# Amazonia, a tropical forest in transition: from natural biogenic conditions to land use change, large scale biomass burning and urbanization

P. Artaxo (1) ; H. Barbosa, (1) ; JF. Brito, (1) ; S. Carbone, (1) ; E. Sena, (1) ; L. Rizzo, (2)
(1) University of São Paulo, Applied Physics Department, Sao Paulo, Brazil; (2) Federal University of São Paulo, UNIFESP , Department of earth and exact sciences, Diadema, Brazil

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**Abstract content**
Amazonia is a large tropical forest in transition, with strong pressures for agriculture expansion, climate change, urbanization and others. Deforestation rate has decreased dramatically, from 27,700 km² in 2004 to 4,700 km² in 2013, being responsible for a strong reduction in greenhouse gas emissions on the order of 70%. Agricultural expansion and climate variability have become important agents of disturbance in the Amazon basin. Recent studies have demonstrated considerable resilience of Amazonian forests to moderate annual drought, but they also show that interactions between deforestation, fire and drought potentially lead to losses of carbon storage and changes in regional precipitation patterns and river discharge. Although the basin-wide impacts of land use and drought may not yet surpass the magnitude of natural variability of hydrologic and biogeochemical cycles, there are some signs of a transition to a disturbance-dominated regime. These signs include changing energy and water cycles in the southern and eastern portions of the Amazon basin.

Feedbacks in Amazonia are very strong between ecosystem functioning, trace gases and aerosol emissions, cloud cover, precipitation, radiation balance and other key issues. In the wet season, a large portion of the Amazon region constitutes one of the most pristine continental areas, with very low concentrations of atmospheric trace gases and aerosol particles. However, land use change modifies the biosphere-atmosphere interactions in such a way that key processes that maintain the functioning of Amazonia are substantially altered. This study presents long term aerosol and trace gases observations at a preserved forest site in Central Amazonia, with observations from 2008 to 2013. Amazonian aerosols were characterized in detail, including aerosol size distributions, aerosol light absorption and scattering, optical depth and aerosol inorganic and organic composition, among others properties. Trace gases analyzed includes volatile organic compounds (VOCs), O3, CO2, CH4, N2O and CO. The central Amazonia region showed very low aerosol concentrations (PM2.5 of 1.3±0.7 μgm-3 and 3.4±2.0 μgm-3 in the wet and dry seasons, respectively), with a median particle number concentration of a low 220 cm-3 in the wet season. Aerosol composition shows organic aerosol accounting to 81% to the PM1 aerosol loading. Aerosol light scattering and absorption coefficients were very low during the wet season, increasing by a factor of 5, approximately, in the dry season due to long range transport of biomass burning aerosols reaching the forest site in the dry season. Remote sensing observations from six AERONET sites and from MODIS from 1999 to 2013, provides a regional and temporal overview of changes in Amazonian atmosphere. Aerosol Optical Depth (AOD) at 550 nm of less than 0.1 is characteristic of natural conditions over Amazonia. At the arc of deforestation region, AOD values greater than 4 were frequently observed in the dry season. Combined analysis of MODIS and CERES showed that the mean direct radiative forcing of aerosols at the top of the atmosphere (TOA) during the biomass burning season was a high –5.6±1.7 Wm–2, averaged over whole Amazon Basin. For high AOD (larger than 1) the maximum daily direct aerosol radiative forcing at the TOA was as high as –20 Wm–2 locally. This change in the radiation balance caused increases in the diffuse radiation flux, with an increase of Net Ecosystem Exchange (NEE) of 18-29% for high values of AOD. Recently the GoAmazon project is analyzing the impacts of urbanization on atmospheric properties, and preliminary results shows important changes in ozone formation, secondary organic aerosol production and cloud properties.

From this analysis, it is clear that land use change in Amazonia shows alterations of many atmospheric properties, and these changes are affecting the functioning of the Amazonian ecosystem in significant ways. The potential impacts on global carbon cycle and on the hydrological cycle are large.

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