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MODIS Aerosol Optical Depth retrieval over land considering surface BRDF effects

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Aerosols in the atmosphere play an important role in the climate system and human health. Retrieval from satellite data, Aerosol Optical Depth (AOD), one of most important indices of aerosol optical properties, has been extensively investigated. Benefiting from the high resolution at spatial and temporal and the maturity of the aerosol retrieval algorithm, MOderate Resolution Imaging Spectroradiometer (MODIS) Dark Target AOD product has been extensively applied in other scientific research such as climate change and air pollution. The latest product – MODIS Collection 6 Dark Target AOD (C6_DT) has been released. However, the accuracy of C6_DT AOD (global mean ± 0.03) over land is still too low for the constraint on radiative forcing in the climate system, where the uncertainty should be reduced to ± 0.02.

The major uncertainty mainly lies on the underestimation/overestimation of the surface contribution to the Top Of Atmosphere (TOA) radiance since a lambertian surface is assumed in the C6_DT land algorithm. In the real world, it requires considering the heterogeneity of the surface reflection in the radiative transfer process. Based on this, we developed a new algorithm to retrieve AOD by considering surface Bidirectional Reflectance Distribution Function (BRDF) effects. The surface BRDF is much more complicated than isotropic reflection, described as 4 elements: directional-directional, directional-hemispherical, hemispherical-directional and hemispherical-hemispherical reflectance, and coupled into radiative transfer equation to generate an accurate top of atmosphere reflectance. The limited MODIS measurements (three channels available) allow us to retrieve only three parameters, which including AOD, the surface directional-directional reflectance and fine aerosol ratio η. The other three elements of the surface reflectance are expected to be constrained by ancillary data and assumptions or "a priori" information since there are more unknowns than MODIS measurements in our algorithm.

We validated three case studies with AErosol Robotic NETwork (AERONET) AOD, and the results show that the AOD retrieval was improved compared to C6_DT AOD, with the increase of within expected accuracy $\pm(0.05 + 15\%)$ by ranging from 2.7% to 7.5% for the best quality only (Quality Assurance =3), and from 5.8% to 9.5% for the marginal and better quality (Quality Assurance ≥ 1).