A COMPARISON OF MISR CLOUD MOTION VECTORS AND NOAA RADAR WIND PROFILER DATA

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Introduction

Cloud motion vectors from MISR are evaluated by comparing them to winds measured by radar wind profilers in the NOAA profiler network. We explore overall agreement between the two types of data as well as changes in MISR performance as a function of algorithm version, cloud top height, and assigned data quality value. We also investigate the prevalence of ground returns in MISR wind retrievals and the rate of data loss due to quality check procedures.

MISR Data

> Level 2 Top of Atmosphere/Cloud Stereo Product
> standard cloud motion vector data for cloud winds
> PrelimERStereoHeights for heights
> chose median heights over a 12 x 12 km^2 region centered on each profiler location
> tests run for Best Winds and Without Winds values
> data from algorithm versions 11-17 included

Table 1. Wind quality flag values (from Bull et al., 2007). "Best Wind" heights require winds with QC = 3 or 4.

Value	Meaning
0	No retrieval
1	Poor
2	Unknown
3	Good
4	Very good

NOAA Profiler Data

> obtained for March 2000 - September 2006
> 23 locations in the continental United States
> vertical profiles of u-, v-, and w-components
> profiles cover 500-16,250 m with 250 m sampling
> hourly averages
> expected precision ~1 m/s
> expected accuracy ~5 m/s based on raob comparisons

Map of NOAA Profiler Network (NPN) sites in the continental US. Data for this study came from those sites marked with filled circles.

Initial Comparisons, Ground Returns

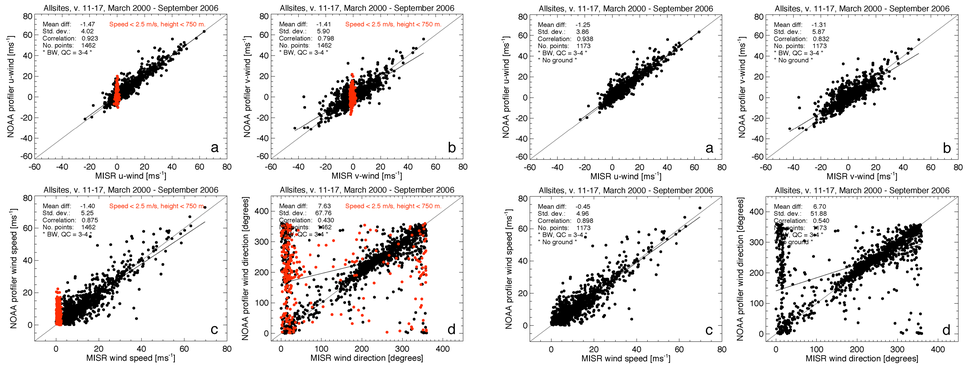
First Best Wind comparisons yield a large number of points with poor directional agreement, particularly with MISR wind direction around 0°. These are most likely due to MISR retrievals from ground returns, for which features match well but wind speeds are near zero. We filter out MISR data with wind speeds less than 2.5 m/s and heights less than 750 m.

After filtering of ground returns, statistics improve. Note that u-components agree better than v-components in either case.

Table 2. Comparison of MISR winds with QC values of 3 or 4 with profiler winds at cloud top. Height of MISR winds determined from "Best Wind" heights. "No ground" values are for points remaining after ground return filtering.

			U-wind component			V-wind component		
Data	Versions	N	Bias	Std. Dev.	CC	Bias	Std. Dev.	CC
No ground	11-17	1173	-1.25	3.86	0.94	-1.31	5.87	0.83
All data	11-17	1462	-1.47	4.02	0.92	-1.41	5.90	0.80

			Wind speed			Wind direction		
Data	Versions	N	Bias	Std. Dev.	CC	Bias	Std. Dev.	CC
No ground	11-17	1173	-0.45	4.96	0.90	6.70	51.9	0.54
All data	11-17	1462	-1.40	5.25	0.88	7.63	67.8	0.43



Comparisons of MISR and NPN winds at MISR cloud top with (left, red dots) and without (right) probable ground returns.

Agreement as a Function of Cloud Height

Stereo matching tends to be more difficult for high cloud types because they are smooth and featureless. Indeed, our comparisons degrade as a function of height (using high quality retrievals only). However, since the mean wind speed also increases with height, the relative discrepancy between MISR and profiler values actually improves with altitude.

Table 5. Difference between MISR and profiler winds as a function of MISR cloud top height. MISR winds with QC = 3 or 4 at Best Winds stereo heights, all processing versions. Relative bias and standard deviation values computed with respect to the mean absolute values of the wind profiler velocity components.

			U-wind component			V-wind component		
Height (m)	N	Abs. Mean	Bias (Rel.)	Std. Dev. (Rel.)	CC	Abs. Mean	Bias (Rel.)	Std. Dev. (Rel.)	CC
1,000-3,000	470	5.60	-1.08 (-0.193)	3.29 (0.588)	0.84	5.81	-0.79 (-0.136)	4.80 (0.826)	0.82
3,000-7,000	235	13.16	-1.06 (-0.081)	3.53 (0.268)	0.94	7.65	-1.03 (-0.135)	5.12 (0.669)	0.87
7,000-20,000	168	24.41	-2.30 (-0.094)	5.36 (0.220)	0.94	15.10	-4.47 (-0.296)	8.31 (0.550)	0.88

Comparisons for Different Versions of the Stereo Wind Algorithm

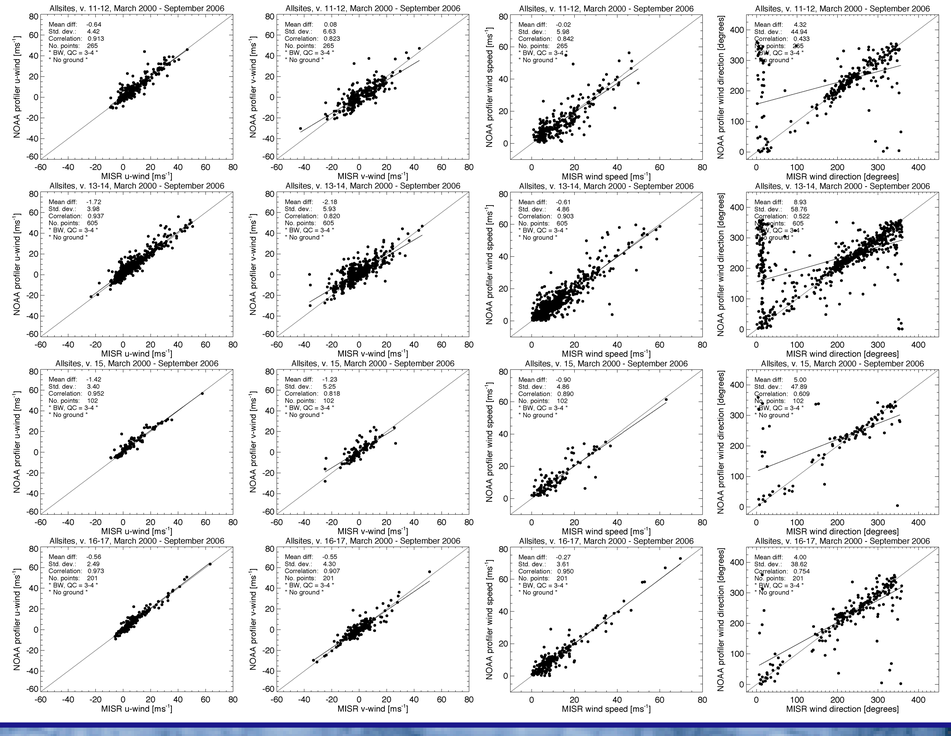
Several variations of the wind retrieval algorithms are represented by these data. Changes included in the algorithm updates are summarized below. Profiler-MISR comparisons plotted to the right and summarized below show that these changes have steadily improved agreement for all wind components. With version 17 of the stereo wind algorithm, individual component biases have dropped well below 1.0 m/s while standard deviations are now just 2.49 m/s (u component) and 4.30 m/s (v).

Cloud Motion Vector Retrieval Algorithm Versions
11-12: Original algorithm applied to forward camera triplet only
13-14: Retrieval with aft-looking cameras added
15: Improvements in geo-location and co-registration, "sub-pixel" version of retrieval, additional quality checks added
16-17: Further tightening of quality control procedures

Table 3. Difference between MISR and profiler winds as a function of processing algorithm. MISR winds with QC = 3 or 4 at Best Winds stereo heights.

		U-wind component			V-wind component		
Versions	N	Bias	Std. Dev.	CC	Bias	Std. Dev.	CC
11-12	265	-0.64	4.42	0.91	-0.08	6.63	0.82
13-14	605	-1.72	3.98	0.94	-2.18	5.93	0.82
15	102	-1.42	3.40	0.95	-1.23	5.25	0.82
16-17	201	-0.56	2.49	0.97	-0.55	4.30	0.91

Note: All existing MISR data is currently being reprocessed using stereo retrieval algorithm version 17.



Data Lost to QC Standards

Tightening of the quality control standards, while improving final data quality, also decreases the number of points meeting the Best Winds criteria (quality code 3 or 4.) Nearly twice the fraction of points are removedby the latest QC standards. Retrievals at high altitudes are hit especially hard.

Table 4. Proportion of available points passing BW QC tests.

Height range (m)	Number of points RW (QC 1-4)	Number of points BW (QC 3-4)	Proportion meeting BW criteria
All useable data (MISR versions 11-17)			
1,000-3,000	724	470	0.65
3,000-7,000	456	235	0.51
7,000-20,000	397	168	0.42
Previous cloud wind retrieval and QC algorithms (stereo product versions 11-14)			
1,000-3,000	407	329	0.81
3,000-7,000	270	177	0.66
7,000-20,000	251	129	0.51
Latest cloud wind retrieval and QC algorithms (stereo product versions 16 and 17)			
1,000-3,000	194	93	0.48
3,000-7,000	117	44	0.38
7,000-20,000	78	22	0.28

Agreement as a Function of MISR Wind QC Value

Data with higher quality codes does agree better with the wind profiler values. Users may wish to select data with higher or lower QC values depending on their application.

Table 6. Difference between MISR and profiler winds as a function of MISR wind QC limit. MISR winds at Raw Wind stereo heights, all processing versions.

		U-wind component			V-wind component		
QC range	N	Bias	Std. Dev.	CC	Bias	Std. Dev.	CC
1-4	1994	-1.87	5.74	0.89	-3.13	11.10	0.62
2-4	1617	-1.54	5.03	0.91	-2.32	9.01	0.68
3-4	1104	-1.22	4.14	0.92	-1.18	6.00	0.82
4-4	848	-1.09	3.71	0.94	-0.79	5.47	0.84

Comparisons to Previous Studies

Marchand et al., 2007, made similar comparisons to profiler data, but had a limited number of samples. We find better agreement with our larger data set and when data processed with more recent algorithms is considered.

Davies et al. 2007, compared a large number of MISR wind retrievals from algorithm version 15 to winds from the GMAO's GEOS-4 analysis. Not surprisingly, our comparisons using older data show poorer agreement. However, comparisons using data from versions 15 and above give better statistics.

Table 7. Comparisons pf MISR cloud winds and profiler winds at cloud top: Results from this study vs. Marchand et al., 2007.

			U-wind component			V-wind component		
Study	Versions	N	Bias	Std. Dev.	CC	Bias	Std. Dev.	CC
MISR winds with QC = 3 or 4 at best winds stereo heights								
Previous*	11-13	43	-0.27	7.64	0.84	-1.69	9.37	0.68
Current	11-14	870	-1.39	4.15	0.93	-1.49	6.23	0.82
Current	15-17	303	-0.85	2.85	0.97	-0.78	4.64	0.88
MISR winds with QC = 1-4 at without winds stereo heights								
Previous*	11-13	66	-1.78	6.64	0.89	-0.65	13.01	0.51
Current	11-14	853	-1.88	5.19	0.90	-2.43	8.78	0.43
Current	15-17	622	-1.45	4.23	0.93	-1.87	7.48	0.51

* From Table 1 in Marchand et al., 2007.

Table 8. Root mean square vector wind differences from this study and from Davies et al. 2007.

	Davies et al., 2007		This study, all data		This study, v. 15-17	
Height range (m)	N	RMS (ms^{-1})	N	RMS (ms^{-1})	N	RMS (ms^{-1})
1,000-3,000	70,091	5.1	470	5.97	141	4.83
3,000-7,000	12,442	7.4	235	6.38	58	4.81
7,000-20,000	2,631	10.5	168	11.06	39	8.47

Conclusions

> For the Best Wind values from all data versions, MISR wind components have biases of about 1.3 m/s and standard deviations of 4-6 m/s compared with winds retrieved by NOAA wind profilers. (These values are similar to the accuracy of wind profiler values.)
> Greater deviations are observed for the v (along-track) components and for higher altitude clouds.
> Standard deviations and cross correlation have steadily improved with stereo retrieval algorithm updates.
> Tightening quality control standards has decreased the number of retrievals meeting Best Wind criteria.
> Users are cautioned that valid retrievals from ground returns are included in the MISR stereo product.

Acknowledgements

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