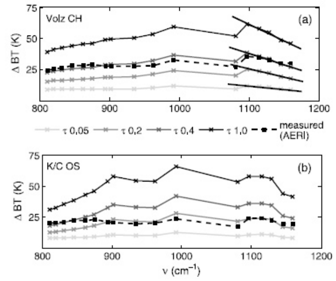
Remote Sensing of Mineral Dust Using AERI

Research Highlight

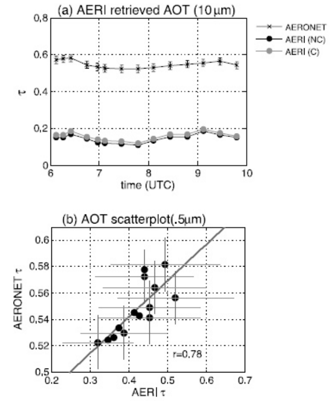
The effect of mineral dust on Earth's climate system remains highly uncertain due in part to the lack of data and a comprehensive understanding of its complex radiative properties, particularly in the thermal IR where common dust minerals exhibit a wide range of spectral features. Although significant progress has been made in exploiting the longwave properties of dust in the past, physically reliable dust parameterizations for remote sensing and climate applications, which require quality global dust data from major source regions around the world, are still lacking.

We have carried out numerical simulations and sensitivity studies to assess potential applications of using the brightness temperature spectra from a ground-based atmospheric emitted radiance interferometer (AERI) during the United Arab Emirates Unified Aerosol Experiment for detecting/retrieving dust aerosols. The objectives of the study are to understand daytime and nighttime dust hazard mitigation, to assess the diurnal effects of regional dust radiative forcing, and to validate satellite-based dust remote sensing products. To these ends, we have developed a methodology for separating dust from clouds by investigating differences between the spectral absorptive power for dust and clouds in prescribed thermal IR window sub-bands, followed by a c2 statistical optimization approach to determine dust IR optical depth. Dust microphysical models were constructed using in situ data from this experiment and prior field studies and its composition was modeled using the refractive index data set for quartz, kaolinite, illite, calcium carbonate, and hematite. In addition, the dust single-scattering properties for oblate spheroids and hexagonal plates, two particle geometries routinely interpreted in electron microscopy, and spheres were determined by using the T-matrix, Finite-Difference Time Domain (FDTD), and Lorenz-Mie light scattering programs. Detailed sensitivity studies of the modeled spectra to key dust and atmospheric parameters have been examined, including mineral composition; dust particle size and shape; dust optical depth; dust layer thickness and altitude; and the vertical distribution of water vapor and temperature. We have selected two daytime cases to demonstrate application of the detection/retrieval technique. The detection and IR optical depth results obtained from the current study closely match the data analyzed from collocated AERONET sun-photometer and micro-pulse lidar measurements

Sensitivity studies show that characterization of the thermodynamic boundary layer is crucial for accurate AERI dust detection/retrieval. Furthermore, AERI sensitivity to dust optical depth is manifested in the strong sub-band slope dependence of the window region. Two daytime UAE2 cases were examined to demonstrate the present detection/retrieval technique, and we show that the results compare reasonably well to collocated AERONET Sun photometer/MPLNET micropulse lidar measurements.



BT sensitivity to dust optical depth at 962 cm-1 with markers denoting locations of AERI subbands 1–17 from left to right. (a) Volz compact hexagon model spectra for four optical depths with best fit AERI spectrum. (b) Same as (a) but for a kaolinite/50% calcium carbonate mixturedust model.



(a) AERI retrieved IR optical depths for 22 September 2004 with/without nonlinearity corrections applied (NC, not corrected; C, corrected). (b) AOT scatterplot of AERI versus AERONET retrieved optical depths at 0.5 mm.

Reference(s)

Hansell R, K Liou, S Ou, S Tsay, Q Ji, and J Reid. 2009. "Remote sensing of mineral dust aerosol using AERI during the UAE2: A modeling and sensitivity study." Journal of Geophysical Research – Atmospheres, 113, D18202, doi:10.1029/2008JD010246.

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Working Group(s)

Aerosol