

Monitoring statistics of the ERS-2 scatterometer for ESA

Cycle 163

(Project Ref. 22025/08/I-EC)

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February, 16th 2011

1. Introduction

The quality of the UWI product was monitored at ECMWF for Cycle 163. Results were compared to those obtained from the previous Cycle, as well for data received during the nominal period in 2000 (up to Cycle 59). No corrections for duplicate observations from overlapping ground stations were applied.

During Cycle 163 data was received between 21:05 UTC 22 November 2010 and 19:59 UTC 27 December 2010. Data was grouped into 6-hourly batches (centred around 00, 06, 12 and 18 UTC). No data was received for the batches from 00 UTC to 12 UTC 1 December 2010, and for 00 UTC and 06 UTC 25 December 2010. A very low amount of data was received for 12 UTC 16 December 2010.

Data is being recorded whenever within the visibility range of a ground station. For Cycle 163, data coverage was over the North-Atlantic, the Mediterranean, part of the Gulf of Mexico, an area in the Pacific west from the US, Canada and Central America and the area in between Antarctica and Australia (see Figure 2).

Time series of the asymmetry between the fore and aft incidence angles shows a reasonably stable behaviour.

Compared to Cycle 162, the UWI wind speed relative to ECMWF first-guess (FG) fields showed a slightly lower standard deviation (1.48 m/s, was 1.50 m/s). Bias levels were a bit less negative (on average -0.84 m/s, was -0.89 m/s). Relative standard deviation for wind direction has enhanced (33.0 degrees, was 31.6 degrees).

Ocean calibration shows that inter-node and inter-beam dependencies of bias levels are similar. Average bias level was stable (-0.54 dB; see Figure 4).

The ECMWF operational assimilation and forecast system was not changed during Cycle 163.

The Cycle-averaged evolution of performance relative to ECMWF first-guess (FG) winds is displayed in Figure 1. Figure 2 shows global maps of the over Cycle 163 averaged UWI data coverage and wind climate, Figure 3 for performance relative to FG winds.

2. ERS-2 statistics from 22 November 2010 to 27 December 2010

2.1 Sigma0 bias levels

The average sigma0 bias levels (compared to simulated sigma0's based on ECMWF model FG winds) stratified with respect to antenna beam, ascending or descending track and as function of incidence angle (i.e. across-node number) is displayed in Figure 4.

Compared to Cycle 162, inter-node and inter-beam dependencies between the fore and aft beam are similar. Average bias level was stable (-0.54 dB), being 0.15 dB more negative than for nominal data in 2000 (around -0.4 dB; see Figure 1 of the reports for Cycle 48 to 59). The asymmetry is slightly worse than that of one year ago (see report for Cycle 153).

Long-term variations correlate with the yearly cycle, which, given the non-global coverage, is understandable. Therefore, the method of ocean calibration will probably only provide accurate information on calibration levels for globally or yearly averaged data sets.

The data volume of descending tracks was about 20% lower than for ascending tracks.

2.2 Incidence angles

From simple geometrical arguments it follows that variations in yaw attitude will lead to asymmetries between the incidence angles of the fore and aft beam. Indeed, this has been observed. Figure 5 gives a time evolution of this asymmetry. Also in this Figure, the occasions for which the combined k_p-yaw quality flag was set are indicated by red stars. The relation with incidence-angle asymmetries is obvious.

During Cycle 163 the behaviour was slightly more volatile than for Cycle 162.

Solar activity was mild during Cycle 163. The Earth was under the influence of solar storms around 23 and 27 November 2010 (source: www.spaceweather.com). These events did not seem to have an effect on ERS-2 attitude control.

2.3 Distance to cone history

The distance to the cone history is shown in Figure 6. Curves are based on data that passed all QC, including the test on the k_p-yaw flag, and subject to the land and sea-ice check at ECMWF (see cyclic report 88 for details).

Like for previous Cycles, time series are (due to lack of statistics) very noisy, especially for the near-range nodes. Most spikes were found to be the result of low data volumes.

Compared to Cycle 162, the average level was stable (1.22), and is higher (by 12%) than for nominal data (see top panel Figure 1).

The fraction of data that did not pass QC is displayed in Figure 6 as well (dashed curves).

2.4 UWI minus First-Guess history

In Figure 7, the UWI minus ECMWF first-guess wind-speed history is plotted. The history plot shows a few peaks, which are usually the result of low data volume.

Figure 11 displays the locations for which UWI winds were more than 8 m/s weaker (top panel), respectively more than 8 m/s stronger (lower panel) than FG winds. Like for Cycle 162, such collocations are isolated, and often indicate meteorologically active regions, for which UWI data and ECMWF model field show reasonably small differences in phase and/or intensity. Deviations near the poles are the result of imperfect sea-ice flagging.

Two examples for which UWI and ECMWF winds differ significantly are presented in Figure 12. The top panel shows a slight shift in an elongated front in the Atlantic, while the lower panel displays a case south of Greenland where the wind direction of ERS-2 and ECMWF differ over a large patch.

Average bias levels and standard deviations of UWI winds relative to FG winds are displayed in Table 1. From this it follows that the bias of UWI winds was slightly less negative (-0.84 m/s, was -0.89 m/s), being around the level of nominal data in 2000.

On a longer time scale seasonal bias trends are observed (see Figure 1). As was highlighted in previous cyclic reports, it is believed that the yearly trend is partly induced by changing local geophysical conditions.

The standard deviation of UWI wind speed versus ECMWF FG was, compared to Cycle 162, slightly lower (1.48 m/s, was 1.50 m/s).

For Cycle 163 the (UWI - FG) direction standard deviations were mostly ranging between 20 and 40 degrees (Figure 8). Average STDV for UWI wind direction was higher than for Cycle 162 (33.0 degrees, was 31.8 degrees). For at ECMWF de-aliased winds (Figure 10) performance is stable (STDV 19.8 degrees, unchanged).

	Cycle 162		Cycle 163	
	UWI	CMOD4	UWI	CMOD4
speed STDV	1.50	1.49	1.48	1.48
node 1-2	1.57	1.54	1.57	1.53
node 3-4	1.47	1.46	1.48	1.47
node 5-7	1.41	1.4	1.43	1.43
node 8-10	1.43	1.44	1.42	1.42
node 11-14	1.49	1.48	1.43	1.43
node 15-19	1.48	1.48	1.45	1.46
speed BIAS	-0.89	-0.88	-0.84	-0.83
node 1-2	-1.52	-1.49	-1.42	-1.39
node 3-4	-1.22	-1.16	-1.13	-1.08
node 5-7	-0.93	-0.89	-0.86	-0.83
node 8-10	-0.72	-0.71	-0.68	-0.67
node 11-14	-0.65	-0.67	-0.65	-0.65
node 15-19	-0.66	-0.68	-0.66	-0.68
direction STDV	31.60	19.8	33.00	19.80
direction BIAS	-2.70	-2.70	-2.00	-2.10

Table 1: Biases and standard deviation of ERS-2 versus ECMWF FG winds in m/s for speed and degrees for direction.

2.5 Scatter plots

Scatterplots of FG winds versus ERS-2 winds are displayed in Figures 13 to 16. Values of standard deviations and biases are slightly different from those displayed in Table 1. Reason for this is that, for plotting purposes, the in 0.5 m/s resolution ERS-2 winds have been slightly perturbed (increases scatter with 0.02 m/s), and that zero wind-speed ERS-2 winds have been excluded (decreases scatter by about 0.05 m/s).

The scatterplot of UWI wind speed versus FG (Figure 13) is very similar to that for (at ECMWF inverted) de-aliased CMOD4 winds (Figure 15). It confirms that the ESACA inversion scheme is working properly.

Winds derived on the basis of CMOD5 are displayed in Figure 16. The relative standard deviation is lower than for CMOD4 winds (1.45 m/s versus 1.50 m/s). Compared to ECMWF FG, CMOD5 winds are 0.33 m/s slower.

Figure Captions:

Figure 1: Evolution of the performance of the ERS-2 scatterometer averaged over 5-weekly Cycles from 12 December 2001 (Cycle 69) to 27 December 2010 (end Cycle 163) for the UWI product (solid, star) and de-aliased winds based on CMOD4 (dashed, diamond). Results are based on data that passed the UWI QC flags. For Cycle 85 two values are plotted; the first value for a global set, the second one for a regional set (for details see the corresponding cyclic report). Dotted lines represent values for Cycle 59 (5 December 2000 to 17 January 2001), i.e. the last stable Cycle of the nominal period. From top to bottom panel are shown the normalized distance to the cone (CMOD4 only) the standard deviation of the wind speed compared to FG winds, the corresponding bias (for UWI winds the extremes in node-wise averages are shown as well), and the standard deviation of wind direction compared to FG.

Figure 2: Average number of observations per 12H and per 125km grid box (top panel) and wind climate (lower panel) for UWI winds that passed the UWI flags QC and a check on the collocated ECMWF land and sea-ice mask.

Figure 3: The same as Figure 2, but now for the relative bias (top panel) and standard deviation (lower panel) with ECMWF first-guess winds.

Figure 4: Ratio of $\langle \sigma_0^{0.625} \rangle / \langle \text{CMOD4}(\text{First Guess})^{0.625} \rangle$ converted in dB for the fore beam (solid line), mid beam (dashed line) and aft beam (dotted line), as a function of incidence angle for descending and ascending tracks. The thin lines indicate the error bars on the estimated mean. First-guess winds are based on the in time closest (+3h, +6h, +9h, or +12h) T799 forecast field, and are bilinearly interpolated in space.

Figure 5: Time series of the difference in incidence angle between the fore and aft beam. Red stars indicate the occurrences for which the combined kp-yaw flag was set.

Figure 6: Mean normalized distance to the cone computed every 6 hours for nodes 1-2, 3-4, 5-7, 8-10, 11-14 and 15-19). The dotted curve shows the number of incoming triplets in logarithmic scale (1 corresponds to 60,000 triplets) and the dashed one indicates the fraction of complete (based on the land and sea-ice mask at ECMWF) sea-located triplets rejected by ESA flags, or by the wind inversion algorithm (0: all data kept, 1: no data kept).

Figure 7: Mean (solid line) and standard deviation (dashed line) of the wind speed difference UWI - first guess for the data retained by the quality control.

Figure 8: Same as Fig. 7, but for the wind direction difference. Statistics are computed for winds stronger than 4 m/s.

Figures 9 and 10: Same as Fig. 7 and 8 respectively, but for the de-aliased CMOD4 data.

Figure 11: Locations of data during Cycle 163 for which UWI winds are more than 8 m/s weaker (top panel) respectively stronger (lower panel) than FG, and on which QC on UWI flags and the ECMWF land/sea-ice mask was applied.

Figure 12: A case in the North Atlantic on 14 December 2010 (top panel) and south of Greenland for 26 December 2010 (lower panel). Red and blue barbs represent UWI winds and ECMWF FG winds, respectively.

Figure 13: Two-dimensional histogram of first guess and UWI wind speeds, for the data kept by the UWI flags, and QC based on the ECMWF land and sea-ice mask. Circles denote the mean values in the y-direction, and squares those in the x-direction.

Figure 14: Same as Fig. 13, but for wind direction. Only winds stronger than 4m/s are taken into account.

Figure 15: Same as Fig. 13, but for de-aliased CMOD4 winds.

Figure 16: Same as Fig. 13, but for de-aliased CMOD5 winds.

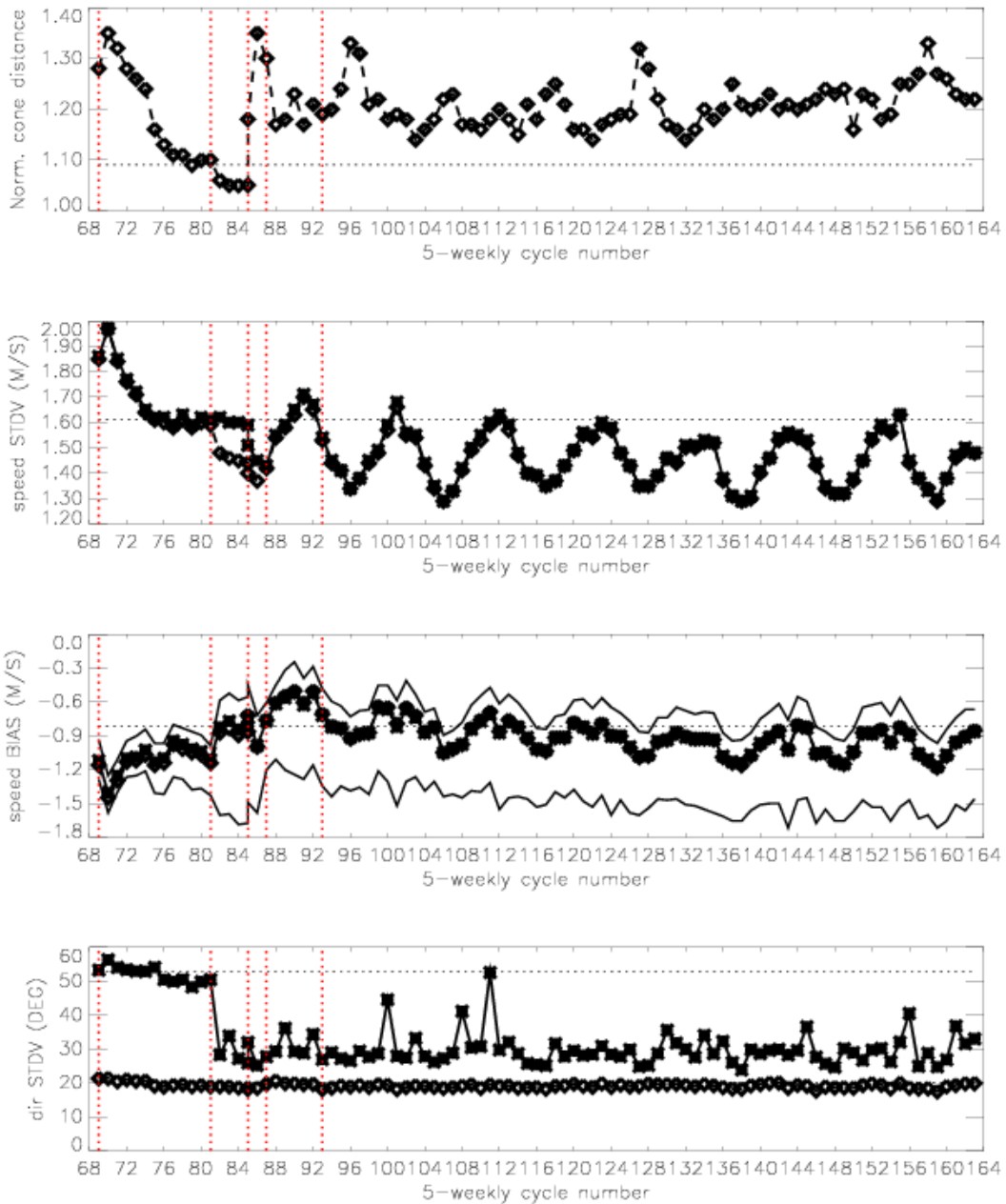
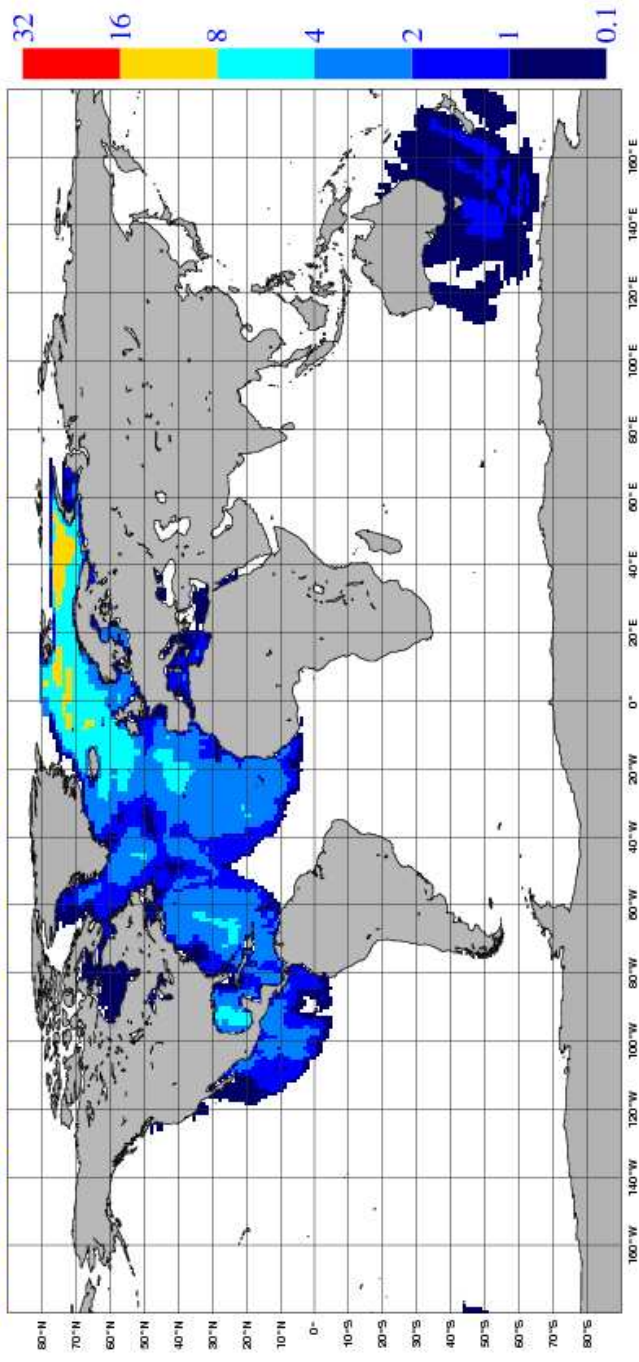


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NOBS (ERS-2 UWI), per 12H, per 125km box
average from 2010112300 to 2010122718 GLOB:1.95



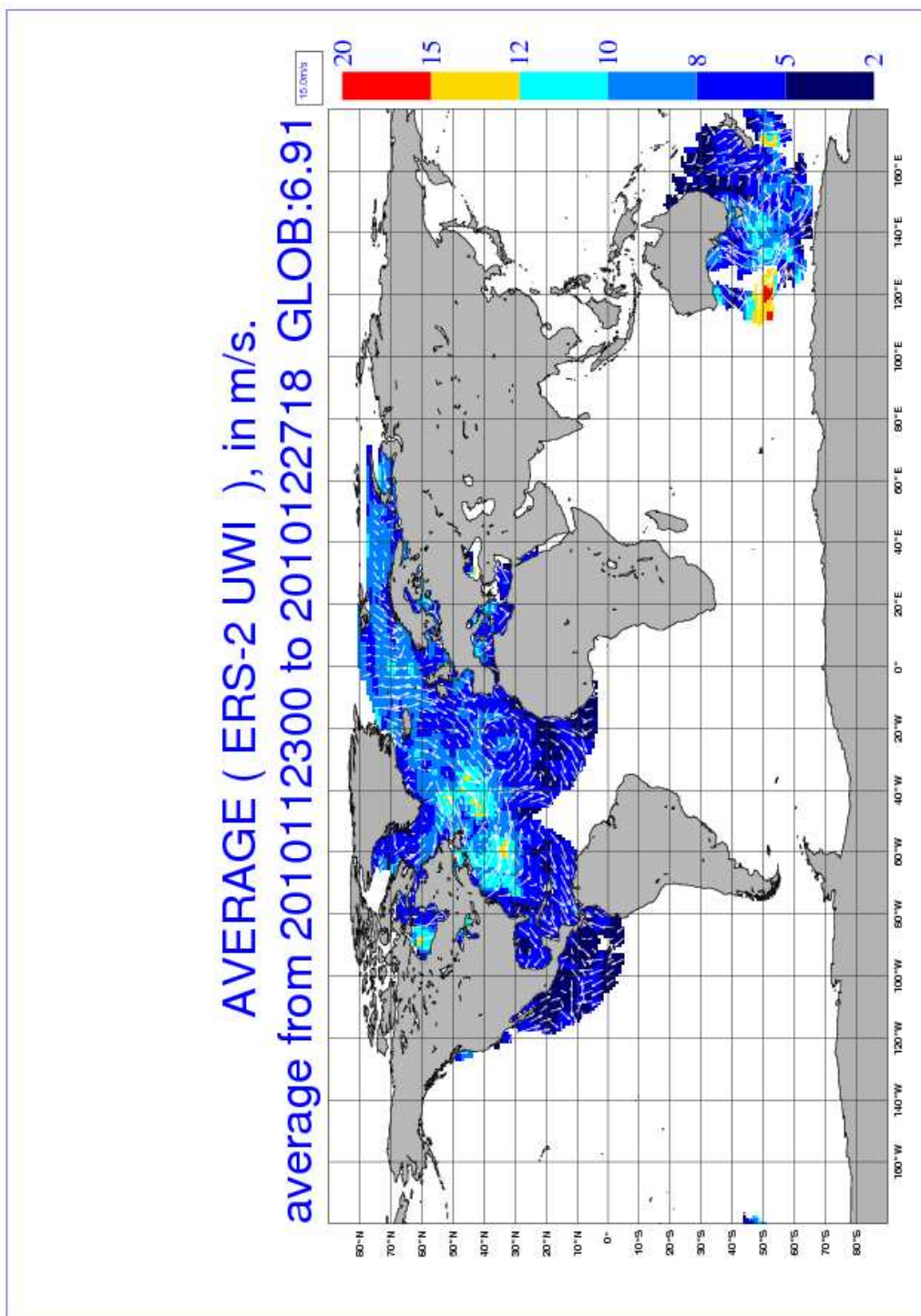
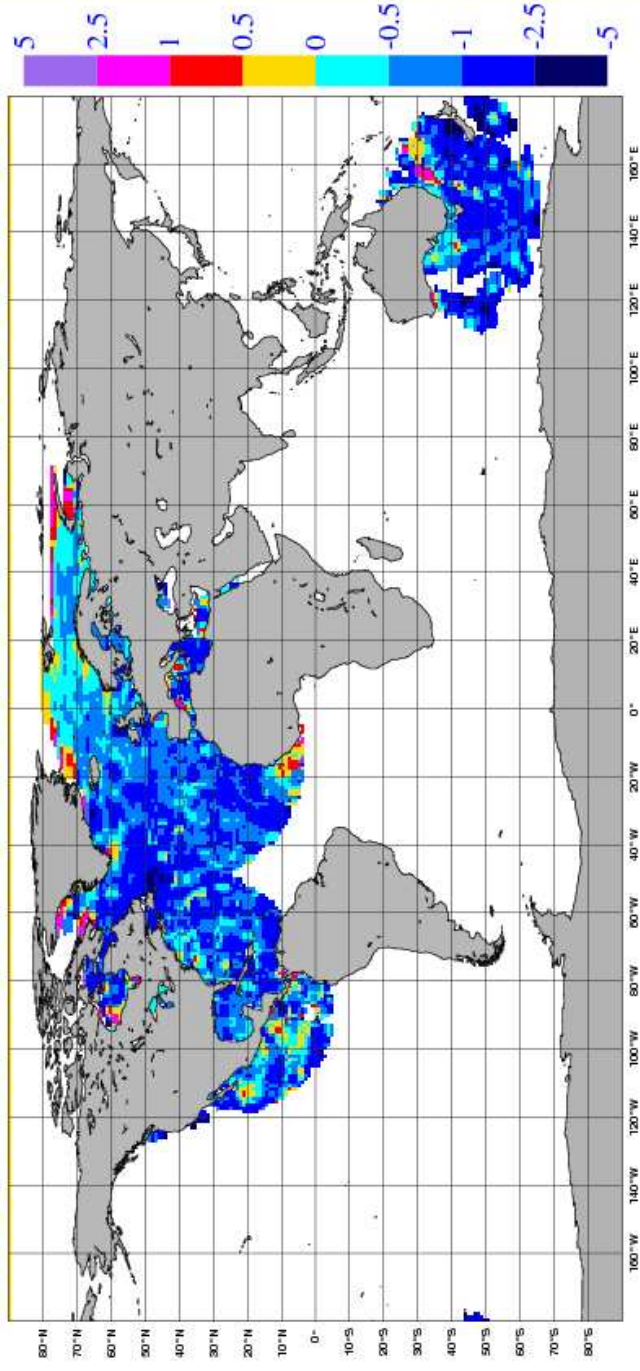


Figure 2: Average number of observations per 12H and per 125km grid box (top panel) and wind climate (lower panel) for UWI winds that passed the UWI flags QC and a check on the collocated ECMWF land and sea-ice mask.

BIAS (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2010112300 to 2010122718 GLOB:-0.92



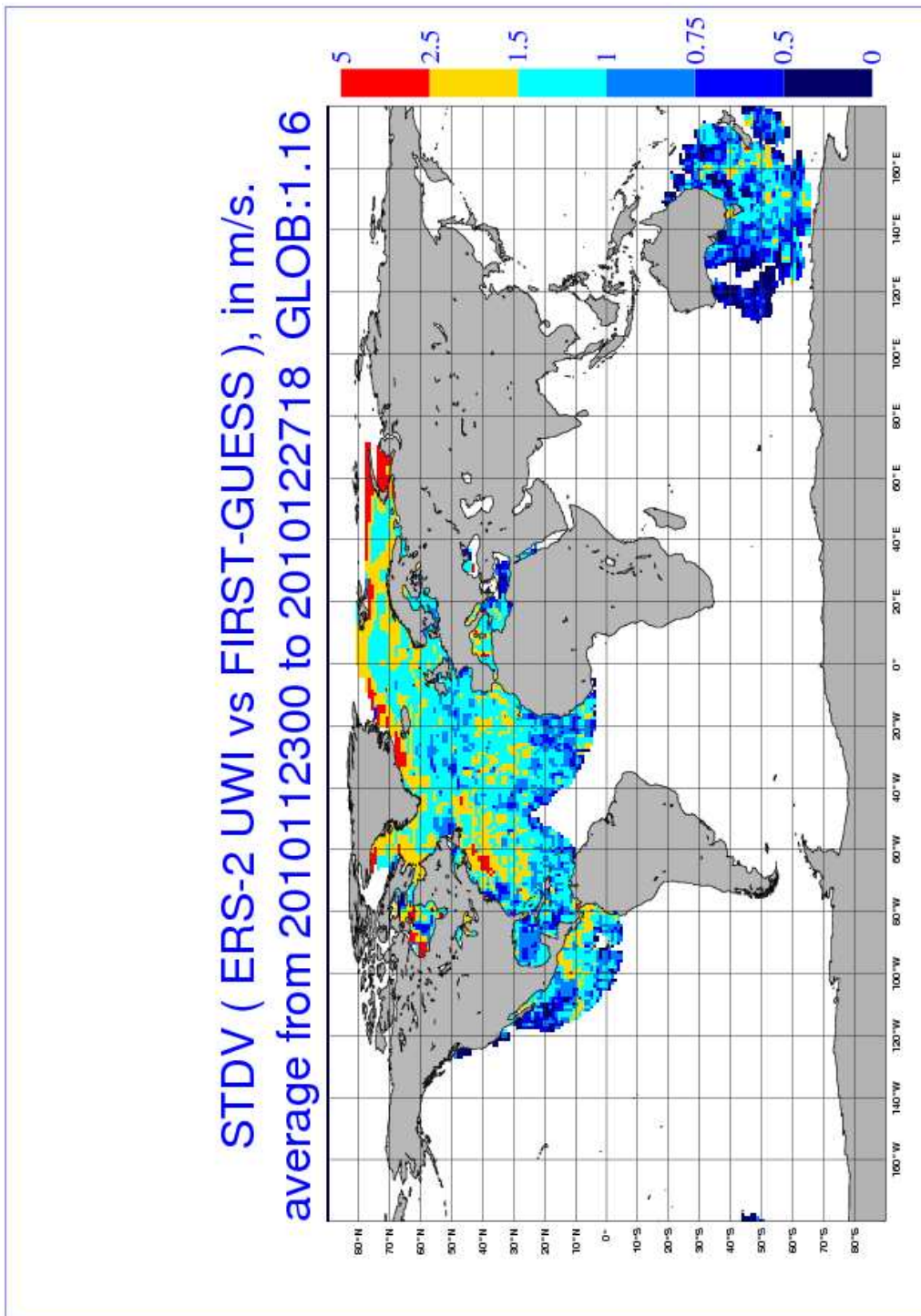


Figure 3: The same as Figure 2, but now for the relative bias (top panel) and standard deviation (lower panel) with ECMWF first-guess winds.

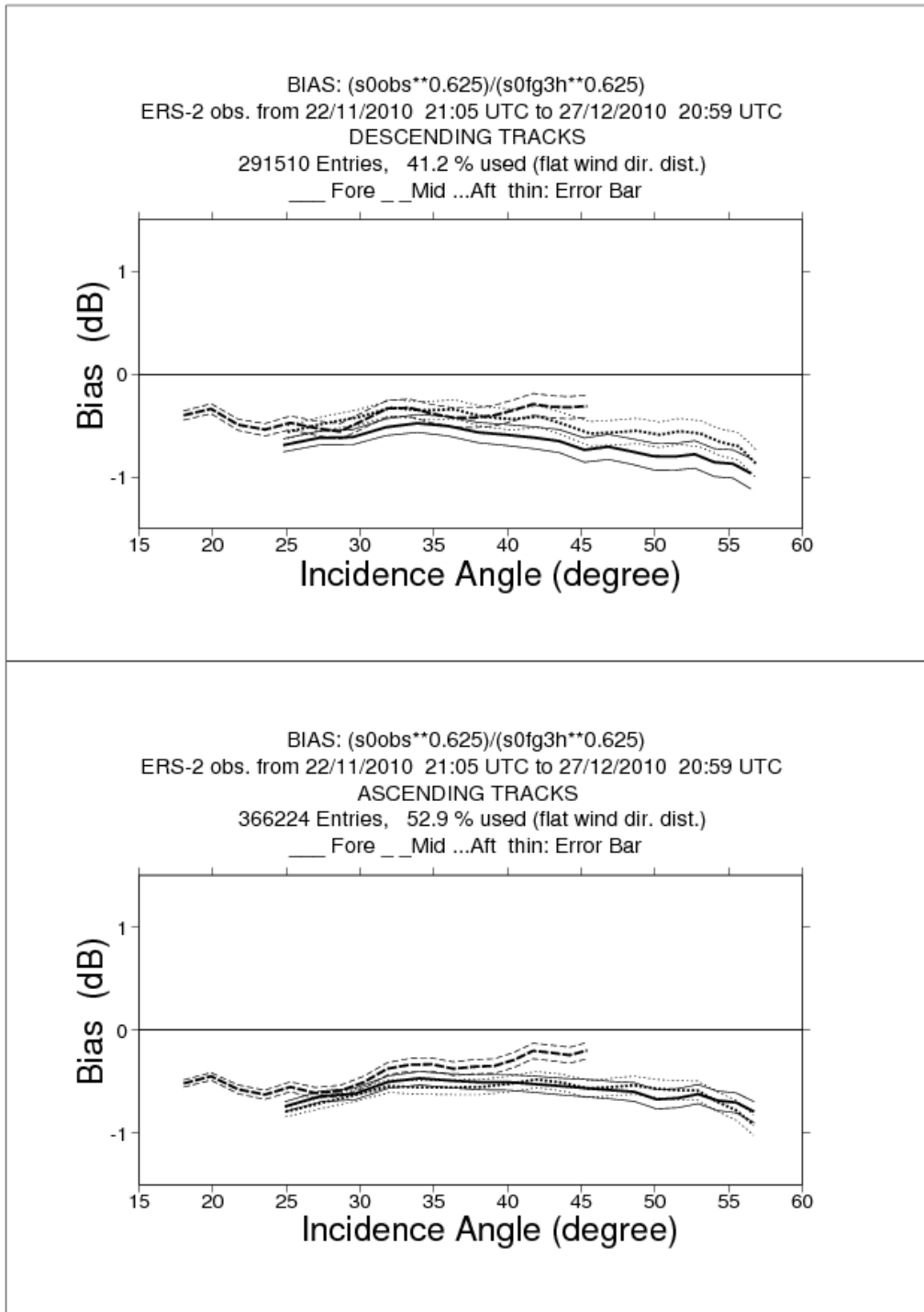


Figure 4: Ratio of $\langle \sigma_0^{0.625} \rangle / \langle \text{CMOD4}(\text{First Guess})^{0.625} \rangle$ converted in dB for the fore beam (solid line), mid beam (dashed line) and aft beam (dotted line), as a function of incidence angle for descending and ascending tracks. The thin lines indicate the error bars on the estimated mean. First-guess winds are based on the in time closest (+3h, +6h, +9h, or +12h) T799 forecast field, and are bilinearly interpolated in space.

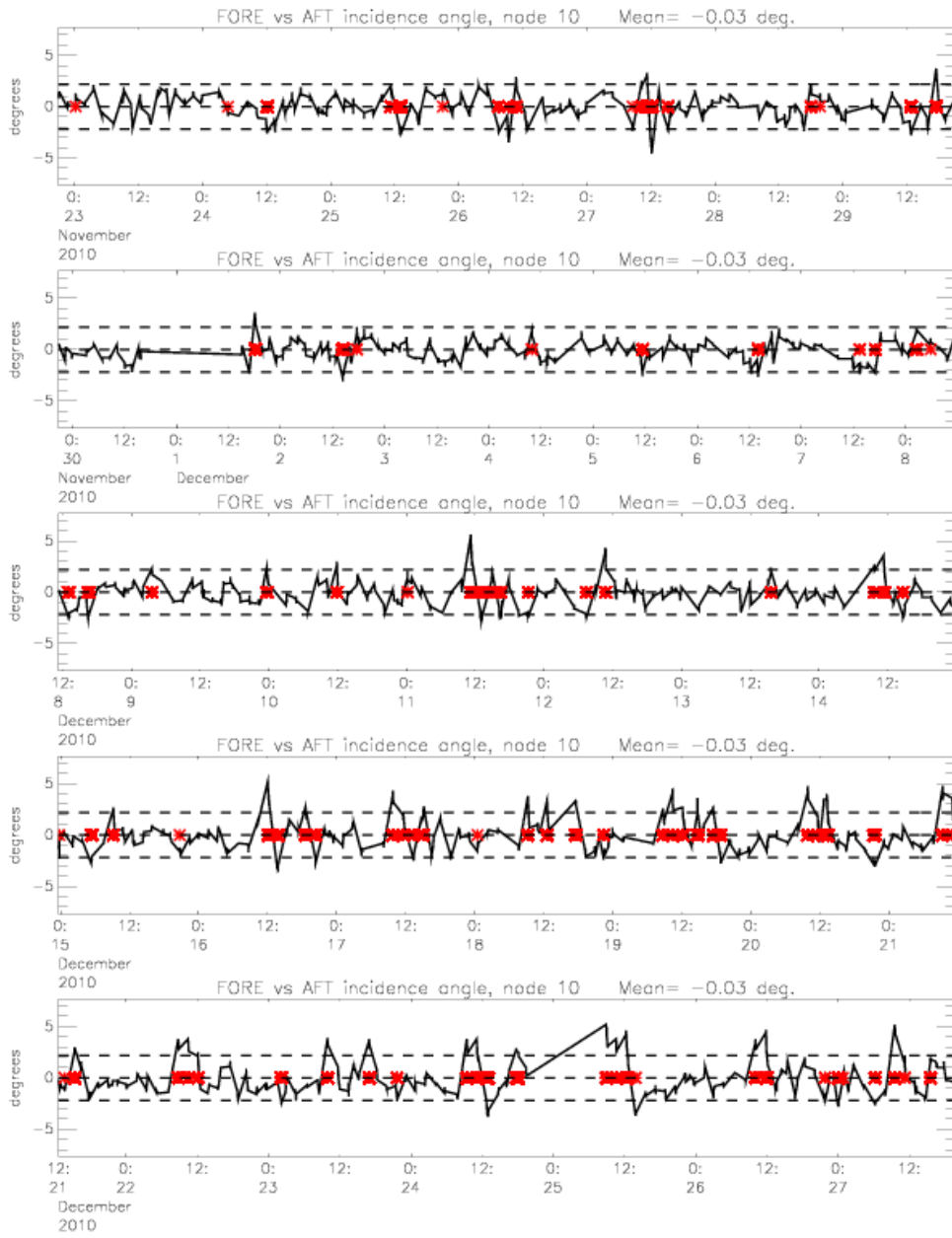


Figure 5: Time series of the difference in incidence angle between the fore and aft beam. Red stars indicate the occurrences for which the combined kp-yaw flag was set.

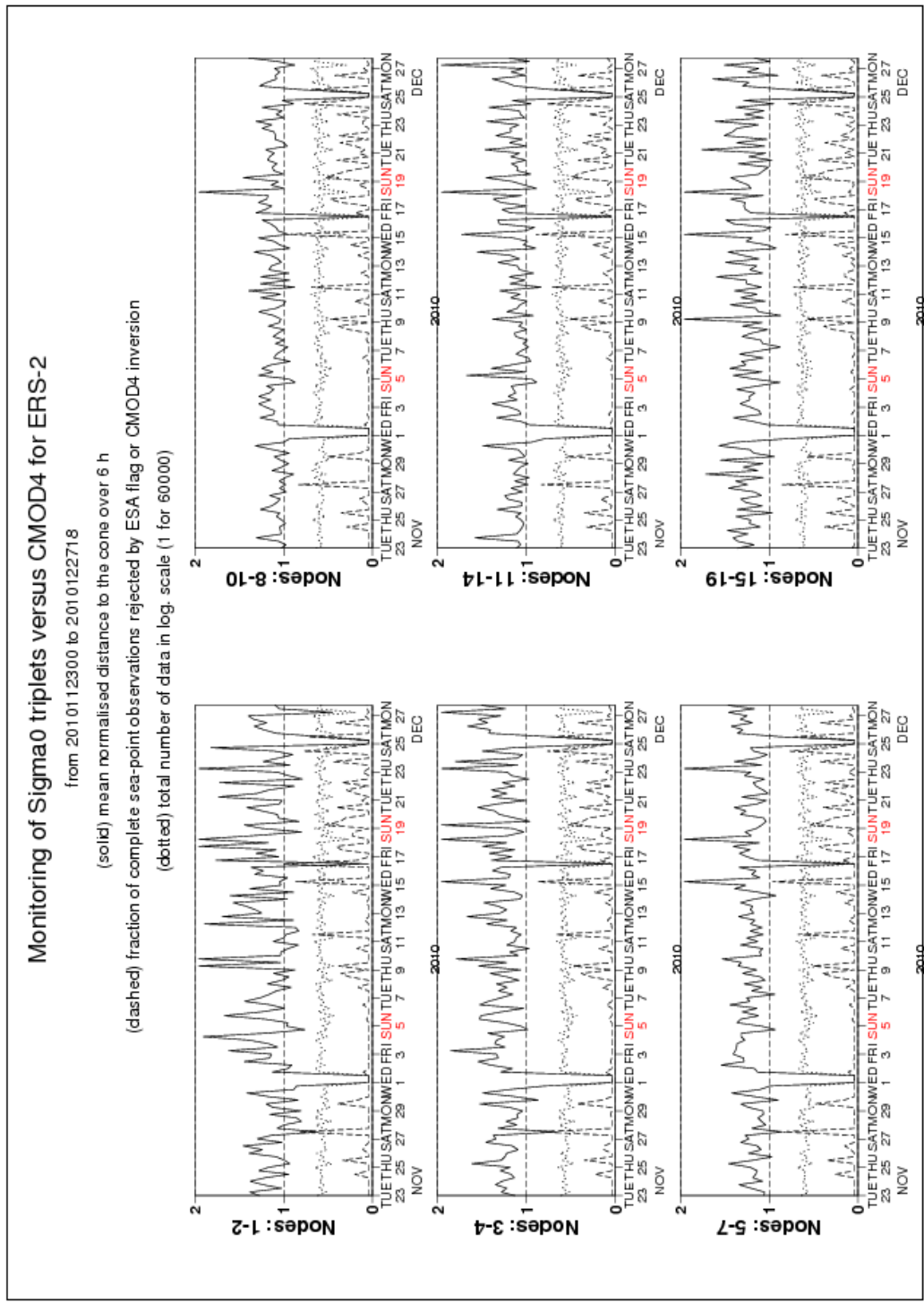


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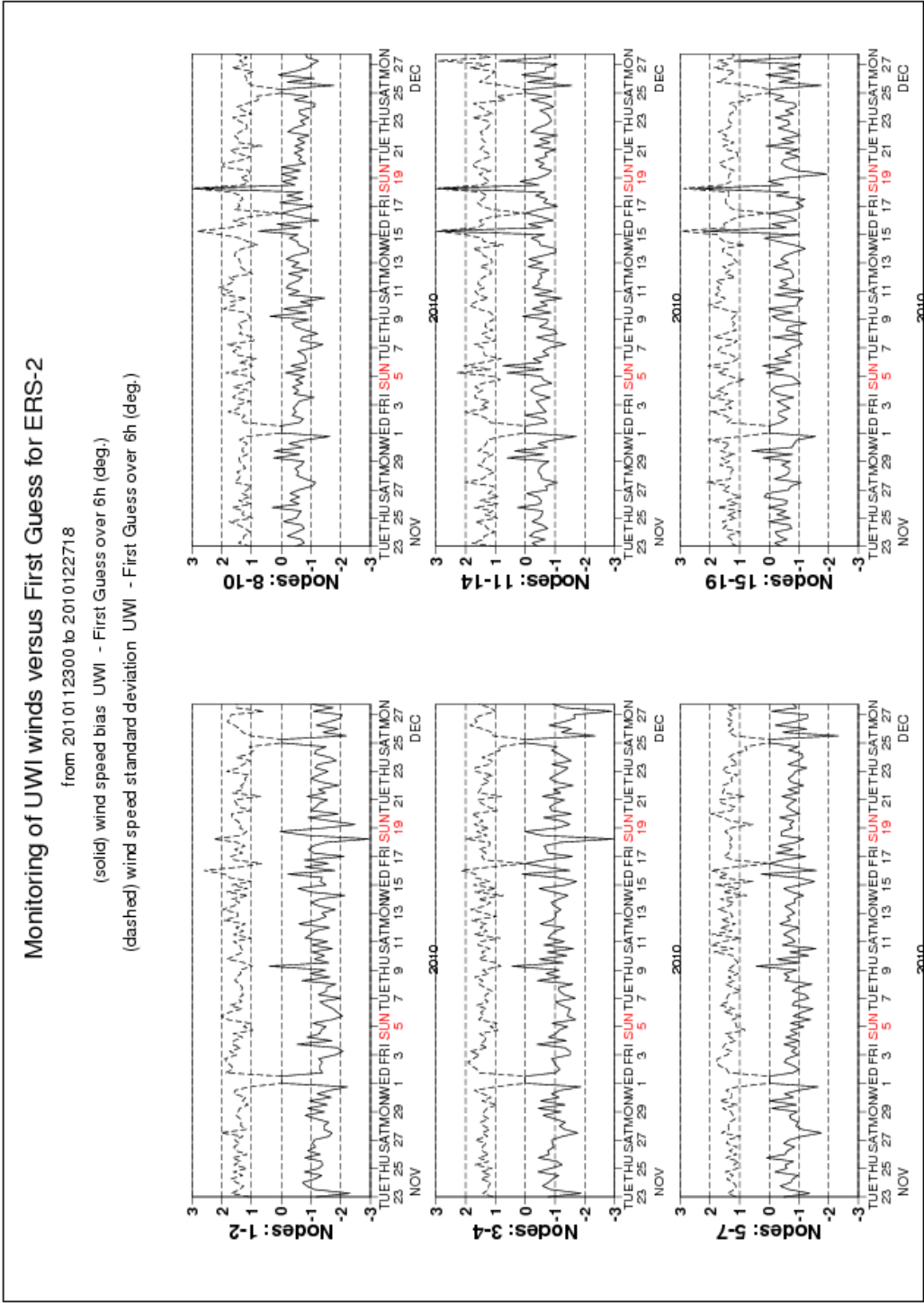


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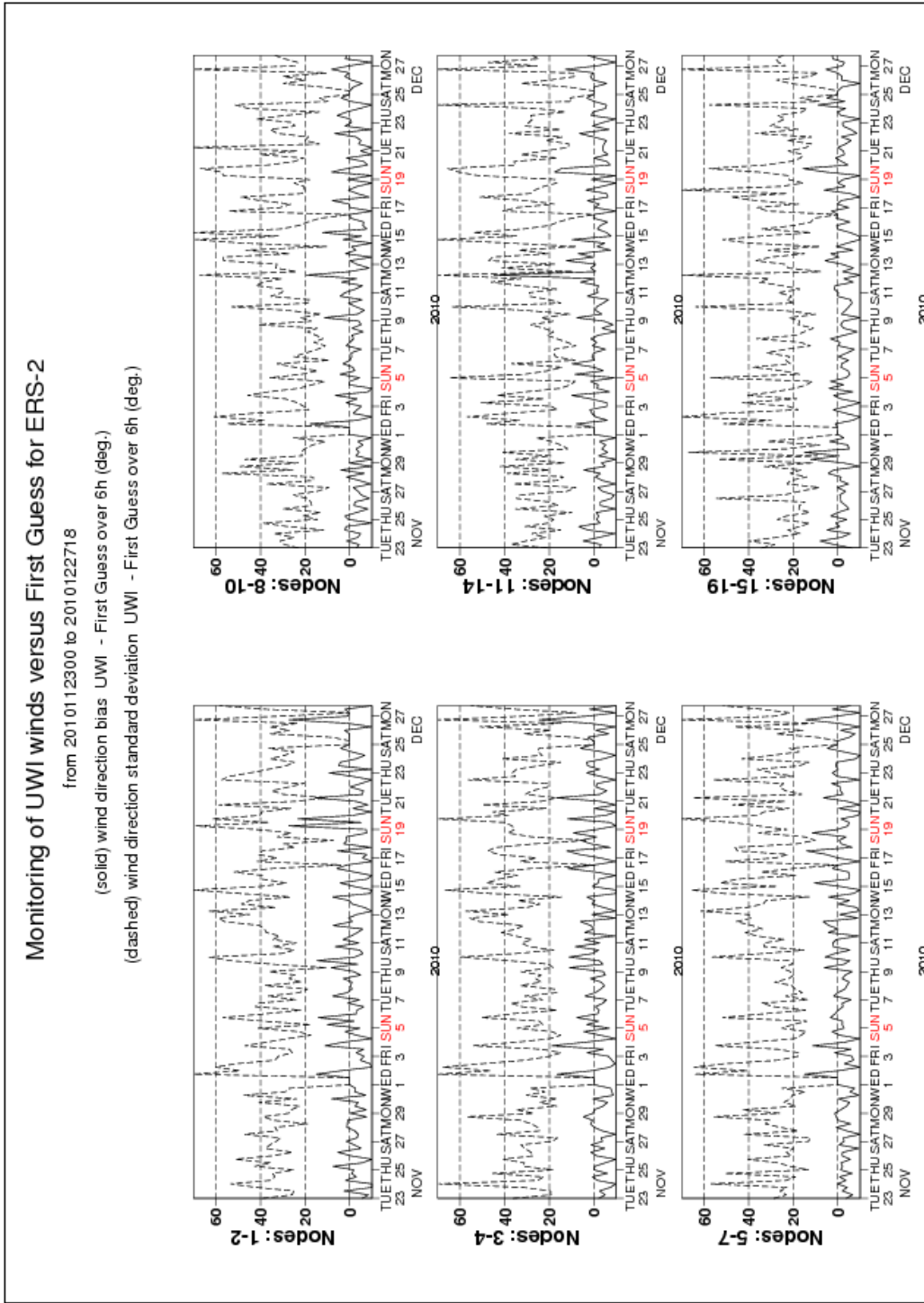
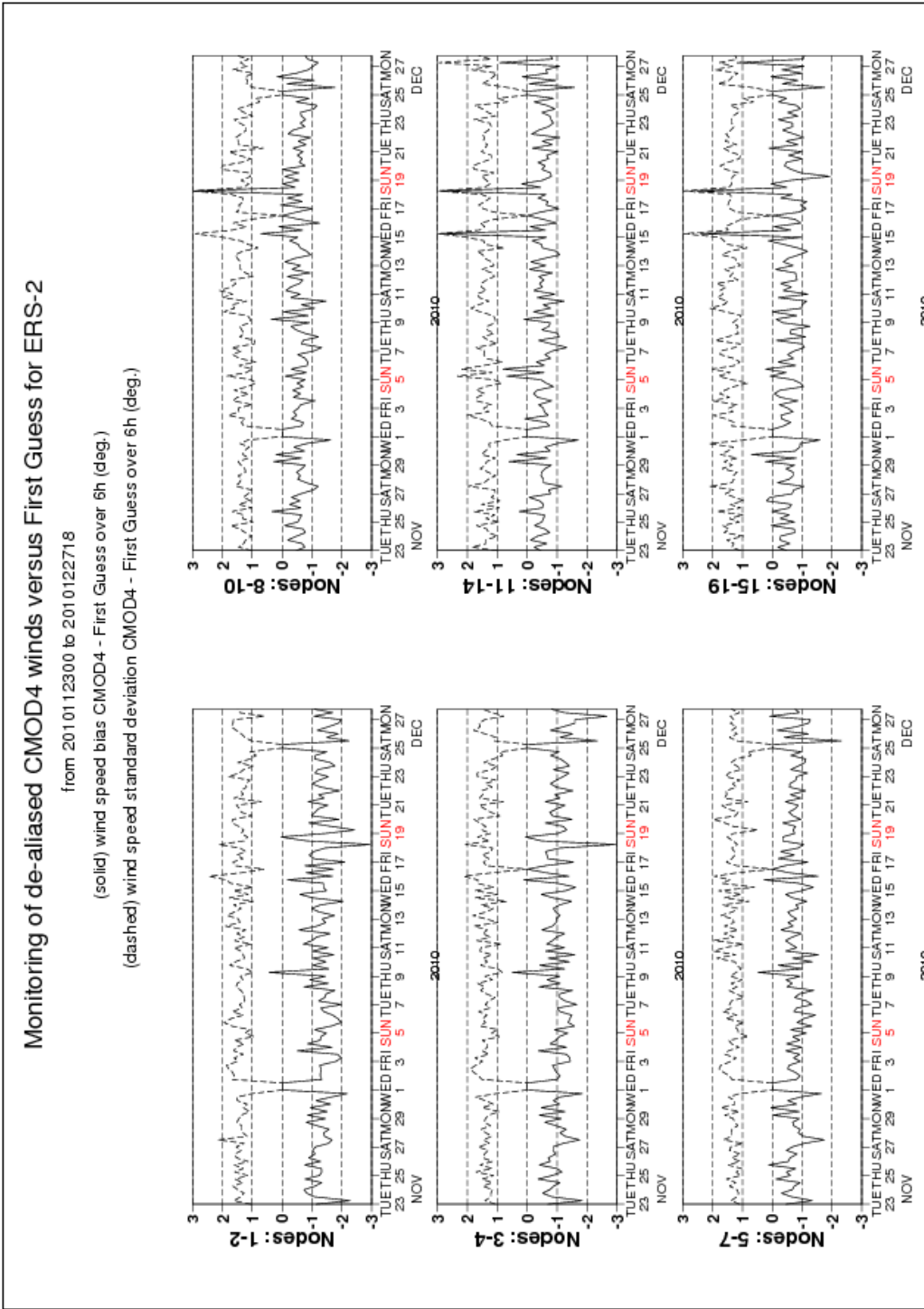
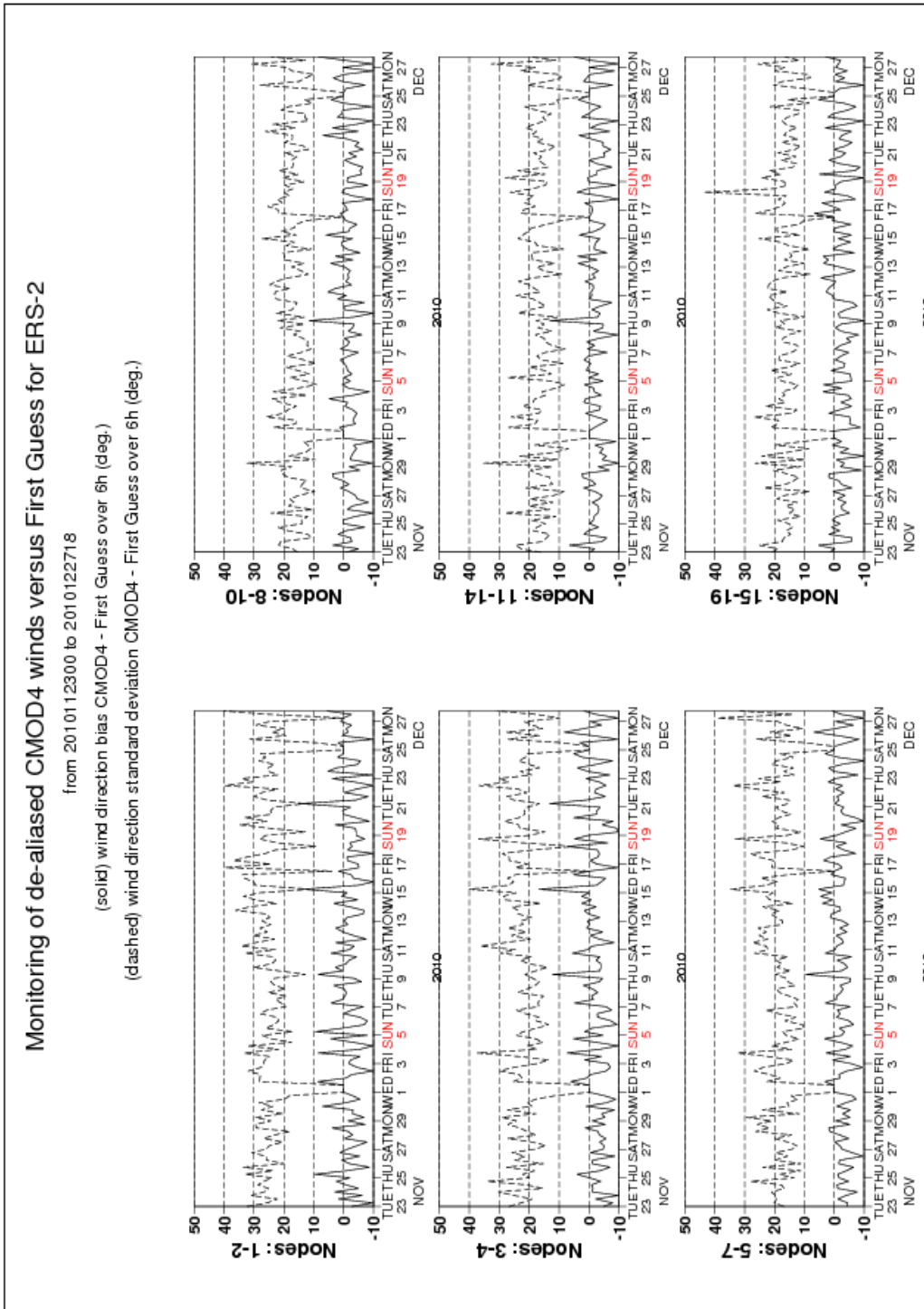


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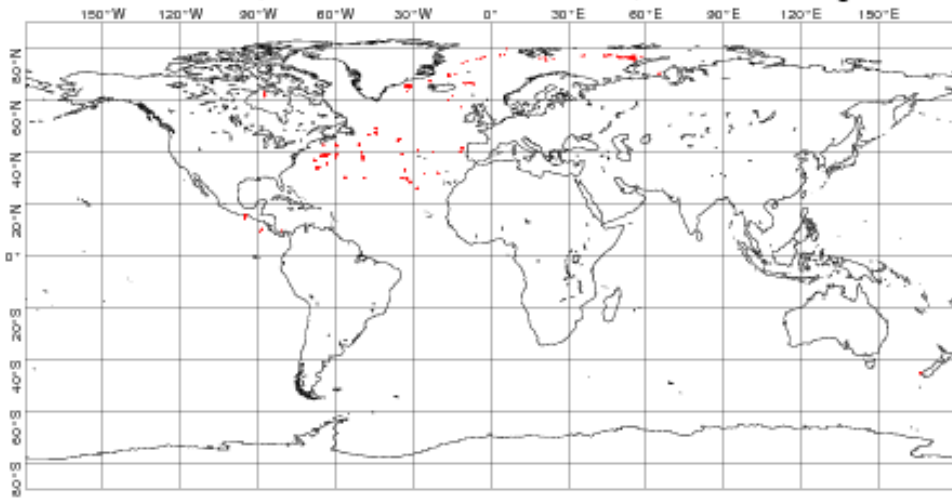


Figures 9: Same as Fig. 7 but for the de-aliased CMOD4 data.



Figures 10: Same as Fig. 8 but for the de-aliased CMOD4 data

UWI winds more than 8 m/s weaker than ECMWF First Guess
CYCLE 163, 2010112300 to 2010122718, QC on ESA flags



UWI winds more than 8 m/s stronger than ECMWF First Guess
CYCLE 163, 2010112300 to 2010122718, QC on ESA flags

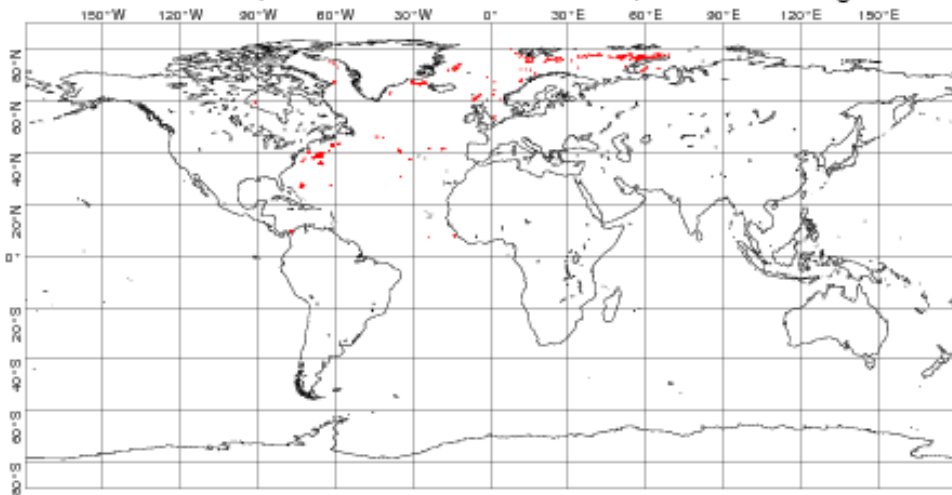


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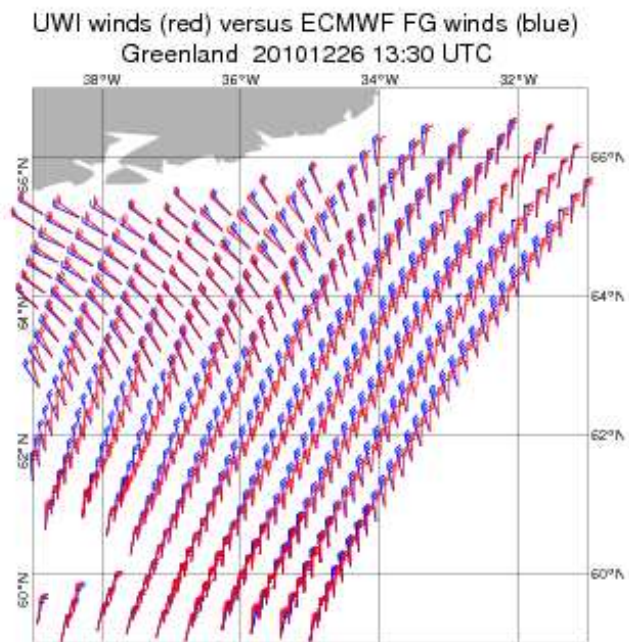
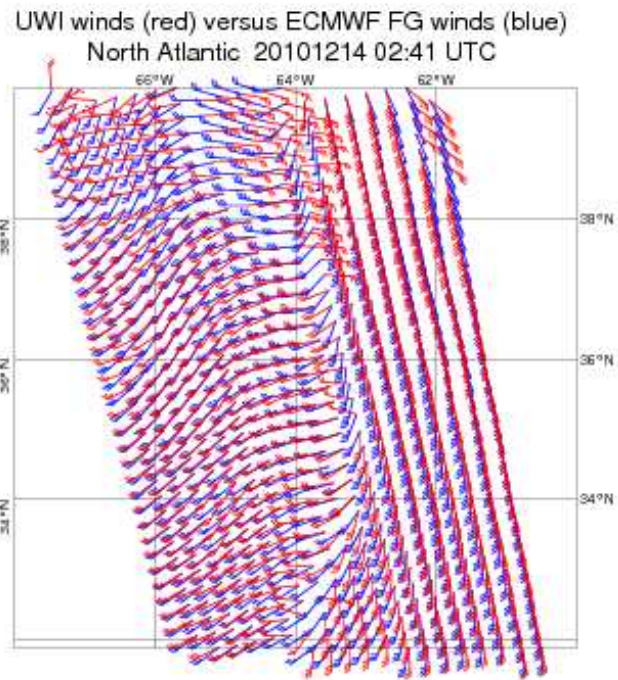


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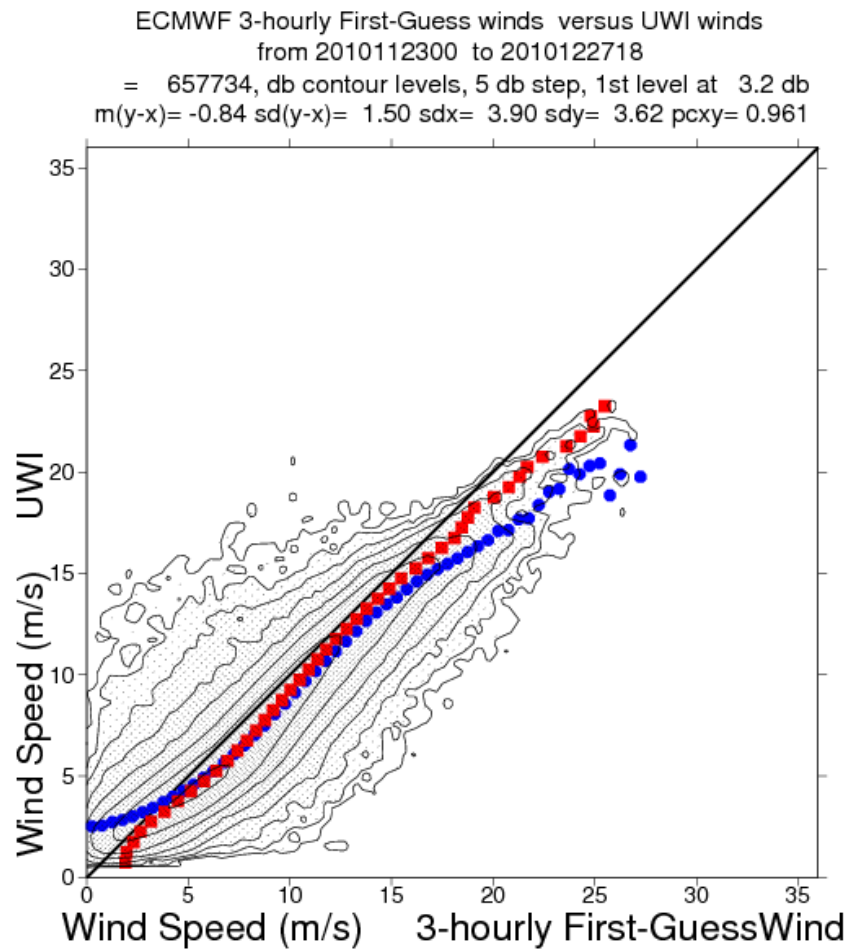


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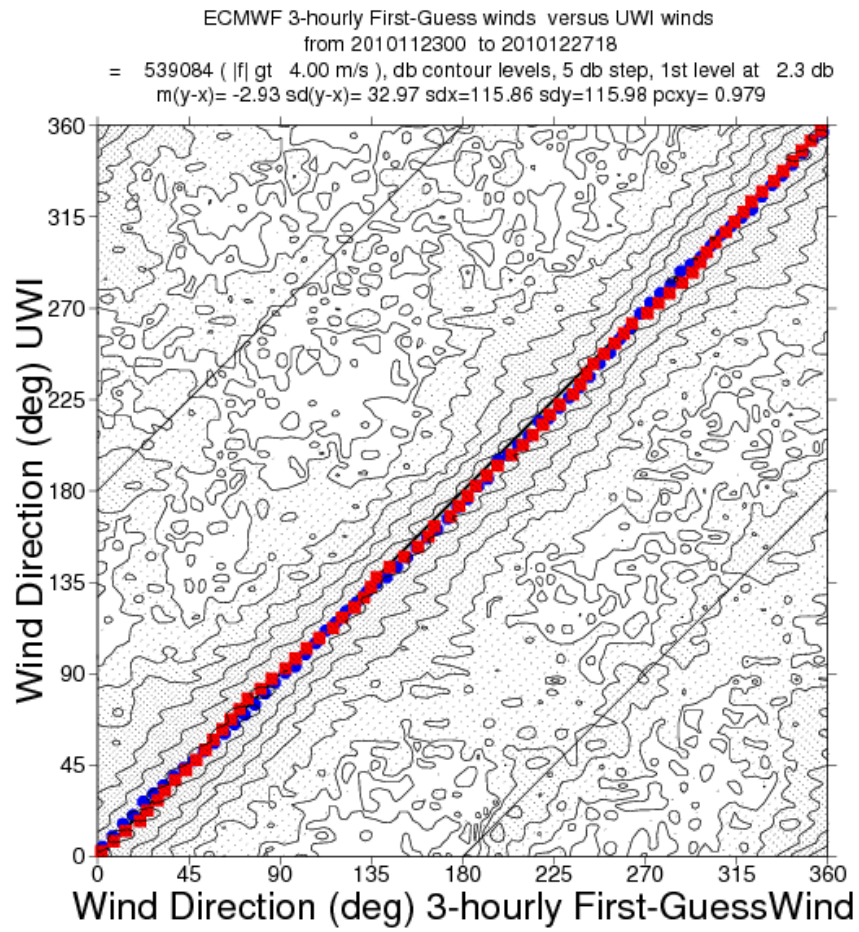


Figure 14: Same as Fig. 13, but for wind direction. Only winds stronger than 4m/s are taken into account.

ECMWF 3-hourly First-Guess winds versus CMOD4 winds
from 2010112300 to 2010122718
= 652885, db contour levels, 5 db step, 1st level at 3.1 db
 $m(y-x) = -0.83$ $sd(y-x) = 1.50$ $sdx = 3.88$ $sd_y = 3.61$ $pcxy = 0.960$

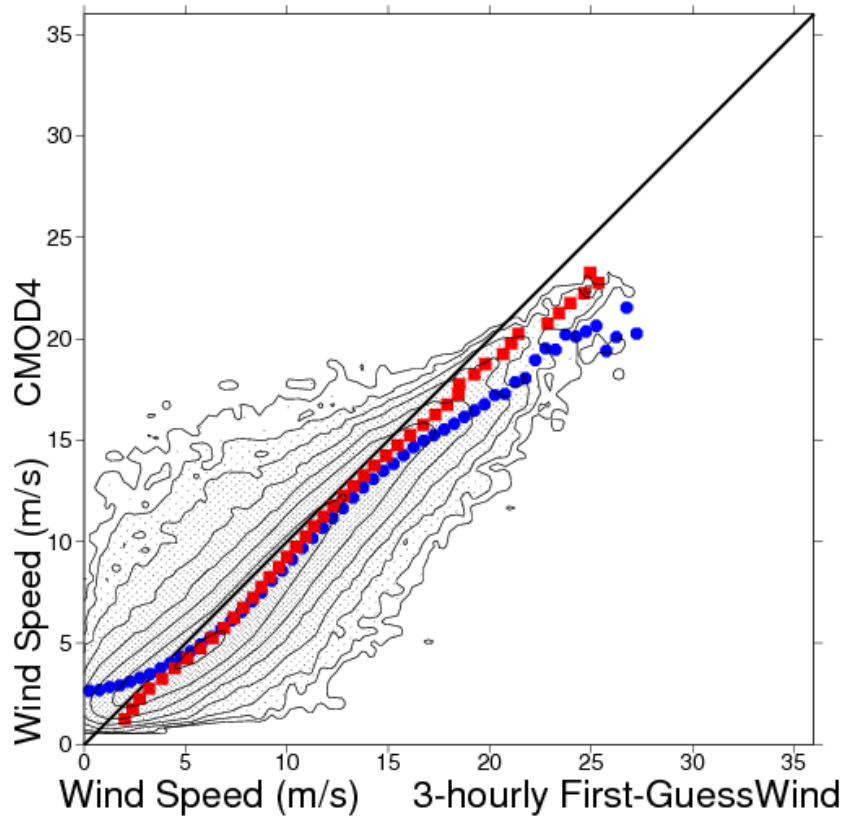


Figure 15: Same as Fig. 13, but for de-aliased CMOD4 winds.

ECMWF 3-hourly First-Guess winds versus CMOD5 winds
from 2010112300 to 2010122718
= 644322, db contour levels, 5 db step, 1st level at 3.1 db
 $m(y-x) = -0.33$ $sd(y-x) = 1.45$ $sdx = 3.84$ $sd_y = 3.70$ $pcxy = 0.963$

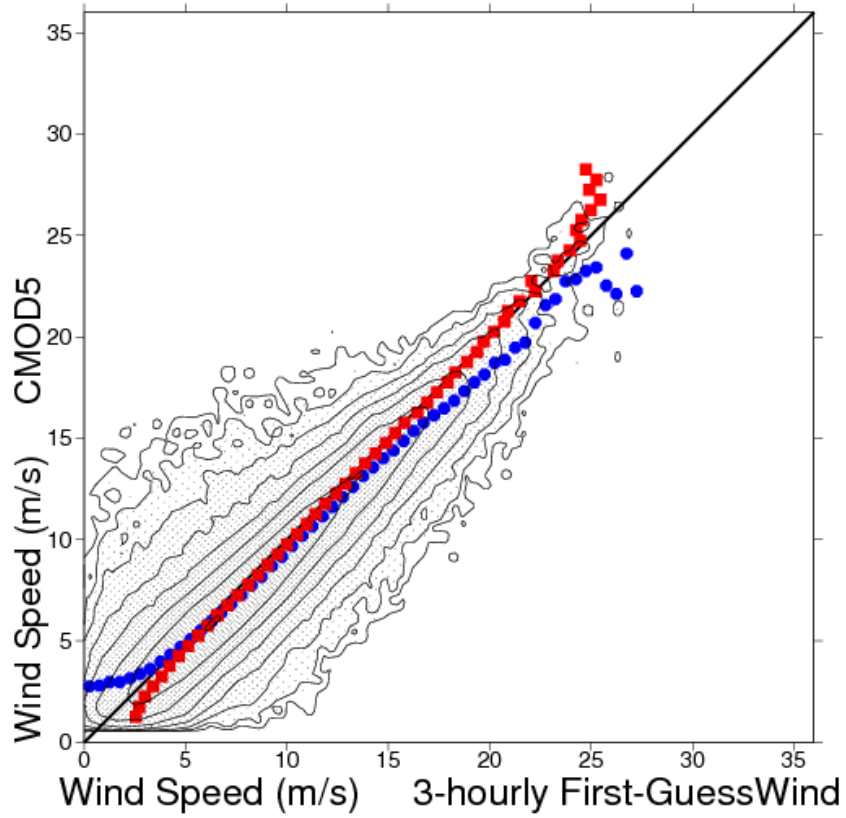


Figure 16: Same as Fig. 13, but for de-aliased CMOD5 winds.