Monitoring statistics of the ERS-2 scatterometer for ESA

cycle 105

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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

The quality of the UWI product was monitored at ECMWF for cycle 105. 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 105 data was received between 21:05 UTC 2 May 2005 and 19:46 UTC 6 June 2005. No data was received for the 6-hourly batch for 12 UTC 24 May 2005.

Data is being recorded whenever within the visibility range of a ground station, leading for cycle 105 to a coverage of the North-Atlantic, part of the Mediterranean, the Caribbean, the Gulf of Mexico, and to a small part of the Pacific west from the US, Canada and Central America (see Figure 2).

The asymmetry between the fore and aft incidence angles showed many peaks, however, was mostly behaving within bounds. The k_p-yaw ESA flag was set accordingly.

Compared to cycle 104, the comparison of the UWI wind speed with ECMWF first-guess (FG) fields showed a reduced relative standard deviation (from 1.44 m/s to 1.35 m/s). The relative bias has become less negative (from -0.85 m/s to -0.80 m/s). For winds based on CMOD5 the negative bias was less reduced (from -0.34 m/s to -0.32 m/s). Standard deviation of the UWI winds is lower than that for 2000; the bias is comparable.

The performance of the UWI wind direction was, with the exception of a few isolated cases, stable for cycle 105.

Ocean calibration shows an increased inter-node and inter-beam dependency of bias levels. The average bias level, however, was almost unchanged (-0.58 dB).

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

2 ERS-2 statistics from 3 May to 6 June 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 dependencies have grown somewhat. Bias levels of the fore and aft beam are the most negative ones, especially at high incidence angles. The bias level of the ascending mid beam was reduced. Average bias level is -0.58 dB, which is similar to that of cycle 104, but 0.15 dB more negative than for nominal data in 2000 (see Figure 1 of the reports for cycle 48 to 59).

The data volume of descending tracks was about 5% 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 105 most peaks were within bounds. A peak on 15 May 2005 coincided with an an extreme geomagnetic storm (source www.spaceweather.com).

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 104, 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 104, the average level was slightly higher (from 1.16 to 1.18), and is now about 9% 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). The peak for 06 UTC 20 May 2005, however, is to be connected with the capture of hurricane Adrian, off the Central-American coast (see upper panel of Figure 12). It shows a difference in position of the eye between the ECMWF first guess (blue) and UWI winds (red); the latter better matching the observed location (black cross). The ECMWF assimilation system was not capable of moving the analysis to the correct position, partly because of some patches of erratic UWI winds in the vicinity of the hurricane. As a result, several scatterometer wind observations were rejected.

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 104, the number of such collocations is reasonably low. The observed patch for hurricane Adrian is clearly visible in the top panel. In the lower panel (stronger UWI winds), a string of dots is visible near the US East Coast, coinciding with a low-pressure system observed between 6 and 8 May 2005. The lower panel of Figure 12 displays this case for 7 May 2005, showing too weak ECMWF winds near the centre.

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 less negative. The average bias level is now comparable to that for nominal data in 2000 (UWI: -0.80 m/s now, was -0.79 m/s for cycle 59). The evolution of the bias from cycles 92 to 105 is displayed in the top panel of Figure 17. The red curve is the 15-day moving average for the at ECMWF inverted ERS-2 winds; i.e., CMOD5 since 9 March 2004. Blue vertical dashed lines indicate ECMWF model changes. This plot shows that the rapidly evolving negative bias for ERS-2 starting in March 2005 has stabilized in May 2005. This is in contrast with the situation in 2004, where the turning point only occured in August.

The standard deviation of UWI wind speed compared to cycle 104 has been reduced significantly (1.35 m/s, was 1.44 m/s), the main reason being a milder wind climate.

For cycle 105 the (UWI - FG) direction standard deviations were mostly ranging between 15 and 40 degrees (Figure 8). Sharp peaks are the result of low data volumes. The average performance for UWI wind direction was slightly better (STDV 26.2 degrees, was 27.8 degrees, bias -2.7 degrees, was -3.7 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

	cycle 104		cycle 105	
	UWI	CMOD4	UWI	CMOD4
speed STDV	1.44	1.43	1.35	1.34
node 1-2	1.54	1.51	1.39	1.37
node 3-4	1.47	1.46	1.33	1.33
node 5-7	1.41	1.41	1.30	1.30
node 8-10	1.39	1.39	1.31	1.31
node 11-14	1.40	1.40	1.31	1.31
node 15-19	1.37	1.37	1.35	1.35
speed BIAS	-0.85	-0.84	-0.80	-0.80
node 1-2	-1.35	-1.32	-1.27	-1.25
node 3-4	-1.09	-1.04	-1.04	-1.00
node 5-7	-0.88	-0.85	-0.81	-0.79
node 8-10	-0.72	-0.72	-0.64	-0.64
node 11-14	-0.68	-0.69	-0.64	-0.66
node 15-19	-0.67	-0.70	-0.66	-0.69
direction STDV	27.8	19.0	26.2	18.8
direction BIAS	-3.7	-3.4	-2.7	-2.7

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

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).

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 (1.34 m/s versus 1.37 m/s). Compared to ECMWF FG, CMOD5 winds are -0.32 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 6 June 2005 (end cycle 105) 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 the global set, the second one for the regional set. 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 extreme inter-node 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 (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 (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 only for wind speeds higher 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 105 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 hurricane Adrian on 20 May 2005 (top panel) and a case off the US East coast on 7 May 2005 (lower panel).

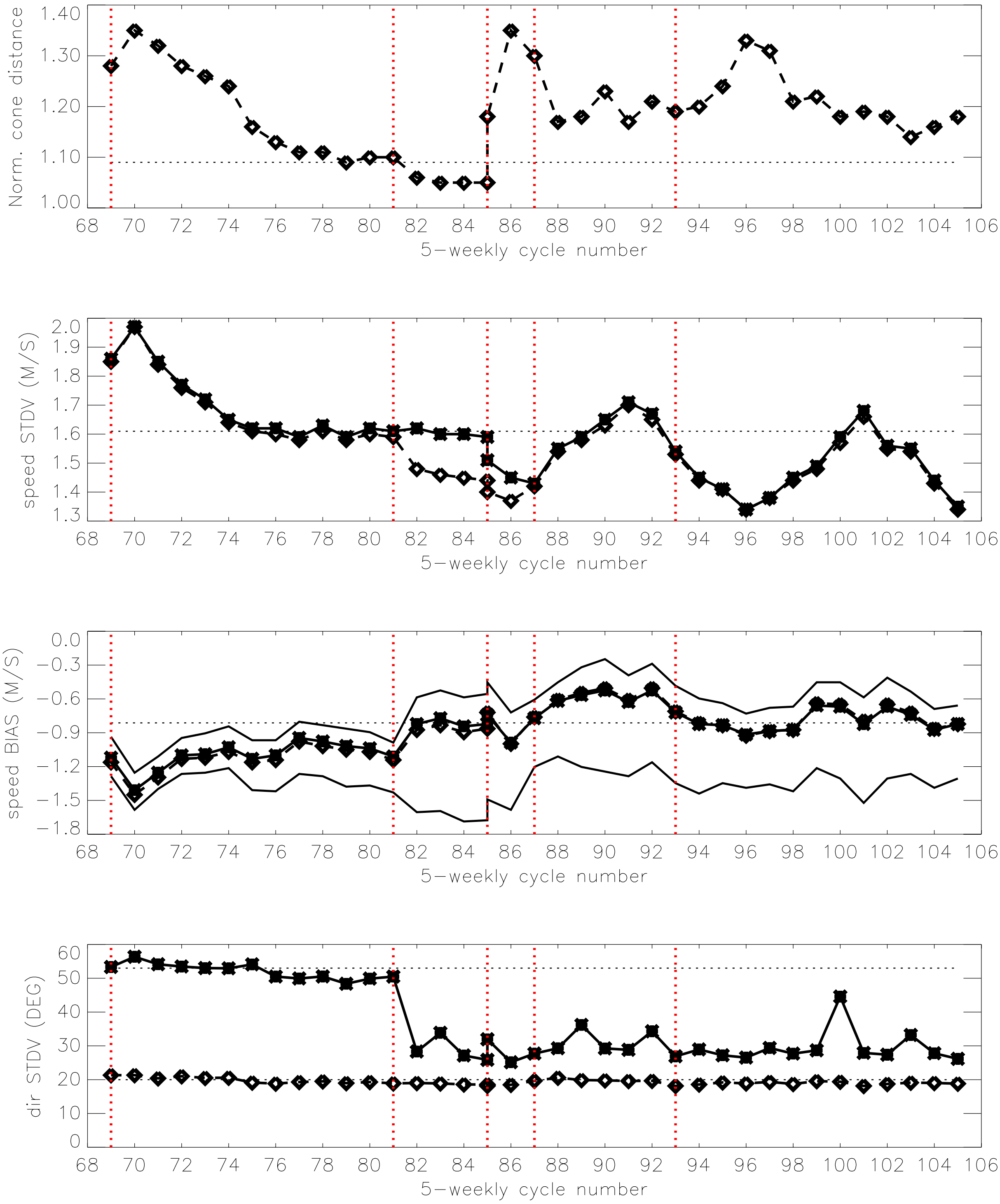
Figure 13: Two-dimensional histogram of first guess and UWI wind speeds, for the data kept by the UWI flags, and QC based on the ECMWF ice and land and sea-ice mask. Circles denote the mean values in the y-direction, and squares those in the x-direction.

Figure 14: Same as Fig. 13, but for wind direction. Only wind speeds higher 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: Bias relative to FG winds of the wind speed of ERS-2 winds (based on bias-corrected CMOD4 before 9 March 2004, and on CMOD5 afterwards) for nodes 1-19 (top panel) respectively of 50-km QuikSCAT (based on the QSCAT-1 model function) for nodes 5-34 (i.e., inner-beam zone; middle and lower panels) versus ECMWF first guess for the period of cycle 92 to 105. Curves represent centred 15-day running means. Vertical dashed blue lines mark ECMWF model changes.



Norm. cone distance
5-weekly cycle number
speed STDV (M/S)
5-weekly cycle number
speed BIAS (M/S)
5-weekly cycle number
dir STDV (DEG)
5-weekly cycle number

Figure 1

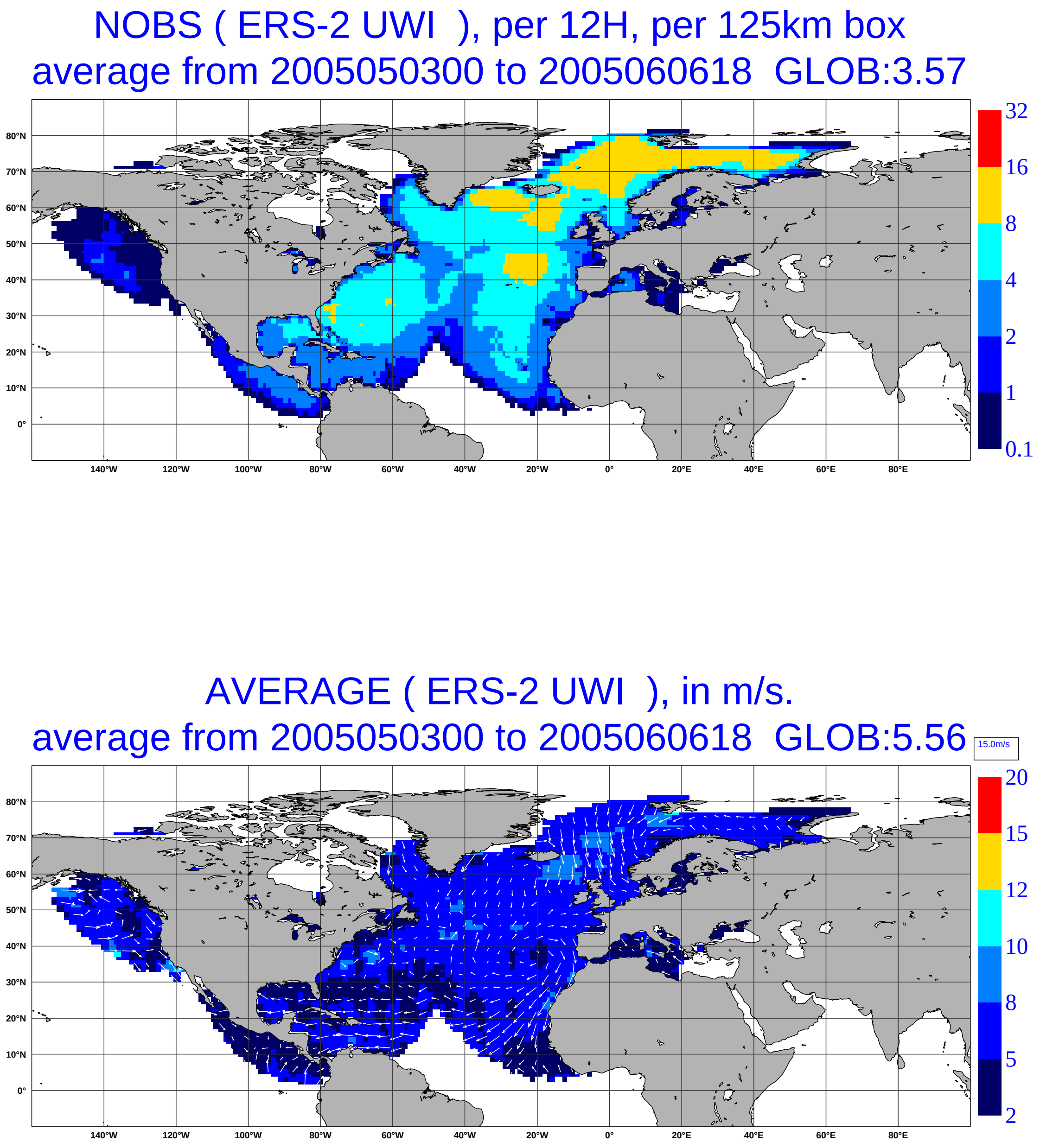

NOBS (ERS-2 UWI), per 12H, per 125km box
average from 2005050300 to 2005060618 GLOB:3.57
32
16
8
4
2
1
0.1
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
AVERAGE (ERS-2 UWI), in m/s.
average from 2005050300 to 2005060618 GLOB:5.56
15.0m/s
20
15
12
10
8
5
2

Figure 2

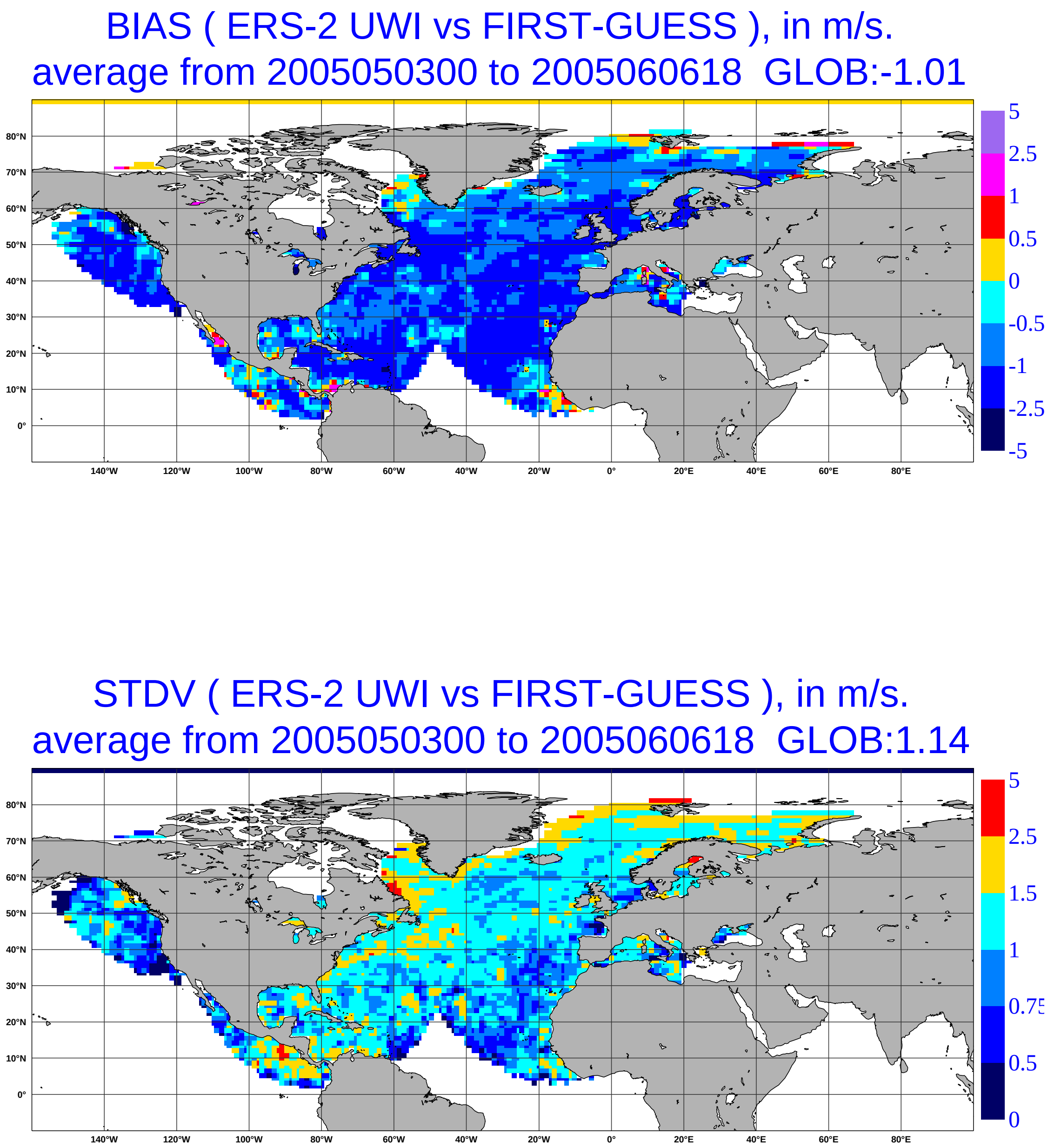

BIAS (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2005050300 to 2005060618 GLOB:-1.01
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
5
2.5
1
0.5
0
-0.5
-1
-2.5
-5
STDV (ERS-2 UWI vs FIRST-GUESS), in m/s.
average from 2005050300 to 2005060618 GLOB:1.14
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
5
2.5
1.5
1
0.5
0

Figure 3

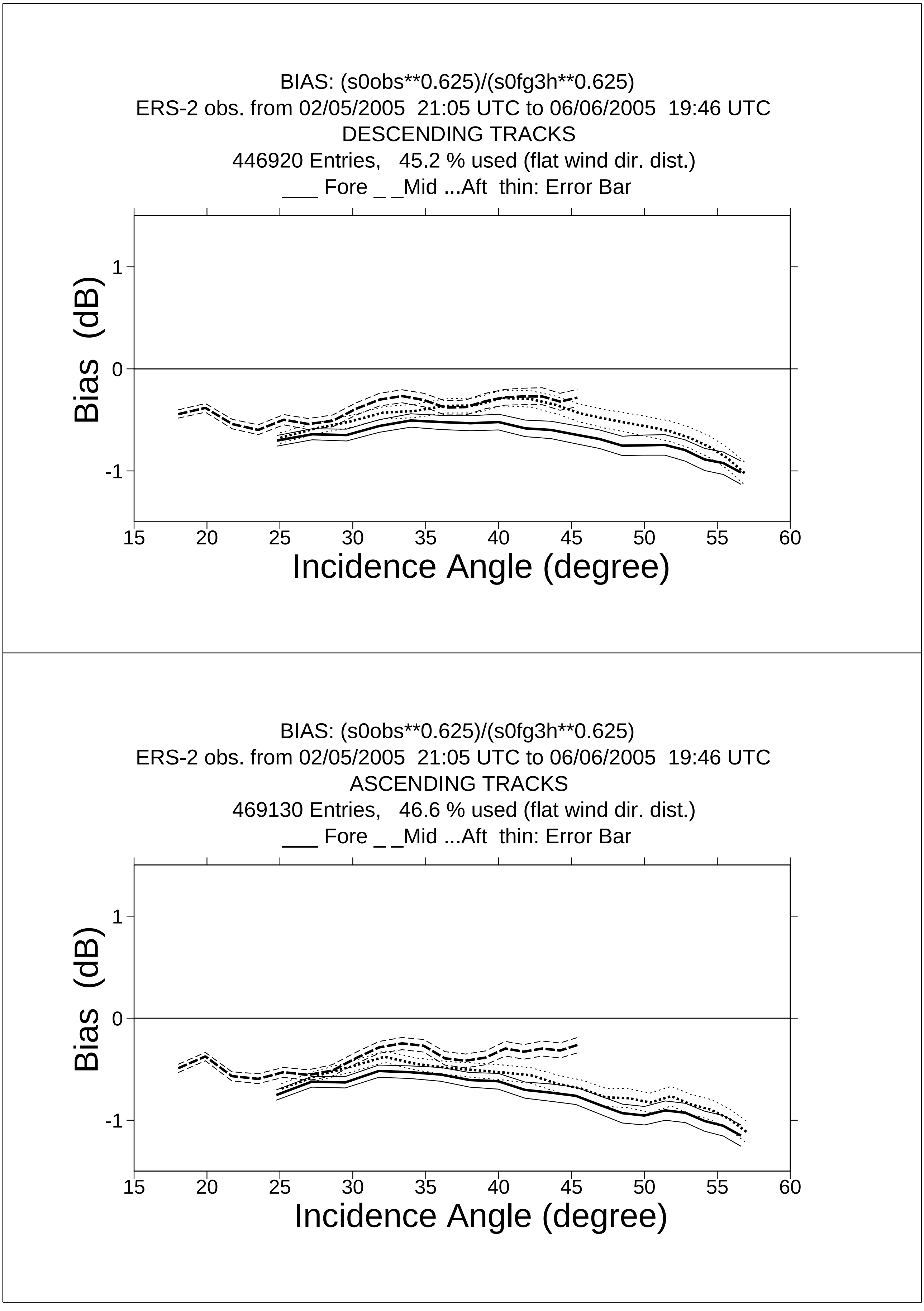

BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 02/05/2005 21:05 UTC to 06/06/2005 19:46 UTC
DESCENDING TRACKS
446920 Entries, 45.2 % used (flat wind dir. dist.)
___ Fore _ _Mid ...Aft thin: Error Bar
Bias (dB)
1
0
-1
15
20
25
30
35
40
45
50
55
60
Incidence Angle (degree)
BIAS: (s0obs**0.625)/(s0fg3h**0.625)
ERS-2 obs. from 02/05/2005 21:05 UTC to 06/06/2005 19:46 UTC
ASCENDING TRACKS
469130 Entries, 46.6 % 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)

Figure 4

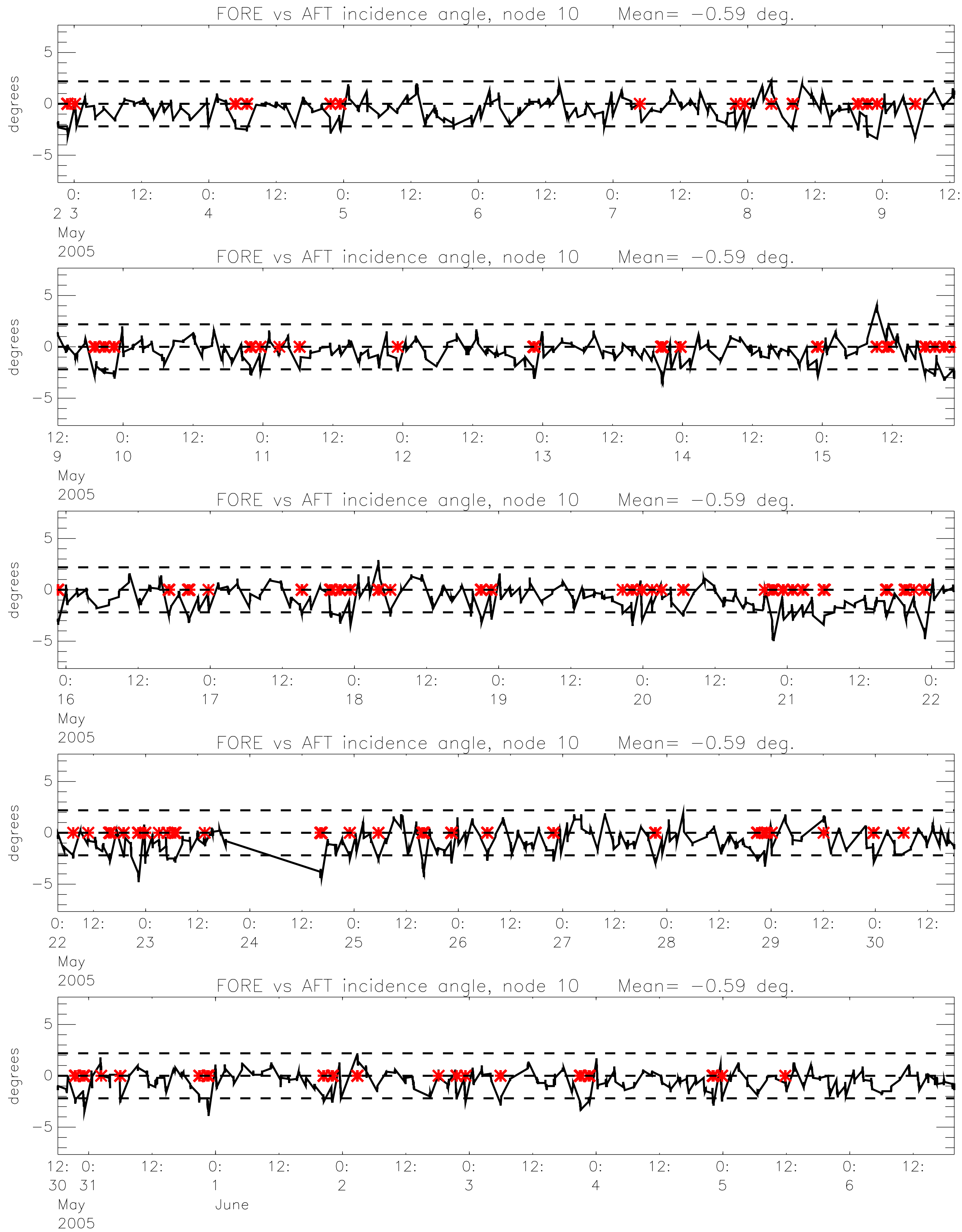

FORE vs AFT incidence angle, node 10 Mean= −0.59 deg.
degrees
5
0
−5
0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
2 3 4 5 6 7 8 9
May
2005
FORE vs AFT incidence angle, node 10 Mean= −0.59 deg.
degrees
5
0
−5
12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
9 10 11 12 13 14 15
May
2005
FORE vs AFT incidence angle, node 10 Mean= −0.59 deg.
degrees
5
0
−5
0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0:
16 17 18 19 20 21 22
May
2005
FORE vs AFT incidence angle, node 10 Mean= −0.59 deg.
degrees
5
0
−5
0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
22 23 24 25 26 27 28 29 30
May
2005
FORE vs AFT incidence angle, node 10 Mean= −0.59 deg.
degrees
5
0
−5
12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12: 0: 12:
30 31 1 2 3 4 5 6
May
2005
June

Figure 5

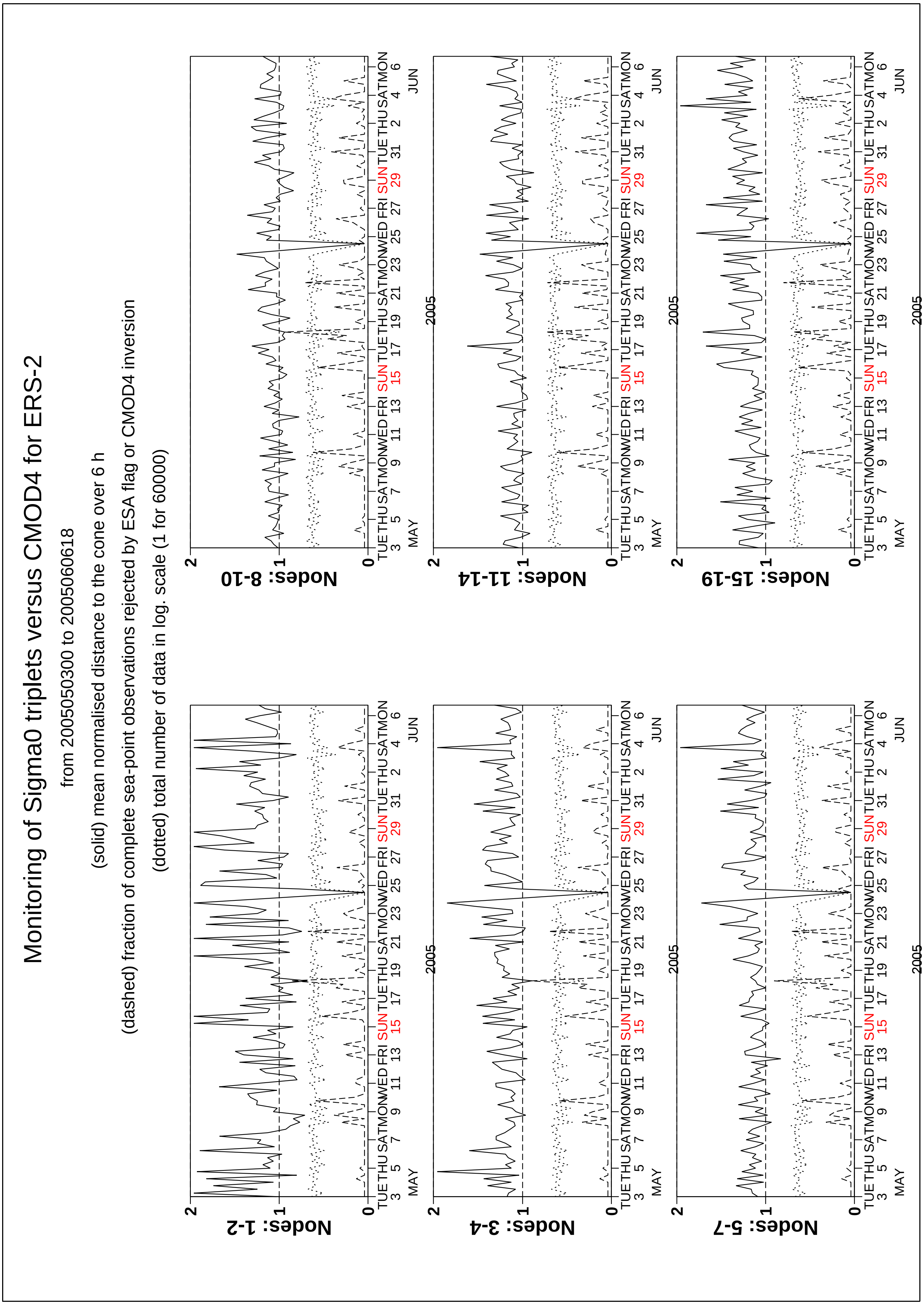

Monitoring of Sigma0 triplets versus CMOD4 for ERS-2
from 2005050300 to 2005060618
(solid) mean normalised distance to the cone over 6 h
(dashed) fraction of complete sea-point observations rejected by ESA flag or CMOD4 inversion
(dotted) total number of data in log. scale (1 for 60000)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
MAY
JUN
2005

Figure 6

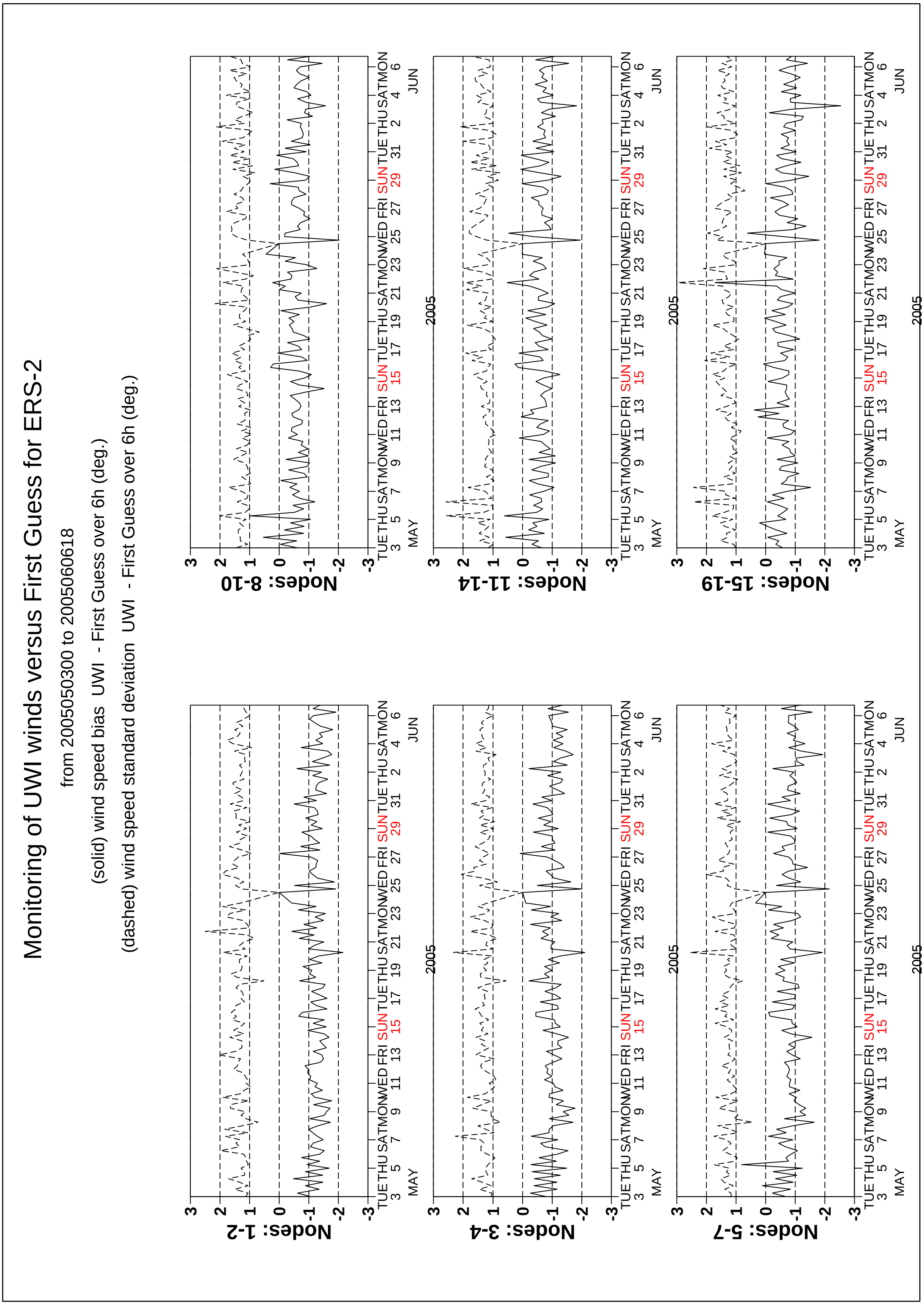

Monitoring of UWI winds versus First Guess for ERS-2
from 2005050300 to 2005060618
(solid) wind speed bias UWI - First Guess over 6h (deg.)
(dashed) wind speed standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
MAY
JUN
2005

Figure 7

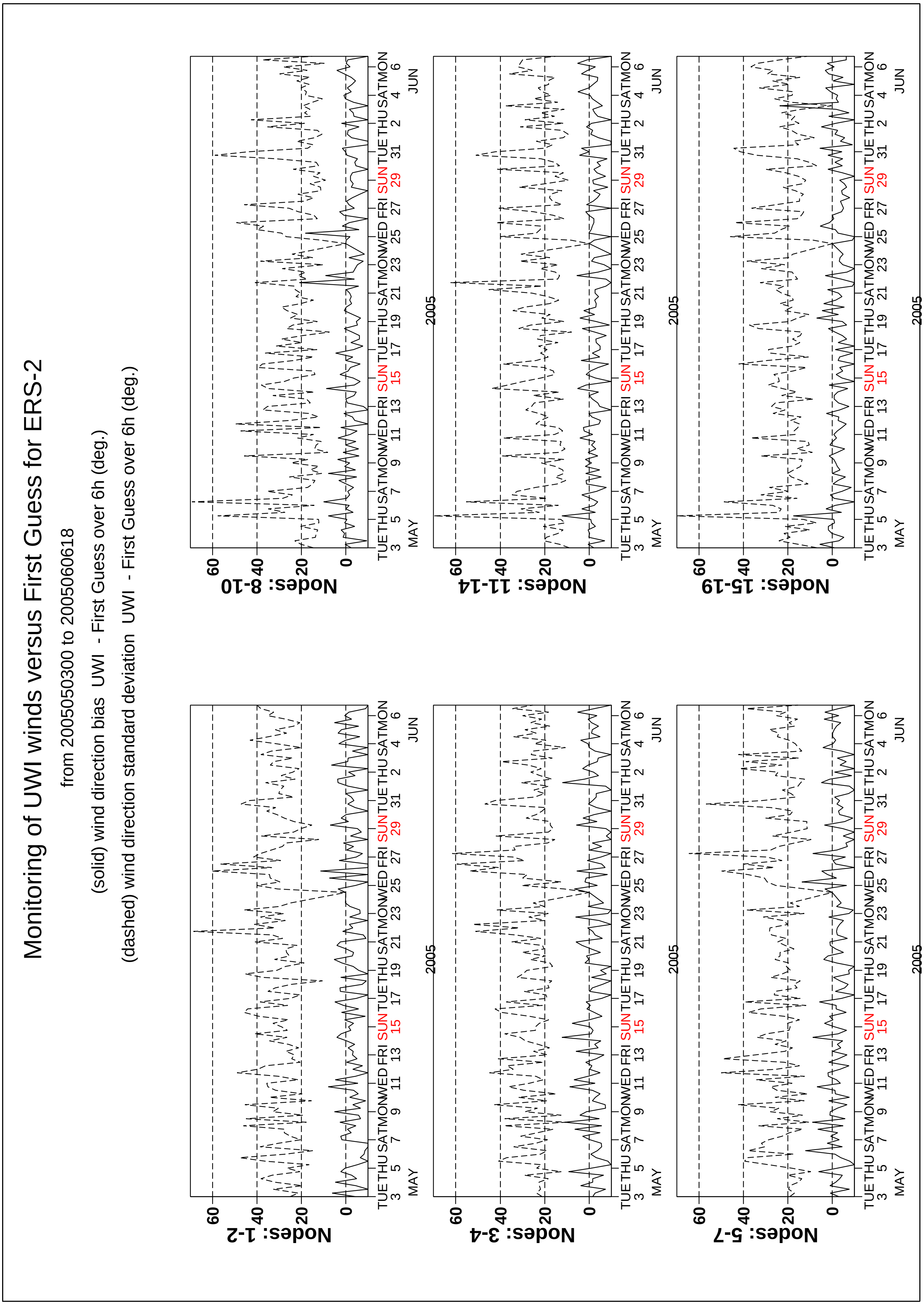

Monitoring of UWI winds versus First Guess for ERS-2
from 2005050300 to 2005060618
(solid) wind direction bias UWI - First Guess over 6h (deg.)
(dashed) wind direction standard deviation UWI - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
2005
MAY
JUN

Figure 8

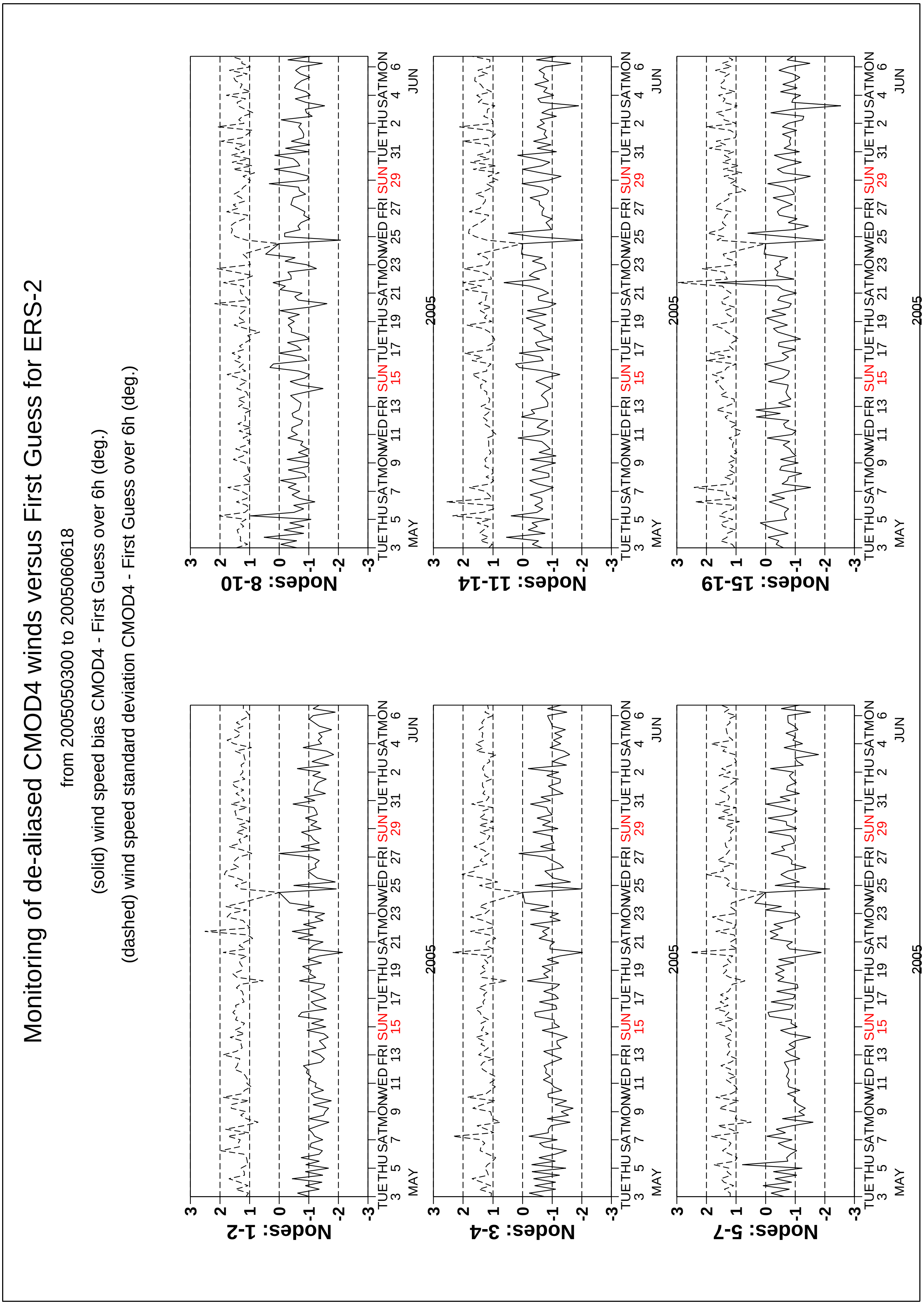

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2005050300 to 2005060618
(solid) wind speed bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind speed standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
MAY
JUN
2005

Figure 9

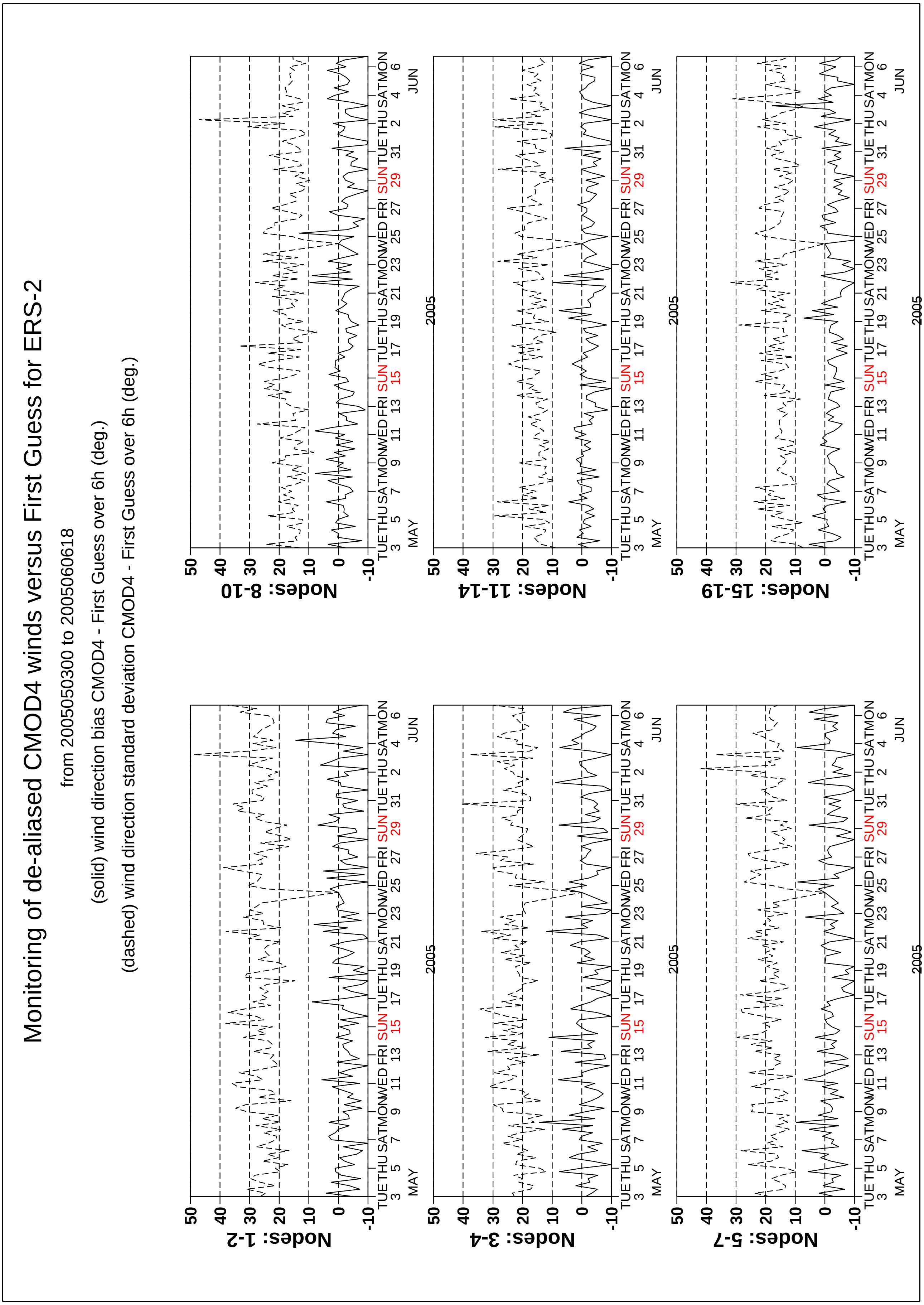
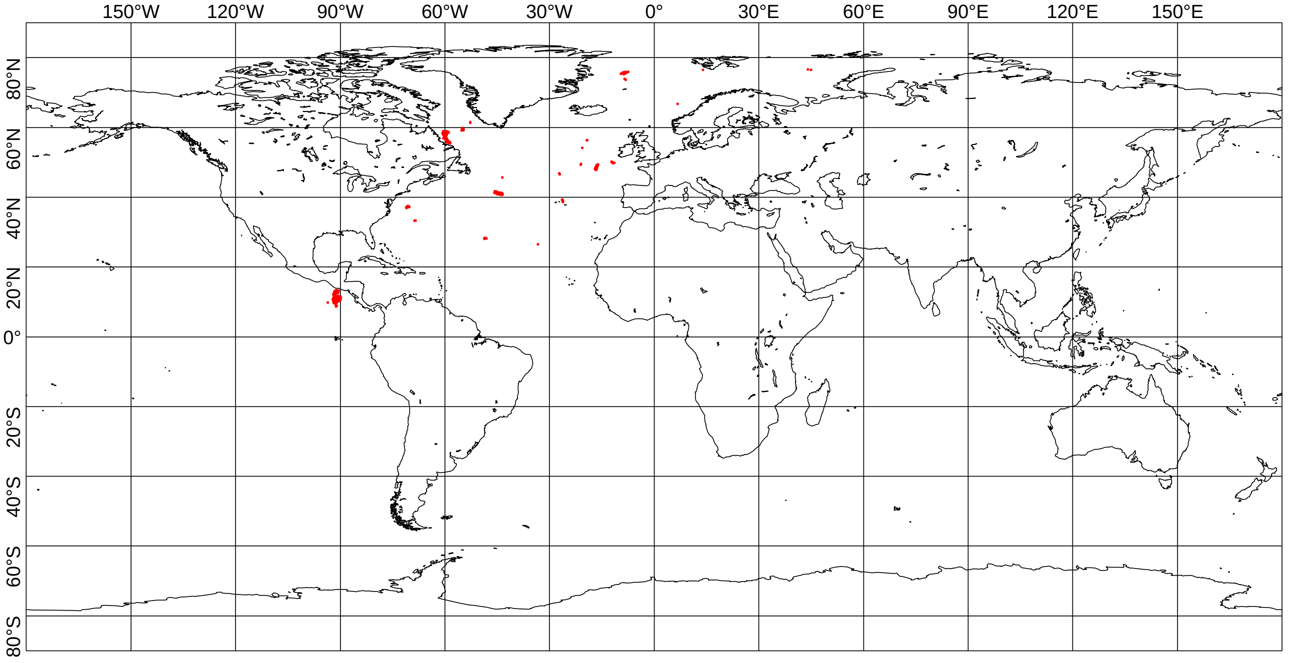

Monitoring of de-aliased CMOD4 winds versus First Guess for ERS-2
from 2005050300 to 2005060618
(solid) wind direction bias CMOD4 - First Guess over 6h (deg.)
(dashed) wind direction standard deviation CMOD4 - First Guess over 6h (deg.)
Nodes: 1-2
Nodes: 3-4
Nodes: 5-7
Nodes: 8-10
Nodes: 11-14
Nodes: 15-19
2005
MAY
JUN

Figure 10

UWI winds more than 8 m/s weaker than FGAT
CYCLE 105, 2005050300 to 2005060618, QC on ESA flags



UWI winds more than 8 m/s stronger than FGAT
CYCLE 105, 2005050300 to 2005060618, QC on ESA flags

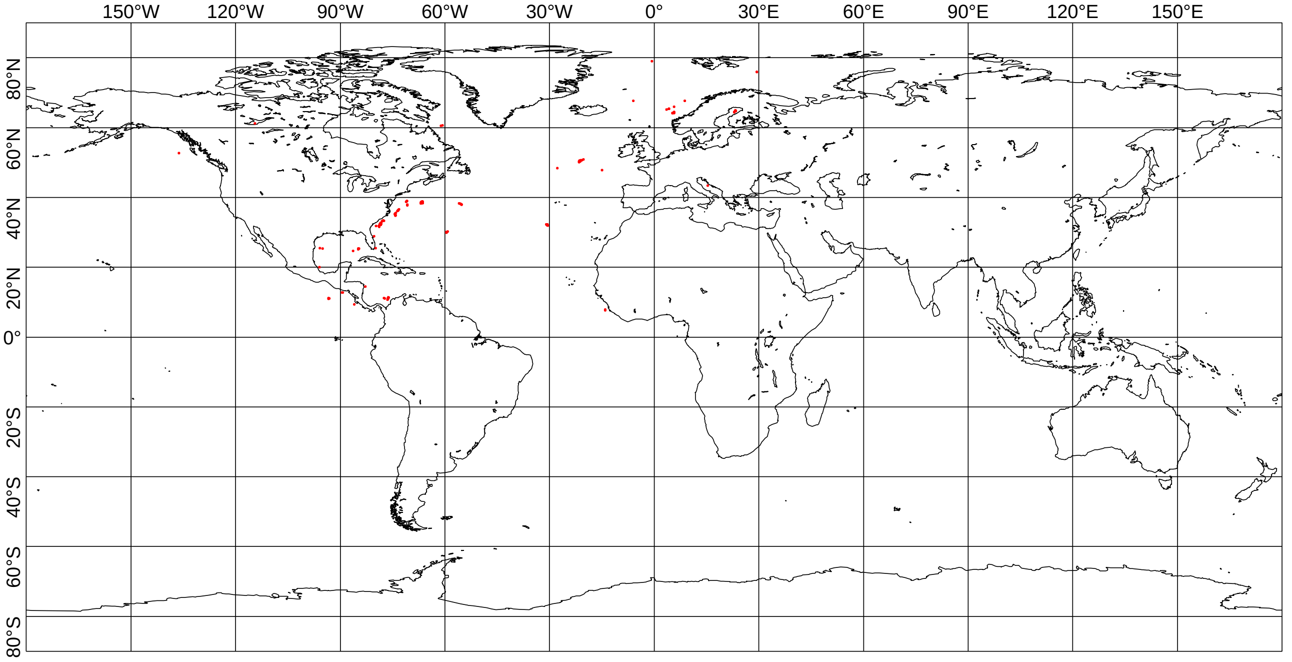


Figure 11

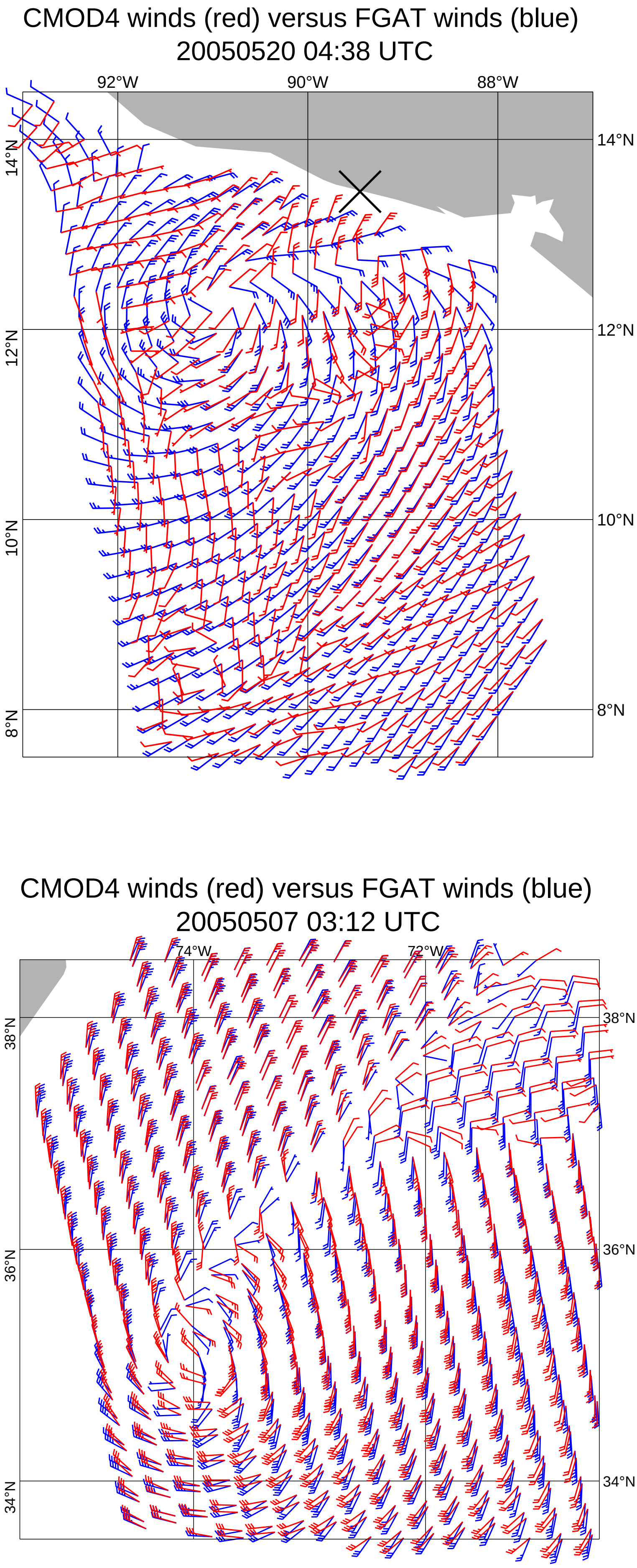

CMOD4 winds (red) versus FGAT winds (blue)
20050520 04:38 UTC
92°W
90°W
88°W
14°N
12°N
10°N
8°N
CMOD4 winds (red) versus FGAT winds (blue)
20050507 03:12 UTC
74°W
72°W
38°N
36°N
34°N

Figure 12

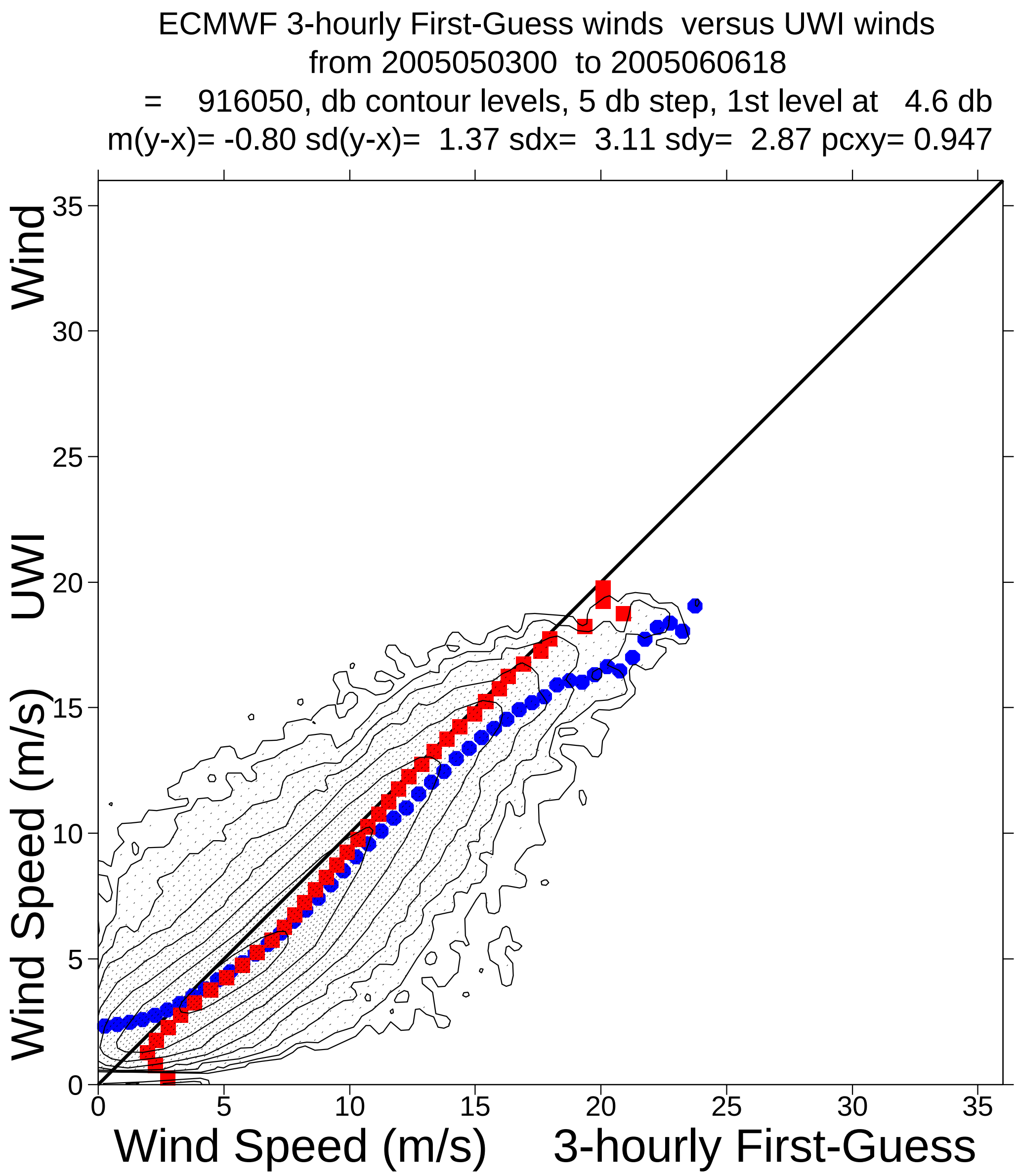

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2005050300 to 2005060618
= 916050, db contour levels, 5 db step, 1st level at 4.6 db
m(y-x)= -0.80 sd(y-x)= 1.37 sdx= 3.11 sdy= 2.87 pcxy= 0.947
Wind Speed (m/s) UWI Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 13

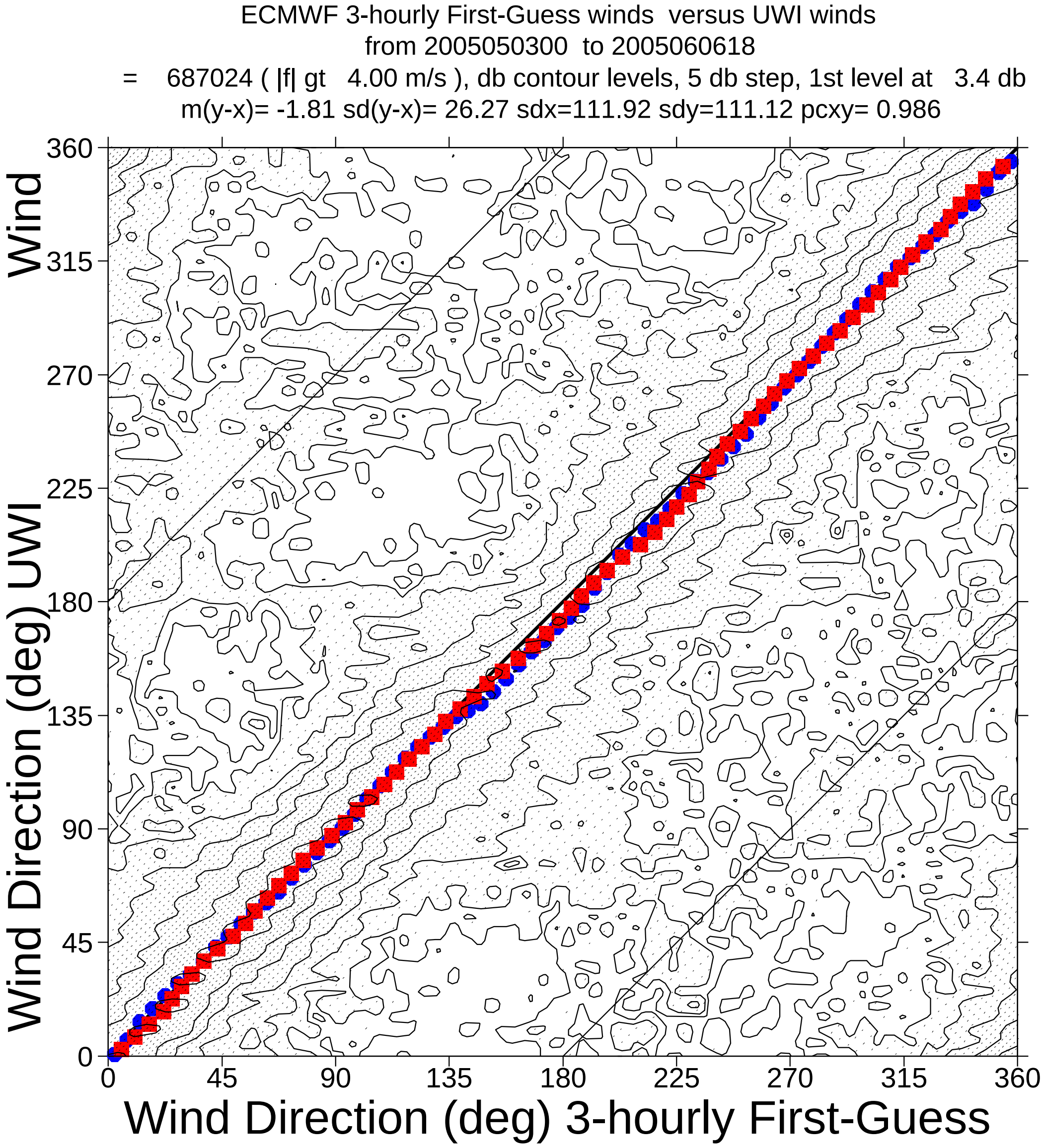

ECMWF 3-hourly First-Guess winds versus UWI winds
from 2005050300 to 2005060618
= 687024 (|f| gt 4.00 m/s), db contour levels, 5 db step, 1st level at 3.4 db
m(y-x)= -1.81 sd(y-x)= 26.27 sdx=111.92 sdy=111.12 pcxy= 0.986
Wind Direction (deg) UWI Wind
Wind Direction (deg) 3-hourly First-Guess
0
45
90
135
180
225
270
315
360

Figure 14

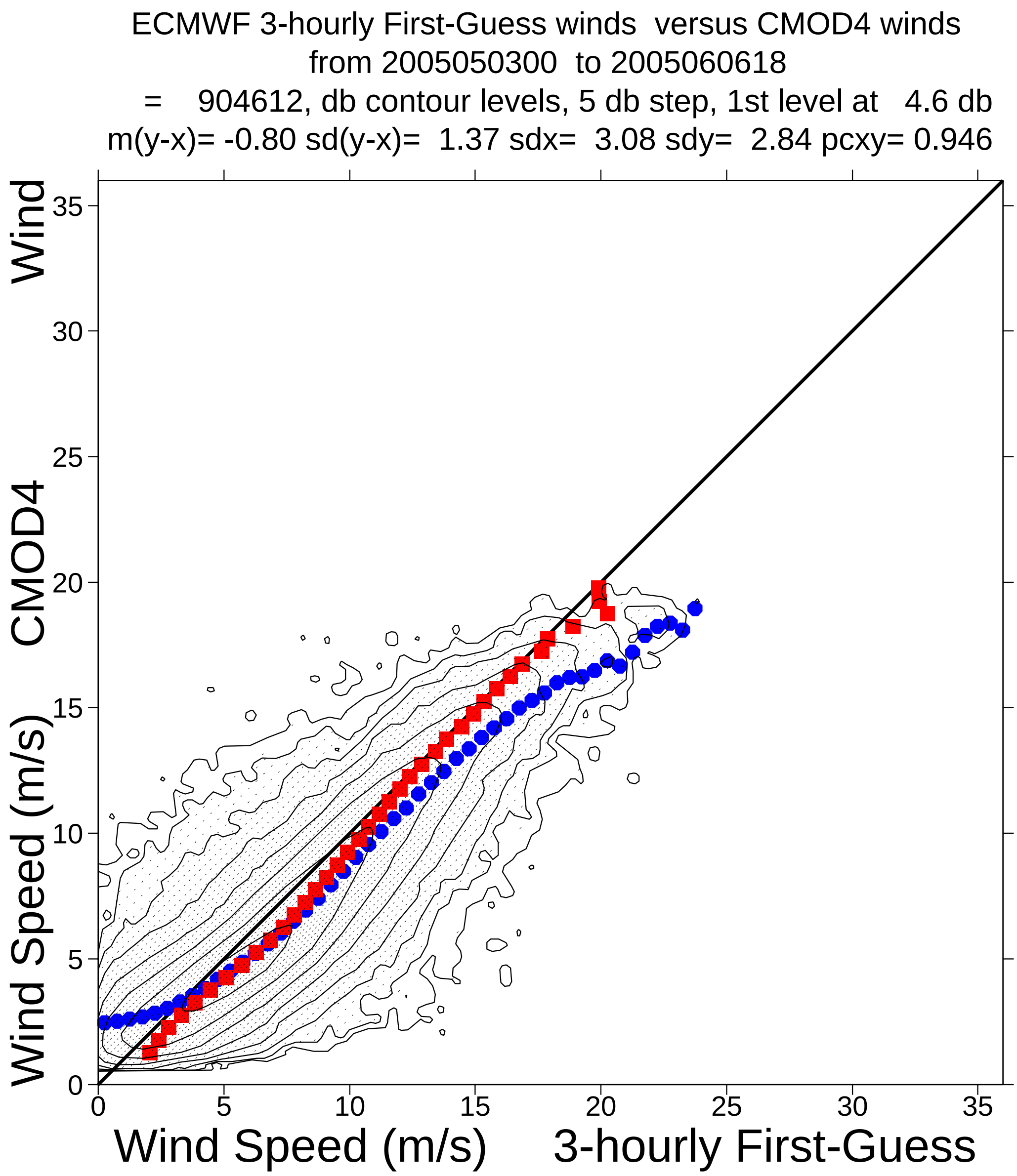

ECMWF 3-hourly First-Guess winds versus CMOD4 winds
from 2005050300 to 2005060618
= 904612, db contour levels, 5 db step, 1st level at 4.6 db
m(y-x)= -0.80 sd(y-x)= 1.37 sdx= 3.08 sdy= 2.84 pcxy= 0.946
CMOD4 Wind Speed (m/s)
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 15

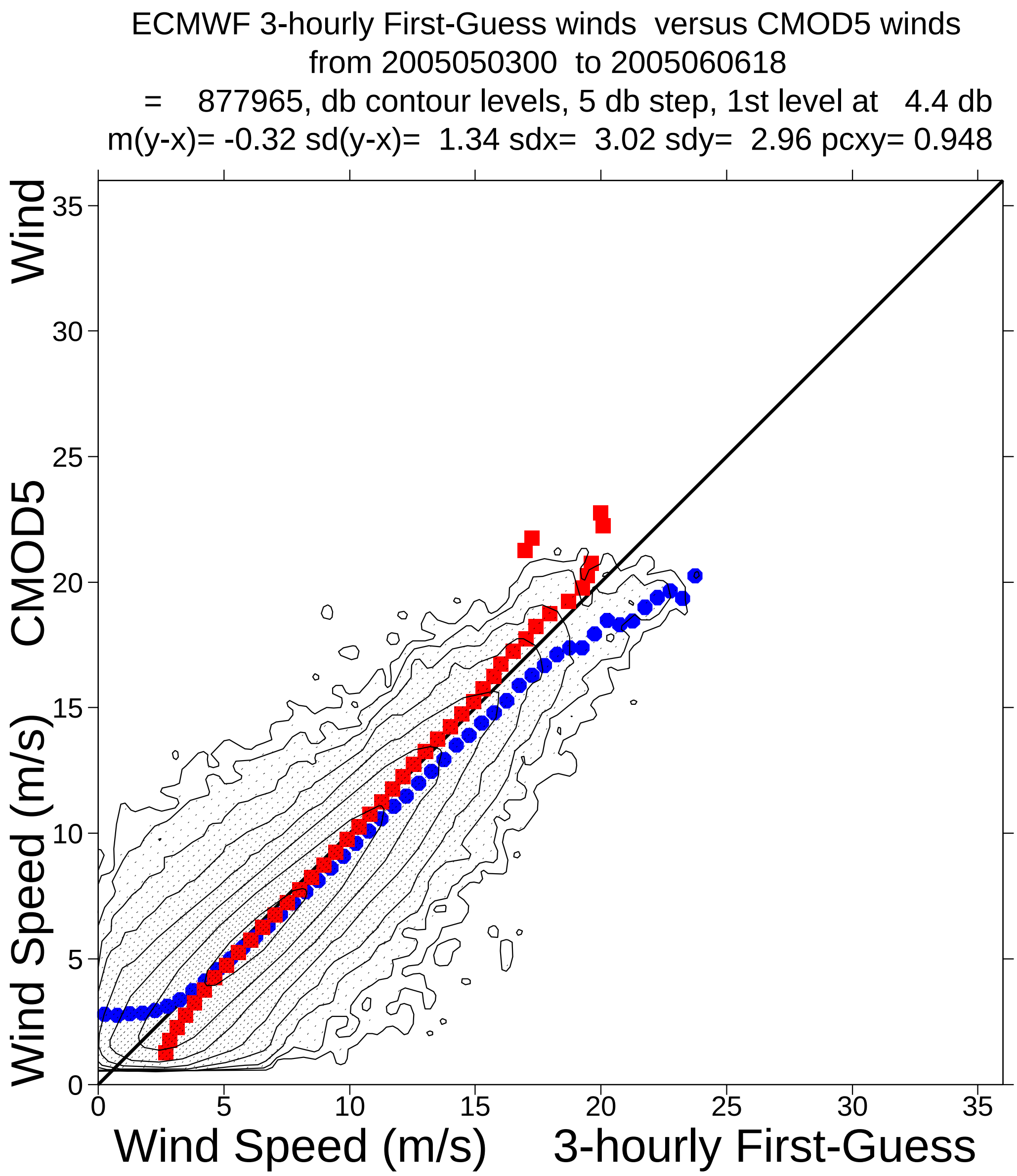
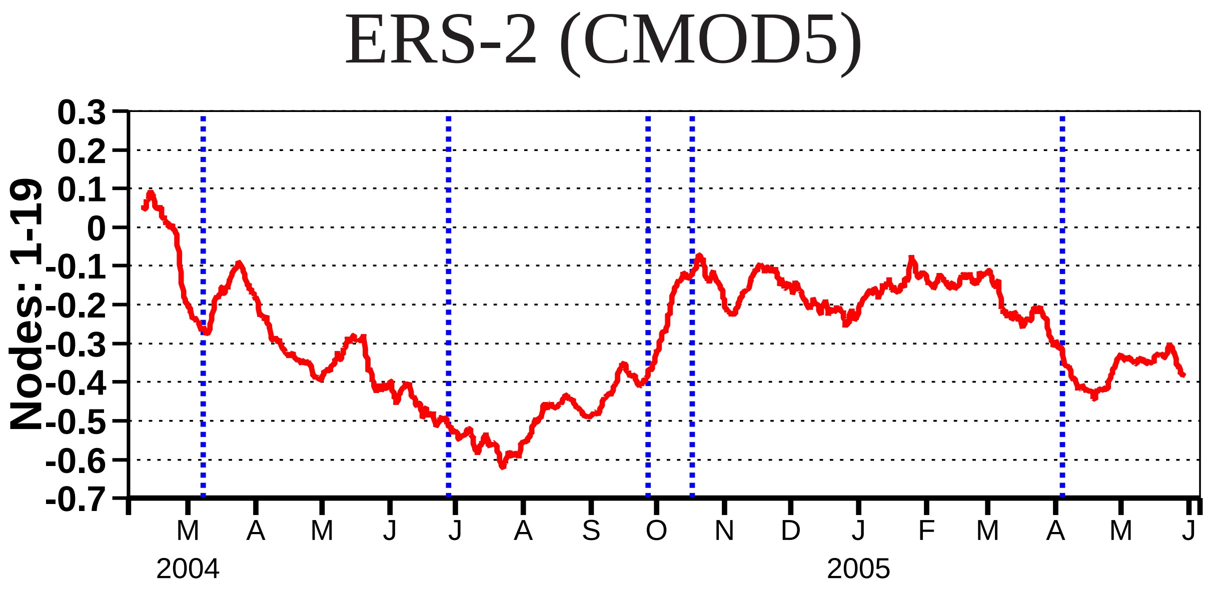

ECMWF 3-hourly First-Guess winds versus CMOD5 winds
from 2005050300 to 2005060618
= 877965, db contour levels, 5 db step, 1st level at 4.4 db
m(y-x)= -0.32 sd(y-x)= 1.34 sdx= 3.02 sdy= 2.96 pcxy= 0.948
Wind Speed (m/s) CMOD5 Wind
Wind Speed (m/s) 3-hourly First-Guess
0
5
10
15
20
25
30
35

Figure 16


ERS-2 (CMOD5)
Nodes: 1-19
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
M A M J J A S O N D J F M A M J
2004
2005

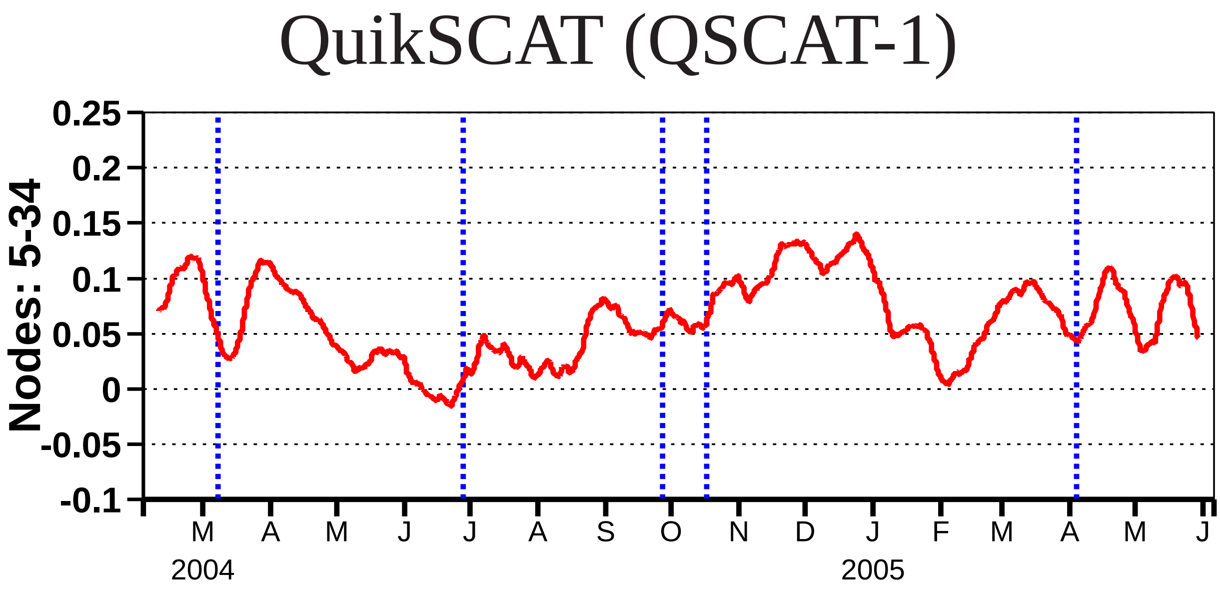

QuikSCAT (QSCAT-1)
Nodes: 5-34
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
M A M J J A S O N D J F M A M J
2004
2005

Figure 17