MISR Cloud-Top-Height (CTH) Optical-Depth (OD) Product Quality Statement

The MISR CTH-OD product contains 2D histograms (joint distributions) of retrieved cloud-top-height and cloud-optical-depth. A lengthy review of the MISR CTH-OD data, including comparison with MODIS and ISCCP CTH-OD datasets can be found in Marchand et al. (2010). We strongly encourage the MISR CTH-OD data be used in combination with ISCCP and MODIS datasets and that comparisons with climate model output be undertaken in conjunction with the CFMIP Observation Simulator Package (COSP; http://cfmip.metoffice.com/COSP.html).

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Know Problems/Limitations:

(1) Coverage and sea ice

The MISR CTH-OD product is not generated over land surfaces or for solar zenith angles greater than 78.5 degrees. Regions with sea-ice are excluded based on monthly SSMI sea ice coverage estimates. The SSMI sea-ice mask does not function well in coastal areas and so coastal areas where ice might be found are also excluded. The SSMI identification of sea-ice is not perfect and at times a few grid-cells with patchy sea-ice go undetected. Sea ice contaminates both the cloud-detection (generating false positives) and optical depth retrievals (which assume a dark-water surface). Typically this appears as an unusually large number of no-CTH-retrieval conditions or a retrieved CTH in the lowest altitude bin (0 to 0.5 km) with a peak in optical depth values between about 4 and 10, as shown below in figure 1. High-latitude regions that display patterns like this should be considered suspect. The CTH retrievals away from the surface (CTH > 1km) are believed to be good, however the associated OD may well be biased high.

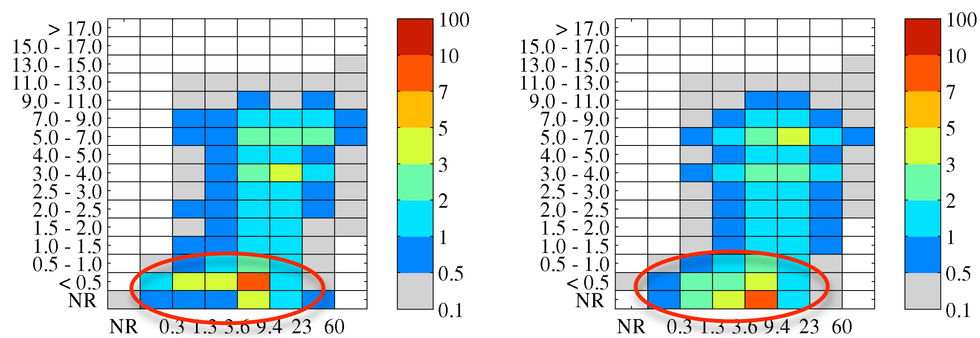

Figure 1 – Examples of CTH-OD results with likely sea-ice contamination

(2) Broken clouds and cloud edges

Because satellite pixels can be partially filled by clouds, the fraction of satellite pixels containing some amount of cloud (what one might call the "imager-retrieved" cloud fraction) will generally be larger than the true fractional area covered by clouds. This especially true of the low-altitude-cloud fraction in areas dominated by trade cumulus, where the MISR cloud fraction (derived with an effective pixel size of 1.1 km) is likely at least 10% larger than would be derived from a much higher resolution imager (Zhao and Di Girolamo 2006). Outside of trade cumulus areas the over-estimate is likely small, perhaps 5% to 10%.

This problem is not unique to MISR, all imagers (MODIS and ISCCP included) suffer from this limitation. However, MISR does better at detecting partially filled pixels with low-clouds than ISSCP and subsequently reports higher low cloud amounts (as much as 10% more than ISCCP in the zonal average, see Marchand et al. 2010).

Small clouds and cloud edges can likewise have a drastic effect on the retrieved optical depth. There has been much discussion in the literature around the subject of error in cloud optical depth retrievals due to three dimensional effect and the result contained in the MISR histograms are perhaps best considered "1D equivalent" optical depths at a scale of 1.1 km. In particular, the preponderance of low-optical depths associated with low-altitude clouds in the tropical and subtropical trade cumulus zones reflects the fact that these clouds only partially fill the MISR pixel.

(3) Errors/Uncertainty in retrieved Cloud-Top-Heights

The MISR Cloud-Top-Height retrieval is based on a stereo-imaging technique. A significant advantage of the MISR CTH retrieval is that the technique is geometric and is not sensitive to the actual value of the observed radiances (i.e., the sensor calibration). The MISR CTH retrieval has been the focus of several studies including Marchand et al. (2007), Naud et al. (2002, 2004, and 2005a,b), Seiz et al. (2005), and Marchand et al. (2001). Error characteristics depends on the cloud-type. Averaged over all clouds, the above studies show that cloud top is found with little bias and a standard deviation of about 1000 m. The dominant source of error in the height retrieval comes from errors in the wind-correction (or lack thereof). As a result of CTH retrieval errors, some fraction of the counts in each CTH bin will be placed one bin too low or too high. In principal, this could approach 50% if the actual cloud tops in a given region predominantly occur close to one of the bin-boundaries but typically should be less than about 30%. Also, because the wind retrieval is not always successful, the MISR histograms are constructed using the MISR height retrieval without wind correction when necessary, so there is likely to be a small bias in cloud top heights in locations with a predominant wind direction in the along-track (more-or-less meridional) direction.

(4) Cloud Phase

Clouds with a CTH below the climatological freezing level are assumed to be composed of water drops with an effective radius of 10 mm, while those above the freezing level are treated as ice particles with an effective radius 50 mm and an aggregate-like crystal habit. No formal analysis on the error in the optical depth due to the assumption of a fixed effective radius or cloud phase has been undertaken. Nonetheless, MISR and MODIS retrievals produce very similar OD distributions in mid-latitude mixed phase regions (in spite of the fact that MODIS retrieves the particle size and cloud phase and MISR applies a climatology) suggesting this is not a large problem, at least in the aggregate.

(5) Multiple Cameras

While there has been some research into the potential advantage of using multiple MISR view angles for cloud optical depth retrieval (Evans et al. 2008, McFarlane and Marchand 2008) much more research is needed and no operational multiangle retrievals yet exist. Only one MISR camera (that is, one view-angle and one radiance measurement) is used in the optical depth retrieval. However, the MISR histograms take advantage of the MISR multi-angle cameras by selecting a ***best camera***, as the camera closest to nadir that has no sun-glint. Most of the time, the best camera is either the nadir viewing camera, or one of the MISR 26^{o} cameras. There is however, a small region in the tropics (the exact location of which moves with the seasonal cycle) where a 45^{o} view is used.

The MISR operational CTH-OD HDF dataset contains the "best camera" result, as well as histograms for each of the 9 MISR views. This permits examination of the sensitivity of the MISR retrieval to the view angle (see Marchand et al. 2010 for examples).

Analysis suggests the sensitivity of the CTH-OD histograms to view angle is modest if the MISR 60^{o} and 70.5^{o} views are not considered. This modest sensitivity to view angle should not be taken to mean that the optical depth of individual pixels remains the same regardless of view angle. Rather, it shows that (given the size of the optical depth bins in the histogram) the net change in the optical depth distribution is not typically large. This result is consistent with previous studies, such as Varnai and Marshak (2007) who found that mean optical depth retrieved from MODIS shows little sensitivity to view angle for solar zenith angles less than about 50^{o}, and Hovarth and Davies (2004) who found that the percentage of clouds for which MISR observations fit plane-parallel model increases dramatically if the MISR 60^{o} and 70.5^{o} views are not considered.

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