

# Events of high particulate matter (smoke) concentrations in eastern Acre and their spatial relationship with regional biomass burning: the case of September 2005

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**Abstract.** A preliminary analysis of satellite images of the regional forest fire distribution and in-situ measurements of particulate matter concentration in eastern Acre, Southwestern Amazonia, Brazil showed extremely high concentrations of particulate matter in late September 2005. These high values appear to be associated with fires within a few hundred kilometers of the city of Rio Branco.

**Palavras-chave:** fires, smoke, Amazon, biomass burning, health, queimadas fumaça, amazônia, queima de biomassa.

## 1. Introduction

While fires and smoke have become commonplace in southwestern Amazonia over the last decades, the extensive fires that penetrated standing rain forests has been a relatively new phenomenon in southwestern Amazonia. In 2005 these fires extended over more than 250,000 ha in eastern Acre, Brazil (Brown et al. 2006). The objective of this paper is to present a preliminary analysis of satellite images of the regional smoke distribution and in-situ measurements of particulate matter concentration in Rio Branco, Acre. The present work is part of a larger, long-term project to determine the sources and health impacts of biomass burning in this part of the Amazon.

## 2. Material and Methods

Three methods for evaluation of particulate matter concentrations were used. They are black carbon (BC) concentration measurements, optical scattering coefficient (bs) determination and solar radiation photometry for aerosol optical thickness (AOT). All these methods are described elsewhere: particulate matter PM<sub>2.5</sub>, PM<sub>10</sub> and (AOT) are discussed concerning air pollution interaction with solar radiation in Artaxo et al. (1999). The model of smoke transportation from biomass burning in Amazonia is detailed in Freitas et al. (2005).

### 3. Results and Discussion

The local values of optical scattering coefficient, black carbon and aerosol optical thickness (**Figure 1**) all show exceptionally high values for the second half of September, among the highest recorded for the Amazon. Both the BC and AOT show extremely high levels during the period 16 to 22 September and peak on 19 September. While for AOT, the dominant pattern is one of a large increase extending from 19 to 21 September. This coincidence verifies the occurrence of this important air pollution event at low elevation in the atmosphere and also its extension to higher altitudes. At the same time the AOT measurements express an increasing accumulation of smoke aerosols in the atmospheric column particularly after 19 September, until its dispersion at the end of the period.

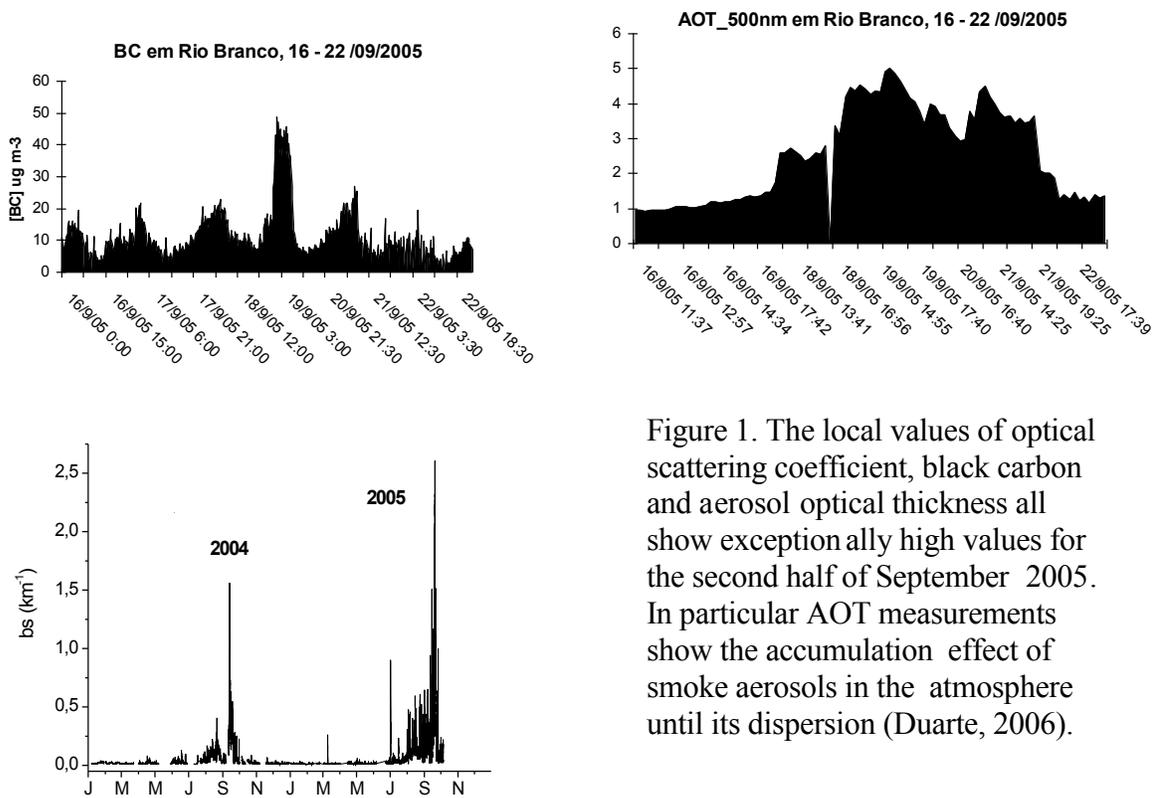


Figure 1. The local values of optical scattering coefficient, black carbon and aerosol optical thickness all show exceptionally high values for the second half of September 2005. In particular AOT measurements show the accumulation effect of smoke aerosols in the atmosphere until its dispersion (Duarte, 2006).

The MODIS imagery and the transport models for this period show extensive smoke coverage in the region (**Figure 2**), supporting the AOT observations of a large increase in smoke concentrations. One limitation is that the model shows smoke concentrations only as equal or greater than  $400 \mu\text{g m}^{-3}$  for particulate matter with effective diameter below  $2.5 \mu\text{m}$  (PM<sub>2.5</sub>). Black carbon may be 1 to 15 % of PM<sub>2.5</sub>. In this case, the 20 to 40  $\mu\text{g m}^{-3}$

$\text{m}^{-3}$  concentrations of black carbon indicate  $\text{PM}_{2.5}$  concentrations of 130 to  $4000 \mu\text{g m}^{-3}$ , well above Brazilian standards.<sup>1</sup>

The nearby Bolivian Department of Pando also suffered extensive burning with more than 200.000 ha of open lands and forests affected by burning (Cots, 2006). The fires in Acre, Pando and western Rondonia and south Amazonas contributed to the smoke that affected the region as near sources of air pollution during the later half of September 2005, when the most intense and expanded forest fires in eastern Acre together with the hardest drought of Amazonia in some decades.

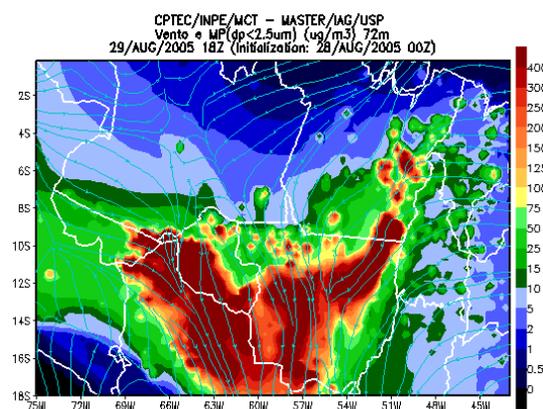
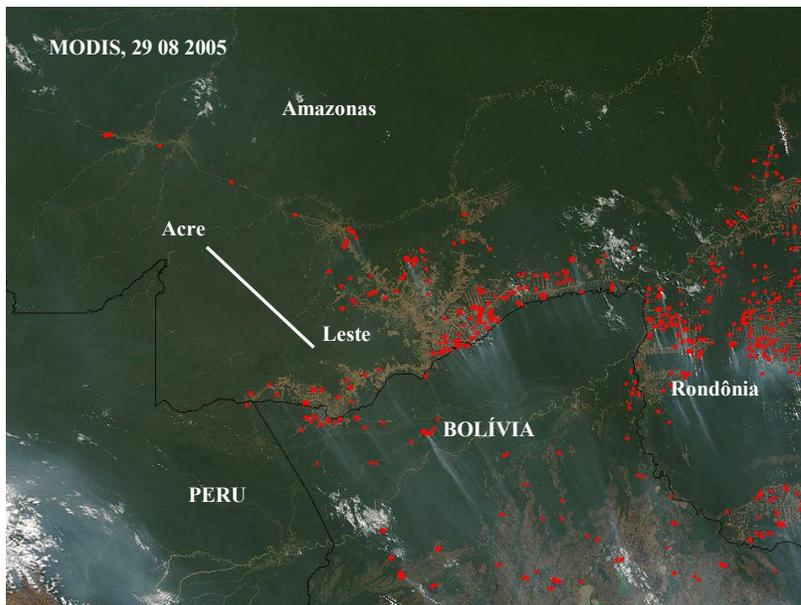


Figure 2. MODIS imagery of forest fires and smoke transportation model. Local fires at the eastern Acre were the sources of very high smoke concentration in the region during the dry season, particularly in September 2005.

#### 4. Conclusions

The anomalous conditions of the 2005 drought in western Amazon combined with a tremendous increase in fire frequency resulted in exceptional levels of optical scattering, black carbon, AOT and fine particulate matter. These values easily exceed international

<sup>1</sup> Resolução do Conselho Nacional de Meio Ambiente, n.3, de 28 de junho de 1990.

standards for air quality and raise serious questions as to the costs of such pollution on human health and on ecosystem functioning.

The sources of the smoke can be divided into two classes: those from near sources, here defined as coming from within Acre State or the nearby border region of Amazonas State and Pando, Bolivia, and distant sources that require long-range (hundreds of kilometers) transport. The result of studies with a regional transport model of smoke caused by biomass burning suggests that during a period of peak particulate matter concentrations near sources are the first-order contributors. In absence or diminished number of fires for these contributions the particulate matter concentration in Rio Branco is limited to values probably not exceeding  $150 - 200 \mu\text{g m}^{-3}$  from distant sources.

While further research is needed to quantify these costs, the impact of accidental and intentional fires in eastern Acre burned on the order of at least 460,000 ha of open land and forests has already served as a motivation for formulation of public policy alternatives to fire as a tool for land clearing and maintenance in southwestern Amazon.

## 5. Acknowledgements

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