Retrievals of aerosol properties using an AERONET tuned implementation of the Dark Target and GRASP inversion frameworks

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In this work we combine novel and well-established retrieval techniques to obtain improved estimates of aerosol optical depth (AOD) over land and ocean from observations made by the Moderate Resolution Imaging Spectroradiometer (MODIS). The radiances used as retrieval inputs are obtained using the gas absorption corrections as well as the pixel screening and aggregation techniques of the well-established Dark Target algorithm. The long heritage of these techniques provides confidence that the resulting radiances are predominantly free from artifacts that can negatively influence retrievals, including cloud contamination, suspended sediment and sun glint. These preprocessed radiances are then fed into the advanced and highly flexible Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm. The versatility of the GRASP inversion framework allows for a set of customized assumptions regarding the surface and intensive aerosol properties. In order to derive a set of assumptions that ultimately best utilizes the limited information content of the MODIS measurement, we make use of the flexibility of the GRASP code and first perform a synergistic joint retrieval on both the MODIS radiances and collocated AOD measurements made by AERONET sun photometers. The resulting retrievals of surface properties as well as aerosol concentration, size, refractive index and shape are then used to constrain a retrieval exclusively utilizing MODIS observations in a manner that is consistent with both the MODIS measurement and the highly accurate AERONET AOD. The tuned MODIS retrieval was then applied to all pixels collocated with 120 globally representative AERONET sites over a 15-year period. Over ocean, the results indicate that at 550 nm the new retrieval was highly correlated with the AERONET AOD's ($R = 0.900$). Furthermore, the net AOD biases of the new method were consistently below 0.01 across all six retrieved wavelengths, significantly less than the corresponding Dart Target biases of 0.02–0.05. Furthermore, the RMS errors were reduced relative to the standard Dark Target algorithm, with 7% more retrievals falling within the World Metrological Organization's target AOD accuracy range of $\Delta\tau = \pm 0.03 \pm 0.1\tau$.

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