Geophysical Research Abstracts
Vol. 13, EGU2011-3248-1, 2011
EGU General Assembly 2011

A PAM-ARCMIP 2009 Arctic Haze case study: ground based and airborne observations with lidar and sun photometry

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Although the Arctic is a very remote region with very little aerosol occurrences, the aerosol optical depth (AOD) annually peaks in the spring months March and April as a result of poleward aerosol transport. On 4 April 2009, large AOD values of up to 0.12 at 532 nm were observed with ground based and airborne lidars and sun photometers above Ny-Ålesund, Spitsbergen. The presented measurements were conducted in an area of 40 x 20 km as part of the 2009 PAM-ARCMIP campaign.

The ground based Koldewey Aerosol Raman Lidar (KARL) is a multiwavelength Raman lidar, which provides highly resolved backscatter and extinction profiles from about 0.5 km above ground up to the mid stratosphere. Onboard the research aircraft Polar 5, the nadir looking Airborne Mobile Aerosol Lidar (AMALi) determined backscatter profiles between 2.5 km altitude and the ground. Airborne sun photometry on Polar 5 provided altitude dependent AOD measurements, which are compared to the KARL extinction retrievals. Deviant from previous years' Arctic Haze observations, where aerosols have been observed in distinct layered structures within the boundary layer and up to 5-6 km, the AOD on 4 April 2009 was uniformly enhanced from the ground up to the tropopause at 8.5 km. Within this enhancement, a sub layer structure can be identified according to the extinction data. At lower altitudes (lowermost 2 km), the extinction proportion at 532 nm, and hence, the lidar ratios are smaller (around 20 sr compared to 40 sr above 2 km). At 355 nm even lower lidar ratios of less than 10 below 2 km and almost 20 above 2 km were observed.

AMALi lidar data shows depolarization values to be less than 2.5% between 0.6 and 2.5 km altitude, hence, particles in this range can be assumed to be of spherical shape. Performing Mie-code based inversion calculations, the backscatter and extinction findings result in larger particle sizes near the ground and smaller particle sizes in the higher troposphere, e.g. reff $\approx$ 0.3 μm at 1.5 km altitude and reff $\approx$ 0.18 μm at 2.5 km altitude.

Co-located radio sounding experiments registered relative humidity values of less than 60%. Comparison studies between the balloon borne RS92 sonde launched at Ny-Ålesund, and a second RS92 sonde dropped from the airplane about 10 km away from the village reveal significant differences in temperature and humidity in the boundary layer, and hence, emphasise the importance of local orographic effects.

In order to identify the source region for this aerosol event, back-trajectories were calculated with the PEP-Tracer model. They identify the central Arctic as the source region, which is in contrast to the prevalent assumption of anthropogenic mid-latitude aerosols being the origin of Arctic Haze.