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Exploring the synergy of active and passive remote observations for enhancement of atmospheric aerosol remote sensing

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Atmospheric remote sensing relying on passive and active observations provides rather different complimentary information about aerosol properties. Passive observations are sensitive mostly to the properties of aerosol in total atmospheric column. Such observations are conducted by satellite or ground-based radiometers and commonly used for deriving the information about aerosol loading estimated via aerosol optical thickness and aerosol type characterized by aerosol particles size, shape and complex refractive index. Observations by radiometers have very limited sensitivity to vertical structure of the atmosphere and, generally, passive remote sensing methods provide no or very limited information about vertical changes in the properties of aerosol. In a contrast, lidar observations of atmospheric responses from different altitudes to laser pulses emitted from ground or space are designed for accurate profiling of the atmospheric properties. Therefore, active remote sensing by lidar systems are very sensitive to vertical variability of atmosphere.

Thus, presently there is a tendency to conduct co-located passive and active measurements in order to obtain complementary information about vertical variability of aerosol and its columnar properties. In addition, the co-availability of these two observations is useful for improving the interpretation of measurements. Indeed, the back-scattering observations by lidar may have an additional sensitivity to some columnar properties of aerosol, while radiometric observations should provide missing constraints on aerosol type and loading for treating lidar signals. Here we describe the development of an inversion that processes simultaneously a combination of lidar and radiometer observations and derives a united set of aerosol parameters. It is expected that such synergetic retrieval can result in additional improvements in aerosol retrieval.

The method is applied for processing of co-incident ground-based observations by AERONET radiometer and multi-wavelength lidar. The retrieval uses the assumption that a mixture of fine and coarse aerosol modes with vertically constant spectral optical properties can satisfactorily describe the vertical variability of aerosol spectral optical properties. In this model the shape of size distribution and complex refractive index are assumed height independent for each mode, while the vertical profiles of aerosol concentrations can change arbitrarily for each mode. Consequently the inversion algorithm retrieves the size distribution, complex refractive index, single scattering albedo and vertical distribution of both fine and coarse aerosol concentrations. The accuracy of the method and inversion sensitivity to the measurement errors and data integrity are discussed. The limitations of bi-component aerosol model, as well as, potential of usage of different observations configurations (with or without polarimetric measurements, Raman scattering, etc.) are discussed.

A similar approach is planned to be applied to combine satellite observations by PARASOL and CALIPSO instruments.