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STATUS OF OPERATIONAL AMVS FROM FY-2 SATELLITES

This paper describes operational status of NSMC AMVs.

1. Operation Status

Since the 9th wind workshop, FY2-C/E (105ºE) and FY-2D (86.5ºE) are both in operation. Infrared (IR) and water vapor (WV) channel AMV derivations are performed for both FY2-C/E and D. For FY2-C/E, AMVs are provided at 00 06 12 18 GMT, while for FY-2D at 03 09 15 21 GMT. AMVs passed quality control are transmitted through GTS in BURF code. Table 1 shows FY2C data availability for the years of 2008 and 2009.

Table 1 AMV data transmitted through GTS in BURF code in 2008 ~2009 for FY2C

Year/ Month	IR AMVs			WV AMVs		
	Disks Derived	AMVs	AMVs Transmitted with QI >0.8	Disks Derived	AMVs	AMVs Transmitted with QI >0.8
2008.01	115		386188	114		510290
2008.02	98		334682	52		249138
2008.03	93		362323	93		514033
2008.04	84	628939	349448	85	609472	471446
2008.05	122	925221	500256	119	895834	692019
2008.06	116	932332	523854	114	885379	689566
2008.07	117	918436	521652	116	890092	707121
2008.08	114	884267	502306	115	861521	680253
2008.09	90	730589	388361	90	710718	558560
2008.10	107	873738	463925	107	834245	646647
2008.11	120	972056	490068	120	909926	680821
2008.12	123	983815	481914	123	909523	676951
2009.01	120	949134	478040	120	868511	655024
2009.02	105	831312	408903	105	745694	562794
2009.03	89	702321	339745	89	683098	518248
2009.04	106	849653	460622	106	820403	637075
2009.05	123	967290	505357	123	951127	726408
2009.06	113	887772	459198	114	878882	688857
2009.07	123	1000366	552009	123	949059	764988
2009.08	115	935581	471344	115	853067	661459
2009.09	89	720239	347850	89	684384	536708
2009.10	112	887558	406161	112	833281	612028

Tables 2-4 show comparisons of FY-2C/E AMVs with Radio sonde winds. From Jan.to April 2009， AMVs are from FY2C before algorithm is improved. From May to Sept.，2009 AMVs are from FY2C after algorithm is improved. From Nov to Sept. 2009， AMVs are from FY2E after algorithm is improved. From tables 2-4， it is seen that after algorithm is improved， differences between FY2 AMVs and Radio sonde winds are reduced. Section 2 analysed the elements which may influence FY2 AMV quality; section 3 shows changes of the algorithm.

Table 2 Comparison of FY-2C/E AMVs with Radio sonde data at high level (above 399hPa)

	IR High Level Wind				WV High Level Wind			
	Pairs	Mean Speed	RMS	Absolute Difference	Pairs	Mean Speed	RMS	Absolute Difference
200901	1610	14.7	13.83	10.26	2547	16.95	12.85	8.75
200902	1661	17.05	14.11	10.19	2760	19.67	12.65	8.63
200903	1916	16.27	12.32	8.37	2916	18.5	11.84	7.71
200904	2084	15.93	11.98	8.18	3355	17.55	9.30	5.92
200905	764	15.12	7.10	4.58	1139	15.38	6.93	4.33
200906	2122	16.19	7.69	4.94	3031	16.62	7.08	4.46
200907	2450	15.30	6.99	4.68	3329	16.12	6.80	4.37
200908	2186	13.40	6.57	4.20	3307	14.53	6.81	4.16
200909	1891	15.90	6.67	4.19	3118	16.39	4.20	3.99
200910	1774	14.76	6.82	4.26	2952	16.06	6.30	3.84
200911	1536	15.29	7.30	4.54	2462	17.46	7.28	4.32
200912	1348	16.04	11.43	7.56	3290	20.98	10.07	6.21

Table 3 Comparison of FY-2C/E AMVs with Radio sonde data at middle level (400-699hPa)

	IR Middle Level Wind				WV Middle Level Wind			
	Pairs	Mean Speed	RMS	Absolute Difference	Pairs	Mean Speed	RMS	Absolute Difference
200901	2598	4.8	16.22	13.85	2013	11.52	15.64	12.20
200902	1842	6.59	15.96	12.99	1294	12.31	15.69	12.11
200903	1313	7.13	15.24	12.27	1204	12.0	14.90	11.26
200904	1500	6.79	10.07	7.69	1386	10.61	9.56	6.48
200905	477	11.06	7.25	5.04	420	12.53	8.14	5.38
200906	1033	11.21	7.13	4.87	725	14.49	9.03	6.24
200907	687	11.67	8.03	5.41	496	15.35	9.88	6.48
200908	818	13.38	8.27	5.51	652	15.55	10.21	7.15
200909	1164	12.69	7.22	4.90	1043	15.62	8.98	6.05
200910	1801	12.22	7.62	5.31	2038	14.11	9.21	6.53
200911	1235	14.25	10.10	7.22	1107	15.35	10.29	7.12
200912	1072	12.76	14.07	10.86	1330	15.22	16.01	12.42

Table 4 Comparison of FY-2C/E AMVs with Radio sonde data at low level (below 700hPa)

	IR low Level Wind			
	Pairs	Mean Speed	RMS	Absolute Difference
200901	2091	2.2	8.43	6.76
200902	1980	2.99	8.64	6.78
200903	1761	3.42	7.93	6.16
200904	1450	2.82	7.48	5.90
200905	21	8.19	7.62	4.28
200906	36	8.0	4.42	3.33
200907	55	9.98	4.56	2.94
200908	71	8.66	4.93	2.92
200909	107	9.34	3.77	2.60
200910	68	8.89	4.41	2.91
200911	44	9.68	5.93	4.14
200912	82	7.7	3.57	2.51

2. Elements which may influence FY2 AMV quality

Elements which may influence FY2 AMV quality are mainly the followings:

2.1 Image navigation quality
Image navigation influences AMV derivation greatly. Except for a period after orbital and attitude control, FY2 image navigation quality is good. Since April 2006, FY2 image navigation quality after orbital and attitude adjustment operations is improved. But orbital and attitude adjustment operations still influence AMV quality. Measurements in improving image navigation quality will be presented in one other paper for this conference.

2.2 Image calibration quality
The GSICS research working group of NSMC (Wu, 2008) compared data between FY-2C/2D and hyper sounders. The radiances observed by hyper sounder channels are accumulated according to the spectral responses of the FY-2C/D infrared and water vapour channels to estimate their radiances as well as the spectral compensation. FY-2C/D GSICS recalibration processing in their whole life time is performed. Figure 1 shows FY-2C L1 calibrated Tbb bias trend with AIRS during its whole liftetime. At the 290k reference scene, FY-2C calibration bias of IR1 and IR2 has the apparent season fluctuation. The maximum Tbb bias is more than 5k. At 250 reference scene, FY-2C calibration bias of water vapor channel has a flat cyclical fluctuation. FY-2C/D calibration bias of water vapor channel has a flat cyclical fluctuation. The bias of FY-2C is small during May to September except for July, 2006. The relatively bigger negative bias appear in other period and the biggest bias in January.

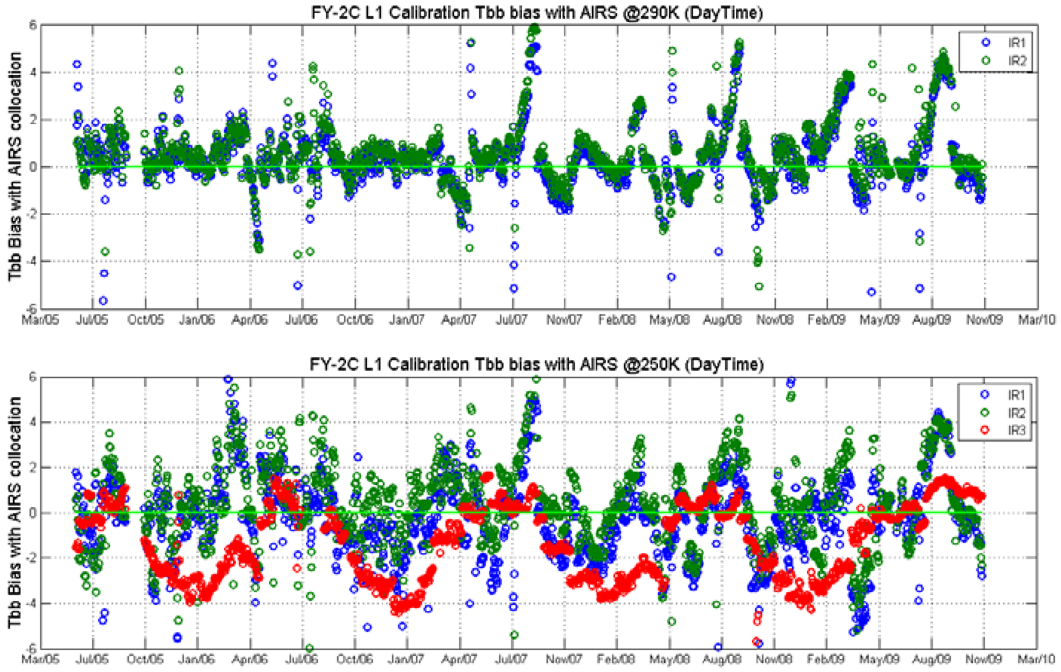

Figure 1. FY-2C L1 calibrated Tbb bias trend with AIRS during its whole liftetime. The top figure is Tbb bias with AIRS at 290k reference scene for IR1 and IR2 (split windows bands). The bottom figure is Tbb bias with AIRS at 250k reference scene for IR1, IR2 and IR3. IR3 is the water vapor channel.

Figure 2 shows the double difference (Tbbairs-Tbbiasi) of Tbb bias of FY-2C with AIRS and IASI since 2007. The double difference is small and stable for long term. The mean of the double difference is less than 1°k. Some anomaly values and small fluctuation of these double difference are still exist.

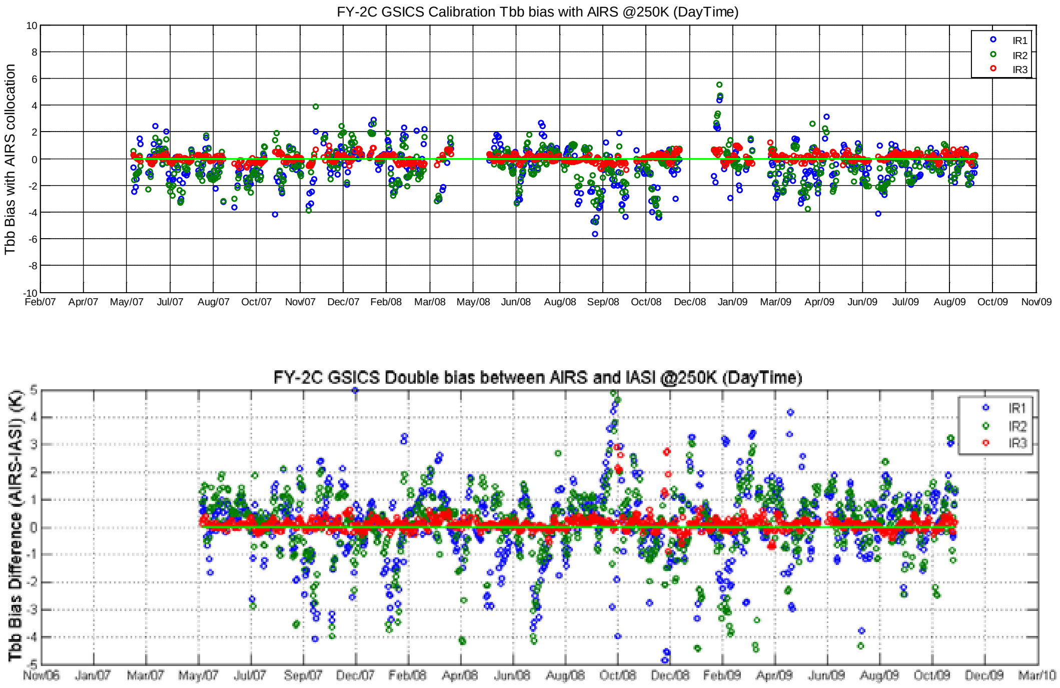

Figure 2 The double difference (Tbbairs-Tbbiasi) of Tbb bias of FY-2C with AIRS and IASI since May, 2007. The top figure is the double difference at 290k reference scene for IR1 and IR2. The bottom figure is the double difference for IR1, IR2 and IR3 at 250k reference scene.

Real time calibration quality has negative influence to the AMV quality. In the future, inter calibration of FY-2 satellites with hyper sounders will be adopted.

2.3 NWP grid data quality

To convert the temperature of the cloud to the height of the cloud, and to make height adjustment to semi-transparent clouds, NWP grid data is need. Now, T639 data is used, rather than previous T213. T639 has simulated satellite data with 3D-Var technique and is much improved than T213.

2.4 Algorithm quality

Original algorithm is reviewed. Elements which may influence AMV quality are modified. It is noticed that the major problems are in the height assignment component. The major efforts on height assignment are in the following 3 aspects: ① the accuracy of the theoretical IR/WV relationship for opaque clouds, ②the accuracy of the observational IR/WV relationship for semi-transparent clouds, ③ the judgement on should this tracer need to make hight adjustment. The above three measures takes action. The following section shows major change of the algorithm.

3. Algorithm modifications

From May 2009 on, algorithm of FY2 wind derivation is modified. The modifications are as follows:

3.1 Calculation scope

Previously, the calculation scope is 50 degrees to the four sides of sub-satellite point. At present, the calculation scope is within 70 degrees from the nadir angle. Figure 3a and b are typical AMV distributions after modification for infrared and water vapour channels.

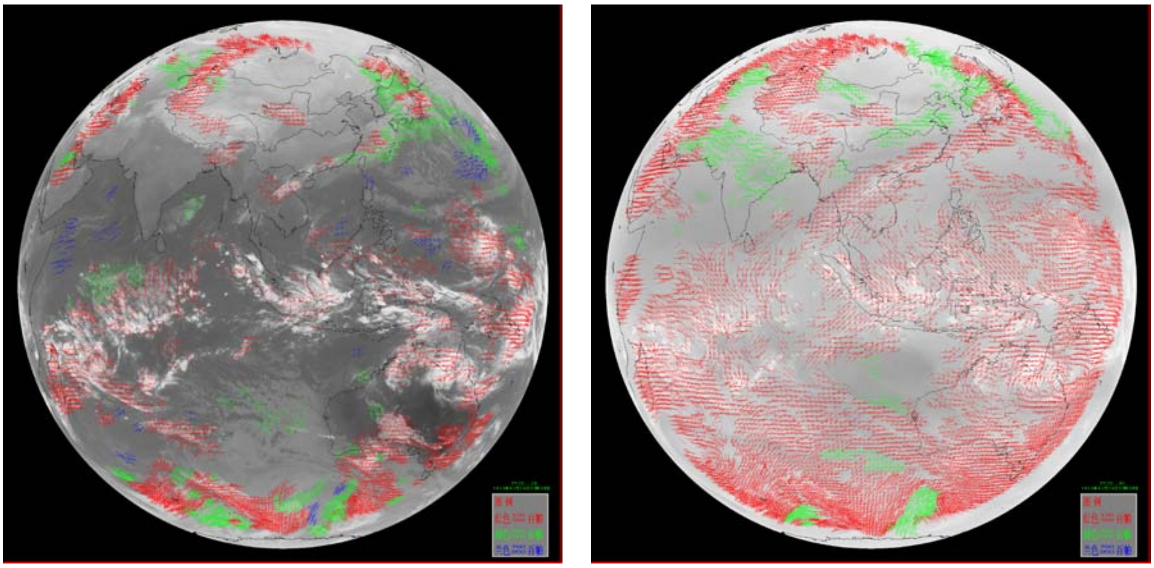

Figure 3 FY2E AMV distributions at 00z 25 Jan. 2010 for a) infrared channel and b) water vapour channel

3.2 The theoretical IR/WV relationship for opaque clouds

For semi transparent cirrus clouds, height assignment needs two infrared/water vapour relationships, one is calculated from NWP data, and the other is from satellite observation.

The infrared/water vapour relationship for opaque clouds are calculated by a radiation model based on NWP parameter fields. The NWP parameter fields are improved. The detail of the change is shown in one other paper presented in this meeting.

3.3 The observational IR/WV relationship for semi-transparent clouds

Theoretically, for the satellite observation, the linear infrared / water vapour relationship is only effective for radiation energy. At present, the statistics is based on observational energy. While previously, the statistics is based on observational brightness temperature which was not correct. Figure 4 shows two scatter diagrams of a typical semi-transparent cirrus cloud. For figure 4a and b, the statistics is based on observational brightness temperature and radiation energy respectively. The brightness temperatures for figure 4a and b are 221.6° and 224.7° respectively. The difference in the magnitude of 3.1° is due to the non linearity of Plank function.

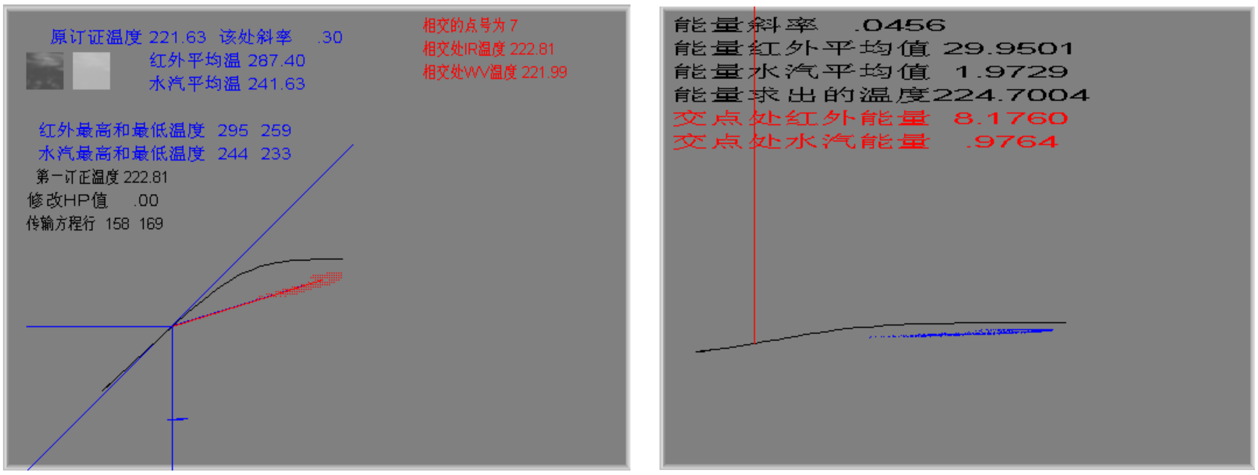

Figure 4 Two scatter diagrams of a typical semi-transparent cirrus cloud
For figure 4a, the left figure, the statistics is based on observational brightness temperature.
For figure 4b, the right figure, the statistics is based on radiation energy.

3.4 A rough evaluation at distinguishing high and low clouds

At NSMC/CMA, any tracer need to a pass a rough evaluation on if it is need to make height adjustment. Height adjustment is only performed to a tracer been judged as the one with high level semitransparent cloud. Figure 5 shows three typical scatter diagrams from the tracers with dense high loud, thin cirrus cloud and low cloud. For tracers with high cloud, infrared and water vapour channel images are close related with each other and water vapour image is rough; for tracers with low cloud, infrared and water vapour channel images are not close related with each other and water vapour image is flat.The infrared/water vapour correlation and water vapour image dynamical range on the scope of the tracer are then calculated. Table 5 shows infrared/water vapour correlation and water vapour image dynamical range on the scope of three tracers in figure 5. From figure 5 and table 5, it is seen that tracers with high IR/WV relations and rough water vapour image are possible cirrus clouds, height adjustment should be performed; while the tracers with low IR/WV relations and flat water vapour image are possible low clouds, height adjustment should not be performed.

At present, low level targets with high IR/WV relationship and rough water vapour image are eliminated; high level targets with high IR/WV relationship and rough water vapour image are accepted. This is a strong measure. Although this measure eliminated some good winds, It ensures the high level winds from thin cirrus are not been put at low levels.

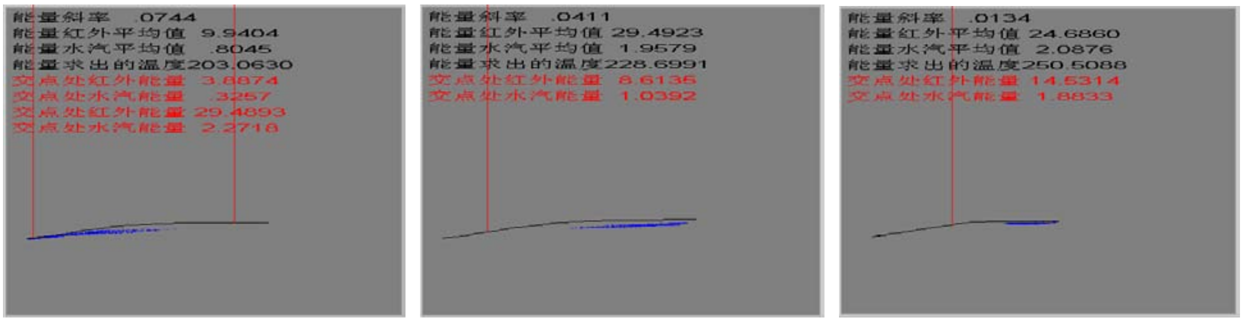

Figure 5 Three typical scatter diagrams from the tracers with dense high loud (left), thin cirrus cloud (middle) and low cloud (right).

Table 5 Infrared/water vapour correlation and water vapour image dynamical range on the scope of the tracer

	Left tracer with dense high cloud	Middle tracer with thin cirrus cloud	Right tracer with low cloud
Infrared/water vapour correlation	94%	92%	35%
water vapour image dynamical range	44°	11°	4°

3.5 Height assignment for water vapour channel at dense high cloud area

Previously, at dense high cloud area, height assignment for water vapour channel is the same as infrared channel. Now, brightness temperature are used directly to give height for water vapour channel at dense high cloud area.

3.6 Quality indexes

EUMETSAT QI definition is adopted with the following differences:

The integer value of QI/200 is the QI with numerical comparisons; while the residue of QI/200 (QI-QI/200) is the QI without numerical comparisons.

For quality indexes with odd values, the tracer heights are normally assigned; for quality indexes with even values, the tracer heights are over adjusted or are considered not as reliable as winds with odd QI. Winds with even QI should be treated more carefully.

For water vapour winds, if in the tracer area (1024 pixels), there are more than 102 pixels with IR-WV bright temperature difference less than 15 degrees, this tracer is considered with high level clouds in it, the wind height is considered more reliable, the QI is given an odd number; if in the tracer area (1024 pixels) there are less than 102 pixels with IR-WV bright temperature difference less than 15 degrees, this tracer is considered without high level clouds in it, the wind height is considered less reliable, the QI is given an even number.

For water vapour channel winds, AMVs with heights higher than 150hPa is adjusted to 150hPa. Those winds are given an even value QI.

For IR channel winds, if wind direction is more than 60 degrees depart from NWP, it is given an extreme low QI value1.

Such QIs do not reflect real quality of the winds. Winds with low QI values are often very good ones.

4. Comparisons with GTS winds

Comparisons with GTS winds are performed. Figure 6 shows AMVs from NSMC and GTS at 1200GMT Oct. 16, 2009. In this case, NSMC AMVs are mainly at high and middle levels. Compare NSMC and GTS AMVs at high and middle level respectively, the flow patterns of the AMVs from the different operation centers are similar.

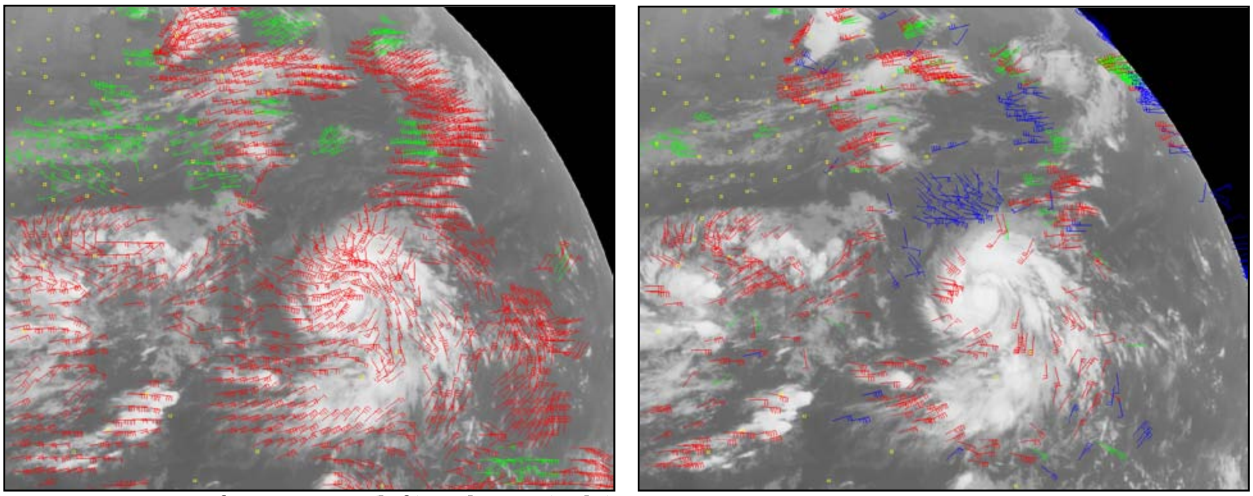

Figure 6 AMVs from NSMC (left) and GTS (right) at 1200GMT Oct. 16, 2009

Red for AMVs above 399 hPa, green for AMVs between 400 and 699 hPa, blue for AMVs below 700 hPa.

Figure 7 shows differences between NSMC and GTS winds for Oct. 2009. 419140 AMVs in 73 observation disks are compared. Comparisons are made for AMVs between the difference operation centers in 1° Lat/Lon. The left figure is for direction differences and the right figure for vector differences, both in RMS. The mean speeds for all comparison pairs are 17.37 (NSMC) and 17.47 (GTS) m/s respectively. Mean vector difference is 4.92m/s. The mean height difference is 73.4 hPa. Considering AMV variability in 1° Lat/Lon, It is considered that NSMC winds do not have major geometry errors. The mean height difference 73.4 hPa is some what higher. This is verified in figure 8. Figure 8 is scatter diagram of wind direction (a, left), speed (b, middle) and height (c, right) between NSMC and GTS AMVs for Oct. 2009. Abscissa and ordinate are for NSMC and GTS respectively. Figure 8 a and b, which represent wind direction and speed, are more symmetry relative the 45° slope line than figure 8c, which represent wind height. Figure 8c shows more NSMC winds are in the right and downward side in the scatter diagram which means NSMC winds are put in higher altitude. Possible reasons are under investigation.

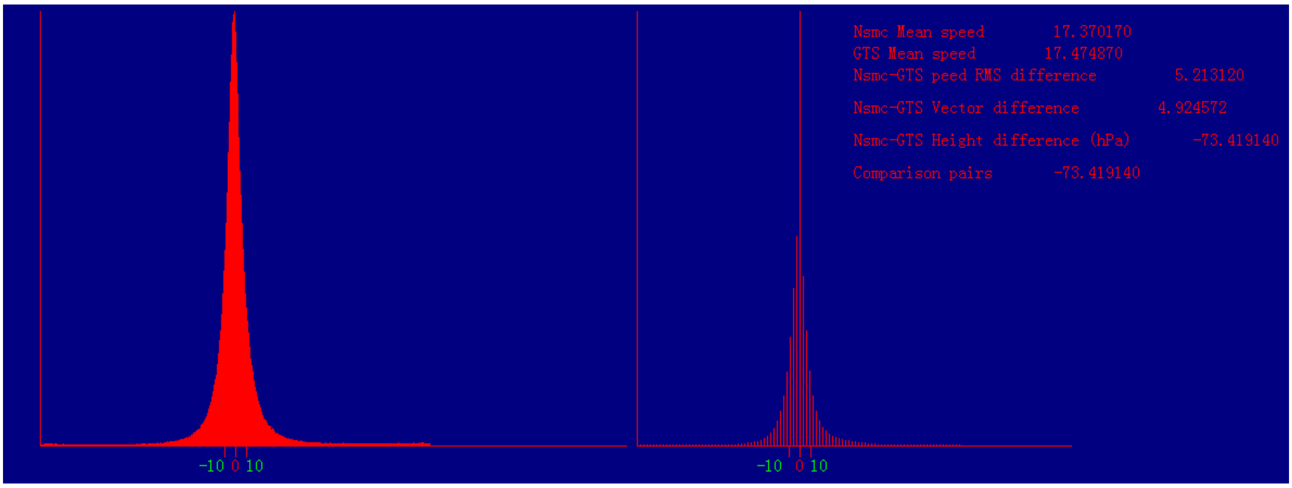

Figure 7 Differences between NSMC and GTS winds for Oct. 2009

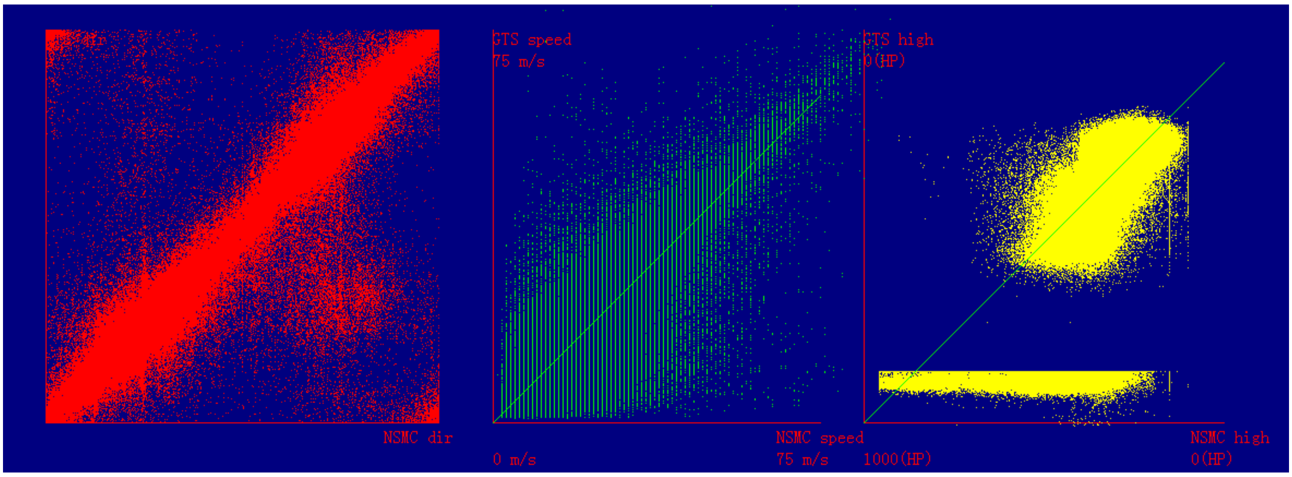

Figure 8 Scatter diagram of wind direction (left), speed (middle) and height (hPa) between NSMC and GTS AMVs for Oct. 2009. Abscissa and ordinate are for NSMC and GTS respectively.

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