Intercomparison of lidar aerosol backscatter and in-situ size distribution measurements

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The atmospheric aerosol is highly variable in time and space with respect to particle size, number, and chemical composition. In-situ observations with point sensors cannot fully represent the spatial variability of aerosol particles in the atmospheric boundary layer. Thus, in-situ observations yield spatially averaged data or disjunct information which may, for example, misrepresent the available aerosol surface area for heterogeneous chemical reactions, or the small-scale effect of aerosol optical properties.

Direct observation of the spatial variability of aerosol concentration with high time resolution is possible through remote sensing techniques. For example, the Raman-shifted Eye-safe Aerosol Lidar (REAL; Mayor et al., 2007) can safely transmit high energy laser pulses in order to visualize small-scale atmospheric motions and changes in the structure of the lower atmosphere through aerosol scattering. However, knowledge of the sensitivity of the lidar to small changes in the microphysical characteristics of aerosol particles is a prerequisite to extract information about the spatial and temporal evolution of the atmospheric aerosol from the backscatter signal.

There is a lack of direct intercomparison studies of lidar and high-time-resolution in-situ aerosol measurements. Here, we compare aerosol backscatter data of the REAL with in-situ measurements of aerosol size distributions during two different field campaigns. The REAL backscatter signal is compared with aerosol size distribution measured with a LASAIR optical particle sizer during the Canopy Horizontal Array Turbulence Study (CHATS; Patton et al., 2011) in Dixon, CA, USA, in May 2007, and with a MetOne optical particle counter and a Compact Lightweight Aerosol Spectrometer Probe (CLASP; Hill et al., 2008) during a field experiment at the Chico State University Farm in Chico, CA, USA, in October 2011.

From an intercomparison of the CHATS field data, preliminary results about the sensitivity of the REAL towards particle size were obtained. Figure 1 shows the time series of the REAL backscatter signal and the aerosol surface concentration in the diameter range from 0.5 to 10 µm during a five-day measurement period. Obviously, the two time series do not trace each other perfectly at all times. In part, this may be due to the spatial separation of the remote sensing volume and the in-situ sensor. However, the influence of particles smaller than 0.5 µm on the backscatter signal was found to be negligible at all times.

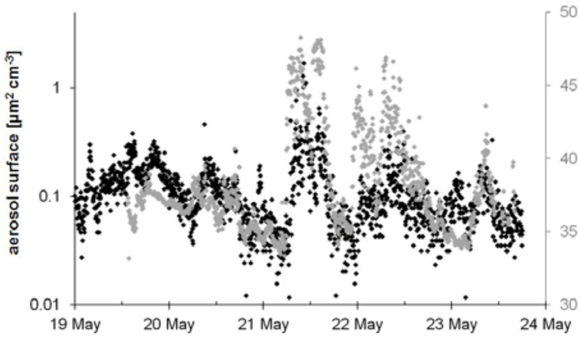

Figure 1: Time series of REAL backscatter signal (grey) and aerosol surface concentration (diameter > 0.5 µm; black) during five days of CHATS 2007.

In 2011, a dedicated intercomparison experiment was carried out. The REAL laser beam was directed horizontally across a very flat field at the Chico State University Farm and passed the inlets of two optical particle counters located approximately 1.3 km away from the REAL within 1 m or less.

We will present additional results from a detailed analysis of the CHATS intercomparison data, and from the Chico intercomparison experiment. After characterization of the sensitivity of the REAL backscatter signal to changes in aerosol size and concentration, this signal can be analyzed for a better representation of the spatial variability of aerosol particles in the atmospheric boundary layer.

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Hill, M.K., Brooks, B.J., Norris, S.J., Smith, M.H., Brooks, I.M. and DeLeeuw, G. (2008) A compact lightweight aerosol spectrometer probe (CLASP). J. Atmos. Ocean Technol. 25, 1996-2006.

Mayor, S.D., Spuler, S.M., Morley, B.M., Loew, E. (2007) Polarization lidar at 1.54-microns and observations of plumes from aerosol generators. Opt. Eng. 46, 096201.

Patton, E. G., et al. (2011) The Canopy Horizontal Array Turbulence Study (CHATS). Bull. Amer. Meteorol. Soc. 92, 593-611.