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MISR dust fraction retrievals over global oceans: Operational algorithm sensitivity to particle non-sphericity

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We present an assessment of the global sensitivities of multi-angular intensity observations to aerosol non-sphericity over ocean based on the view and illumination geometries and measurement uncertainties of the Multi-angle Imaging SpectroRadiometer (MISR) instrument, which has been acquiring data from NASA's Terra platform since 2000, and the characteristics of the currently operational MISR Version 22 (V22) Dark Water aerosol retrieval algorithm.

Non-spherical dust models, which were introduced with Version 16 of the MISR product, improved the quality and coverage of aerosol retrievals in dusty regions. That made MISR aerosol product suitable for dust source mapping and for scientific investigations of Trans-Atlantic dust transport. However, the retrieved global non-spherical aerosol optical depth (AOD) fraction has been found to have climatological artifacts, which appear as zonal bands of high non-spherical fraction, one in each hemisphere, that shift in latitude as a function of season. To explain the reason for these features, we introduce a formal approach to examine the ability of the operational MISR Dark Water algorithm to distinguish among various spherical and non-spherical particles as a function of the variable MISR view-illumination geometry. We demonstrate that under the criteria currently implemented in the algorithm: (1) the retrievals are able to distinguish between spherical and non-spherical particles at all MISR viewing geometries when the AOD exceeds 0.1, (2) sensitivity to particle non-sphericity decreases for AOD below 0.1 due to an unnecessarily large lower bound imposed on the uncertainty in MISR observations at low light levels, and improves when this lower bound is removed (3) the sensitivity of the MISR retrievals to aerosol non-sphericity varies in a complex way that depends on the sampling of the scattering phase function and the contribution from multiple scattering, and (4) non-sphericity artifacts occur at those view-illumination geometries at which dust aerosols are indistinguishable from certain types of cirrus particles.

Based on these results we assemble and evaluate the MISR-retrieved dust climatology under various assumptions regarding the goodness of fit of aerosol models to the MISR data. The climatological evaluation is done through qualitative comparisons with the expected dust climatology. Based on the evaluation, we describe the strengths and limitations of the current operational non-sphericity retrievals to climatic and environmental studies of airborne dust.