# Study of the absorption properties of Brown Carbon and Black Carbon using remote sensing (AERONET and AURA) and in situ measurements in the Amazon

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## Abstract

This research plans to investigate a new and important component of the effect of aerosols on the radiative balance, which is the absorption of radiation by the so-called Brown Carbon. In particular, this aspect has never been investigated for biogenic aerosols, and even for biomass burning aerosols. Also, this kind of measurements has never been done in tropical regions.

Using a time series of 15 to 18 years in the Amazon, with several sites with different impacts of biomass burning aerosols and natural biogenic emissions will provide new knowledge in this critical area. The measurements of aerosol absorption trough he OMI sensor over the Amazon is important, since this sensor that operates in the ultraviolet, is fundamental to find out a separation between black carbon and brown carbon in the Amazon. In situ measurements on Nuclepore filters with a high-resolution spectrometer in a wide range of wavelengths will also bring insights of new aerosol properties in Amazonia. We also point out the combination of in situ measurements, remote sensing from the ground, remote sensing with satellites and the use of radiative transfer models is an innovative aspect in the same work, especially applied to the Amazon region.

## Brown Carbon

Brown Carbon (BrC), consists of particles of organic carbon with properties of absorption of visible and ultraviolet radiation.

It is known for its light brownish color, strongly absorbs at wavelengths near of ultraviolet.

Examples: Tar produced by slow and low-temperature combustion, degradation products from biomass burning, mixtures of organic compounds emitted from the soil, and volatile organic compounds emitted by vegetation after being oxidized into the atmosphere.

Fig.2- Samples of BrC obtained during the 6 hour period next to a burning funeral pyre in India. Chakrabarty, 2014.

## The absorption Ångström coefficient for BC is always 1?

For the determination of BrC we use the Absorption Ångström Exponent (AAE), using a pair of absorption measures, usually covering the extremes of the visible light spectrum.

Absorption at the largest wavelength is assumed to be mostly by BC and this absorption is extrapolated to the smaller wavelengths assuming that the AAE is approximately 1 to BC.

The difference between the measured BC and the absorption at the smaller wavelength is then attributed to the absorption for a non-BC component, called BrC.

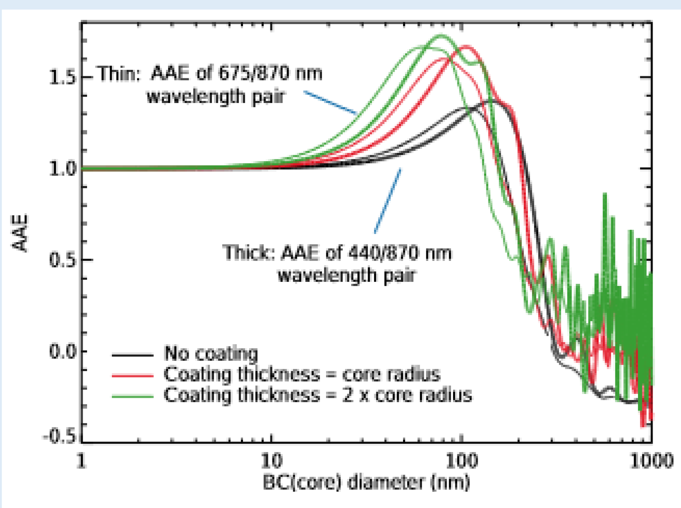


Fig.5 – The absorption coefficient of Angström (AAE) for estimated for several coatings. We observed that the AAE of the BC can be different from 1 depending on the thickness of the coating of the particle. This greatly affects the absorption. (Lack, 2013).

## Preliminary results

Figure 7 bellow shows the time series of in situ measurements of light scattering and absorption at the ZF2 and ATTO sites from 2008 to 2016. We observe strong increase during the dry season, and very low values during the wet season.

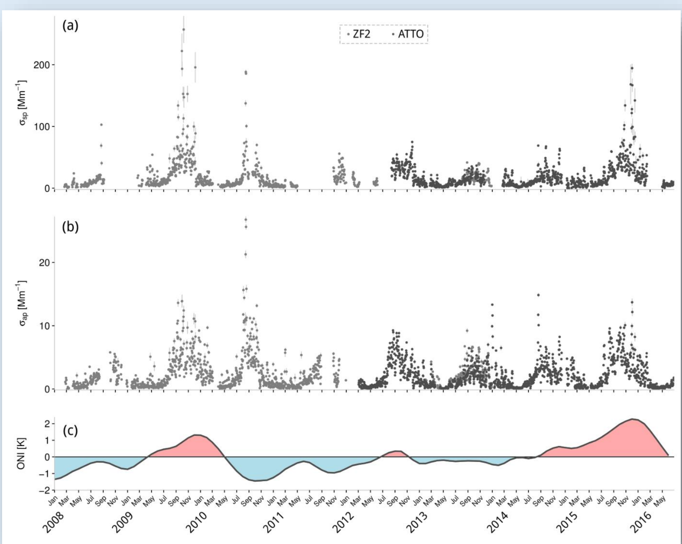


Fig.7 – In situ aerosol light scattering and absorption at the ZF2 and ATTO sites in Central Amazonia. The time series spans from 2008 to 2016. The third variable is the El-Nino index showing the oscillation between El Nino and La Nina over the same period. The single scattering albedo also changes significantly. No Brown Carbon measurements is being done so far in Amazonia.

## Black Carbon (BC)

The BC consist of particles emitted during combustion processes at high temperatures and is directly emitted into the atmosphere. It strongly absorbs solar radiation in the visible region [Bond et al., 2013] and has important effects in the global radiation budget.

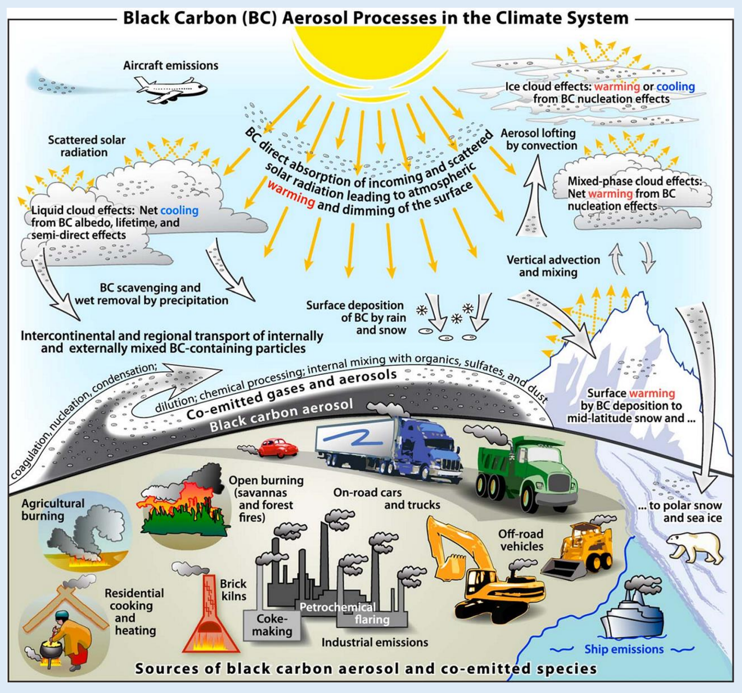


Figure 1 illustrates the transformation and deposition of BC in the Earth's atmosphere (Bond et al., 2013). The illustration shows the complex behavior of the BC in the atmosphere, with industrial emissions, fires, transport and others. The deposition in snow is important in the alteration of the terrestrial albedo. Its role in cloud development is also illustrated.

Fig.1- Sources and processes involved in BC in the Earth's atmosphere

## What is the real global impact of BC?

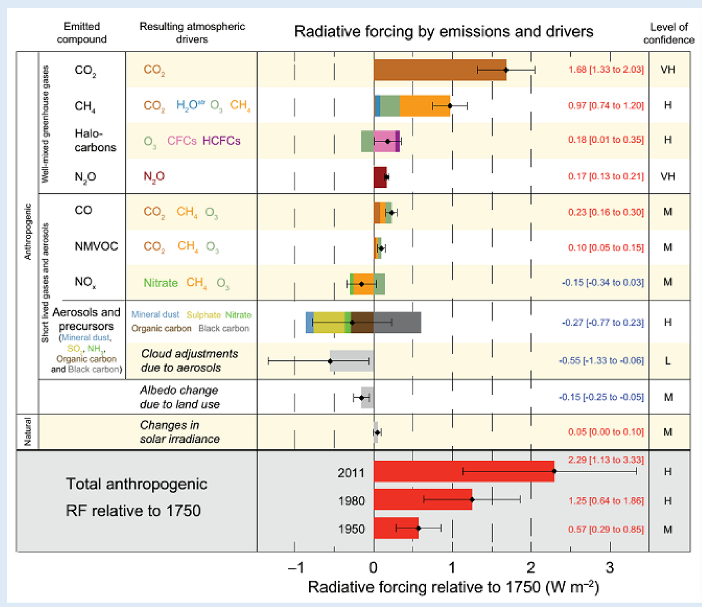


Fig.3 - The BC is important for the global radiative forcing (IPCC 2013), and according to the last report it accounts for about +0.65 w / m².

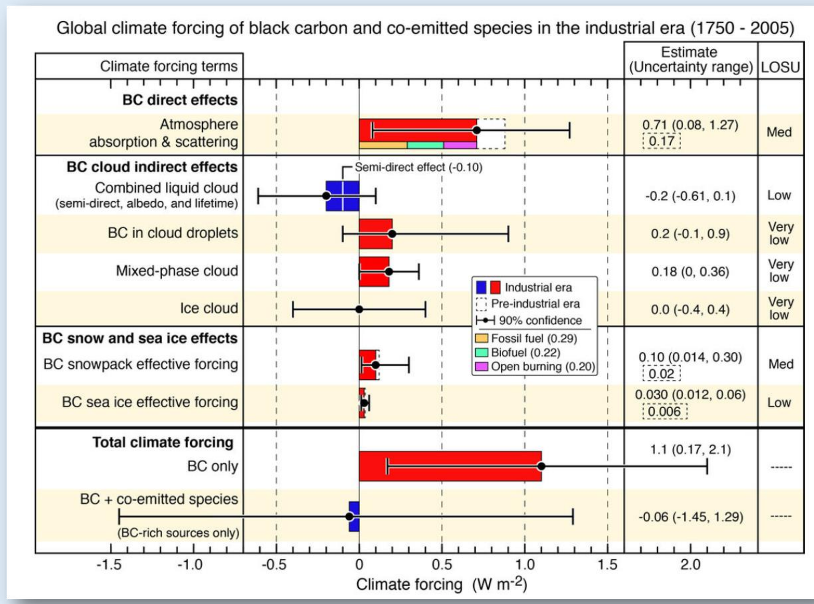


Fig.4- Bond et al. 2013, estimates the same forcing of the BC in +1.1 w / m², extremely high value, and if we take into account co-emitted particles, the forcing is -0.06 w / m².

## Preliminary results

This study will use remote sensing to measure the distribution and properties of aerosol absorption in Amazonia. The ground based AERONET CIMEL sunphotometers network will be used, since we have a 17 years of continuous measurements over several sites in Amazonia. The new retrieval algorithm from AERONET derives the refractive index and the absorption aerosol thickness that will be used in this study. Radiative transfer codes will calculate the aerosol radiative forcing over the several sites.

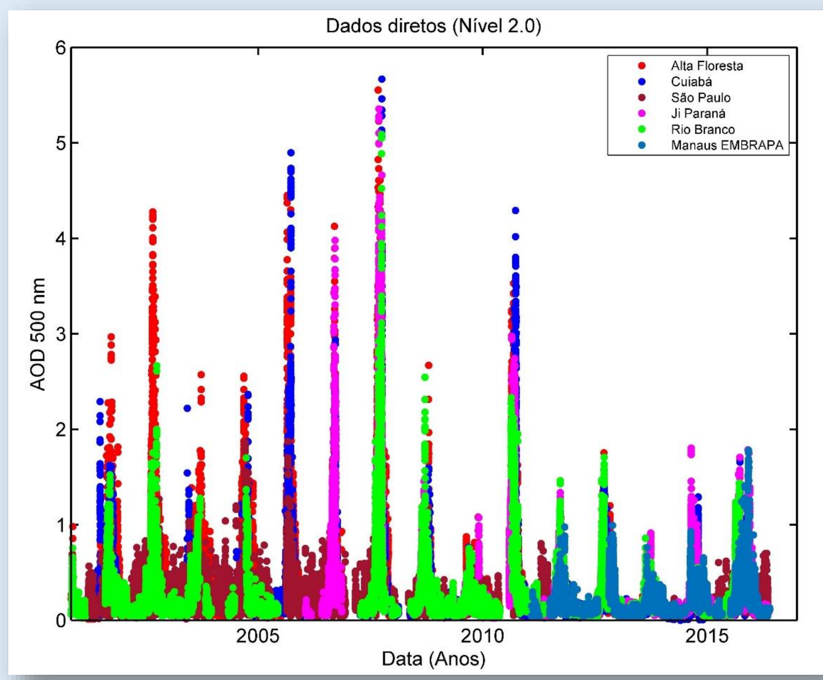


Fig.6 – Aerosol optical thickness measured from 2000 to 2017 using the AERONET sunphotometer network in several sites in Amazonia

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