Ten Years of Cloud Products from MODIS Terra: Trend Analysis

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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 algorithms developed and applied to this sensor are cloud detection, cloud-top properties, cloud optical and microphysical properties (including 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.

All cloud algorithms underwent numerous changes and enhancements between Collection 4 and Collection 5 (the existing production version); this process continues with the current Collection 6 development. Collection 5 cloud detection algorithm changes focused on the improved detection of polar clouds, among other modifications. For cloud-top properties, the net effect of Collection 5 changes was to lower cloud heights slightly (raise cloud pressures) and to raise effective cloud emissivities slightly where the full CO_2–slicing algorithm is performed (middle and upper tropospheric clouds). Cloud optical property enhancements included: (a) improvements in the cloud thermodynamic phase algorithm, (b) improvements and substantial changes in the ice cloud light scattering libraries, (c) new clear-sky restoral algorithm for flagging heavy aerosol, sunglint, and partly cloudy pixel removal via cloud edge removal and 250 m bands, (d) vastly improved spectral surface albedo maps, including the spectral albedo of snow by ecosystem, (e) 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, (f) 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 (g) a multi-layer

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cloud detection indicators. Collection 6 efforts include a number of improvements that are being planned for implementation sometime in late 2010.

We will show example MODIS Collection 5 cloud climatologies derived from global spatial and temporal aggregations provided in the archived gridded Level-3 MODIS atmosphere team product (product names MOD08 and MYD08 for MODIS Terra and Aqua, respectively). Data sets in this Level-3 product include scalar statistics as well as 1- and 2-D histograms of many cloud properties, allowing for higher order information and correlation studies. As an example, 1-D probability density functions of cloud optical thickness and effective radius for land and ocean surfaces are highly skewed distributions with the mode effective radius and optical thickness being substantially less than the mean values of these variables. Examples of 2-D distributions include cloud-top pressure vs. optical thickness, cloud-to pressure vs. effective emissivity (high clouds), and cloud optical thickness vs. effective radius. In particular, we will show trends in annual and seasonal means for a variety of the MODIS cloud properties, as well as estimates for the statistical significance of the trends.

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