Elemental composition of atmospheric aerosol particles in the GoAmazon experiment

André Bürger[1]*; Paulo Artaxo[1]

(1) Institute of Physics, University of São Paulo, São Paulo, Brazil

Work Summary

- The objective of this work was to analyze aerosol sources and processes looking at the aerosol elemental composition.
- Aerosols were collected in Nuclepore filters at three sites in Central Amazonia between mar/14 and sept/15 using stacked filter units (SFU), which separate fine and coarse particulate matter (FPM and CPM). They were analyzed in order to obtain mass concentration, equivalent Black Carbon (eBC) and elemental chemical composition;
- Comparisons of eBC from these filters with absorption coefficient measured by aethalometers were made in order to validate the data;
- PMF 5.0 (Positive Matrix Factorization) was applied on the filter time series and extracted several factors for each site: biomass burning, biogenic processes, soil dust, marine aerosol, vehicular, and urban pollution factors.

Sampling Sites

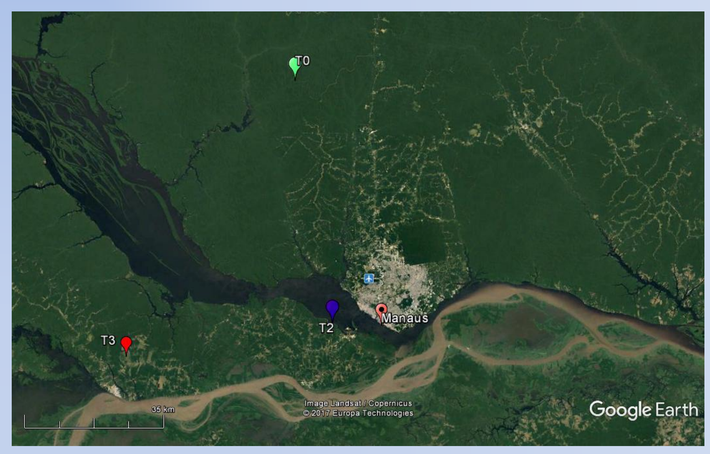

Figure 1: Sampling sites at Central Amazonia

Figure 1 shows the locations of the sites ZF2-T0 (green flag, about 60km upwind of Manaus), TIWA-T2 (dark blue flag, 8km downwind of Manaus) and Manacapuru-T3 (red flag, 60km downind of Manaus). The aerossol samples were collected from the begining of 2014 until the end of 2015.

Results and Discussion

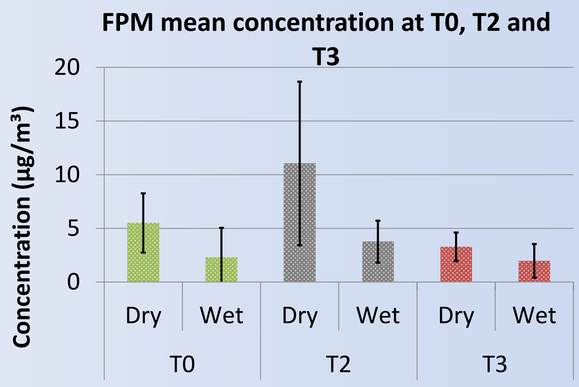

Figure 2 – Mean fine particle (FPM) concentrations at T0, T2 and T3 for the GoAmazon14/15 for wet and dry seasons.

At Figure 2 the FPM mean concentration can be observed at all sampling sites. At the pristine site, T0, the mean FPM concentration varied from 2,3±2,7 µg/m³ at the wet season to 5,5±2,7 µg/m³ in the dry season. Those values are similar to other measurements made at pristine sites in the Amazon Basin.

FPM mean concentration at T2 is 3,7±2,0 µg/m³ (wet season) and 11,0±7,6 µg/m³ (dry season). While in the wet season the FPM concentration is slightly higher than that found at T0, at the dry season it is comparable to values measured in São Paulo.

At T3 the FPM mean concentration is 3,2±1,3 µg/m³ at the dry season and 1,9±1,5 µg/m³ at the wet season.

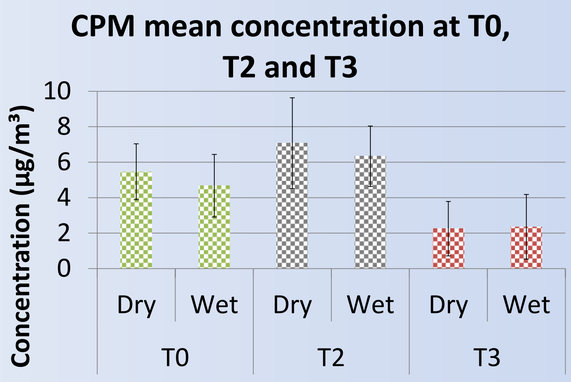

Figure 3 – mean coarse particle mode (CPM) concentrations at T0, T2 and T3 for the GoAmazon14/15.

At figure 3 it can be observed the CPM mean concentration at the three sampling sites. At the pristine site of T0 the CPM mean concentration varied between 4,7±1,7 µg/m³ (wet season) and 5,4±1,5 µg/m³ (dry season). At pristine sites, CPM aerosols are mainly related to primary biogenic particles, and also dust transport from Sahara at the wet season. CPM mean concentration at TIWA was of 7,1±2,5 µg/m³ during dry season and 6,3 µg/m³ during wet season, and finally, at T3, 2,2±1,5 µg/m³ at the dry season and 2,3±1,8 µg/m³ at the wet season.

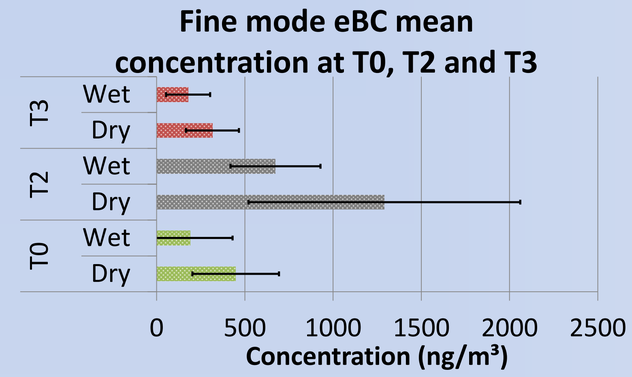

Figure 4 – mean equivalent black carbon (eBC) (fine mode) concentrations at T0, T2 and T3 for the GoAmazon14/15.

At figure 4 it can be observed the fine mode eBC mean concentration at T0, T2 and T3. The mean concentration at the pristine site is of 448±245ng/m³ at dry season and 190±240ng/m³ at wet season. For T2, the mean eBC concentration at fine mode is of 673±254ng/m³ at the wet season and 1220±653ng/m³ at the dry season and, finally, at T3 the mean concentration is of 316±150ng/m³ and 178±124ng/m³ at dry and wet season, respectively.

The values found at T0 are similar to previous studies and is a combination of the absorption properties of biogenic and biomass burning particles.

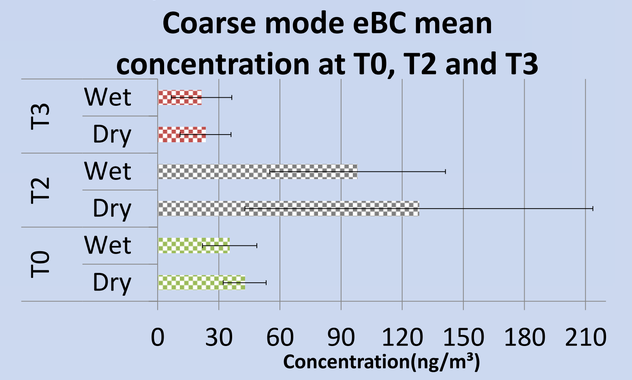

Figure 5 – mean equivalent black carbon (eBC) (coarse mode) concentrations at T0, T2 and T3 for the GoAmazon14/15.

At figure 5 the eBC mean concentration can be observed at coarse mode.

For T0 we found concentrations of 42±11ng/m³ at the wet season and 35±13ng/m³ at the dry season, similar to previous studies. At T2 these concentration were of 98±43ng/m³ for the wet season and 120±73ng/m³ at the dry season and, finally, at T3 these concentrations were of 23±12ng/m³ at the dry season and 21±14ng/m³ at the wet season.

In pristine regions, the coarse mode eBC is mainly composed of absorbing primary biogenic particles and is essentially constant throughout the year, as seen at T0 concentrations.

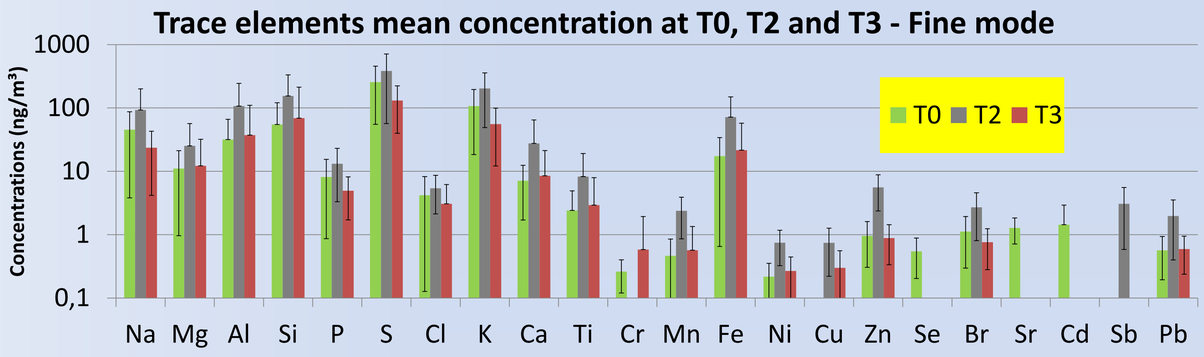

Figure 6 – mean concentration of trace elements (fine mode) measured by X-ray Fluorescence at the sites T0, T2 and T3. Please note the logarithm scale.

At figure 6, it is possible to observe higher concentrations for all elements at T2, specially for elements related to industrial/vehicular processes like Al, Ti, Mn, Fe, Ni, Cu, Zn and Pb. This group of elements showed Pearson Correlation Coefficient higher than 0,5 at T2 ($p>0,05$) between each other and the ratio between T2 mean concentration and T0 range from 3,4 (Al, Ti and Pb) to 5,8 (Zn). Meanwhile, the elements that are mainly emitted by regional sources such as marine (Cl), biogenic processes and biomass burning (P, S, K), showed a ratio that ranged from 1,3 (Cl) to 1,9 (K).

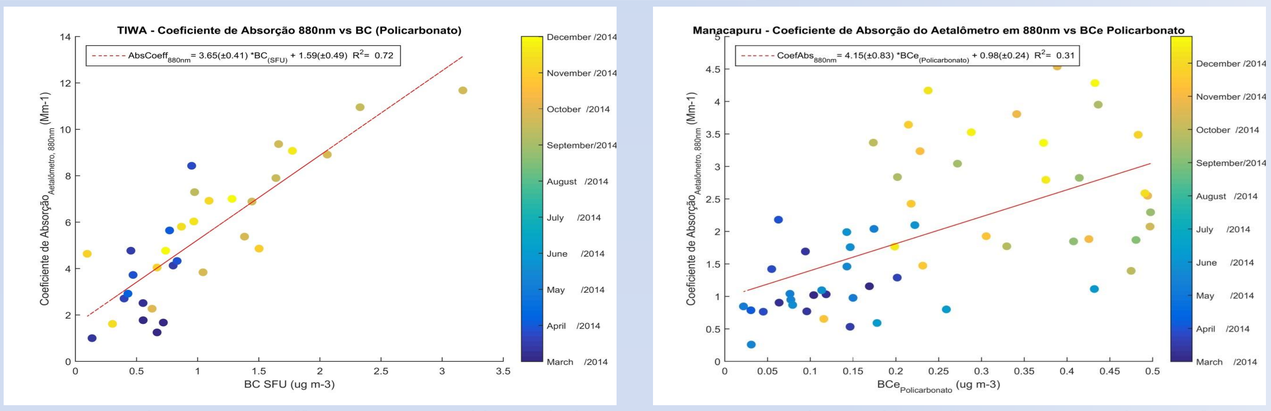

Figure 7 – absorption coefficient measured by aethalometers versus eBC obtained by reflectance on Nuclepore filters for a)T2 (left) and b)T3 (right).

At figure 7.a, a significant correlation is observed between the absorption coefficient measured by aethalometer at 880nm and eBC obtained by reflectance (white light with peak at 550nm) from Nuclepore filters at T2. At Figure 7.b, with the same comparison for T3, is possible to observe a wide dispersion, specially for the dry season (green to yellow points) that leads to a low R^2 (0,31). That low R^2 for T3 indicates a problem in the collection of aerosol by SFU.

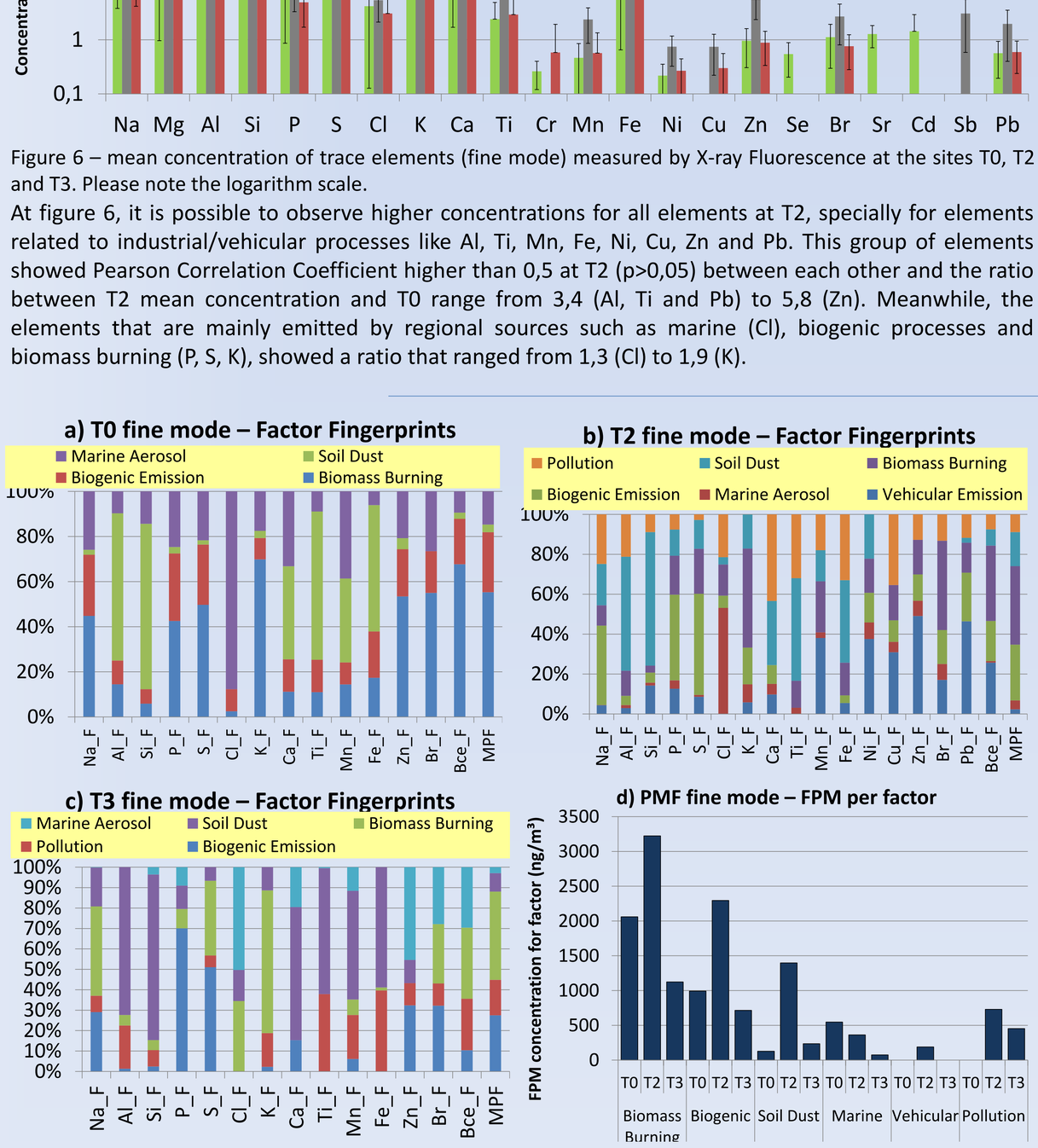

Figure 8 – Factor fingerprints extracted by the Receptor Model PMF 5.0 for a) T0, b)T2 and c)T3 fine mode aerossol. General results of FPM extracted per factor for each site is present on d).

At figure 8 the factor fingerprints extracted by PMF5.0 can be observed at T0, T2 and T3 for the GoAmazon14/15 period.

The figure 8a shows that at the pristine region T0 four factors were extracted: Marine Aerosol (with high percentage of Cl concentration along Mn and Na), Biogenic Emission (with considerably percentage of P, S and eBC concentration), Soil Dust (with high percentage of Al, Si, Ca, Ti, Mn and Fe concentration) and Biomass Burning (with high percentage of P, S, K, Zn, Br and eBC concentration). These four factors were found at all sites.

At T2 factor fingerprints, figure 8b, two more factors can be recognized: Pollution and Vehicular Emission. The first is related with Na, Al, Si, Ca, Ti, Mn, Fe, Cu, Zn, Pb and eBC and the second is related to high percentage of Ni, Cu, Zn, Br, Pb and eBC concentration.

At T3, only one more factor was found in relation to T0: Pollution. This factor is characterized by considerably contributions to Al, Si, K, Ti, Mn, Fe, Zn, Br and eBC concentration.

At figure 8d the contribution of each factor for the FPM is shown. We can see that for all sites, biomass burning is the main contributor for the FPM mass. Comparing the FPM associated with this factor at T0 and T2, we can see that PMF extracted 1ug/m³ more from the latter. This may have happened due the ambiguity of the elements K, Zn and Br, key tracers for biomass burning, but are also present in lubricants and additives used in light-duty vehicles (K and Br) and Zn is commonly used as an antiwear and antioxidant additive in engine oil. The same happen to the second mainly factor at Amazon Basin, Biogenic processes, that has as key element S, also associated with vehicular emission.

The Soil dust factor is also much more higher in TIWA, probably associated with the high activity of the city.

Marine factor decreases from T0 to T2 and analyzing the composition of this factor, from T0 to T2 is possible to notice the reaction of Cl depletion, as less Na and S is found at T2 than at T0, but the Cl concentration still similar on both sites.

The last two factors of figure 8d shows that vehicular and pollution accounts for 918ng/m³ on the FPM of T2. At T3 the pollution factor accounted to 17% of FPM mean concentration.

Contact: andre-burger@hotmail.com