Night Time Ground Hyperspectral Imaging for Urban-Scale Remote Sensing of Ambient PM. I. Aerosol Optical Thickness Acquisition

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Abstract

Aerosol loadings in vertical atmospheric columns are commonly measured by satellite-borne or ground instruments that remotely sense the spectral extinction through the optical path. However, correlations of these integrated measurements with ground level particulate matter concentrations are highly influenced by local meteorology, seasonality, and the surface albedo. Moreover, as most measurements are based on solar radiation they are limited to daytime. To account for these limitations, we study the feasibility of using a ground hyperspectral camera for acquiring images of artificial light sources through horizontal urban-scale open paths during the night, in order to retrieve the apparent spectral aerosol optical thickness. Laboratory-scale measurements demonstrated a linear response of the camera and set the spectral operational range. A procedure for night time imaging of illuminating targets through ambient open paths has been developed to enable a consistent selection of pixels for analysis, providing measurable apparent aerosol optical thickness. We demonstrate the validity of this procedure by field acquisition of hyperspectral signatures through different arid and rural open paths in the Negev desert, Israel. An open path of 180 m provided a test case for imaging during clear and stable ambient conditions, from which an inherent measurement error of ~4% was estimated. Imaging through a very long open path indicated an uppermost open path limit of about 4 km, resulting from a significant attenuation of the sensor's spectral response. Imaging and aerosol optical thickness retrieval under common environmental conditions through urban scale open paths of about 1 km in Haifa is also demonstrated.