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Bioaerosol Analysis by Online Fluorescence Detection and Fluorescence Microscopy

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Primary biological aerosol particles (PBAPs), including bacteria, spores and pollen, are essential for the spread of organisms and disease in the biosphere, and numerous studies have suggested that they may be important for atmospheric processes, including the formation of clouds and precipitation. The atmospheric abundance and size distribution of PBAPs, however, are largely unknown. At a semi-urban site in Mainz, Germany, we used an ultraviolet aerodynamic particle sizer (UV-APS) to measure fluorescent biological aerosol particles (FBAPs), which can be regarded as viable bioaerosol particles representing a lower limit for the actual abundance of PBAPs. Fluorescence of non-biological aerosol components are likely to influence the measurement results obtained for fine particles (< 1 μm), but not for coarse particles (1 – 20 μm). Microscopy studies were later performed at the same location to more directly investigate and identify biological particles.

Averaged over the four-month measurement period (August – December 2006), the mean number concentration of coarse FBAPs was $3x10^{-2}$ cm^{-3}, corresponding to 4% of total coarse particle number [1]. The mean mass concentration of FBAPs was 1 μg m^{-3}, corresponding to 20% of total coarse particle mass. The FBAP number size distributions exhibited alternating patterns with peaks at various diameters, though a pronounced peak at 3 μm was essentially always observed. This peak is likely due to fungal spores or agglomerated bacteria, and it exhibited a pronounced diel cycle with maximum intensity during early/mid-morning. FBAP peaks around 1.5 μm, 5 μm, and 13 μm were also observed, but less pronounced and less frequent. These may be explained by single bacterial cells, larger fungal spores, and pollen grains, respectively.

The observed number concentrations and characteristic sizes of FBAPs are consistent with microscopic, biological and chemical analyses of PBAPs in aerosol filter samples. To our knowledge, however, this is the first study reporting continuous online measurements of bioaerosol particles over several months, a range of characteristic size distribution patterns, and a persistent bioaerosol peak at 3 μm. The measurement results confirm that PBAPs account for a substantial proportion of coarse aerosol particle number and mass in continental boundary layer air. Moreover, they suggest that the number concentration of viable bioparticles is dominated by fungal spores or agglomerated bacteria with aerodynamic diameters around 3 μm rather than single bacterial cells with diameters around 1 μm.

Filter samples were later collected at the same sampling location and analyzed with a fluorescence microscope. By observing collected particles both with transmitted white light and with fluorescent emission from near-UV excitation, the technique provides information about whether individual particles are biological and regarding their viability. Characteristic images of FBAPs are shown. Further goals are to correlate size distributions from the UV-APS with size information gained from microscopy, and also to constrain uncertainties that arise from non-biological particles that also exhibit fluorescence.

[1] Huffman et al. (2009) Atmos. Chem. Phys. Discuss., 9, 17705 – 17751.