Remote sensing of aerosol hygroscopic enhancement in the ambient atmosphere using a combination of lidar and microwave radiometer

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It is important to understand aerosol hygroscopic properties to accurately assess aerosol radiative forcing and how they interact with clouds by acting as cloud condensation nuclei or ice nuclei, which can impact cloud formation and precipitation processes[1]–[3]. One of the major challenges related to studying aerosol hygroscopicity using in situ techniques is the alteration of aerosol properties that is inevitable due to the processing of air samples as a part of sample collection[4]. Remote sensing methods are capable of overcoming this limitation by directly examining particles in the atmosphere without modifying them[5]. The present study conducted a quantitative analysis of the hygroscopic growth factor of tropospheric aerosols in the ambient atmosphere by simultaneously measuring aerosols and water vapor by coupling active and passive observations of the atmosphere. It is the first time that monitoring of hygroscopic aerosol growth in the real atmosphere has been performed over the Indian region. The study makes use of backscatter observations of a ceilometer (Luft CHM 15k) at 1064 nm and vertical profiles of relative humidity from a Ground-based, passive, multi-frequency microwave radiometer employed at the tropical coastal station, the National Centre for Earth Science Studies (NCESS), Thiruvananthapuram (8.5°N, 76.9°E, 20 m amsl) in Kerala, India. The backscatter values obtained by the ceilometer are calibrated using the Rayleigh calibration technique to estimate the attenuated backscattering coefficient, which is then used to retrieve the aerosol backscattering coefficient using the forward iterative method. To identify the hygroscopic events in the ambient atmosphere, simultaneous variations in relative humidity and attenuated backscatter are analyzed using the linear regression method, and attenuated backscatter enhancement factors are estimated.

Keywords: aerosol hygroscopicity, growth factor, scattering enhancement, ceilometer

References

[1] G. Titos *et al.*, "A global study of hygroscopicity-driven light-scattering enhancement in the context of other in situ aerosol optical properties," *Atmos. Chem. Phys.*, vol. 21, no. 17, pp. 13031–13050, Sep. 2021, doi: 10.5194/acp-21-13031-2021.

[2] C. M. Carrico, P. Kus, M. J. Rood, P. K. Quinn, and T. S. Bates, "Mixtures of pollution, dust, sea salt, and volcanic aerosol during ACE-Asia: Radiative properties as a function of relative humidity," *J. Geophys. Res. Atmos.*, vol. 108, no. 23, p. 8650, 2003, doi: 10.1029/2003jd003405.

[3] X. Liu and J. Wang, "How important is organic aerosol hygroscopicity to aerosol indirect forcing?," *Environ. Res. Lett.*, vol. 5, no. 4, 2010, doi: 10.1088/1748-9326/5/4/044010.

[4] P. Zieger *et al.*, "Comparison of ambient aerosol extinction coefficients obtained from in-situ, MAX-DOAS and LIDAR measurements at Cabauw," *Atmos. Chem. Phys.*, vol. 11, no. 6, pp. 2603–2624, 2011, doi: 10.5194/acp-11-2603-2011.

[5] A. E. Bedoya-Velásquez *et al.*, "Long-term aerosol optical hygroscopicity study at the ACTRIS SIRTA observatory: Synergy between ceilometer and in situ measurements," *Atmos. Chem. Phys.*, vol. 19, no. 11, pp. 7883–7896, 2019, doi: 10.5194/acp-19-7883-2019.