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Reflections on current and future applications of multiangle imaging to aerosol and cloud remote sensing

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The Multi-angle Imaging SpectroRadiometer (MISR) instrument has been collecting global Earth data from NASA's Terra satellite since February 2000. With its 9 along-track view angles, 4 spectral bands, intrinsic spatial resolution of 275 m, and stable radiometric and geometric calibration, no instrument that combines MISR's attributes has previously flown in space, nor is there is a similar capability currently available on any other satellite platform.

Multiangle imaging offers several tools for remote sensing of aerosol and cloud properties, including bidirectional reflectance and scattering measurements, stereoscopic pattern matching, time lapse sequencing, and potentially, optical tomography. Current data products from MISR employ several of these techniques. Observations of the intensity of scattered light as a function of view angle and wavelength provide accurate measures of aerosol optical depths (AOD) over land, including bright desert and urban source regions. Partitioning of AOD according to retrieved particle classification and incorporation of height information improves the relationship between AOD and surface PM2.5 (fine particulate matter, a regulated air pollutant), constituting an important step toward a satellite-based particulate pollution monitoring system. Stereoscopic cloud-top heights provide a unique metric for detecting interannual variability of clouds and exceptionally high quality and sensitivity for detection and height retrieval for low-level clouds. Using the several-minute time interval between camera views, MISR has enabled a pole-to-pole, height-resolved atmospheric wind measurement system. Stereo imagery also makes possible global measurement of the injection heights and advection speeds of smoke plumes, volcanic plumes, and dust clouds, for which a large database is now available.

To build upon what has been learned during the first decade of MISR observations, we are evaluating algorithm updates that not only refine retrieval accuracies but also include enhancements (e.g., finer spatial resolution) that would have been computationally prohibitive just ten years ago. In addition, we are developing technological building blocks for future sensors that enable broader spectral coverage, wider swath, and incorporation of high-accuracy polarimetric imaging. Prototype cameras incorporating photoelastic modulators have been constructed. To fully capitalize on the rich information content of the current and next-generation of multiangle imagers, several algorithmic paradigms currently employed need to be re-examined, e.g., the use of aerosol look-up tables, neglect of 3-D effects, and binary partitioning of the atmosphere into "cloudy" or "clear" designations. Examples of progress in algorithm and technology developments geared toward advanced application of multiangle imaging to remote sensing of aerosols and clouds will be presented.