Preliminary characterization of submicron secondary aerosol in the amazon forest – ATTO station

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Introduction

Biogenic secondary organic aerosol particles are investigated in the Amazon. The forest naturally emits a large number of gaseous compounds; they are called the volatile organic compounds (VOCs). They are emitted through processes that are not totally understood. Part of those gaseous compounds are converted into aerosol particles, which affect the biogeochemical cycles, the radiation balance, the mechanisms involving cloud formation and evolution, among few other important effects. In this study chemical and physical aerosol properties are investigated (especially optical), with emphasis on the organic component.

Methodology

The ATTO station is located about 150 km northeast of Manaus in the remote Amazon forest. The measurements were taken above the canopy at 60 m height.

Table 1 – Instrumentation used in this study.

Instrumentation	Information
ACSM Aerodyne Res. Inc.	Non-refractory species: organic, sulfate, nitrate, ammonium and chloride.
MAAP (Thermo, 5012)	Black carbon (BC)
Nephelometer (Ecotech, Aurora 3000)	Scattering coefficient
SMPS (TSI, 3081)	Number of particles and size distribution

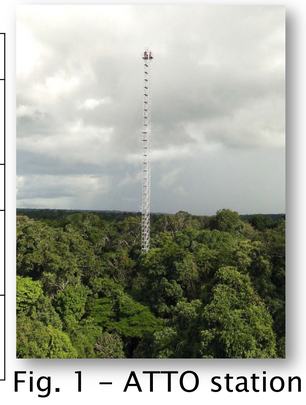


Fig. 1 – ATTO station

Results and discussions

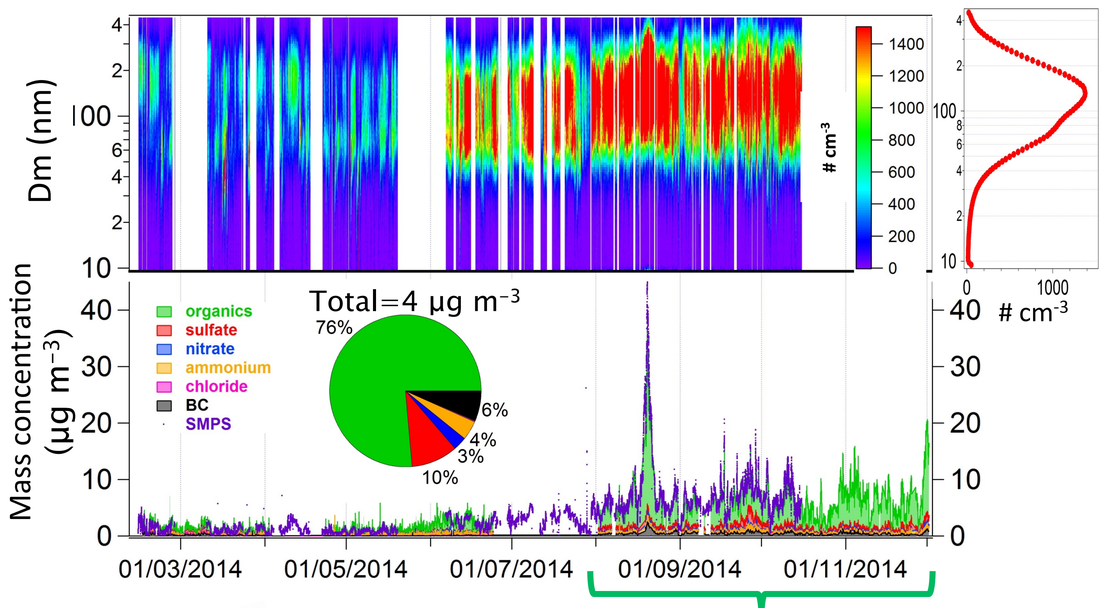


Fig. 2 – Aerosol particles mass closure and SMPS mass concentration (lower panel). The SMPS mass was calculated as described by De Carlo et al., (2008) and the organic density (1.51 ± 0.06 g cm^{-3}) was estimated as described by Kuwata et al., (2012). The average density for the dry season was 1.56 ± 0.07 g cm^{-3}. The particles size distribution (upper panel) presented two different modes (Aiken and accumulation) and few new particle formation events mainly during the wet season (Jan–Jun).

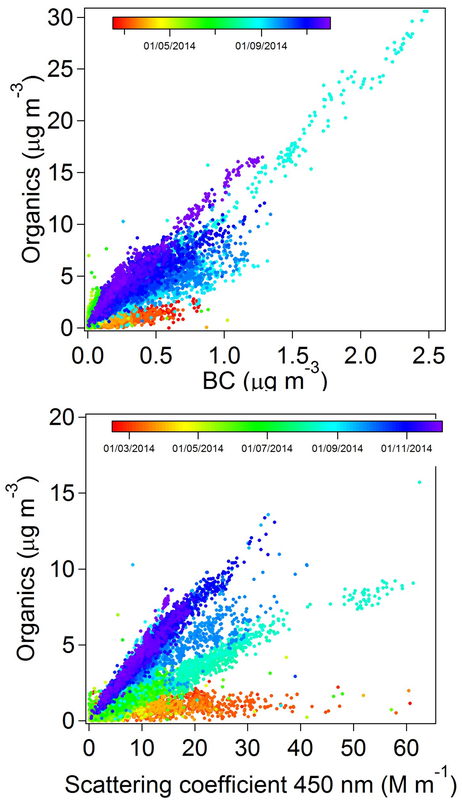
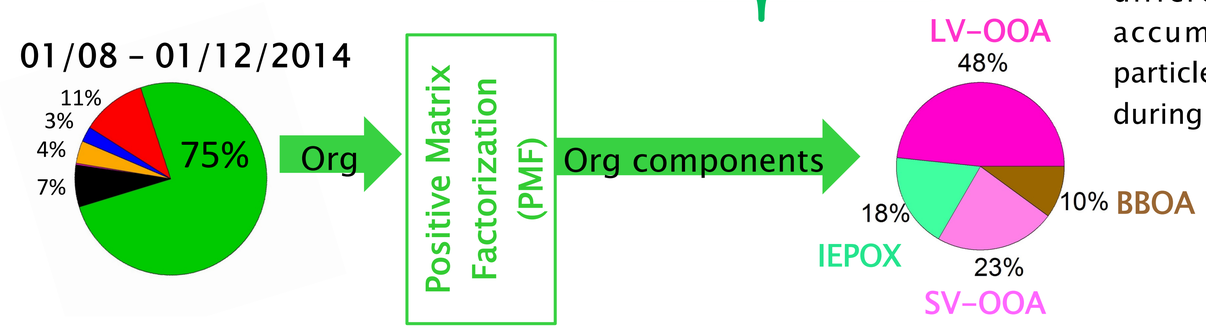


Fig. 3 – The organics made up to 76% of the fine particles and when investigated as a function of the scattering coefficient (σ_{450}, lower panel) different patterns (with different slopes) were observed over time. Likewise, different patterns, although less evident, were observed when the organic fraction was studied as a function of BC (upper panel).

In order to further investigate the organic fraction, the positive matrix factorization (PMF) was used from August 1st to December 1st, 2014. This period corresponds to the dry season.



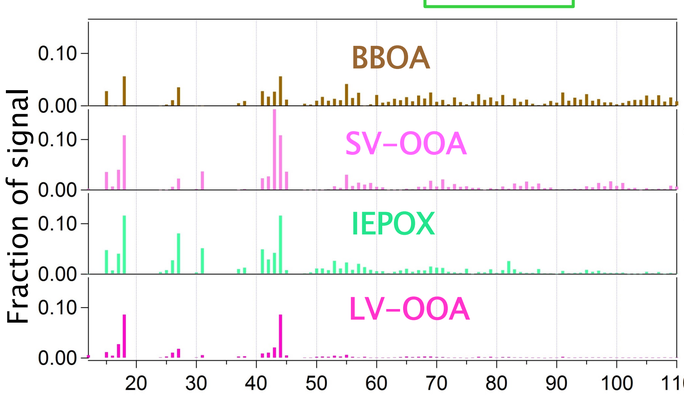


Fig. 4 – PMF profiles.

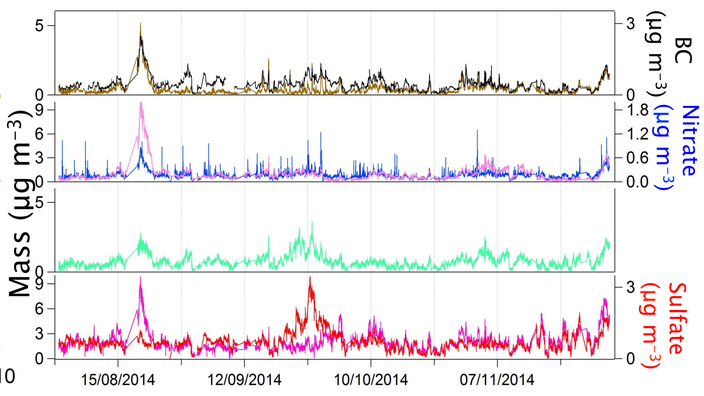


Fig. 5 – PMF time series.

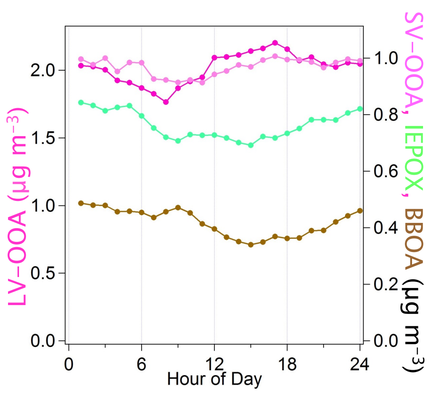


Fig. 6 – PMF diurnal profiles.

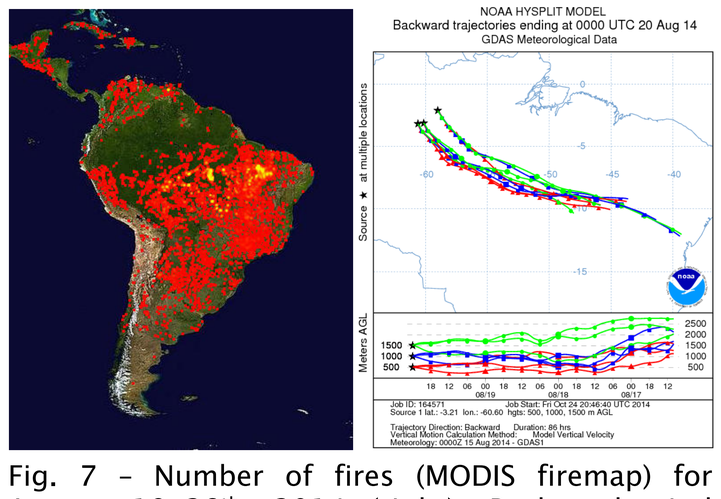


Fig. 7 – Number of fires (MODIS firemap) for August 19–28th, 2014 (right). Backward wind trajectories (left) calculated with HYSPLIT reaching the ATTO site (and two others) at the day of the biomass burning event (August 20th).

Four different organic components were obtained, low-volatility oxygenated organic aerosol (LV-OOA), semi-volatile organic aerosol (SV-OOA), isoprene epoxydiols (IEPOX) and biomass burning oxygenated organic aerosol (BBOA). The LV-OOA represents the most oxygenated and processed fraction of the OA. It did not present a clear correlation with sulfate (low volatile compound). However Figure 8 shows that those compounds still present certain agreement (different slopes) for short specific periods sugesting sources/transformation similarities. Moderate correlation was found between the IEPOX and sulfate (Pearson, R=0.64), which confirms that the acidic condition may facilitate the conversion of isoprene to epoxydiols SOA (Lin et al., 2012). Based on backward wind trajectories (Fig. 7), one clear biomass burning episode was identified on August 20th, likely originated at southeast Amazon basin or northeast of Brazil. Another event with ~30% sulfate was identified (September 23rd – October 1st). Aerosol particles during this event presented single scattering albedo value of 0.77 (Figure 8) suggesting slightly absorbing character. The low SSA value is likely related to the increase of the BC contribution in the same period.

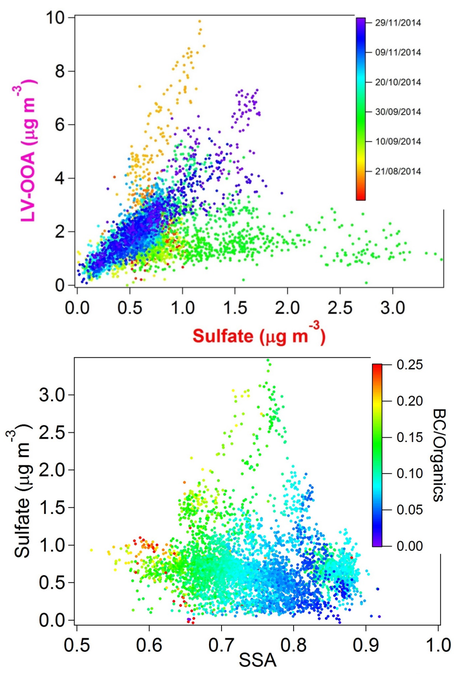
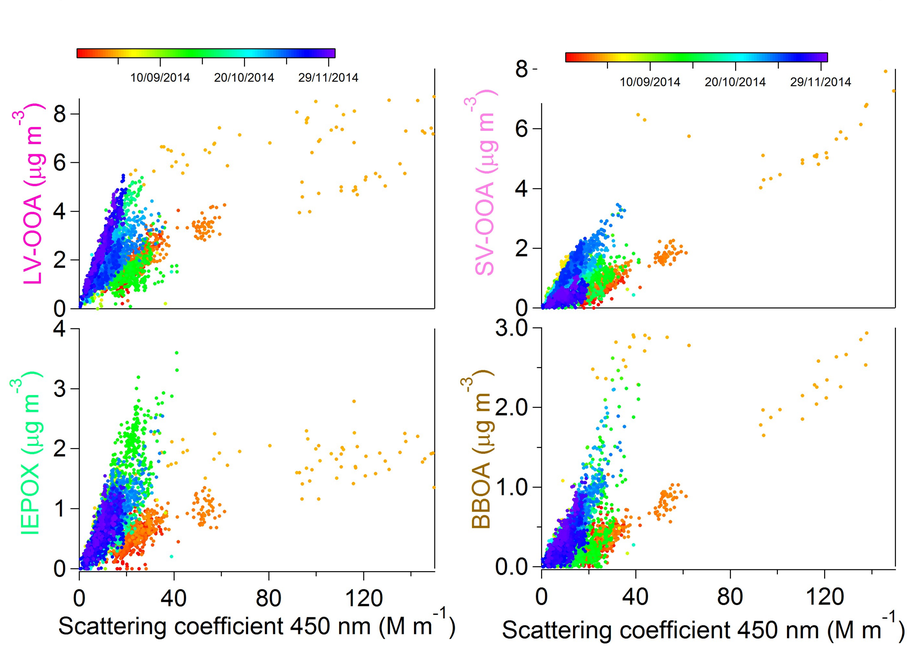


Fig. 8 – LV-OOA vs. sulfate (upper) and sulfate vs SSA at 637 nm (lower).



Figs. 9 – The four organic aerosol components as a function of the scattering coefficient at 450 nm.

It was possible to characterize individual episodes based on the σ_{450}. For example, two episodes of biomass burning were observed, one on Aug 20th and the second on Nov 29th with different characteristics. While the first presented elevated σ_{450} (suggesting more scattering particles) and no increase in sulfate, the second presented lower values of σ_{450} and a clear increase in sulfate concentration. Those facts could indicate different sources of biomass burning that were not fully resolved by the PMF analysis.

Key findings

- ✓ The organic fraction was dominant in the mass closure (76%) → elevated degree of oxidation → aerosol density (1.56 g cm^{-3});
- ✓ Four componentes of the AO were identified, LV-OOA, SV-OOA, IEPOX and BBOA;
- ✓ Episodes with high mass concentrations presented very distinct chemical and optical characteristics;
- ✓ Possible presence of biomass burning related to different sources or atmospheric transformations.

References

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