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Black Carbon and Aerosol Absorption Measurements during Global Circumnavigation and Arctic Campaigns

Griša Močnik (1,2), Luka Drinovec (1,2), Primož Vidmar (1), Grega Razoršek (1), and Matevž Lenarčič (3)
(1) Aerosol d.o.o., Research and Development Dept., Ljubljana, Slovenia (grisa.mocnik@aerosol.eu), (2) Condensed Physics Dept. J. Stefan Institute, Ljubljana, Slovenia, (3) Aerovizija, Nazarje, Slovenia

During four flight campaigns: around the world (2012, 2016), in the Mediterranean (2017) and over the Arctic (2013) we demonstrated the feasibility of scientific research and aerial measurements of aerosolized black carbon (BC) with ultra-light aircraft. Measurements provided first ever information on BC concentrations and sources over such a large area at altitude. These data and especially the vertical distribution of BC are a crucial requirement for our understanding of the dispersion of pollutant species of anthropogenic origin, and their possible effects on radiative forcing, cloud condensation, and other phenomena which can contribute to adverse outcomes. Light absorbing carbonaceous aerosols and BC in particular are a unique tracer for combustion emissions, and can be detected rapidly and with great sensitivity by filter-based optical methods.

We have demonstrated that an ultra-light aircraft can provide valuable information on BC concentrations, their regional heterogeneity and vertical profiles with a minor payload and for a fraction of the cost associated with large airborne platforms. We have modified the aircraft to include an aerosol inlet and have developed a dedicated filter photometer, the Aethalometer prototype to measure black carbon in this challenging environment. The flights covered all continents and oceans, and operated at altitudes around 3000 m ASL and up to 9000 m ASL.

The results have shown that the BC concentrations are highly variable and reach above 2500 ng/m3 at 3200 m ASL. Measuring the dependence of the aerosol absorption on the wavelength, we show that aerosols produced during biomass combustion can be transported to high altitude in high concentrations and we estimate the underestimation of the direct forcing by models assuming a simple linear relationship between BC concentration and forcing in comparison to observations.