The Impact of NASA TERRA MISR Atmospheric Motion Vector Assimilation into JMA's Operational Global NWP System

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1. Introduction

MISR is the Multi-angle Imaging SpectroRadiometer on board the National Aeronautics and Space Administration's (NASA) Terra satellite, and MISR Atmospheric Motion Vectors (AMVs) are produced by NASA's Jet Propulsion Laboratory (JPL) using the MISR Level 2 Cloud product (Muller et al. 2012). AMVs derived from the MISR instrument have several unique strengths that are especially relevant to NWP systems. First, the integrated height retrievals are insensitive to radiometric calibration and atmospheric temperature profiles, giving more accurate height assignment for AMVs. Second, the cameras capture motion over a period of 200 seconds, providing effective 17.6 km gridded resolution data. Finally, MISR provides good global coverage up to 85 degrees north and south of the equator (Muller et al. 2012).

This report outlines the results of comparing MISR AMVs against collocated first-guess values of the operational global NWP system (JMAGSM) run by the Japan Meteorological Agency (JMA). It also details the outcomes of observing system experiments (OSEs) assimilating these AMVs in operational global four-dimensional variational data assimilation (4D-VAR) on the NWP system (GSM-DA) .

2. Characteristics of MISR AMV data

Table 1 shows statistics such as the number of AMV data and the mean deviation/standard deviation of AMV wind speed departure from first-guess values (O-B) for the period from March to May 2012. The AMV numbers in the table indicate that most data are distributed in the low vertical layers (LL, below 700 hPa) and have positive biases against first-guess values of JMAGSM in all layers. The AMVs in LL have larger O-B standard deviation (STD) values than those of geostationary satellite AMVs (GEO-AMVs)[1]. Figure 1 shows a normalized histogram of O-B for the same period. The histogram of O-B for AMVs in the Northern Hemisphere (NH) exhibits approximate Gaussian distribution, which is favorable for data assimilation. The O-B histograms for other regions indicate the same characteristics as those of the Northern Hemisphere (not shown). The spatial correlation distance of O-B is longer than that of GEO-AMVs (e.g., MTSAT visible AMVs) in LL (Fig. 2). The O-B data for layers above 700 hPa has the same characteristics as those observed in Fig. 2 (not shown).

3. OSEs of MISR AMV data

OSEs were performed to evaluate the impacts of MISR AMVs using GSM-DA. Global 4D-VAR data assimilation cycles were run every six hours, and 264-hour forecasts were executed from 12 UTC using JMAGSM, which is a hydrostatic spectral model with a horizontal resolution of about 20 km (as opposed to the 55 km resolution of the inner model for GSM-DA) and 60 vertical layers with the top at 0.1 hPa. The OSE target period was July 2012.

Large differences were observed in the OSEs between the test without MISR AMV (CNTL) and that with MISR AMV (TEST). The AMV heights were converted from geometric heights to pressure levels with the assumption of International Civil Aviation Organization (ICAO) standard atmospheric conditions. MISR AMVs were thinned in 1.5° × 1.5° × 100 hPa horizontal-vertical boxes, and the minimum horizontal distance was set as 150 km. The thinning settings here were the same as those for polar AMVs. The quality control (QC) system adopted was the same as that indicated for GEO-AMVs on the NWP SAF AMV monitoring page[2] as a first step.

4. OSE results

[1] The STD of GEO-AMVs in LL is generally within 2 m/s.
[2] http://research.metoffice.gov.uk/research/interproj/nwpsaf/satwind_report/amvusage/jmamodel.html

Figure 3 shows differences in the mean analyzed field for 700 hPa geopotential heights between TEST and CNTL. Large differences are observed all over the globe, especially at around 700 hPa. The number of assimilated MISR AMV data per analysis is approximately 1% against the whole body of input data. Figure 4 shows the normalized RMSE difference from one-day to eleven-day forecasts for July 2012. Although negative impacts are seen on two-day forecasts (especially in the tropics (EQ) and the Southern Hemisphere (SH)), positive impacts are seen on three-day forecasts in the Northern Hemisphere (NH).

The improvement of AMV coverage is contributing to the positive impact for the forecast skills in NH. The degraded forecasts seen for EQ and SH may stem from large observation error correlations or a positive bias of observation data against first-guess values as described in Section 2. Further research is required regarding the usage of MISR AMVs and other AMVs.

Acknowledgements

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References

Muller, K., M. Garay, C. Moroney and V. Jovanovic, 2012: MISR 17.6 km gridded cloud motion vectors: overview and assessment, *Proceedings of 11th IWW*, Auckland, Feb. 20 – 24.

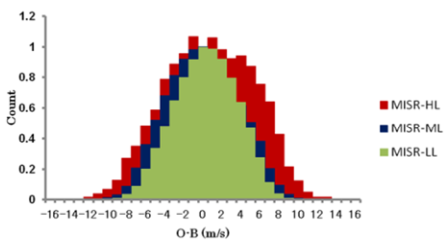

Figure 1. O-B histogram of MISR AMVs for the Northern Hemisphere (poleward of 20°N) during the period from March to May 2012. The red, blue and green bars correspond to the layers above 400 hPa (HL), from 400 to 700 hPa (ML) and below 700 hPa (LL), respectively.

	Count	ME (m/s)	STD (m/s)
NH-HL	9460	0.63	4.62
NH-ML	88987	-0.06	3.69
NH-LL	883638	0.29	3.26
EQ-HL	80495	0.32	4.72
EQ-ML	179916	0.52	3.43
EQ-LL	718210	0.77	3.10
SH-HL	9287	1.02	5.19
SH-ML	99164	0.35	3.96
SH-LL	526174	0.05	3.39

Table 1. Numbers of data (Count), mean errors (ME) and standard deviations (STD) for MISR AMVs. NH, EQ and SH represent the Northern Hemisphere (poleward of 20°N), the tropics (20°S – 20°N) and the Southern Hemisphere (poleward of 20°S), respectively. The other legend details are the same as those in Fig. 1.

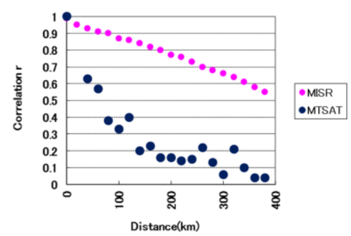

Figure 2. Spatial O-B error correlation coefficients for distance in MISR AMVs (pink plots) and MTSAT visible AMVs (blue plots) in the layer below 700 hPa for May 2012.

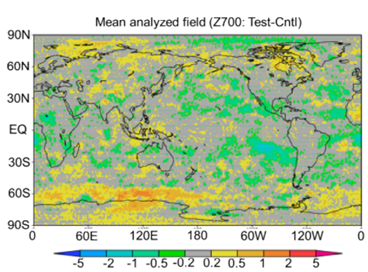

Figure 3. Mean analyzed field differences between TEST and CNTL at 700 hPa geopotential height for July 2012.

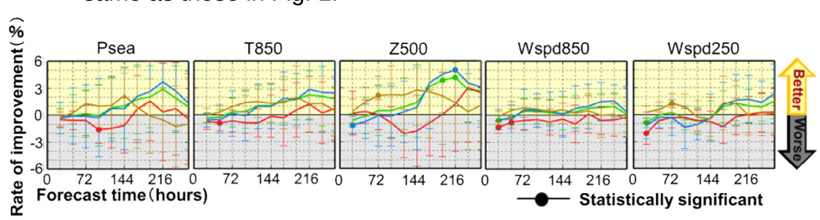

Figure 4. Forecast improvement rates with regard to RMSEs for 1 – 11-day forecasts for July 2012. The graph labeled Psea corresponds to surface pressure, T850 corresponds to 850 hPa temperatures, Z500 corresponds to 500 hPa geopotential heights, Wspd850 corresponds to 850 hPa wind speeds and Wspd250 corresponds to 250 hPa wind speeds. Positive values represent better scores. The green, brown, red and blue lines show forecast improvement rates for the global, Northern Hemisphere (poleward of 20°N), tropic (20°S – 20°N) and Southern Hemisphere (poleward of 20°S) regions, respectively. The error bars represent a 95% confidence interval.