Monitoring statistics of the ERS-2 scatterometer for ESA

cycle 108

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1 Introduction

The quality of the UWI product was monitored at ECMWF for cycle 108. 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 were applied.

During cycle 108 data was received between 21:02 UTC 15 August 2005 and 20:56 UTC 19 September 2005. No data was received for the 6-hourly batches centred around 12 UTC 26 August 2005 and 18 UTC 15 September 2005.

Data is being recorded whenever within the visibility range of a ground station. For cycle 108 data coverage was over the North-Atlantic, part of the Mediterranean, the Caribbean, the Gulf of Mexico, a small part of the Pacific west from the US Canada and Central America, the Chinese and Japanese Sea, and the Southern Ocean south of Australia and New Zealand (see Figure 2).

Between 17 August and 9 September 2005, the asymmetry between the fore and aft incidence angles showed more pronounced and volatile peaks than for previous cycles. The k_p-yaw ESA flag was set accordingly. Within this period, apart from one geomagnetic storm (24-25 August 2005), solar activity was low. Another period of enhanced solar activity (11-15 September 2005, source: www.spaceweather.com) occurred after the fluctuations in the asymmetry in incidence angles had returned to a nominal behaviour.

Compared to cycle 107, the UWI wind speed relative to ECMWF first-guess (FG) fields showed an increased standard deviation (from 1.33 to 1.42 m/s), representing a natural seasonal trend, also observed one year ago. Bias levels have become slightly less negative (from -0.98 m/s to -0.95 m/s), the same pattern being observed for QuikSCAT data within the area of ERS-2 data coverage.

On three occasions within cycle 108 the performance of the UWI wind direction was highly degraded. Since at ECMWF de-aliased winds did not show such a behaviour, these indicate temporary problems with the de-aliasing of the UWI product. For the remainder of cycle 108, the performance of the UWI wind direction was nominal.

Ocean calibration shows that the large inter-node and inter-beam dependency of bias levels as observed for the previous three cycles were reduced. The large negative average bias level diminished as well (-0.71 dB, was -0.92 dB, see Figure 4).

The ECMWF assimilation/forecast system was not changed during cycle 108.

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 108 averaged UWI data coverage and wind climate, Figure 3 for performance relative to FG winds.

2 ERS-2 statistics from 16 August to 19 September 2005

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.

Inter-node and inter-beam (mainly mid versus the fore/aft beam) dependencies are much smaller than for cycles 105 to 107. However, backscatter from the mid antenna is still about 0.2 dB higher than that for the other two antennas. Average bias level is less negative (-0.71 dB, was -0.92 dB), being comparable to that for nominal data in 2000 (see Figure 1 of the reports for cycle 48 to 59).

The data volume of descending tracks was about 11% lower than for ascending tracks.

2.2 Incidence angles

For ESACA, across-node binning is, like the old processor, retained on a 25km mesh. 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, showing rapid variations, which are typical for yaw attitude errors. 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 108 there were several periods (18-20 August 2005, 23-25 August 2005, 31 August-8 September 2005) in which asymmetries were more volatile and showing larger peaks than encountered in previous cycles. The Earth was subject to geomagnetic storms between 24-25 August 2005 and 11-15 September 2005 (source: www.spacewather.com). Although this first period coincided with large asymmetries in incidence angle, there was virtually no solar activity during the other volatile periods.

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 cycle 107, 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 107, the average level was lower (from 1.23 to 1.17), and is now about 7% higher than for nominal data (see top panel Figure 1).

2.4 UWI minus First-Guess wind history

In Figure 7, the UWI minus ECMWF first-guess wind-speed history is plotted.

The history plot shows several peaks, most of which are related to low data volumes. Similar results apply for the history of de-aliased CMOD4 winds versus FG (Figure 9).

Figure 11 displays the locations for which UWI winds were more than 8 m/s weaker (top panel) and more than 8 m/s stronger (lower panel) than FG winds. Like for cycle 107, the number of such collocations is low. Two cases are presented in Figure 12. The top panel shows the capture of Typhoon Nabi on 4 September 2005 (Category 3 at that moment), one and a half day before it made landfall on Kyushu, Japan. The agreement between the ERS-2 and ECMWF FG winds is fair. CMOD5 inverted winds up to 50 knots were actively assimilated, deepening the central pressure in the ECMWF model from 973 hPa to 969 hPa, and slightly enhancing maximal model wind speed from 25.6 to 26.2 m/s.

The lower panel of Figure 12 shows a case in the Atlantic, indicating a patch of erroneous looking UWI winds. Although such cases seem reasonably rare, they do occur.

Average bias levels and standard deviations of UWI winds relative to FG winds are displayed in Table 1. From this it is seen that the bias of both the UWI and CMOD4 product have become somewhat less negative, though are still more negative than that for nominal data in 2000 (UWI: -0.95 m/s now, was -0.79 m/s for cycle 59).

The trend of a large increase of negative bias between April and July, followed by a decrease starting in August was also observed in 2004. As was highlighted in the previous cyclic report, it is now believed that this yearly trend is induced by changing local geophysical conditions, variation in the atmospheric density stratification being the most likely candidate. Strong indication for this is a similar trend observed for

	cycle 107		cycle 108	
	UWI	CMOD4	UWI	CMOD4
speed STDV	1.33	1.33	1.42	1.41
node 1-2	1.39	1.38	1.47	1.46
node 3-4	1.35	1.34	1.41	1.40
node 5-7	1.31	1.31	1.38	1.38
node 8-10	1.27	1.28	1.36	1.36
node 11-14	1.29	1.29	1.38	1.38
node 15-19	1.31	1.32	1.41	1.40
speed BIAS	-0.98	-0.99	-0.95	-0.95
node 1-2	-1.38	-1.37	-1.41	-1.39
node 3-4	-1.19	-1.16	-1.20	-1.16
node 5-7	-1.01	-0.99	-1.00	-0.96
node 8-10	-0.87	-0.87	-0.83	-0.82
node 11-14	-0.83	-0.86	-0.76	-0.77
node 15-19	-0.85	-0.90	-0.79	-0.81
direction STDV	28.8	18.7	41.0	19.1
direction BIAS	-3.3	-3.5	-1.7	-3.0

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

QuikSCAT data when restricted to an area well-covered by ERS-2 (20N-90N, 80W-20E). In Figure 17 time series are shown for that area for both ERS-2 (top panel) and QuikSCAT (lower panel) for the period between 1 January 2004 and 19 September 2005 (end of cycle 108). Results are displayed for at ECMWF actively assimilated data, i.e., CMOD5 winds for ERS-2 and 4%-reduced QuikSCAT winds on a 50km resolution. It shows a rapid increase of scatterometer winds relative to model winds since half of July 2005, confirming the observed decreased negative bias for the UWI product.

The standard deviation of UWI wind speed compared to cycle 107 has increased somewhat (1.42 m/s, was 1.33 m/s), the main reason being a less mild wind climate.

For cycle 108 the (UWI - FG) direction standard deviations were mostly ranging between 20 and 40 degrees (Figure 8). However, for three occasions (16-17 August, 22 September and 28-29 September 2005) the performance of the UWI wind direction was highly degraded. For these periods, at ECMWF de-aliased CMOD4-based winds did not show peaks, therefore, indicating temporary problems with the de-aliasing of the UWI product.

Due to these anomalies, the average performance for UWI wind direction was highly reduced (STDV 41.1 degrees, was 28.8 degrees), while that of de-aliased CMOD4 winds was more stable (STDV 19.1 degrees, was 18.7 degrees).

2.5 Scatterplots

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 (1.41 m/s versus 1.44 m/s). Compared to ECMWF FG, CMOD5 winds are 0.49 m/s slower; this average arising from mostly moderate winds. However, also for the more extreme winds there now is a tendency of underestimation.

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 19 September 2005 (end cycle 108) 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 $< \sigma_0^{0.625} > / <$ CMOD4(FirstGuess)$^{0.625} >$ 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) T511 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 k_p-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 108 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: Comparison between UWI (red) and ECMWF FG (blue) winds for Typhoon Nabi on 4 September 2005 (top panel) and an Atlantic case on 13 September 2005 (lower panel).

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.

Figure 17: Wind-speed bias relative to FG winds for actively assimilated ERS-2 winds (based on CMOD5) for nodes 1-19 (top panel) respectively 50-km QuikSCAT (based on the QSCAT-1 model function and reduced by 4%) for nodes 5-34 (lower panel), averaged over the area (20N-90N, 80W-20E), and displayed for the period 01 January 2004 - 19 September 2005. Curves represent centred 15-day running means. Vertical dashed blue lines mark ECMWF model changes.

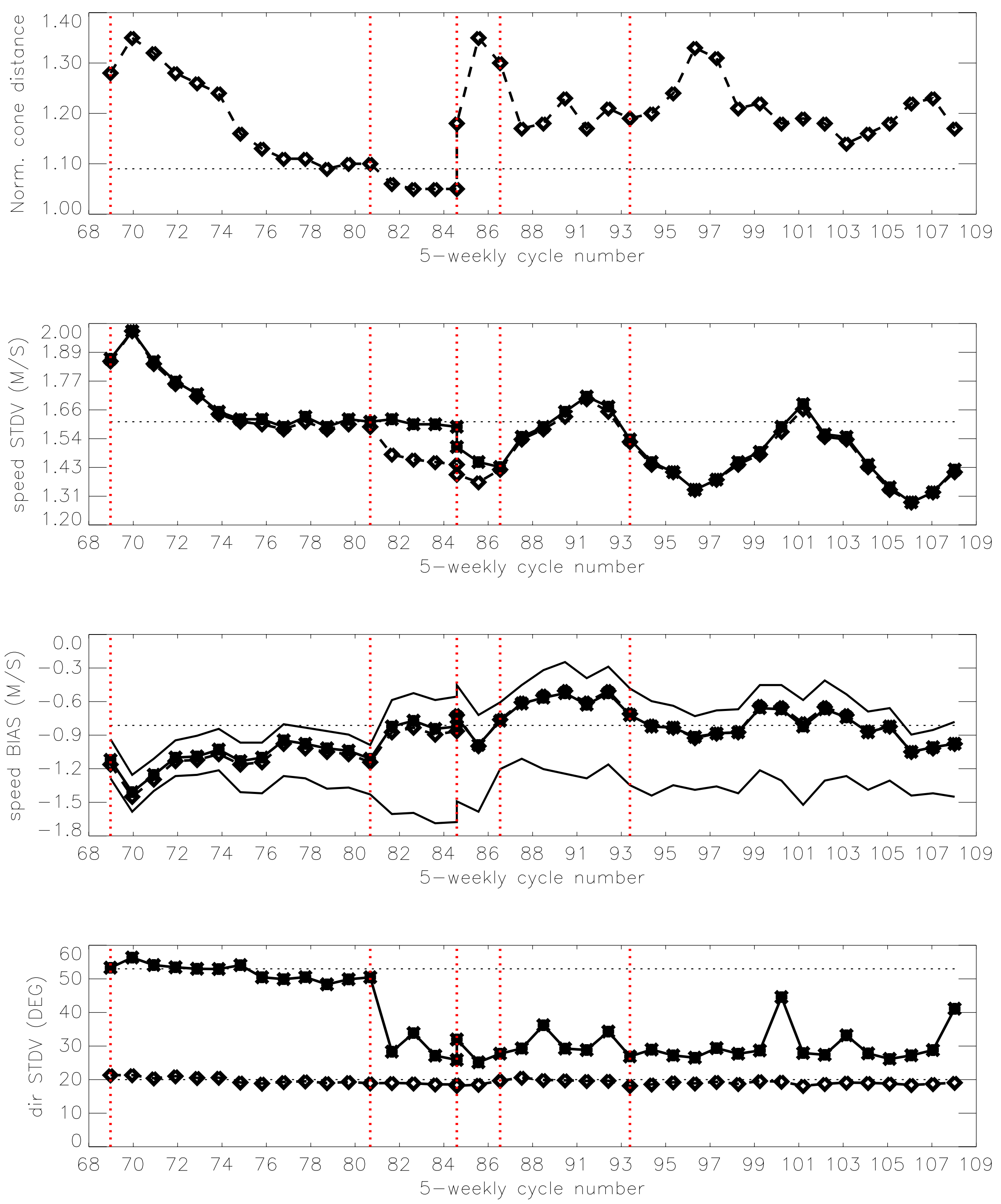

Norm. cone distance
1.40
1.30
1.20
1.10
1.00
68 70 72 74 76 78 80 82 84 86 88 91 93 95 97 99 101 103 105 107 109
5−weekly cycle number
speed STDV (M/S)
2.00
1.89
1.77
1.66
1.54
1.43
1.31
1.20
68 70 72 74 76 78 80 82 84 86 88 91 93 95 97 99 101 103 105 107 109
5−weekly cycle number
speed BIAS (M/S)
0.0
−0.3
−0.6
−0.9
−1.2
−1.5
−1.8
68 70 72 74 76 78 80 82 84 86 88 91 93 95 97 99 101 103 105 107 109
5−weekly cycle number
dir STDV (DEG)
60
50
40
30
20
10
0
68 70 72 74 76 78 80 82 84 86 88 91 93 95 97 99 101 103 105 107 109
5−weekly cycle number

Figure 1

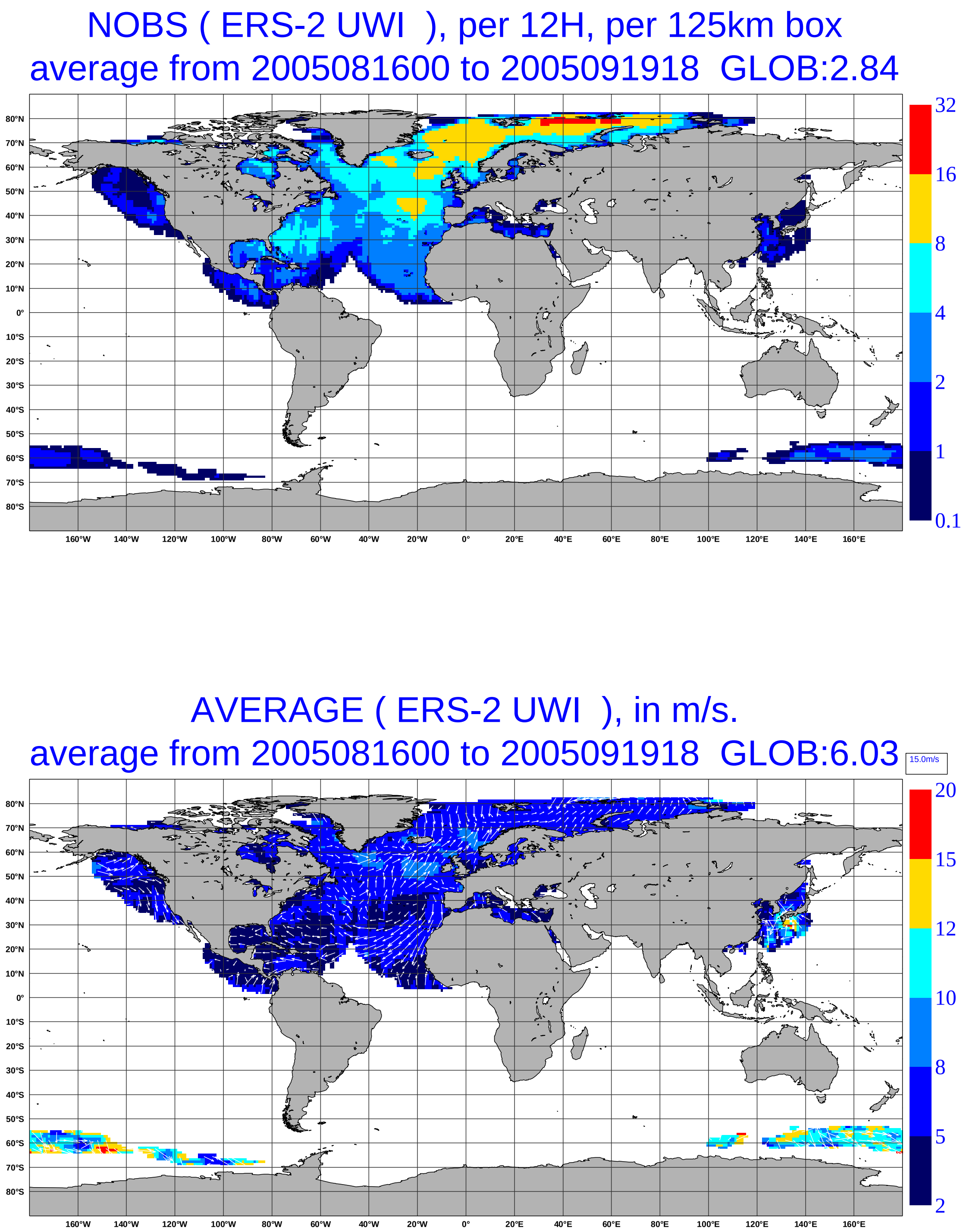

NOBS (ERS-2 UWI), per 12H, per 125km box
average from 2005081600 to 2005091918 GLOB:2.84
0.1
1
2
4
8
16
32
AVERAGE (ERS-2 UWI), in m/s.
average from 2005081600 to 2005091918 GLOB:6.03
15.0m/s
2
5
8
10
12
15
20

Figure 2

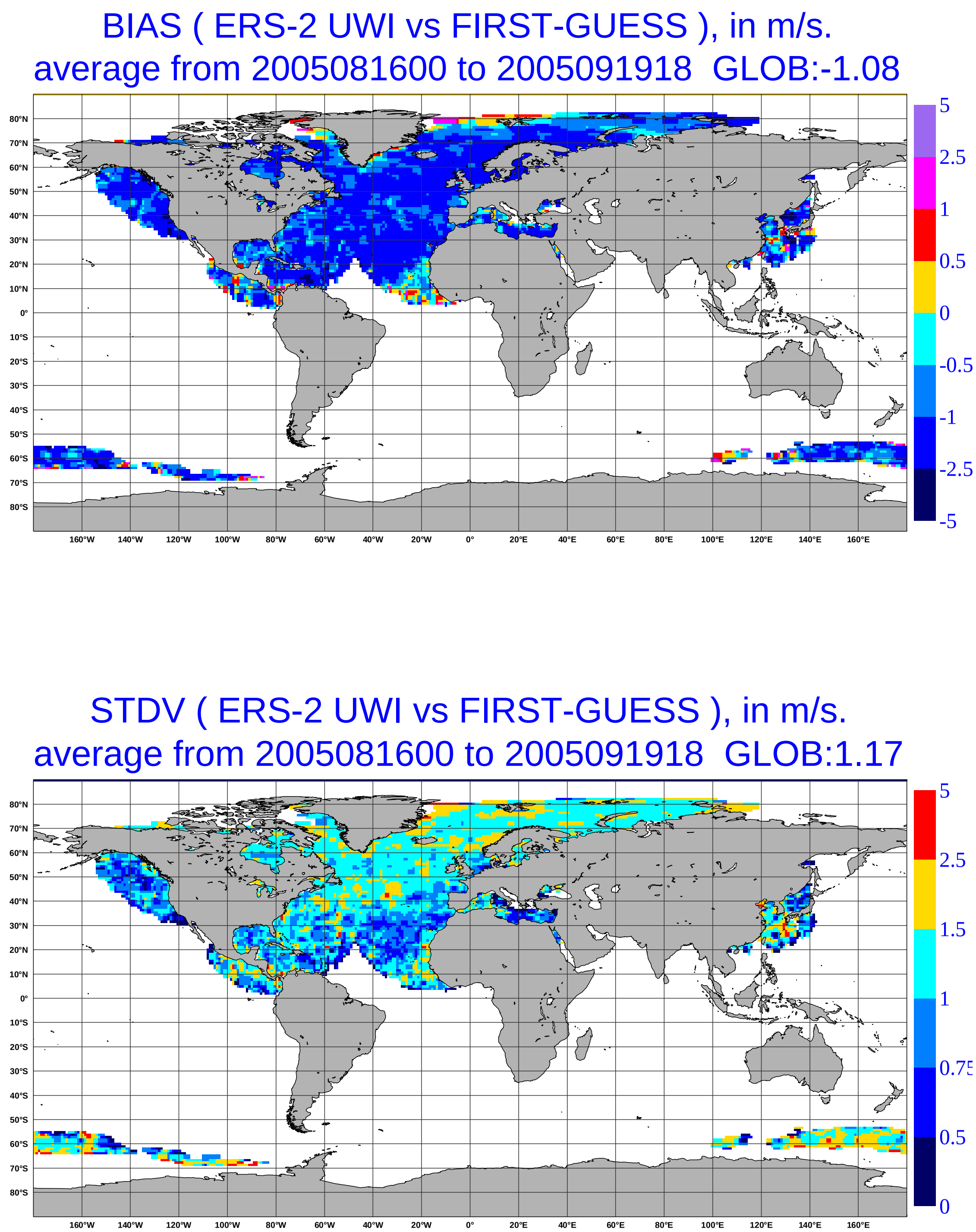

BIAS (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2005081600 to 2005091918 GLOB:-1.08
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S
80°S
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
100°E
120°E
140°E
160°E
5
2.5
1
0.5
0
-0.5
-1
-2.5
-5
STDV (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2005081600 to 2005091918 GLOB:1.17
5
2.5
1.5
1
0.75
0.5
0

Figure 3

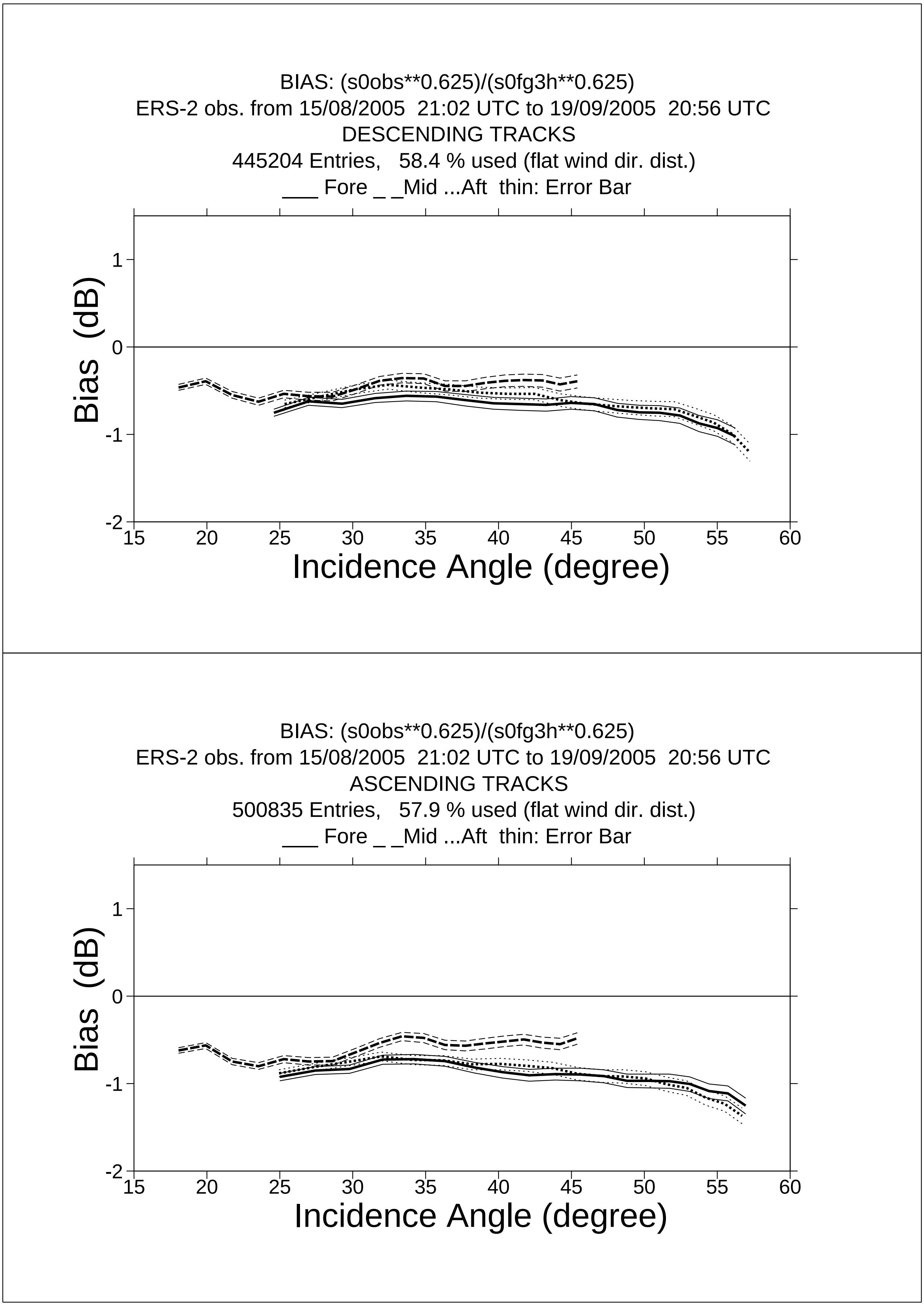

BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 15/08/2005 21:02 UTC to 19/09/2005 20:56 UTC
DESCENDING TRACKS
445204 Entries, 58.4 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
Incidence Angle (degree)
BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 15/08/2005 21:02 UTC to 19/09/2005 20:56 UTC
ASCENDING TRACKS
500835 Entries, 57.9 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
Incidence Angle (degree)

Figure 4

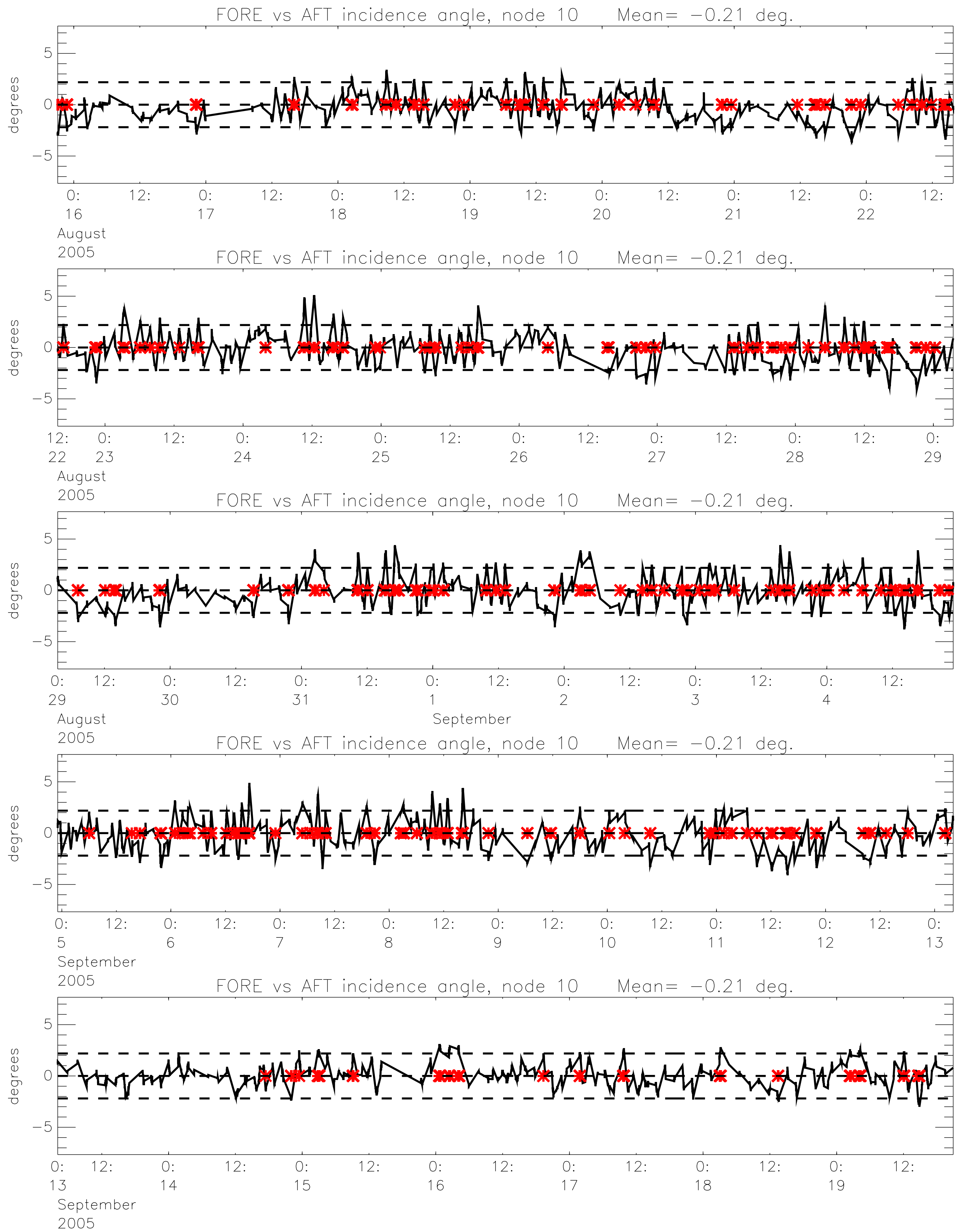
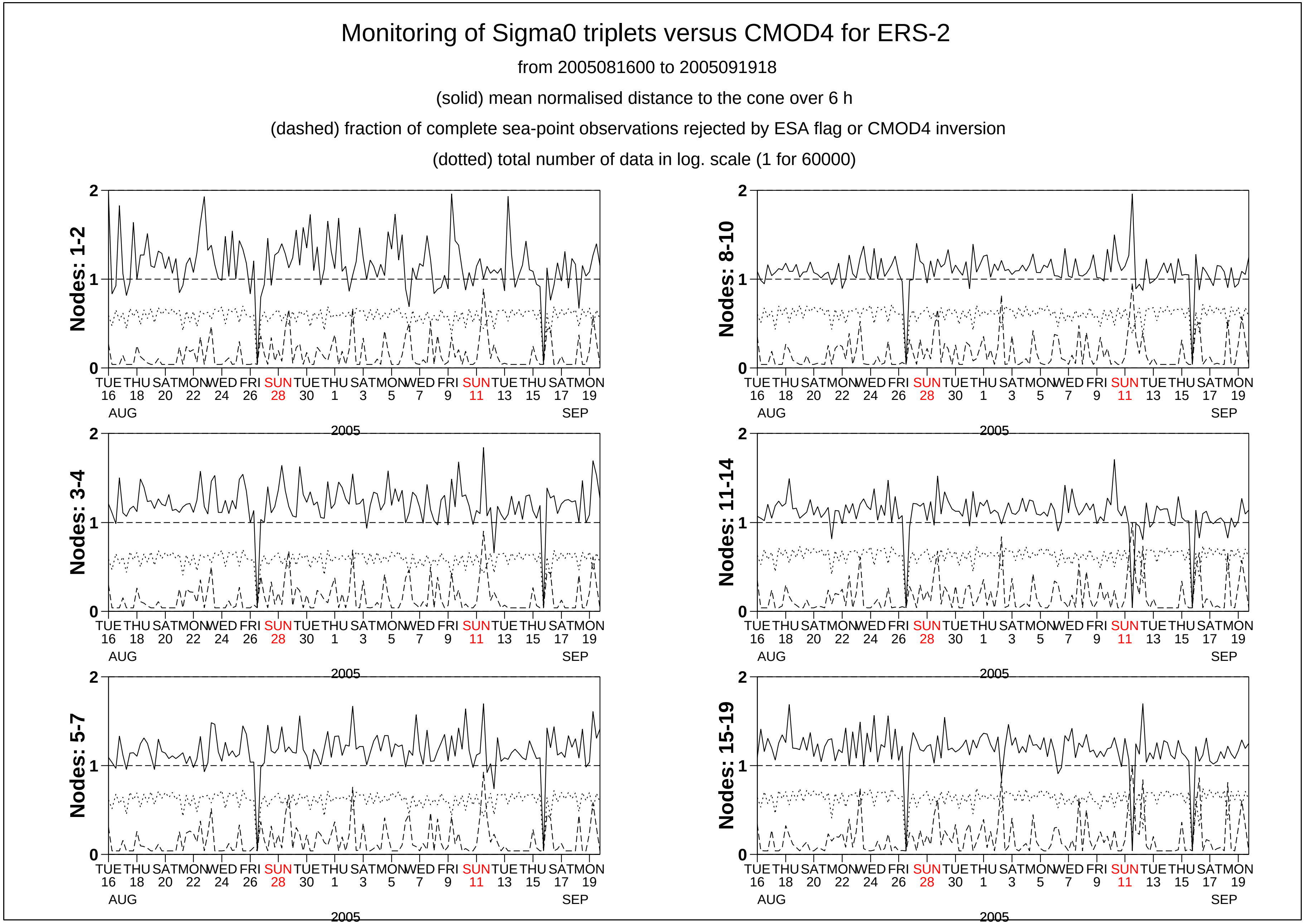

FORE vs AFT incidence angle, node 10 Mean= −0.21 deg.
degrees
August
2005
FORE vs AFT incidence angle, node 10 Mean= −0.21 deg.
August
2005
FORE vs AFT incidence angle, node 10 Mean= −0.21 deg.
August
September
2005
FORE vs AFT incidence angle, node 10 Mean= −0.21 deg.
September
2005
FORE vs AFT incidence angle, node 10 Mean= −0.21 deg.
September
2005

Figure 5



Monitoring of Sigma0 triplets versus CMOD4 for ERS-2
from 2005081600 to 2005091918
(solid) mean normalised distance to the cone over 6 h
(dashed) fraction of complete sea-point observations rejected by ESA flag or CMOD4 inversion
(dotted) total number of data in log. scale (1 for 60000)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19
AUG
SEP
2005

Figure 6

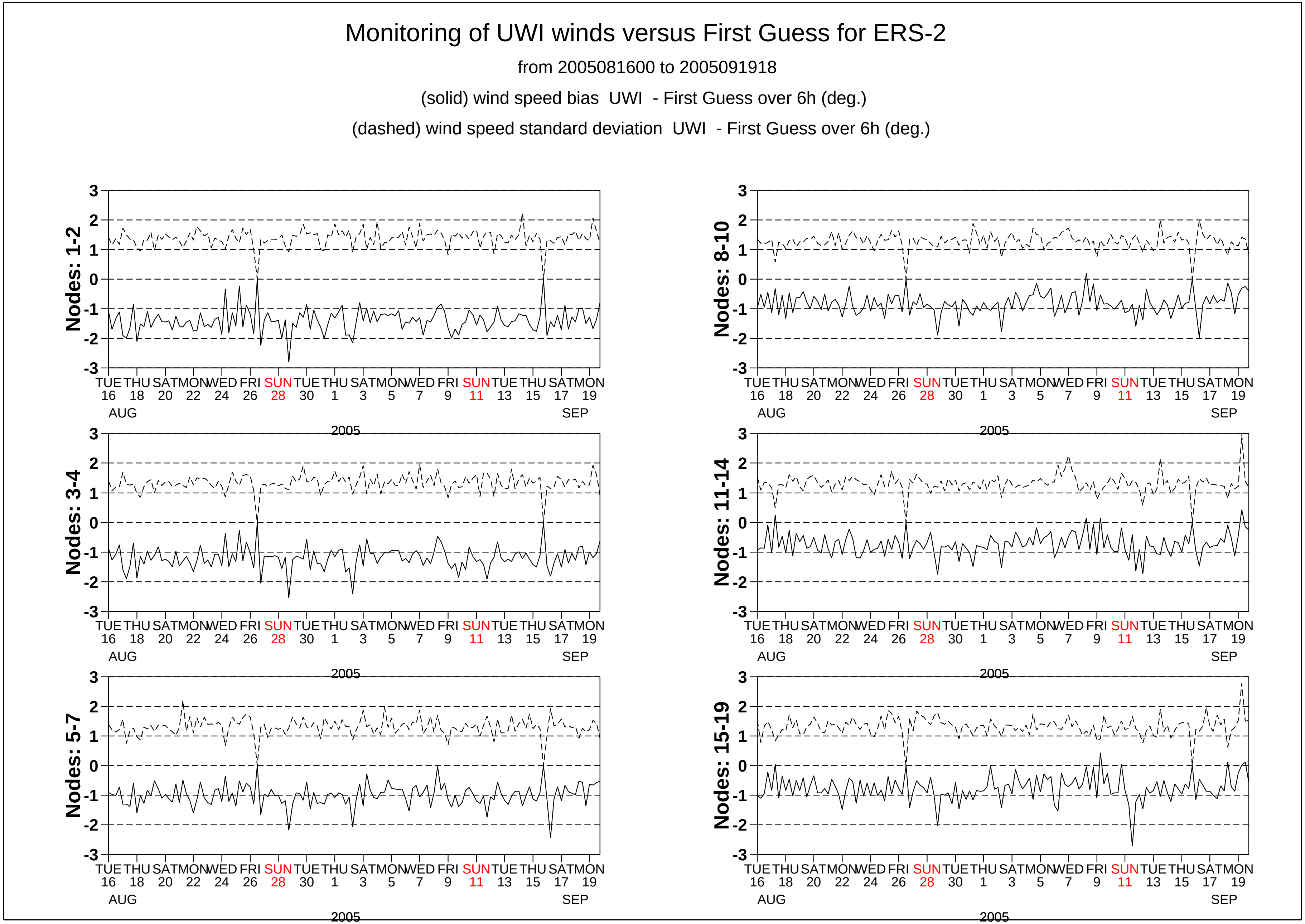

Monitoring of UWI winds versus First Guess for ERS-2
from 2005081600 to 2005091918
(solid) wind speed bias UWI - First Guess over 6h (deg.)
(dashed) wind speed standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
3 2 1 0 -1 -2 -3
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19
AUG
SEP
2005

Figure 7

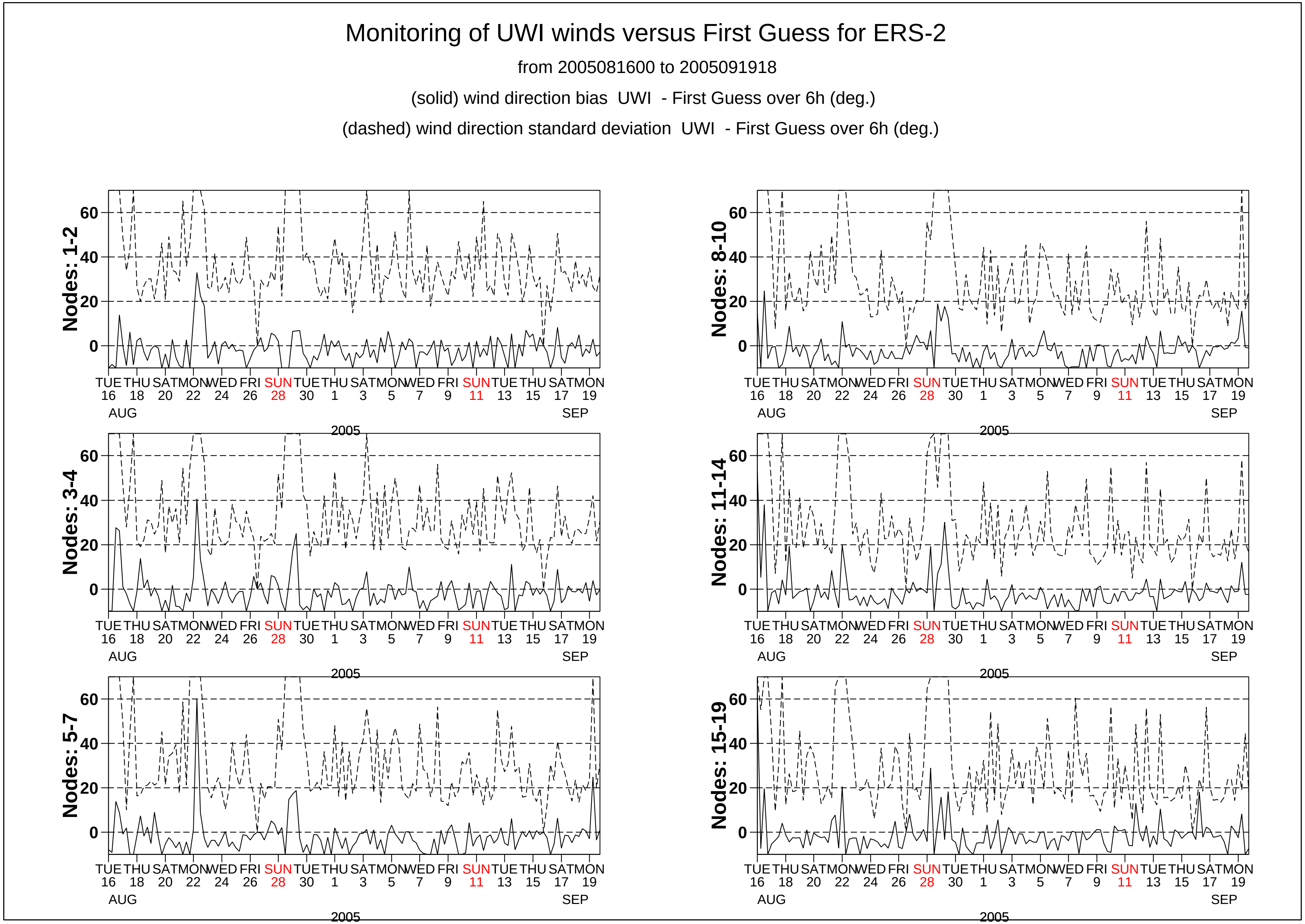
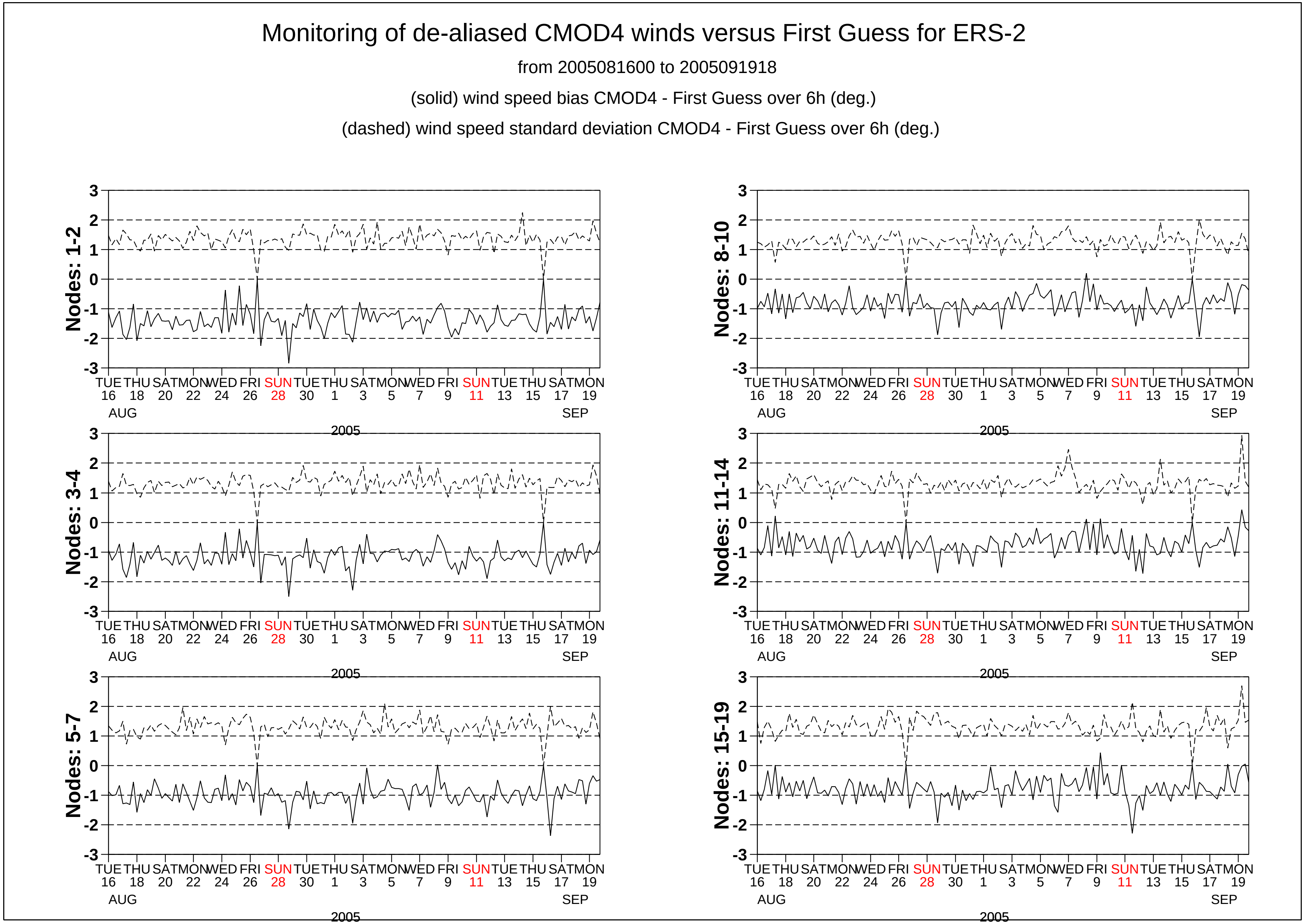
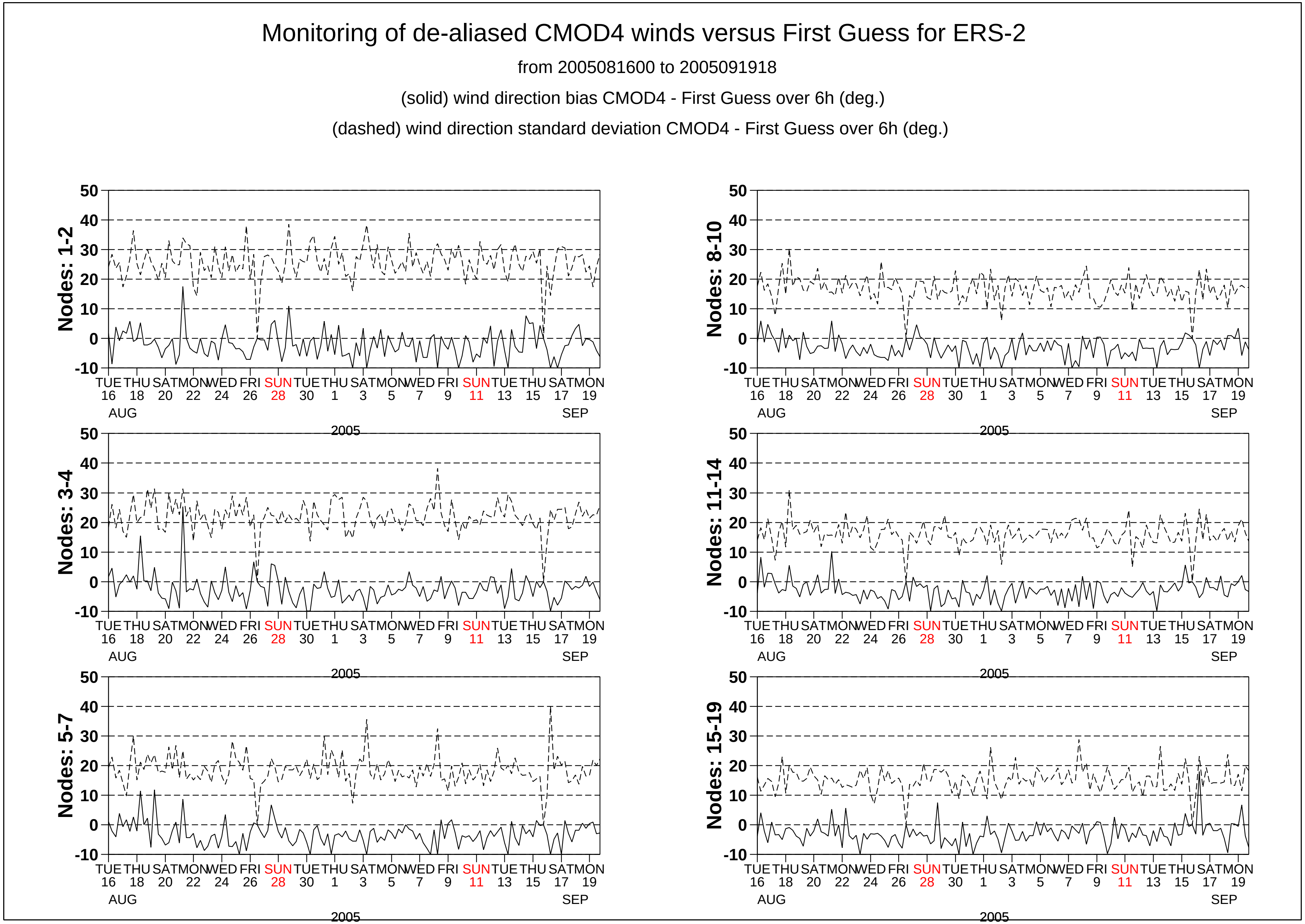

Monitoring of UWI winds versus First Guess for ERS-2
from 2005081600 to 2005091918
(solid) wind direction bias UWI - First Guess over 6h (deg.)
(dashed) wind direction standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
60
40
20
0
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19
AUG
SEP
2005

Figure 8



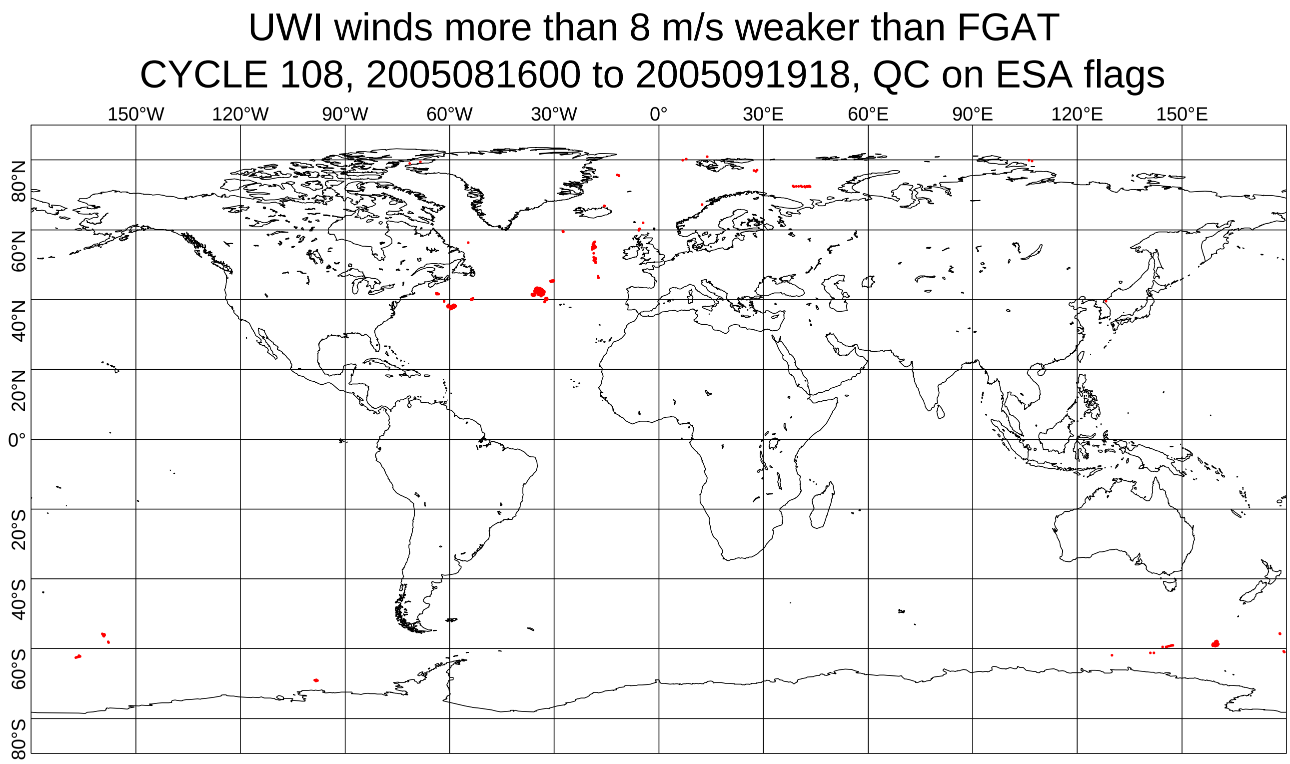
Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2005081600 to 2005091918
(solid) wind speed bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind speed standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
3 2 1 0 -1 -2 -3
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19
AUG
SEP
2005

Figure 9



Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2005081600 to 2005091918
(solid) wind direction bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind direction standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
50
40
30
20
10
0
-10
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19
AUG
SEP
2005

Figure 10


UWI winds more than 8 m/s weaker than FGAT
CYCLE 108, 2005081600 to 2005091918, QC on ESA flags
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

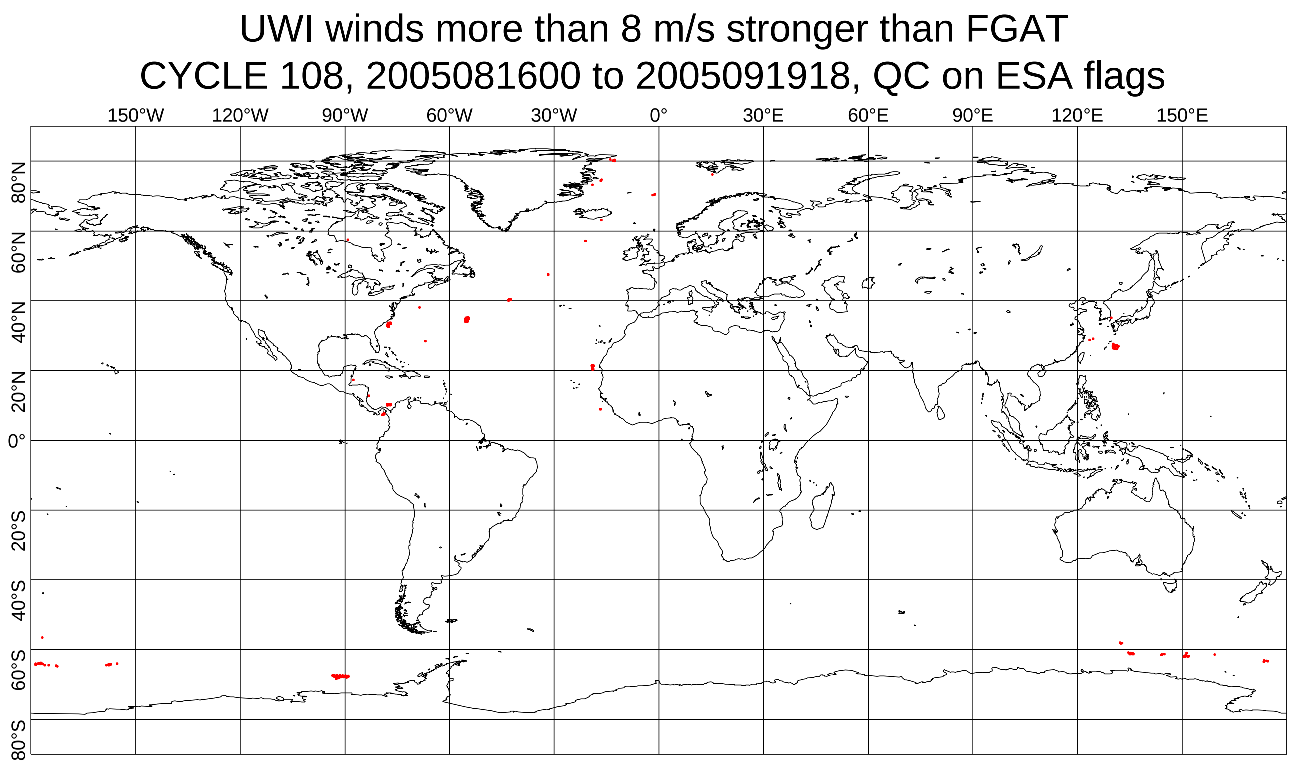

UWI winds more than 8 m/s stronger than FGAT
CYCLE 108, 2005081600 to 2005091918, QC on ESA flags
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

Figure 11

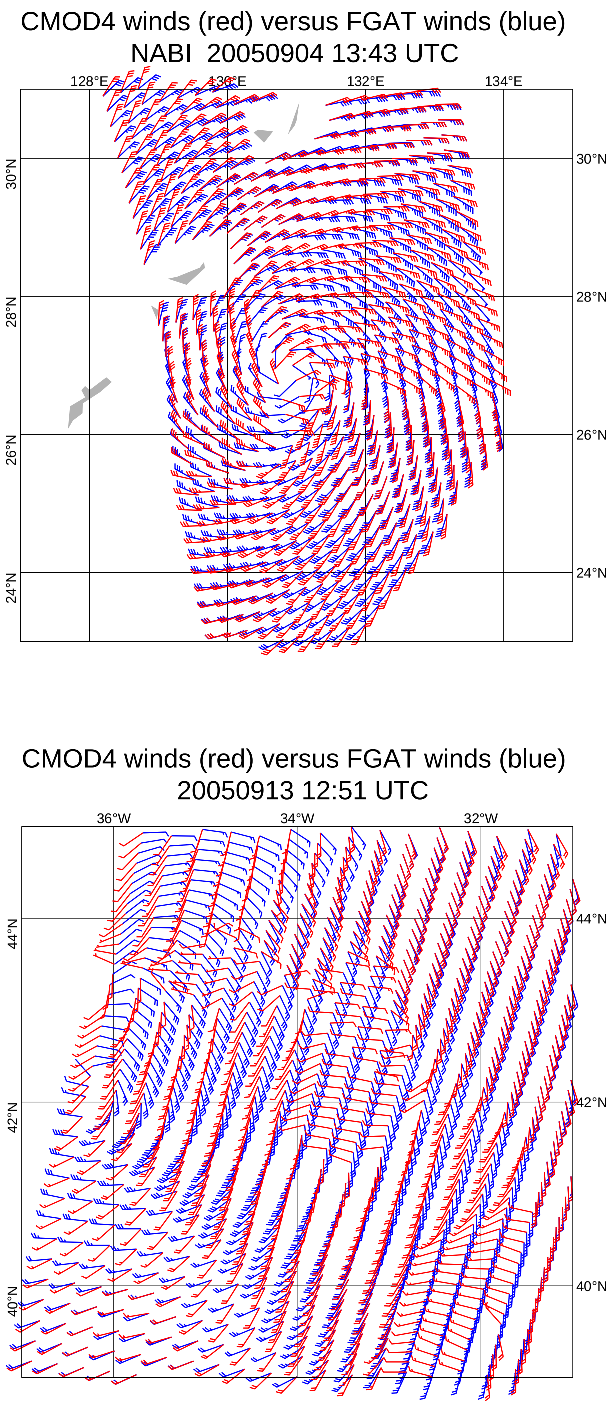

CMOD4 winds (red) versus FGAT winds (blue)
NABI 20050904 13:43 UTC
128°E
130°E
132°E
134°E
30°N
28°N
26°N
24°N
CMOD4 winds (red) versus FGAT winds (blue)
20050913 12:51 UTC
36°W
34°W
32°W
44°N
42°N
40°N

Figure 12

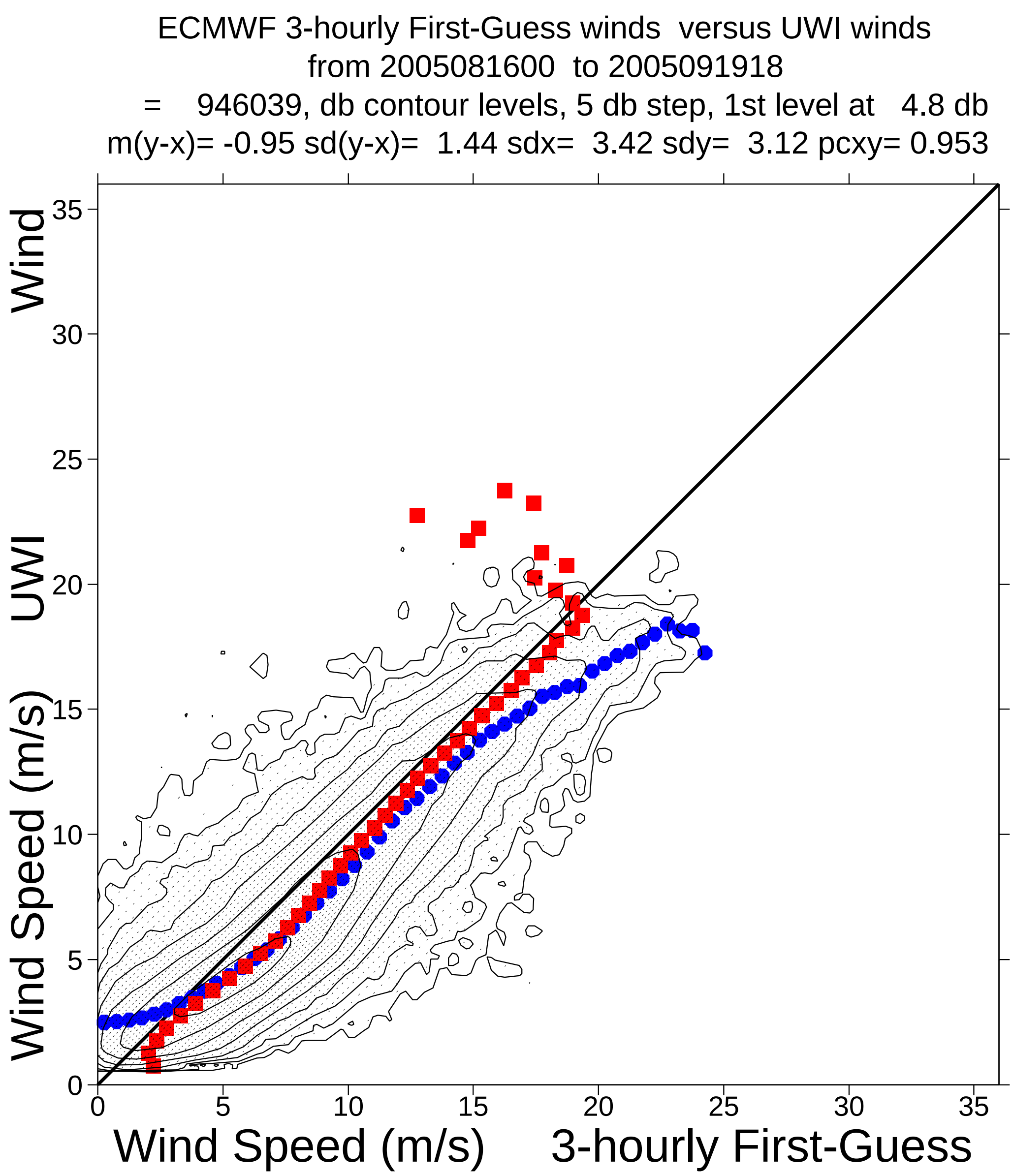

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2005081600 to 2005091918
= 946039, db contour levels, 5 db step, 1st level at 4.8 db
m(y-x)= -0.95 sd(y-x)= 1.44 sdx= 3.42 sdy= 3.12 pcxy= 0.953
Wind Speed (m/s) UWI Wind
0
5
10
15
20
25
30
35
Wind Speed (m/s) 3-hourly First-Guess

Figure 13

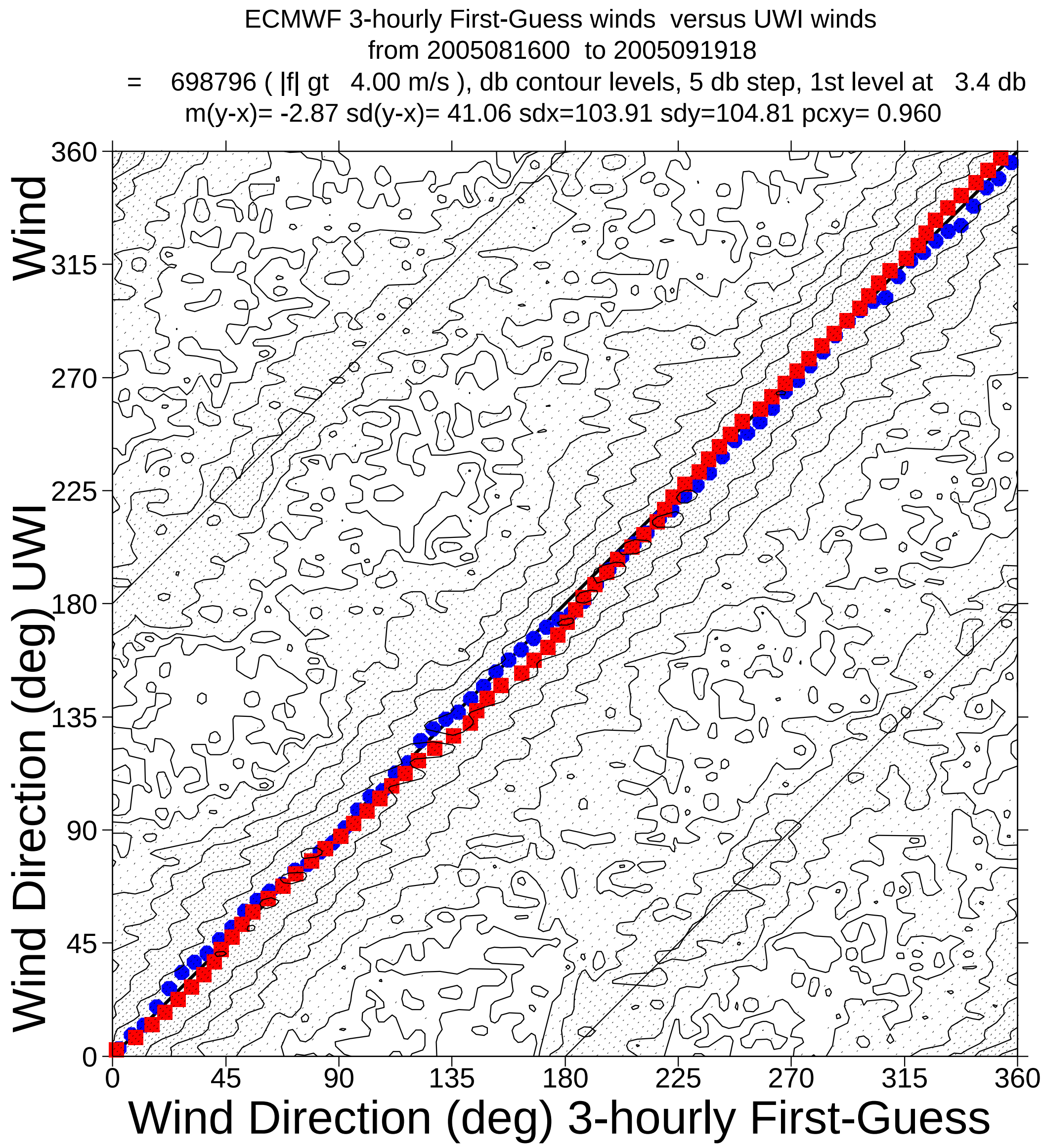

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2005081600 to 2005091918
= 698796 (|f| gt 4.00 m/s), db contour levels, 5 db step, 1st level at 3.4 db
m(y-x)= -2.87 sd(y-x)= 41.06 sdx=103.91 sdy=104.81 pcxy= 0.960
Wind
Wind Direction (deg) UWI
Wind Direction (deg) 3-hourly First-Guess
0
45
90
135
180
225
270
315
360

Figure 14

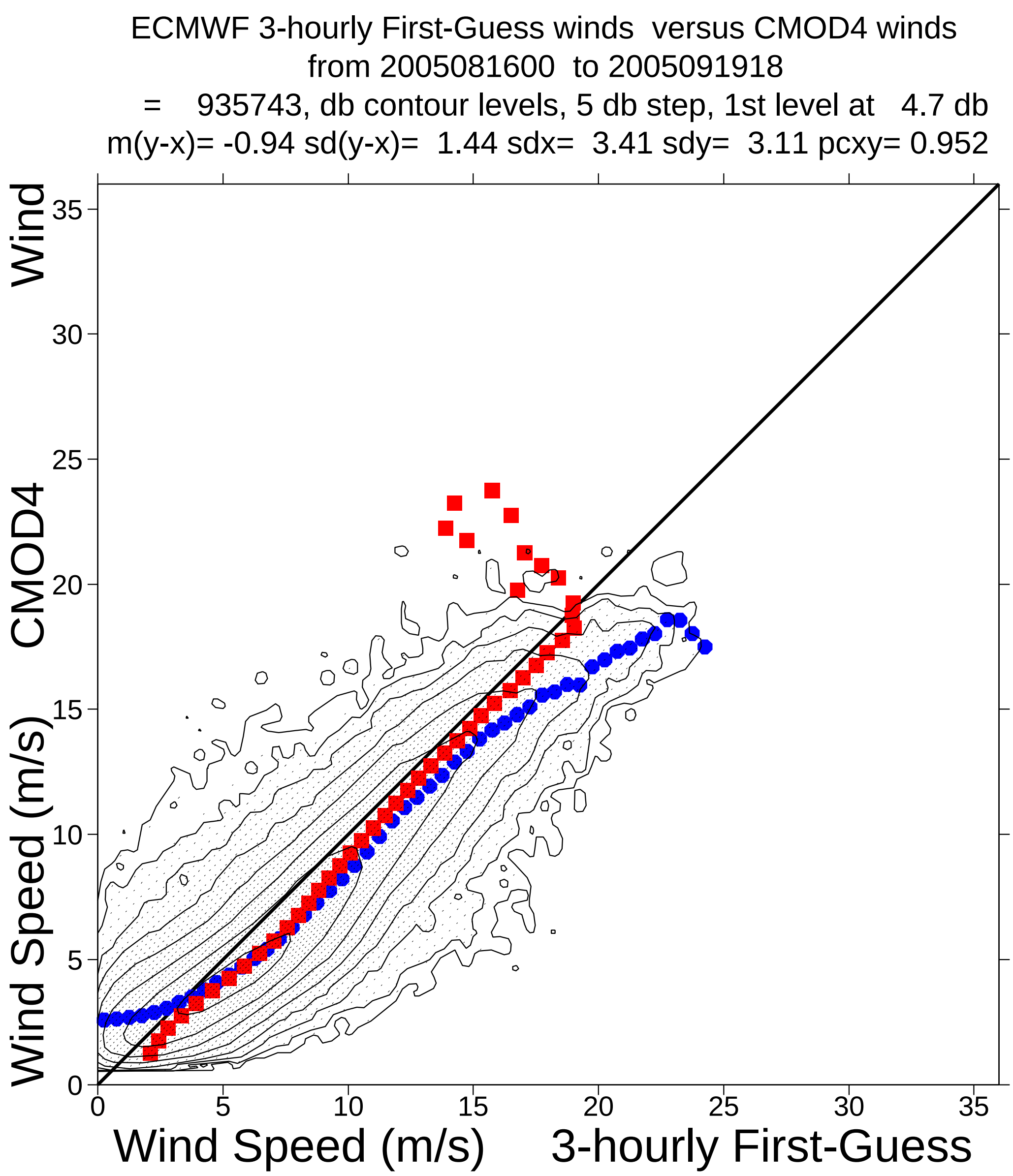

ECMWF 3-hourly First-Guess winds versus CMOD4 winds
from 2005081600 to 2005091918
= 935743, db contour levels, 5 db step, 1st level at 4.7 db
m(y-x)= -0.94 sd(y-x)= 1.44 sdx= 3.41 sdy= 3.11 pcxy= 0.952
Wind Speed (m/s) CMOD4 Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 15

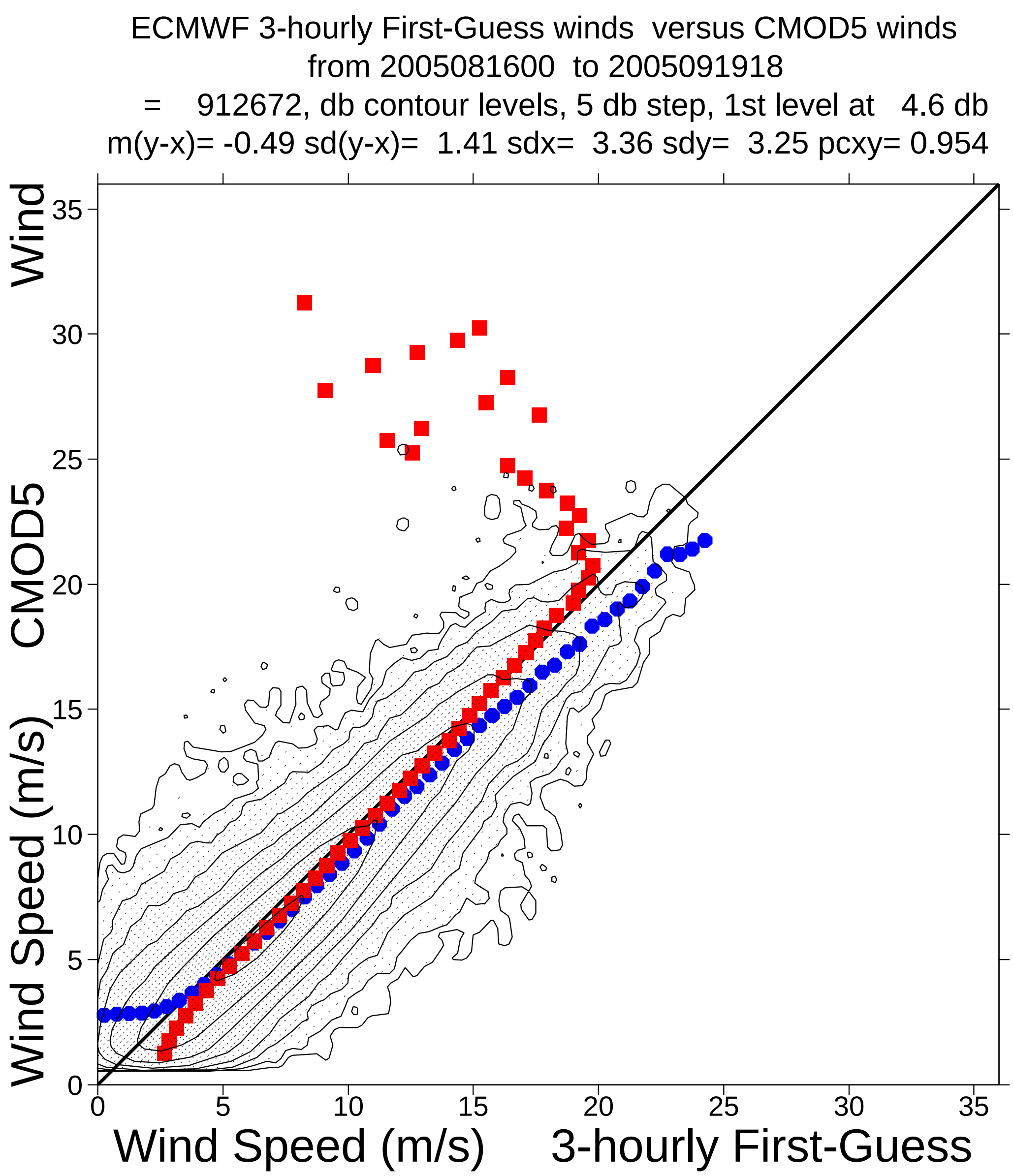
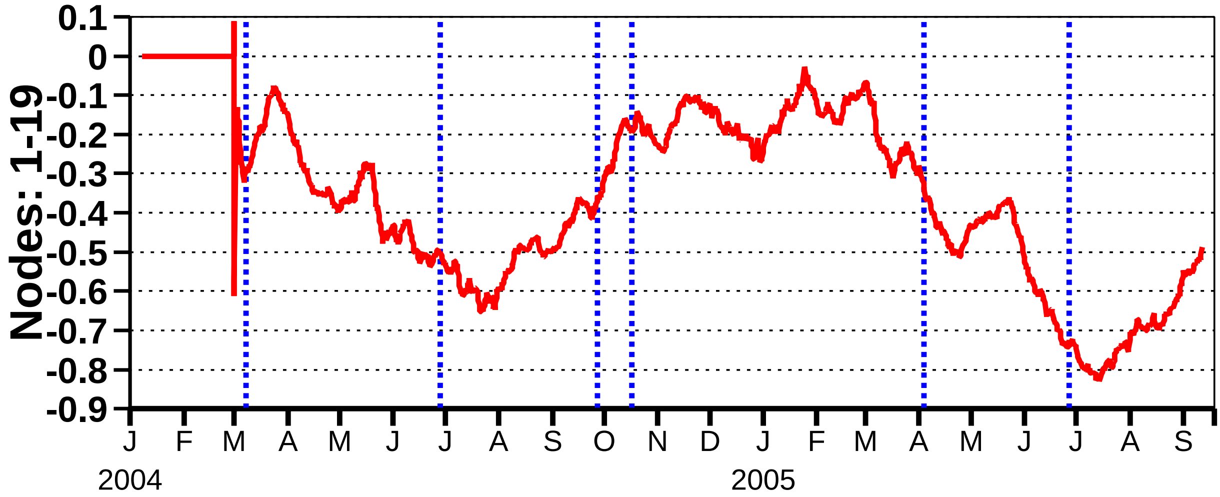

ECMWF 3-hourly First-Guess winds versus CMOD5 winds
from 2005081600 to 2005091918
= 912672, db contour levels, 5 db step, 1st level at 4.6 db
m(y-x)= -0.49 sd(y-x)= 1.41 sdx= 3.36 sdy= 3.25 pcxy= 0.954
Wind Speed (m/s) CMOD5 Wind
0
5
10
15
20
25
30
35
Wind Speed (m/s) 3-hourly First-Guess

Figure 16

ERS-2 (CMOD5)



QuikSCAT (QSCAT-1)

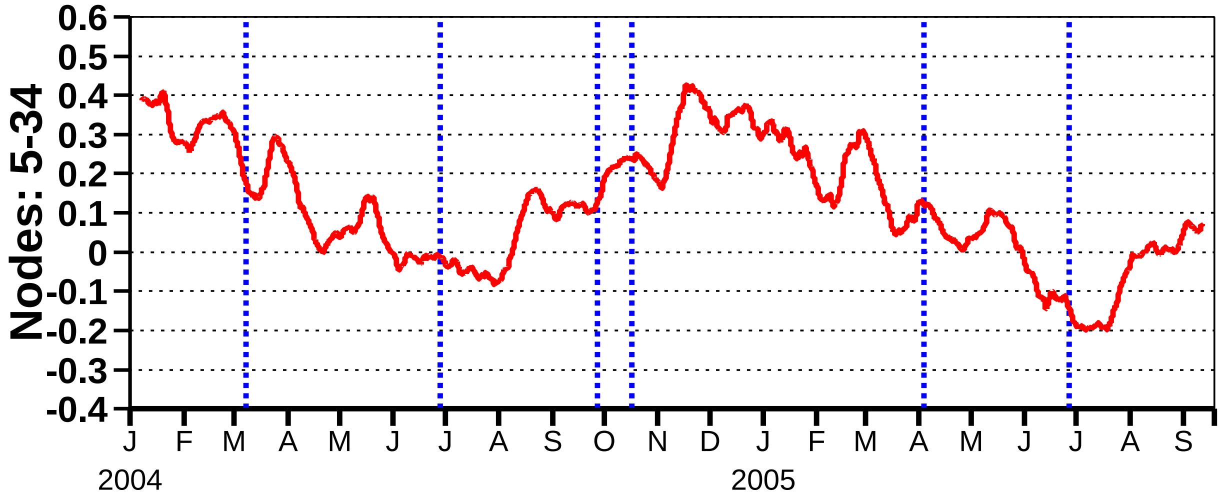


Figure 17