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Observations and Modeling of the Green Ocean Amazon 2014/15: Nanoparticle Size Distribution (NPSD) Field Campaign Report

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Observations and Modeling of the Green Ocean Amazon 2014/15: Nanoparticle Size Distribution (NPSD) Field Campaign Report

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Executive Summary

Aerosol nucleation and initial growth were investigated during the Green Ocean Amazon (GoAmazon) 2014/15 campaign. Aerosol sampling occurred during the wet and dry seasons of 2014, and took place at the T3 measurement site, downwind of the city of Manaus, Brazil. Characterization of the aerosol size distribution from 10 to 500 nm was accomplished through the deployment of a conventional Scanning Mobility Particle Spectrometer (SMPS) and a fine condensation particle counter (> 10 nm). In order to directly measure aerosol nucleation and initial growth, a Nano SMPS (1.5-20 nm) was also deployed, consisting of a condensation particle counter-based electrical mobility spectrometer that was modified for the detection of sub-3 nm aerosol. Measurements of the aerosol size distribution from 1.5 nm to 10 nm were obtained during the first observational period, and from 3 nm to 15 nm during the second observational period. Routine, stable measurement in this size range was complicated due to persistent water condensation in the Nano SMPS and diffusional transport losses

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement Climate Research Facility
CNPq	Brazilian National Council for Scientific and Technological Development
CPC	Condensation Particle Counter
DMA	Differential Mobility Analyzer
DOE	U.S. Department of Energy
GoAmazon 2014/15	Green Ocean Amazon 2014/15
INPA	Instituto Nacional de Pesquisas da Amazonia
LBA	Large Scale Biosphere Atmosphere Experiment in Amazonia
NSMPS	Nano Scanning Mobility Particle Sizer
SMPS	Scanning Mobility Particle Spectrometer
UEA	Universidade do Estado do Amazonia

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1.0 Background

Atmospheric particle nucleation is an important environmental nano-scale process, with field measurements and modeling studies indicating that freshly nucleated particles are a significant source of global cloud condensation nuclei (Kuang et al. 2009, Spracklen et al. 2008). However, our understanding of atmospheric nucleation and its influence on climate is limited because few ambient measurements have been made of either the nucleation rate (at 1 nm) or the initial growth rate of newly formed clusters (from 1 to 3 nm), both of which are necessary to constrain and investigate the nucleation mechanism and to develop process-level models. Aerosol nucleation and initial growth were investigated during the Green Ocean Amazon (GoAmazon) campaign spanning the wet season (February 1-March 31) and dry season (August 15-October 15) of 2014. Measurement of the aerosol size distribution was accomplished through the deployment of a Nano Scanning Mobility Particle Sizer (NSMPS), which is a condensation particle counter-based electrical mobility spectrometer, optimized for the detection of aerosol down to 1 nm in diameter (Jiang et al. 2011). Measurements were made at the U.S. Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) Climate Research Facility T3 measurement site in the vicinity of Manacapuru, Brazil, downwind of the city of Manaus, Brazil.

Collaborators for this work include Chongai Kuang (Brookhaven National Laboratory), Paulo Artaxo (University of Sao Paulo), Scot Martin (Harvard University), Rodrigo Souza (UEA), and Jian Wang (Brookhaven National Laboratory).

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2.0 Notable Events or Highlights

Routine, stable measurements of the aerosol size distribution in this size range were complicated by the persistent condensation of ambient water vapor within various components of the Nano SMPS: the Polonium 210 neutralizer, the Nano Differential Mobility Analyzer (DMA), and the Condensation Particle Counter (CPC). The presence of liquid water in the sampling lines likely led to increased sampling losses, while liquid water in the Nano DMA led to electrical arcing in the classifying region, and liquid water in the CPC led to contamination of the working fluid and subsequent increase in the 50% cut-off size.

3.0 Lessons Learned

In order to lessen the impact of water condensation within the Nano DMA, a water condenser should be installed just upstream of the aerosol neutralizer, which would actively condense water out of the inlet air stream before reaching the Nano DMA and the CPC.

In order to minimize transport losses of aerosol due to diffusion, a high-flow-rate inlet should be constructed of minimal length, and characterized in the laboratory.

4.0 Results

Primary results from this deployment are measurements of the aerosol size distribution from up to 20 nm down to 1.5 nm. When combined with measurements of the aerosol size distribution at larger sizes, a full aerosol size distribution can be constructed. Examples of measured size distributions showing evidence of nucleation mode growth are shown below in Figure 1 and Figure 2.

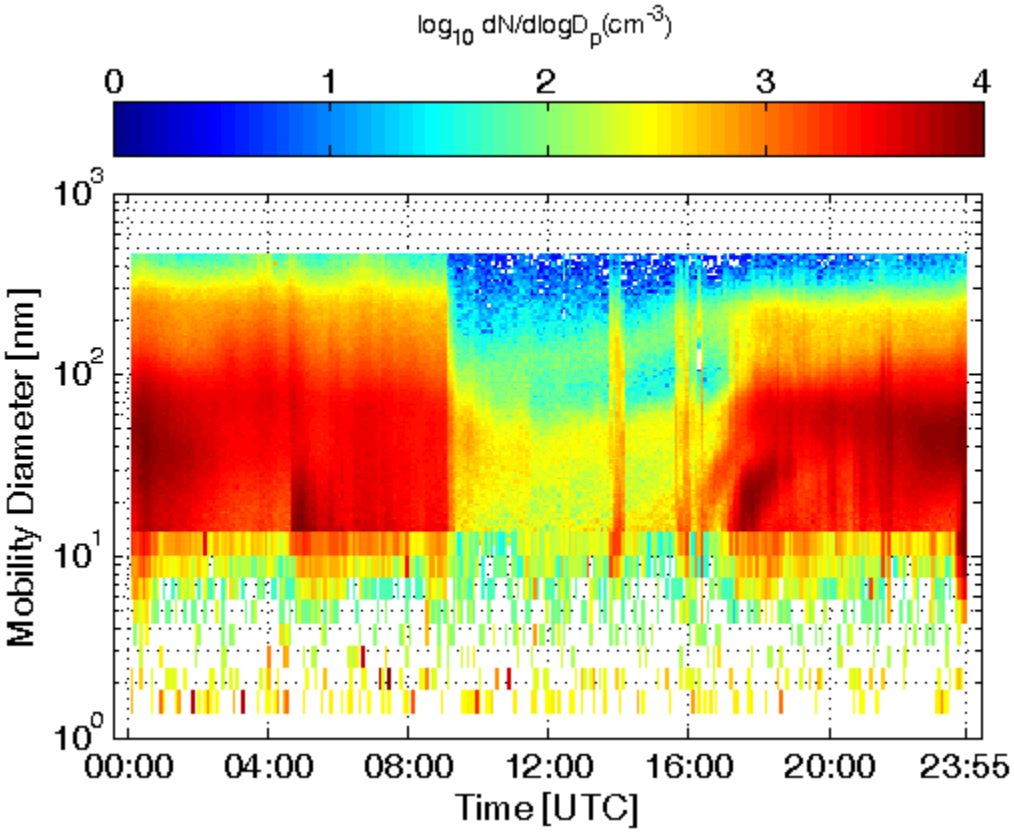

Figure 1. Aerosol number size distribution, measured during the wet season on February 21, 2014 at the T3 site.

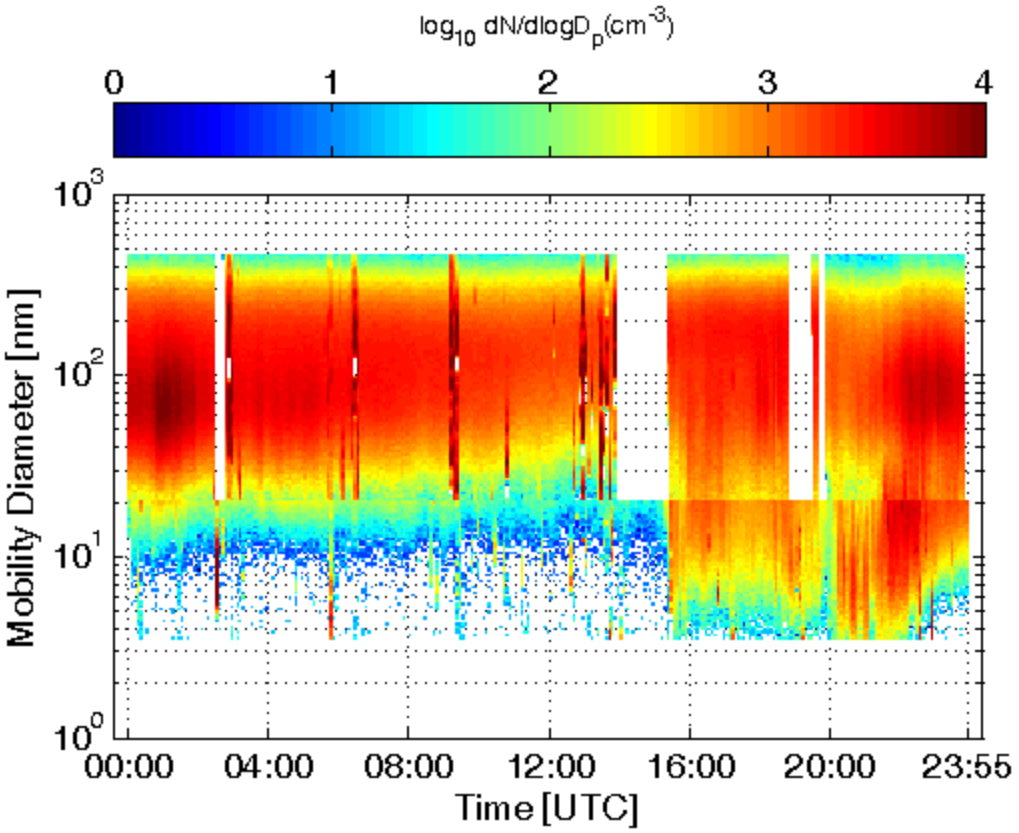

Figure 2. Aerosol number size distribution, measured during the dry season on October 11, 2014 at the T3 site.

An electrometer-based neutral air ion spectrometer (neutral and charged fraction of aerosol down to 1.5 nm in diameter) and particle size magnifier (neutral aerosol size distribution down to 1 nm) were also deployed by collaborators from the University of Helsinki (Markku Kulmala and Tuukka Petaja) at the same location. From these combined size distribution measurements, periods of nucleation can be identified, and the resulting nucleation rates and initial growth rates can be presented. Concurrent and co-located measurements of gas-phase sulfuric acid from the collaborators at the University of California, Irvine (Saewung Kim) will provide the opportunity to investigate the functional contribution of sulfuric acid to the observed nucleation rate and initial growth rate.

5.0 Public Outreach

A campaign overview with accompanying data sets can be found at http://www.arm.gov/campaigns/amf2014goamazon.

6.0 GoAmazon 2014/15 Publications

6.1 Meeting Abstracts/Presentations/Posters

Kuang, C, P Artaxo, J Backman, S Kim, MT Kulmala, ST Martin, T Petaja, R Seco, JN Smith, and RAFD Souza. 2014. "Measurements of the aerosol size distribution down to 1 nanometer to investigate aerosol nucleation and initial growth during the GoAmazon Campaign." Abstract #23A-3195, American Geophysical Union Annual Meeting 2014, San Francisco, CA.

7.0 References

Kuang, C., PH McMurry, and AV McCormick. 2009. "Determination of cloud condensation nuclei production from measured new particle formation events." *Geophysical Research Letters* 36(9): L09822, doi:10.1029/2009GL037584.

Spracklen, DV, KS Carslaw, M Kulmala, VM Kerminen, S-L Sihto, I Riipinen, J Merikanto, GW Mann, MP Chipperfield, A Wiedensohler, W Birmili, and H Lihavainen. 2008. "Contribution of particle formation to global cloud condensation nuclei concentrations." *Geophysical Research Letters* 35(6): L06808, doi:10.1029/2007GL033038.

Jiang, J., M Chen, C Kuang, M Attoui, and PH McMurry. 2011. "Electrical mobility spectrometer using a diethylene glycol condensation particle counter for measurement of aerosol size distributions down to 1 nm." *Aerosol Science and Technology* 45(4): 510-521, doi:10.1080/02786826.2010.547538.

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