Monitoring statistics of the ERS-2 scatterometer for ESA

Cycle 118

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1 Introduction

The quality of the UWI product was monitored at ECMWF for Cycle 118. 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 118 data was received between 21:02 UTC 31 July and 20:57 UTC 4 September 2006. Except for 06 UTC 25 August 2006, data was received for all 6-hourly batches (centred around 00, 06, 12 and 18 UTC).

Data is being recorded whenever within the visibility range of a ground station. For Cycle 118 data coverage was over the North-Atlantic, 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 around Australia and New Zealand (see Figure 2). A less than usual amount of data was received from West Freugh. As a result, data volume on the Northern Atlantic was somewhat reduced.

During Cycle 118, the asymmetry between the fore and aft incidence angles showed a calm behaviour. The Sun is in a period of minimal activity (source: www.spaceweather.com), and will for that reason probably not influence ERS-2 attitude control too much.

Compared to Cycle 117, the UWI wind speed relative to ECMWF first-guess (FG) fields showed a slightly higher standard deviation (from 1.35 m/s to 1.37 m/s). Bias levels were less negative (from -1.00 m/s to -0.89 m/s).

During Cycle 118, the performance of the UWI wind direction showed some degradation after 12 August 2006.

Ocean calibration shows that inter-node and inter-beam dependencies of bias levels are still large. Though average bias levels improved (-0.72 dB was -0.84 dB; see Figure 4).

The ECMWF assimilation/forecast system was not changed during Cycle 118.

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

2 ERS-2 statistics from 31 July to 4 September 2006

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 dependencies are similar to that of Cycle 117, i.e., displaying a large asymmetry between the for/aft and mid beam for ascending tracks at higher incidence angles. Average backscatter bias level is less negative compared to Cycle 117 (-0.72 dB, was -0.84 dB), being about 0.25 dB more negative than for nominal data in 2000 (see Figure 1 of the reports for Cycle 48 to 59). The situation is similar to that of one year ago (see cyclic report 107), and is likely induced by seasonal variations. Therefore, the method of ocean calibration will probably only provide accurate information on calibration levels for globally averaged data, for which seasonal effects are filtered out.

The data volume of descending tracks was lower (by 11%) 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. Fluctuations were found to be mild. 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.

The Sun currently resides near the minimal point of its (roughly 11-yearly) cycle. There was some magnetic activity around 20 August 2006 (source: www.spaceweather.com), but it did not seem to harm 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 Cycle 117, 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 117, the average level was higher (1.25 versus 1.23), which is about 15% higher 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 (dash curves). High rejection rates are often related to activity of the k_p-yaw flag.

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, which are often the result of low data volume (e.g., 00 UTC 07 August 2006). Similar results apply for the history of de-aliased CMOD4 winds versus FG (Figure 9). The improved behaviour observed since 25 July 2006 (see previous Cyclic report) seems to be sustained during Cycle 118.

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 117, such collocations are isolated, and often indicate meteorologicaly active regions, for which UWI data and ECMWF model field show reasonably small differences in phase and/or intensity. Now coverage of the Southern hemisphere has been further extended, large differences are increasingly found near ice edges. It indicates non-optimal flagging in the ECMWF quality control, rather than anomalous ERS-2 backscatter triplets.

Two cases where UWI and ECMWF wind speed differ significantly are presented in Figure 12. Top panel shows the observation of Hurricane Ileana on 21 August 2006 South-West of Mexico. The displayed de-aliased CMOD5 winds are much stronger than the ECMWF first-guess field, which, in addition, show a displayed centre of the vortex. Ileana was still a tropical depression at that time, and its early observation by ERS-2 enabled the correction of the ECMWF analysis at an early stage. The lower panel displays a displacement of a front in the North-Atlantic on 28 August 2006.

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 both the UWI and CMOD4 product was reduced by 0.1 m/s, however, is still more negative to that for nominal data in 2000 (UWI: -0.89 m/s now, was -0.79 m/s for Cycle 59).

On a longer time scale seasonal bias trends are observed (see Figure 1). As was highlighted in previous cyclic reports, it is believed that this yearly trend is partly induced by changing local geophysical conditions. Strong indication for this is a similar trend observed for QuikSCAT data when restricted to an area well-covered

	Cycle 117		Cycle 118	
	UWI	CMOD4	UWI	CMOD4
speed STDV	1.35	1.35	1.37	1.37
node 1-2	1.41	1.40	1.41	1.39
node 3-4	1.34	1.34	1.36	1.35
node 5-7	1.30	1.30	1.32	1.32
node 8-10	1.29	1.30	1.33	1.33
node 11-14	1.31	1.32	1.35	1.36
node 15-19	1.35	1.35	1.36	1.37
speed BIAS	-1.00	-1.01	-0.89	-0.89
node 1-2	-1.47	-1.45	-1.36	-1.34
node 3-4	-1.24	-1.21	-1.14	-1.10
node 5-7	-1.02	-1.00	-0.93	-0.90
node 8-10	-0.84	-0.85	-0.76	-0.76
node 11-14	-0.82	-0.84	-0.72	-0.74
node 15-19	-0.87	-0.91	-0.71	-0.75
direction STDV	25.1	18.2	31.6	19.1
direction BIAS	-2.1	-2.3	-1.4	-1.7

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

by ERS-2 (20N-90N, 80W-20E). Figure 17 shows time series for that area for both ERS-2 (top panel) and QuikSCAT (lower panel) for the period between 1 January 2004 and 4 September 2006 (end of Cycle 118). 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.

The standard deviation of UWI wind speed compared to Cycle 117 has slightly increased (1.37 m/s, was 1.35 m/s).

For Cycle 118 the (UWI - FG) direction standard deviations were mostly ranging between 20 and 40 degrees (Figure 8), representing nominal variations. However, larger deviations were observed between 12 and 16 August 2006. This increase was due to an anomaly at West Freugh station in the meteo files that are used for de-aliasing of the UWI product. Averaged over the entire cyclic period, STDV for UWI wind direction had, therefore, increased (31.6 degrees, was 25.1 degrees). Performance for at ECMWF de-aliased winds was 19.1 degrees, i.e., somewhat worse than for Cycle 117 (STDV 18.2 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 (1.37 m/s versus 1.39 m/s). Compared to ECMWF FG, CMOD5 winds are 0.44 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 4 September 2006 (end Cycle 118) 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 $< \sigma_0^{0.625} > / < \mathrm{CMOD4(FirstGuess)}^{0.625} >$ 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 118 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 de-aliased CMOD5 (red) and ECMWF FG (blue) winds for Hurricane Ileana on 21 August 2006 (top panel) and between UWI (red) and ECMWF FG (blue) winds for a case in the North-Atlantic on 28 August 2006 (lower panel).

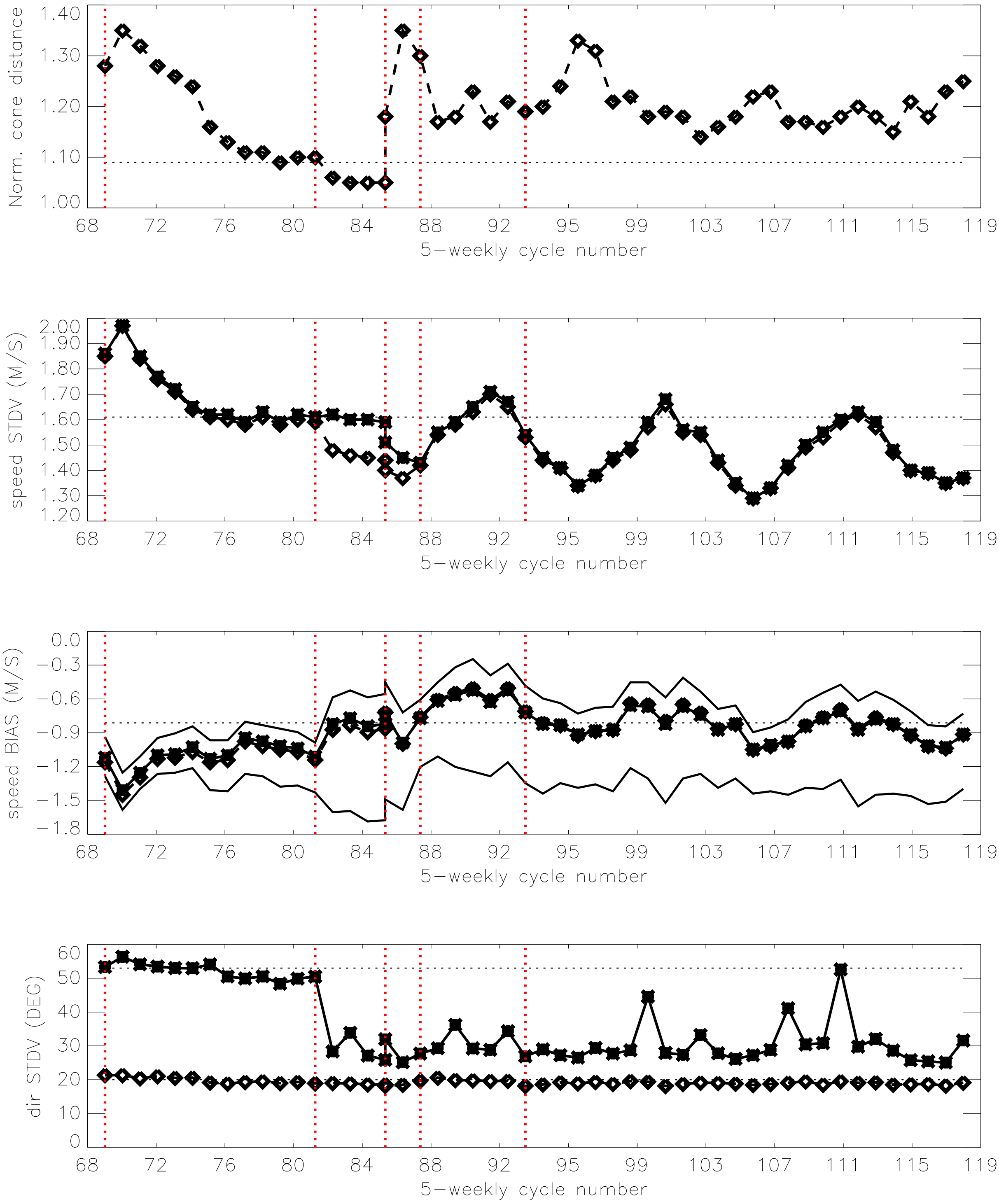
Figure 13: Two-dimensional histogram of first guess and UWI wind speeds, for the data kept by the UWI flags, and QC based on the ECMWF land and sea-ice mask. Circles denote the mean values in the y-direction, and squares those in the x-direction.

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 1 January 2004 - 4 September 2006. Fat curves represent centred 15-day running means, thin curves values for 6-hourly periods. Vertical dashed blue lines mark ECMWF model changes.



Norm. cone distance
1.40
1.30
1.20
1.10
1.00
68 72 76 80 84 88 92 95 99 103 107 111 115 119
5−weekly cycle number
speed STDV (M/S)
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
68 72 76 80 84 88 92 95 99 103 107 111 115 119
5−weekly cycle number
speed BIAS (M/S)
0.0
−0.3
−0.6
−0.9
−1.2
−1.5
−1.8
68 72 76 80 84 88 92 95 99 103 107 111 115 119
5−weekly cycle number
dir STDV (DEG)
60
50
40
30
20
10
0
68 72 76 80 84 88 92 95 99 103 107 111 115 119
5−weekly cycle number

Figure 1

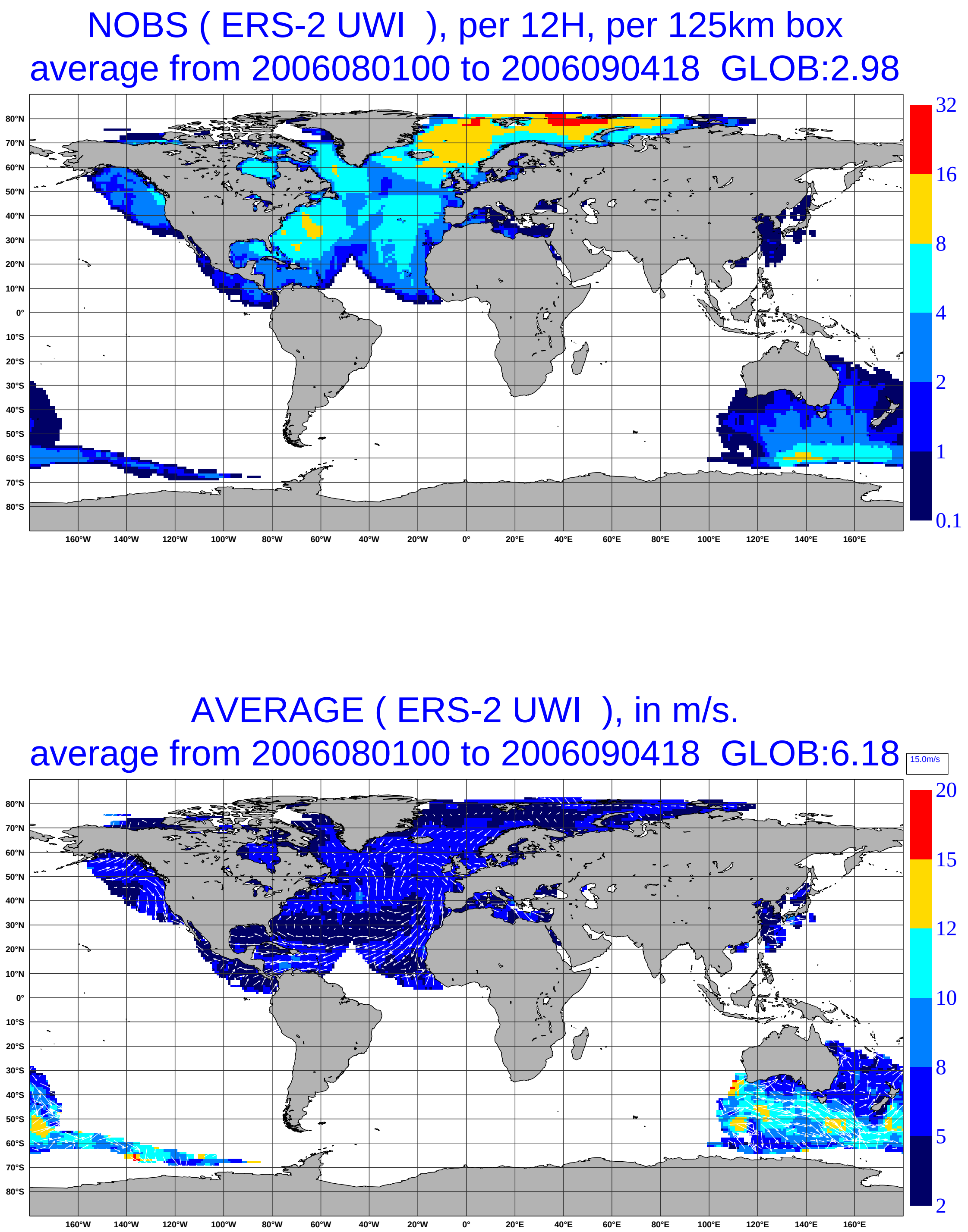
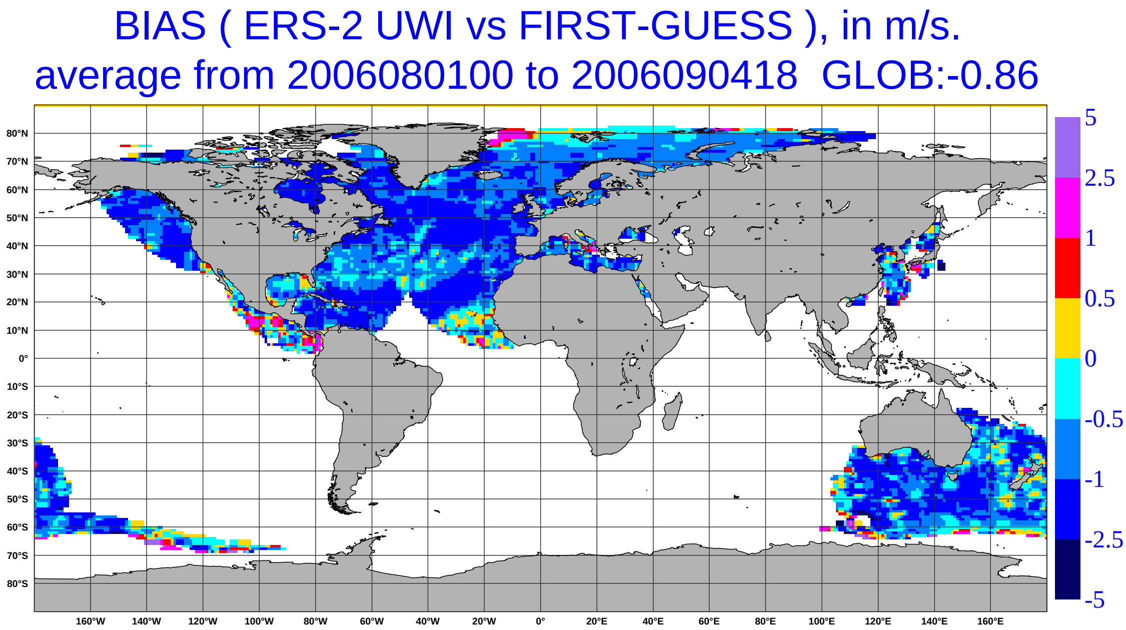

NOBS (ERS-2 UWI), per 12H, per 125km box
average from 2006080100 to 2006090418 GLOB:2.98
32
16
8
4
2
1
0.1
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S
80°S
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
100°E
120°E
140°E
160°E
AVERAGE (ERS-2 UWI), in m/s.
average from 2006080100 to 2006090418 GLOB:6.18
15.0m/s
20
15
12
10
8
5
2

Figure 2


BIAS (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2006080100 to 2006090418 GLOB:-0.86
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

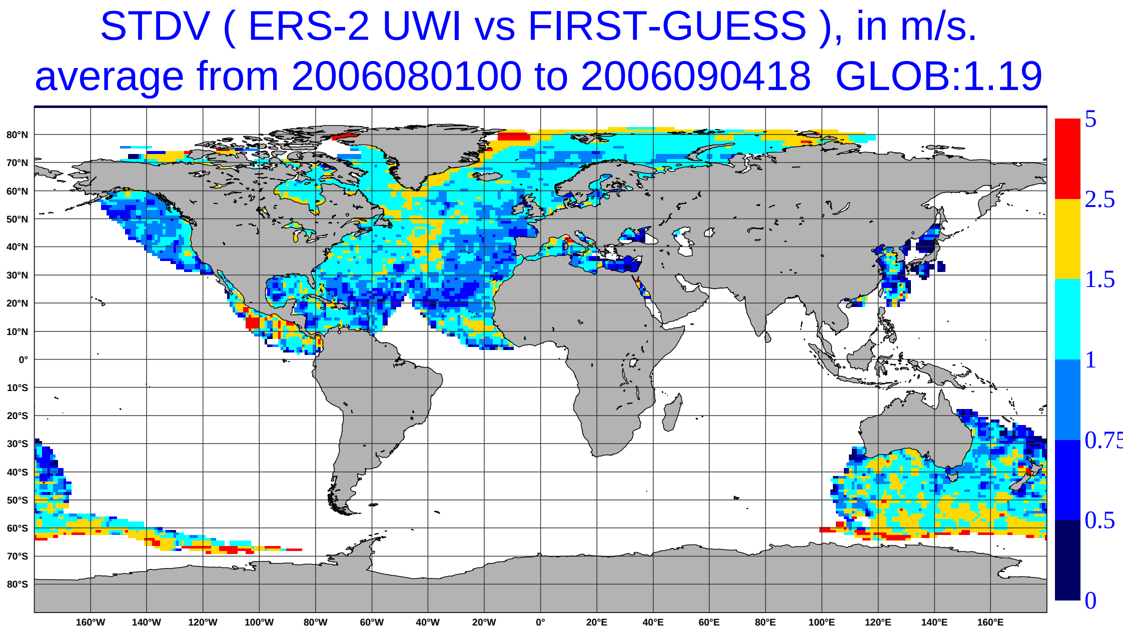
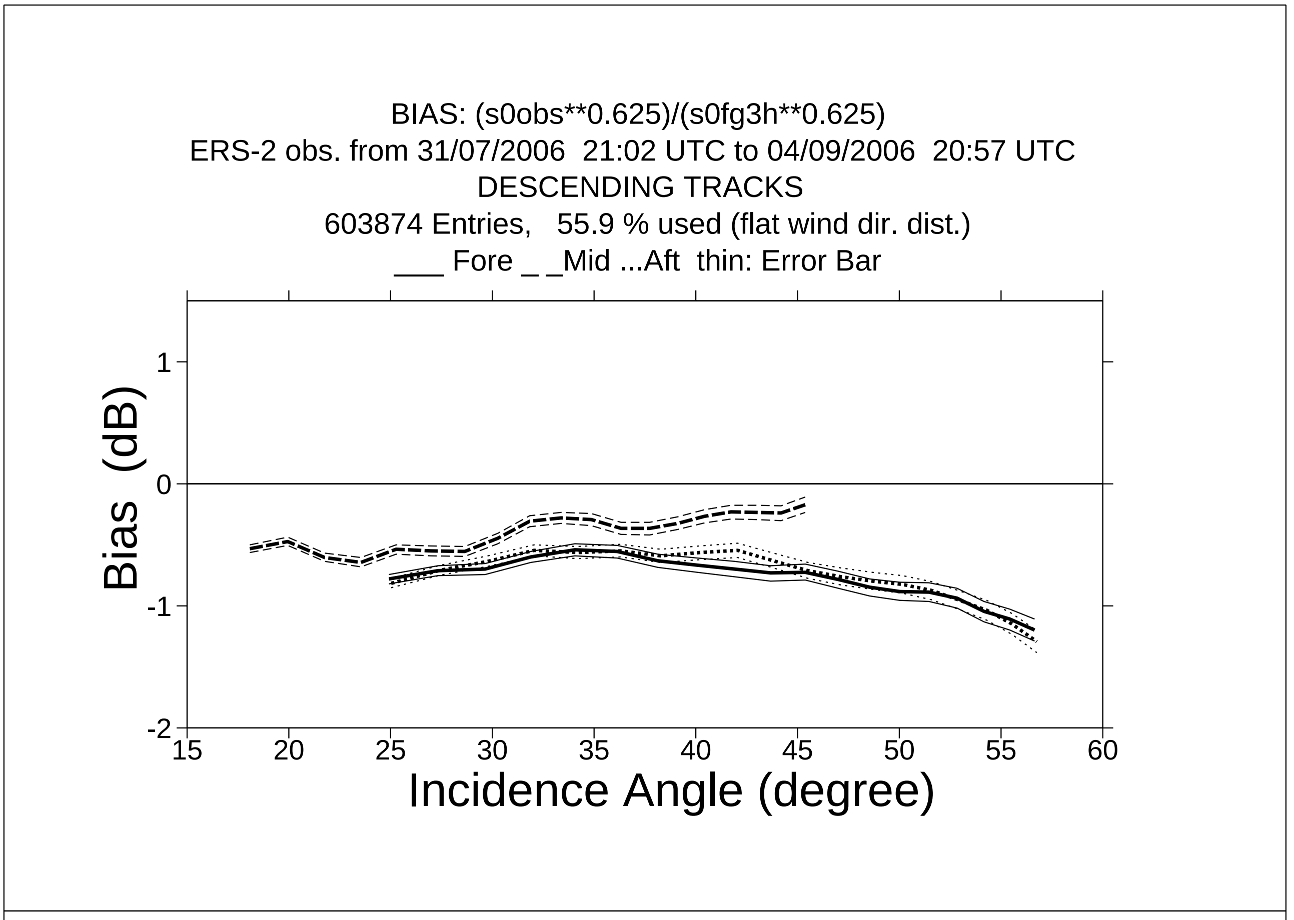

STDV (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2006080100 to 2006090418 GLOB:1.19
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S
80°S
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
100°E
120°E
140°E
160°E
5
2.5
1.5
1
0.7
0.5
0

Figure 3


BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 31/07/2006 21:02 UTC to 04/09/2006 20:57 UTC
DESCENDING TRACKS
603874 Entries, 55.9 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
Incidence Angle (degree)

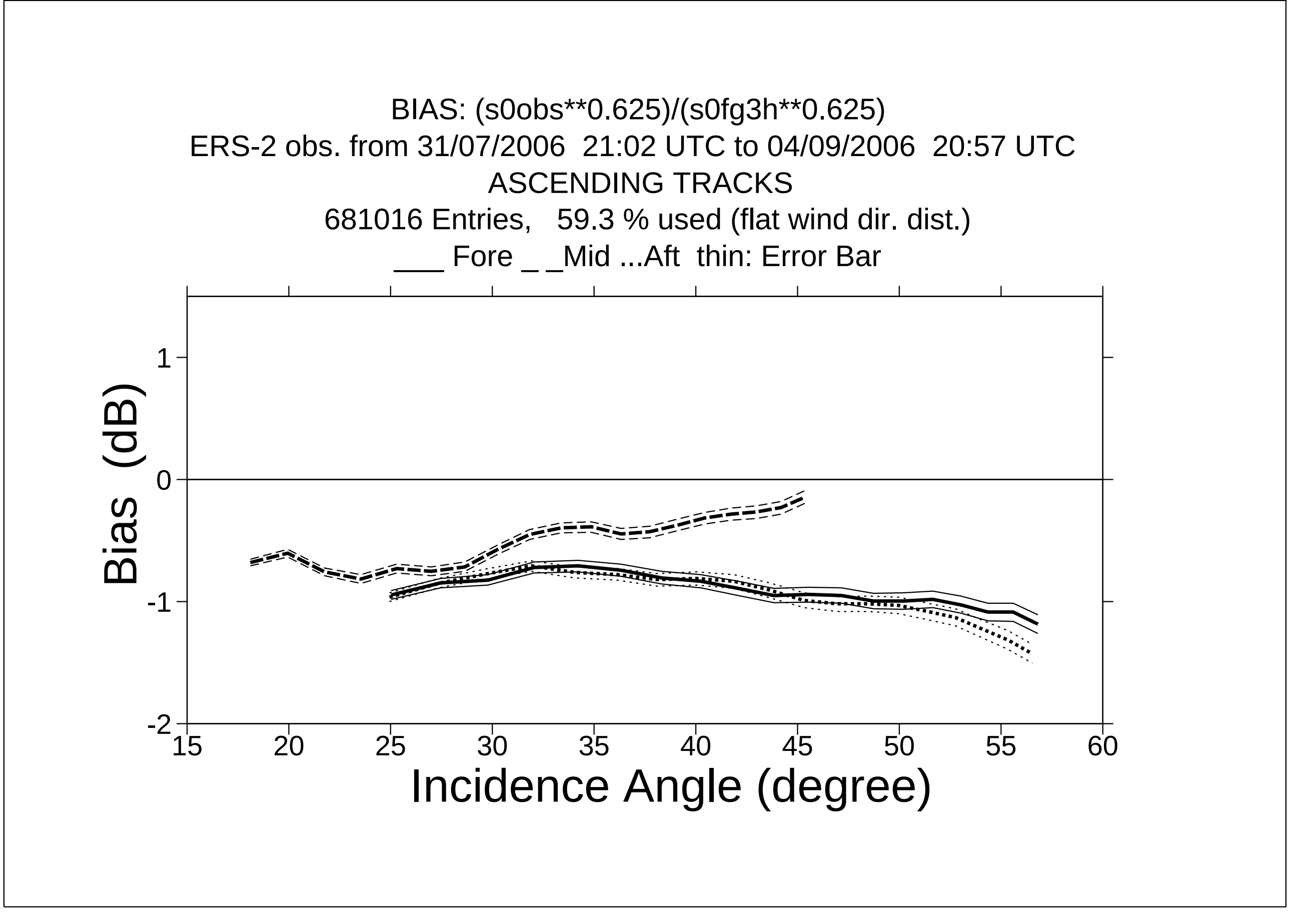

BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 31/07/2006 21:02 UTC to 04/09/2006 20:57 UTC
ASCENDING TRACKS
681016 Entries, 59.3 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
Incidence Angle (degree)

Figure 4

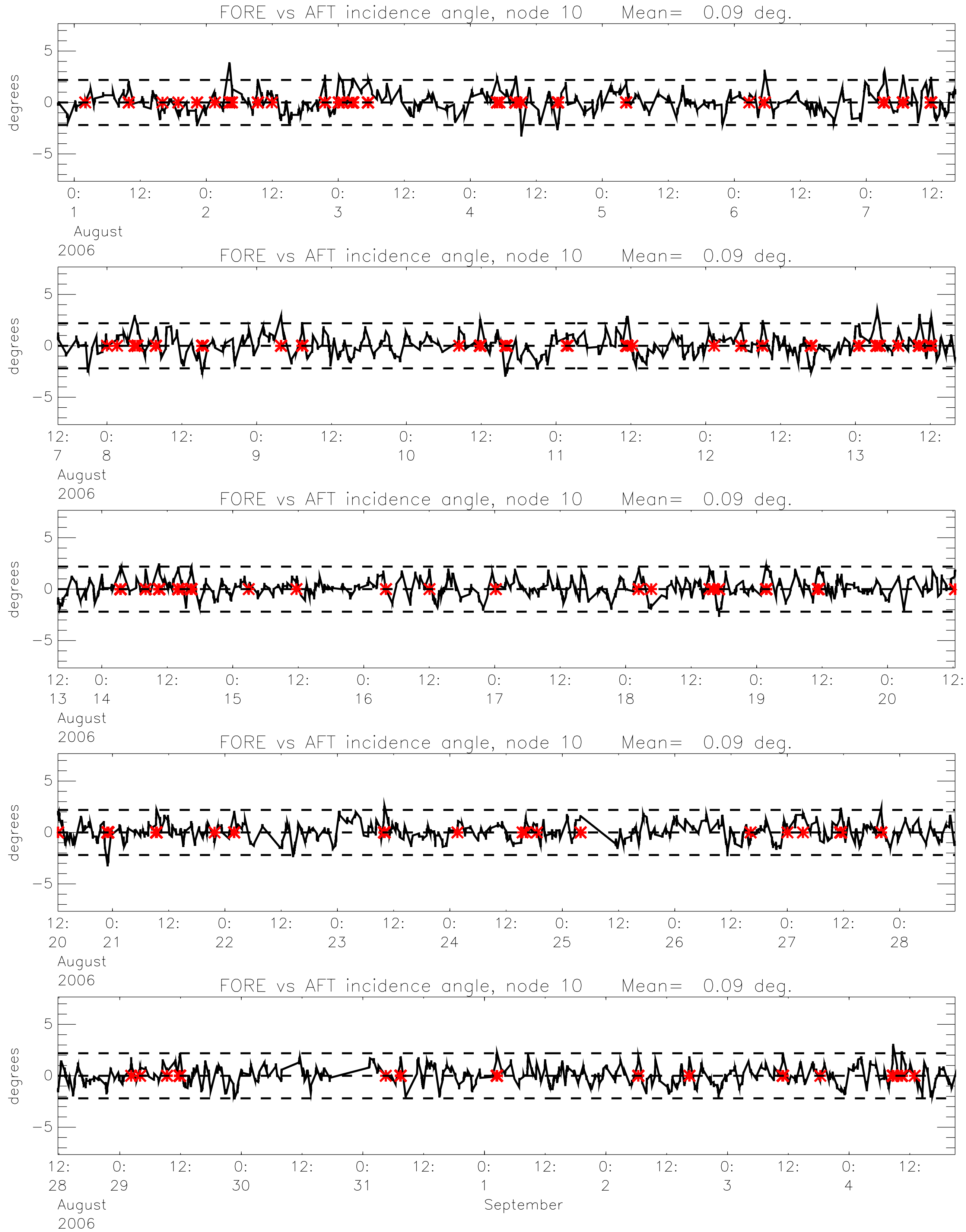

FORE vs AFT incidence angle, node 10 Mean= 0.09 deg.
degrees
August
2006
September

Figure 5

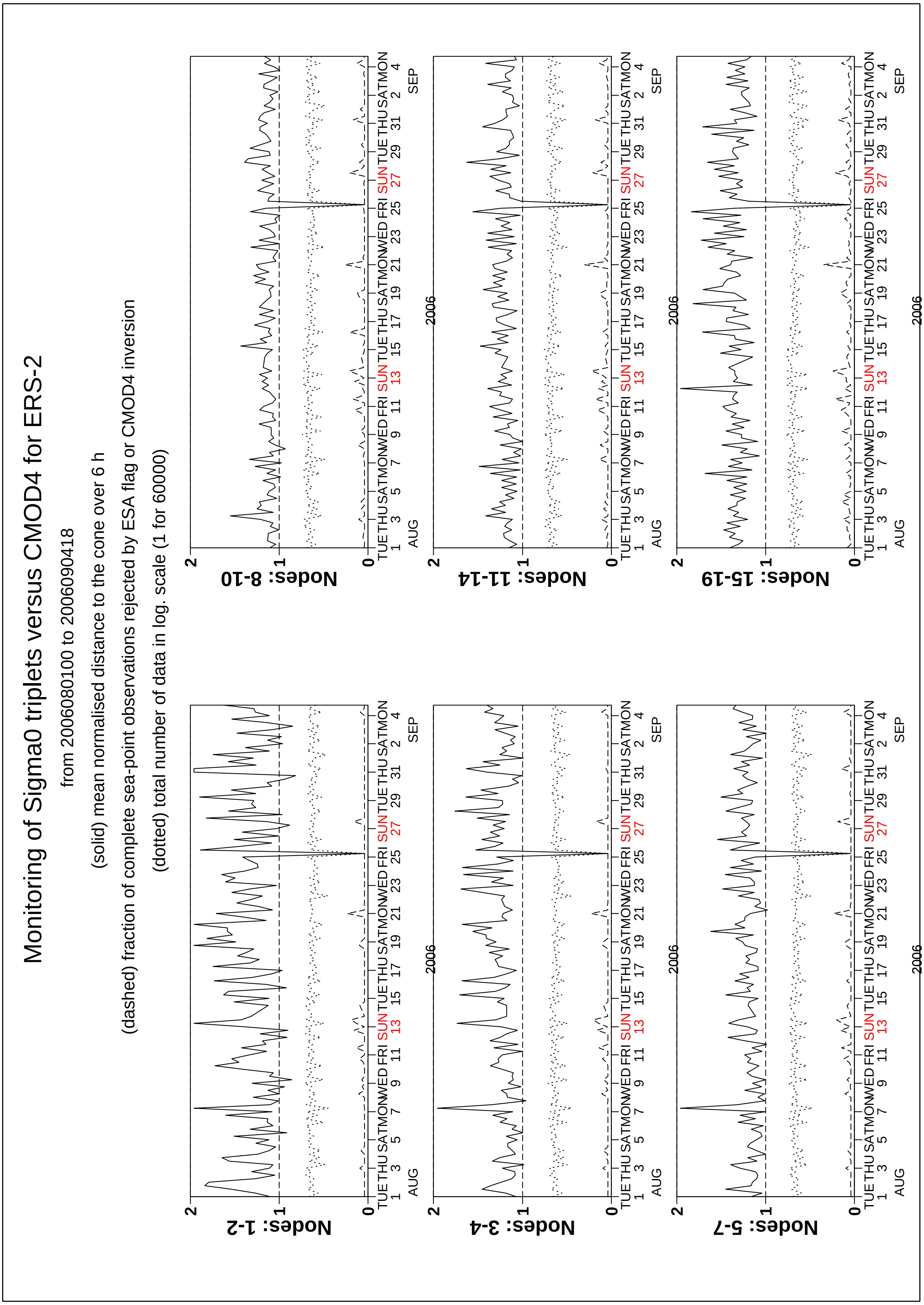

Monitoring of Sigma0 triplets versus CMOD4 for ERS-2
from 2006080100 to 2006090418
(solid) mean normalised distance to the cone over 6 h
(dashed) fraction of complete sea-point observations rejected by ESA flag or CMOD4 inversion
(dotted) total number of data in log. scale (1 for 60000)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
AUG
SEP
2006

Figure 6

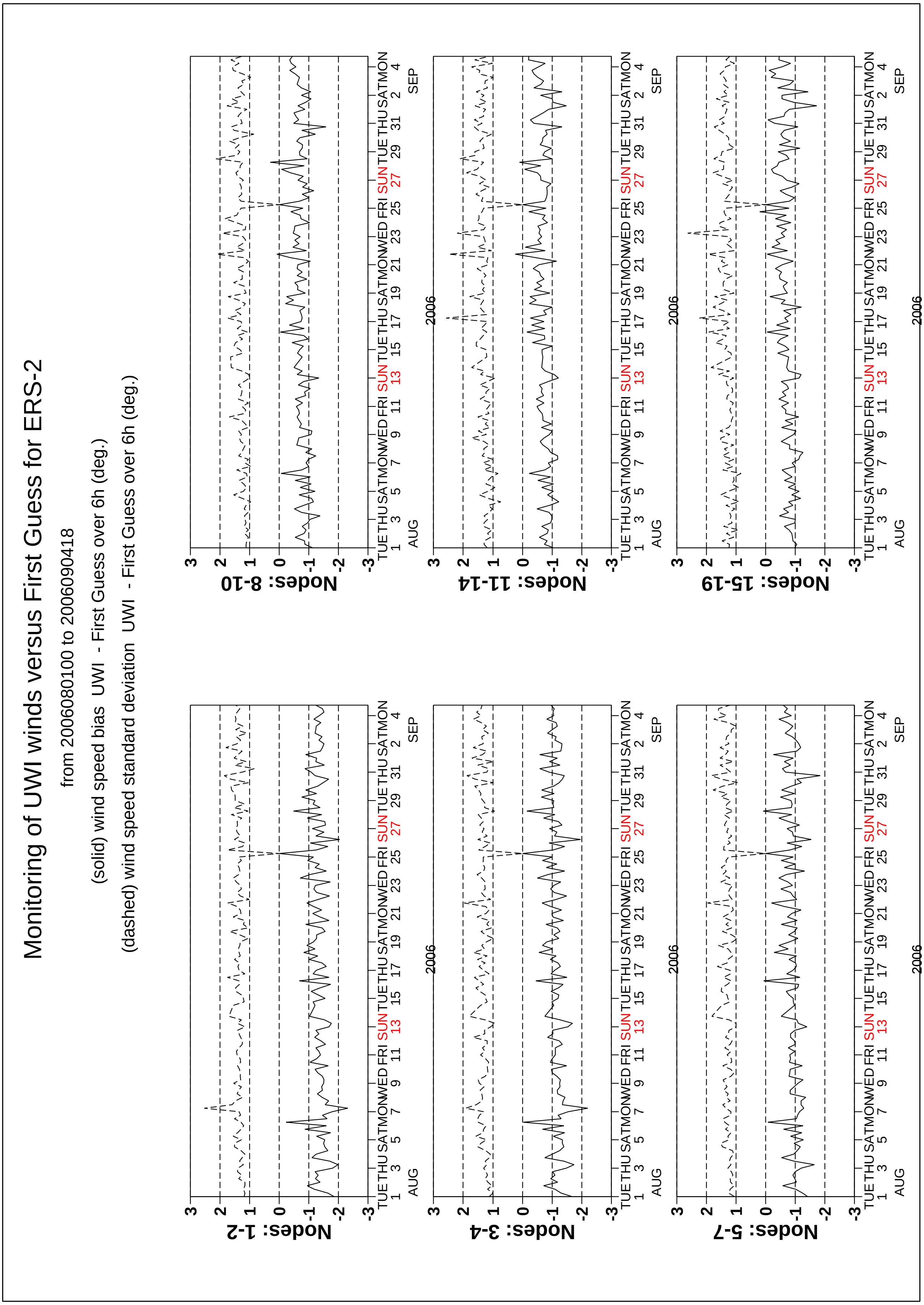

Monitoring of UWI winds versus First Guess for ERS-2
from 2006080100 to 2006090418
(solid) wind speed bias UWI - First Guess over 6h (deg.)
(dashed) wind speed standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
AUG
SEP
2006

Figure 7

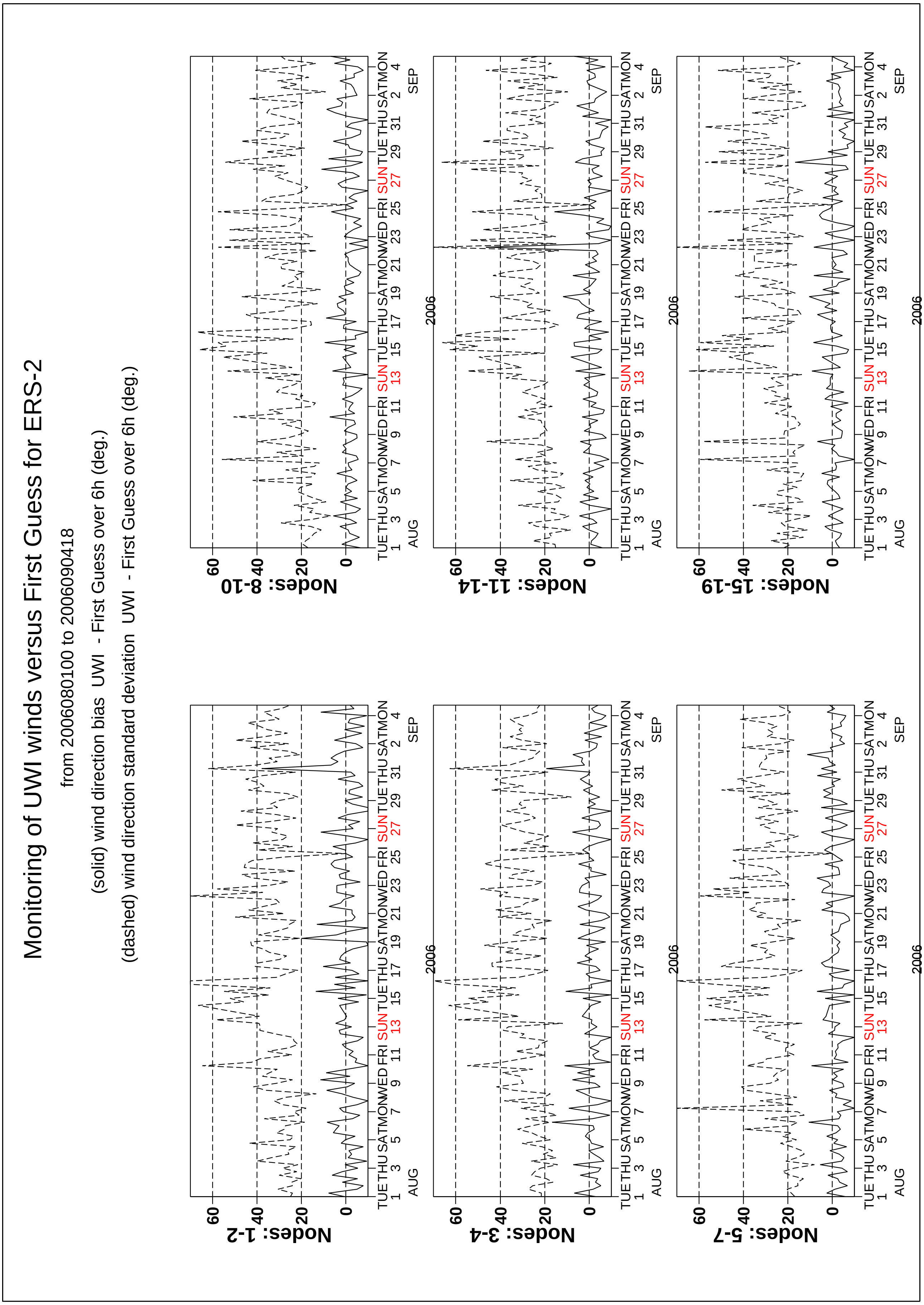

Monitoring of UWI winds versus First Guess for ERS-2
from 2006080100 to 2006090418
(solid) wind direction bias UWI - First Guess over 6h (deg.)
(dashed) wind direction standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
AUG
SEP
2006

Figure 8

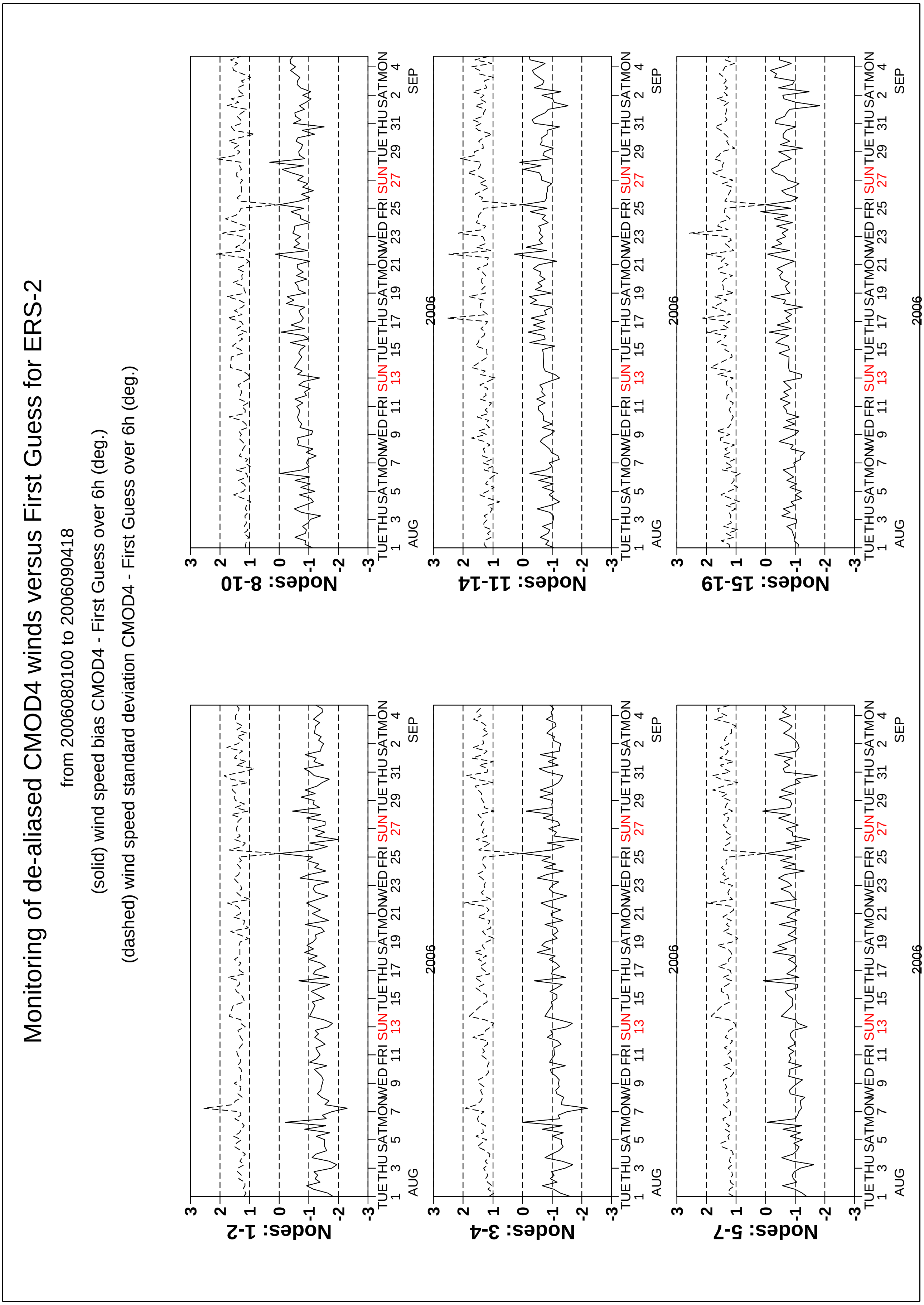
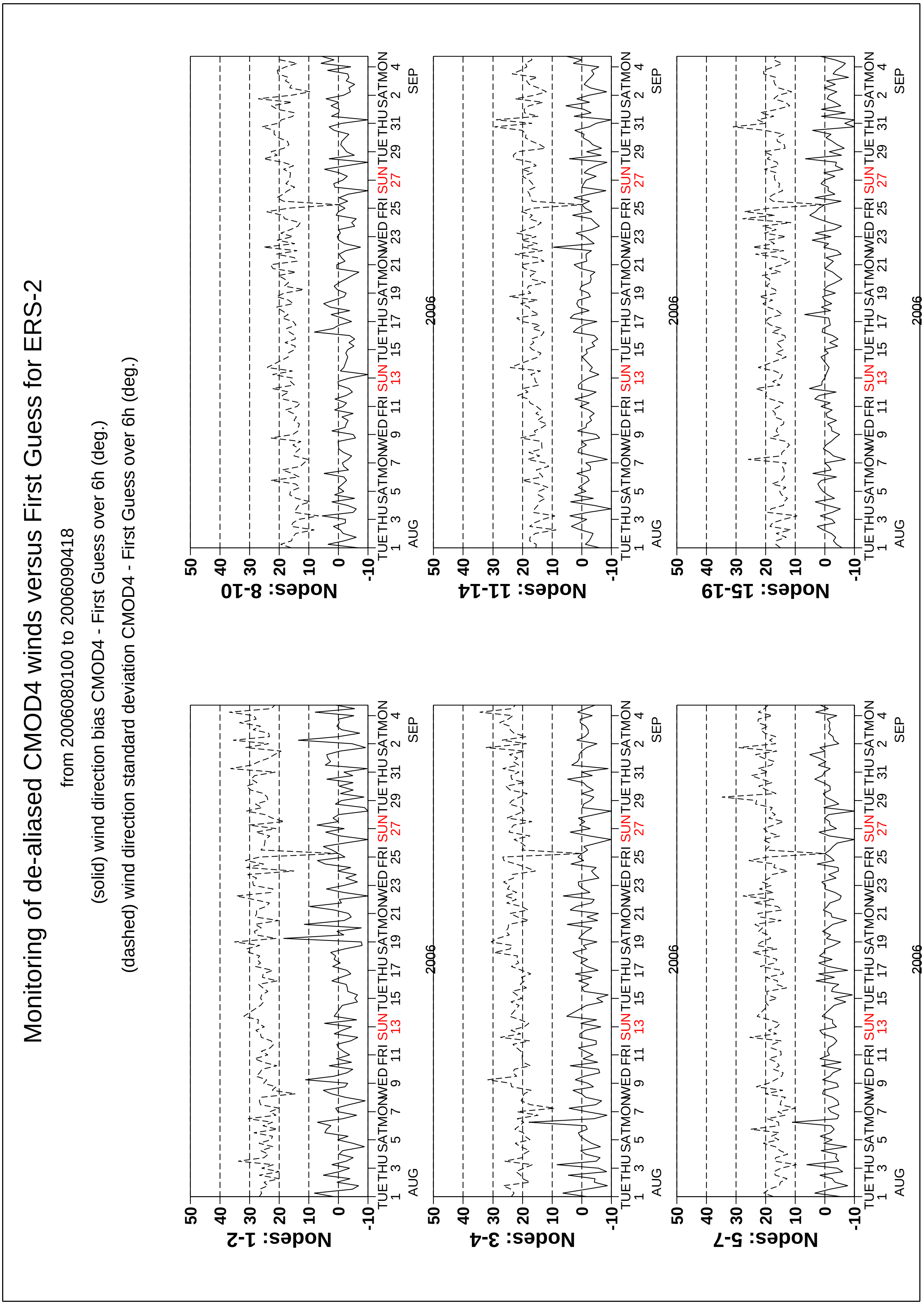
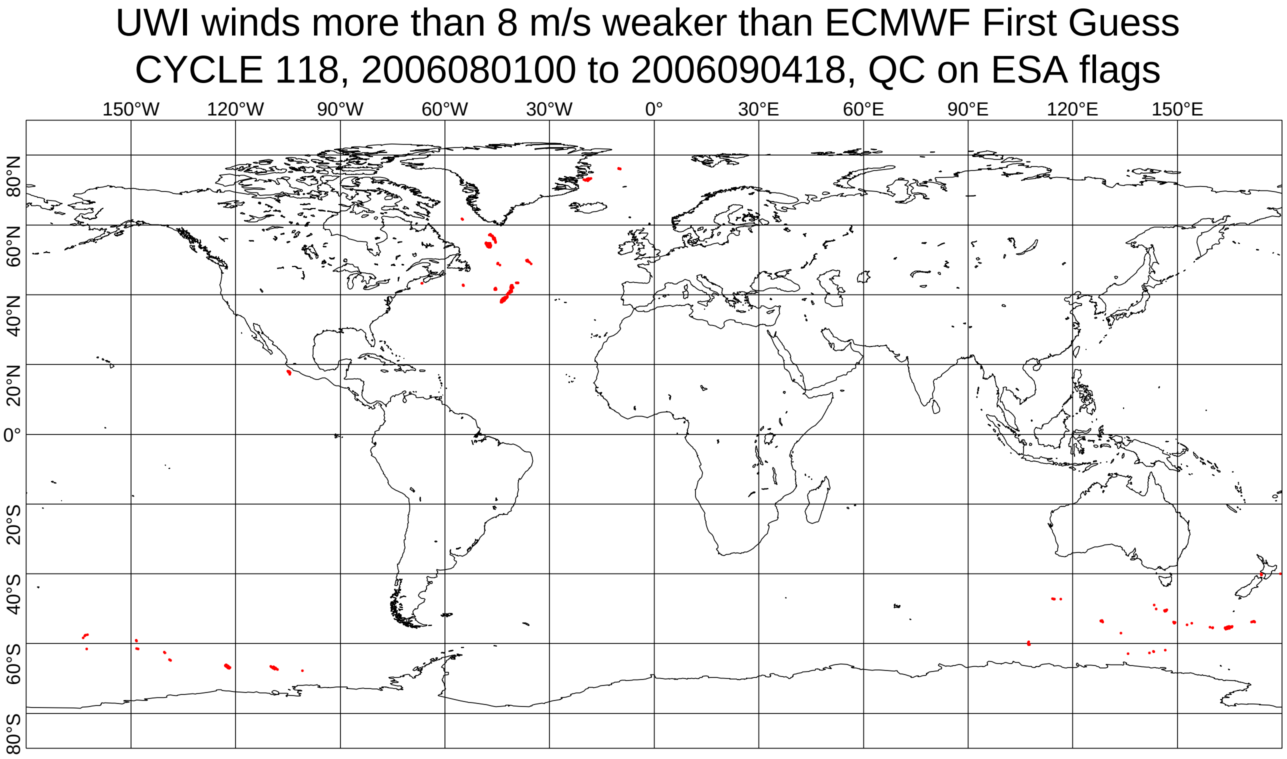

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2006080100 to 2006090418
(solid) wind speed bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind speed standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
AUG
SEP
2006

Figure 9



Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2006080100 to 2006090418
(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: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19

Figure 10


UWI winds more than 8 m/s weaker than ECMWF First Guess
CYCLE 118, 2006080100 to 2006090418, 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

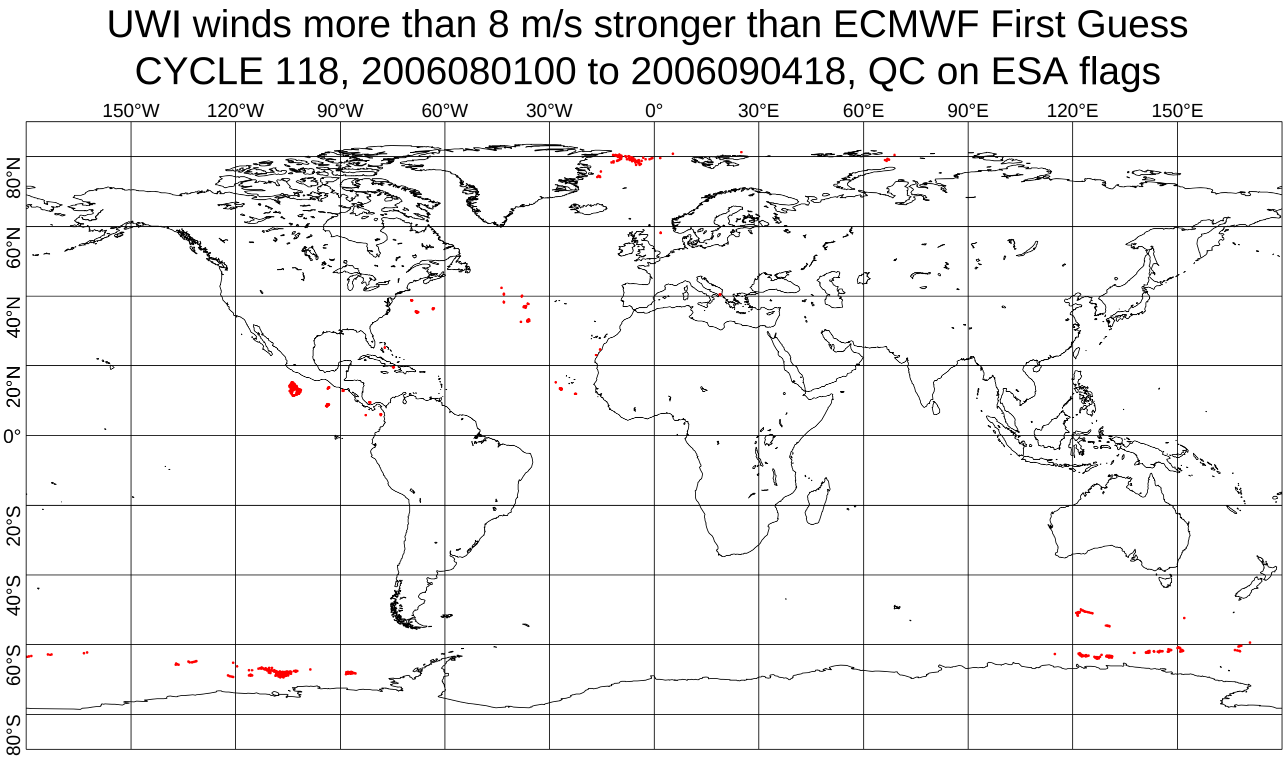
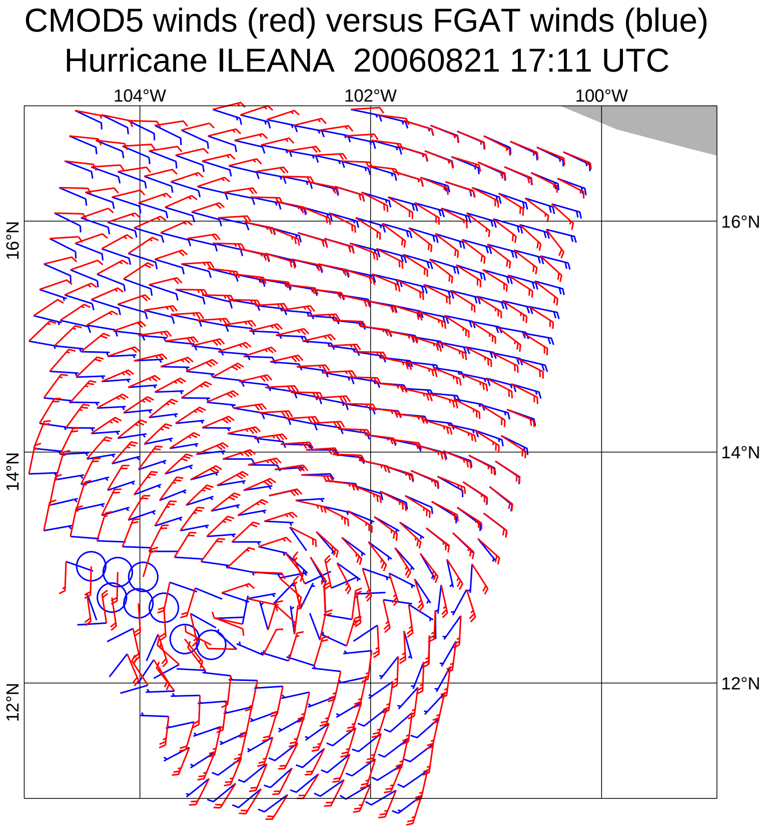

UWI winds more than 8 m/s stronger than ECMWF First Guess
CYCLE 118, 2006080100 to 2006090418, QC on ESA flags
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

Figure 11


CMOD5 winds (red) versus FGAT winds (blue)
Hurricane ILEANA 20060821 17:11 UTC
104°W
102°W
100°W
16°N
14°N
12°N

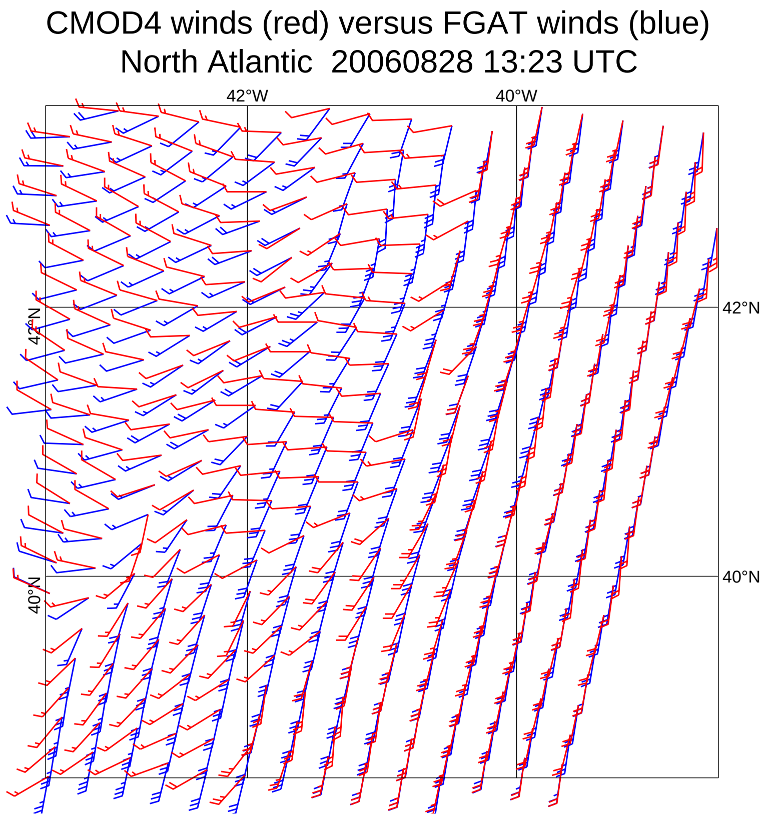

CMOD4 winds (red) versus FGAT winds (blue)
North Atlantic 20060828 13:23 UTC
42°W
40°W
42°N
40°N

Figure 12

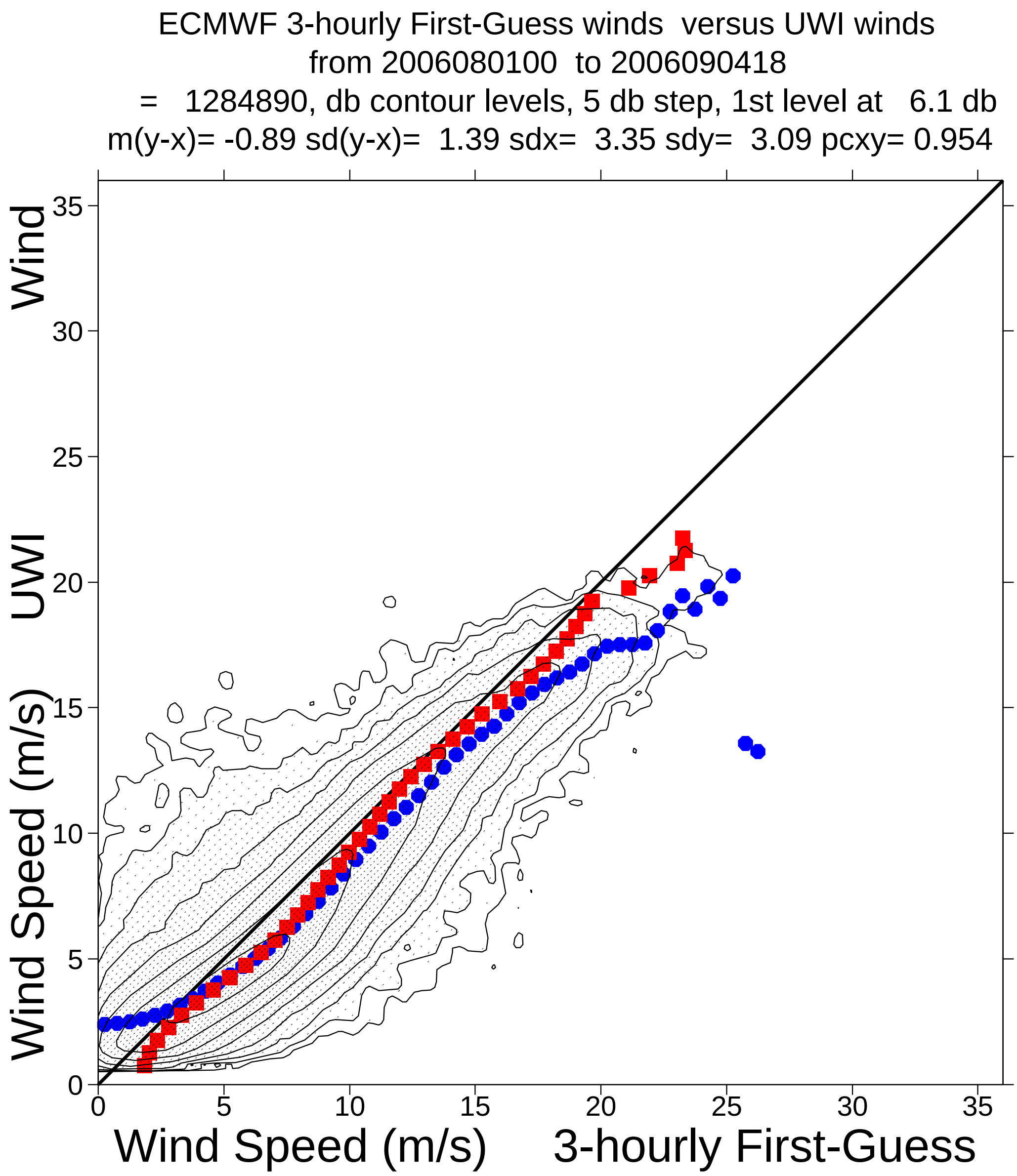
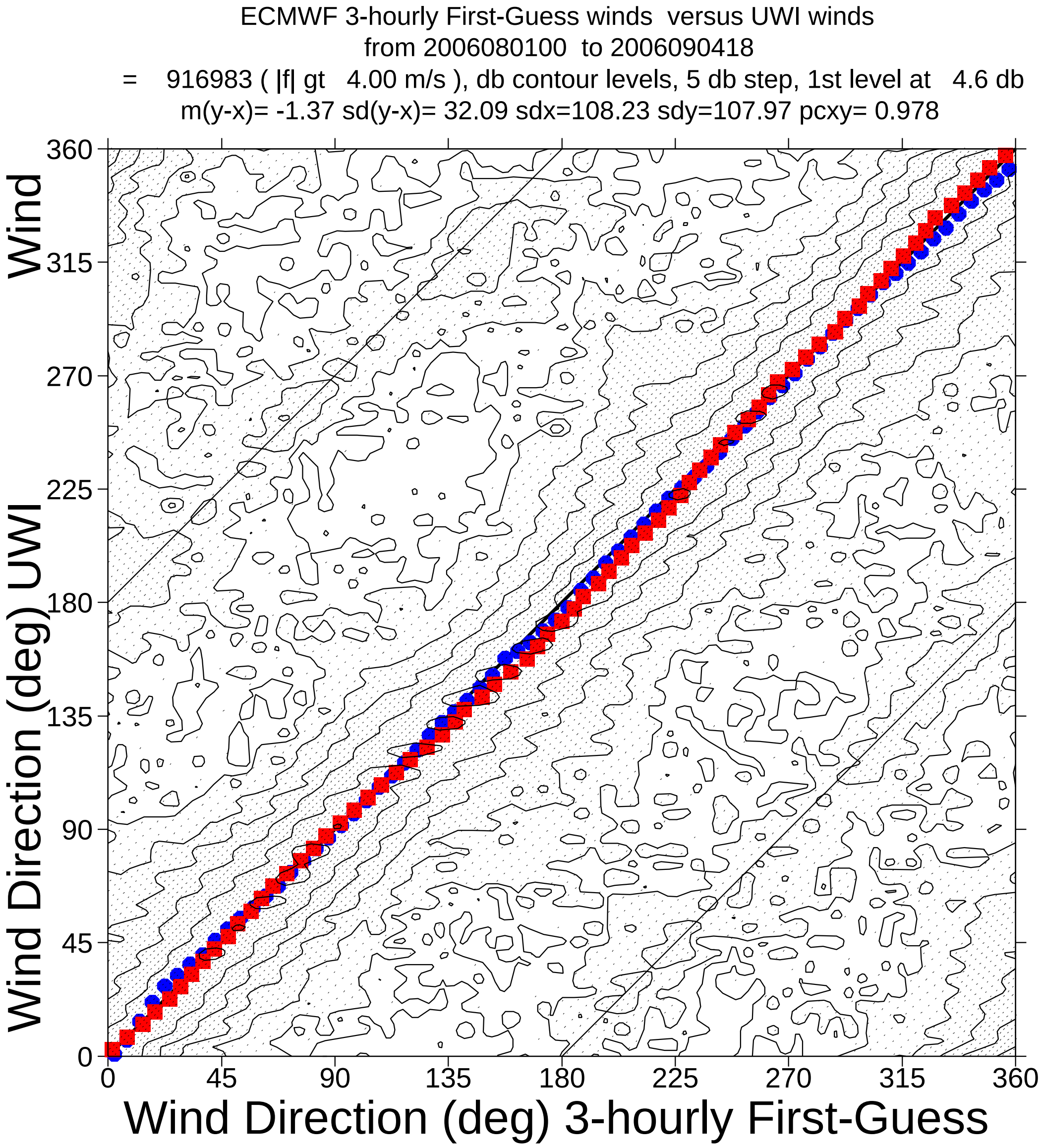

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2006080100 to 2006090418
= 1284890, db contour levels, 5 db step, 1st level at 6.1 db
m(y-x)= -0.89 sd(y-x)= 1.39 sdx= 3.35 sdy= 3.09 pcxy= 0.954
Wind Speed (m/s) UWI Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 13



ECMWF 3-hourly First-Guess winds versus UWI winds
from 2006080100 to 2006090418
= 916983 (|f| gt 4.00 m/s), db contour levels, 5 db step, 1st level at 4.6 db
m(y-x)= -1.37 sd(y-x)= 32.09 sdx=108.23 sdy=107.97 pcxy= 0.978
Wind Direction (deg) UWI Wind
0
45
90
135
180
225
270
315
360
Wind Direction (deg) 3-hourly First-Guess

Figure 14

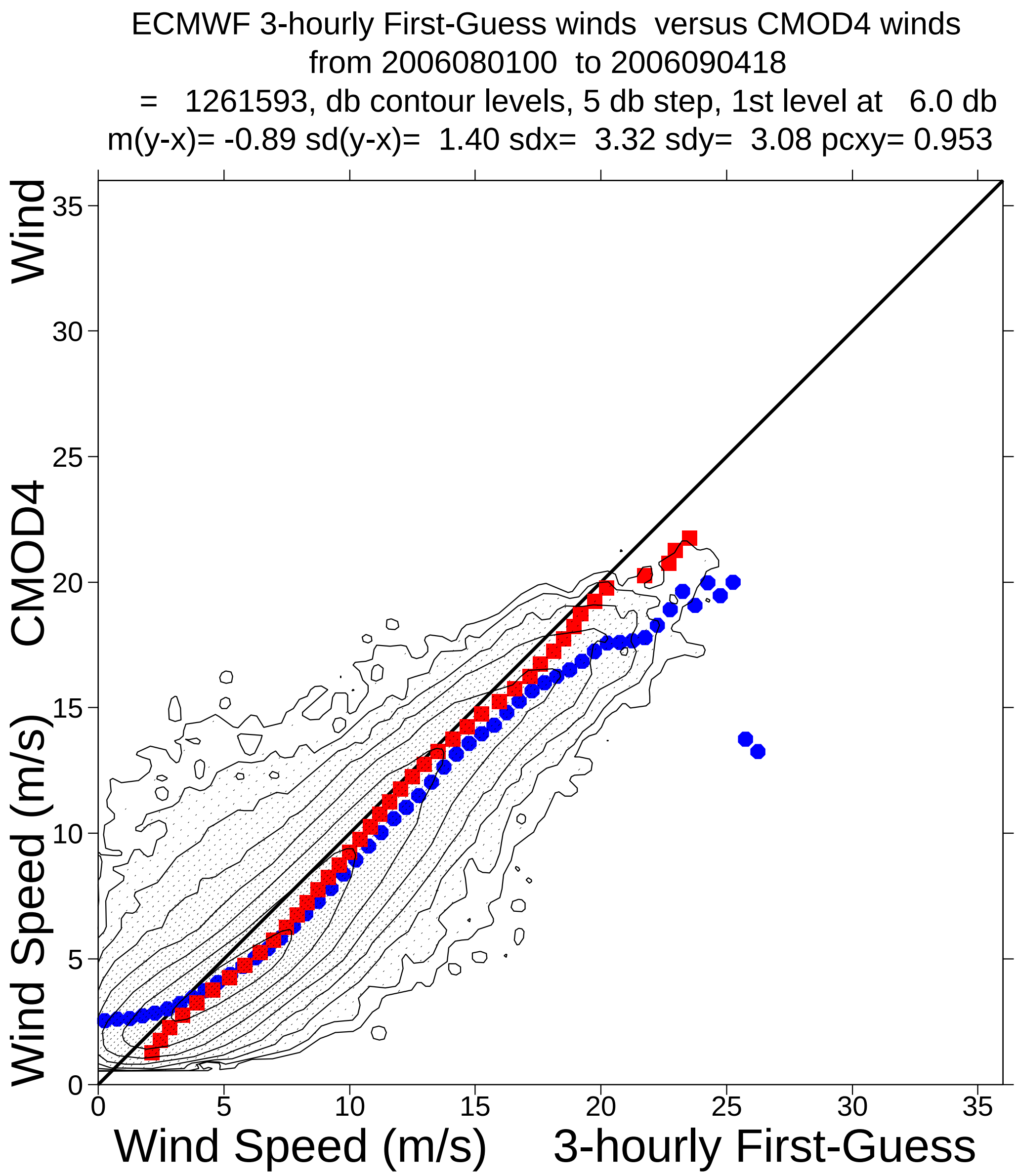
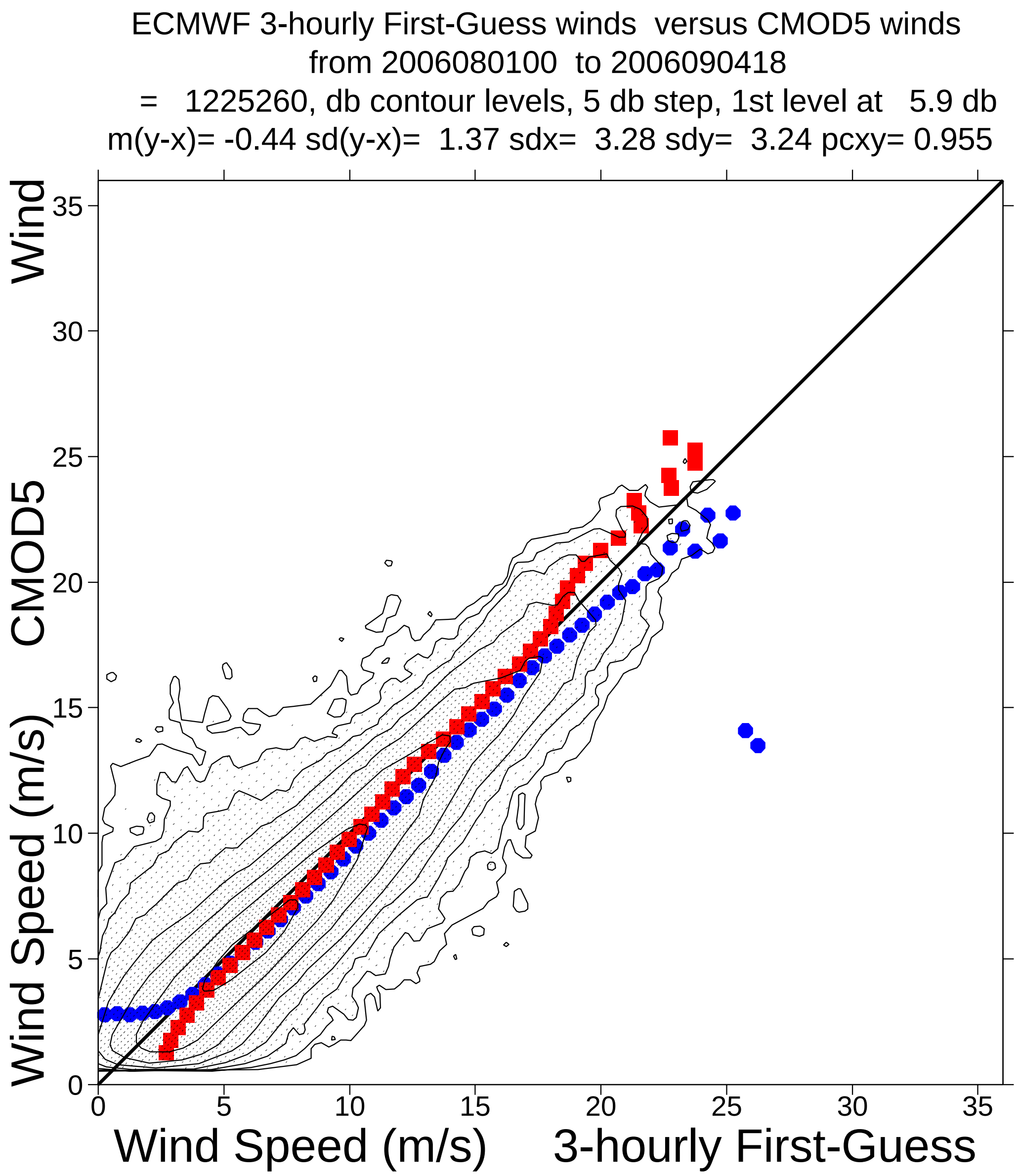

ECMWF 3-hourly First-Guess winds versus CMOD4 winds
from 2006080100 to 2006090418
= 1261593, db contour levels, 5 db step, 1st level at 6.0 db
m(y-x)= -0.89 sd(y-x)= 1.40 sdx= 3.32 sdy= 3.08 pcxy= 0.953
Wind Speed (m/s) CMOD4 Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 15



ECMWF 3-hourly First-Guess winds versus CMOD5 winds
from 2006080100 to 2006090418
= 1225260, db contour levels, 5 db step, 1st level at 5.9 db
m(y-x)= -0.44 sd(y-x)= 1.37 sdx= 3.28 sdy= 3.24 pcxy= 0.955
Wind Speed (m/s) CMOD5 Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 16

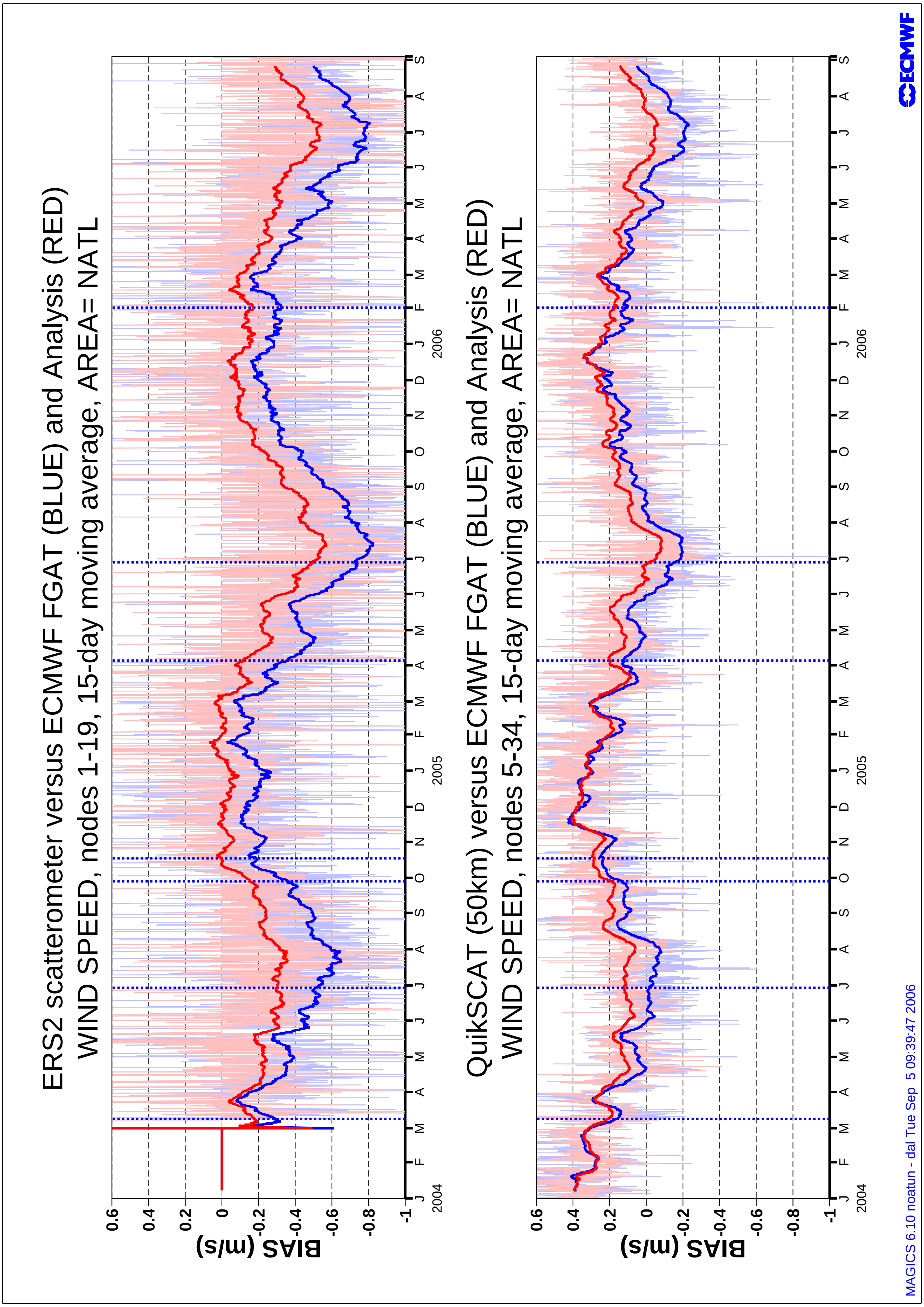

ERS2 scatterometer versus ECMWF FGAT (BLUE) and Analysis (RED)
WIND SPEED, nodes 1-19, 15-day moving average, AREA= NATL
QuikSCAT (50km) versus ECMWF FGAT (BLUE) and Analysis (RED)
WIND SPEED, nodes 5-34, 15-day moving average, AREA= NATL
BIAS (m/s)
2004
2005
2006
ECMWF
MAGICS 6.10 noatun - dal Tue Sep 5 09:39:47 2006

Figure 17