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Long-range transport of dust and smoke towards and over the Amazon rain forest observed with lidar during the wet and dry season

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The Amazon basin with its extensions of more than six million square kilometres contains the world's largest tropical rain forest. Investigations of aerosol characteristics in this large area are important for the understanding of the local and global influence of Amazonian aerosol on radiation budget and cloud formation. Compared to its global importance, knowledge of the vertical distribution of aerosols in this region is still inadequate. For the first time in Amazonia, long-term observations of the vertical aerosol structure were made with a multi-wavelength Raman lidar. These measurements were performed with the automated polarization-Raman lidar Polly^{XT} of the Leibniz Institute for Tropospheric Research (IfT) in the framework of the European Integrated project on Aerosol Cloud Climate and Air Quality Interactions (EUCAARI) and the Amazonian Aerosol Characterization Experiment (AMAZE-08). The almost continuous measurements were taken near Manaus, Brazil (2˚S, 60˚W) from January to November 2008. With Polly^{XT}, vertical profiles of the backscatter coefficient at 355 nm, 532 nm, and 1064 nm, of the extinction coefficient at 355 nm and 532 nm, and of the particle depolarization ratio at 355 nm can be determined. Microphysical aerosol properties like effective radius and volume concentration are calculated from the optical properties with an inversion algorithm. In total, more than 2500 hours of observations on 211 days were made during the wet (November-May) and dry season (June-October). Back-trajectory calculations have been used to define the origin of the air masses at different height levels. The analysis of these observations reveals that intrusions of biomass burning aerosol from Africa in association with Saharan dust could be observed frequently during the wet season. The separation of dust and smoke in the lidar backscatter profiles by depolarization quantities showed that the dust fraction in the African aerosol plumes is less than 40% during the months with high fire activity in Central Africa (January-April). When long-ranged transported aerosol was absent, very clean conditions in terms of aerosol were observed. Usually heavy mesoscale precipitation events took place before these observations. The aerosol optical thickness at 532 nm was then below 0.02. In contrast to these clean cases, aerosol conditions during the dry season are dominated by the high fire activity on the South American continent. The fires occur usually at the edges of the Amazon rain forest and are then transported towards the interior regions of the Basin within some days. Thus, aerosol conditions at the lidar site were dominated by aged biomass-burning aerosol during this season. In general a much higher, but highly variable aerosol load in comparison to the wet season was observed. High vertical aerosol variability was observed during that season, too, as well as the frequent occurrence of lofted aerosol layers. The maximum observed values of the extinction coefficient at 532 nm were about 350 Mm^{-1}. These high values were usually observed in connection with hygroscopic growth at around 2000 m agl. The statistical analysis of the observations also reveals that the aerosol-layer top in the dry season is typically between 3000 and 4500 m, but also reaches maximum values up to 5500 m. In the wet season, the aerosol layer top is usually well below 3000 m.

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