Monitoring statistics of the ERS-2 scatterometer for ESA

CYCLE 82

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Hans Hersbach
European Centre for Medium-Range Weather Forecasts,
Shinfield Park, Reading, RG2 9AX, England
Tel: (+44 118) 9499476, e-mail: dal@ecmwf.int

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1 Introduction

From 12 December 2001 onwards, ESRIN redistributes ERS-2 scatterometer data to a selected group of users. The quality of this experimental gyroless product was monitored at ECMWF for cycle 82. The gyroless ERS-2 scatterometer data was not used in the 4D-Var data assimilation system at ECMWF.

At 06 UTC 4 February 2003, a new processor, ESACA, was introduced. It is an upgrade of the existing LRDPF and includes new scatterometer processing algorithms that anticipate errors in the satellites yaw attitude control. It was installed at Kiruna station only and was running in test phase during cycle 82.

For the ESACA data received during cycle 81, it appeared that for high incidence angles around 50% of the data was rejected. The same behavior was observed for cycle 82. An examination learned that these high rejection rates are induced by a large amount of high k_p values. Although average values of low k_p values have decreased since the introduction of ESACA (from 7% to 3-4%), towards high incidence angles a secondary peak for k_p values between 20% and 25% was introduced. A comparison of data with high k_p values versus ECMWF FGAT fields learned their quality is not low. In fact, they were found to be of higher quality than that of low k_p data. This probably is an indication for a bug in the BUFR encoding software. This conjecture is currently being scrutinized. For the time being, the monitoring at ECMF will not discriminate on k_p values, i.e., the QC threshold (10%) was removed. As a result, rejection rates at high nodes were reduced to the levels occuring at lower nodes.

During cycle 82, data was received between 21:01 UTC 17 February and 20:55 UTC 24 March 2003. Due to the reception of data from Kiruna station only, for most days in cycle 82, no data was recieved for the 6-hourly data periods centered around 00 UTC. In case data was recieved for 00 UTC, data volumes were low. Occasionally low volumes for 18 UTC and 6 UTC can also be attributed to the lack of data from the other stations. Besides these daily data gaps, no data was recieved for the 6-hourly period of 06 UTC and 21 UTC 20 March 2003.

The average quality of low-k_p data for cycle 82 is of slightly lower quality than that of ESACA data recieved during cycle 81. Although the bias w.r.t. ECMWF FGAT winds is less negative, the standard deviation has increased by 0.02 m/s. Including high-k_p values has a beneficial effect on the bias.

Like for ESACA data of cycle 81, UWI winds differ from CMOD4 winds (inverted at ECMWF). Especially for strong winds, the UWI winds have a larger random error w.r.t. ECMWF FGAT winds.

Time series for the asymmetry between the incidence angles of the fore and aft beam (related to yaw attitude errors), show a number of large peaks (from 4 up to 7 degrees) for the end of February and beginning of March. Near the end of March fluctuations become smaller. This behavior is similar to that of observed solar activity: enhanced up to mid March, then back to normal.

The ECMWF assimilation system was not changed during cycle 82.

2 ERS-2 statistics from 17 February 2003 to 24 March 2003

2.1 Sigma0 bias levels

The average sigma0 bias levels (compared to simulated sigma0's based on ECMWF model first-guess winds, see Figure 1) showed the following evolution w.r.t. corresponding levels for ESACA data recieved during cycle 81. For the descending tracks, bias levels for all beams and incidence angles have become 0.15 dB more negative in a rather uniform way. For ascending tracks, bias levels have become slightly less negative. For the mid beam the reduction is around 0.1 dB. Fore and aft beam biases are 0.1 dB less negative at low incidence angles, growing up to 0.2 dB at high incidence angles.

The general picture that emerges from the ocean calibration displayed in Figure 1 is as follows. Bias levels are between 0.3 and 1.1 dB too low. Levels are rather uniform and interbeam differences are reasonably small for the mid beam in general, and the fore and aft beam at mid to high incidence angles. At low incidence angles the fore and aft beam also agree, however, their levels are up to 1.1 dB too low. The difference between ascending and descending tracks is smaller than it was for cycle 81.

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 2 gives a time evolution of this asymmetry, showing the rapid variations, which are typical for yaw attitude errors. Peaks up to 7 degrees are observed. Most peaks occur for the first four weeks of cycle 82, which coincided with a period of enhanced solar activity.

2.3 Distance to cone history

The distance to the cone history is shown in Figure 3. Most of the peaks are due to low data volumes that now occur at a daily basis. The peaks at 18 UTC 18 February and 06 UTC 28 February 2003 are not connected to a low data volume. They are most pronounced at high incidence angles.

On average, the cone distance is close to the normalized levels. For lower nodes it is slightly lower, for mid-range nodes it is slightly higher.

2.4 UWI minus First-Guess wind history

In Figure 4, the UWI minus ECMWF first-guess wind history is plotted.

Both the wind-bias and the standard deviation history show a number of peaks, which all seem to be connected to low data volumes. The peaks in cone distance for 18 UTC 18 February and 06 UTC 28 February 2003, occurring at nominal data volumes, do not correspond to peaks in the UWI wind history.

In Figure 8, all locations are shown for which UWI winds were more than 8 m/s weaker than the FGAT winds. Although there is still a number of cases for which this occurs, its frequency has been reduced substantially (see e.g., to Figure 8 of the monitoring report for cycle 80).

Average bias levels and standard deviations of UWI winds relative to FGAT winds are displayed in Table 1. From this it is seen that, compared to cycle 81, the average bias level is reduced by 0.11 m/s. Part of it (0.06 m/s) is due to the inclusion of data with high k_p values. For cycle 81 these were rejected. Since this mainly occurs at high incidence angles, for which the bias of the UWI product is lower, the inclusion of such winds will, as observed, reduce the average bias. The large negative wind bias for the lower nodes (-1.56 m/s) is a result of the large negative biases in sigma0 levels (see Figure 1). Standard deviations are on average unchanged, although, the inter-node dependency has become slightly stronger.

Like for ESACA data recieved for cycle 81, the at ECMWF inverted CMOD4 winds do not match the UWI winds. The quality of these CMOD4 winds is considerably higher than that of the UWI winds (standard deviation of 1.48 m/s versus 1.62 m/s). Best results are obtained for CMOD5 (shown below).

For cycle 82 the (scatterometer - model) direction standard deviations were ranging between 20 and 40 degrees (Figure 5). For de-aliased CMOD4 winds values between 20 and 30 degrees are most common. On average (see Table 1), the quality in wind direction is very similar to that for ESACA data recieved during cycle 81.

	Cycle 81		Cycle 82	
	UWI	CMOD4	UWI	CMOD4
speed STDV	1.62	1.50	1.62	1.48
node 1-2	1.57	1.53	1.60	1.55
node 3-4	1.50	1.46	1.49	1.46
node 5-7	1.54	1.43	1.53	1.44
node 8-10	1.61	1.44	1.60	1.43
node 11-14	1.63	1.46	1.61	1.43
node 15-19	1.63	1.49	1.62	1.46
speed BIAS	-0.91	-0.96	-0.80	-0.85
node 1-2	-1.59	-1.65	-1.56	-1.61
node 3-4	-1.20	-1.21	-1.16	-1.16
node 5-7	-0.88	-0.88	-0.83	-0.82
node 8-10	-0.66	-0.70	-0.61	-0.64
node 11-14	-0.61	-0.69	-0.57	-0.64
node 15-19	-0.69	-0.77	-0.64	-0.72
direction STDV	28.5	19.8	28.3	19.0

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

2.5 Scatter plots

Scatterplots of model 10 m first-guess winds versus ERS-2 winds are displayed in Figures 9 to 12. 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 with about 0.05 m/s). These scatterplots elucidate the trends described in the previous section. Like for cycle 81, the quality of the CMOD4 winds (Figure 11) is higher than that of the UWI winds (Figure 9). This seems to be especially true for strong winds. Values of standard deviations are very similar to those of cycle 81.

The average bias of the UWI wind direction is small (1.0 degrees, was 0.7 degrees for cycle 81) and its standard deviation is almost unaltered (25.8 degrees, was 25.9).

Only few collocations of low UWI winds with high ECMWF FGAT winds are found (Figure 9). Such collocations, which used to occur quite often for data retrieved with the old processor (i.e., cycle 81 and before), were caused by incorrect filter characteristics for large yaw errors ($>$ 2 degrees). Although such yaw errors still seem to occur, ESACA is able to adapt the filter characteristics appropriately.

Winds derived on the basis of CMOD5 are displayed in Figure 11. Both the bias level and the standard deviation are better than those for CMOD4 and UWI winds. Although CMOD5 winds are too low (induced by too low backscatter levels, see Figure 1), the random error of CMOD5 winds w.r.t. FGAT winds is lower than it used to be for UWI winds during the nominal period (i.e., before January 2001).

Figure Captions

Figure 1: Ratio of $< \sigma_0^{0.625} > / <$ CMOD4(FirstGuess)$^{0.625} >$ converted in dB for the for beam (solid line), mid beam (dashed line) and aft beam (dotted line), as a function of incidence angle for descending and ascending tracks of ESACA data within cycle 82. 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 2: Time series of the difference in incidence angle between the fore and aft beam.

Figure 3: 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 (solid curve close to 1 when no instrumental problems are present). 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 sea-located triplets rejected by the ESA flag, or by the wind inversion algorithm (0: all data kept, 1: no data kept).

Figure 4: 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 5: Same as Fig. 3, but for the wind direction difference. Statistics are computed only for wind speeds higher than 4 m/s.

Figures 6 and 7: Same as Fig. 5 and 6 respectively, but for the de-aliased CMOD4 data.

Figure 8: Locations of data during cycle 82 for which UWI winds are more than 8 m/s weaker than the collocated FGAT winds.

Figure 9: Two-dimensional histogram of first guess and UWI wind speeds, for the data kept by the quality control, however, disregarding the level of k_p. Circles denote the mean values in the y-direction, and squares those in the x-direction.

Figure 10: Same as Fig. 11, but for wind direction. Only wind speeds higher than 4m/s are taken into account.

Figure 11: Same as Fig. 9, but for de-aliased CMOD4 winds.

Figure 12: Same as Fig. 9, but for de-aliased CMOD5 winds.

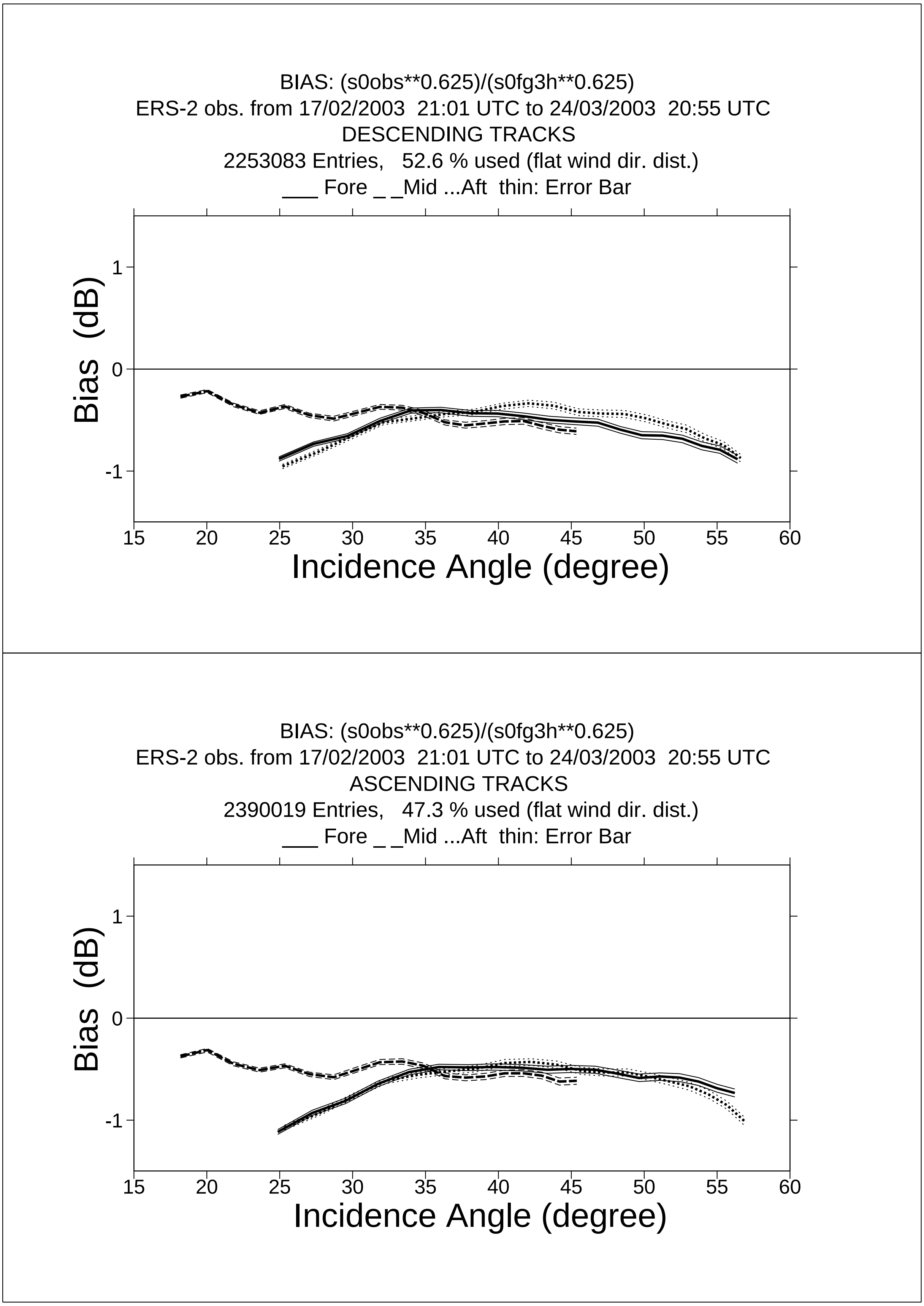

BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 17/02/2003 21:01 UTC to 24/03/2003 20:55 UTC
DESCENDING TRACKS
2253083 Entries, 52.6 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
1
0
-1
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)
BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 17/02/2003 21:01 UTC to 24/03/2003 20:55 UTC
ASCENDING TRACKS
2390019 Entries, 47.3 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
1
0
-1
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)

Figure 1

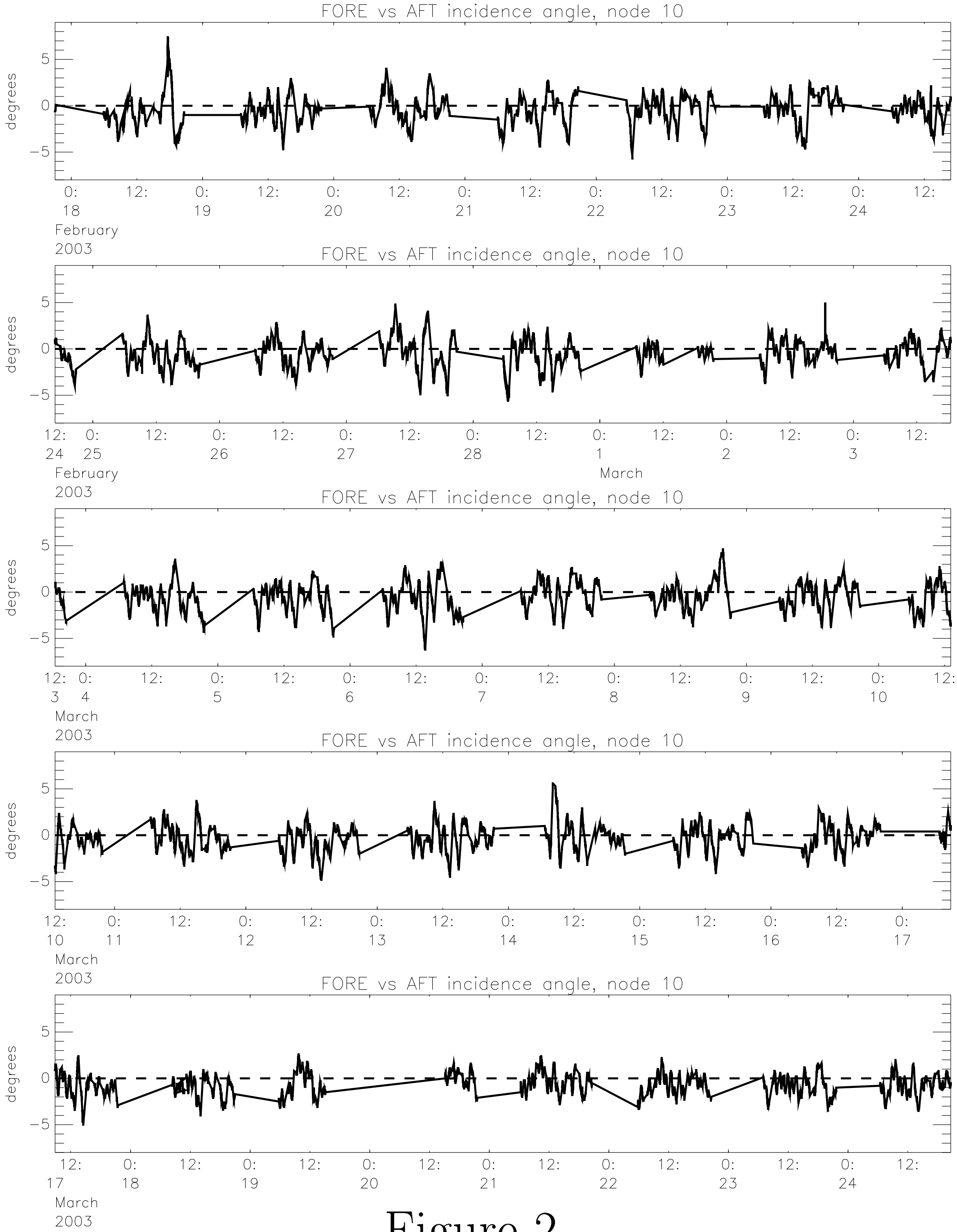

FORE vs AFT incidence angle, node 10
degrees
5
0
−5
0:
12:
18
19
20
21
22
23
24
February
2003
25
26
27
28
March
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Figure 2

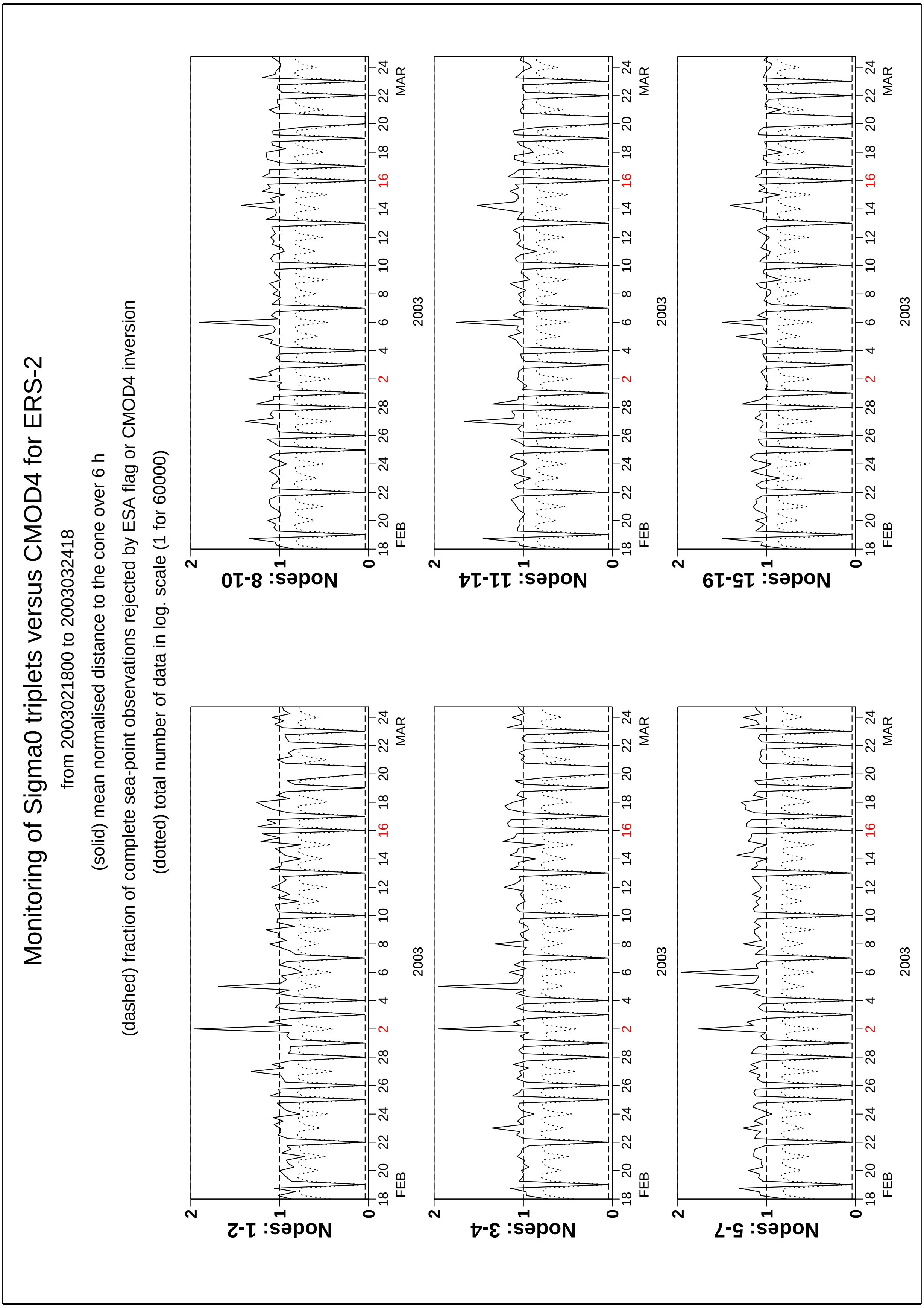
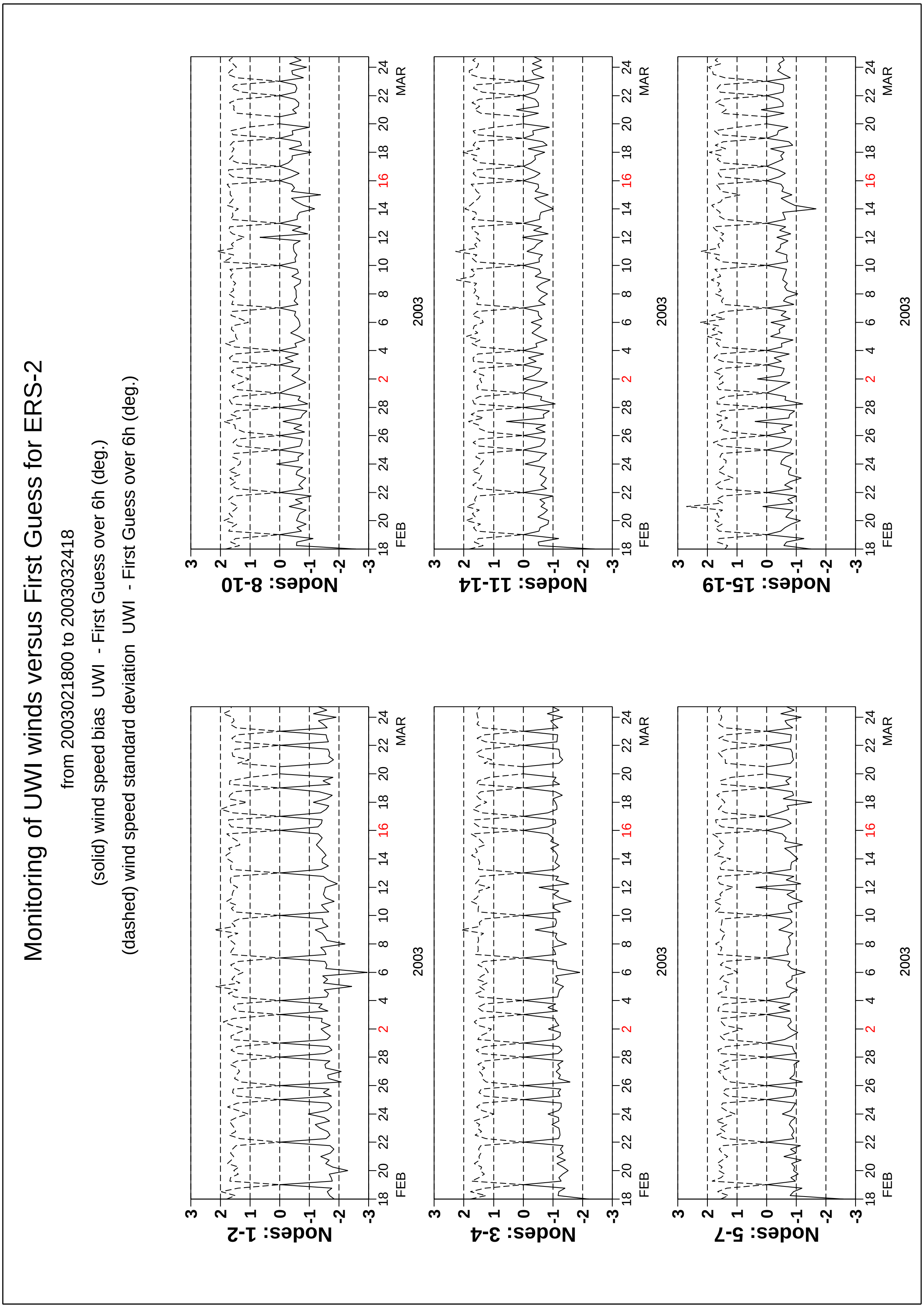

Monitoring of Sigma0 triplets versus CMOD4 for ERS-2
from 2003021800 to 2003032418
(solid) mean normalised distance to the cone over 6 h
(dashed) fraction of complete sea-point observations rejected by ESA flag or CMOD4 inversion
(dotted) total number of data in log. scale (1 for 60000)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
FEB
MAR
2003

Figure 3



Monitoring of UWI winds versus First Guess for ERS-2
from 2003021800 to 2003032418
(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
FEB
MAR
2003

Figure 4

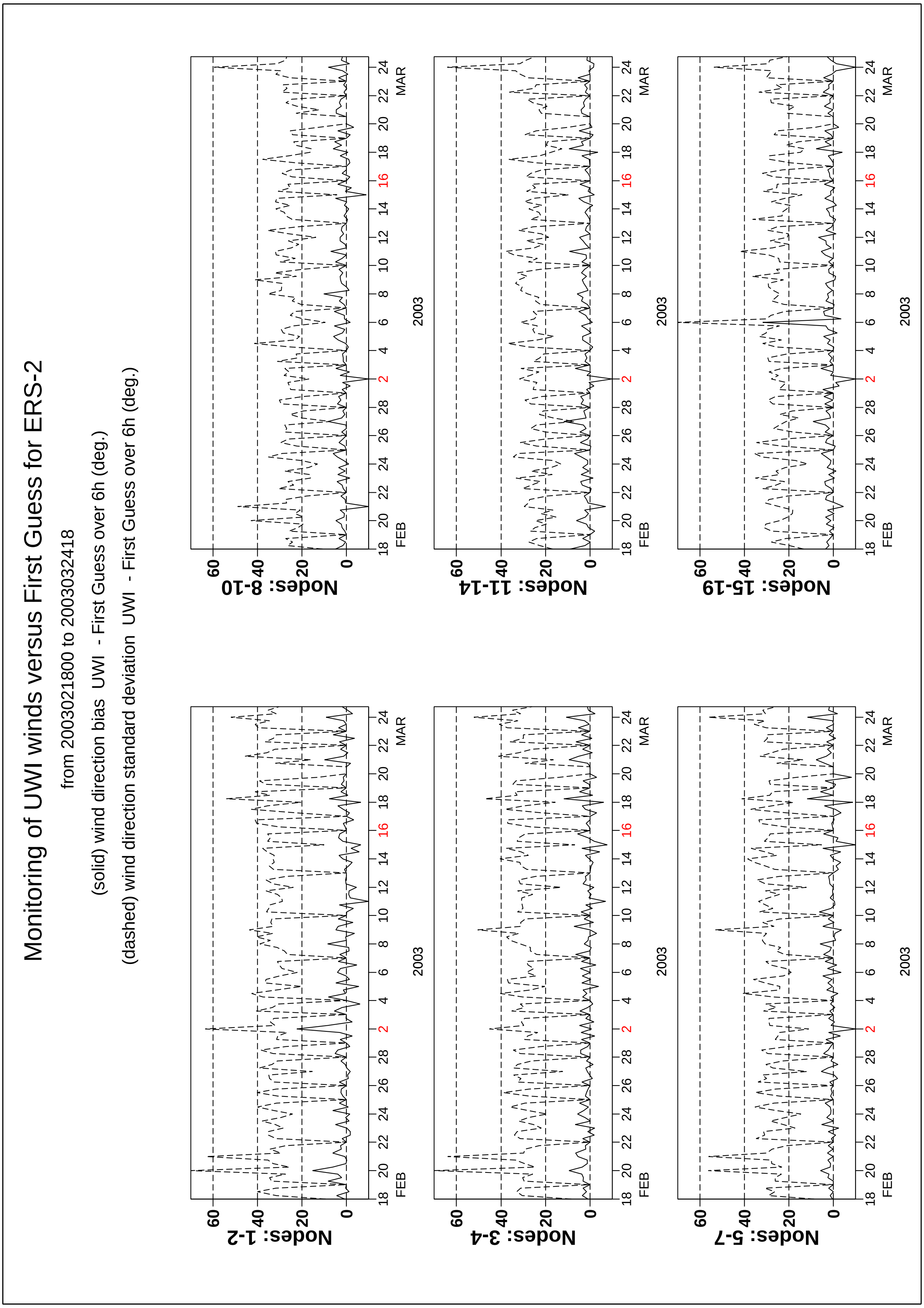

Monitoring of UWI winds versus First Guess for ERS-2
from 2003021800 to 2003032418
(solid) wind direction bias UWI - First Guess over 6h (deg.)
(dashed) wind direction standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
FEB
MAR
2003

Figure 5

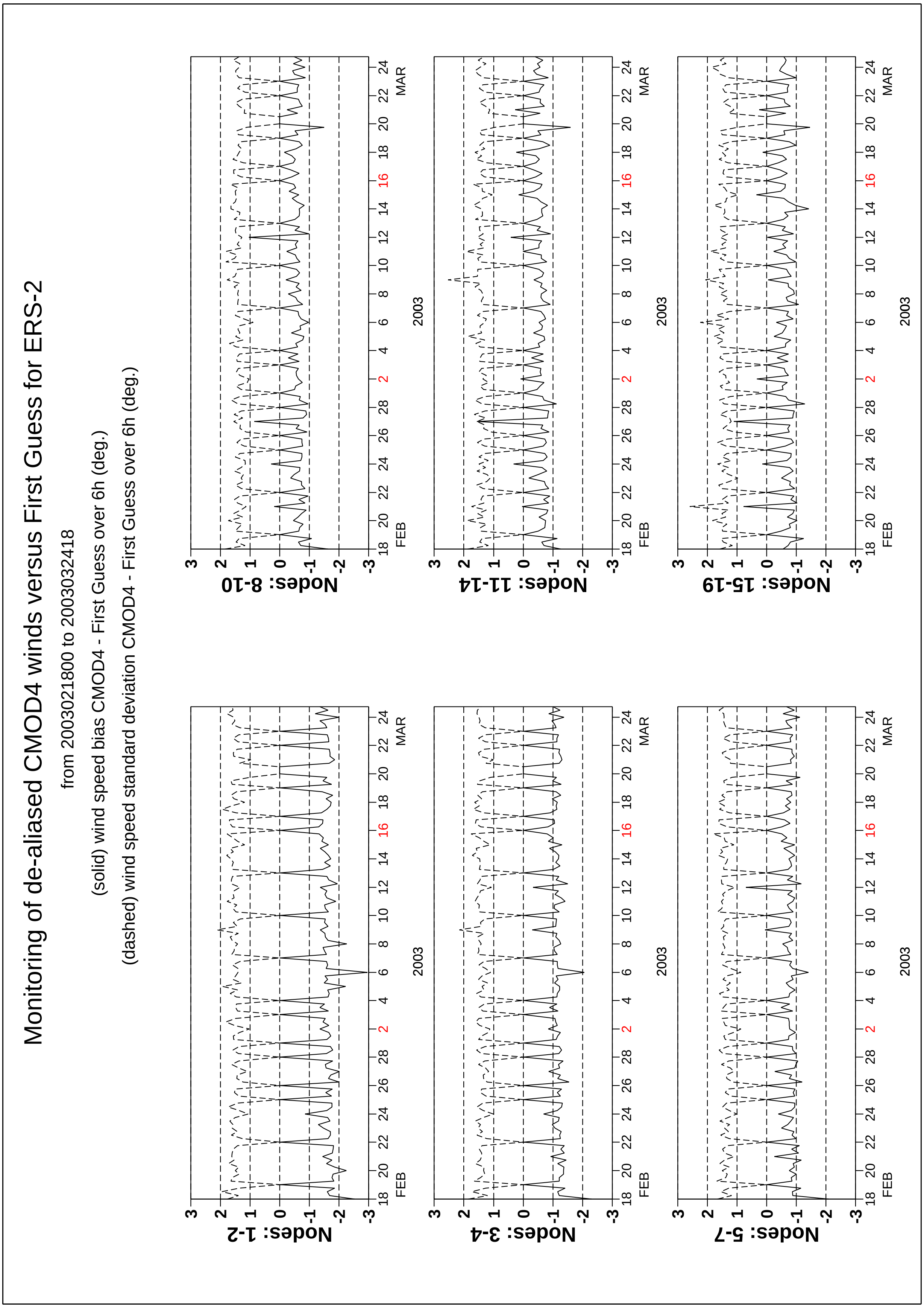
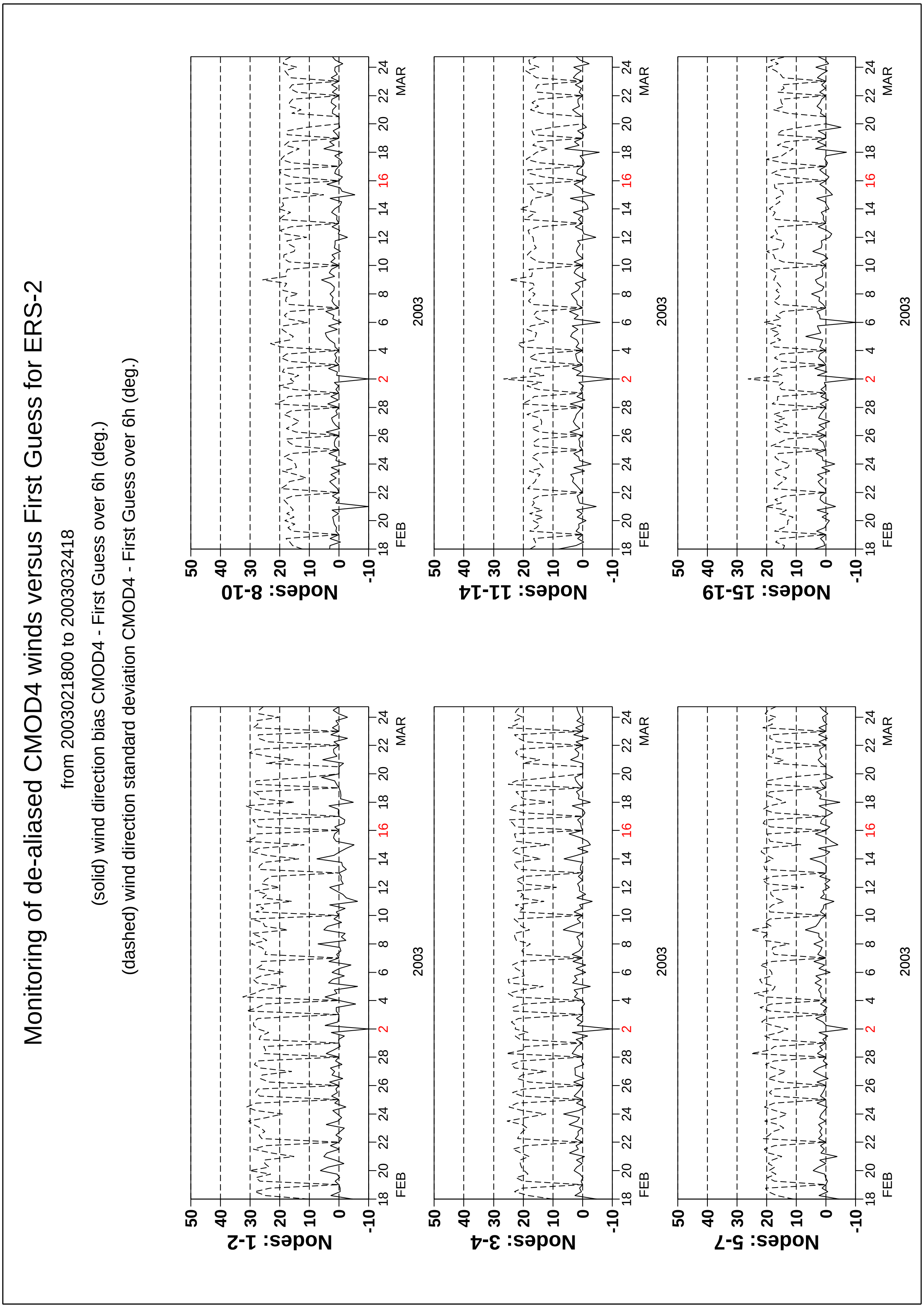

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2003021800 to 2003032418
(solid) wind speed bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind speed standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
FEB
MAR
2003

Figure 6



Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2003021800 to 2003032418
(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
FEB
MAR
2003

Figure 7

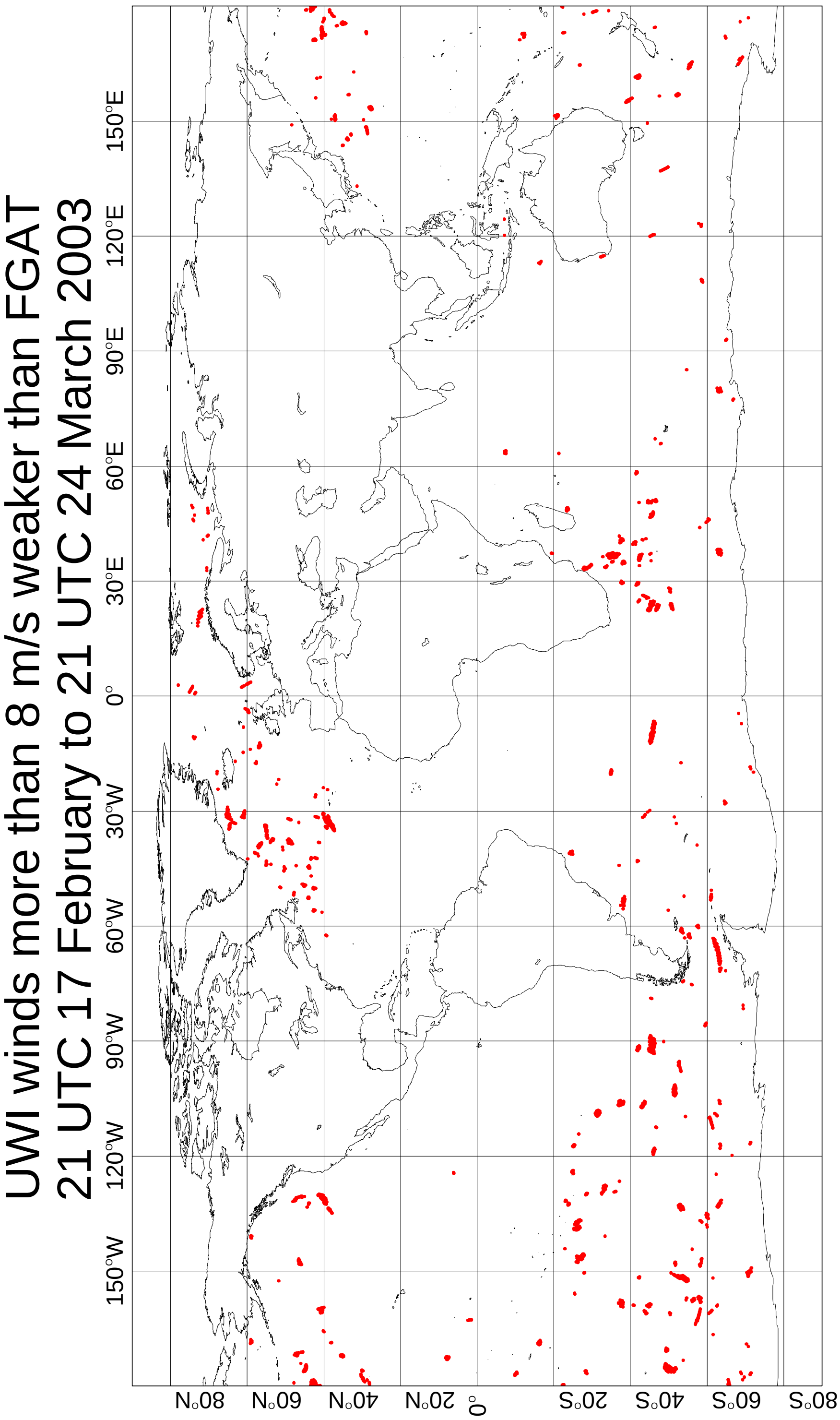

UWI winds more than 8 m/s weaker than FGAT
21 UTC 17 February to 21 UTC 24 March 2003
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

Figure 8

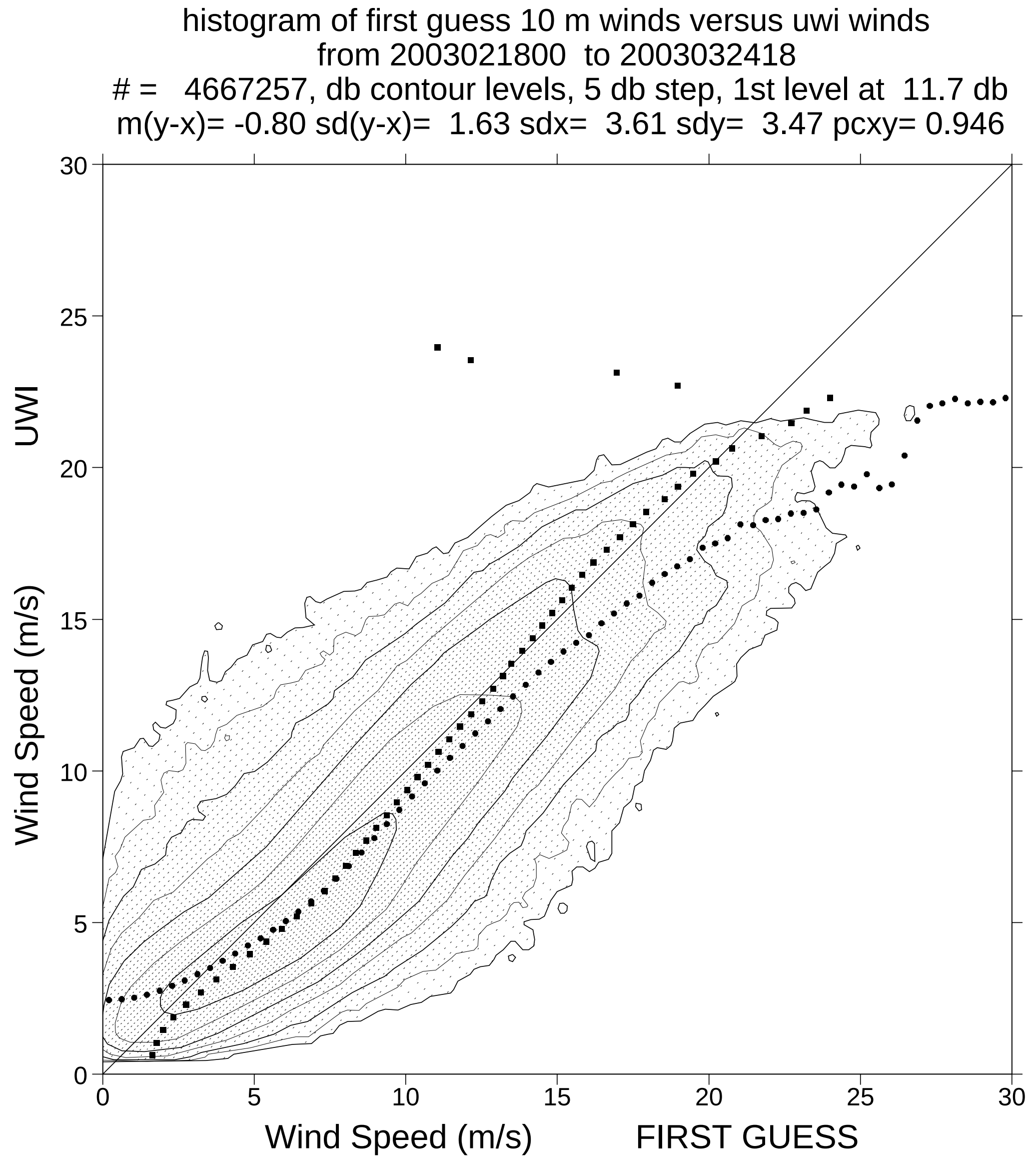

histogram of first guess 10 m winds versus uwi winds
from 2003021800 to 2003032418
= 4667257, db contour levels, 5 db step, 1st level at 11.7 db
m(y-x)= -0.80 sd(y-x)= 1.63 sdx= 3.61 sdy= 3.47 pcxy= 0.946
UWI
Wind Speed (m/s)
0
5
10
15
20
25
30
Wind Speed (m/s)
FIRST GUESS

Figure 9

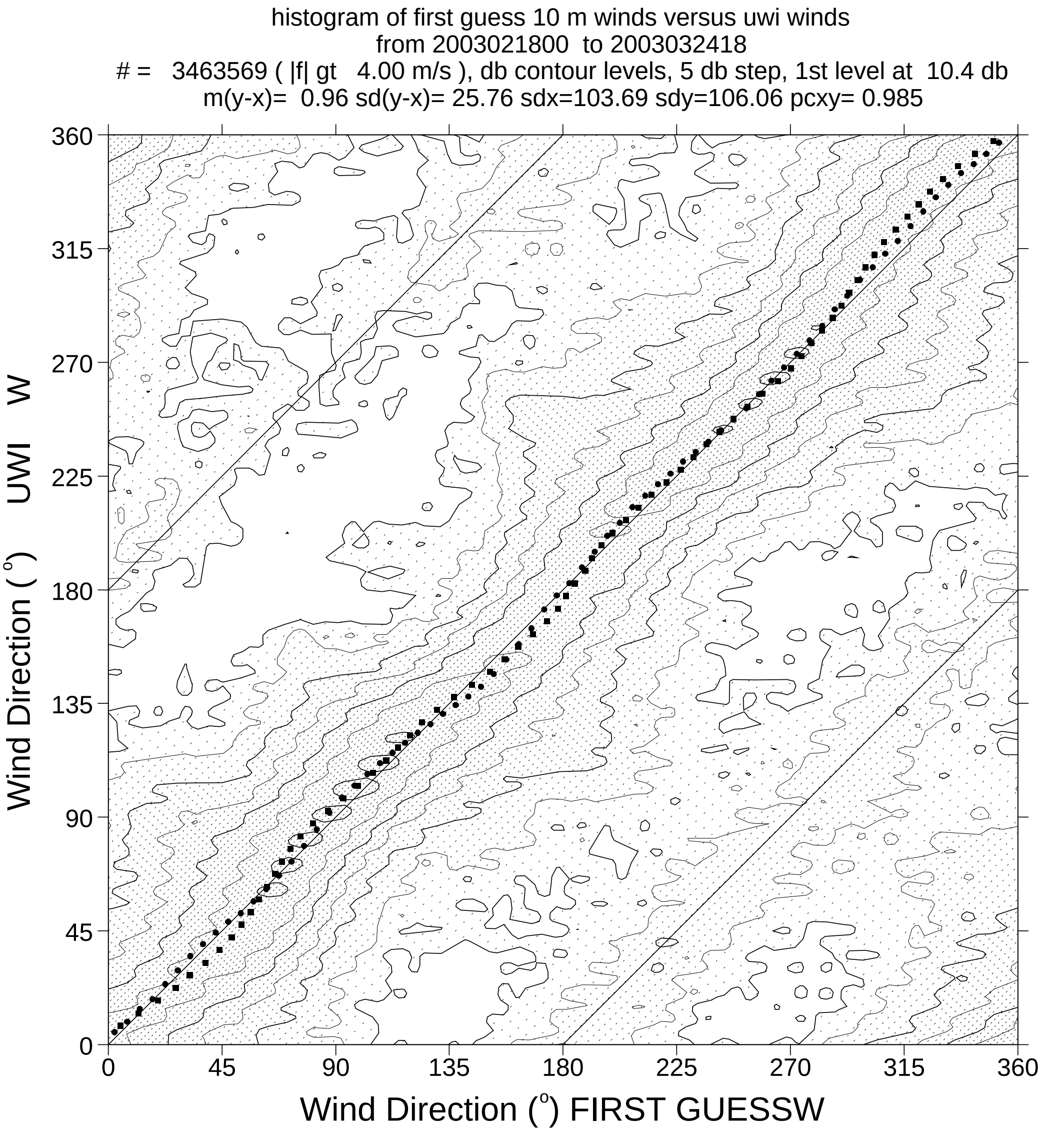

histogram of first guess 10 m winds versus uwi winds
from 2003021800 to 2003032418
= 3463569 (|f| gt 4.00 m/s), db contour levels, 5 db step, 1st level at 10.4 db
m(y-x)= 0.96 sd(y-x)= 25.76 sdx=103.69 sdy=106.06 pcxy= 0.985
Wind Direction (°) UWI W
Wind Direction (°) FIRST GUESSW
0
45
90
135
180
225
270
315
360

Figure 10

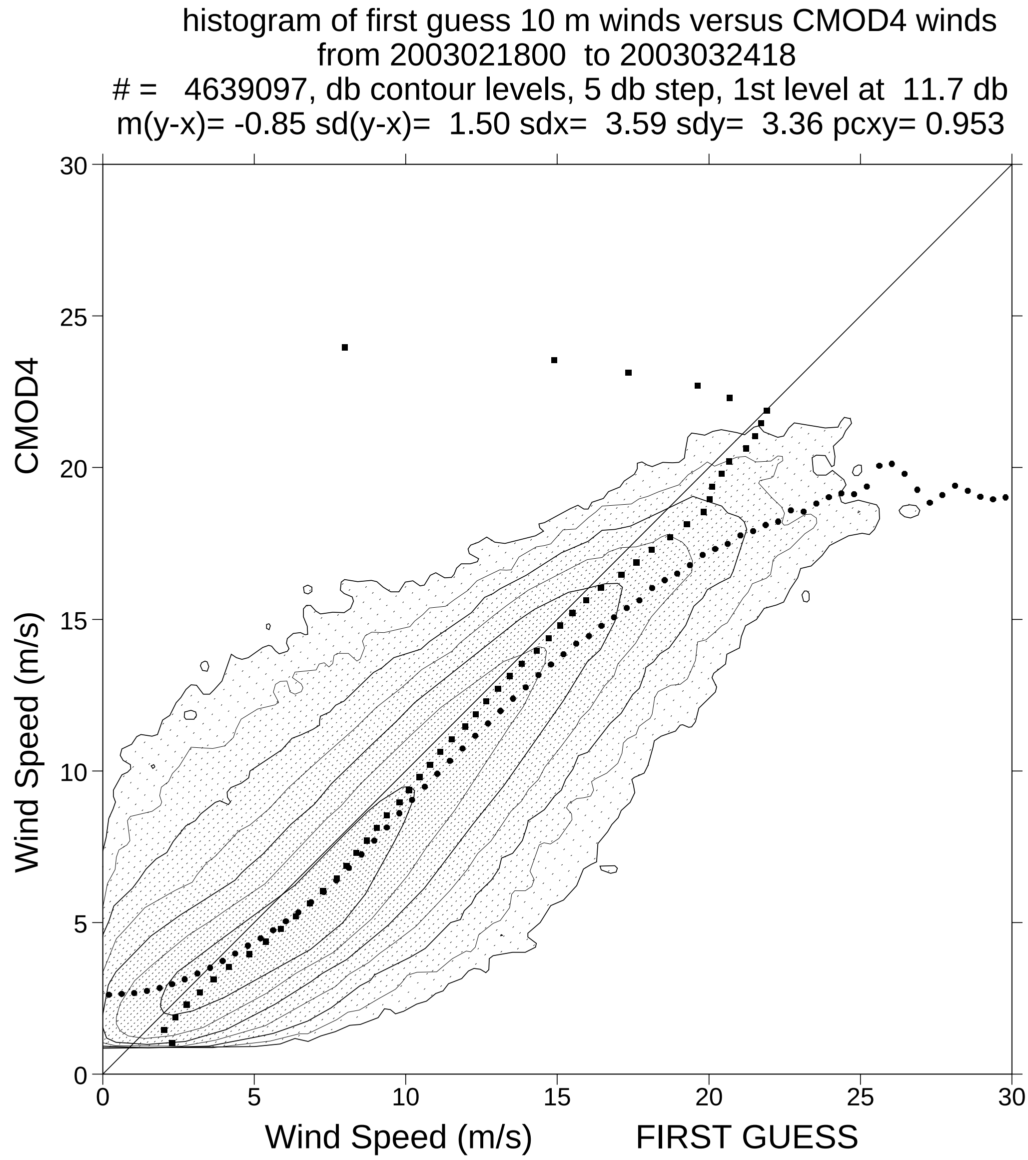

histogram of first guess 10 m winds versus CMOD4 winds
from 2003021800 to 2003032418
= 4639097, db contour levels, 5 db step, 1st level at 11.7 db
m(y-x)= -0.85 sd(y-x)= 1.50 sdx= 3.59 sdy= 3.36 pcxy= 0.953
CMOD4
Wind Speed (m/s)
Wind Speed (m/s)
FIRST GUESS
0
5
10
15
20
25
30

Figure 11

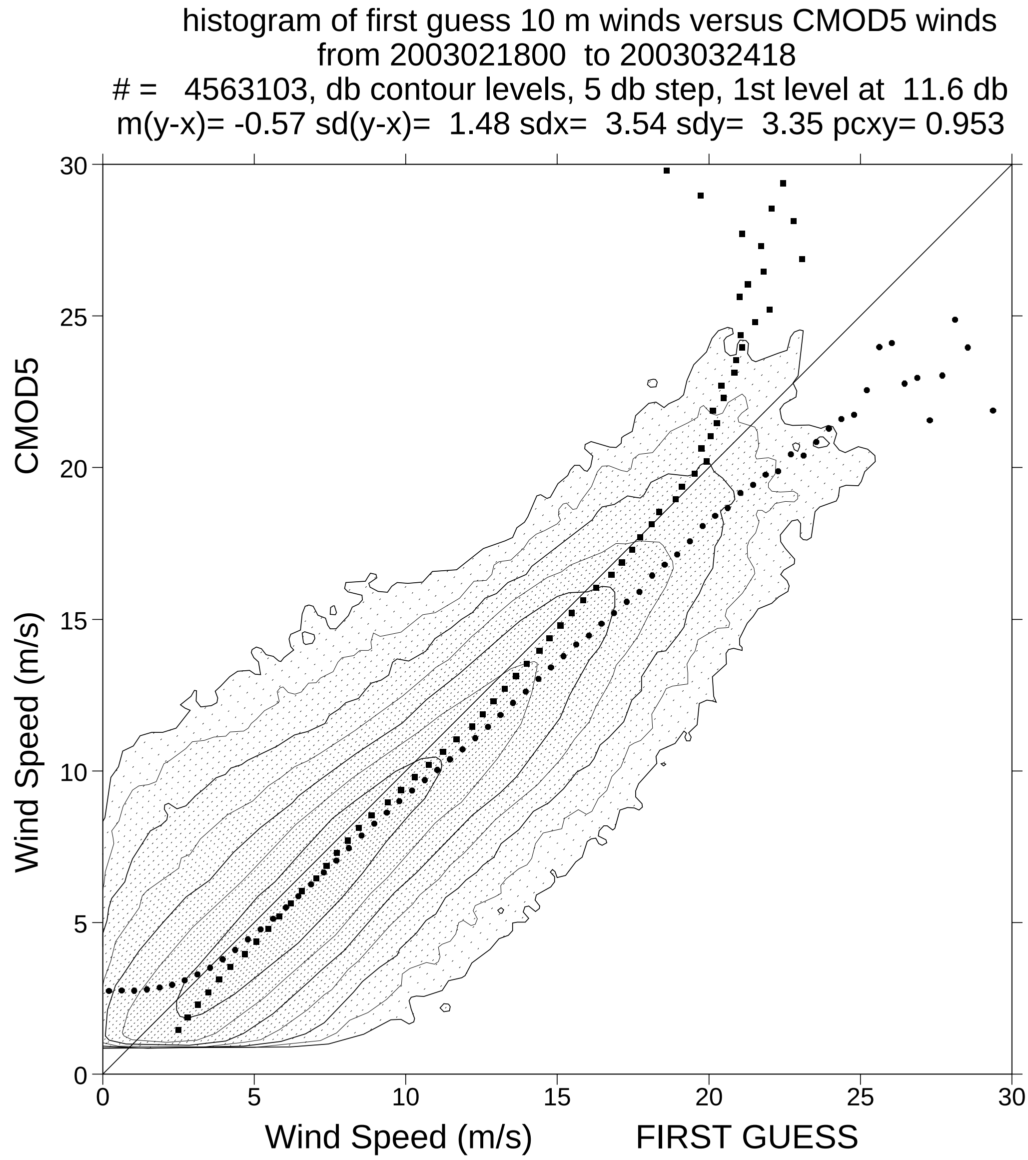

histogram of first guess 10 m winds versus CMOD5 winds
from 2003021800 to 2003032418
= 4563103, db contour levels, 5 db step, 1st level at 11.6 db
m(y-x)= -0.57 sd(y-x)= 1.48 sdx= 3.54 sdy= 3.35 pcxy= 0.953
CMOD5
Wind Speed (m/s)
Wind Speed (m/s)
FIRST GUESS
0
5
10
15
20
25
30

Figure 12