

Version 2 Change Summary for the MODIS/VIIRS Cloud-Top and Optical Property (CLDPROP) Algorithms

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Cloud Optical Properties

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Cloud-Top Properties

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High Impact Change Overview

The most significant Version 2 (v2) changes are, in no particular order:

Cloud Optical Properties

- New pixel-level broadband flux calculations using in-line radiative transfer (RRTM-G);
- New “research and evaluation” datasets, including thin cirrus optical thickness retrievals using the 1.38 μm channel and a new cloud thermodynamic phase algorithm based on machine learning (Random Forest);
- Updated ancillary datasets, including transition to the GEOS-IT atmospheric profiles and land/ocean surface properties datasets produced by the Goddard Modeling and Assimilation Office (GMAO);
- Miscellaneous updates.

Cloud-Top Properties

- Changes include updated cloud type (used for phase) and a few science updates.

Change Details

A high-level summary of the changes implemented in v2 of the CLDPROP cloud optical property algorithm (part of the shared-core “CHIMAERA” suite (Wind et al., 2020)) is given below. Additional details on these changes will be provided in a subsequent v2 update to the CLDPROP User’s Guide.

- **Pixel-level broadband flux calculations.** The RRTM-G broadband RT code has been integrated within CHIMAERA to provide in-line shortwave (SW) and longwave (LW) clear and cloudy sky flux calculations at the top of atmosphere and the surface. These calculations, using the CLDPROP cloud-top and optical property retrievals as input, along with a host of ancillary atmospheric and surface datasets, are performed and

reported every fifth (MODIS) or fourth (VIIRS across-track) pixel, corresponding to the same pixel sampling used for the L3 aggregated statistics products. These flux datasets enable, e.g., computations of cloud radiative effects, etc., consistent with the forward RT and assumptions used in the retrievals themselves.

- **Thin cirrus retrievals from the 1.38 μm channel (research/evaluation dataset).** Retrievals of cirrus cloud optical thickness using the 1.38 μm channel described in (Meyer & Platnick, 2010) have been implemented. The 1.38 μm channel resides within a strong atmospheric water vapor absorption band, thus its signal at the top of atmosphere is due primarily to reflection from high altitude clouds, with reflection from lower-level clouds and the surface nearly completely attenuated. These 1.38 μm retrievals provide enhanced skill for optically thin cirrus clouds that often yield retrieval failures for the standard retrieval channel pairs. COT retrievals and associated pixel-level retrieval uncertainties are reported in the new variables `Cloud_Optical_Thickness_138` and `Cloud_Optical_Thickness_Uncertainty_138`, respectively, both in the new `research_evaluation_data` group.
- **Cloud Optical Properties (COP) thermodynamic phase algorithm (research/evaluation datasets).** A new machine learning algorithm using Random Forest (RF) models (Wang et al., 2020) has been implemented. While an accelerated timeline imposed on v2 development precluded an extensive continuity evaluation of this algorithm, model outputs (probabilities of liquid phase, ice phase, and clear sky) and the surface ecosystem type used to select the appropriate RF model (seven independent RF models are trained for various IGBP surface categories – ocean, forest, shrub, grass, cropland, snow/ice, barren) are reported in the new `Random_Forest_*` variables within the new `research_evaluation_data` group. When fully implemented, this RF algorithm will enable significant improvements in computational efficiency over the existing CLDPROP algorithm (Marchant et al., 2016) that requires separate retrievals of liquid and ice phase COT/CER from each spectral channel pair for each cloudy pixel, while retaining similar skill when compared against a co-located CALIPSO lidar (CALIOP) phase dataset benchmark. A full evaluation of this algorithm will be performed in expectation of implementation in future CLDPROP versions.
- **GEOS-IT ancillary datasets.** Atmospheric profiles and land surface snow/ice and sea ice extent now are obtained from the Goddard Earth Observing System (GEOS) for Instrument Teams (GEOS-IT) meteorological dataset, based on the GEOS-5 data assimilation system (Rienecker et al., 2008), produced by NASA's GMAO; previously, NCEP GDAS provided atmospheric profiles, and NISE and NCEP sea ice products provided land surface snow/ice and sea ice extents, respectively. The atmospheric profiles of temperature, pressure, water vapor, and ozone are used, along with pre-computed RT look-up tables, to derive spectral atmospheric transmittance for above-cloud atmospheric absorption corrections, and also are used as input to the RRTM-G broadband flux calculations. The land surface snow/ice and sea ice extents are used to determine an

appropriate surface boundary condition (albedo) in the cloud forward RT models used for the COT/CER retrievals and in the RRTM-G calculations. The transition to GEOS-IT from the NCEP GDAS, NISE, and NCEP sea ice products provides stability across the entire MODIS data record along with a single, internally consistent atmosphere and land ancillary product suite.

References

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