Geophysical Research Abstracts
Vol. 16, EGU2014-14367, 2014
EGU General Assembly 2014

Effective density measurements of fresh particulate matter emitted by an aircraft engine

Manuel Abegglen (1), Lukas Durdina (2), Amewu Mensah (1), Benjamin Brem (2), Joel Corbin (1), Theo Rindlisbacher (4), Jing Wang (2,3), Ulrike Lohmann (1), and Berko Sierau (1)

(1) ETHZ, Institute for Atmospheric and Climate Science, Zurich, 8092, Switzerland, (2) Swiss Federal Laboratories for Materials Science and Technology (EMPA), Dubendorf, 8600, Switzerland, (3) ETHZ, Institute of Environmental Engineering, Zurich, 8093, Switzerland, (4) Federal Office of Civil Aviation, Bern, 3003, Switzerland

Introduction

Carbonaceous particulate matter (commonly referred to as soot), once emitted into the atmosphere affects the global radiation budget by absorbing and scattering solar radiation. Furthermore, it can alter the formation, lifetime and distribution of clouds by acting as cloud condensation nuclei (CCN) or ice nuclei (IN). The ability of soot particles to act as CCN and IN depends on their size, morphology and chemical composition. Soot particles are known to consist of spherical, primary particles that tend to arrange in chain-like structures. The structure of soot particles typically changes in the atmosphere when the particles are coated with secondary material, thus changing their radiative and cloud microphysical properties. Bond et al. (Journal of Geophysical Research, 2013: *Bounding the Role of Black Carbon in the Climate System.*) estimated the total industrial-era (1750 to 2005) climate forcing of black carbon to be 1.1 W/m^2 ranging from the uncertainty bonds of 0.17 W/m^2 to 2.1 W/m^2. Facing the large uncertainty range, there is a need for a better characterization of soot particles abundant in the atmosphere.

We provide experimental data on physical properties such as size, mass, density and morphology of freshly produced soot particles from a regularly used aircraft engine and from four laboratory generated soot types. This was done using a Differential Mobility Analyzer (DMA) and a Centrifugal Particle Mass Analyzer (CPMA), a relatively new instrument that records mass distributions of aerosol particles.

Experimental

Aircraft engine exhaust particles were collected and analysed during the Aviation Particle Regulatory Instrumentation Demonstration Experiments (A-PRIDE) campaigns in a test facility at the Zurich airport in November 2012 and August 2013. The engines were operated at different relative thrust levels spanning 7 % to 100 %. The sample was led into a heated line in order to prevent condensation of water and evolution of secondary organic aerosols. The soot masses/densities were determined using a DMA-CPMA system as described in the following.

The freshly generated soot particles were first charge equilibrated to account for multiple charging and selected according to their mobility size (d_m) by a DMA. The monodisperse flow then entered the CPMA which measured the corresponding mass. A condensation particle counter counted the particle number concentration. The effective density (ρ_{eff}) can be derived using the fractal relationship between mass and d_m and the definition of the effective density.

Additionally, we investigated four different laboratory-generated soot types at ETHZ. In detail, a Combustion Aerosol Standard burner ((1) fuel-rich and (2) fuel-lean), a (3) PALAS GFG aerosol generator and (4) carbon black (Cabot Regal Black) from an atomizer, were used. The corresponding results are compared to the aircraft engine exhaust measurements.

Results

The size, mass, effective density distributions, and the corresponding mobility based fractal dimensions (D_{fm}) from fresh soot particles emitted by a common aircraft engine and from four laboratory generated soot types were analysed. D_{fm} is used to describe aggregate particles. It relates the number of primary particles to d_m. In general, the effective density decreases with increasing mobility diameter and depends on engine thrust.