Constraining aerosol vertical profile in the boundary layer using hyperspectral measurements of oxygen absorption

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Atmospheric aerosols have a major impact on climate, air quality and human health, and also influence greenhouse gas retrievals from space by modifying the path of atmospheric radiation. However, uncertainties about the origin and composition of aerosol particles, their size distribution, concentration, spatial and temporal variability make it challenging to characterize aerosols.

There are four ways to obtain aerosol information from passive remote sensing measurements: multi-angle, multi-wavelength, hyper-spectral and polarization measurements. Multi-angle measurements provide information on the aerosol single scattering albedo and phase function, while observations at multiple wavelengths provide extinction as a function of wavelength, and hence the loading and Ångström exponent. Together, they provide information on the aerosol loading and composition. Polarization measurements provide aerosol particle size, optical depth, and some information on speciation. They can also distinguish between spherical and non-spherical particles. Further, they provide constraints to discriminate from the underlying surface. However, these measurements lack sensitivity to the vertical distribution of aerosols. On the other hand, hyperspectral measurements in gaseous absorption bands (e.g. O_2 A-, B- and γ-bands and H_2O bands) can be used to characterize the vertical distribution of aerosol loading. This is because the large dynamic range of absorption in these bands allows different regions of the atmosphere to be probed at different absorption line strengths. Measurements in different bands also provide information on the wavelength dependence of aerosol extinction. Further, usage of O_2 absorption has the advantage that O_2 is well mixed with known concentration. H_2O, on the other hand, is variable, but has absorption features all across the electromagnetic spectrum.

We infer aerosol vertical structure in the urban boundary layer using passive hyperspectral measurements. Our algorithm, which uses hyperspectral measurements in the 1.27 μm oxygen absorption band to retrieve the total aerosol optical depth (AOD) and effective aerosol layer height, is applied to data from the California Laboratory for Atmospheric Remote Sensing instrument, located on a mountaintop overlooking the Los Angeles Basin. The effectiveness and accuracy of the retrievals are assessed by comparisons with AOD measurements from AERONET and aerosol backscatter profile measurements from a Mini MicroPulse Lidar lidar measurements. The proposed method can potentially be applied to existing and future satellite missions with hyperspectral oxygen measurements to constrain aerosol vertical distribution on a global scale.

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