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Aerosol optical depth for fine and coarse modes from NASA/AERONET measurements for the Amazon

Pedro H. T. Tavares [1]*, Paulo Artaxo [1], Marco A. Franco [2]
[1] Institute of Physics, University of São Paulo, São Paulo / Brazil
[2] Institute of Astronomy, Geophysics, and Atmospheric Sciences, University of São Paulo, São Paulo / Brazil
* e-mail: pedrotavares@usp.br

INTRODUCTION

The Amazon rainforest is the largest tropical forest in the planet, therefore being critical for regulating local, regional, and global atmospheric processes. Among the many ways it contributes to the Earth's radiative balance, the relevance of fine and coarse mode aerosols stands out. Their impacts on the radiative forcing are a relevant scientific question, as these particles are significantly diverse due to their different sources and formation mechanisms, leading to large uncertainties in their contribution to planetary energy balance.

Objectives: to characterize the seasonality of aerosol optical depth (AOD) due to fine and coarse modes and their contributions to radiative forcing (RF), through measurements from NASA/AERONET (AErosol RObotic NETwork) photometers in the Amazon Biome.

DATA and METHODOLOGY

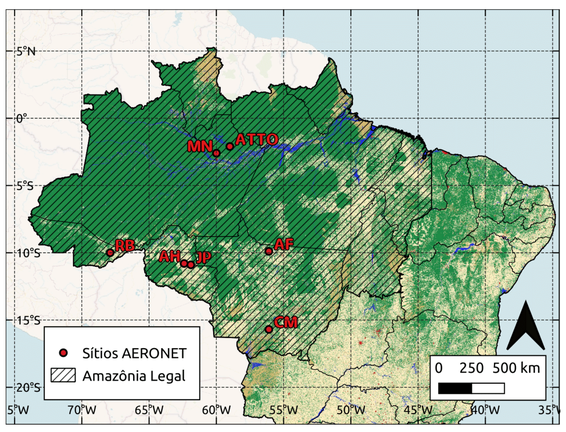

Figure 1: NASA/AERONET site locations in the Amazon region. AF, AH, ATTO, CM, JP, MN, and RB represents Alta Floresta, Abracos Hill, ATTO Tower and ATTO Campina, Cuiabá-Miranda, and Rio Branco, respectivelly. Data from ATTO Tower and ATTO Campina have being merged, as well as from Abracos Hill and Ji Paraná as this sites are close and their measurements compatible.

AOD and RF data: measurements from 8 sites displayed in Figure 1, whose time series span from 2000 to 2023. Measurements obtained by solar/lunar spectral automatic radiometers (CIMEL Electronic 318A/318T models), and through the AERONET network inversion algorithms. Only data level 1.5 were considered in this study. Available at https://aeronet.gsfc.nasa.gov/.

Site characteristics: ATTO sites are located at central Amazon, in a well preserved area. Manaus is located at a rather preserved area near a big city. The other sites are located inside the deforestation belt.

Statistical analysis: The characterization of AOD and radiative forcing seasonalities was based on boxplots, the correlation between AOD and radiative forcing was tested with linear models based on Pearson coefficient and p-value.

AMAZON RAINFOREST SEASONS

In this study, it is defined that the wet/dry season is the sequence of 4 months in which the median AOD is lowest/highest. Note that this definition does not necessairily coincides with the highest/lowest precipitable water vapor daily medians, as the time scale of wetting and dewetting of vegetation is in the order of 1 to 2 months.

AOD SEASONALITY

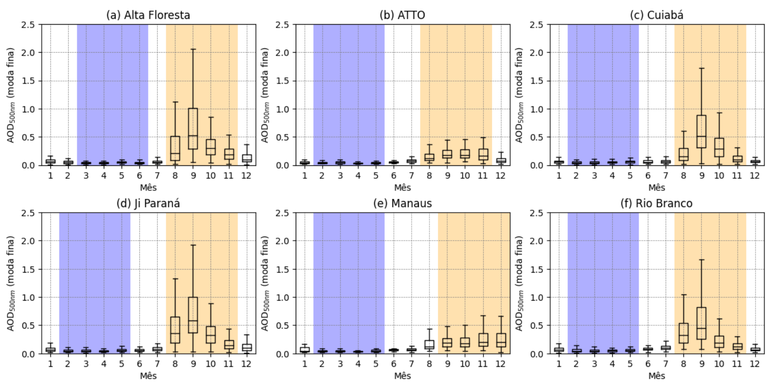

Figure 2: Boxplots for fine mode contribution to AOD for each site.

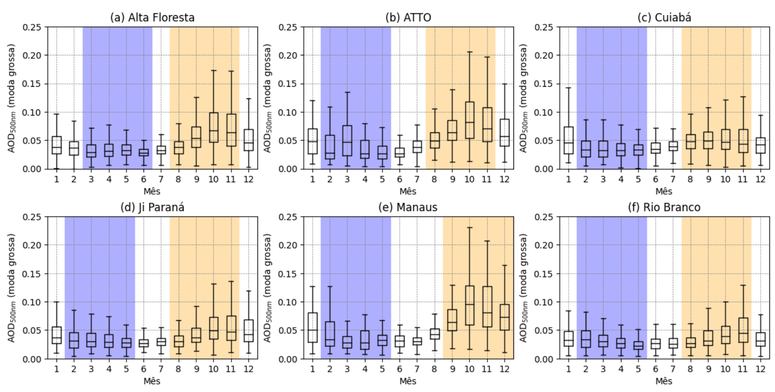

Figure 3: Boxplots for coarse mode contribution to AOD for each site.

Figures 2 & 3 display boxplots for each site for fine and coarse mode aerosol contributions to the AOD, respectively. The color code indicates the season: blue denotes wet season, orange denotes dry season, and white represents the transition between the other two seasons.

The results show a marked seasonal pattern for both fine and coarse mode contributions to total AOD. However, the maxima and minima in each mode contribution are non-coincidental.

Each mode display non-coincidental maxima and minina as the processes that originate those aerosol modes are very different. The peaks in fine mode are related to biomass burning; the peaks in coarse mode are related to long-distant transport.

Over the year, the total AOD is governed by the fine mode contribution. During the dry season, the average contribution of the fine mode fraction is about 84%, whereas that of the coarse mode fraction is about 16%; however, during wet season the contributions of each mode are comparable: 58% versus 42%, respectivelly.

RADIATIVE FORCING

AERONET provides an inversion product which estimates the RF relative to all the species present in the local atmosphere, not differentiating between fine and coarse mode contributions. As one of the future goals of this study is to quantify the respective contribution to the energy balance of fine and coarse modes, an important step towards it is to ensure the statistical significance of the correlation between RF and fine/coarse mode AODs.

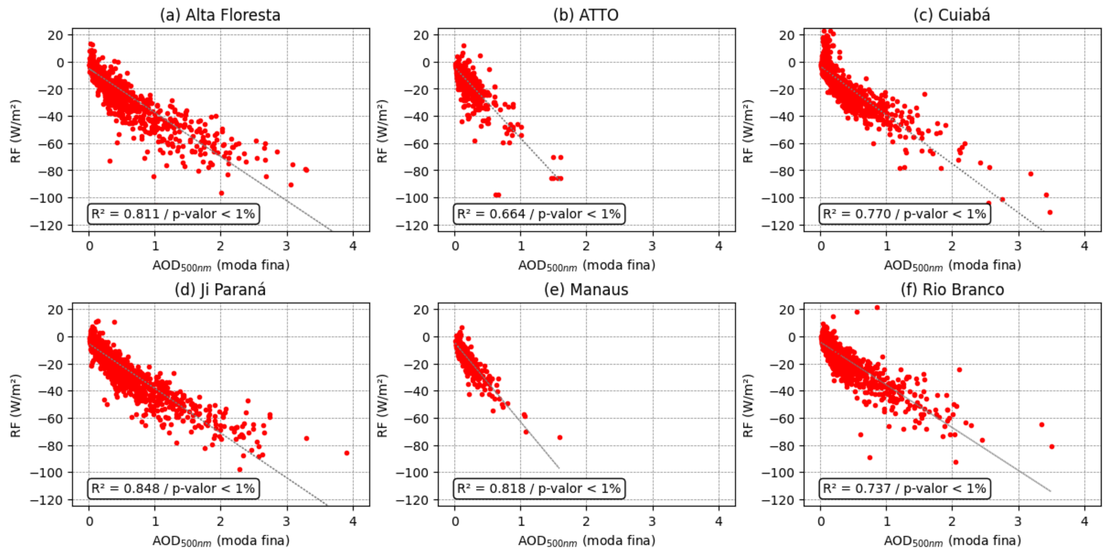

Figure 4: Correlation between RF and finemode AOD for each site.

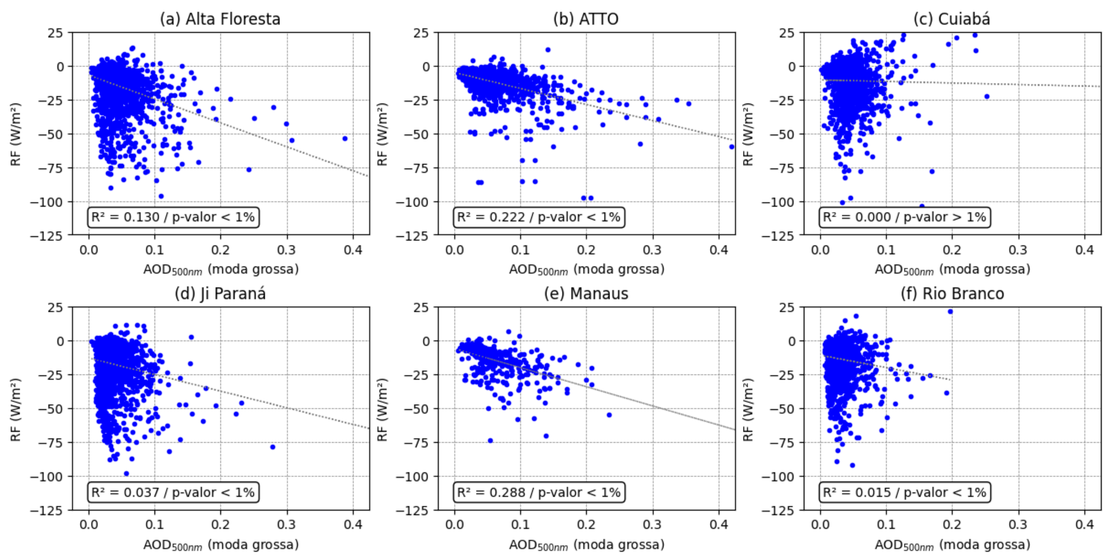

Figure 5: Correlation between RF and coarsemode AOD for each site.

The results show that there is a higher correlation between RF and fine mode AOD, Figure 5, (with average $R^2 = 0.77 \pm 0.03$) than between RF and coarse mode AOD, Figure 6, (with average $R^2 = 0.12 \pm 0.05$). The strenght of this correlation varies in each season, being larger both for fine and coarse modes during the dry season in opposition to smaller during the wet season. Table 1 displays the specific values for R^2 for each site and each season.

Table 1: Values for R^2 for each correlation between RF and fine or coarse mode AOD for each site.

	AF	ATTO	CM	JP	MN	RB
finemode wet season	0.349	0.069	0.132	0.346	0.532	0.255
finemode dry season	0.804	0.692	0.792	0.841	0.815	0.722
coarsemode wet season	0.009	0.133	0.146	0.034	0.434	0.001
coarsemode dry season	0.120	0.227	0.001	0.035	0.303	0.009

Even though the correlation between RF and coase mode AOD is low, the p-value for each site regression shows us this correlation is still statistically significant. Except for a few sites in specific seasons, the immense majority of cases show us statistical significance of the null hypothesis both for the correlation between RF and fine and coarse modes, in each season. Further studies may determine the multivariate regression coefficients for each contribuint.

CONCLUDING REMARKS

This study shows that fine and coarse mode AODs have a defined seasonality for Amazon region and that both contribute to total AOD and RF, in different proportions. It is shown that the RF have a high anti-correlation with fine mode AOD and a low anti-correlation with coarsemode. Next steps are to implement a multivariate regression to quantify the contribution of fine and coarse modes to RF and to improve the spatial resolution by using satellite data.

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