MISR Cloud Motion Vector Quality Statement

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Quality Designator

- Stage 2 Validated: All parameters

MISR maturity level definitions

This statement applies to the Level 2 Near Real Time (NRT) Cloud Motion Vector (CMV) product (version F01_0001) and to the Level 3 Cloud Motion Vector product (version F02_0002).

OVERVIEW

The Multi-angle Imaging SpectroRadiometer (MISR) Cloud Motion Vector (CMV) product provides retrievals of the height-resolved cloud motion determined from two multi-angle image triplets, each spanning a 3.5 minute window. The CMV product offers both Level 2 datasets available in near real time (NRT) for rapid response applications such as numerical weather prediction and Level 3 datasets aggregating observations over longer time scales to facilitate climate studies. Level 2 NRT CMV datasets are distributed within three hours of satellite overflight as HDF or BUFR format files comprising data collected over a 10 to 50 minute observational session. Level 3 CMV product datasets are distributed as NetCDF format files comprising data collected over the course of a month, season, or year. (For further format information, see the MISR CMV Data Product Specifications.)

The MISR CMV product is closely related to the MISR Level 2 Cloud product. Level 3 MISR CMV product datasets consist of high quality subsets of CMVs reported in the operational Level 2 Cloud product. The Level 2 NRT CMV product is generated by the same sequence of algorithms as the operational Level 2 product and yields nearly equivalent results. Additional information on the performance of the Level 2 Cloud product can be found in the MISR Level 2 Cloud Quality Statement.

CMV product algorithms are detailed in two Algorithm Theoretical Basis Documents (ATBDs), the Level 2 Cloud ATBD (pdf) and Level 3 CMV ATBD (pdf). The first describes the raw CMV retrieval and the second describes additional quality control procedures applied afterward for the CMV product.

This document assesses the Level2 NRT CMV and Level 3 CMV products that share the same underlying algorithms and science content. It is composed of sections documenting expected CMV precision and accuracy, known differences between Level 2 and Level 3 CMV, and known limitations of each product.

EXPECTED CMV PRECISION AND ACCURACY

Cloud motion vectors from the MISR Level 3 CMV product have been compared with collocated Geostationary Operational Environmental Satellite (GOES), Meteosat-9, MODIS (aboard Terra), and radiosonde (RAOB) atmospheric motion vectors (AMV). In most comparisons, MISR cloud top height (CTH) has been used to divide the analysis into low

(CTH < 3 km), middle (3 km < CTH < 7 km), and high (CTH > 7 km) clouds. The most recent peer reviewed assessment is Horvath (2013).

MISR vs. GOES AMV Intercomparison, Jan./Jul. 2007

Statistic	MISR height bin		
	0-3 km	3-7 km	7+ km
Number of Collocations	52600	3700	8500
Component bias (along, cross-track)	(0.1, -0.3) m/s	(1.4, 0.0) m/s	(1.8, -0.2) m/s
Component RMS (along, cross-track)	(2.7, 1.8) m/s	(5.1, 3.5) m/s	(5.7, 3.5) m/s
Vector RMSE	3.3 m/s	6.3 m/s	6.8 m/s

MISR vs. Meteosat-9 AMV Intercomparison, 2008

Number of Collocations	225155
Component bias (north, east)	(-0.0, -0.3) m/s
Component RMS (north, east)	(3.1, 2.8) m/s
Height bias	190 m
Height RMS	1220 m
Results courtesy of Akos Horvath, Leibniz Institute for Tropospheric Research	

MISR vs. arctic MODIS AMV Intercomparison, Jan./Jul. 2007

Statistic	MISR height bin		
	0-3 km	3-7 km	7+ km
Number of Collocations	8740	13490	1030
Component bias (along, cross-track)	(1.5, -0.4) m/s	(1.3, -0.1) m/s	(3.5, 0.2) m/s
Component RMS (along, cross-track)	(4.3, 3.7) m/s	(4.1, 3.2) m/s	(6.7, 4.7) m/s
Vector RMSE	5.9 m/s	5.4 m/s	8.9 m/s

MISR vs. arctic RAOB AMV Intercomparison, 2002-2008

Statistic	MISR height bin		
	0-3 km	3-7 km	7+ km
Number of Collocations	206	67	19
Component bias			

(along, cross-track)	(0.6, 0.0) m/s	(1.3, 0.0) m/s	(0.3, 0.5) m/s
Component RMS (along, cross-track)	(4.7, 3.5) m/s	(4.1, 3.2) m/s	(3.8, 1.9) m/s
Vector RMSE	5.9 m/s	5.3 m/s	4.3 m/s

DIFFERENCES BETWEEN LEVEL 2 NRT CMV AND LEVEL 3 CMV PRODUCTS

MISR Level 2 NRT CMV products are intended to contain nearly equivalent science information as MISR CMV product files produced with monthly and seasonal file granularity. The cloud-tracking and reconstruction algorithms of each are equivalent, except for the following details:

- Whereas the L3 CMV product includes in the product only wind speeds up to speeds of 50 ms^{-1}, the Level 2 NRT CMV product includes wind speeds up to 100 ms^{-1}. Wind speeds greater than 50 ms^{-1} were originally excluded from the L3 CMV product because they can only be obtained for wind orientations aligned with the ground track of the satellite. The potential sampling bias associated with this limitation is less relevant for rapid response applications.
- The Level 2 NRT CMV product introduces a new requirement for valid MISR wind retrievals. For data sessions in which fewer than 1000 valid retrievals are obtained prior to quality filtering, all retrievals will be omitted on the basis that insufficient data is available to perform necessary checks on the accuracy of camera pointing information.

Aside from the previously noted algorithm differences, the nature of NRT processing causes additional differences between the Level 2 NRT CMV and Level 3 CMV products. During standard processing, incoming MISR L0 data are consolidated into data for entire orbits. Terra platform navigation information (ATT/EPH) is also refined and consolidated into two hour intervals. These consolidation steps are not available for NRT processing. The absence of ATT/EPH refinement entails a theoretical loss of robustness that has not proven significant in testing. The absence of data consolidation also diminishes coverage. Because CMV retrievals require observations collected over a 7 minute span, this margin of coverage is lost at the boundaries of incoming MISR L0 or ATT/EPH session data. Level 2 NRT CMV products provide a nominal 75% of the coverage provided by Level 3 CMV products.

Level 2 NRT CMVs are derived from data sessions typically comprising less than the full orbit employed by standard processing from which Level 3 CMVs are derived. This results in a relative reduction in the quantity of recent observations available to the Level 1 software for performing updates to a continuous record of corrections to camera pointing maintained in order to perform in-flight geometric camera calibration. This difference causes NRT geometric corrections to differ from standard production leading to respective differences in retrieved CMV on the order of 3 ms-1.

LEVEL 2 AND LEVEL 3 CMV PRACTICAL LIMITATIONS

Some reported cloud motion vectors may contain values not representative of meteorological clouds. Cloud motion vectors are derived by identifying and tracking features within MISR camera images. These features can be associated with cloud, terrain, or aerosol, and can also be spurious. Features found to be near surface *and* slow moving are screened from the product, on the basis that they may not be representative of the wind field, either due to being associated with terrain or with orographic clouds. The nominal threshold defining near surface is 330 m above terrain, while the nominal thresholds defining slow moving are 1.2 ms^{-1} cross-track and 4.0 ms^{-1} along-track. The ambiguity inherent to screening with these thresholds is illustrated by the bimodal distribution of feature motion heights, and its segregation into included CMV, and excluded near-surface, slow-moving features.

Cloud motion vector accuracy is sensitive to the georegistration accuracy of the MISR L1B2 input. This sensitivity is estimated to range from 6 m/s/pixel to 16 m/s/pixel depending on the camera view angle [Davies et al., 2007; Zong et al., 2002]. Georegistration accuracy depends on the accuracy of corrections to camera pointing information that are continuously updated with each orbit. Correction updates are established by tracking known terrain features sighted by all nine cameras. The accuracy of these updates is a function of the seasonally varying quantity of terrain potentially seen during an orbit, the quality of the Digital Elevation Model for the terrain seen, and the potential presence of obscuring clouds.

In standard processing, camera corrections are inherited from the previous orbit, and updated based on data spaning the entire current orbit. In NRT processing, corrections are inherited from the orbit most recently processed in standard processing and updated using data spanning the session being processed. Quality control procedures flag roughly 7% of orbits as having insufficient georegistration accuracy for wind retrieval. No valid retrievals will be reported for these flagged orbits. In NRT processing, sessions rather than orbits can be so flagged. For a flagged session, a Level 2 NRT CMV file in HDF format file will be generated that contains only fill values, but no Level 2 NRT CMV file in BUFR format will be generated.

Cloud motion vectors are subject to bias related to L1B2 georegistration that is weakly correlated with cross-track position within the MISR swath. The northward and eastward components of this bias are constrained within ± 1 m/s over the range of positions across the swath, as is shown in the Figure 1 comparison between TC_CLOUD and Meteosat-9 motion vectors.

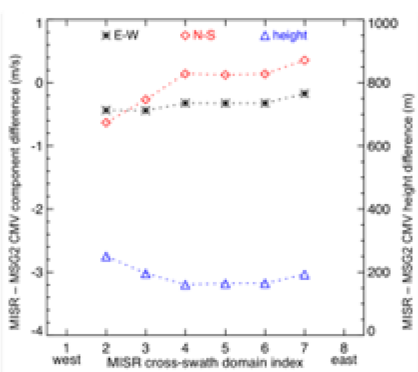

Figure 1: Differences in height, northward motion (N-S), and eastward motion (E-W) of MISR cloud motion vectors (CMV) relative to collocated Meteosat-9 (MSG2) CMV as a function of cross-swath domain index ranging from the 70.4 km interval at the far western edge of a MISR block (index 1) to the interval at the far eastern edge (index 8). For the analysis shown, MISR CMV have been averaged from 17.6 km resolution to 70.4 km resolution. Data are from 2008. Methodology is detailed by Lonitz and Horvath, 2011. Figure courtesy of Akos Horvath, Leibniz Institute for Tropospheric Research.

Unlike the atmospheric motion vectors derived from comparable passive sensors, cloud motion vectors are not obtained independently from their associated cloud top heights. Notably, error in the height of a cloud motion vector is not independent of error in the along-track component of motion [Zong et al., 2002].

REFERENCES

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Horváth, Á. (2013), Improvements to MISR stereo motion vectors, J. Geophys. Res. Atmos., 118, 5600–5620

Marchand, R.T., Ackerman, T.P., and Moroney, C. (2007), An assessment of Multiangle Imaging Spectroradiometer (MISR) stereo-derived cloud top heights and cloud top winds using ground-based radar, lidar, and microwave radiometers. Journal of Geophysical Research, Volume 112, D06204.

Mueller K. M., Garay M. J., Di Girolamo L., Jovanovic V., and Moroney, C.M. (2010), MISR Cloud Motion Vector Product Algorithm Theoretical Basis, JPL D-64973

Mueller, K., M. J. Garay, C. Moroney, and V. Jovanovic (2012), MISR 17.6 km gridded cloud motion vectors: Overview and assessment, paper presented at Eleventh International Winds Workshop, The University of Auckland, New Zeeland.

Also see:

Level 3 CMV Quality Statement dated September 16, 2012

Level 2 Cloud Quality Statement dated September 14, 2012