MISR Level 3 Cloud Fraction by Altitude Product Quality Statement September 9, 2010

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Quality Designator:

- **Stage 2 Validated:** Global Cloud Fraction by Altitude Product

MISR maturity level definitions

This statement applies to the MISR Level 3 Cloud Fraction by Altitude product with a version of F01_0001 or greater, effective until further improvements to MISR software or ancillary inputs are made. See the Versioning Page for an in-depth explanation of the differences between various MISR product versions. Quality statements covering earlier time periods may be accessed through links at the bottom of this page.

The evaluation of product quality is ongoing. Please read the summary words of caution if you have not done so already.

The MISR Level 3 CFbA software which generated this product is believed to be functioning well except where noted below. This statement highlights major known problems with the products, as well as functionalities which are currently not implemented.

Global Cloud Fraction by Altitude Product (a.k.a. MIL3DCFA, MIL3MCFA, MIL3QCFA, MIL3YCFA) (from MISR PGE 30b)
Quality Designator: Stage 2 Validated

PRODUCT MATURITY

The CFbA product is designated "Stage 2 Validated." The GEWEX Cloud Assessment Working Group is currently undertaking a global comparison of cloud cover by altitude generated by a wide range of satellite programs. The CFbA product will be raised to "Stage 3 Validated" pending the publication of the GEWEX Cloud Assessment report, which is anticipated to be complete by the end of 2010.

OVERVIEW

The CFbA product provides the frequency of cloud occurrence partitioned into different cloud-top altitude bins at a global and monthly scale with a spatial resolution 0.5° x 0.5° latitude/longitude and vertical resolution of 500m. The vertical integration of these frequencies leads to the total cloud fraction, which is also reported in the CFbA product. The algorithm accounts for the strengths and weaknesses of the MISR cloud products, as well as sampling characteristics of the instrument and its products, so as to provide the best estimate of monthly cloud fraction by altitude that can be derived from the MISR Level 2 cloud products. Complete CFbA algorithm details can be found in the *Level 3 Cloud Fraction by Altitude Algorithm Theoretical Basis* Document.

Only the heights that are deemed to be cloud (as determined by the SDCM) are reported in this product. Since the SDCM is calculated by comparing the retrieved height against that of the sum of the (a) terrain height, (b) standard deviation of the terrain heights and (c) a constant 562m, and its algorithm calls any heights less than this sum "Clear or Near Surface", it is rare to see any entries in the 0-500 m height bin. Indeed, this can only happen when surface altitudes are significantly below the WGS84 surface ellipsoid. The northern Indian ocean is a large area where the sea surface is nearly 100 m below the surface ellipsoid. Hence, it is one of the few places where clouds can be found in the 0 - 500m altitude bin.

CFbA KNOWN LIMITATIONS

The CFbA product uses as input the RCCM, SDCM, ASCM, and stereo heights from the Level 2 TC_Classifiers product. Therefore, the Level 2 cloud quality statement applies.

Keep the following in mind when using the CFbA product in scientific analyses:

1. The heights are calculated by a stereoscopic method and therefore retrieve the altitude of greatest spatial contrast as viewed by multiple MISR cameras. This may differ from the heights retrieved by a LIDAR or an IR sensor. The cloud optical depth threshold at which the stereo algorithm identifies thin clouds depends, in part, on the contrast of the underlying surface. Therefore, MISR can detect thinner single-layered clouds over ocean than compared to land. Where heights are retrieved, RMS errors have been determined to be ~ 560 m (see Level 2 cloud quality statement).

2. When a thin high-altitude cloud layer is present over lower and thicker clouds, MISR-Stereo will preferentially (and accurately) retrieve the height of the lower cloud layer, since this layer probably offers the greater spatial contrast. This has an advantage over conventional IR-based techniques that may place the cloud at an altitude that is between the high thin cloud and low thick cloud, that is, where no cloud actually exists. (This may open opportunities for multi-layered cloud detection by combining stereo and conventional IR techniques). Therefore, if comparing MISR cloud heights with those derived from conventional IR, MISR will report a smaller fraction of high cloud and larger fraction of low cloud, but the total cloud fraction remains comparable assuming the datasets have the same cloud detection sensitivities.

3. MISR stereo does not report cloud heights for all pixels detected as cloud by the MISR cloud masks. For example, a thick cloud that has no spatial contrast over some horizontal scale will have no retrieved heights over that scale. A nearest-neighbor search for heights, combined with the MISR cloud masks, is used to minimize the sampling artifacts that may arise from these no-retrieval heights. Where the search is unsuccessful, the no-retrieval heights cloud fraction is recorded in the CFbA product and accounted for in the total cloud fraction as reported in the product (see Alogrithm Theoretical Basis Document for details).

4. The total cloud fraction is the fraction of pixels detected as containing "some" cloud. Over snow- and ice-free regions, the MISR cloud mask effectively reveals sub-pixel clouds (see Level 2 cloud quality statements). Since sub-pixel clouds (by definition) do not fully cover a pixel, the true cloud fractions (as would be defined by a perfect cloud detector using pixels that are near infinitesimal in size) reported in the CFbA will be overestimated in regions populated by small clouds (e.g., trade wind cumulus regions). A full discussion on this issue is given in Zhao and Di Girolamo (2006). An algorithm to correct the overestimation of cloud fraction, based on Di Girolamo and Davies (1997), is anticipated to be implemented in the TC_Classifiers product for use as input to the next version of the CFbA Product. Its impact on the cloud climatology over the tropical eastern Atlantic is shown in Jones et al. (2010).

5. Since land surfaces provide greater underlying spatial contrast compared to ocean, the MISR stereo and cloud detection algorithms will miss a greater fraction of visibly thin clouds over land. It has been determined that total cloud fraction over snow-free land and ice-free ocean is biased low by ~7% and ~2%, respectively (see Level 2 cloud quality statements and Di Girolamo et al. (2010)). This is relative to supervised support vector machine classification on a large number of randomly selected scenes applied to the RCCM, which acts as the main input for cloud fraction for the CFbA over snow- and ice-free surfaces.

6. The CFbA algorithm uses different inputs depending on whether or not the underlying surface contains snow or ice. To do so requires a snow and ice mask. The snow and ice mask used by MISR is a monthly mask at 1-degree resolution. A 1-degree grid is labeled snow/ice if > 5% of the region has snow/ice for more than 4 days of the month based on NSIDC/NISE data. Where labeled snow/ice covered, snow/ice thresholds for the ASCM are used. When these thresholds are applied to 1.1-km pixels that are, in truth, not covered by snow/ice within the snow/ice-labeled 1-degree region, an underestimation of cloud occurs. The result is that the CFbA produces an underestimate in cloud fraction in polar regions, particularly near the snow/ice - snow/ice-free boundaries. The MISR team is currently considering updating the monthly sea/ice mask to a daily mask at higher spatial resolution.

7. Because the CFbA product is processed using all daylight data, a monthly grid-cell in the high-latitude summer hemisphere will contain data that have been sampled from two ranges of solar zenith angles: one from the ascending branch of the orbit, the other from the descending branch of the orbit. Any diurnal cycle in cloud cover that exists in the high-latitude summer hemisphere, or unknown solar zenith angle bias in cloud detection and cloud-height retrievals, gets folded into the mean values of cloud fraction by altitude reported in the CFbA. For all other regions and times, the data that goes into the CFbA is sampled solely from the local mid-morning time that is characterized by the orbit's mid-morning equator-crossing-time of the descending branch (~10:30 A.M.). The MISR team is currently considering separating the descending branch data from the ascending branch data within the CFbA product.

8. Stereo processing requires high-quality image navigation of the orbit. Orbits that are deemed to be poorly registered (as determined by either the results of Level 1 or Level 2 analysis) are removed from processing. These poorly registered orbits are not evenly distributed as some orbits have fewer ground-control points than others. The number of ground-control points varies based on geographic path and time of year. As a result, not all longitudes along a given latitude line are sampled equally. We strongly recommend that users of the CFbA product consider the sampling information provided within the product.

9. Optically thick aerosols, such as from smoke and sand storms, may be misclassified as cloud by the MISR cloud masks, thus contributing to the cloud fraction. In regions of the world where these thick aerosols are prone to occur, the cloud fraction may be overestimated. The degree to which this occurs and its impact on the CFbA has not been ascertained, but the impact on the CFbA monthly product is expected to be small for most of the globe given the infrequent occurrence of thick aerosols over the course of a month for most locations on the globe.

References

- Di Girolamo, L., and R. Davies, 1997: Cloud fraction errors caused by finite resolution measurements. *J. Geophys. Res.*, 102, 1739-1756.

- Di Girolamo, L. et al., 2010: The Multi-angle Imaging SpectroRadiometer cloud masks: algorithm descriptions and performances. *J. Atmos. Ocean. Tech.* (in preparation).

- Jones, A., G. Zhao, S. Dey, and L. Di Girolamo, 2010: Correcting cloud fraction biases caused by finite resolution measurements with application to the Multi-angle Imaging SpectroRadiometer. *J. Geophys. Res.* (in preparation).

- Zhao, G. and L. Di Girolamo, 2006: Cloud fraction errors for trade wind cumuli from EOS-Terra instruments. *Geophys. Res. Lett.*, 33, L20802, doi:10.1029/2006GL027088.

There are no previous versions of this quality statement.