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Intercomparison of Lidar Aerosol Backscatter and in-situ Size Distribution Measurements

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Objective

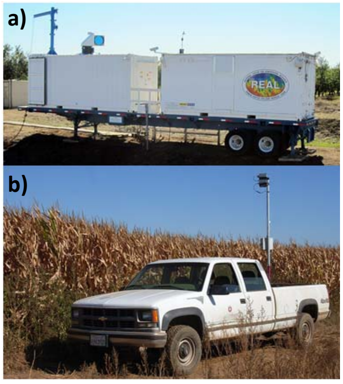
Compare lidar backscatter and aerosol size distribution data, and characterize the sensitivity of an aerosol backscatter lidar to changes in aerosol size and concentration

Motivation

Aerosol point sensors cannot fully represent the variability of atmospheric aerosol in time and space. Aerosol backscatter lidars may provide valuable information about the spatial distribution of aerosol concentrations.

Instrumentation

- REAL (Raman-shifted Eye-safe Aerosol Lidar)[1]
  1543 nm wavelength, 170 mJ pulses at 10 Hz
- CLASP aerosol spectrometer[2]
  16 size channels, 600 nm – 17 µm diameter at 10 Hz
- LasAir aerosol spectrometer (PMS, Boulder, CO, USA)
  8 size channels, 100 nm – 10 µm, 5 min resolution



Field experiments

- *Canopy Horizontal Array Turbulence Study[3], 2007:*

Horizontal and vertical lidar scans over walnut orchard, and in-situ aerosol spectra measurements

- *Chico State University Farm, 2011:*

Horizontal lidar stares 3 m above ground towards aerosol spectrometer 1320 m from lidar:

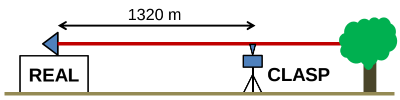


Fig. 1: a) REAL at Chico State University Farm; b) CLASP mounted 3 m above ground, October 2011.

Spatial variability of backscatter signal

- Large variation of backscatter intensity is observed both in horizontal and vertical dimensions.
- Identification of aerosol plumes and tracking of plume transport is possible.

How is this variability reflected in aerosol size and number?

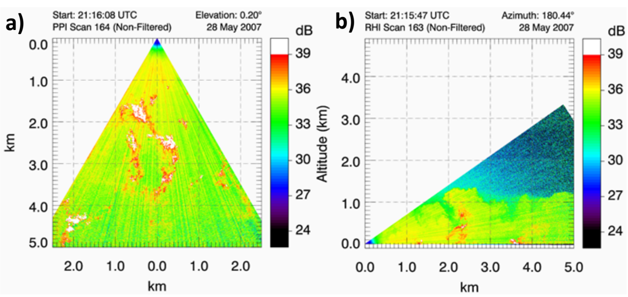


Fig. 2: a) Horizontal and b) vertical lidar scan showing aerosol plumes over a walnut orchard in Dixon, CA on May 28, 2007.

Backscatter signal vs. aerosol properties

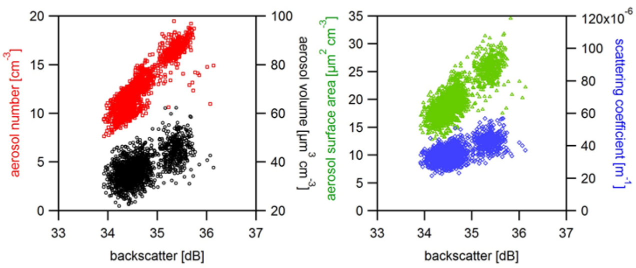


Fig. 3: REAL backscatter signal vs. aerosol number, surface area and volume concentration (0.1 Hz) in Chico, CA on Oct 8, 2011, and aerosol scattering coefficient calculated from CLASP aerosol size distribution using Mie theory approximation:

$$b_{scat} = \sum_i \frac{\pi D_i^2}{4} N_i Q_{scat,D_i}$$

b_{scat}: scattering coefficient [m^{-1}]
D_i: particle diameter i [m]
N_i: particle number [m^{-3}]
Q_{scat}: scattering efficiency [-]

Sensitivity to aerosol concentration changes

- Small changes in aerosol properties are readily observed in backscatter intensity on time scales of seconds:

10 Mm^{-1}/dB resolution with $\sigma_{residuals} \approx 4.3$ Mm^{-1}

- Counting statistics of aerosol spectrometer limit the comparability at high time resolution (1 Hz and faster).

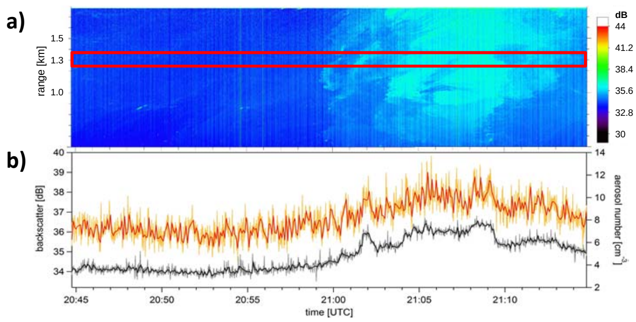


Fig. 4: a) Time series of REAL backscatter in the range 500 – 1700 m, b) total aerosol number (orange 1 Hz, red 0.2 Hz) measured by CLASP, and backscatter intensity (grey 1 Hz, black 0.2 Hz) at range 1320 m, in Chico, CA on October 9, 2011.

Conclusions and outlook

- REAL backscatter signal reveals spatial variability of aerosol distribution within several kilometers.
- Backscatter intensity is correlated with aerosol properties measured in-situ.
- Uncertainty analysis of lidar and aerosol spectrometer data required for further intercomparison studies.
- Sensitivity analysis of aerosol refractive index in calculation of scattering coefficient required for lidar vs. in-situ closure study.

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References:
[1] Mayor et al. (2007) Opt. Eng. 46, 096201.
[2] Hill et al. (2008) J. Atmos. Ocean Technol. 25, 1996-2006.
[3] Patton et al. (2011) B. Am. Meteorol. Soc. 92, 593-611.

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