Collection 5 Changes to
MODIS Cloud Top Properties (06_CT)

Version 2

The cloud top pressure algorithm from the University of Wisconsin-Madison (MOD_PR06CT) for MODIS Collection 5 reprocessing has been delivered to the Goddard DAAC for integration. Here is a synopsis of the changes made:

Apply new forward model coefficients for radiative transfer calculations
Read in all available levels of input GDAS temperature and moisture profiles
Reduced total number of forward model calculations for efficiency
SSTs, GDAS land surface temperatures and surface pressures are bi-linearly interpolated to smooth surface data input
Removed use of the band 33/31 ratio
Use average cloudy radiance data from 5x5s as input to CO2-slicing retrieval rather than average of all radiances - improves retrievals in partly cloudy 5x5s (mostly seen in low cloud fields)
Removed band 35/33 ratio from Aqua processing
Simple land vs. water surface emissivity correction is applied
More accurate saturation water vapor pressure calculation is applied
Lowered Aqua noise limits (allowable clear vs. cloudy radiance differences)
Removed several QC checks on CO2-slicing process – increases number of valid CO2-slicing retrievals

The net effect of Collection 5 changes will be 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). Figure 1 shows the changes in cloud top pressure for daytime Aqua data from December 1, 2004. One can see the generally blue shading that indicates slightly negative Collection 4 minus Collection 5 cloud top pressure differences, especially in regions characterized by high clouds. This effect is mainly due to the new forward model coefficients applied in the algorithm.

In addition to changes in the algorithm itself, input radiances will be “de-striped” before use in Collection 5 processing. This will partially address the issue of inconsistent radiometric response and quality between detectors in the long wave CO_2 absorption bands (33-36). Sensitivity to thin clouds is reduced, especially in Terra data, where band 34 is severely compromised. The problem has also been ameliorated somewhat by a judicious choice of clear vs. cloudy radiance thresholds, but a more robust correction is still desired. Figure 2 shows a tropical ocean scene observed by Aqua MODIS on August 24, 2002 beginning at 23:00 UTC. The three images show 11 μm brightness temperatures (left) and cloud top pressures from the Collection 4 algorithm (center) and the updated version (right). Colors show clouds with tops higher than 390 mb where white represents the highest ($\approx$100 mb) and navy somewhat lower (360-390 mb) cloud tops. Cloud top pressures are calculated and reported at 5-km resolution (5x5 boxes). The benefits of de-striping may be seen in the top center of the image where more spatially consistent values are reported.

In many scenes, boundary layer clouds were assigned a cloud height that was too low (cloud pressure too high) and a cloud effective emissivity that was too high (previously always 1.0 for clouds derived from the "window channel method"). This is remedied by averaging only cloudy radiances in a 5x5 for input to the algorithm. Then, the effective emissivity of the cloud is simply the cloud fraction (still assuming the cloud is opaque, but not that the 5x5 is completely cloud-filled). The cloud fraction is taken from cloud mask (MOD35) results. The impact of using only cloudy radiances on high cloud scenes is less dramatic since these clouds usually fill 5x5s completely except for edges of cloud systems. Figure 3 shows an example of the change in low cloud top pressures when the new algorithm is implemented. Only low clouds (CTP > 700 hPa) are shown in colors. Black denotes clear skies.

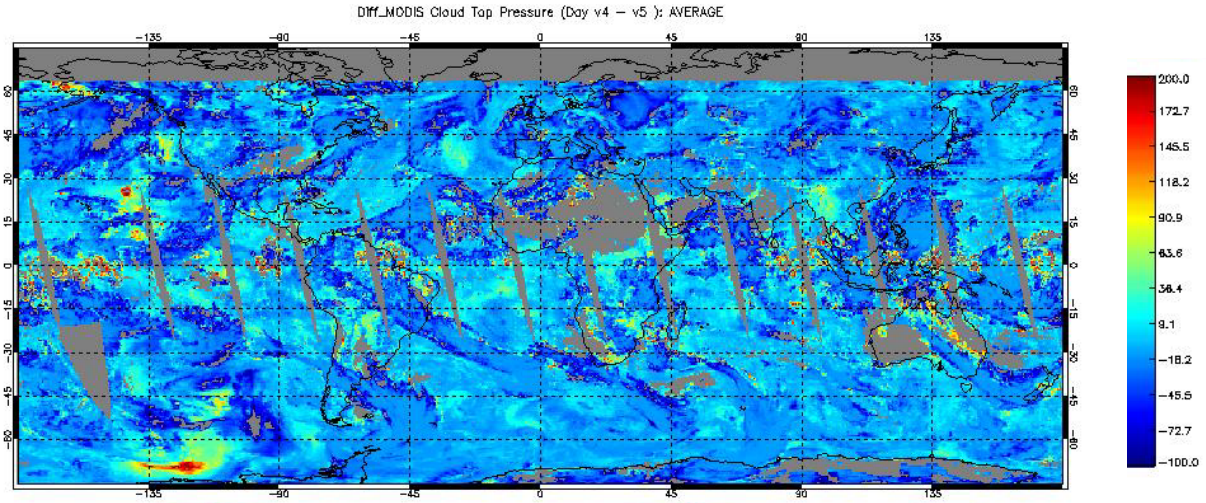

Figure 1. Daytime Collection 4 minus Collection 5 cloud top pressure differences in hPa.

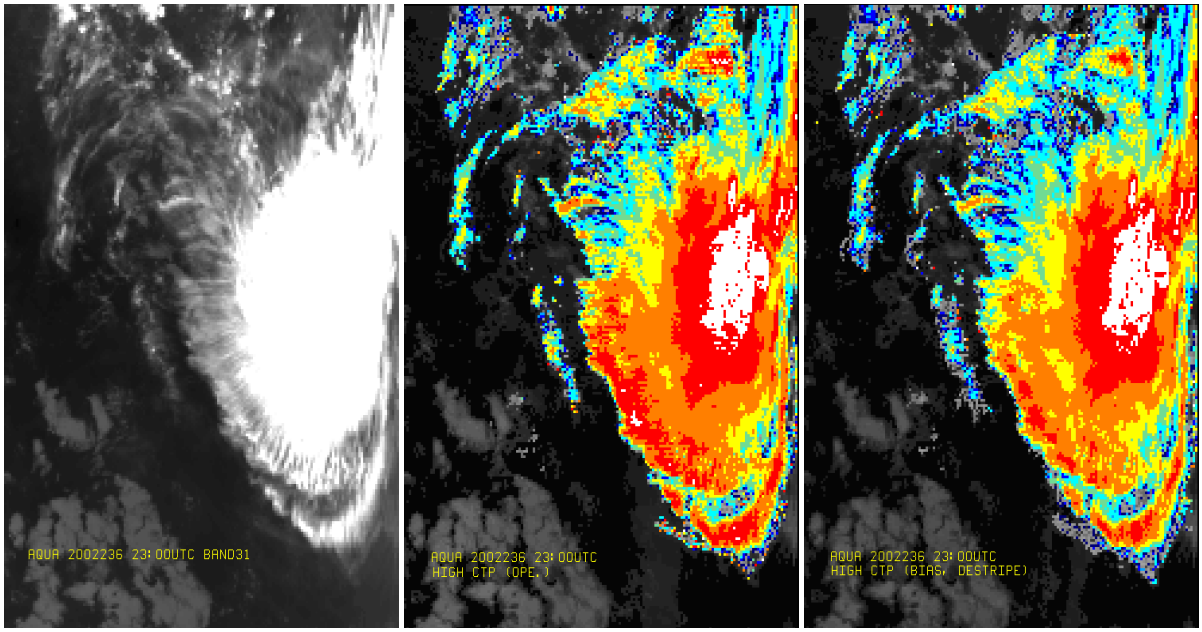

Figure 2. A tropical ocean scene (2002236 at 23:00 UTC) observed by Aqua MODIS. Left-hand image shows 11 μm brightness temperatures (white is cold, dark is warm), middle is cloud top pressures from current operational algorithm, right is latest update. Colors show cloud top pressures higher than 390 mb with white being the highest (about 100 mb) and navy 360-390 mb.

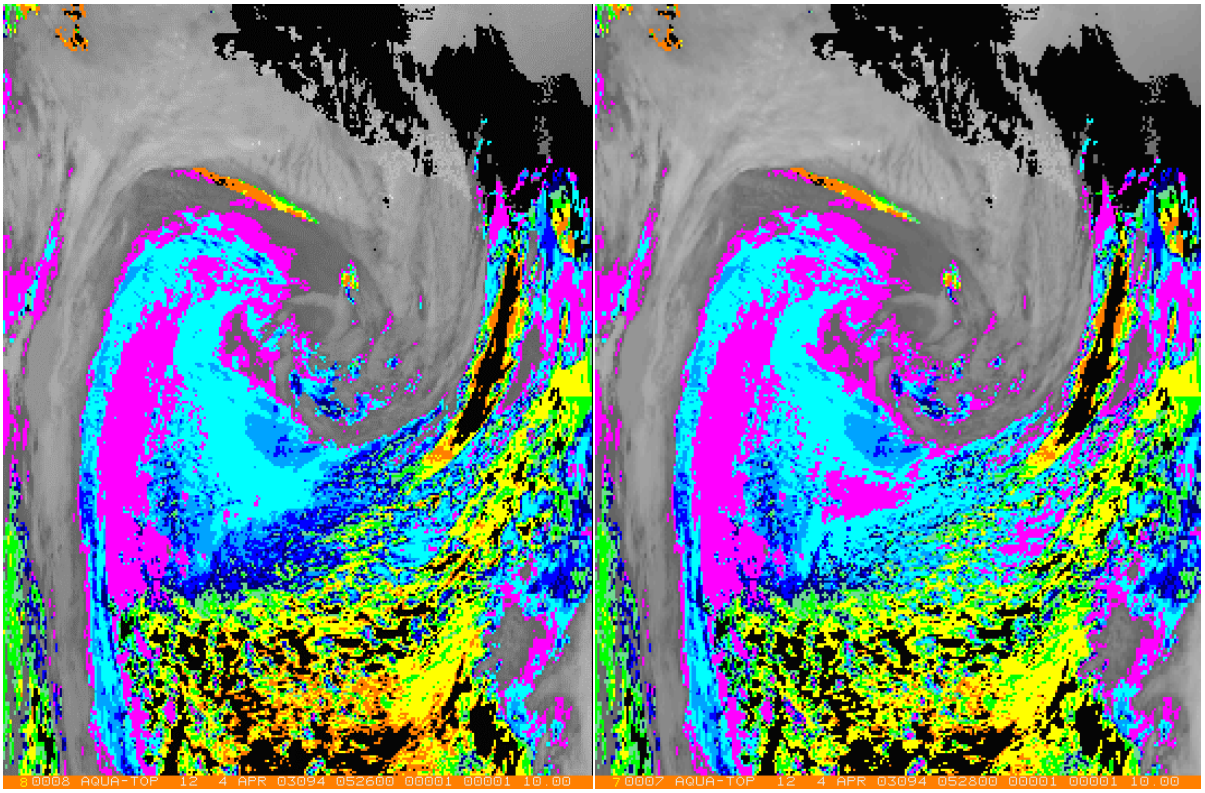

Figure 3. Shown above are MOD06CT cloud top pressure results for an Aqua MODIS scene from April 4, 2003 at 05:25 UTC. Note the increase in the pink color (705-755 hPa) over the cyan (755-805 hPa) near the center of the image, and cyan over blue and navy (855-905 hPa) just below. These changes are the result of adding valid CO2-slicing retrievals that were previously generated from the window channel algorithm. Most notably, much of the orange color (985-1015 hPa) near cloud edges has been replaced by yellow (960-985 hPa) and green (930-960 hPa). This is a direct result of using only cloudy radiances as input to the algorithm.