How Different are the INP Populations in the Central and Northwestern Amazon?

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Introduction

- Aerosol particles are key players in cloud formation, and most of the precipitation in Tropical latitudes is originated in ice-containing clouds (Mülmenstädt et al., 2015).
- Besides the ubiquitous local biogenic aerosol particles, anthropogenic particles can be locally emitted or transported into the Amazon throughout the year (Graham et al., 2003).
- The ice nucleating abilities of the aerosol particles in this unique and pristine region are poorly understood, with a single study available for the central Amazon (Prenni et al., 2009).

Objective

The aim of the present study is to improve the current understanding of the role that the Amazonian aerosol particles play in mixed-phase cloud formation.

Methods

The Spring NOrthern Amazon eXperiment (SNOMAX) campaign was carried out between March 14 and 27, 2024 in the northwestern Amazon. The sampling took place in El Trueno, Guaviare (Colombia), as shown in Figure 1. Aerosol particles were collected on different substrates to characterize their chemical composition (elemental, ionic, and organic content) and microbiological diversity. Additionally, on-line sensors were deployed to measure the total particle number concentration (TPNC>30 nm), particle size distribution (300 nm to 25 μm), and particle mass concentration ($PM_{2.5}$ and PM_{10}).

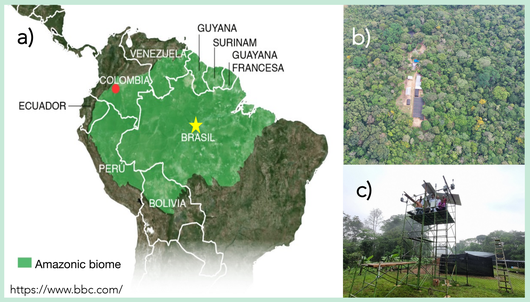


Figure 1. a) Amazon basin extension b) Aerial view of the El Trueno Experimental Station, and c) Photo of the experimental arrangement used in the SNOMAX campaign. The red circle and the yellow star shows the northwestern (i.e., the SNOMAX sampling location) and central Amazon, respectively.

A MicroOrifice Uniform Impactor (MOUDI, 100R) was used to collect aerosol particles at six different size bins for Scanning Electron Microscopy (SEM-EDX) analysis and to determine the ice nucleating particles (INP) concentration using the UNAM-MOUDI-Droplet Freezing Technique (Córdoba et al., 2021) as shown in Figure 2.

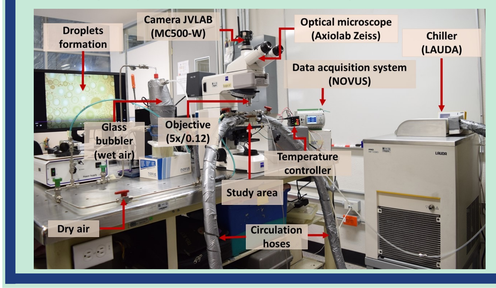


Figure 2. The UNAM-DFT experimental setup (Córdoba et al., 2021).

Results

1. Aerosol variability

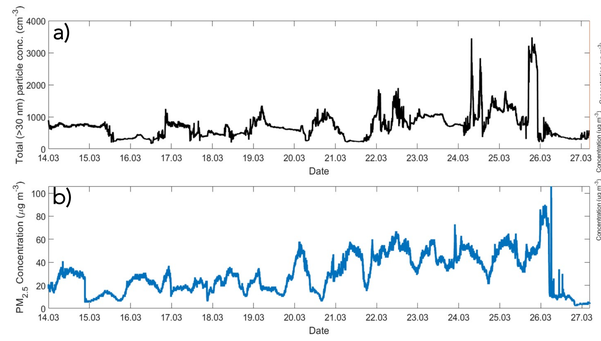


Figure 3. Timeseries of a) the total particle concentration (>30 nm) and b) $PM_{2.5}$ concentration for the SNOMAX campaign.

2. Aerosol composition

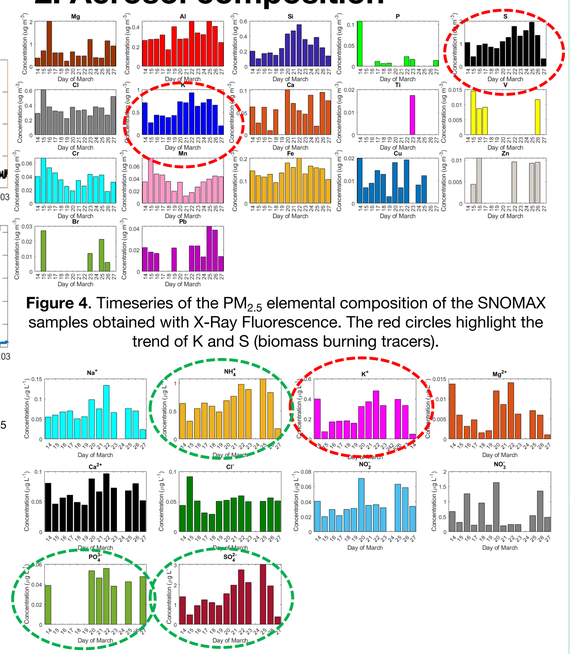


Figure 4. Timeseries of the $PM_{2.5}$ elemental composition of the SNOMAX samples obtained with X-Ray Fluorescence. The red circles highlight the trend of K and S (biomass burning tracers).

Figure 5. Timeseries of the $PM_{2.5}$ ionic composition of the SNOMAX samples obtained by Ion Chromatography. The red circles highlight the trend of K^+ (a biomass burning tracer). The green circles highlight the trend of NH_4^+, PO_4^{3-}, and SO_4^{2-} (agricultural fertilizer tracers).

3. Bacteria diversity

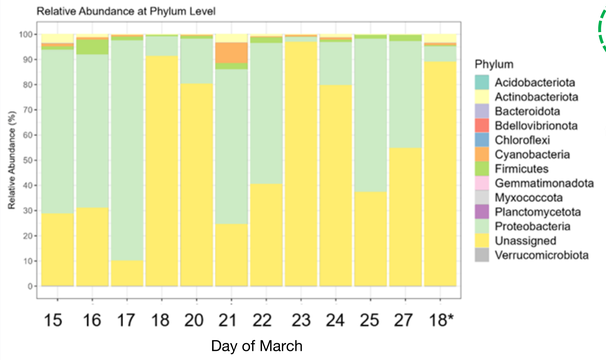


Figure 7. Relative Abundance of bacteria at phylum level of the SNOMAX campaign. All samples were collected with a Minivol except for 18*, which was collected using an Impinger.

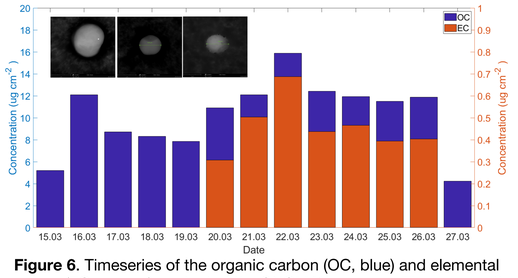


Figure 6. Timeseries of the organic carbon (OC, blue) and elemental carbon (EC, orange) content of the SNOMAX samples. The upper-left photos are examples of the morphology of most of the collected aerosol particles obtained from Scanning Electron Microscopy.

4. Ice nucleating abilities

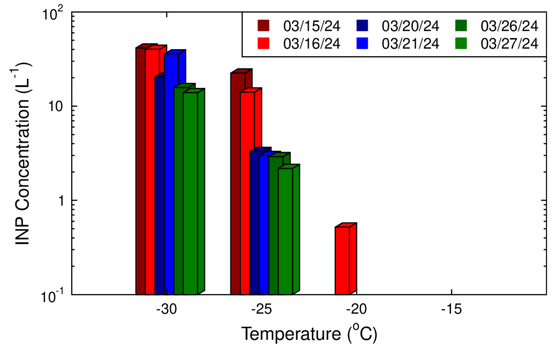


Figure 8. INP concentration (560 nm – 10 μm) as a function of temperature for the beginning (red), middle (blue), and end (green) of the SNOMAX campaign.

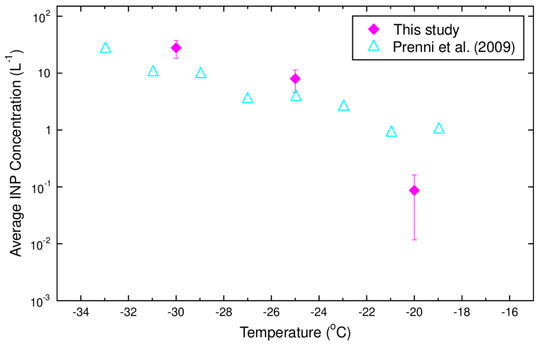


Figure 9. Average INP concentration for the northwestern Amazon (filled magenta diamonds, this study) and central Amazon (open aqua triangles, Prenni et al. (2009)).

Conclusions

- A high concentration of particles $PM_{2.5}$ (up to 100 μg m^{-3}) and TPCN (up to 3500 cm^{-3}) were observed during the dry season, with the first part of the campaign being the "cleanest".
- The high particle concentrations are likely related to biomass burning and agricultural fertilizers emissions along the Orinoco River Basin.
- The collected aerosol particles acted as INPs, via immersion freezing, between -20 °C and -30 °C, with a maximum INP concentration of 41.4 L^{-1} at -30 °C.
- The highest INP concentrations were observed during the "cleanest" period (i.e., 03/14 – 03/20).
- It seems that the higher organic content observed during the second half of the campaign (i.e., 03/20 – 03/26) negatively impacted the ice-nucleating abilities of the particles from the northwestern Amazon.
- Although different bioparticles were present at the sampling site, ice nucleation was not observed at temperatures above -15 °C.
- The INP concentrations in the northwestern Amazon were found to be comparable with those reported in the Central Amazon.

Acknowledgements

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