UPDATE ON AMV ACTIVITIES AT THE MET OFFICE

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Abstract

Many new AMV datasets have been trialled in the Met Office global model since the 12th International Winds Workshop. These include the Single-Metop and Dual-Metop products from EUMETSAT, and the LeoGeo product from CIMSS. Single-Metop and LeoGeo entered operations at the Met Office in February 2015. Other datasets trialled include Himawari-8, which replaced MTSAT-2 in operations in February 2016, and VIIRS AMVs which are expected to enter operations in Autumn 2016.

Test data derived by NESDIS from SEVIRI imagery using the nested tracking algorithm designed for GOES-R was assessed. The test data observation-minus-background differences (O-Bs) were compared to those of the operational EUMETSAT SEVIRI AMVs for the same period revealing that O-B biases were larger in some regions and smaller in others. The effect on O-Bs of using information on cluster and cloud properties included with each test AMV was studied. Median optical depth, and median pressure error, of the local vectors in the largest cluster, showed skill at reducing mean and RMS O-B speed differences.

AMV USAGE UPDATE:

Filling the LEO-GEO Gap

A coverage gap exists between polar AMVs derived using image triplets and geostationary AMVs. One way to increase coverage is by deriving AMVs from polar-orbiting satellites using image pairs instead of image triplets. This increases the region of overlap to lower latitudes; the EUMETSAT Single-Metop AMVs are derived in this way and have coverage stretching past 50º N/S. Also using image pairs, the EUMETSAT Dual-Metop AMVs take advantage of the fact that Metop-A and Metop-B have orbits that are around 50 minutes apart to derive AMVs using one image from each Metop. This allows for an AMV dataset with global coverage. The CIMSS Leo-Geo AMVs are derived using image triplets where each image can be from a different polar or geostationary satellite.

These three AMV products were trialled in the Met Office global model. The LeoGeo AMVs were trialled using a QI1 threshold of 70, a blacklist above 300 hPa, and were not used if a conventional AMV was available within the same 200km thinning box. The Single-Metop AMVs were trialled with a 2 m/s minimum speed threshold. Single-Metop and LeoGeo were trialled separately and apart from the restrictions mentioned, their quality control was the same as that currently used for MODIS and AVHRR AMVs [i]. Dual-Metop was later trialled on top of Single-Metop and LeoGeo, using observations polewards of 40º N/S and a blacklist above 350 hPa.

Single-Metop and LeoGeo showed small but beneficial results overall. Single-Metop has most benefit in the southern hemisphere (SH), while the benefits of LeoGeo were spread more evenly between the SH and NH. Partly based on the NWP index[ii] results shown in Table 1, these two changes were approved for operations. Dual-Metop showed mixed NWP index results and a degradation in fit-to-observations for some observation types, and so has not yet been approved for operations.

Change	Impact on NWP Index		Outcome
	Vs Observations	Vs Own Analyses	
EUMETSAT Single-Metop	+ 0.04 %	+ 0.17 %	Operational February 2015
CIMSS LeoGeo	+ 0.04 %	+ 0.10 %	Operational February 2015
EUMETSAT Dual-Metop	- 0.04 %	+ 0.03 %	On hold

***Table 1*: trial results of LEO-GEO gap filling AMV datasets in the Met Office global model, shown as percentage change of NWP index.**

New Geostationary and Polar AMVs

Himawari-8 AMVs replaced MTSAT-2 AMVs in operations in February 2016. The replacement was trialled over one season and found to have neutral impact (Table 2). Quality control was kept the same but new height error profiles were derived for Himawari-8 with errors that were generally lower than those used for MTSAT-2.

Extended use of Himawari-8 AMVs was also trialled. This included the new 6.2 and 7.3 micron water vapour channels and a reduction of the QI1 threshold from 85 to 75. Results were disappointing with the NWP index showing neutral impact in summer and negative impact in the NH winter season, particularly winds at 250 hPa in the tropics. Fit-to-observations also showed degraded fit to radiances and AMVs.

Change	Impact on NWP Index		Outcome
	Vs Observations	Vs Own Analyses	
Himawari-8 replacing MTSAT-2	- 0.02 %	0.00 %	Operational February 2016
Himawari-8 extended use versus Himawari-8 basic use.	Summer + 0.04% Winter - 0.15%	Summer + 0.04 % Winter - 0.21 %	On hold
GOES Visible	- 0.05 %	- 0.57 %	On hold
GOES Shortwave-Infrared	+ 0.06 %	- 0.30 %	
VIIRS (NESDIS + direct broadcast)	Summer +0.11 % Winter +0.19 %	Summer + 0.13 % Winter + 0.12 %	Expected operational use November 2016

***Table 2:* trial results of new geostationary and polar AMV data in the Met Office global model, shown as percentage change of NWP index.**

GOES Visible and Shortwave-Infrared AMVs were trialled as these are already used operationally at most other NWP centres. However, NWP index results were poor, especially against own analyses. It is possible that height assignment problems in regions with temperature inversions could be responsible, and that better results may be obtained if the trial is repeated with the AMV inversion correction scheme due to go operational in Autumn 2016.

VIIRS polar AMVs (the nested tracking product from NESDIS together with the direct broadcast, heritage algorithm product from CIMSS) were trialled using similar quality control to other polar AMVs and gave a small positive impact. They are planned for operational assimilation from November 2016.

ANALYSIS OF NESTED TRACKING TEST DATA:

AMVs from GOES-R will be derived using a technique called nested tracking. In nested tracking, a matching is found from each 5x5 pixel of the target scene to the search area, to give a field of local vectors. Then, a cluster analysis algorithm groups similar local vectors into clusters. The average motion of the largest cluster is then used as the AMV. (Bresky et al)

NESDIS produced test data by using the nested tracking algorithm on SEVIRI imagery. A comparison of O-Bs between the nested tracking data and operational EUMETSAT revealed some differences (see Figure 1). For infra-red AMVs above 400 hPa the negative mean O-B speed difference in the extratropics was lower in the nested tracking AMVs than the EUMETSAT AMVs. However the positive mean O-B speed difference in the tropics was higher in the nested tracking data for both infra-red and water vapour AMVs. Infrared AMVs below 700 hPa generally had smaller O-B differences in the nested tracking data than the EUMETSAT data. Looking at collocated nested tracking and EUMETSAT AMVs reveals that the AMV speeds are similar and the differences seen in O-B characteristics seem to be due to height assignment differences.

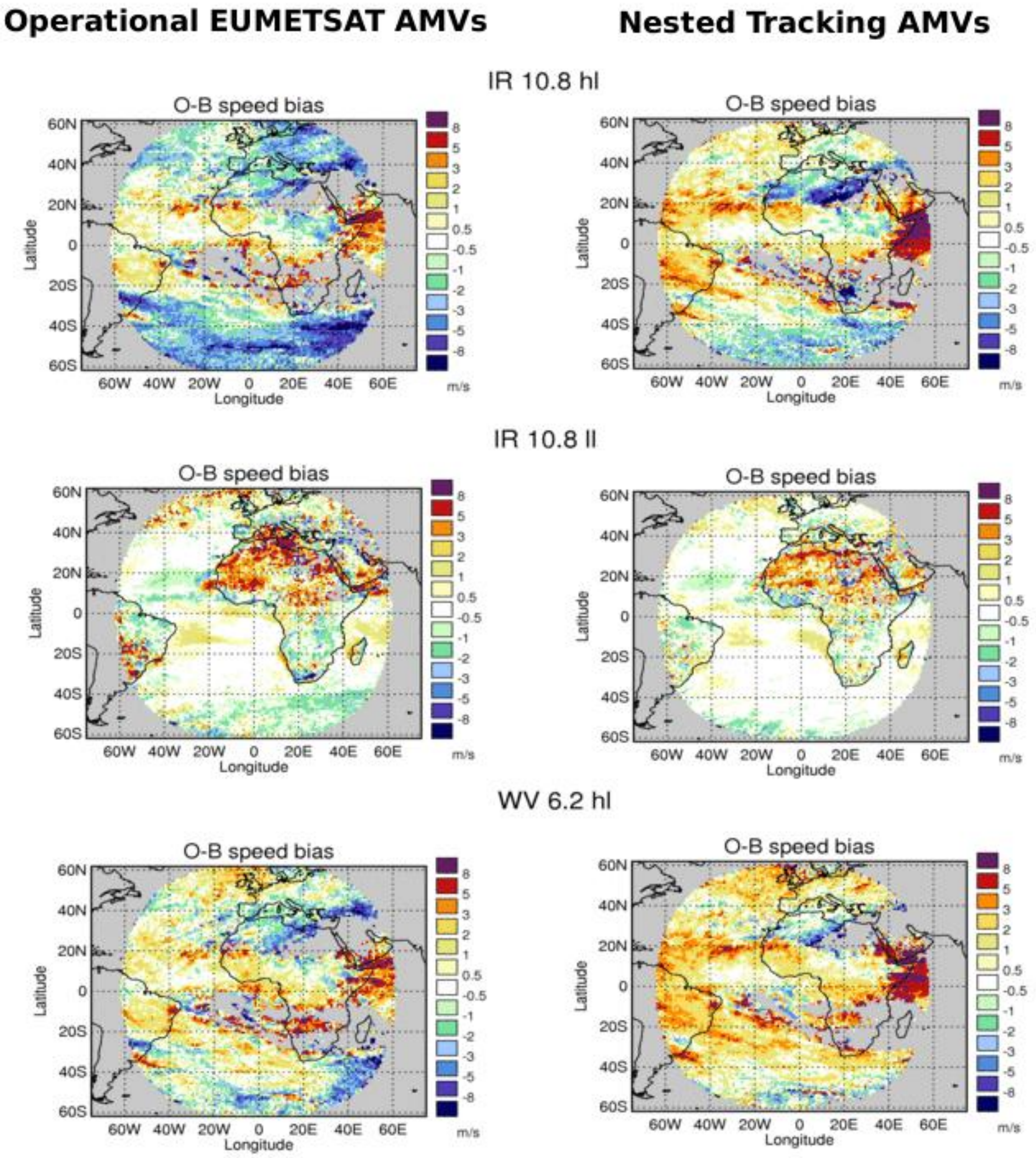

Figure 1: **Mean O-B speed difference of EUMETSAT and nested tracking SEVIRI AMVs, June 2014. Top row: infrared above 400 hPa, middle row: infrared below 700 hPa, bottom row: water vapour above 400 hPa.**

The test data included information on cluster and cloud properties with each AMV. The effect of filtering the AMVs by various thresholds for each property was investigated to see if they showed skill at reducing AMV O-B differences, without excessive reduction of spatial coverage or loss of the high speed AMVs.

Removing AMVs from clusters with median optical depths of less than 1.00 left a subset of AMVs with greatly reduced positive O-B biases in the tropics. Negative O-B biases in the extratropics were slightly larger (Figures 2, 4). The average bias of high level infrared switches from positive to negative after applying this filter (Figure 3). The same optical depth threshold reduces RMSVD and standard deviation (Figures 2, 3, 4) Higher optical depth thresholds left a subset of AMVs with a more severe slow bias. These results were seen for infrared AMVs above 700 hPa and for water vapour AMVs.

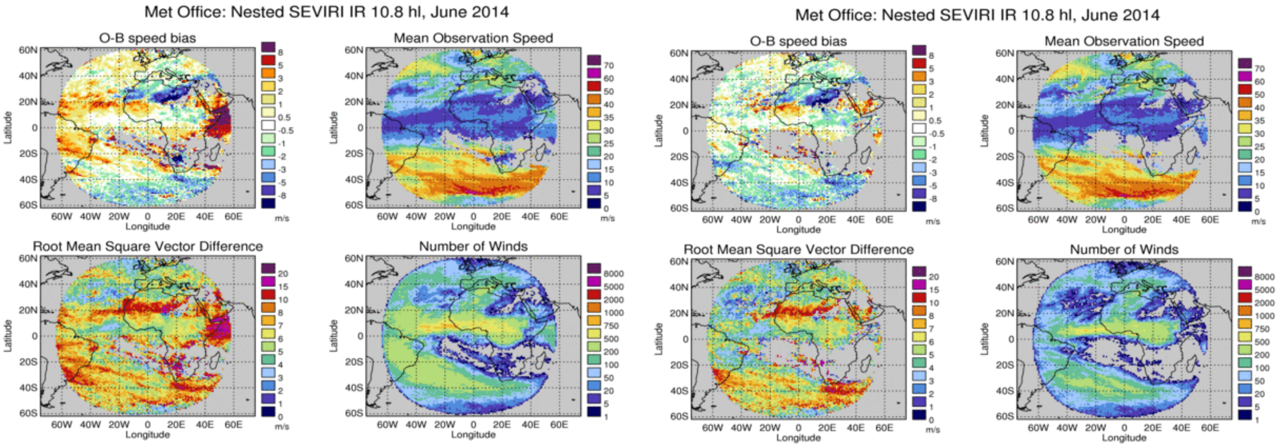

Figure 2: **O-B statistics for infrared AMVs above 400 hPa, left: full dataset, right: optical depth > 1.00**

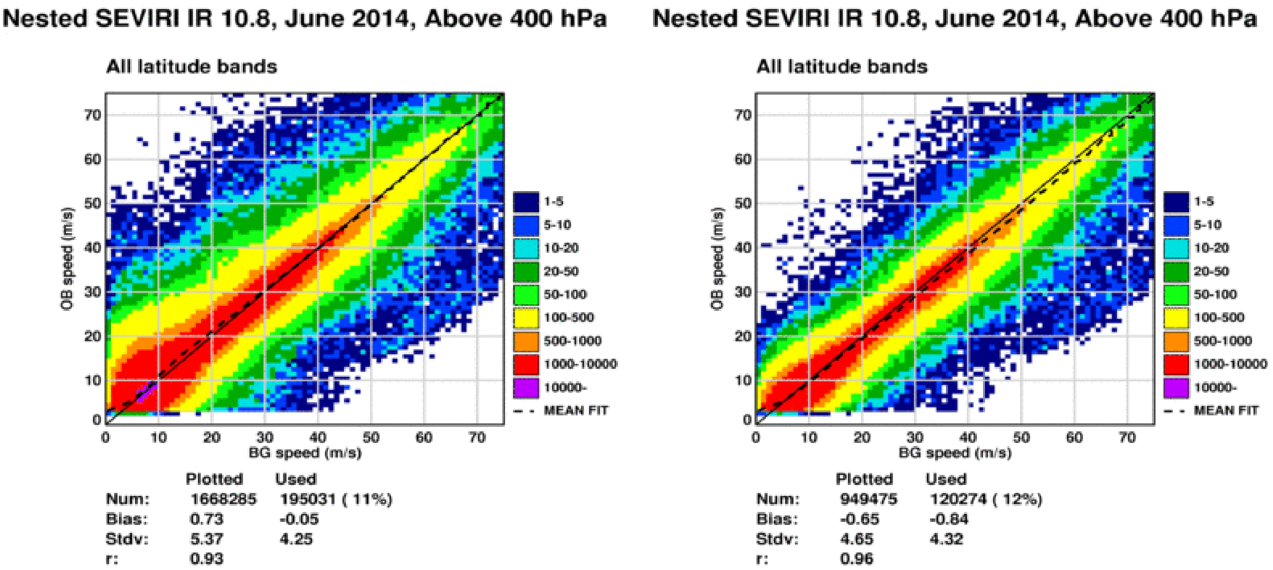

Figure 3: **O-B speed histogram for infrared AMVs above 400 hPa , left: full dataset, right: optical depth > 1.00**

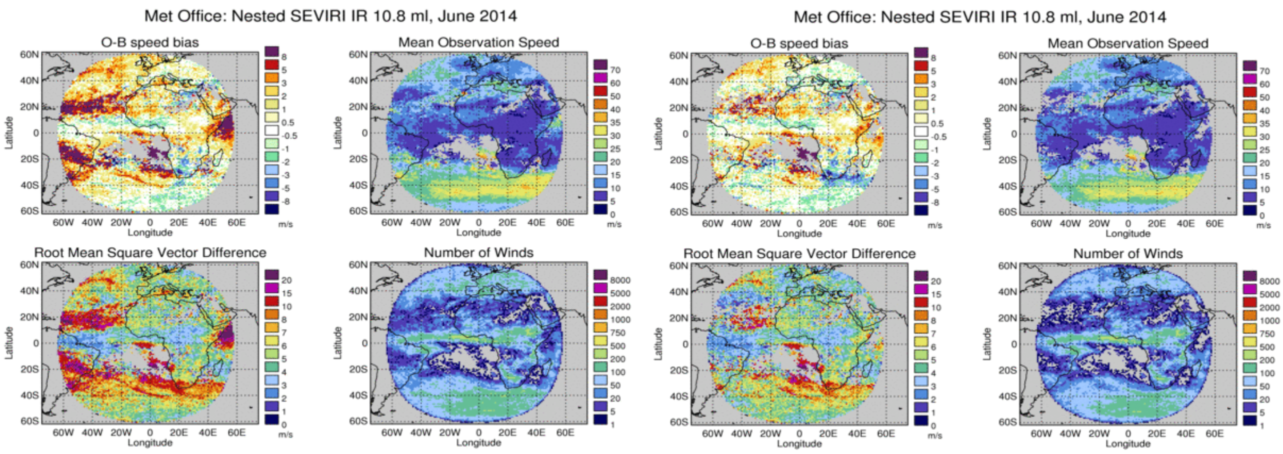

Figure 4: **O-B statistics for infrared AMVs between 400 and 700 hPa, left: full dataset, right: optical depth > 1.00**

Filtering by the median pressure error of the cluster gave good results with a maximum threshold of 140 hPa. This filter is effective at reducing fast biases and RMSVD for high level AMVs without losing much spatial coverage or many fast AMVs (Figures 5 and 6).

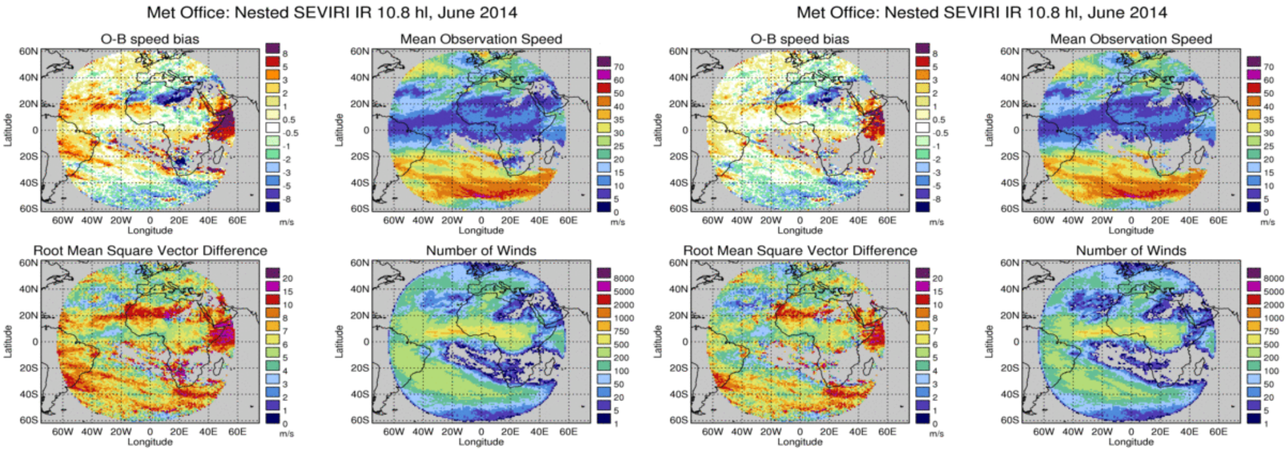

***Figure 5*: O-B statistics for infrared AMVs above 400 hPa, left: full dataset, right: pressure error < 140 hPa.**

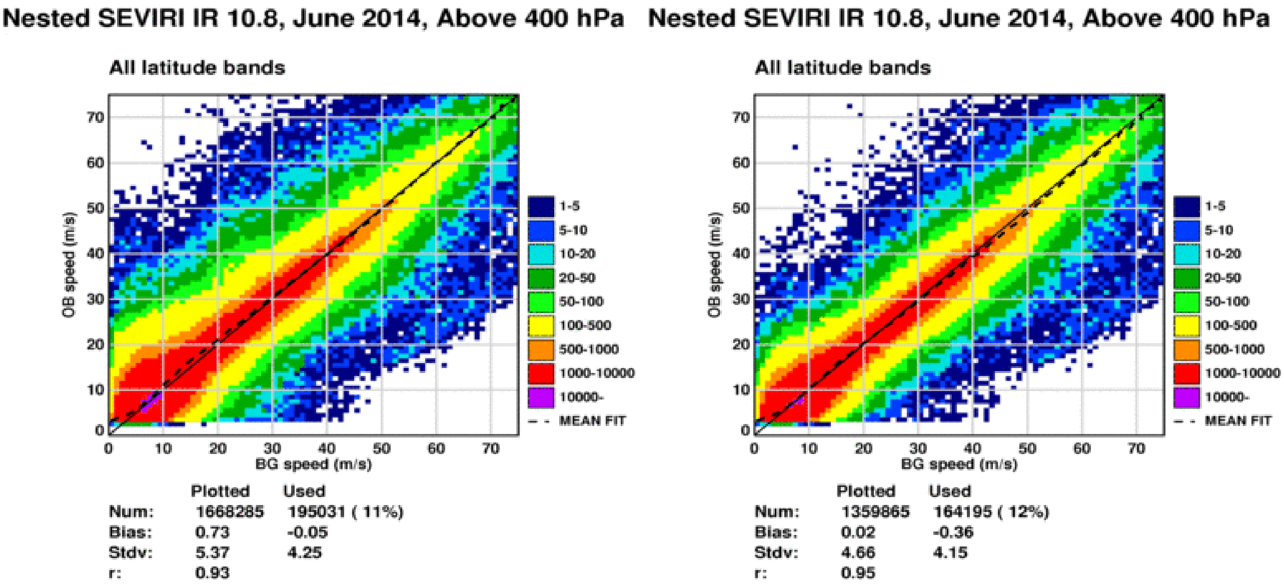

***Figure 6:* O-B speed histogram for infrared AMVs above 400 hPa, left: full dataset, right: pressure error < 140 hPa.**

Other parameters were investigated but not found to be useful for quality control. Filtering by standard deviation of the local vectors within the largest cluster led to a largely uniform reduction in data density everywhere without reducing O-B bias or RMSVD. Filtering by the number of vectors in the largest cluster had a similar effect.

Sorting the AMVs by the dominant cloud type of the target scene revealed some large differences in O-B characteristics. For the infrared channel, most of the winds are low-level and from water clouds, with low speeds and low O-Bs (Figure 7). Most of the high level infrared winds are either classified thin cirrus which have high observation speeds and a fast O-B bias on average, or as ‘overlap’ which are even faster but have smaller O-Bs.

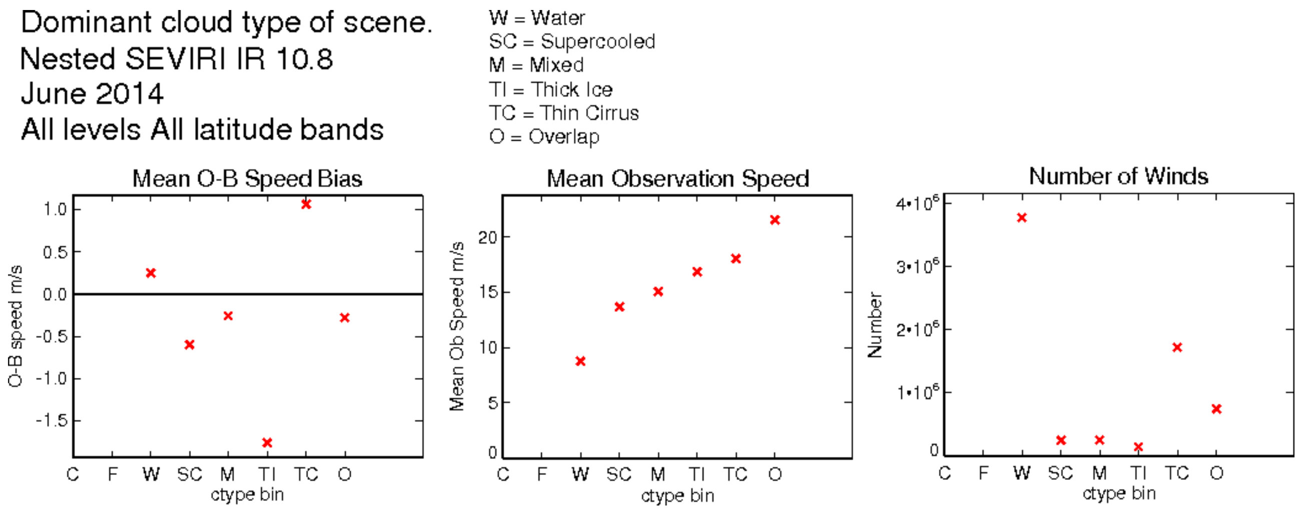

***Figure 7*: Statistics of infra-red AMVs, split by cloud type .**

Most of the water vapour AMVs are classified as thin cirrus, with a significant amount classified as overlap and thick ice. All cloud types show a fast bias on average except thick ice with a slow bias (Figure 8).

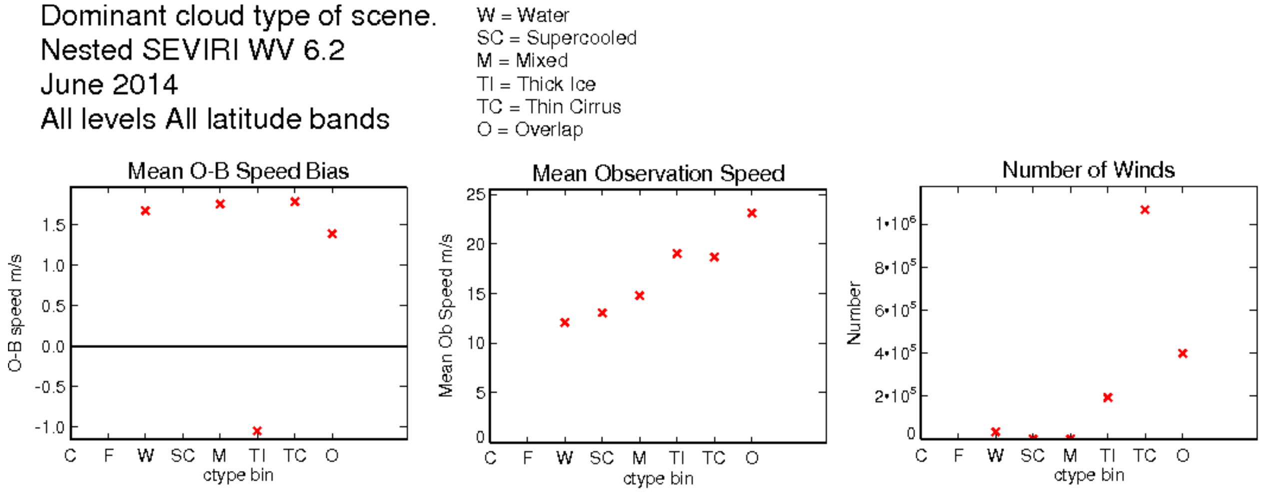

***Figure 8*: Statistics of water-vapour AMVs, split by cloud type**

Summary

The effect of filtering using the additional cloud and cluster information provided with the nested tracking test data was investigated. The median pressure error and median optical depth of the largest cluster were found to be the most effect at reducing mean and RMS O-B speed difference.

REFERENCES

Bresky, W. C. et al, 2012, 'New Methods toward Minimizing the Slow Speed Bias Associated with Atmospheric Motion Vectors', Journal of Applied Meteorology and Climatology, **51**, pp 2137-2151

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i Details available here: http://nwpsaf.eu/monitoring/amv/amvusage/ukmodel.html

[ii] The NWP index is a weighted average of meteorological variables at a range of forecast lengths. More details can be found at http://www.metoffice.gov.uk/research/weather/numerical-modelling/verification/global-nwp-index-doc