MEMORANDUM
RESEARCH DEPARTMENT

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To: HR, HO, HMD, HMOS, RD staff and consultants

Copy: Milan Dragosavac and Antonio Garcia-Mendez

From: Jean-Raymond Bidlot

Date: August 12, 2005   File: R60.9/JB/0579

Subject: **Impact of using the actual anemometer height when assimilating DRIBU surface wind data.**

Abstract

It was found that using the actual height of the anemometer when assimilating surface wind observations from DRIBU's moored and drifting buoys was beneficial.

1   Introduction.

Over the open oceans,conventional surface wind observations are reported on the GTS either as SHIP or DRIBU. These observations are usually made by anemometers mounted on ships, platforms, drifting or moored buoys. The height above mean sea level of the respective anemometer can however vary from a few meters for buoys to hundred meters for platforms. Unfortunately, information about the anemometer is not available in the data reports. This problem has long been identified for SHIP data. Before cycle 21r2 (July 1999), surface wind data were assumed to be at 10m. Understandably, modern ships rarely carry their instruments at 10m, rather, since 21r2, a default height of 25m was assumed for the ship anemometers. Furthermore a list of known ship anemometer height was used to add this information to the GTS data before input to the assimilation processing (by adding an extra entry in the SHIP bufr template). Within the SHIP data, buoy and platform data, which can be differentiated from 'real' ships because of their 5 digit code name, were assumed to still be at 10m. Information about known buoys and platforms were added to the operational list in the course of 1999. However, due to a few technical glitches, the updates were only used with the implementation of cycle 22r3 in

June 2000 (Bidlot research memo April 2000). Since then, the operational list has been updated a few times.

DRIBU wind data are mostly supplied by moored buoys from the Tropical Atmosphere Ocean (TAO) project in the central and eastern equatorial Pacific, from the TRITON buoys (Triangle Trans-Ocean buoy Network) in the western equatorial Pacific and the eastern Indian Ocean and by PIRATA (Pilot Research Moored Array in the Tropical Atlantic) in the tropical Atlantic. Recently Indian buoy data from the National Institute of Ocean Technology (NIOT) have also become available on the GTS. There are also a few drifting buoys reporting wind (Fig. 1). None of these buoys actually observe wind at 10m above the mean sea level. However, the current operational model assumes a default of 10m for all DRIBU winds because the procedure used to provide the actual height of the wind observations is not yet functional. In the past, the amount of DRIBU wind data was quite limited. But since February 2005, the GTS data stream was enhanced following the switch to multi-satellite status by Service Argos. The impact of this change on the volume of hourly surface met data (winds, air temperature, relative humidity, SST, and surface pressure) on the GTS was evident (see daily report of February 4th, 2005), resulting in nearly a two-fold increase. Finally, from February 2005, all newly deployed buoy moorings are programmed to transmit 16-hours per day. Previously, transmissions have been limited to 8 daytime hours due to budgetary constraints. The increased transmission schedule has the potential to again double the volume of surface met data above the already increased multi-satellite data throughput. It is therefore imperative to make the best use possible of the data.

As it turns out, the current system is already geared to use information on the height of the DRIBU anemometer if it is provided by adding an extra entry in the bufr template used to describe the data (as it is the case for SHIP data). This memo describes briefly the results obtained if such a correction is put in place.

2   Assimilation experiment.

An update to the ship anemometer list was put together to include DRIBU data by collecting information from the different data providers. Indeed most moored buoys have their anemometers at about 3-4 m, whereas drifting buoys measure winds around 2m above the sea surface. The script used for the pre-processing of the bufr DRIBU and SHIP data was modified to include anemometer heights from this new list. Note that the bufr utility bufr_ship_anmh_ERA is used instead of bufr_ship_anmh since it works with both SHIP and DRIBU data and always overwrites the value for the anemometer height with the entry from the supplied list. An analysis experiment (engq) was set for a period when cycle 29r1 was operational. The operational suite is the reference. The starting date was April 15th, 2005 but due to the corruption of the run by the accidental de-blacklisting of Jason altimeter wave height data on hpcd, the run was reset from April 24th, 2005, 12UTC.
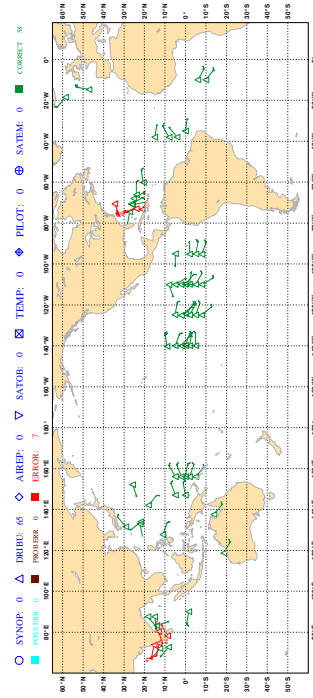
(a) 0 UTC

(b) 6 UTC

(c) 12 UTC
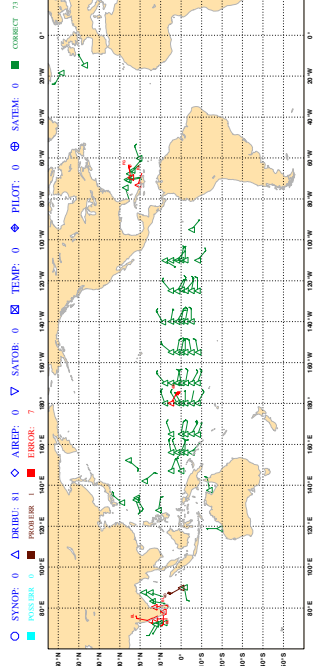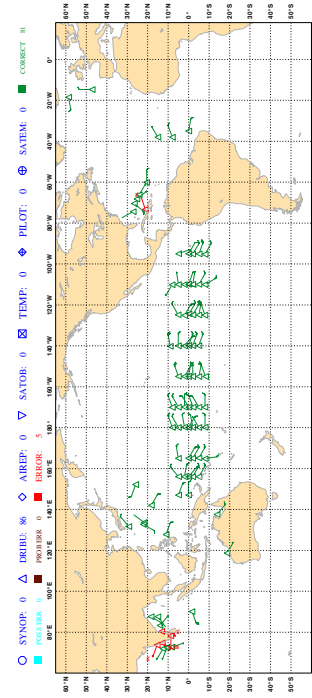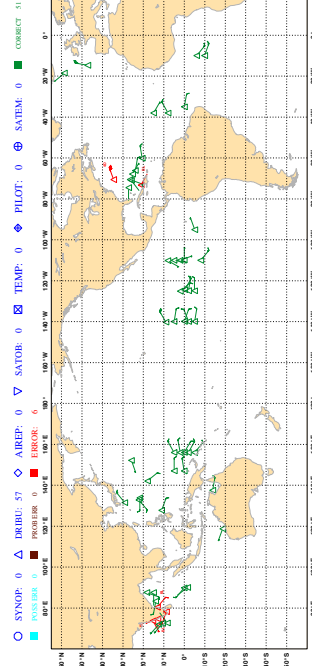
(d) 18 UTC

Figure 1: DRIBU wind from operational feedback files (stream dcda) for May 3, 2005. wind data are usually accepted (green symbols), a few are blacklisted for being too close to land (BL), or are rejected by the first guess check (FG) or the variational quality control (4V) (red symbols).
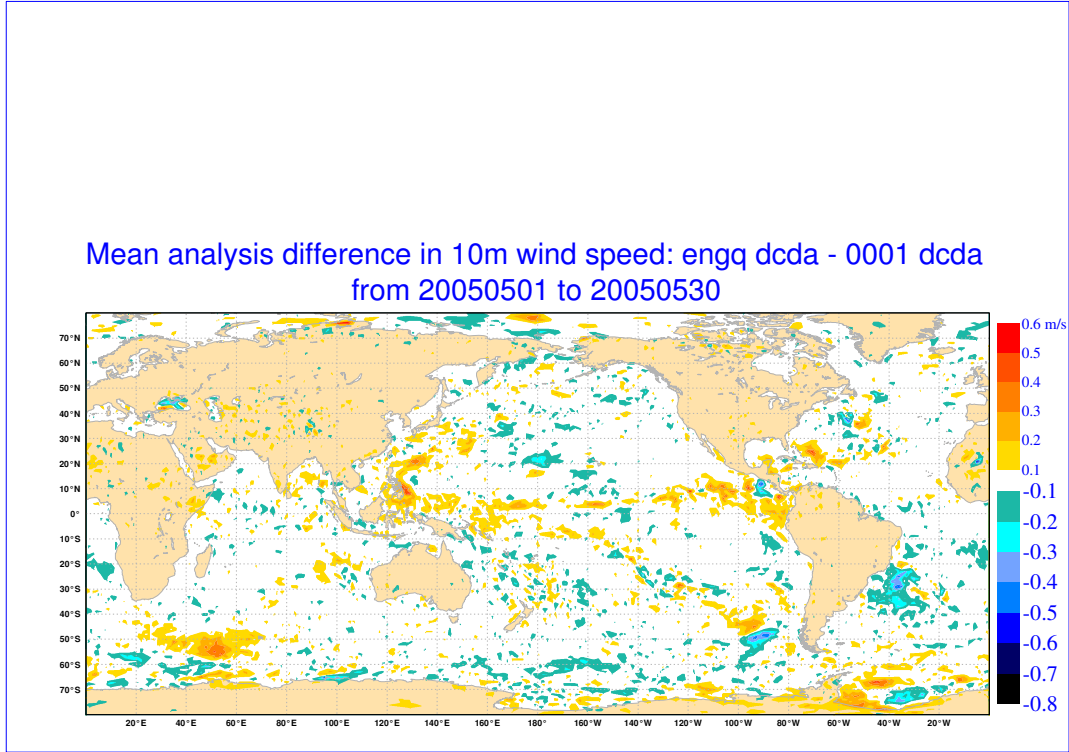
Figure 2: Analysed wind speed mean difference between an analysis using the actual anemometer height of the dribu data (engq) and a reference (0001) using a default of 10m for May 2005. Only absolute differences larger than 0.1 m/s are shown.
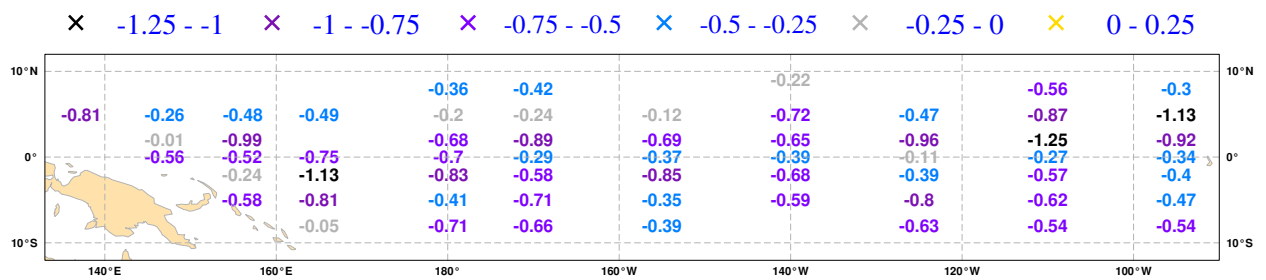
2.1 Analysis verification.

Figure 2 shows the mean difference in 10m wind speed from the two delayed-cut-off analyses for May 2005. Instantaneous surface wind fields tend to show a lot of short scale variations but in the mean there is a hint of an increase in the tropical winds in the areas where DRIBU wind data have been assimilated (Fig. 1).

This is verified by comparing the analysed 10m winds with the DRIBU moored buoys for the Pacific (Fig. 3) and for the Indian Ocean (Fig. 4). Note that if no adjustement is done, then the operational 10m winds appear only slightly biased low with respect to the data (not shown), however if the height of the observations is properly accounted for (Fig. 3a and 4a) then a markedly negative bias is apparent. Using the anemometer height information (Fig. 3b and 4b) reduces this negative bias by 0.1 to 0.2 m/s. Note however that the model winds are still quite low with respect to the data.

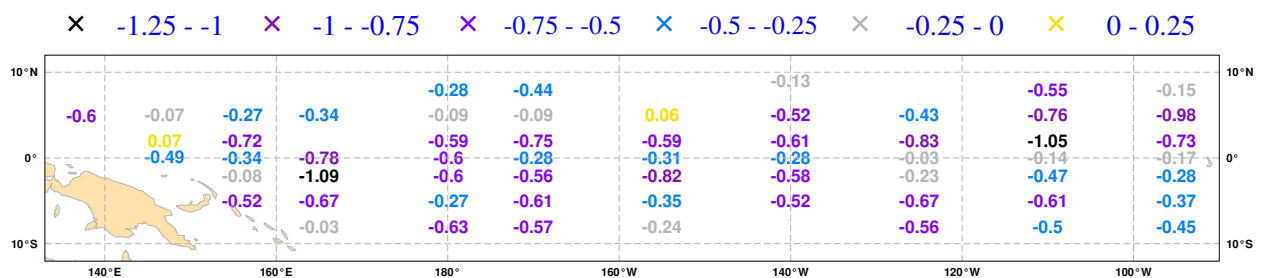This mostly negative bias in the tropics is also present if we compare the analysis field to Quickscat winds (Fig. 5). Note that the Quickscat data were assimilated in both experiments. Fig. 5 also confirms that assimilating the TAO/TRITON buoy winds at the proper height results in a better fit with the observations both in terms of bias and standard deviation of the error (compare the bottom panels with the top ones).

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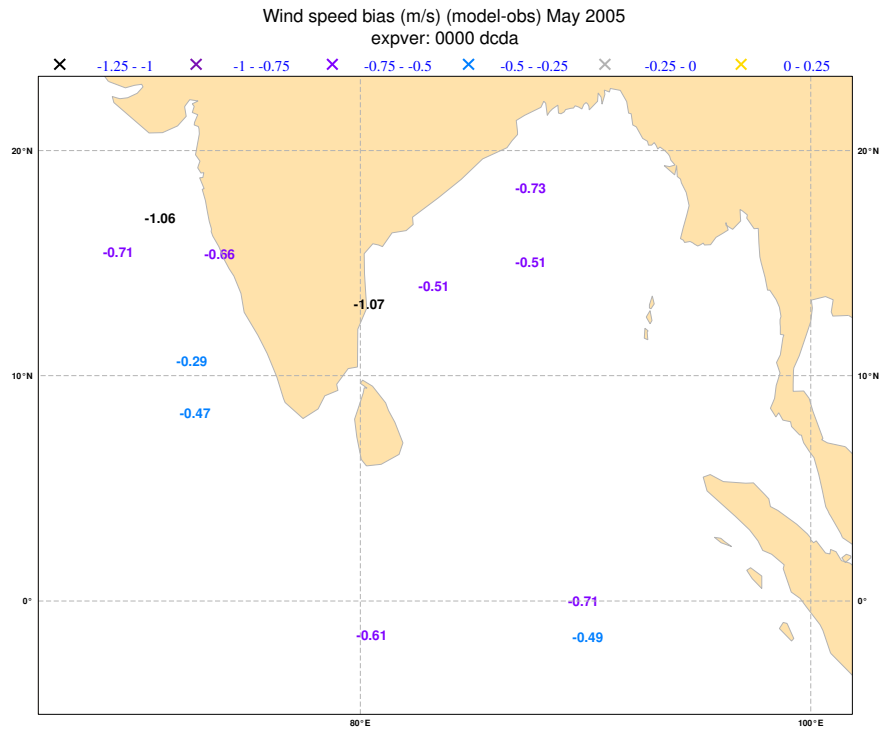# Wind speed bias (m/s) (model-obs) May 2005
expver: 0000 dcda

✕	-1.25 - -1	✕	-1 - -0.75	✕	-0.75 - -0.5	✕	-0.5 - -0.25	✕	-0.25 - 0	✕	0 - 0.25

```
10°N                                        -0.36  -0.42              -0.22                    -0.56        -0.3     10°N
      -0.81  -0.26  -0.48  -0.49     -0.2   -0.24        -0.12        -0.72        -0.47        -0.87       -1.13
             -0.01  -0.99             -0.68  -0.89        -0.69        -0.65        -0.96        -1.25       -0.92
  0°         -0.56  -0.52  -0.75      -0.7   -0.29        -0.37        -0.39        -0.11        -0.27       -0.34     0°
                    -0.24  -1.13      -0.83  -0.58        -0.85        -0.68        -0.39        -0.57       -0.4
                    -0.58  -0.81      -0.41  -0.71        -0.35        -0.59        -0.8         -0.62       -0.47
                    -0.05             -0.71  -0.66        -0.39                     -0.63        -0.54       -0.54
10°S                                                                                                                  10°S
     140°E      160°E        180°        160°W        140°W        120°W        100°W
```

(a) ops

Wind speed bias (m/s) (model-obs) May 2005
expver: engq dcda

✕	-1.25 - -1	✕	-1 - -0.75	✕	-0.75 - -0.5	✕	-0.5 - -0.25	✕	-0.25 - 0	✕	0 - 0.25

```
10°N                                        -0.28  -0.44              -0.13                    -0.55        -0.15    10°N
      -0.6   -0.07  -0.27  -0.34    -0.09   -0.09        0.06         -0.52        -0.43        -0.76       -0.98
             0.07   -0.72             -0.59  -0.75        -0.59        -0.61        -0.83        -1.05       -0.73
  0°         -0.49  -0.34  -0.78      -0.6   -0.28        -0.31        -0.28        -0.03        -0.14       -0.17     0°
                    -0.08  -1.09      -0.6   -0.56        -0.82        -0.58        -0.23        -0.47       -0.28
                    -0.52  -0.67      -0.27  -0.61        -0.35        -0.52        -0.67        -0.61       -0.37
                    -0.03             -0.63  -0.57        -0.24                     -0.56        -0.5        -0.45
10°S                                                                                                                  10°S
     140°E      160°E        180°        160°W        140°W        120°W        100°W
```
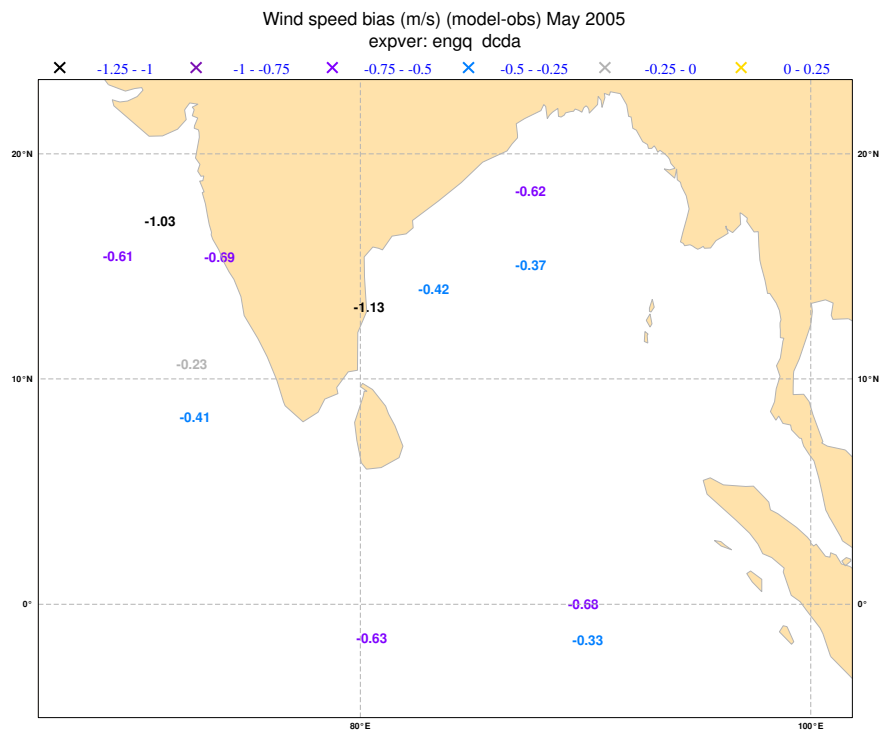
(b) new

Figure 3: Analysis 10m wind speed bias (model-buoy) at the TAO/TRITON buoys for May 2005.
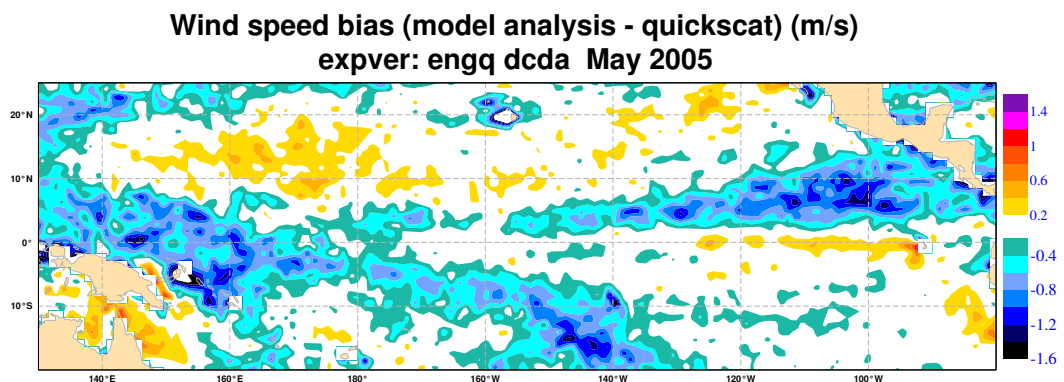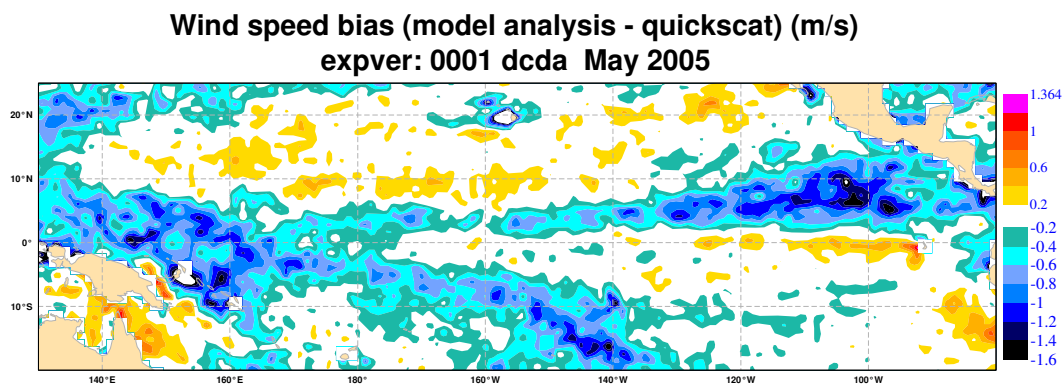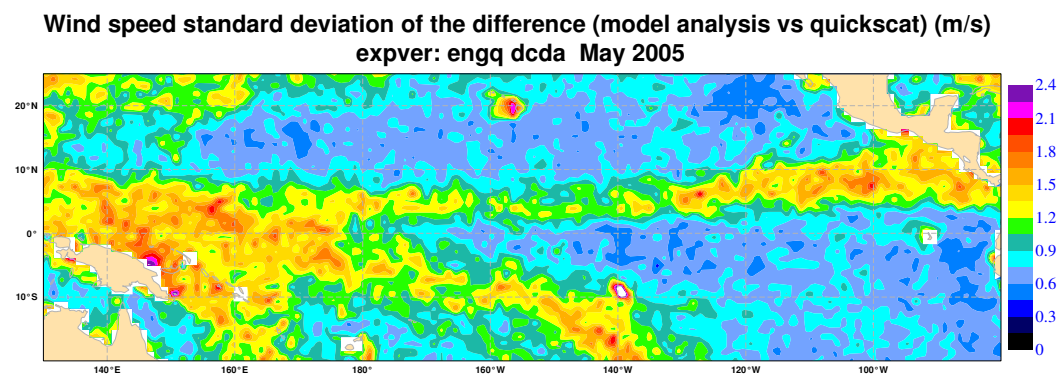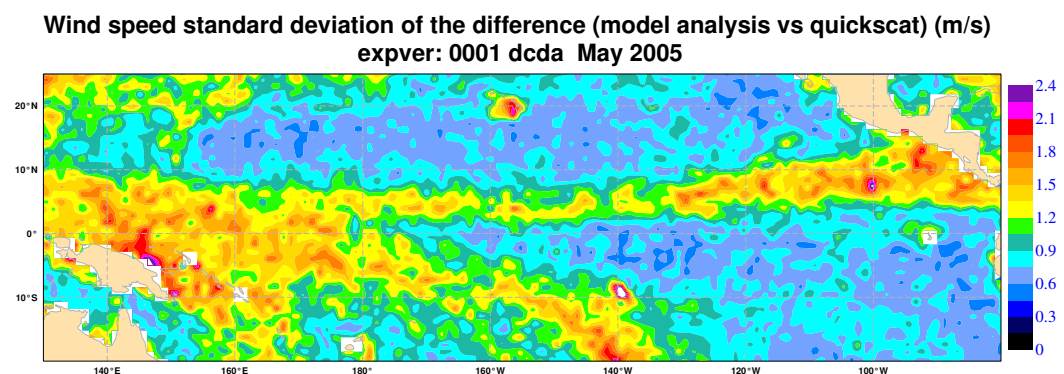
(a) ops

(b) new

Figure 4: Analysis 10m wind speed bias (model-buoy) at the Indian Ocean buoys for May 2005.

**Wind speed bias (model analysis - quickscat) (m/s)
expver: 0001 dcda May 2005**

**Wind speed bias (model analysis - quickscat) (m/s)
expver: engq dcda May 2005**

(a) bias (model-Quickscat)

**Wind speed standard deviation of the difference (model analysis vs quickscat) (m/s)
expver: 0001 dcda May 2005**

**Wind speed standard deviation of the difference (model analysis vs quickscat) (m/s)
expver: engq dcda May 2005**

(b) STDEV

Figure 5: Analysed surface wind speed comparison with Quickscat for May 2005. (a) mean difference, (b) standard deviation of the error. The top panel of each statistic is for the operational analysis (0001 dcda) and the bottom one for the new analysis (engq dcda).

2.2   Forecast scores.

Forecast scores for the 1000 hPa geopotential are presented in Fig. 6, 7 and 8 and the corresponding significance level in Tables 1 and 2. The verifying analysis is operations. Similar scores and significance were also obtained when verifying against own analysis and also for other levels. The beneficial impact of using the actual anemometer height when assimilating DRIBU data is clearly visible at medium range. Only the North Atlantic area shows a detrimental impact at later forecast range albeit with little significance. Note in particular the improved scores for the North Pacific (Fig. 8), using the proper anemometer height for all surface wind observations in the tropical Pacific (the area for which we have seen the largest increase in the amount of DRIBU winds) is certainly advantageous.

Forecast scores for the oceanic 10m wind speed are presented in Fig. 9, 10 and 11 Comparable scores were obtained for wave heights. The change to the DRIBU assimilation is globally fairly neutral, even in the tropics. There is some impact for smaller areas that reflects the geopotential scores.
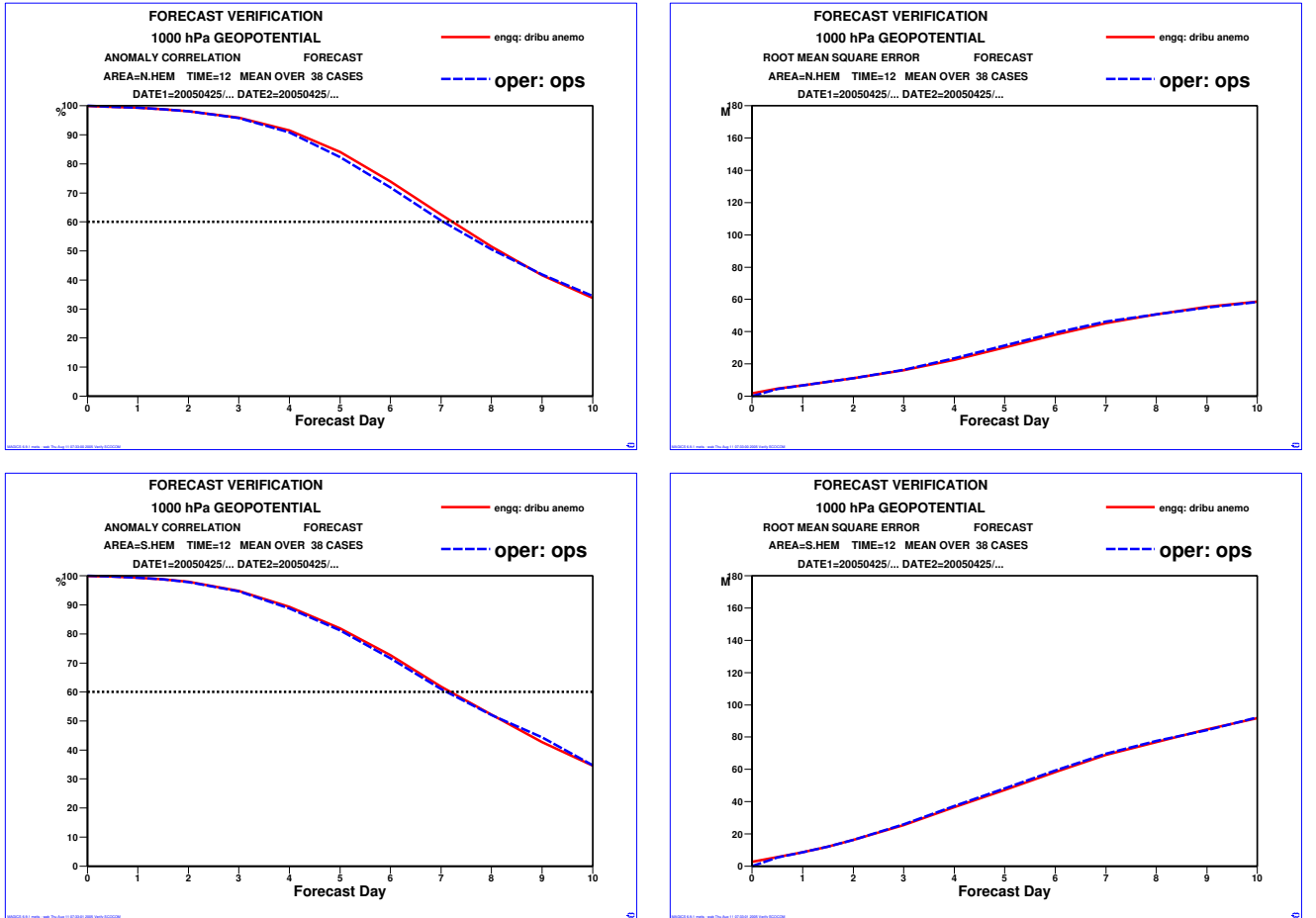
Figure 6: 1000 hPa geopotential scores for a period from April 25th to June 1st 2005. Northern and Southern Hemisphere extra tropics. Solid red curves are for the new experiment whereas dash blue curves are for the o-suite. Verifying analysis is operations.

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1000 hPa anomaly correlation				
data source	day 5	day 6	day 7	day 8
N.H.	+	+	+	
S.H.	+	+		
Europe	+	+		
N Atlantic	+		-	
N Pacific	+	+	+	+
N America		+	+	

Table 1: Significance levels for 1000hPa anomaly correlation. + indicates that the new experiment was found to be better than operations, whereas - is the opposite.
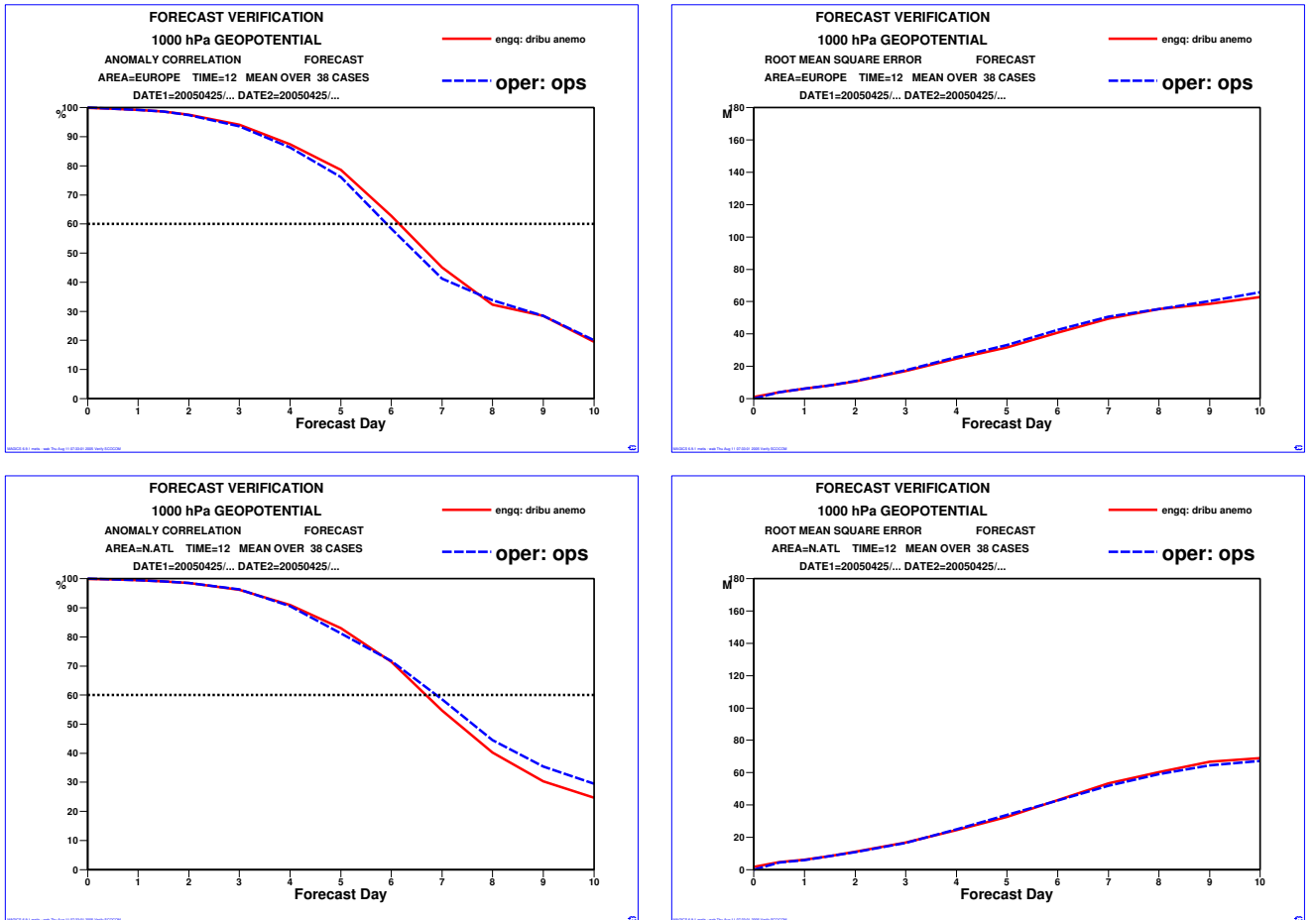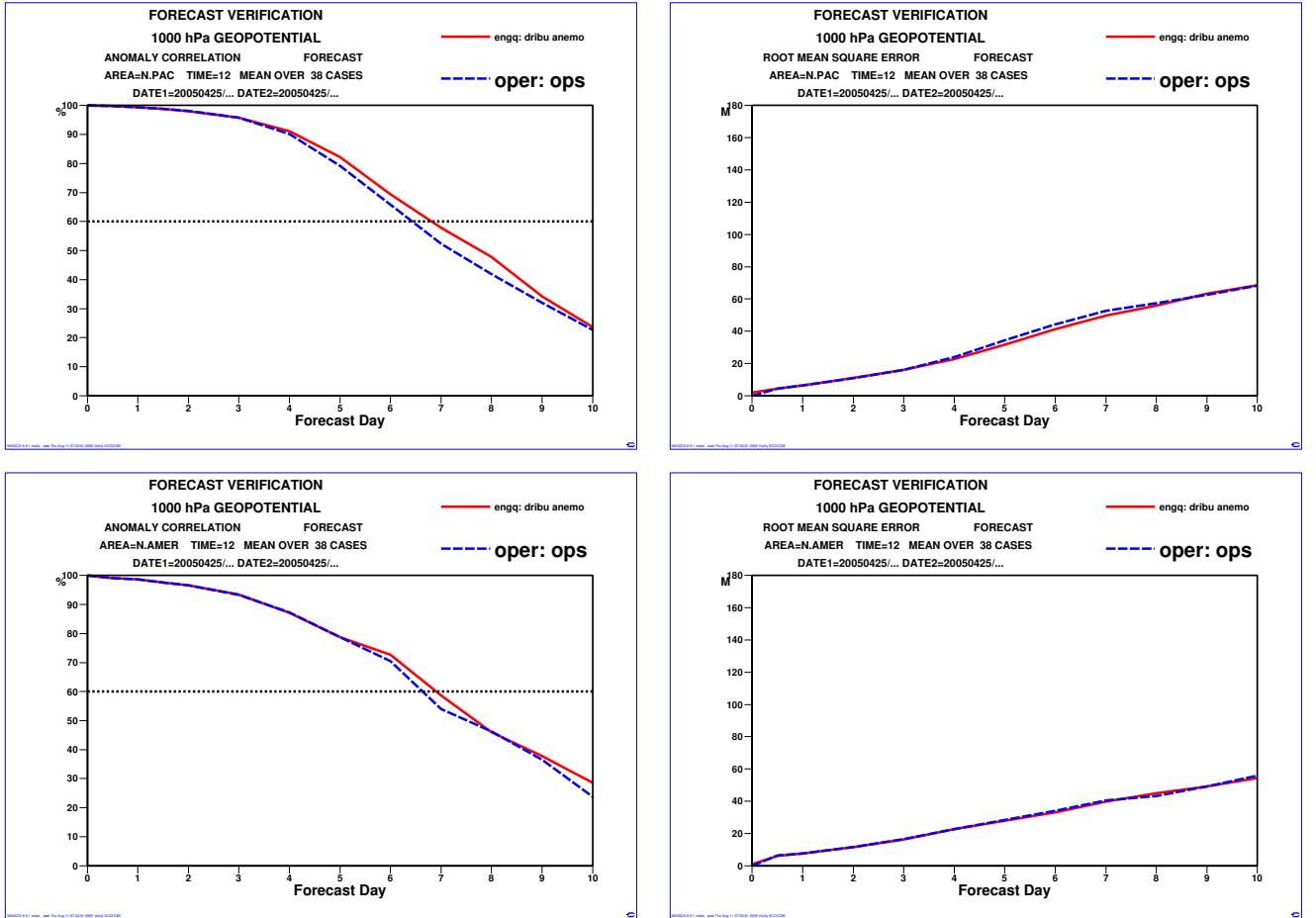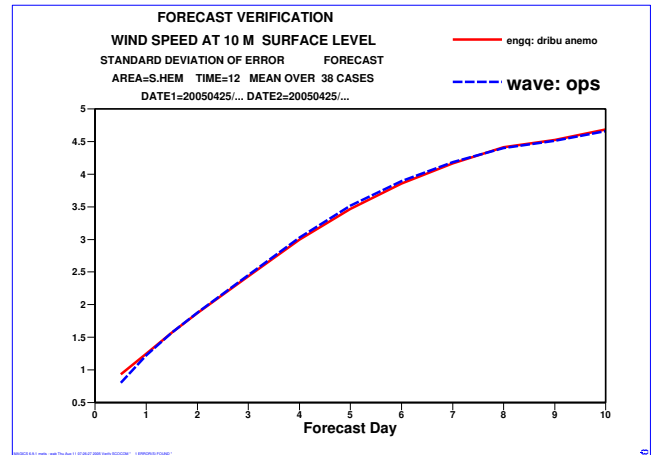

Figure 7: 1000 hPa geopotential scores for a period from April 25th to June 1st 2005. Europe and North Atlantic. Solid red curves are for the new experiment whereas dash blue curves are for the o-suite. Verifying analysis is operations.

1000 hPa RMSE				
data source	day 5	day 6	day 7	day 8
N.H.	+	+	+	
S.H.	+	+	+	
Europe	+	+		
N Atlantic	+		-	
N Pacific	+	+	+	
N America		+	+	

Table 2: Significance levels for 1000hPa RMSE. + indicates that the new experiment was found to be better than operations, whereas - is the opposite.

Figure 8: 1000 hPa geopotential scores for a period from April 25th to June 1st 2005. North Pacific and North America. Solid red curves are for the new experiment whereas dash blue curves are for the o-suite. Verifying analysis is operations.

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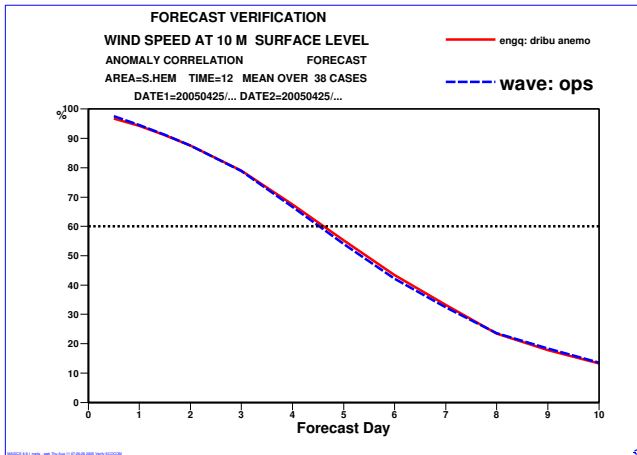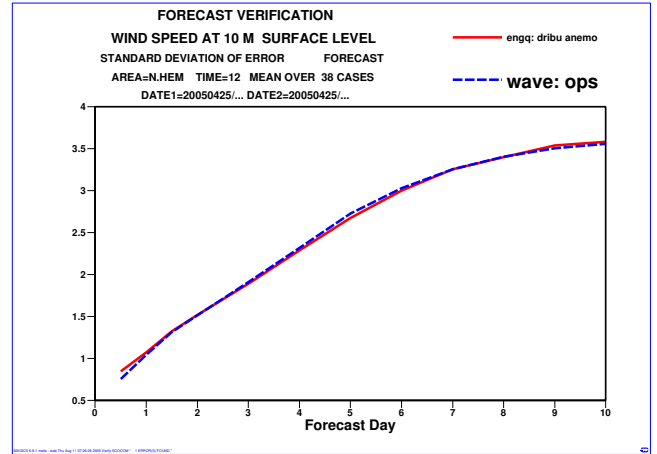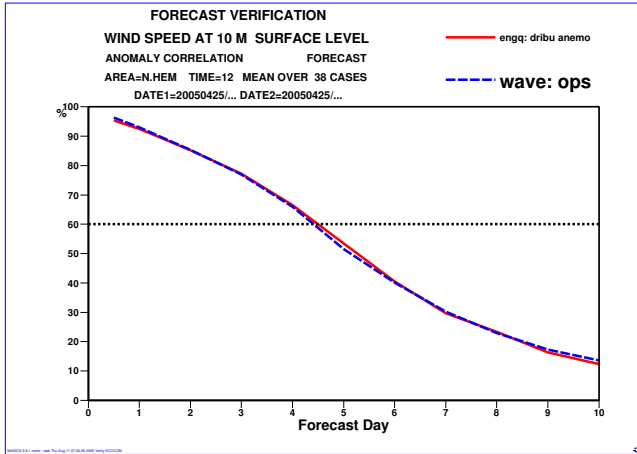
Figure 9: Oceanic 10 m wind speed scores for a period from April 25th to June 1st 2005. Northern and Southern Hemisphere extra tropics. Solid red curves are for the new experiment whereas dash blue curves are for the o-suite. Verifying analysis is operations.
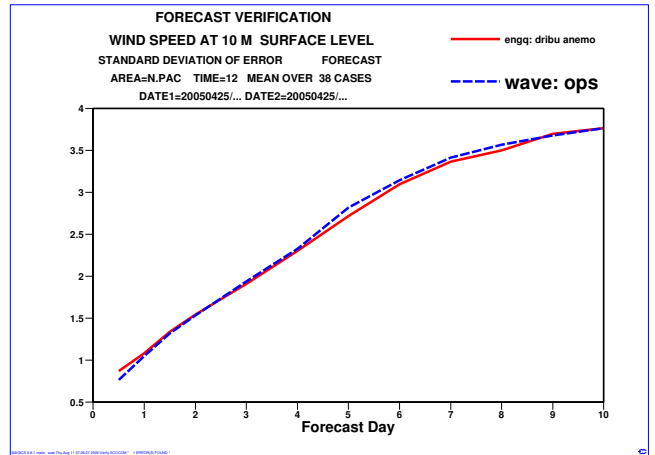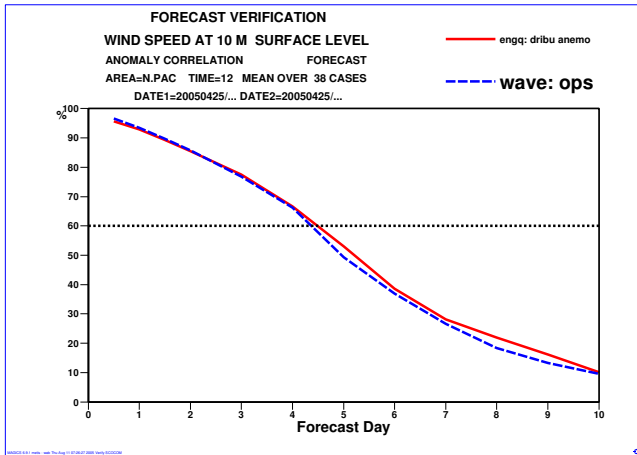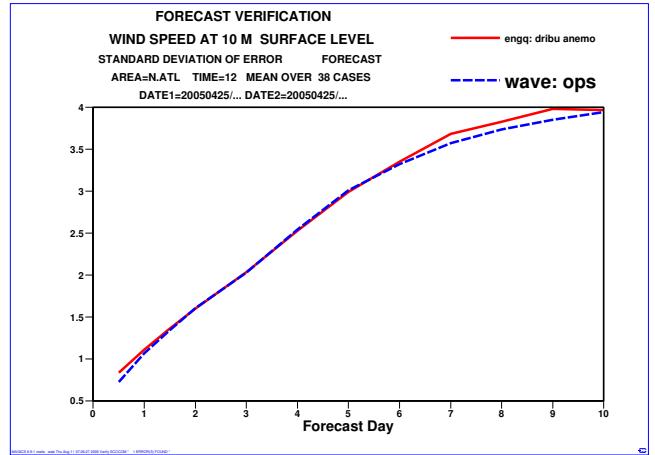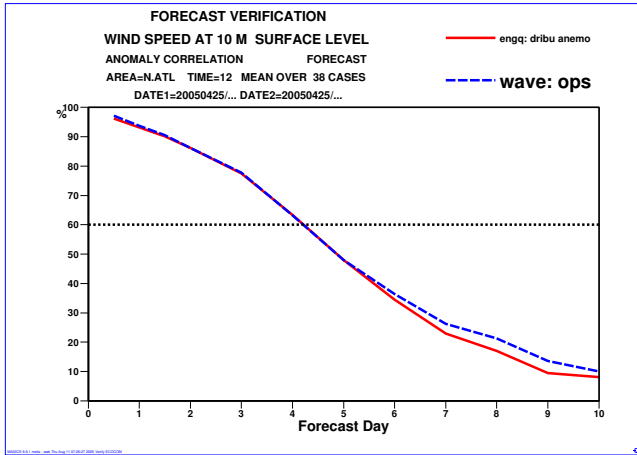
Figure 10: Oceanic 10 m wind speed scores for a period from April 25th to June 1st 2005. North Atlantic and North Pacific. Solid red curves are for the new experiment whereas dash blue curves are for the o-suite. Verifying analysis is operations.
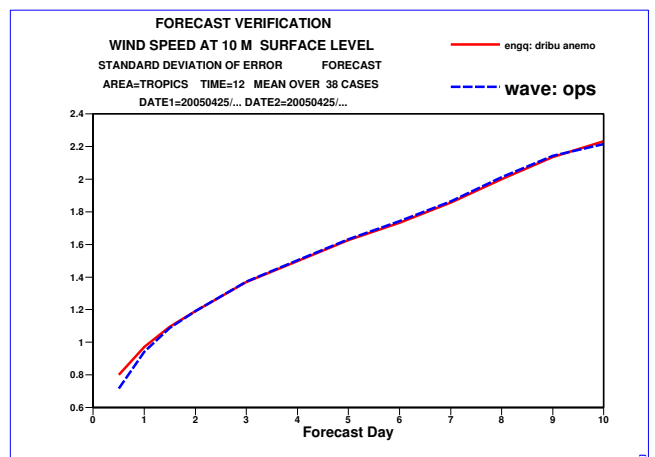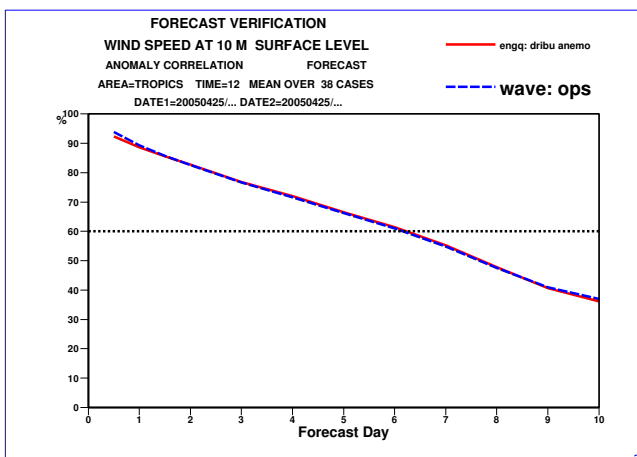

Figure 11: Oceanic 10 m wind scores for a period from April 25th to June 1st 2005. Tropics. Solid red curves are for the new experiment whereas dash blue curves are for the o-suite. Verifying analysis is operations.

3 Conclusions and comments.

Since February 2005, the amount of DRIBU wind data that we receive daily via the GTS has increased significantly. Their impact on the ECMWF assimilation system was revisited.

It has been shown that assimilating DRIBU surface wind observations at their actual height instead of the default height of 10 m has a positive impact on the surface wind analysis in the tropics. Moreover, a beneficial impact was also found on forecast scores.

If the DRIBU winds are not adjusted to the true anemometer height, then the comparison between current operational model values and observations only reveals a small tendency to underestimate wind speed by the model in the tropics. However, if the actual height of the observations is taken into account then a large negative bias is clearly visible over large areas of the tropical oceans (Fig. 3a and 5a). Assimilating surface winds at the proper height above mean sea level reduces this negative bias. Nevertheless, model surface winds are still too weak. Some more efforts should be spent on understanding the reason for this underestimation.

4 Recommendations.

In light with the results presented here, the updated anemometer height list should become operational AND the operational bufr tool used to include the anemometer height to the SHIP data should also do so for DRIBU data. Doing so, as this study has shown, will automatically ensure that the current operational cycle will include the added anemometer heights into the assimilation of both SHIP and DRIBU data (i.e. there isn't any need for a cycle update).

Note that in the latest ERA40 reruns, an earlier version of the updated list is already being used with a proper bufr utility. More work is however needed to check where and how the TOGA-COARE data (and all TAO data used by ERA40 that were not available from the GTS stream) are treated as the data might not be recognised as SHIP or DRIBU data.

One problem which remains is the maintenance of the anemometer height list. Information on real ship can be obtained from WMO publication 47- International List of Voluntary Observing Ships. The last update is dated December 31, 2004. Information from this latest update was not included in this study but was extracted for the next change to the centre list. This WMO list does however only contain a fraction of all ships that can be found in the GTS received. Information on moored buoys was gathered from the different web pages that exist for all major buoy networks either directly or by emails. This is a time consuming task, moreover it tends to lag behind any buoy deployments. Update for the drifting buoys is even more problematic even though there seems to be some initiative by WMO to concentrate the information (JCOMMOPS program). The easier solution would be if the information came with the data. A recent new bufr subtype

for buoys is currently received, but not archived on the ground that it is not used by the operational analysis system. A bit short sighted I might say. This new bufr subtype contains data that are otherwise already dissiminated as DRIBU, however there is a lot more information with it. Anemometer height is one of the new entry, but the last time I checked, all reported values were 0 ! We are still investigating the problem but in the mean time, the data should at least be archived.

5   Acknowlegdements.