Airborne measurements of biomass burning layers over Central Europe: A case study

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Biomass burning aerosol exerts a significant direct radiative forcing by scattering and absorption of solar radiation (IPCC, 2007) and causes a large uncertainty on the estimates of aerosol radiative forcing driven climate change. Biomass burning aerosol layers are highly variable in time and space and can occur throughout the entire troposphere and lower stratosphere. To determine the impact of particle layers containing absorbing materials like black carbon (BC), on the Earth's radiation budget, it is necessary to learn more about their particle size distributions and mixing state, the aerosol aging, and optical properties. These layers can be characterized directly using airborne in-situ measurements.

During the CONCERT 2011 (Contrail and Cirrus Experiment) campaign in September 2011 eleven research flights were conducted over Central Europe with the DLR research aircraft Falcon. CONCERT 2011 focussed on microphysical, chemical and radiative properties of contrails and natural cirrus clouds, but also several elevated aerosol layers from different origins were detected with extended aerosol in-situ instrumentation.

On 16 September 2011 an elevated biomass burning aerosol layer was measured at altitudes between 10000 m and 11500 m above sea level over north-eastern Germany. Backward trajectories show that this layer originated from boreal forest fires in Northern America around 3 - 5 days before measurement. The biomass burning layer was not only detected by the Falcon, but also by several ground-based LIDAR stations, e.g. at IfT in Leipzig. The combination of airborne and ground-based data provides information on the vertical and horizontal extent of this layer which is necessary to quantify the layer's radiative effects. In our presentation we show data from a Single Particle Soot Photometer (SP2) which demonstrate that a distinct fraction of the particles (6 – 13 %) contains a BC core core (> 70 nm BC mass equivalent diameter) surrounded by a volatile coating. Such coatings can enhance the absorption of BC particles (e.g. Schwarz et al., 2008). The calculated coating thickness of the BC particles in the biomass burning layer is unusually high and distinctly larger than the coating thickness of freshly emitted boundary layer aerosol particles (Fig. 1). BC mass concentrations of the layer reach up to 0.13 µg m^{-3} in the BC (core) mass equivalent diameter range of roughly 70 nm up to 440 nm with the mode of distribution in-between 140 and 220 nm.

We performed additional calculations of optical properties for the biomass burning layer. The imaginary part of refractive index is lower than that of tropical biomass burning layers observed during the SAMUM campaign (Weinzierl et al., 2011). The Ångström exponents of absorption are larger than expected for pure black carbon but agree well with brown carbon (BrC), which can be produced during biomass burning events.

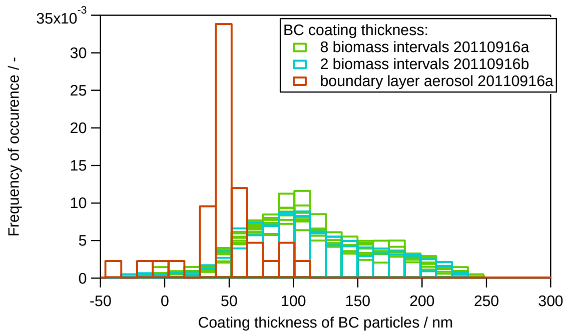

Fig. 1: Coating thickness of BC particles from observed layer (green and blue) in comparison to boundary layer BC particles (red).

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