA Collaborative Research: GoAmazon – FAPESP/DOE/FAPEAM

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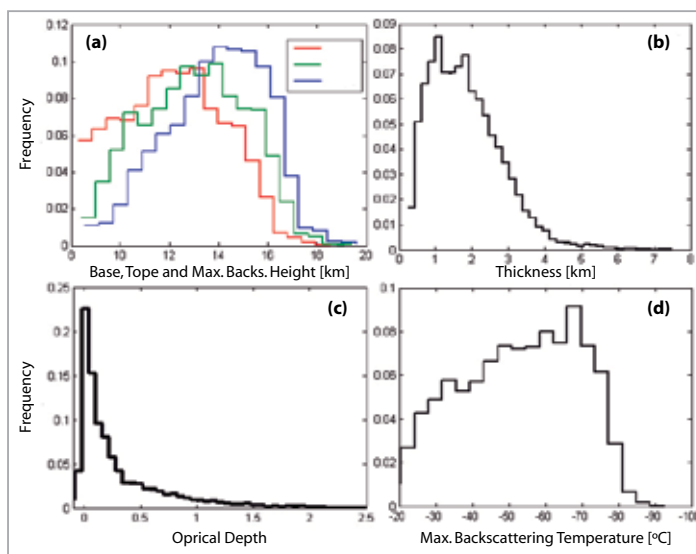


Figure 1. Normalized frequency histograms with the macro and microphysical properties of the cirrus clouds from one year of observations showing in a) base (red), top (blue) and maximum backscattering (green) heights; in b) cirrus thickness; in c) cirrus optical depth, and in d) temperature of the cirrus max backscattering height. GoAmazon T0 experimental site, Embrapa, Rio Preto do Eva-AM. Source: Gouveia et al, OPA, 2014

The effects of aerosol particles on cloud microphysical properties, cloud cover, precipitation, and regional climate are significant. The Amazon region is particularly susceptible to changes in number-diameter distributions of the atmospheric particle population $n(d)$ because of the low background concentrations and high water vapor levels, indicating a regime of cloud properties that is highly sensitive to aerosol microphysics. A particle-limited regime means that for modest to vigorous updrafts the cloud droplet number concentration (CDNC) is dominated by cloud condensation nuclei (CCN) number instead of updraft velocity. This natural regime, different from most other continental areas world-

wide, is expected to be disrupted by the interaction of Manaus urban plume with the natural aerosol population.

Manaus, a city of two million people and growing rapidly, is an isolated, highly polluted urban area located in the central Amazon basin with clean conditions in the surrounding 2000 km. The city's urban plume is about 20-25 km wide, resembling the dimension of the city itself, with distinct clean air on both sides of the pollution plume. As a combined consequence of the meteorology, emissions, and chemistry, the fetch of the main research site T3, north of Manacapuru and about 80 km from Manaus, oscillates between the extremes of (a) a pristine atmosphere when the Manaus pollution plume meanders somewhat north or south and (b) heavy pollution and the interactions of that pollution with the natural environment when the plume conforms to its mean flow. The GoAmazon campaign, taking place around Manaus-Brazil from January 2014 to

December 2015, seeks to quantify and understand how aerosol and cloud life cycles in a particularly clean background in the tropics are influenced by pollutant outflow from a large tropical city, all in the context of addressing the susceptibility of cloud-aerosol-precipitation interactions to present-day and future pollution in the tropics.

As a Brazil-USA collaboration, the goals of this project are (i) to measure and mechanistically understand the factors affecting $n(d)$ over a tropical rainforest, especially the effects of anthropogenic pollution as a perturbation to natural state, and (ii) to develop and implement an upscaling analysis from this new data set and knowledge of $n(d)$ to prognosticate possible climatic impacts of present-day urban pollution and possibly greater pollution in the future.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

It was observed significant changes in the physics and chemistry of the atmospheric aerosol particles at the research sites T2 and T3 under the influence of the Manaus plume. High concentrations of SO_2 , NO_x , and soot, among other pollutants were measured. Very strong formation of photochemical pollution was observed, e.g., a threefold increase in ozone mixing ratios 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.

Continuous measurement of the aerosol vertical distribution at sites T_0 (upwind) and T_2 (downwind from Manaus) combined with back trajectories from NOAA's Hysplit model and INPE's fire detection maps allowed the clear identification of layers with long range biomass burning transport aloft of the Manaus plume layer. It was also used the LIDAR measurements to identify cloud layers and was observed a persistent cirrus cover of 60% over the region. Evaluation of its radiative impact is underway. Additional measurements of size-resolved effective hygroscopicity parameter k , obtained from a cloud condensation nuclei counter coupled to a differential mobility analyzer, are being performed up and downwind from Manaus. Results indicate a lower hygroscopicity under polluted conditions, with mean value around 0.15, than under clean conditions, with a mean value around 0.25. Under natural conditions, it was possible to identify peaks of large sea salt particles with organic coating, while small particles seems to be pure organic. The activation fraction and hygroscopicity under different conditions are being compared as a function of particle size and analyzed together with an aerosol chemical speciation monitor.

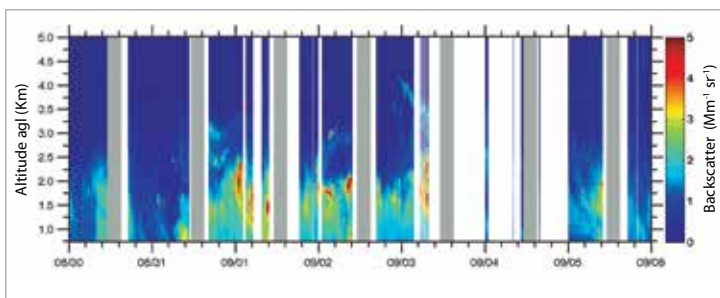


Figure 2. Vertical distribution of the aerosol backscatter coefficient ($\text{Mm}^{-1} \text{sr}^{-1}$) during a week of measurements at GoAmazon T0 experimental site, Embrapa, Rio Preto do Eva-AM, showing the long range transport of biomass burning smoke. Source: Barbosa et al, AMT, 2014

MAIN PUBLICATIONS

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