Monitoring statistics of the ERS-2 scatterometer for ESA

Cycle 117

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1 Introduction

The quality of the UWI product was monitored at ECMWF for Cycle 117. 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 117 data was received between 21:04 UTC 26 June and 20:58 UTC 31 July 2006. For all 6-hourly batches (centred around 00, 06, 12 and 18 UTC) data was received.

Data is being recorded whenever within the visibility range of a ground station. For Cycle 117 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).

During Cycle 117, 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 116, the UWI wind speed relative to ECMWF first-guess (FG) fields showed a slightly lower standard deviation (from 1.39 m/s to 1.35 m/s). Bias levels were stable (from -0.99 m/s to -1.00 m/s).

During Cycle 117, the performance of the UWI wind direction was nominal.

Towards the end of Cycle 117 (25 July 2006 onwards) an improved behaviour

in both wind speed and wind direction was observed. During Cycle 118 it must become clear whether the change is realistic or represents a statistical fluctuation.

Ocean calibration shows that inter-node and inter-beam dependencies of bias levels are still large. Average bias levels were reasonably stable (-0.84 dB was -0.81 dB; see Figure 4).

The ECMWF assimilation/forecast system was not changed during Cycle 117.

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

2 ERS-2 statistics from 26 June to 31 July 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 116, 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 slightly more negative compared to Cycle 116 (-0.84 dB, was -0.82 dB), being about 0.35 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 106), 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 3%) 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. A high-speed solar wind stream hit Earth on 27 July 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 116, 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 116, the average level was higher (1.23 versus 1.18), which is about 13% 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 only mild peaks. Similar results apply for the history of de-aliased CMOD4 winds versus FG (Figure 9). In addition, for both UWI and de-aliased CMOD4 wind speed, a slightly improved behaviour is observed after 25 July 2006. Since this change occurred near the end of Cycle 117, it must appear during Cycle 118 whether the improved behaviour is realistic or just a statistical fluctuation.

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 116, 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, where de-aliased CMOD5 winds are shown, rather than the UWI winds. Top panel shows the observation of Super Typhoon Ewiniar on 9 July 2006 South-West from Korea, the lower panel displays the capture of tropical storm Beryl, South-East of New York. Both the scatterometer and model capture these cyclones well, and part of the difference in UWI and ECMWF FG wind speed reflects the under-estimation of CMOD4 for extreme cases. Differences are smaller for CMOD5. Note the lack of cross-isobar flow and underestimation of the ECMWF winds near the centre of Beryl.

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 is stable, and is more negative to that for nominal data in 2000 (UWI: -1.00 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

	Cycle 116		Cycle 117	
	UWI	CMOD4	UWI	CMOD4
speed STDV	1.39	1.39	1.35	1.35
node 1-2	1.40	1.39	1.41	1.40
node 3-4	1.35	1.34	1.34	1.34
node 5-7	1.33	1.33	1.30	1.30
node 8-10	1.35	1.35	1.29	1.30
node 11-14	1.37	1.37	1.31	1.32
node 15-19	1.41	1.41	1.35	1.35
speed BIAS	-0.99	-0.99	-1.00	-1.01
node 1-2	-1.49	-1.47	-1.47	-1.45
node 3-4	-1.25	-1.22	-1.24	-1.21
node 5-7	-1.02	-1.00	-1.02	-1.00
node 8-10	-0.84	-0.84	-0.84	-0.85
node 11-14	-0.81	-0.83	-0.82	-0.84
node 15-19	-0.82	-0.86	-0.87	-0.91
direction STDV	25.4	18.7	25.1	18.2
direction BIAS	-1.6	-1.9	-2.1	-2.3

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

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 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 31 July 2006 (end of Cycle 117). 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 116 was reduced (1.35 m/s, was 1.39 m/s).

For Cycle 117 the (UWI - FG) direction standard deviations were mostly ranging between 20 and 40 degrees (Figure 8), representing nominal variations. Averaged over the entire cyclic period, STDV for UWI wind direction was stable (25.1 degrees, was 25.4 degrees). Performance for at ECMWF de-aliased winds was 18.2 degrees, almost equal to that for Cycle 116 (STDV 18.7 degrees). Like for wind speed, an improved behaviour is observed after 25 July 2006, especially for UWI wind direction (Figure 8).

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 (1.35 m/s versus 1.38 m/s). Compared to ECMWF FG, CMOD5 winds are 0.54 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 31 July 2006 (end Cycle 117) 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 117 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 super Typhoon Ewiniar on 9 July 2006 (top panel) and tropical storm Beryl on 20 July 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 - 31 July 2006. Fat curves represent centred 15-day running means, thin curves values for 6-hourly periods. Vertical dashed blue lines mark ECMWF model changes.

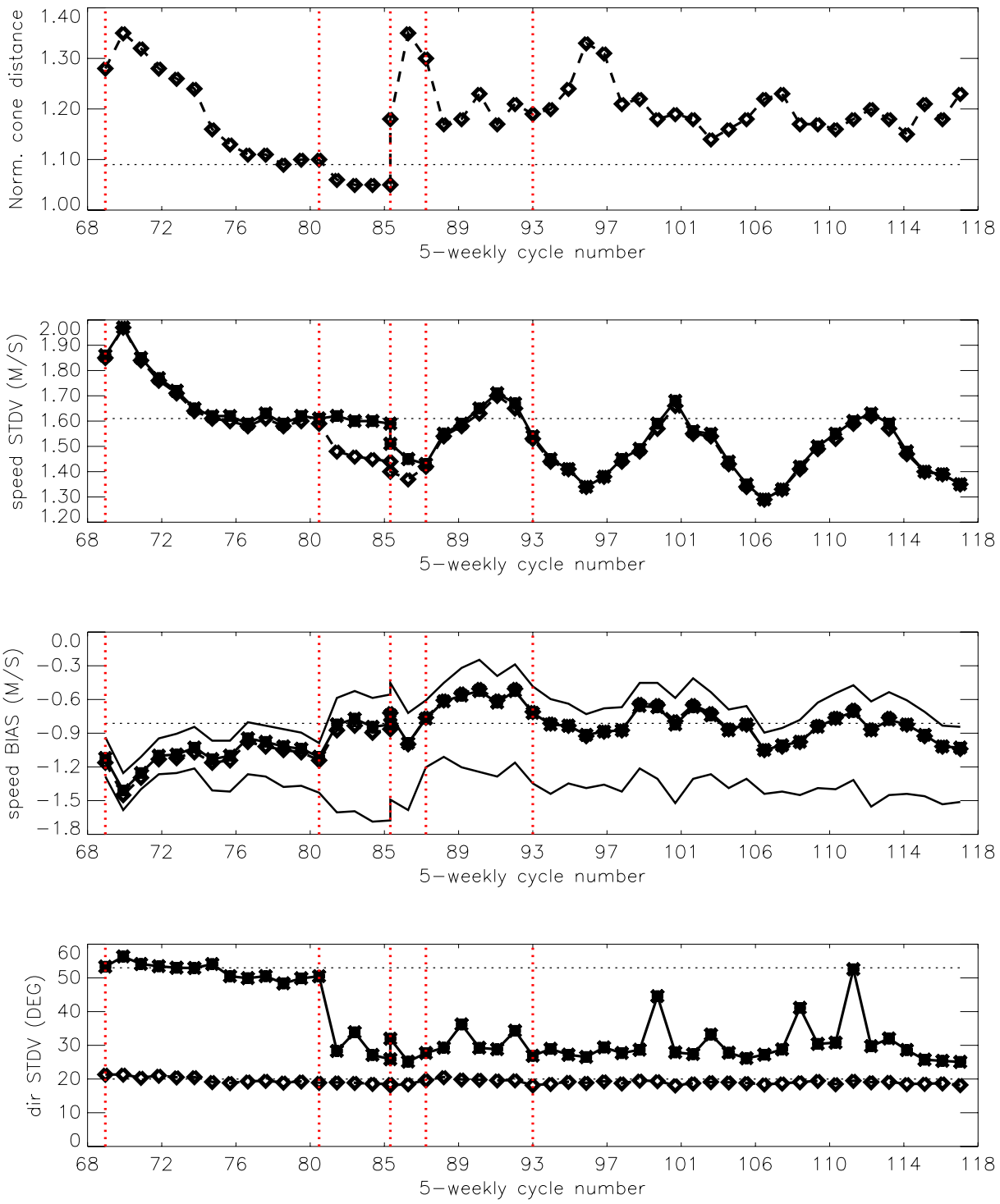
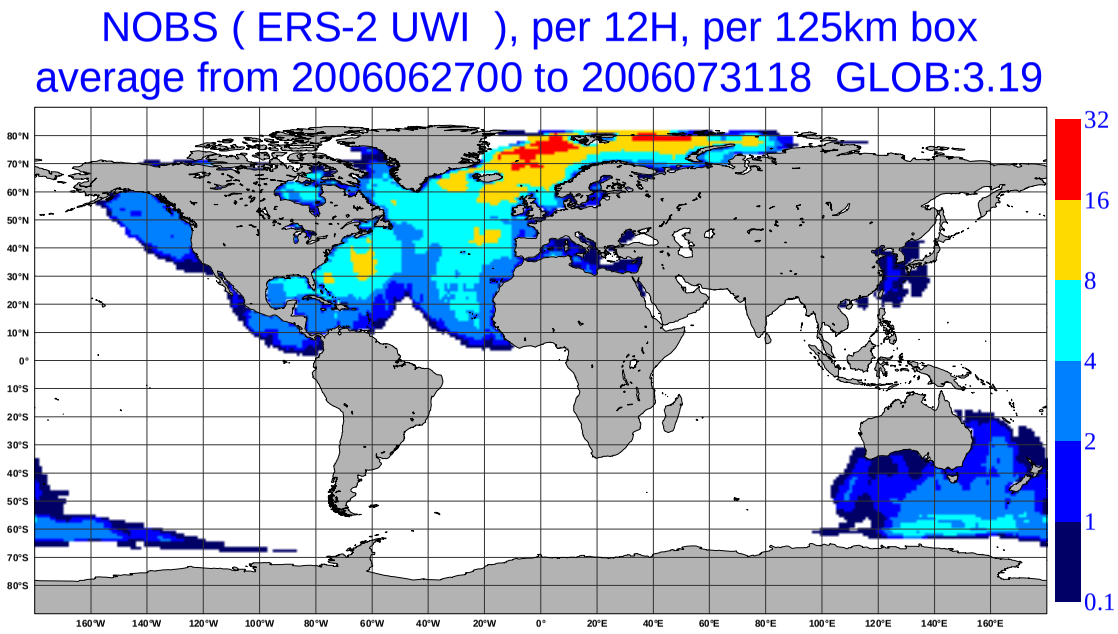

Norm. cone distance
1.40
1.30
1.20
1.10
1.00
68 72 76 80 85 89 93 97 101 106 110 114 118
5−weekly cycle number
speed STDV (M/S)
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
68 72 76 80 85 89 93 97 101 106 110 114 118
5−weekly cycle number
speed BIAS (M/S)
0.0
−0.3
−0.6
−0.9
−1.2
−1.5
−1.8
68 72 76 80 85 89 93 97 101 106 110 114 118
5−weekly cycle number
dir STDV (DEG)
60
50
40
30
20
10
0
68 72 76 80 85 89 93 97 101 106 110 114 118
5−weekly cycle number

Figure 1


NOBS (ERS-2 UWI), per 12H, per 125km box
average from 2006062700 to 2006073118 GLOB:3.19
32
16
8
4
2
1
0.1

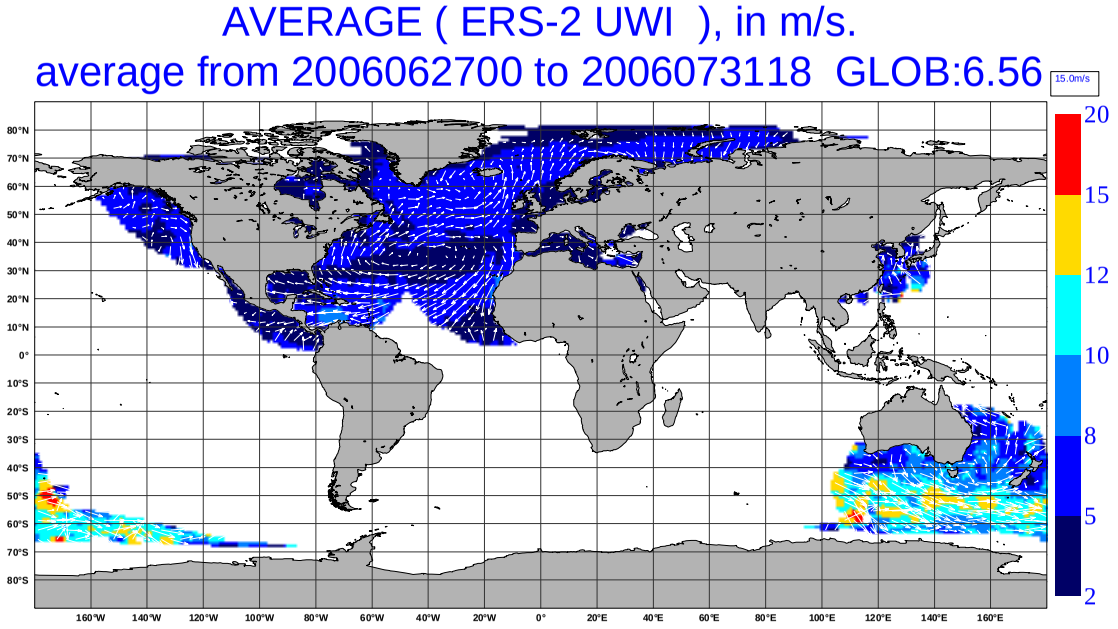
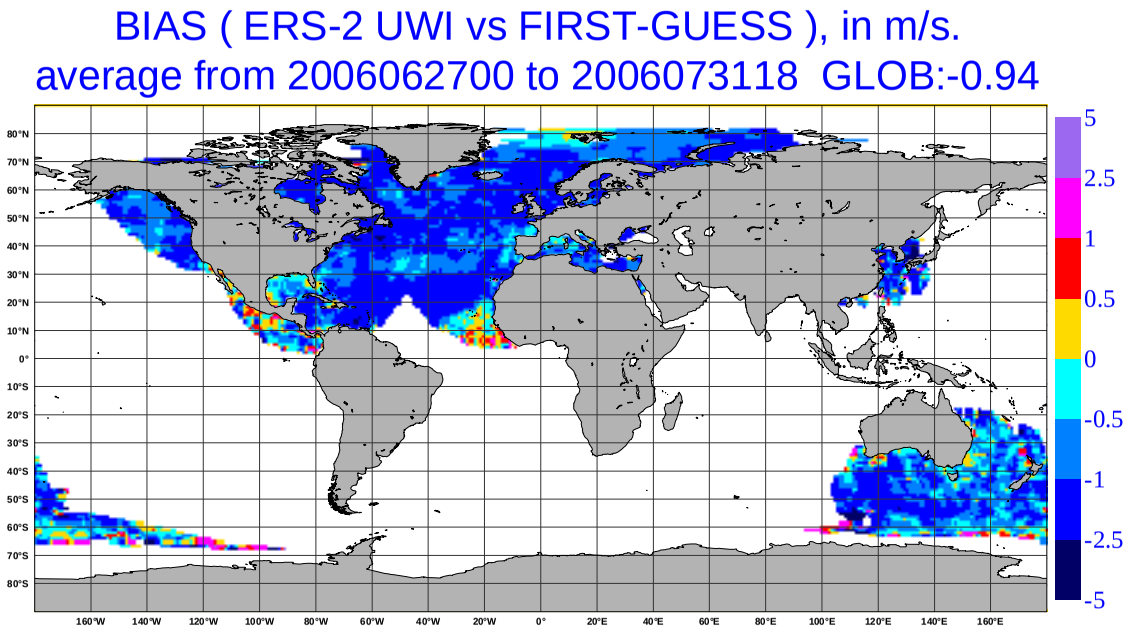

AVERAGE (ERS-2 UWI), in m/s.
average from 2006062700 to 2006073118 GLOB:6.56
15.0m/s
20
15
12
10
8
5
2

Figure 2


BIAS (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2006062700 to 2006073118 GLOB:-0.94
5
2.5
1
0.5
0
-0.5
-1
-2.5
-5

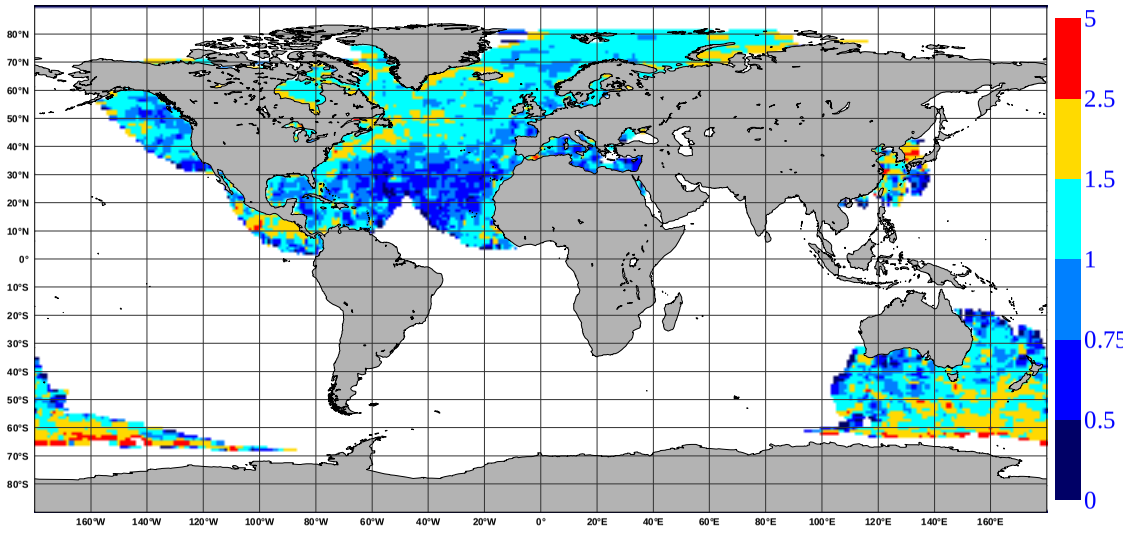

STDV (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2006062700 to 2006073118 GLOB:1.18
5
2.5
1.5
1
0.75
0.5
0

Figure 3

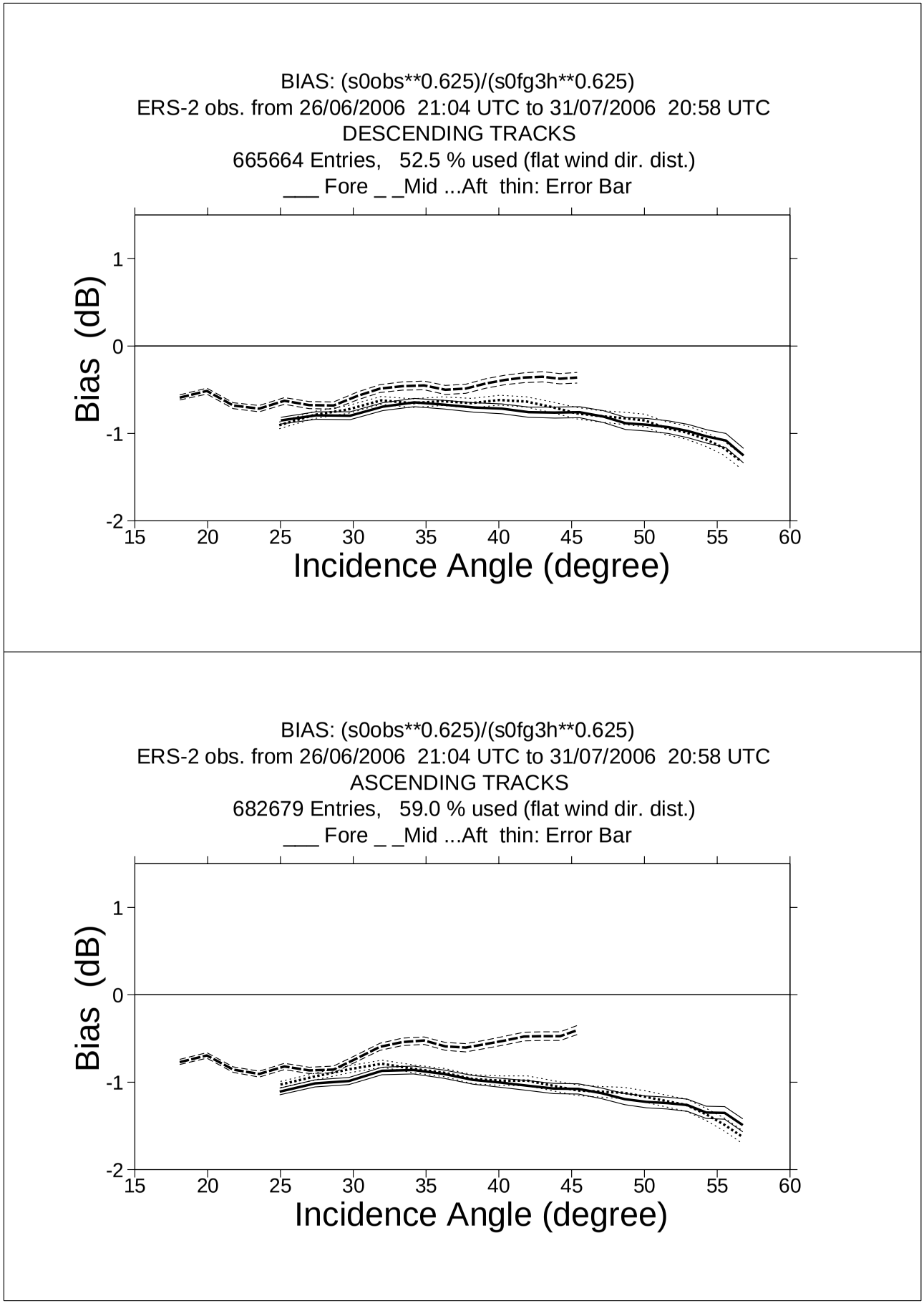

BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 26/06/2006 21:04 UTC to 31/07/2006 20:58 UTC
DESCENDING TRACKS
665664 Entries, 52.5 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
1
0
-1
-2
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)
BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 26/06/2006 21:04 UTC to 31/07/2006 20:58 UTC
ASCENDING TRACKS
682679 Entries, 59.0 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
1
0
-1
-2
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)

Figure 4

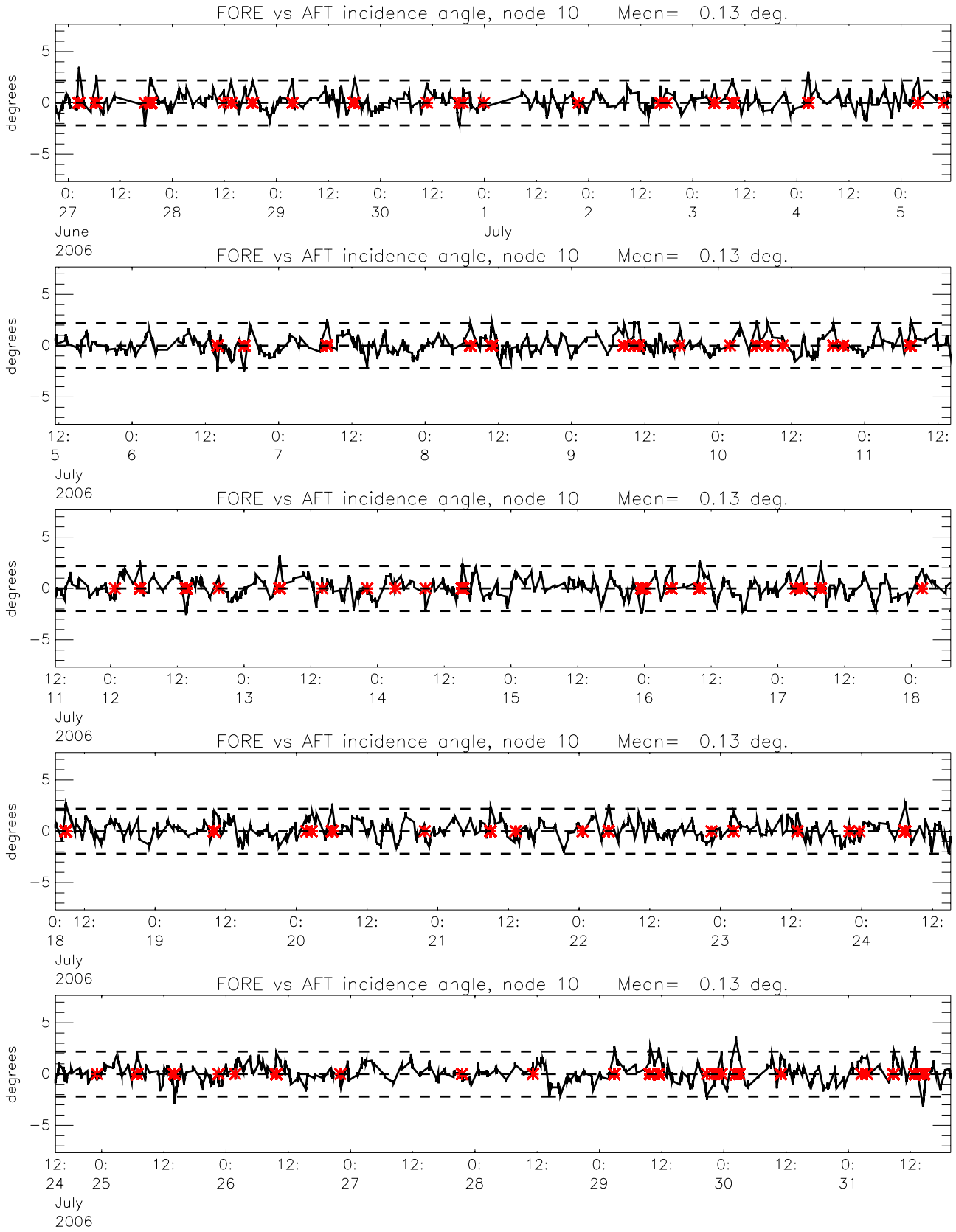

FORE vs AFT incidence angle, node 10 Mean= 0.13 deg.
degrees
5
0
−5
0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0:
27 28 29 30 1 2 3 4 5
June July
2006
FORE vs AFT incidence angle, node 10 Mean= 0.13 deg.
degrees
5
0
−5
12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
5 6 7 8 9 10 11
July
2006
FORE vs AFT incidence angle, node 10 Mean= 0.13 deg.
degrees
5
0
−5
12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0:
11 12 13 14 15 16 17 18
July
2006
FORE vs AFT incidence angle, node 10 Mean= 0.13 deg.
degrees
5
0
−5
0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
18 19 20 21 22 23 24
July
2006
FORE vs AFT incidence angle, node 10 Mean= 0.13 deg.
degrees
5
0
−5
12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
24 25 26 27 28 29 30 31
July
2006

Figure 5

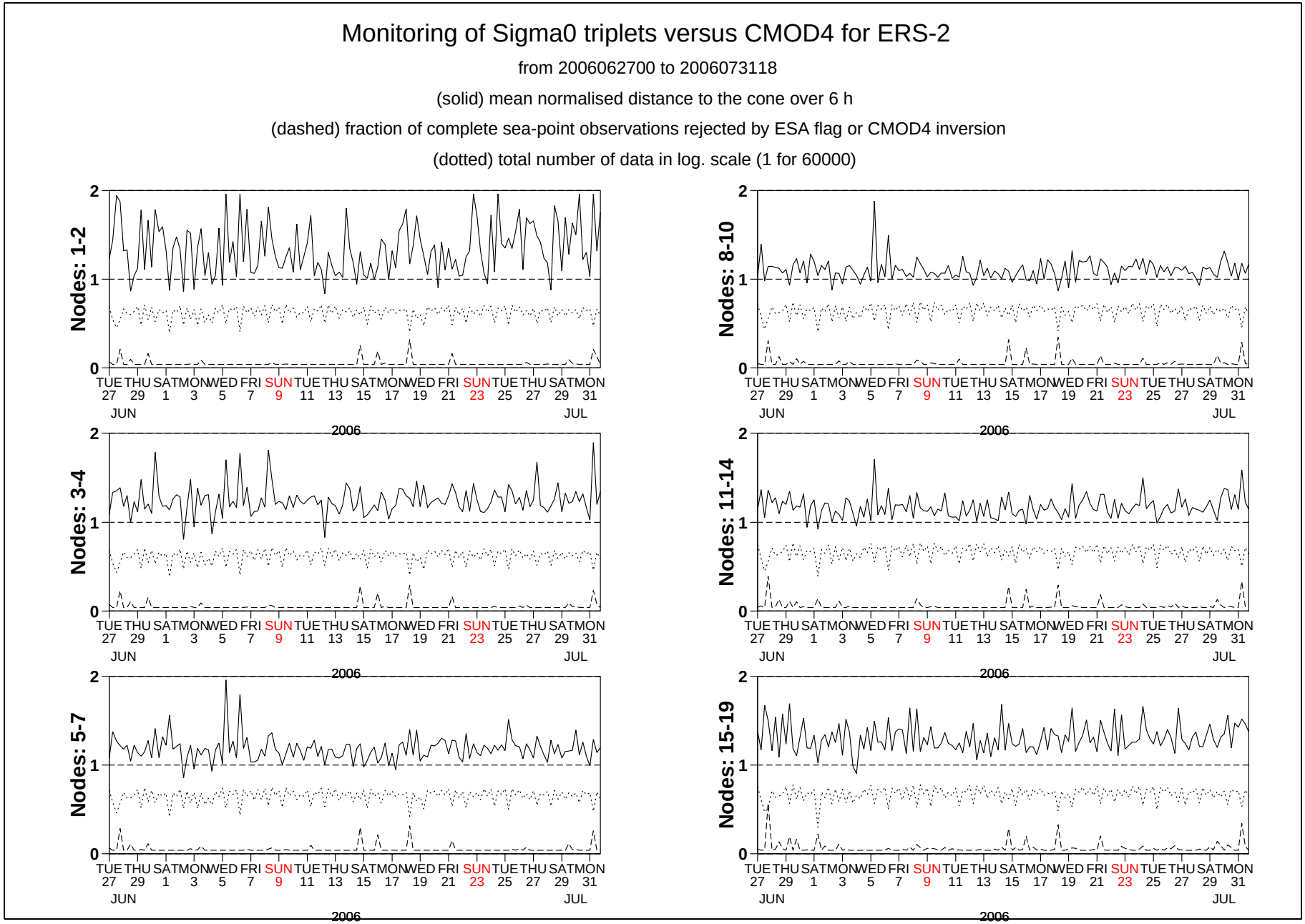

Monitoring of Sigma0 triplets versus CMOD4 for ERS-2
from 2006062700 to 2006073118
(solid) mean normalised distance to the cone over 6 h
(dashed) fraction of complete sea-point observations rejected by ESA flag or CMOD4 inversion
(dotted) total number of data in log. scale (1 for 60000)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
0
1
2
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
27 29 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
JUN
JUL
2006

Figure 6

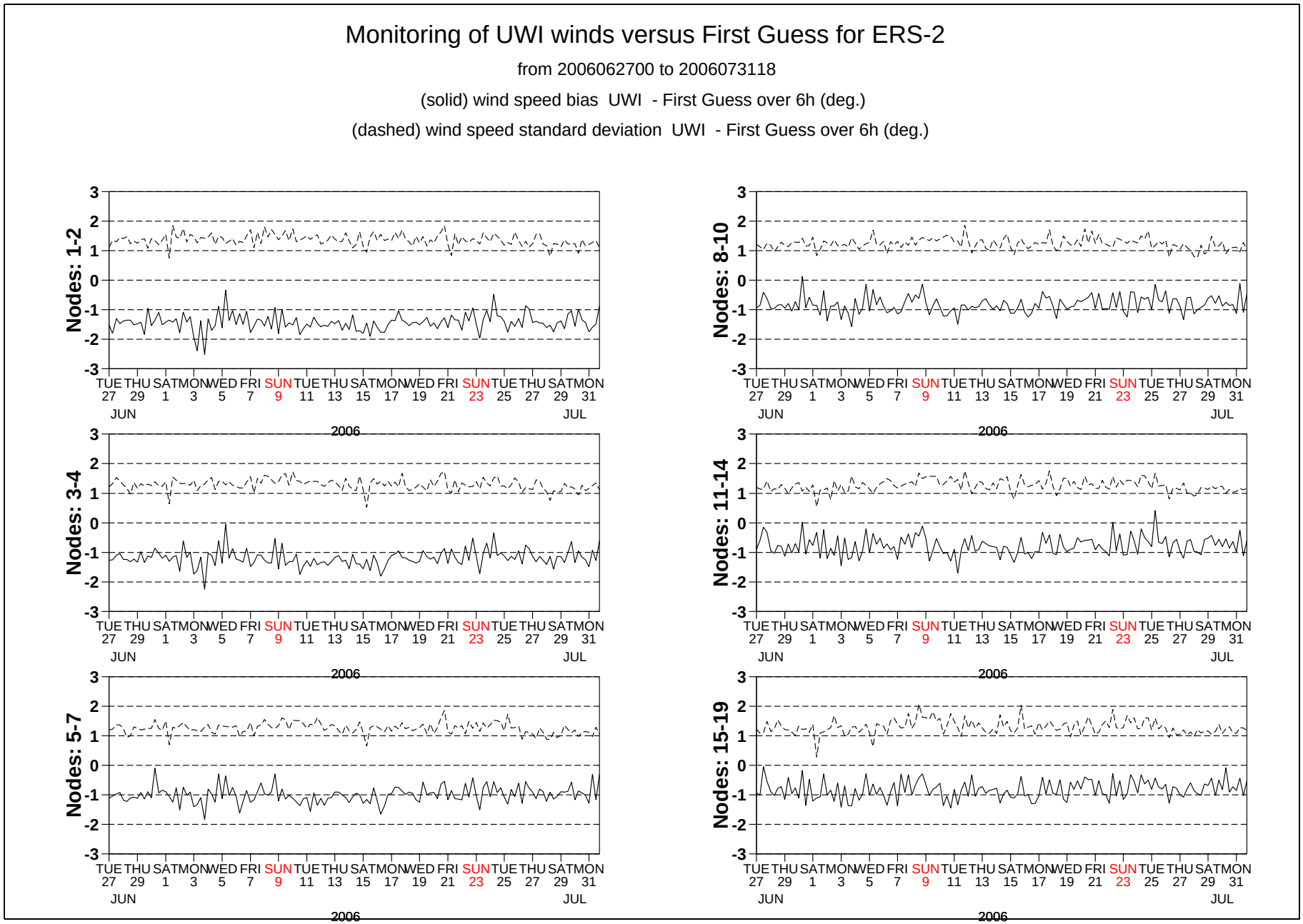

Monitoring of UWI winds versus First Guess for ERS-2
from 2006062700 to 2006073118
(solid) wind speed bias UWI - First Guess over 6h (deg.)
(dashed) wind speed standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
3
2
1
0
-1
-2
-3
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
27 29 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
JUN
JUL
2006

Figure 7

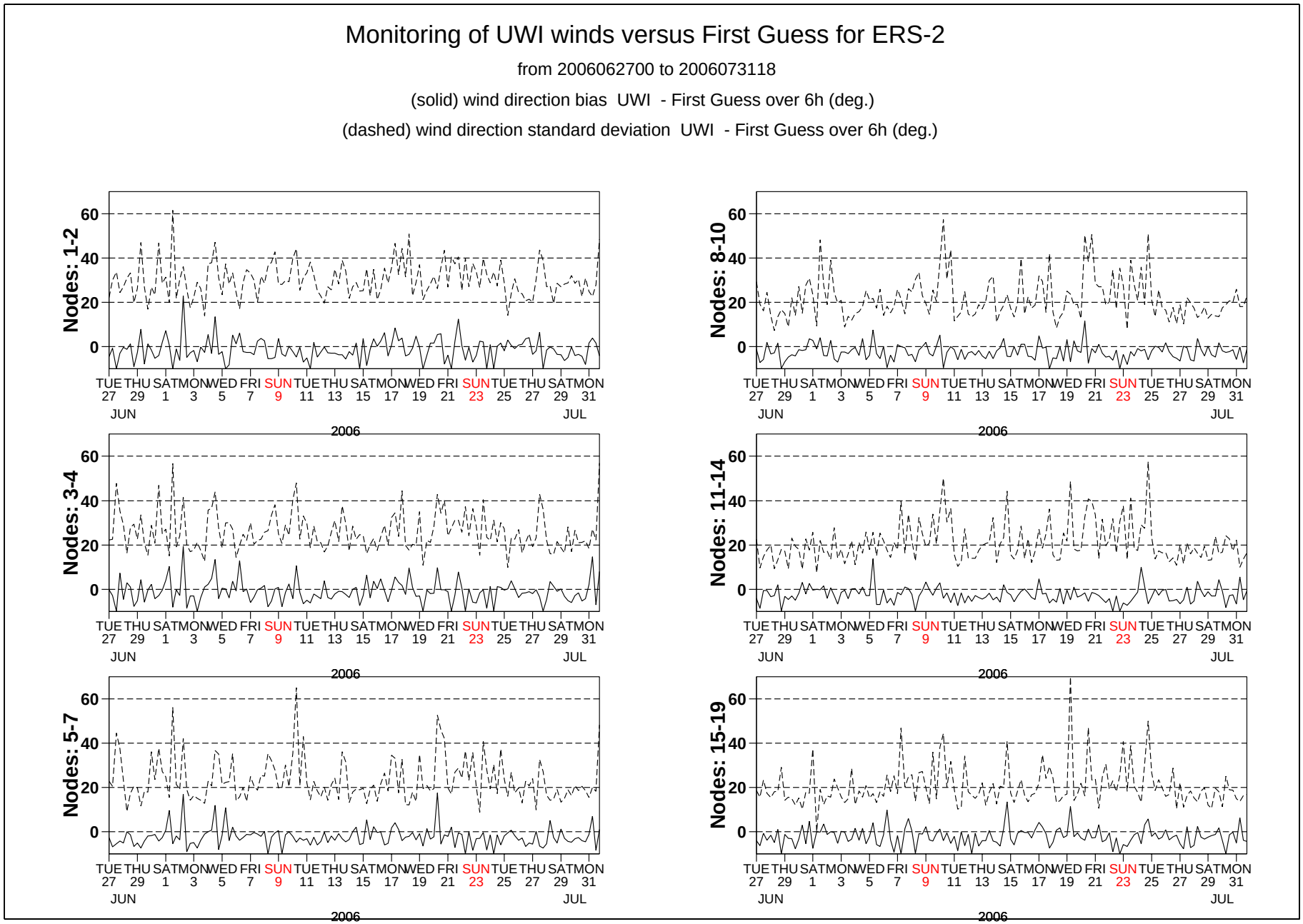

Monitoring of UWI winds versus First Guess for ERS-2
from 2006062700 to 2006073118
(solid) wind direction bias UWI - First Guess over 6h (deg.)
(dashed) wind direction standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
0
20
40
60
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
27 29 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
JUN
JUL
2006

Figure 8

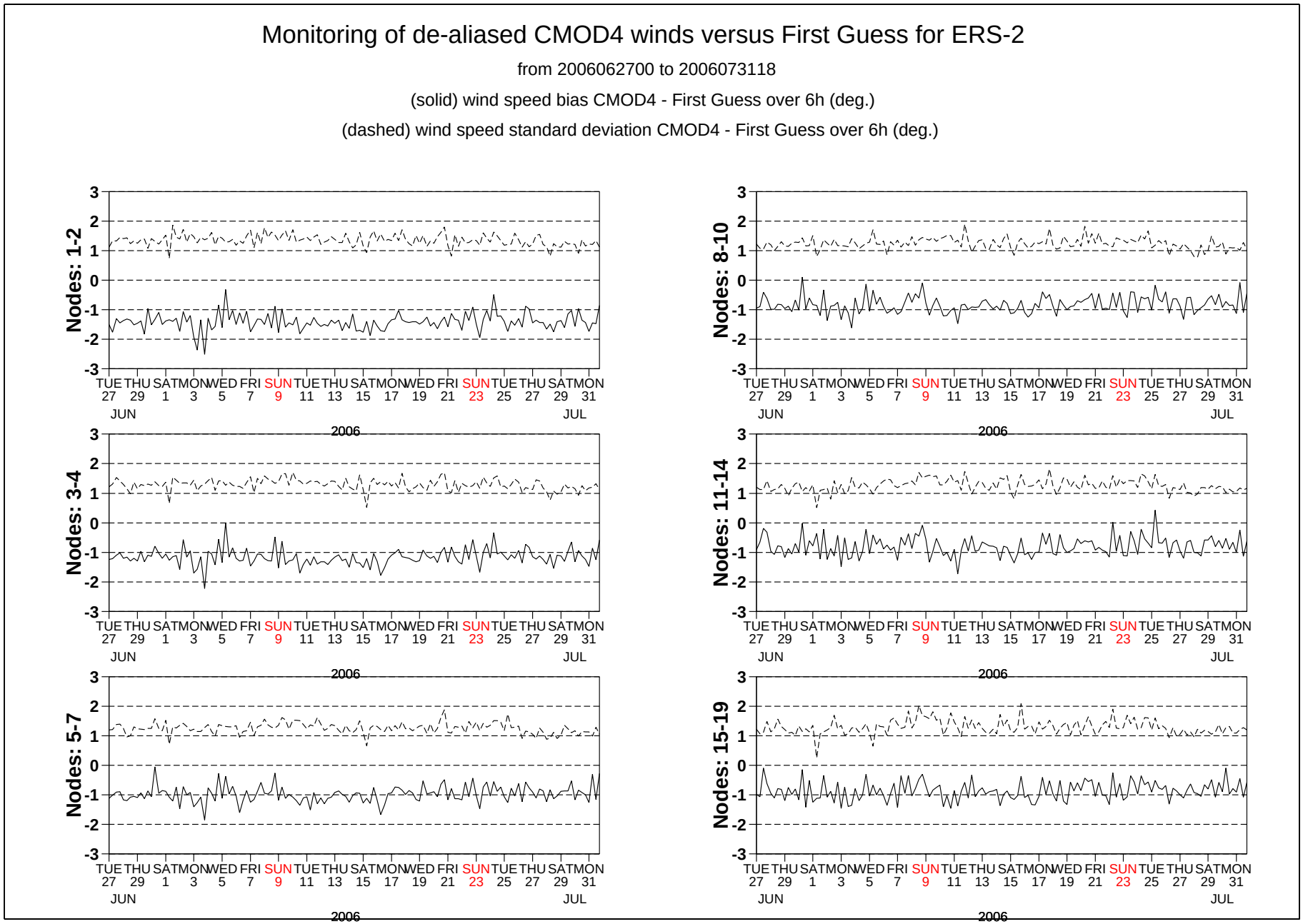

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2006062700 to 2006073118
(solid) wind speed bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind speed standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 15-19
3
2
1
0
-1
-2
-3
TUE THU SAT MON WED FRI SUN TUE THU SAT MON WED FRI SUN TUE THU SAT MON
27 29 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
JUN
JUL
2006

Figure 9

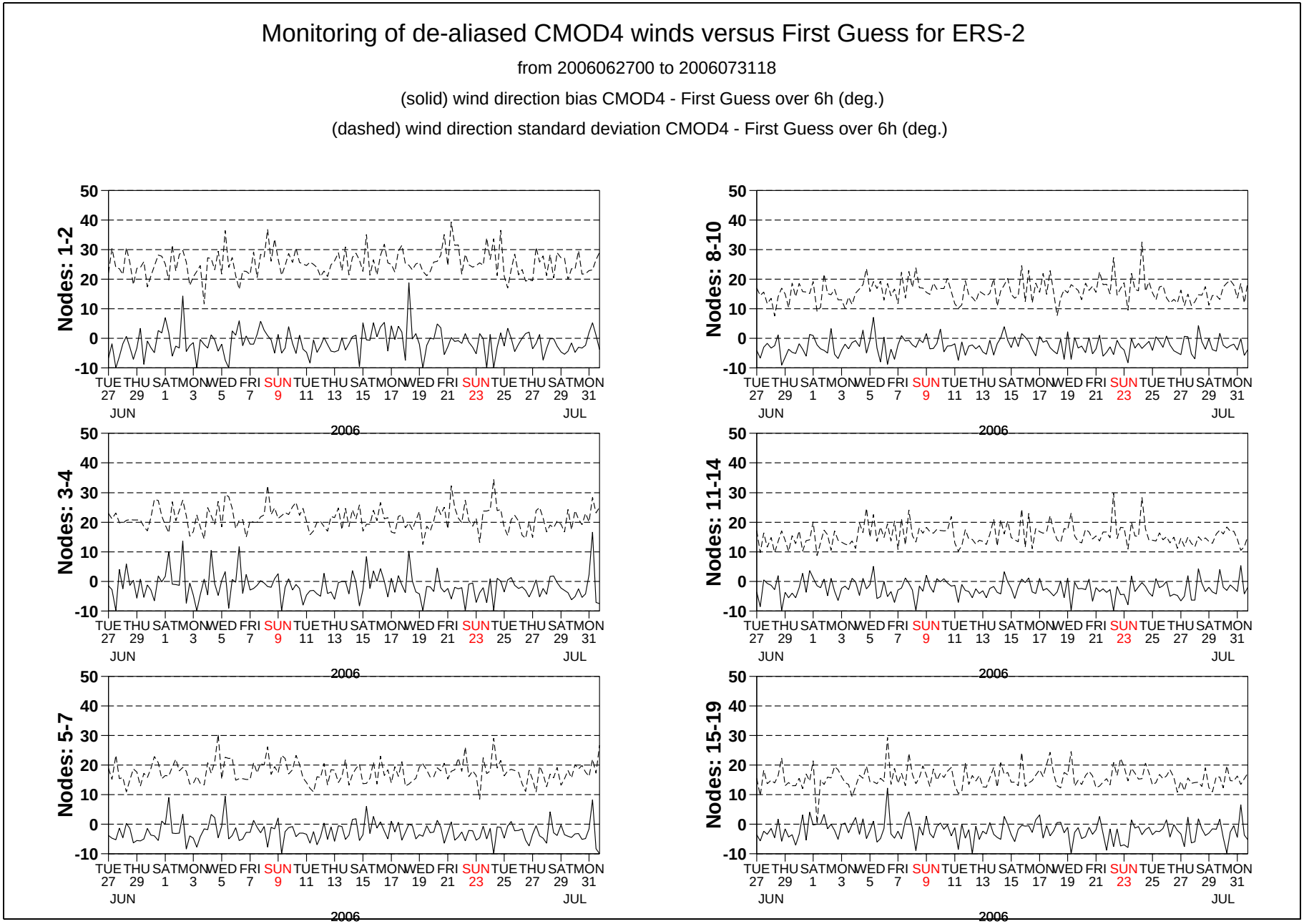
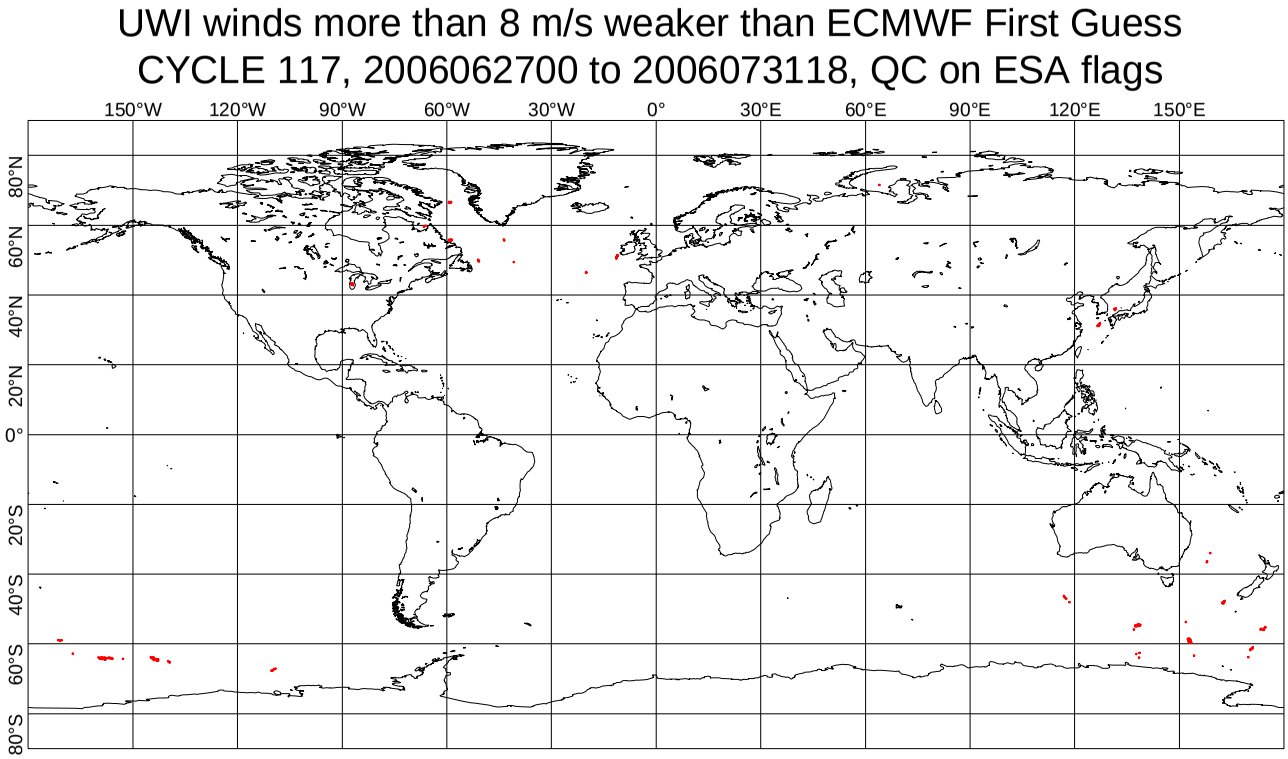

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2006062700 to 2006073118
(solid) wind direction bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind direction standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 8-10
Nodes: 3-4
Nodes: 11-14
Nodes: 5-7
Nodes: 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
27 29 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
JUN
JUL
2006

Figure 10


UWI winds more than 8 m/s weaker than ECMWF First Guess
CYCLE 117, 2006062700 to 2006073118, 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

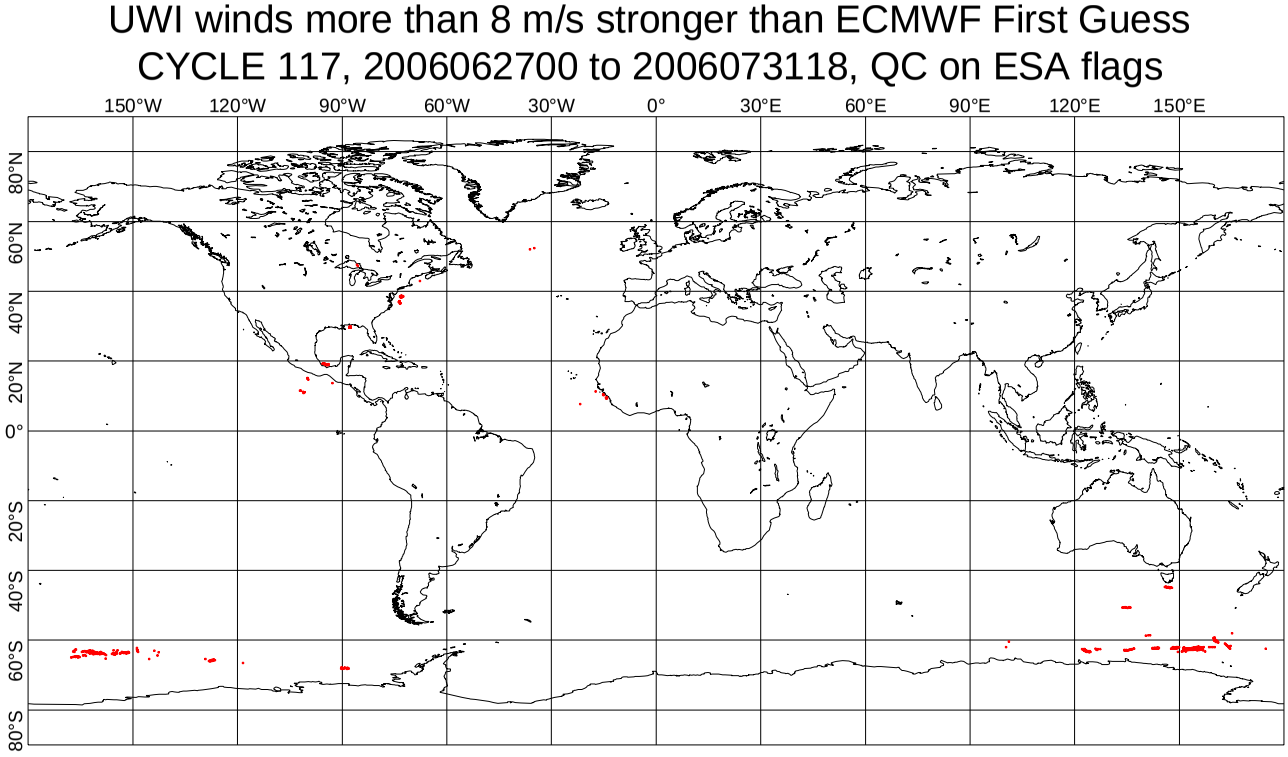
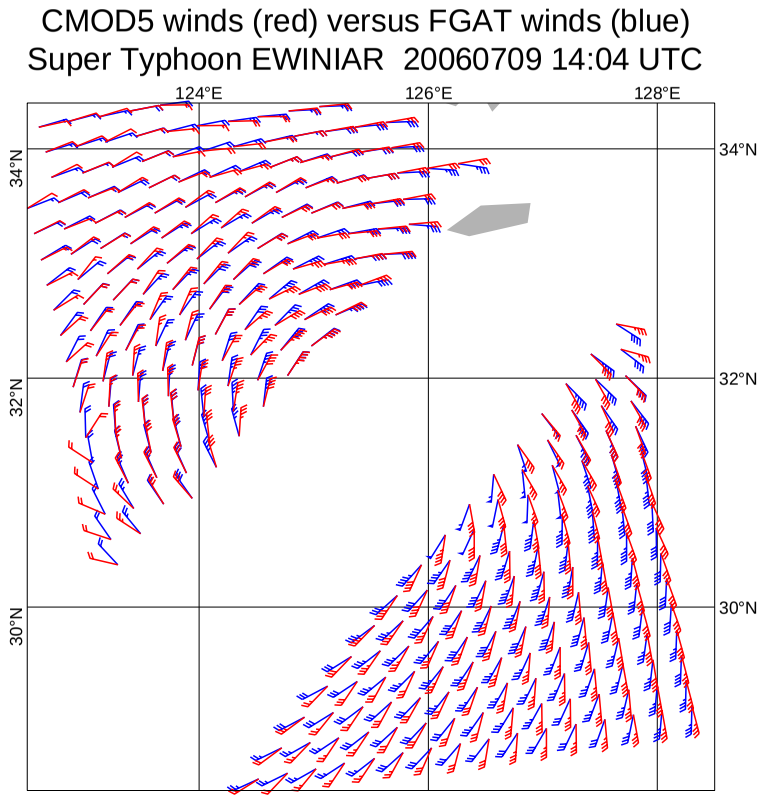

UWI winds more than 8 m/s stronger than ECMWF First Guess
CYCLE 117, 2006062700 to 2006073118, QC on ESA flags
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

Figure 11


CMOD5 winds (red) versus FGAT winds (blue)
Super Typhoon EWINIAR 20060709 14:04 UTC
124°E
126°E
128°E
34°N
32°N
30°N

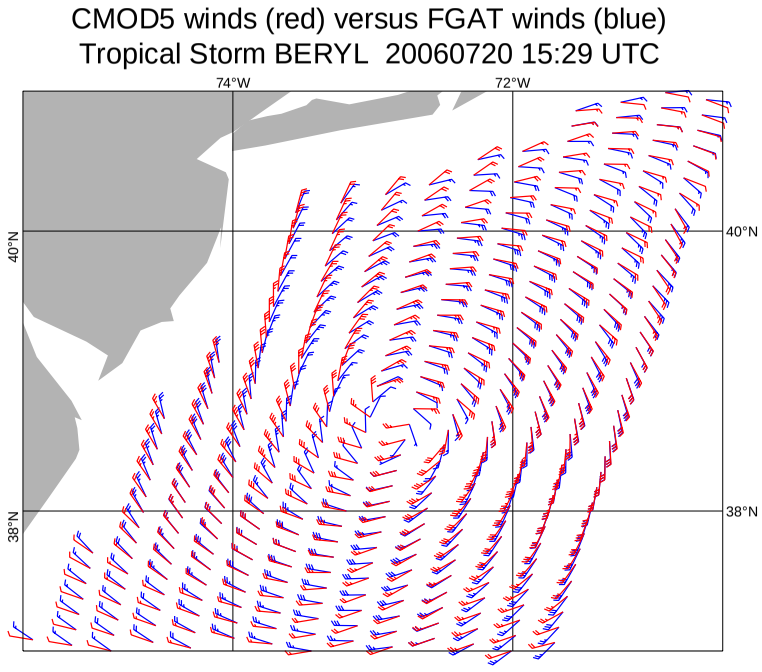

CMOD5 winds (red) versus FGAT winds (blue)
Tropical Storm BERYL 20060720 15:29 UTC
74°W
72°W
40°N
38°N

Figure 12

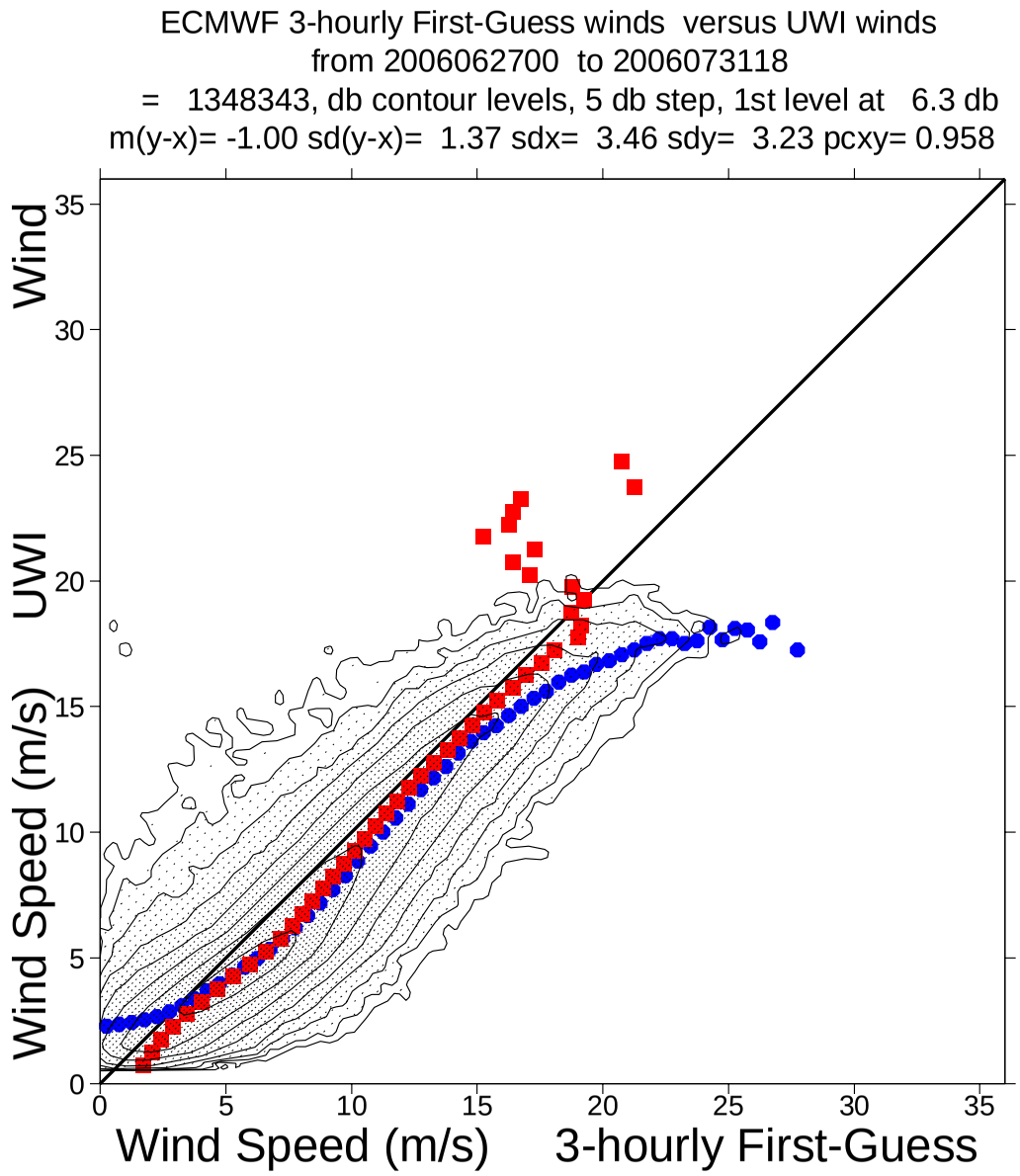

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2006062700 to 2006073118
= 1348343, db contour levels, 5 db step, 1st level at 6.3 db
m(y-x)= -1.00 sd(y-x)= 1.37 sdx= 3.46 sdy= 3.23 pcxy= 0.958
Wind Speed (m/s) UWI Wind
0
5
10
15
20
25
30
35
Wind Speed (m/s) 3-hourly First-Guess

Figure 13

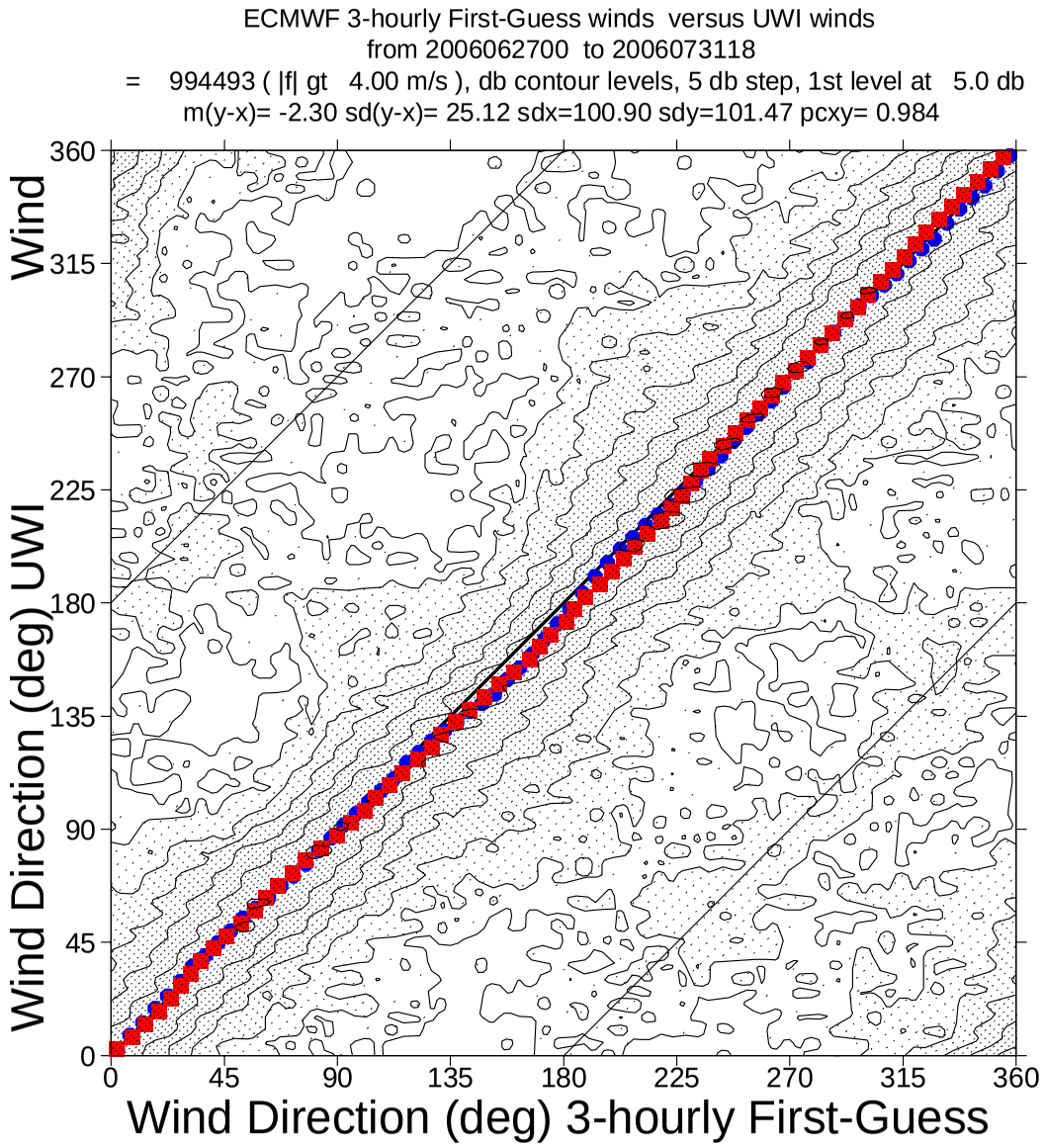

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2006062700 to 2006073118
= 994493 (|f| gt 4.00 m/s), db contour levels, 5 db step, 1st level at 5.0 db
m(y-x)= -2.30 sd(y-x)= 25.12 sdx=100.90 sdy=101.47 pcxy= 0.984
Wind Direction (deg) UWI
Wind Direction (deg) 3-hourly First-Guess
0
45
90
135
180
225
270
315
360

Figure 14

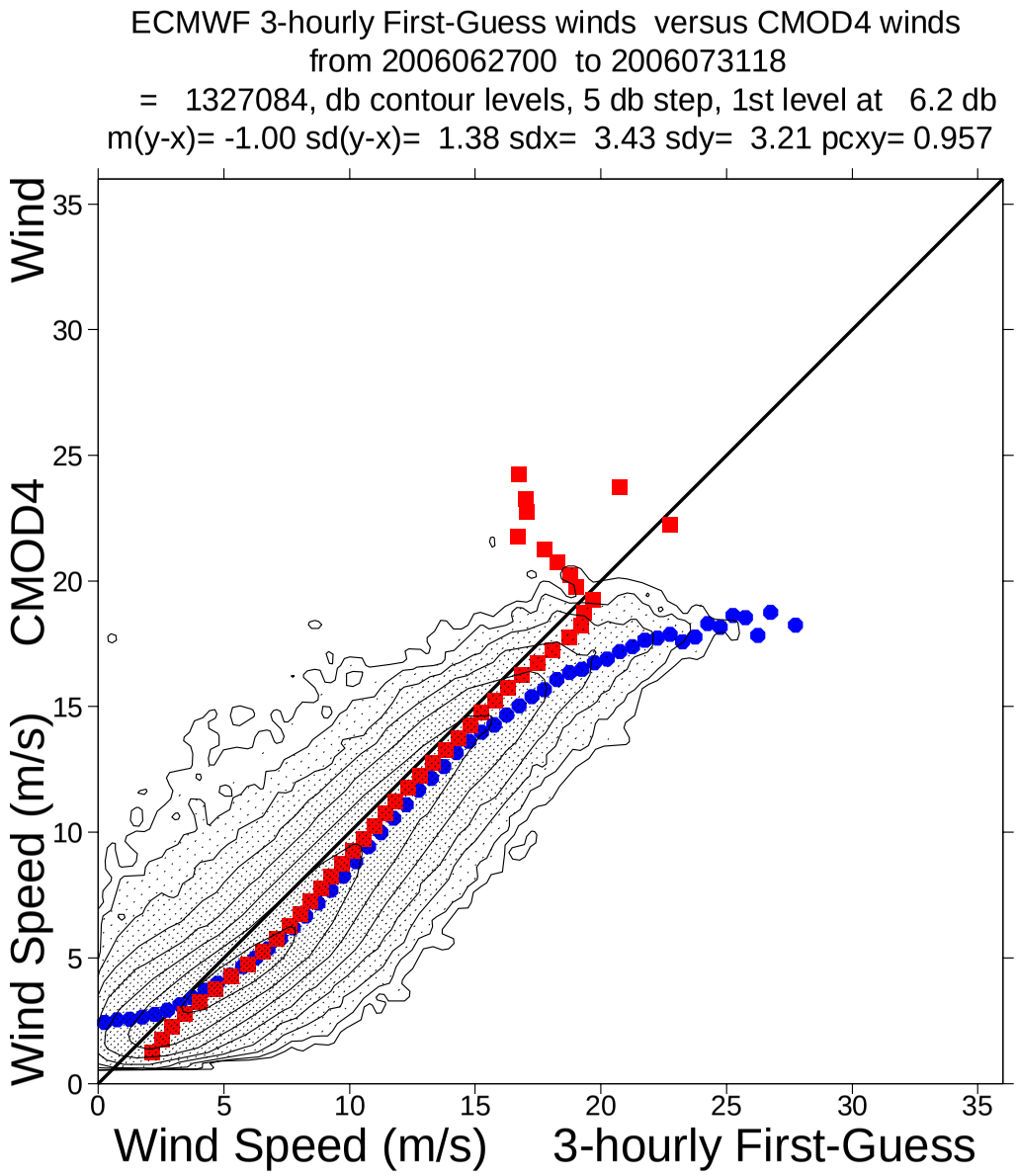

ECMWF 3-hourly First-Guess winds versus CMOD4 winds
from 2006062700 to 2006073118
= 1327084, db contour levels, 5 db step, 1st level at 6.2 db
m(y-x)= -1.00 sd(y-x)= 1.38 sdx= 3.43 sdy= 3.21 pcxy= 0.957
Wind Speed (m/s) CMOD4 Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 15

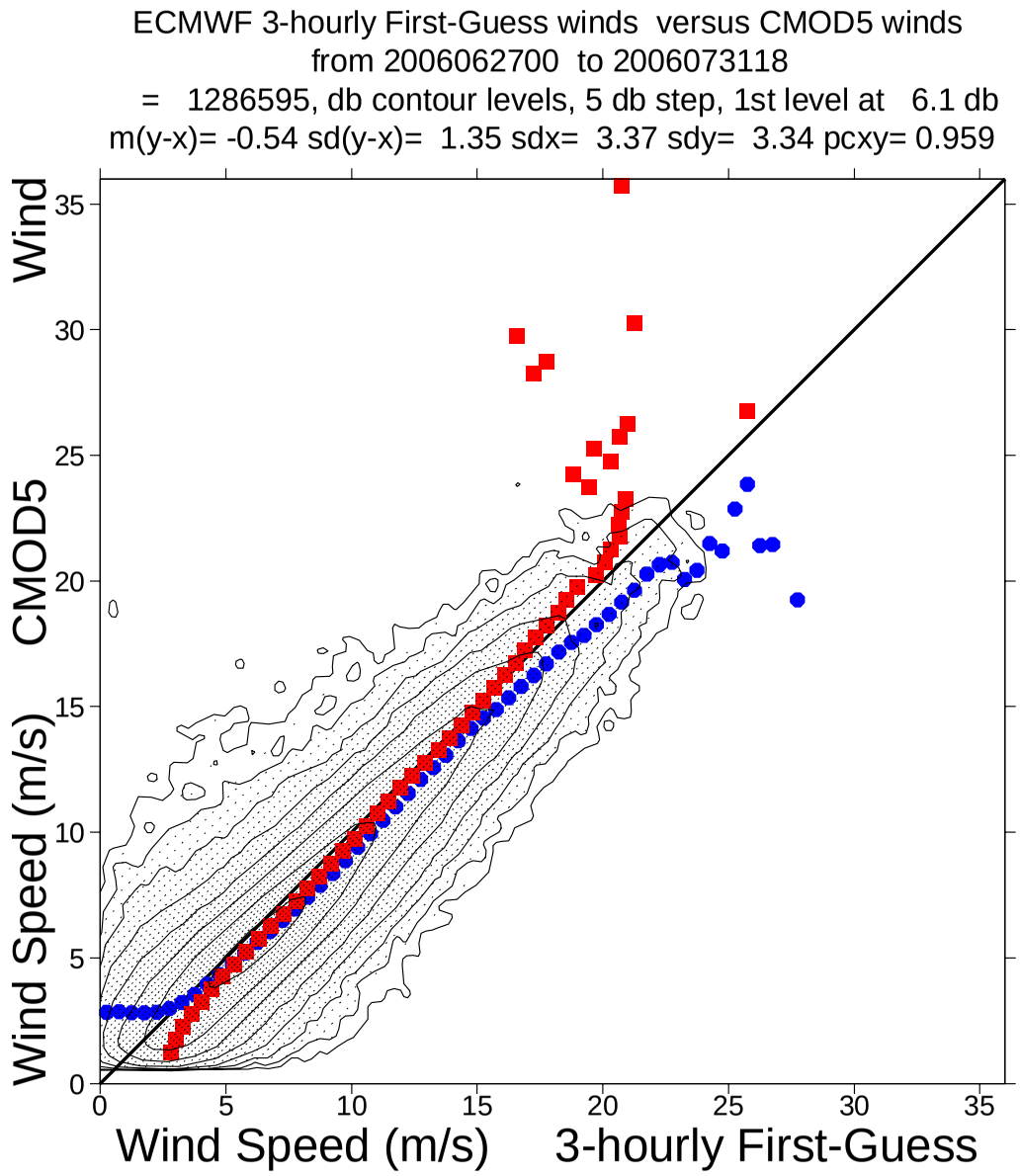

ECMWF 3-hourly First-Guess winds versus CMOD5 winds
from 2006062700 to 2006073118
= 1286595, db contour levels, 5 db step, 1st level at 6.1 db
m(y-x)= -0.54 sd(y-x)= 1.35 sdx= 3.37 sdy= 3.34 pcxy= 0.959
Wind Speed (m/s) CMOD5 Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 16

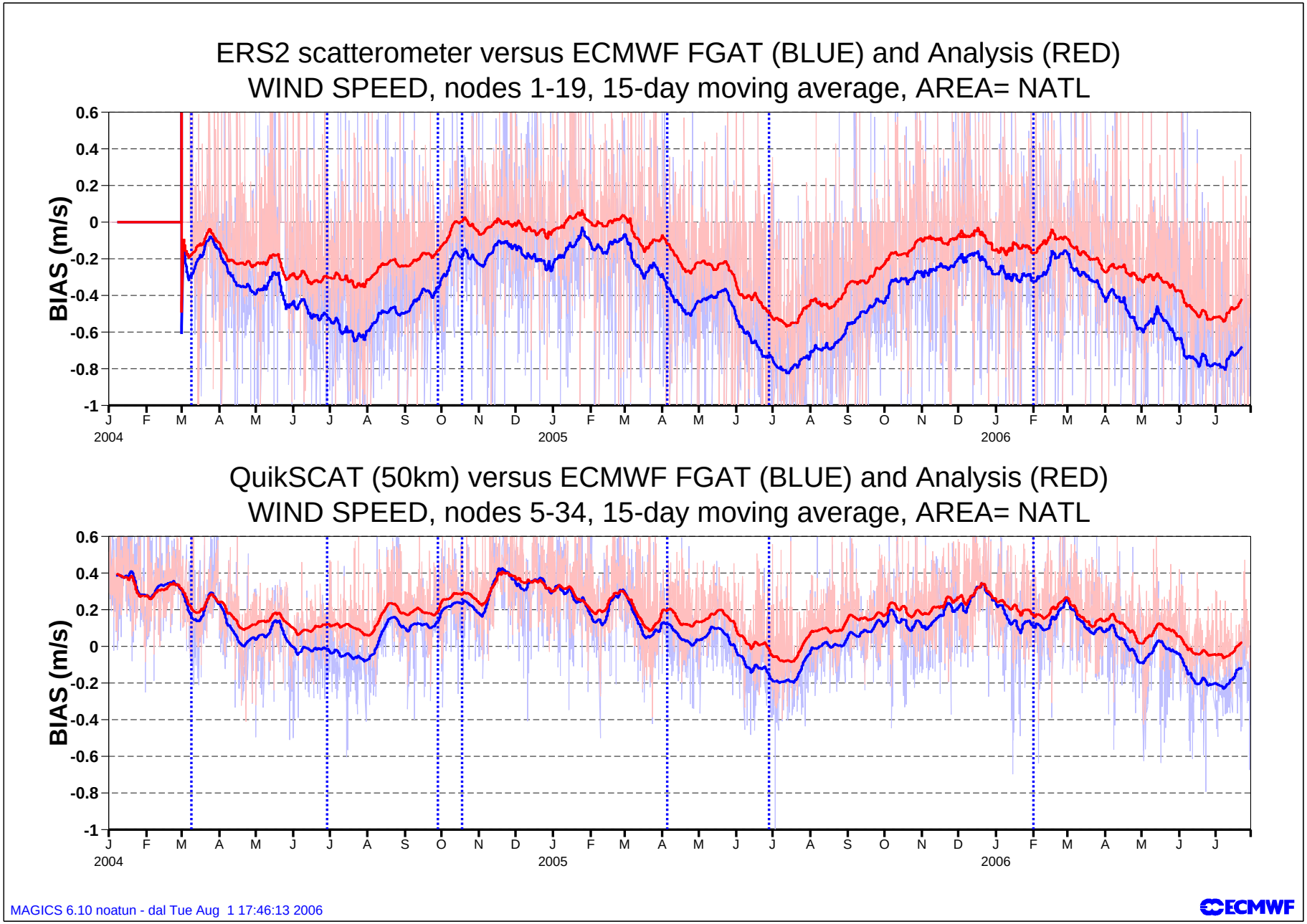

ERS2 scatterometer versus ECMWF FGAT (BLUE) and Analysis (RED)
WIND SPEED, nodes 1-19, 15-day moving average, AREA= NATL
BIAS (m/s)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
2004
2005
2006
QuikSCAT (50km) versus ECMWF FGAT (BLUE) and Analysis (RED)
WIND SPEED, nodes 5-34, 15-day moving average, AREA= NATL
BIAS (m/s)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
2004
2005
2006
MAGICS 6.10 noatun - dal Tue Aug 1 17:46:13 2006
ECMWF

Figure 17