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Aerosols in Amazonia: Natural Biogenic Particles and Large Scale Biomass Burning Impacts

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Abstract. The Large Scale Biosphere Atmosphere Experiment in Amazonia (LBA) is a long term (20 years) research effort aimed at the understanding of the functioning of the Amazonian ecosystem. In particular, the strong biosphere-atmosphere interaction is a key component looking at the exchange processes between vegetation and the atmosphere, focusing on aerosol particles. Two aerosol components are the most visible: The natural biogenic emissions of aerosols and VOCs, and the biomass burning emissions. A large effort was done to characterize natural biogenic aerosols that showed detailed organic characterization and optical properties. The biomass burning component in Amazonia is important in term of aerosol and trace gases emissions, with deforestation rates decreasing, from 27,000 Km^2 in 2004 to about 5,000 Km^2 in 2011. Biomass burning emissions in Amazonia increases concentrations of aerosol particles, CO, ozone and other species, and also change the surface radiation balance in a significant way. Long term monitoring of aerosols and trace gases were performed in two sites: a background site in Central Amazonia, 55 Km North of Manaus (called ZF2 ecological reservation) and a monitoring station in Porto Velho, Rondonia state, a site heavily impacted by biomass burning smoke. Several instruments were operated to measured aerosol size distribution, optical properties (absorption and scattering at several wavelengths), composition of organic (OC/EC) and inorganic components among other measurements. AERONET and MODIS measurements from 5 long term sites show a large year-to year variability due to climatic and socio-economic issues. Aerosol optical depths of more than 4 at 550nm was observed frequently over biomass burning areas. In the pristine Amazonian atmosphere, aerosol scattering coefficients ranged between 1 and 200 Mm-1 at 450 nm, while absorption ranged between 1 and 20 Mm-1 at 637 nm. A strong seasonal behavior was observed, with greater aerosol loadings during the dry season (Jul-Nov) as compared to the wet season (Dec-Jun). During the wet season in Manaus, aerosol scattering (450 nm) and absorption (637 nm) coefficients averaged, respectively, 14 and 0.9 Mm-1. Angstrom exponents for scattering were lower during the wet season (1.6) in comparison to the dry season (1.9), which is consistent with the shift from biomass burning aerosols, predominant in the fine mode, to biogenic aerosols, predominant in the coarse mode. Single scattering albedo, calculated at 637 nm, did not show a significant seasonal variation, averaging 0.86. In Porto Velho, even in the wet season it was possible to observe an impact from anthropogenic aerosol. Black Carbon was measured at a high 20 ug/m³ in the dry season, showing strong aerosol absorption. This work presents a general description of the aerosol optical properties in Amazonia, both during the Amazonian wet and dry seasons.

Nucleation and Atmospheric Aerosols
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Keywords: Aerosol particles, Amazonia, biosphere-atmosphere interactions, Biomass Burning, aerosol composition, optical properties, remote sensing of aerosols.
PACS: 92.60.Mt , 42.68.Jg.

INTRODUCTION

Amazonia is one of the regions that is experiencing fast environmental changes with important climatic implications, and has been studied through the LBA (The Large Scale Biosphere-Atmosphere Experiment in Amazonia) experiment [1]. It is well established that tropical rainforests are critically important in the global hydrological cycle and in the global carbon budget [2]. Natural aerosols from Amazonia have been recently reviewed and indicate that in the wet season, Amazonia presents very pristine aerosol concentrations, typical of continental pre-industrial atmosphere [3,4]. Tropical emissions from biomass burning from deforestation and agricultural practices play a major role in controlling atmospheric composition [5]. Smoke from fires after deforestation have a large impact in convection, cloud formation and affects the precipitation regime [6, 7]. Aerosols from biomass burning have also been associated with precipitation pattern changes such as the delay in the beginning of the Amazon Basin's dry season [8]. The accumulated deforested area over the Amazon Basin until 2011, was approximately 741,365 km2, or around 18% of the original forest area. However, the rate of deforestation has significantly decreased since 2004. In that year, 2004, 27,200 km² were deforested, while only 4,656 km² were deforested in 2012 (Fig. 1).

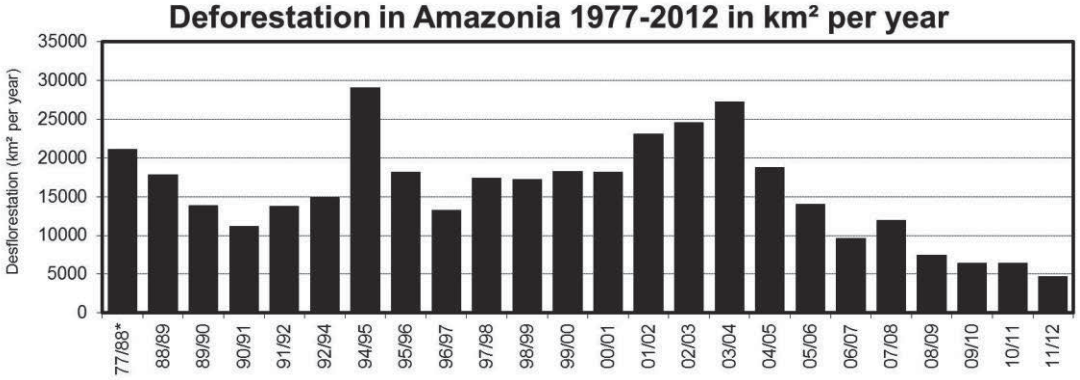

FIGURE 1. Deforestation rates in Amazonia from 1977 to 2012.

Aerosol Properties Measured for Background Areas in Amazonia

Aerosols were collected in a pristine area North of Manaus from 2008 to 2012, at the ZF2 ecological reservation (2º 35.65 S, 60º 12.55W, 110 m a.s.l.). Fig. 2 shows the time series of fine and coarse mode aerosol mass concentration for this site. There is a small seasonal behavior for wet to dry seasons. Biogenic coarse mode aerosol dominates the coarse mode and Secondary Organic Aerosol (SOA) dominates the fine mode. Fig. 3 shows the time series for back carbon (BC) concentrations in fine and coarse mode. During the wet season, fine mode BC averages a low 98 ng/m³.

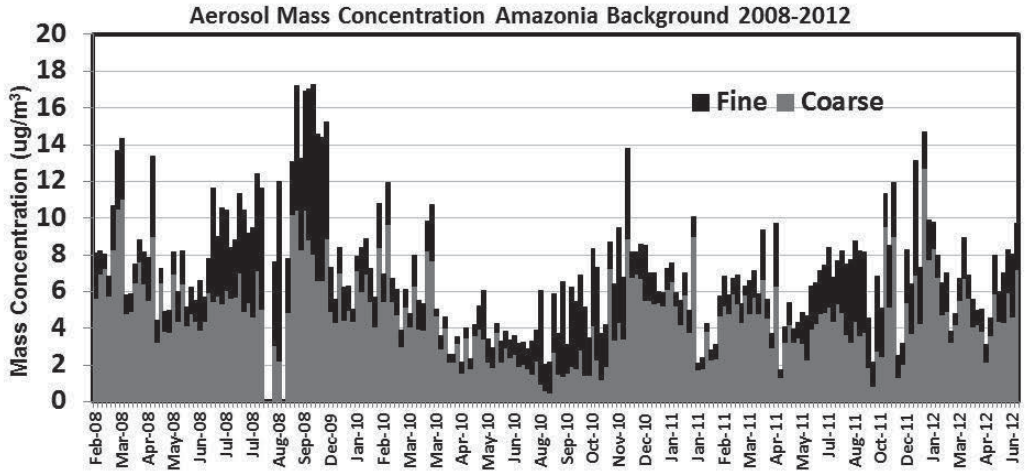

FIGURE 2. Time series of fine and coarse mode aerosol mass concentration for the background area in Central Amazonia.

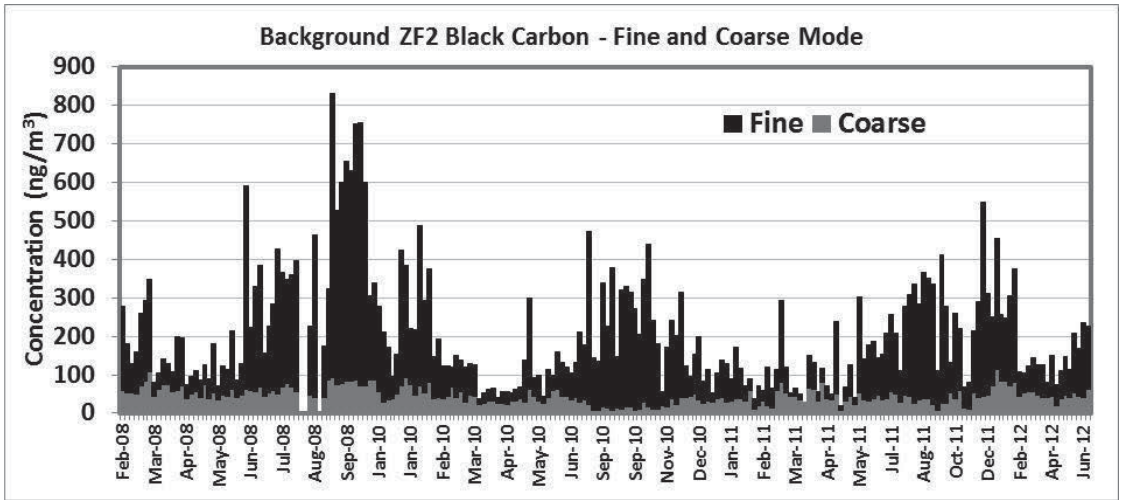

FIGURE 3. Time series of fine and coarse mode black carbon concentrations for the background site in central Amazonia.

There is a strong seasonal variability in optical properties (Fig 4). Very low aerosol lights scattering and absorption is observed in the wet season, showing a very pristine continental atmosphere. The work of Rizzo et al., discuss in details the optical properties [9], and Sena et al. [10] details the radiative forcing calculations.

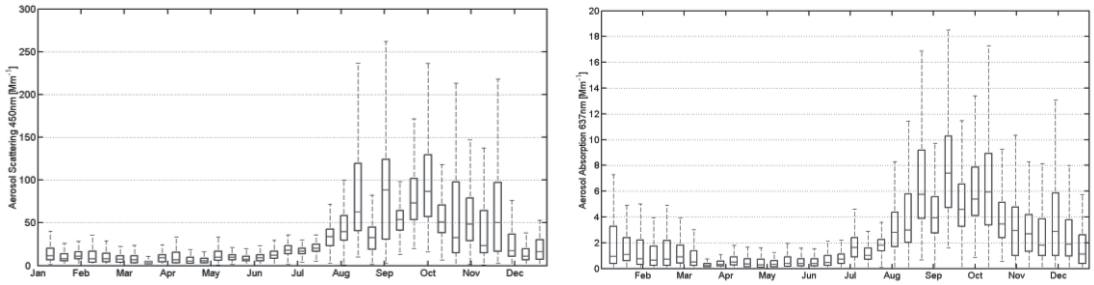

FIGURE 4. Seasonal variability of optical properties for the background area in Central Amazonia, with light scattering at 450 nm and light absorption at 637 nm, showing strong seasonal variability from wet to dry season for aerosol optical properties.

Aerosol characteristics in biomass burning impacted areas

Since September 2009 an aerosol and trace gas monitoring station was operated in Porto Velho (8,69°S; 63,87°O), with similar measurements as in the background station in Central Amazonia. Porto Velho is a heavily impacted area by biomass burning emissions as well as local anthropogenic pollution. Figure 5 shows the time series of fine, coarse and PM_{10} aerosols. The impact of biomass burning particles is easily observed. Optical properties and elemental composition shows clearly the large impact of biomass burning. The effect on carbon uptake by the forest due to the increase in diffuse radiation flux can reach a significant increase of 38% [11].

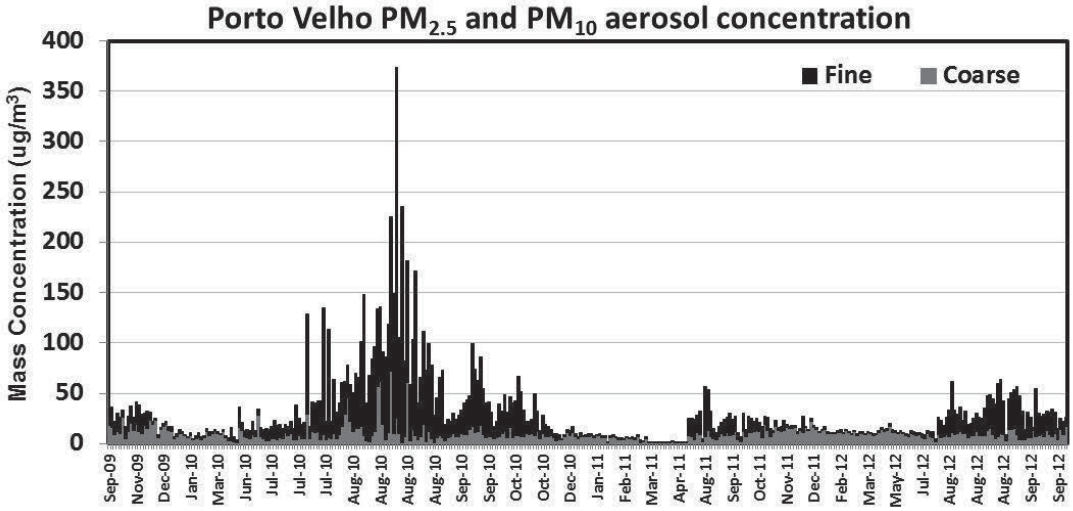

FIGURE 5. Time series of fine, coarse and PM_{10} aerosol mass concentration for the Porto Velho monitoring station. Biomass burning impacts are easily observed during the dry season, especially for 2010, a very dry year in Amazonia.

ACKNOWLEDGMENTS

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