TEN YEARS OF CLOUD MICROPHYSICS MEASUREMENTS FROM MODIS

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ABSTRACT

The Moderate Resolution Imaging Spectroradiometer (MODIS) was developed by NASA and launched onboard the Terra spacecraft on December 18, 1999 and Aqua spacecraft on May 4, 2002. It achieved its final orbit and began Earth observations on February 24, 2000 for Terra and June 24, 2002 for Aqua. Among the remote sensing algorithms developed and applied to this sensor are cloud optical and microphysical properties that include cloud thermodynamic phase, optical thickness, and effective particle radius of both liquid water and ice clouds. The archived products from these algorithms have applications in climate change studies, climate modeling, numerical weather prediction, and fundamental atmospheric research.

The cloud optical properties algorithm has undergone extensive improvements and enhancements between Collection 4 and Collection 5 (the current version). These changes have included, but are not limited to, (i) improvements in the cloud thermodynamic phase algorithm, (ii) improvements and substantial changes in the ice cloud light scattering libraries, (iii) new clear-sky restoral algorithm for flagging heavy aerosol and sunglint as cloud-free regions, (iv) vastly improved spectral surface albedo maps, including the spectral albedo of snow by ecosystem, (v) improvements in the effective radius solution logic, and (vi) addition of pixel-level uncertainty estimates for cloud optical thickness, effective radius, and water path, based on uncertainties in calibration, above-cloud water vapor correction, and surface albedo, and taking into consideration the sensitivity of the retrieval algorithm to solar and viewing geometries. In addition, we have (i) eliminated failed retrievals due to detector saturation for large optical thickness (by switching spectral band used in the retrieval), (ii) implemented cloud edge detection and removal, (iii) added a supplementary cloud optical thickness and effective radius algorithm over snow and sea ice surfaces and over the ocean, which enables comparison with the 'standard' retrieval, and (iv) added new multi-layer cloud detection indicators.

We will show examples of cloud optical properties retrieved for selected 5-minute (2000x2330 km) regions, with a special emphasis on southern Africa. We will then discuss the spatial and temporal distribution of monthly mean cloud fraction, cloud optical thickness, and effective particle radius of liquid water and ice clouds. Zonal plots of liquid water and ice cloud properties will be shown to highlight the significant difference in cloud properties, especially effective ra-

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dius, between ocean and land surfaces. Finally, our grid-averaged and time-averaged level-3 MODIS atmosphere product allows us to look at marginal and joint histograms of many cloud properties, and to look at correlations and relations between cloud optical thickness and effective radius. We will also show the marginal probability density function of cloud optical thickness and effective radius for land and ocean surfaces that will highlight the fact that these distributions are highly skewed and that the mode effective radius and optical thickness are substantially less than the mean values of these variables. In conclusion, we will show joint histograms of cloud optical thickness and effective radius for selected geographical regions, contrasting morning (Terra) and afternoon (Aqua) observations separately for liquid water and ice clouds.