ASSESSMENT AND APPLICATIONS OF MISR WINDS

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ABSTRACT

Due to its high spatial resolution and unique multiangle capability, the Multi-angle Imaging SpectroRadiometer (MISR) offers the promise to retrieve the cloud motion and height simultaneously at a high accuracy from pole to pole. In this study, an experimental dataset consisting of MISR winds retrieved over a period of six weeks is examined in detail against the model forecasts from the GMAO data assimilation and forecast systems. It is seen that the normalized RMSVD of MISR winds data is slightly larger compared to other satellite winds, though this comparison is not strictly fair since these other satellite winds have been assimilated in the GMAO system. The results also show that the MISR winds over ocean are superior to those over land.

Meanwhile, the assimilation experiments are also conducted to assess the impact of the MISR winds. Although the impact of MISR winds on the model forecast skills is small, an independent validation indicates that the assimilation of MISR winds improves the fit of analysis to the MODIS wind observations in the southern hemisphere.

1 Introduction

The geostationary satellite winds have been used successfully in the data assimilation and forecast systems in the numerical weather prediction (NWP) community. However, there are obvious limitations in the applications of the geostationary winds to global NWP, in part due to their data coverage that does not extend poleward of 60 degrees latitude, in part due to the uncertainty of the height assignment of the cloud-tracked winds as well as their dependence on a particular forecast as prior information. With the launch of the polar-orbiting Terra satellite in December 1999, the Multi-angle Imaging SpectroRadiometer (MISR) on the Terra satellite is expected to provide a unique potential to produce cloud-tracked winds with high accuracy from pole to pole. Its high spatial resolution and multiangle capability make it feasible to simultaneously retrieve cloud height and motion using a purely geometric stereoscopic technique (Horváth and Davies 2001). A six-week test dataset consisting of MISR cloud-tracked winds was generated by Roger Davies and Catherine Moroney at the Jet Propulsion Laboratory (JPL). The initial evaluation of this dataset is presented here in the context of a global data assimilation system.

2 Assessment of MISR winds

The six-week test dataset consists of MISR winds for the period from Sept. 1 to Oct. 15, 2003. Only those MISR winds that pass both the wind retrieval QA flag and the stereo match flag are used in the subsequent studies. Due to its narrow swath, it takes 9 days for MISR to cover the whole globe. Figure 1 gives the vertical distribution of MISR winds for this period. It is seen that the MISR winds are mainly distributed in the lower levels of the atmosphere at about 700 to 900 hPa.

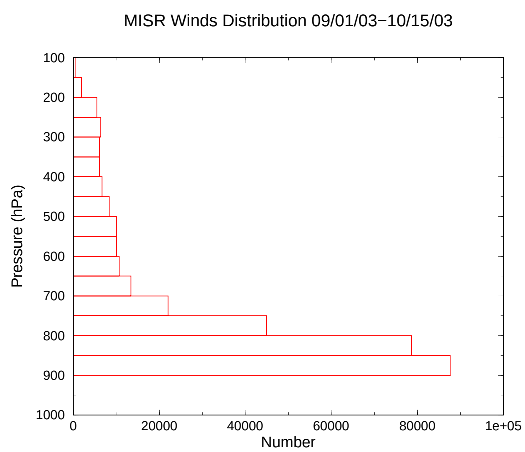

Figure 1: The vertical distribution of MISR winds for the period of Sept. 1 to Oct. 15, 2003.

The MISR winds are examined closely against the model forecasts from the data assimilation and forecast systems of the Global Modeling and Assimilation Office (GMAO). In general, they match well with the streamlines of the model forecasts. However, it is found that a few MISR winds over land or ice are below the model ground level, which may indicate an error in the geometric registration or the non-cloud feature tracking. An example of such winds is given in Fig. 2 for Sept. 3, 2003, where the red dots represent the "below ground" MISR winds.

Further study on the differences between the MISR wind observations and the GMAO 6-hour model forecasts/first guess (OmF) are conducted. The global average wind speed bias and RMS vector difference against GMAO model forecasts are displayed in Table 1. The MISR winds are excluded in this calculation

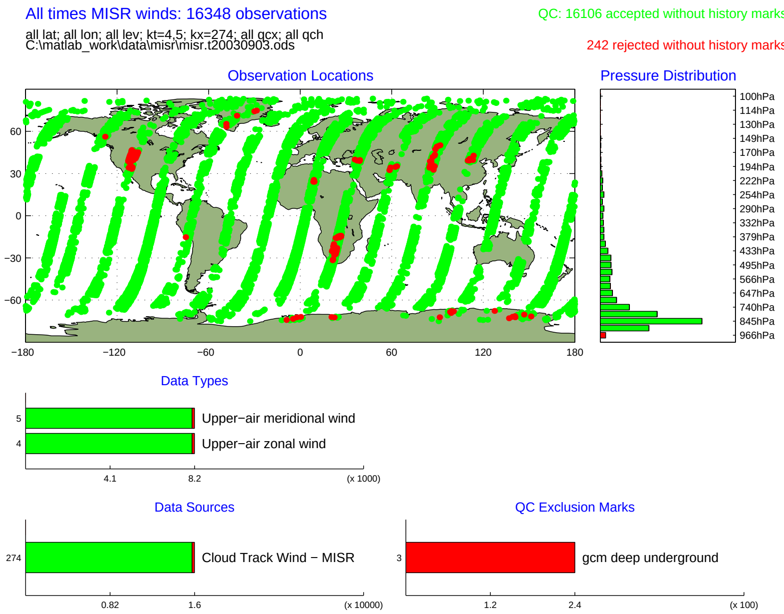

Figure 2: The MISR winds on Sept. 3, 2003. Red dot represents the wind that is below ground.

if they fail to pass the quality control (Dee et al. 2001) of the GMAO data assimilation system. Compared to other satellite winds used in GMAO system (table not shown), it is seen that the normalized RMSVD of MISR winds is a little larger, though this comparison is not strictly fair since the other satellite winds have been assimilated in the GMAO system. It is also shown that most of the MISR winds are located in the lower levels of the atmosphere with smaller wind speed bias. The time-average-gridded OmF bias

Table 1: Statistics of MISR winds against model forecasts over the period of Sept. 1 to Oct. 15, 2003

levels	> 700hPa	400-700hPa	< 400hPa
speed bias (ms^{-1})	0.45	0.92	1.26
NRMSVD	0.70	0.72	0.47
mean speed (ms^{-1})	8.80	12.07	22.32
No. of obs	214365	50825	21507

(upper panel), standard deviation (middle panel), and wind observation numbers (lower panel) in each grid cell for the u- and v- component of the wind are given in Figures 3 and 4 (at least 15 wind observations are required in the calculation of the statistics). The results show that, during the test period, more MISR winds are retrieved over ocean than over land, and MISR winds over ocean generally have smaller OmF bias and standard deviation than those over land. These results lead to the exclusion of many MISR winds over land in the subsequent data assimilation experiment.

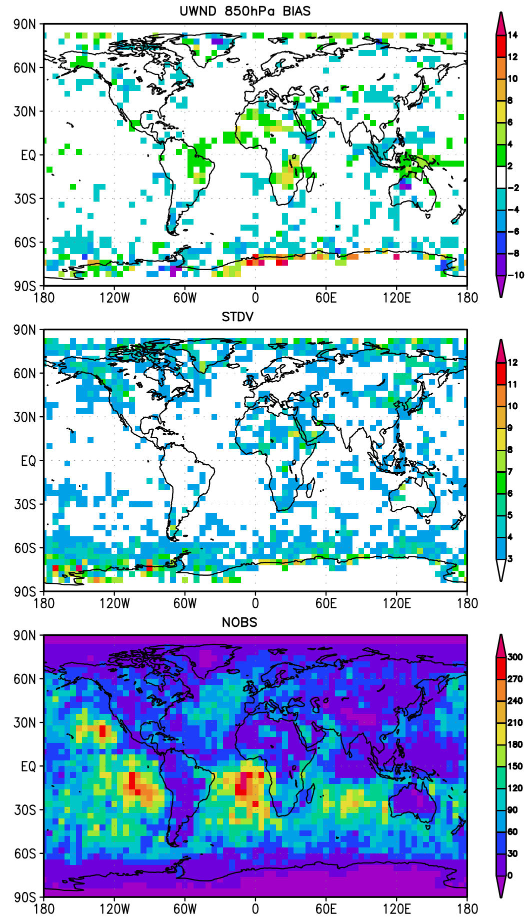

Figure 3: The time-average-gridded MISR wind OmF bias (upper), standard deviation (middle), and wind observation numbers (lower) in each grid cell for the u- component of the wind.

3 Experimental setup and results

The GMAO operational finite-volume data assimilation system (fvDAS), version 4.03, was used to study the impact of MISR winds over the period from Sept. 1 to Oct. 15, 2003. Two sets of data assimilation and forecast experiments were conducted. The control experiment has the configuration of the operational run, i.e., the horizontal resolution of finite-volume general circulation model (fvGCM; Lin and Rood 1998) is 1^o latitude by 1.25^o longitude with 55 vertical levels, the analysis increment is computed by the Physical-space Statistical Analysis System (PSAS; Cohn et al. 1998) at the resolution of 2×2.5^o and 25 levels, and all observations are quality controlled by a Statistical On-line Quality Control System (SOQCS). The observations used in the control experiment include radiosondes, aircraft measurements, conventional surface data, HIRS/AMSU temperature and humidity profiles, geostationary winds, Q-SCAT surface winds and SSM/I total precipitable water. The MISR experiment is the same as the control experiment except that it also includes the MISR winds dataset. For the MISR winds over land and ice, they are excluded from the data assimilation if they are below 400 hPa due to the above assessment results. Like other satellite winds used in GMAO system, MISR winds are thinned to 204×128 grids.

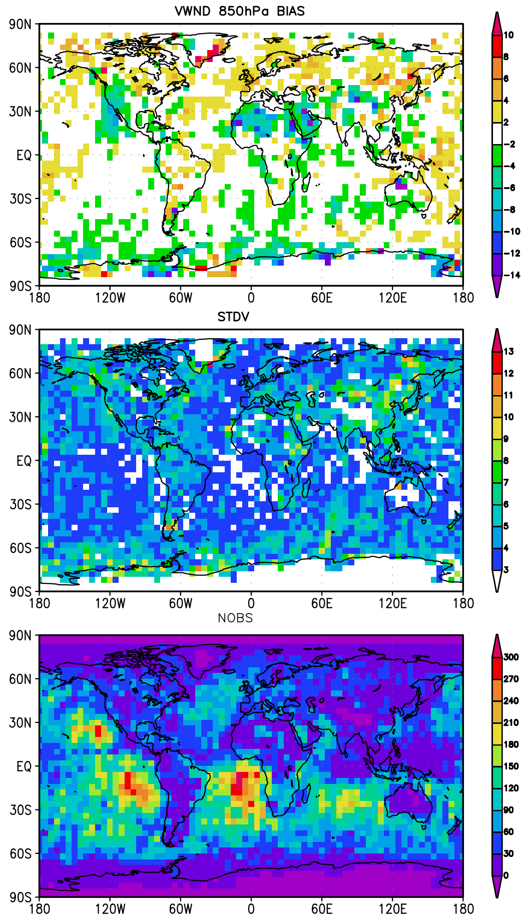

Figure 4: The same as Fig. 3 except that it is for the v- component of the wind.

Although the MISR winds coverage is quite limited due to its narrow swath and our data selection procedure, we still expect that MISR winds would provide some valuable wind information, especially in the southern hemisphere. The medium-range five-day forecast skill is calculated as a metric of the impact of the MISR winds. Figure 5 shows the anomaly correlations of the 700 and 500 hPa geopotential height fields, verified against their respective analyses, for the northern (left panels) and southern (right panels) hemisphere. However, the results indicate that they have negligible impact in the northern hemisphere, and slightly negative impact at the end of the forecast period in the southern hemisphere. It appears that the MISR winds data are overwhelmed by the satellite mass observations in the southern hemisphere.

An independent validation using MODIS winds is conducted against the wind fields produced from the control and MISR forecast experiments. The MODIS winds are not used in the two experiments in this study, and it has been proved in a series of separate studies that they have a positive impact on GMAO systems (Key et al. 2002). The global RMS of time-average-gridded MODIS Infrared wind OmF bias is presented in Figure 6 for the southern hemisphere, with the left for the zonal and the right for the meridional wind. It is seen that the OmF bias for the MISR experiment (dashed line) is smaller than that for the control experiment (solid line). The standard deviation of MODIS Infrared wind OmF has the similar pattern (Fig. 7). In a word, the assimilation of MISR winds and subsequent propagation of the wind information improve

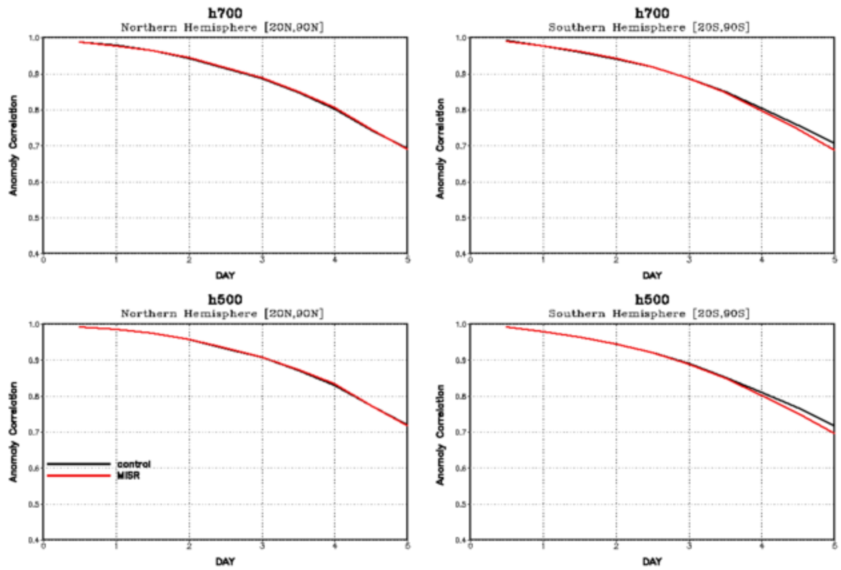

Figure 5: Anomaly correlations for 700 and 500 hPa geopotential heights in the northern (left panels) and southern (right panels) hemisphere for the control (black line) and MISR (red line) experiments verified against their respective analyses.

the fit of the model short-term forecasts to the MODIS Infrared wind in the southern hemisphere.

4 Summary and conclusions

The evaluation of the six-week MISR winds dataset from Sept. 1 to Oct. 15, 2003 was performed against GMAO model forecasts. The results show that as more MISR winds are retrieved over ocean, the quality of the MISR winds over ocean is also better than that of MISR winds over land. Meanwhile, the impact of MISR winds on the GMAO systems is investigated. Our experimental results indicate that the impact of MISR winds data is small in terms of the medium-range forecast skill, probably because the instrument covers such a narrow swath of the Earth. However, an independent validation using MODIS winds show that the MISR winds indeed contain valuable wind information. The use of the MISR winds improves the fit of the model short-term forecasts to the MODIS winds.

More studies remain to be done for MISR winds. Subsequent to this study it was discovered that the MISR winds were significantly affected by intermittent coregistration errors, especially in the Da camera. Operational corrections to the coregistration are now being implemented and the impact of the improved winds will be assessed in a future study.

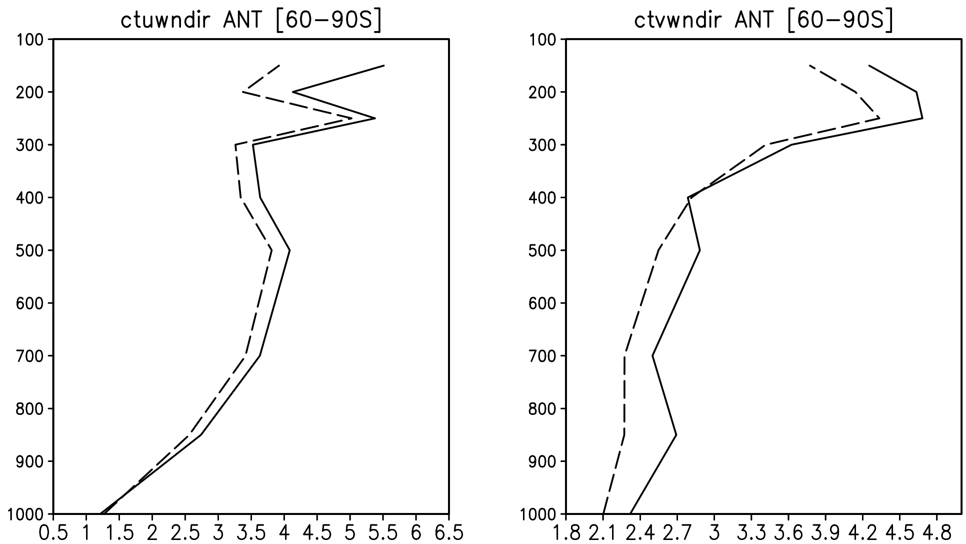

Figure 6: Global RMS of time-average-gridded MODIS Infrared wind OmF bias for the southern hemisphere. Left is for the zonal and right is for the meridional wind.

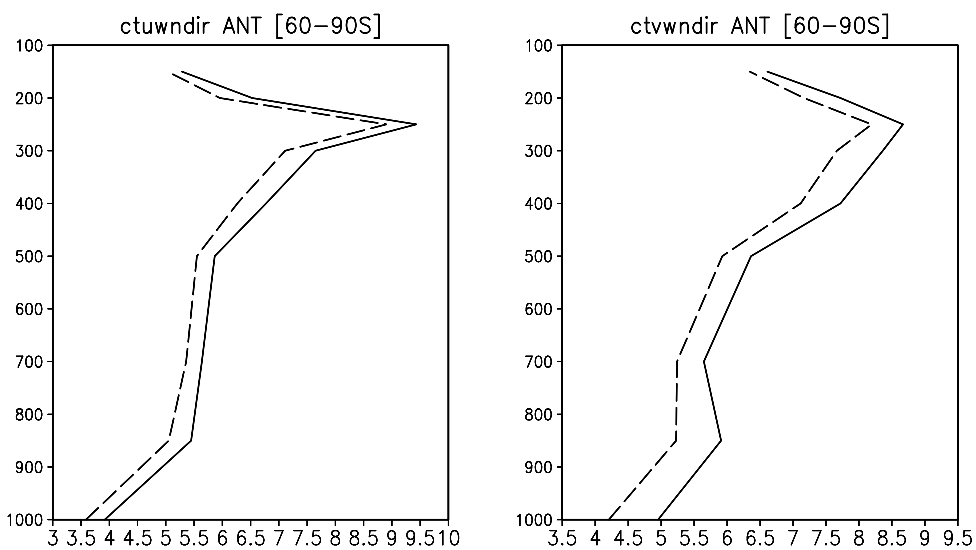

Figure 7: Standard deviation of MODIS Infrared wind OmF for the southern hemisphere. Left is for the zonal and right is for the meridional wind.

Acknowledgments

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