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BIOMASS BURNING AEROSOLS IN THE AMAZON BASIN, CHARACTERISED BY LIDAR, OPTICAL PARTICLE COUNTERS, AND MODELLING

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1. INTRODUCTION

Biomass burning is the second largest global source of anthropogenic aerosols, and South America is one of the major source regions. In the dry season, the atmosphere of the Amazon basin features a remarkable haze, with layers containing high loadings of smoke. Aerosols with different degrees of ageing, are encountered in the boundary layer and the free troposphere. The South American Biomass Burning Analysis (SAMBBA) was an intensive observation campaign in September-October 2012 that involved measurements of the Amazonian atmosphere using the Facility for Airborne Measurements (FAAM) BAe-146 research aircraft.

2. LIDAR OBSERVATIONS

Twenty research flights were carried out from Porto Velho, Brazil, totaling 65 flying hours. A large range of conditions were sampled, from very low aerosol concentrations in pristine areas to large quantities of smoke within fresh plumes. The aircraft carried a nadir-pointing elastic backscatter lidar, operating at 355 nm. In situ probes sampled particle size distributions and gas-phase chemistry. Six flights have been selected that span a 2400 km wide area extending East-West across Brazil along a latitude of approximately 10°S. The lidar data presented here have a vertical resolution of 45 m and an integration time of 1 min (corresponding to a 9 km footprint). From these flights, 334 lidar profiles have been reviewed individually, and analysed.

Processing has undergone a double iteration, to firstly to determine the lidar ratio (extinction-to-backscatter ratio), and subsequently to estimate the aerosol extinction coefficient. The lidar ratio determination is based on iterating the retrieval method detailed in the next paragraph, until a good match to the overlying Rayleigh scattering layer is obtained (see e.g. Ref. [1]). A single value of the lidar ratio (constant with height) is thus obtained for each profile. It is then further averaged over all profiles in order to achieve a single lidar ratio for the campaign. The lidar ratio deduced from the lidar profiles using this methodology was found to be 73 ± 6 sr^{-1}, and is compatible with Ref. [2–5].

The determination of the aerosol extinction coefficient has followed Ref. [6]. This is a variant of the Fernald–Klett method [7–8], where the reference is taken within an aerosol layer. This permits using the stable (inward) solution in the unfavourable geometry represented by a nadir-looking lidar. Very large uncertainties (50-100%) exist near the surface, but they are quickly damped when moving upwards (< 20% above 2 km).

3. LIDAR RATIO ESTIMATED FROM IN SITU MEASUREMENTS

The lidar ratio obtained from the lidar profiles has been compared to estimates derived from the Mie scattering theory, using the particle size-distribution from the optical particle counters. Fig. 1(a) shows the campaign-mean size-distribution, and Fig. 1(b) shows the resulting lidar ratio as a function of the real and imaginary parts of the reftractive index.

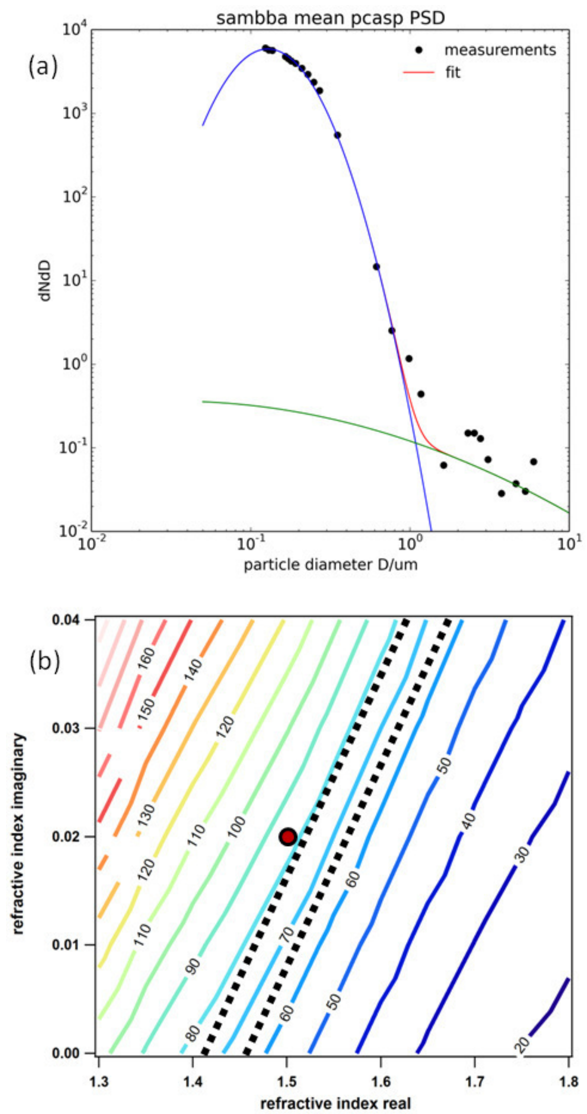

Fig. 1. (a) Campaign mean particle size-distribution from the wing-mounted PCASP optical particle counter; (b) Lidar ratio computed for the campaign mean size-distribution and different values for the real and imaginary parts of the refractive index. Red dot: SCAR-B refractive index (1.5 – 0.02i). Black dotted lines: range of lidar ratios estimated from the lidar.

4. MODEL COMPARISONS

The lidar data have been compared to high resolution (12km) simulations from a limited area model (LAM) configuration of the Met Office Unified Model (UM), which was set up over Brazil for the SAMBBA campaign. Biomass burning aerosol was simulated on-line using the CLASSIC biomass burning aerosol scheme [9], while all other aerosol species were represented by climatologies. Fire emissions were taken from the Global Fire Assimilation System, GFAS emission dataset [10]. Operationally the model used emission from the previous day due to the time lag in providing near real time data. Fig. 2 compares modeled and observed aerosol extinction from a 1500km West-East transit over Amazonia. The model represents many realistic features of the aerosol layers, although plumes from individual fires are not always captured.

The next step of the present research, will be to compare the airborne dataset with the aerosol forecasts by the European Centre for Medium-range Weather Forecasts (ECMWF), provided as part of the EU-funded projects GEMS, MACC and MACC-II [11–12]. Five types of tropospheric aerosols are considered in the model, and they are fully coupled with the meteorology. Biomass burning emissions are taken from the GFAS inventory; moreover, MODIS AOD data are routinely assimilated in a 4D-Var framework. The result of this comparison will be shown at the conference.

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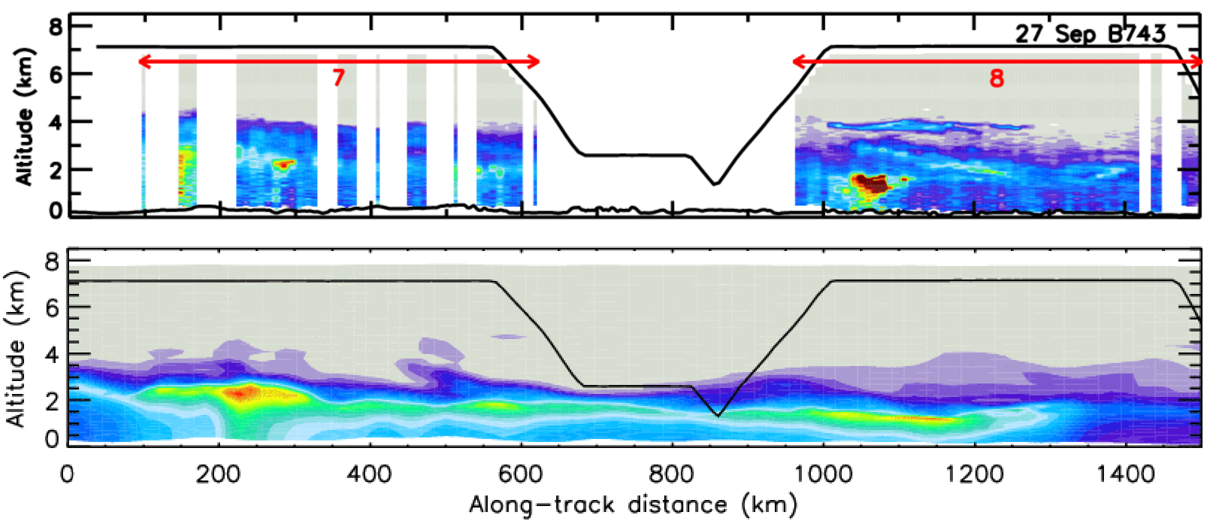

Fig. 2 Extinction coefficient evaluated by lidar for 27 September 2012 (top) and predictions with the UM.