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Meteorology Research and Development

**OSI-SAF level 2 ASCAT wind product performance against Met Office
background winds 1st June 2007 – 31st May 2008.**



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Abstract.

This report compares OSI-SAF level 2 ASCAT wind product with that from the Met Office global forecast model for the period 1st June 2007 until 31st May 2008. The Met Office monitors these ASCAT data as part of its commitment to the NWP SAF.

The conclusions from these comparisons are that:-

- ASCAT data are of at least as high quality as wind data from other scatterometers
- The Met Office forecast wind speeds have improved over the last 12 months in terms of the standard deviation against scatterometer measurements
- OSI SAF level 2 ASCAT data have low bias relative the Met Office forecast model, which makes it suitable for NWP assimilation applications
- Changes in the lower level ASCAT data processing at EUMETSAT have not fed through to produce adverse effects to the OSI SAF level 2 wind product during the period

1. Introduction.

1.1 MetOp ASCAT

The MetOp series of satellites are Europe's first polar-orbiting satellites dedicated to operational meteorology. MetOp-A was launched on 16th October 2006 carrying a variety of earth observation instruments. Amongst these instruments was the advanced scatterometer (ASCAT). ASCAT is an active C-band (5.3GHz) radar scatterometer that has VV polarisation. This gives the instrument an all-weather capability as atmospheric attenuation of the signal is weak in this waveband and at this polarisation even in rainy conditions.

The swath geometry for ASCAT is shown in figure 1. Six radar beams (3 either side of the spacecraft) trace out 2x 550km swaths with a 670km gap between them. The primary use of ASCAT is in determining the surface wind speed and direction over the ocean. In addition, ASCAT can also be used for determining sea-ice properties as well as soil moisture conditions.

ASCAT wind vectors over the ocean are produced on the principle that radar energy will be backscattered from the sea surface differently according to its roughness. If we assume that the roughness of the sea surface is governed primarily by the surface wind field then it is reasonable to expect that there is a strong relationship between the wind and the radar backscatter signal. This relationship is exploited by KNMI who produce a level 2 wind vector product from the radar backscatter signals (so called "sigma nought" or σ^0) for the Ocean and Sea Ice Satellite Application Facility (OSI-SAF). For more detail on scatterometry methods the reader is referred to [1].

The Met Office has strategically chosen to utilise the OSI-SAF level 2 50km wind product (at 25km spacing) produced by KNMI rather than develop its own level 2 processing scheme. This has the following advantages:

- Very good technical support from KNMI scatterometer team
- There is no need to upgrade/retune coefficients and algorithms when EUMETSAT issue new backscatter calibration data because the KNMI scatterometer team will do this leaving the change transparent to end users
- Reduced complexity in our data processing code thereby reducing Met Office code development and maintenance resources required

1.2 Met Office model characteristics

The Met Office global forecast model has the following characteristics:

- Resolution of ~40km in mid-latitudes
- 640 x 481 grid size
- 50 vertical levels
- Lid at ~63km
- Forecast out to 120 hours.

ASCAT was operationally assimilated into the Met Office forecast model on 17th November 2007. The reader is referred to [2] for more details of the ASCAT assimilation implementation. QuikSCAT and ERS-2 scatterometer data are also assimilated into the model. The reader is referred to [3], [4] and [5] for further details of the assimilation methodology.

2. Data used in this study.

2.1 OSI-SAF level 2 ASCAT wind product.

The Met Office is working with the 50km level 2 OSI-SAF ASCAT BUFR product produced by KNMI. A description of this product can be found in the ASCAT wind product user manual [6]. The product consists of ocean surface wind vectors with typically two directional ambiguities. This means that each observation is reported with two possible wind directions approximately 180 degrees apart. This is similar for ERS-2 wind vectors, which are also derived from C-band measurements. A flag is set in the BUFR to tell the user which of the two wind directions is most probable. However, this flag is not reliable because it relies on comparing the two wind directions with an old forecast. It is therefore replaced in the observations processing system by a new flag that corresponds to the wind vector closest to a more up to date Met Office forecast wind value.

The ASCAT instrument has left and right hand 500km swaths separated by a gap of 670km. This is illustrated in figure 1. The ASCAT swath has 42 measurement cells or “nodes”. The backscatter measurement for each node is an average of many radar shots (1111 shots for 50km x 50km product). These shots are weighted to produce 50km averages at 25km spacing, with shots closest to the centre of the node having greater weight than those near the edge.

2.2 Collocation of model data.

The observation and model data are collocated by the Met Office observation processing system. Observation data are extracted from the database every 6 hours and matched up with model data from the most recent 6 hour forecast (commonly referred to as “background” values denoted by the letter B). The statistics generated are used to generate graphics for the NWP SAF website (http://www.metoffice.gov.uk/research/interproj/nwpsaf/scatter_report/nrt.html) and are then archived for use in future studies.

2.3 Quality control of OSI-SAF ASCAT data.

Only very basic quality control was applied to the ASCAT data for this report i.e. the statistics were generated not only using the data used in assimilation but also those that would have been rejected due to thinning and distance to cone checks. Nevertheless the data quality are still excellent. Dealiasing of the winds was performed by choosing the ASCAT wind closest to the T+6 forecast valid near the observation time.

3. Comparison of data

By and large it is evident that the ASCAT data has remained of good quality over the 12 month period. This is despite many processing changes that have taken place both at EUMETSAT and KNMI to the ASCAT data at various stages of processing. We can therefore conclude that upstream processing changes at both institutes have not resulted in any negative change in the quality of the final OSI SAF level 2 wind product. The following sections explore the ASCAT OSI-SAF level 2 data performance in comparison with Seawinds in more detail.

3.1 Time series of global and regional wind speed and direction

3.1.1 Wind speed.

Northern Hemisphere (Figures 2a and 2b)

- Shape of bias similar with larger bias for both ASCAT and Seawinds instruments during NH winter
- Shape of standard deviation very similar with largest values in NH winter

Southern Hemisphere (Figures 3a and 3b)

- Shape of bias similar with larger bias for both instruments during SH winter
- Shape of standard deviation very similar with largest values in SH winter

Tropics (Figures 4a and 4b)

- Small fluctuation in ASCAT speed bias in period though fluctuation is larger for Seawinds
- Standard deviation falls over the year for both ASCAT and Seawinds instruments

Global (Figures 5a and 5b)

- Small fluctuation in ASCAT speed bias in period though fluctuation is larger for Seawinds
- Decrease in standard deviation as the year progresses for both ASCAT and Seawinds instruments

3.1.2 Wind direction.

- Northern Hemisphere, Southern Hemisphere, TROPICS and GLOBAL regions: ASCAT and Seawinds standard deviations follow similar trends over the period (figures 6a-9b)
- The directional biases are similar for both instruments but regionally dependent in the period as shown in the table below

Table 1. Directional bias compared to model background by region for each scatterometer for the entire period 01/06/2007 – 31/05/2008.

Region	ASCAT degrees	SEAWINDS degrees
Northern Hemisphere >23N	+2	+2
Southern Hemisphere >23S	-2	-2
Tropics <23S & <23N	0	0
Global	+0.5	+0.5

3.2 Cross-track performance of OSI-SAF level 2 wind product

3.2.1 Wind speed performance

The bias in the observed winds with respect to the model background (O-B) is very low across the swath – typically less than 0.3m/s (Fig. 10a). The structure in the bias across the swath is also persistent showing little sign of change from June 2007 to May 2008 (Fig. 10b). This low bias makes the product suitable for assimilation since 4D Var needs data to be as bias free as possible.

The standard deviation in the O-B wind speeds is very low and in May 2008 was $<1.14\text{m/s}$ across the entire swath (Fig. 10a). This is a reduction of 0.7m/s across the swath since June 2007 (Fig. 10b).

3.2.2 Wind direction performances

The absolute value of the wind direction bias across the swath is typically < 1 degree. In June 2007 the standard deviation on node 22 was very high at 21.5 degrees. Fig. 10c shows how node 22 had a clearly reduced performance compared to neighbouring nodes. In May 2008 node 22 performs more similarly to neighbouring nodes (Fig. 10d) following processing enhancements at KNMI in October 2007.

3.3 Global maps of O-B wind speed and direction.

Global maps of O-B wind speed and direction have been produced for this period. Unfortunately they are too numerous to be presented in a document so this report presents only a sub-sample of highlights (figures 11a-d and 12a-d for June and December 2007 respectively) to give an idea of what kind of information these graphics contain. The following casual observations can be made:-

Table 2. Global Maps of O-B Wind Speed

Mean O-B Wind Speed	For June 2007 (fig. 11a) the model winds look to be too slow off the western coast of South America, west coast of India and in the Indonesian region.
Standard Deviation O-B Wind Speed	For June 2007 (fig. 11c) there is high variability in the O-B wind speeds in the Gulf of Aden and also in the Indonesian region. This variability is much reduced for December 2007 (fig. 11d).

Table 3. Global Maps of O-B Wind Direction

Mean O-B Wind Direction	In June 2007 (fig. 12a) larger wind direction biases are observed off the coast of south west India and off the north west coast of South America.
Standard Deviation O-B Wind Direction	In June 2007 (fig. 12c) High standard deviations in O-B wind direction are visible in the Indonesian region, off the south west coast of India and is quite striking across the intertropical convergence zone (ITCZ). This variability is reduced for December 2007 (fig. 12d) but is still very evident.

4. Discussion and further work

4.1 Increase in accuracy of model wind speed

Both ASCAT and SEAWINDS O-B wind speed standard deviations show a steady reduction over the year by 0.1m/s. This can be interpreted as being due to successful improvements to forecast wind speeds from changes made to the model system throughout the period. The fact that two global coverage scatterometers have been used to evaluate the model adds weight to this interpretation. If only one global coverage scatterometer mission had been used then another interpretation would be that the scatterometer data had improved instead, which is not believed to be the case for both instruments.

4.2 ASCAT climatology

One year of ASCAT observation and model forecast data have been gathered into an O-B climatology at the Met Office. Figures 11a-d and 12a-d show some examples of the regional monthly statistics that have been generated. The figures show detailed systematic geophysical structures in the O-B fields. It is hoped that the O-B climatology will enable modellers to identify areas for improving the ocean surface wind forecasts. Some examples of areas for improvement that are evident in the figures include coastal outflows, ITCZ winds and the sheltering effects of islands.

4.3 Conclusions.

The conclusions from these comparisons are that:-

- ASCAT data are of at least as high quality as wind data from other scatterometers e.g. Seawinds
- The Met Office forecast wind speeds have improved over the last 12 months in terms of the standard deviation against scatterometer measurements
- OSI SAF level 2 ASCAT data have low bias relative the Met Office forecast model, which makes it suitable for NWP assimilation applications
- Changes in the lower level ASCAT data processing at EUMETSAT have not fed through to produce adverse effects to the OSI SAF level 2 wind product during the period

4.4 Further work.

Further work with ASCAT level 2 wind data at the Met Office includes:-

- Monitoring the data via the NWP SAF web site
- Checking that the product characteristics do not change due to changes in the instrument performance or upstream changes in the ASCAT wind data processing
- Evaluating higher resolution ASCAT scatterometer products
- Evaluating the usefulness of the ASCAT O-B climatology for model improvement studies
- Determine day/night differences in O-B wind fields

5. Acknowledgements

The authors would like to acknowledge the diligent work of the KNMI scatterometer team in supporting our use of the OSI-SAF level 2 ASCAT wind data. We would also like to thank the other members of the ASCAT SAG for interesting discussions and feedback.

6. References

[1] Kerkmann, J., 1998: Review on Scatterometer Winds, EUMETSAT technical Department Technical Memorandum No. 3.

[2] [Keogh, S.J and B. Candy., 2008: The Impact of MetOp-A ASCAT ocean surface wind vectors on Met Office Global Model Forecasts, Forecasting Research Technical Report 511.](#)

[3] Candy, B., 2001: The Assimilation of Ambiguous Scatterometer Winds Using a Variational Technique: Method and Forecast Impact. Forecasting Research Tech. Rep. 349.

[4] [Candy, B. and Keogh S.J. 2006: The Impact of Seawinds Scatterometer Data on Met Office Global Model Analyses and Forecasts, Forecasting Research Tech. Rep. 493.](#)

[5] [Keogh, S.J., Candy, B and Offiler D., 2006: ERS-2 scatterometer - reintroduction into Met Office global model. Forecasting Research Tech. Rep. 473.](#)

[6] ASCAT product user manual, KNMI, 2007.
http://www.knmi.nl/scatterometer/publications/pdf/ASCAT_Product_Manual.pdf

Annex 1. Figures.

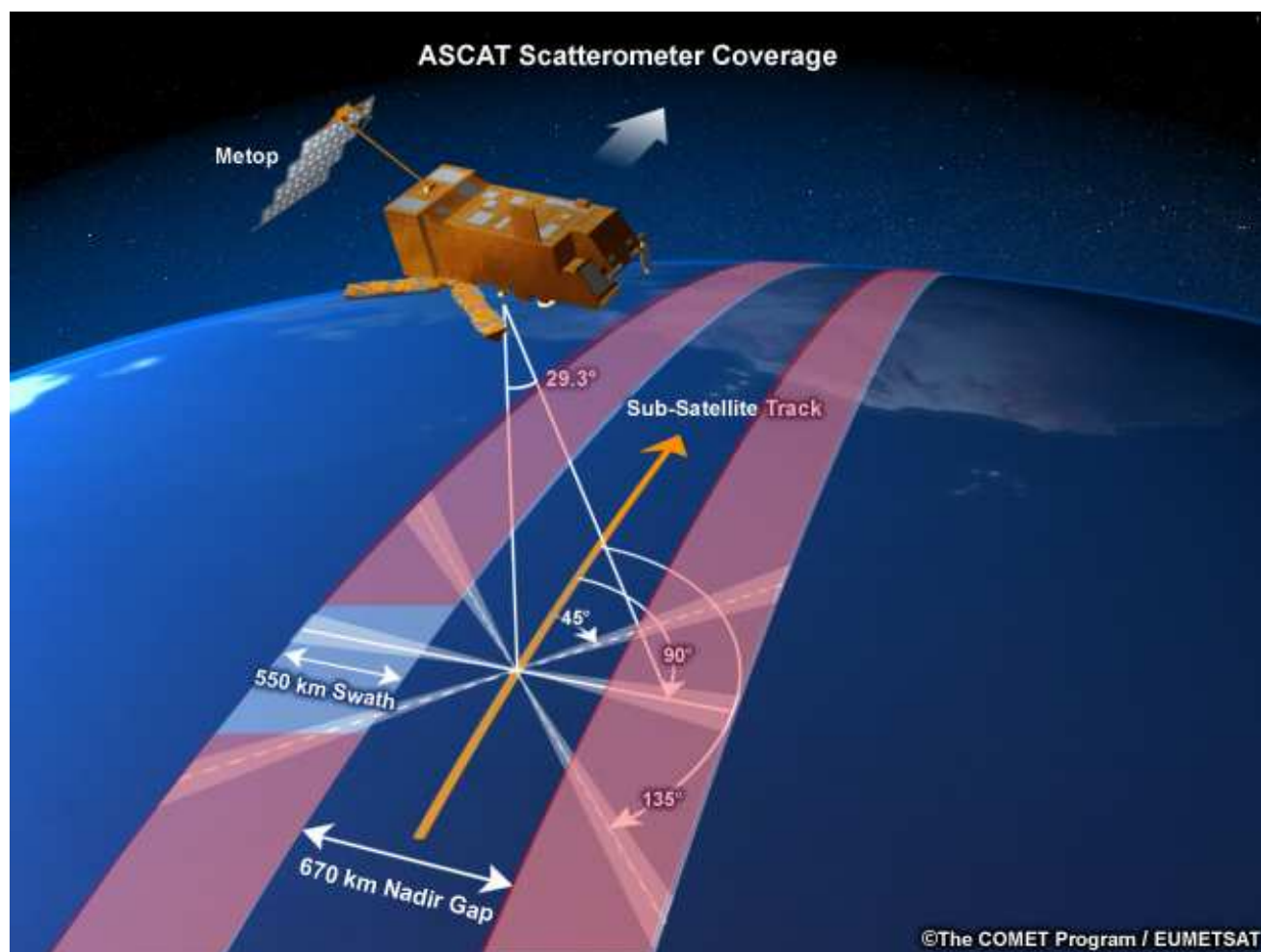


Figure 1. The ASCAT swath, from EUMETSAT web site.

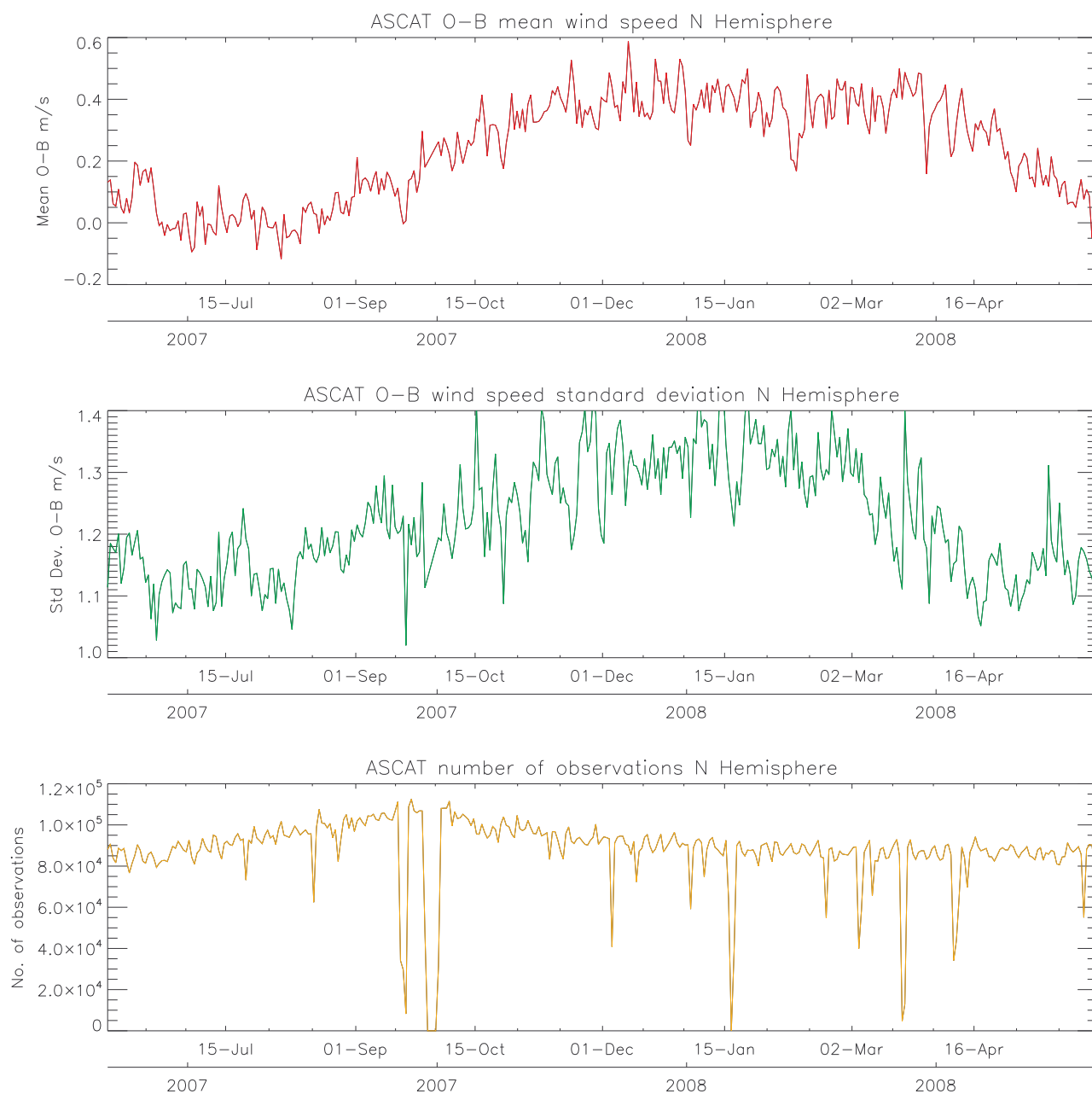


Figure 2a. ASCAT wind speed statistics for northern hemisphere. The bias and standard deviation in O-B wind speed are clearly large in northern hemisphere winter than in summer.

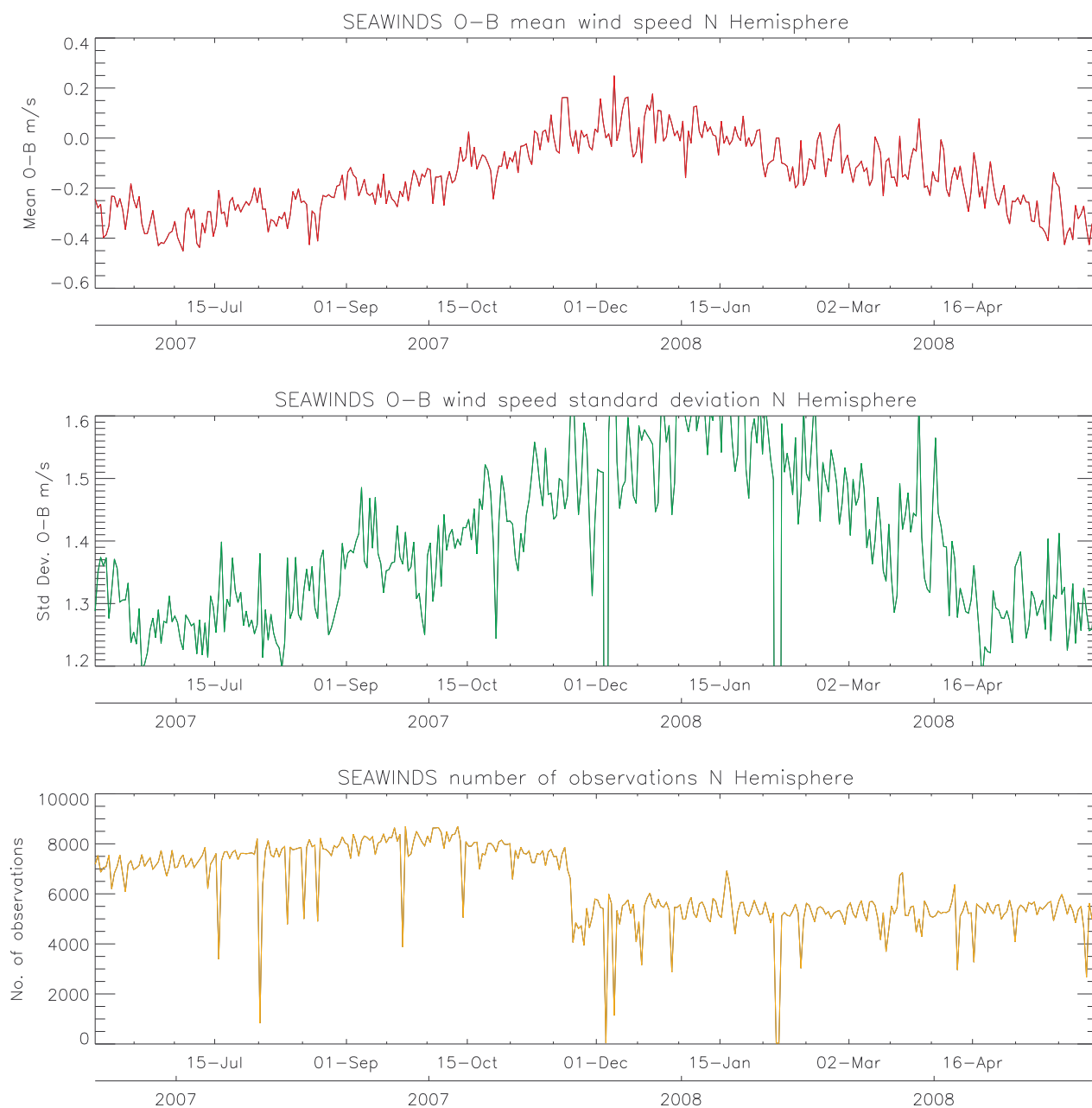


Figure 2b. SEAWINDS wind speed statistics for northern hemisphere. The bias and standard deviation in O-B wind speed follow a similar trend to those for ASCAT throughout the year.

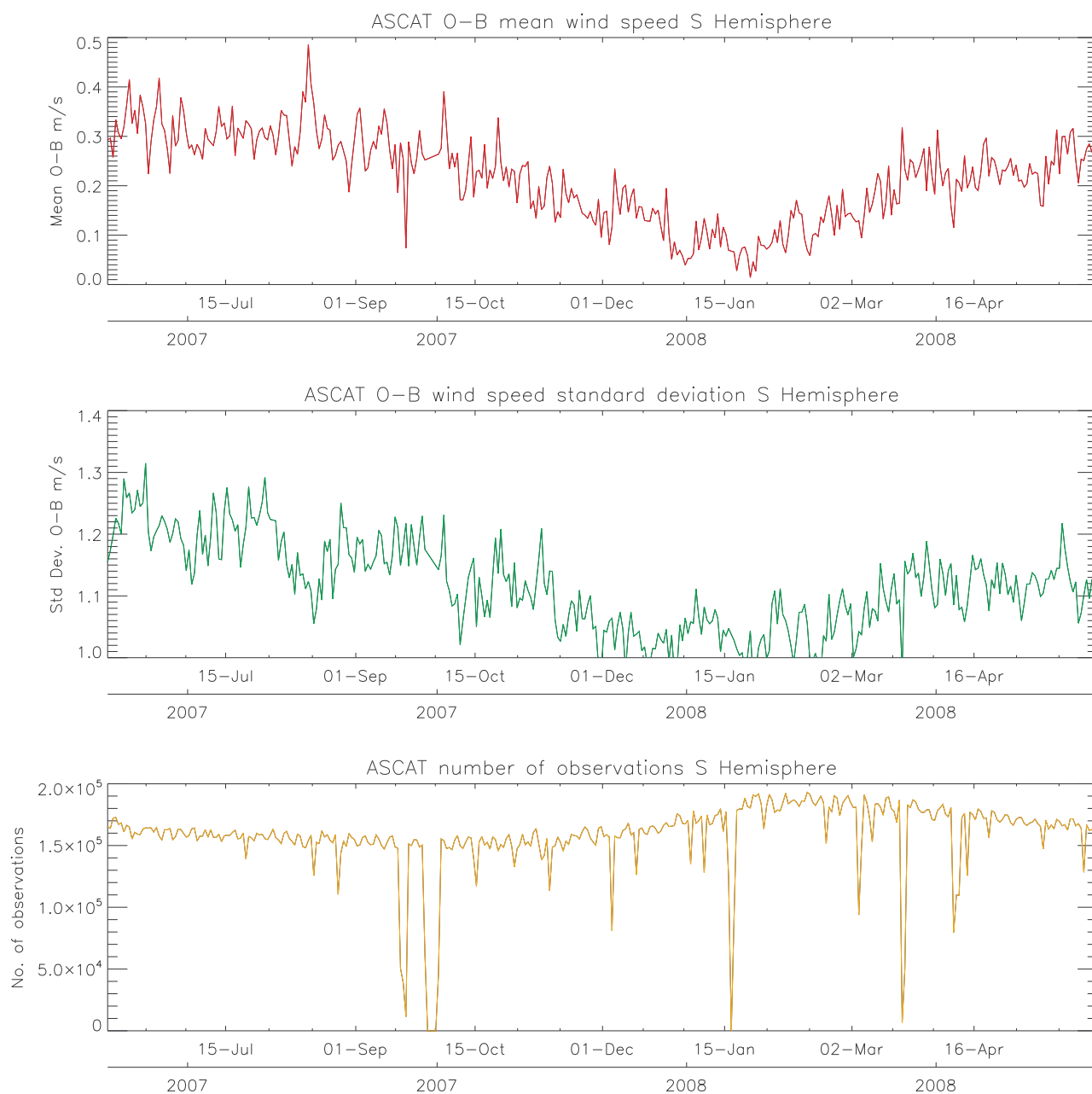


Figure 3a. ASCAT wind speed statistics for southern hemisphere. The bias and standard deviation in the O-B wind speed are clearly larger during the southern hemisphere winter than summer.

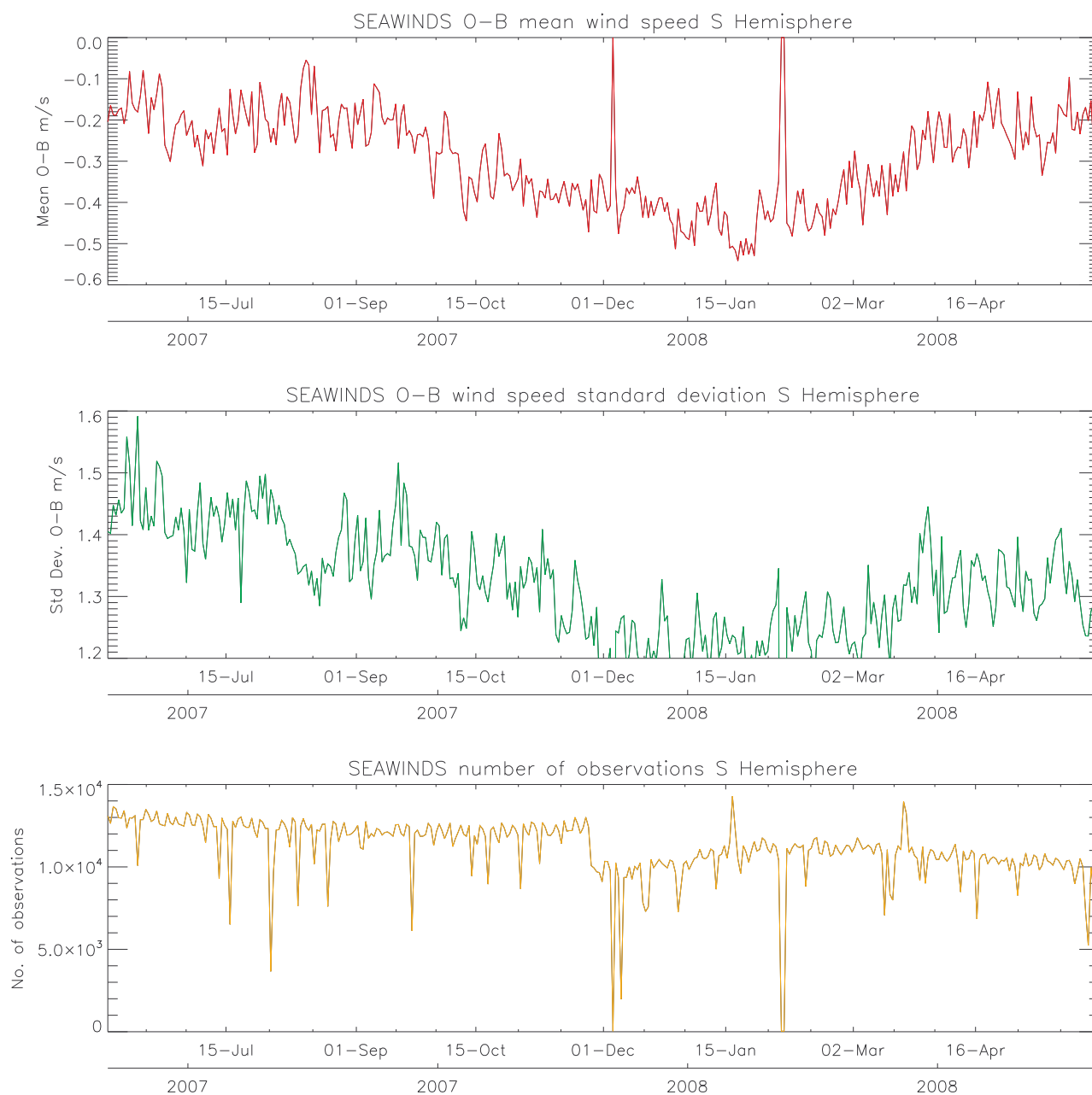


Figure 3b. SEAWINDS wind speed statistics for southern hemisphere. The mean and standard deviation in the O-B wind speed follow a similar trend to those for ASCAT in the southern hemisphere throughout the year.

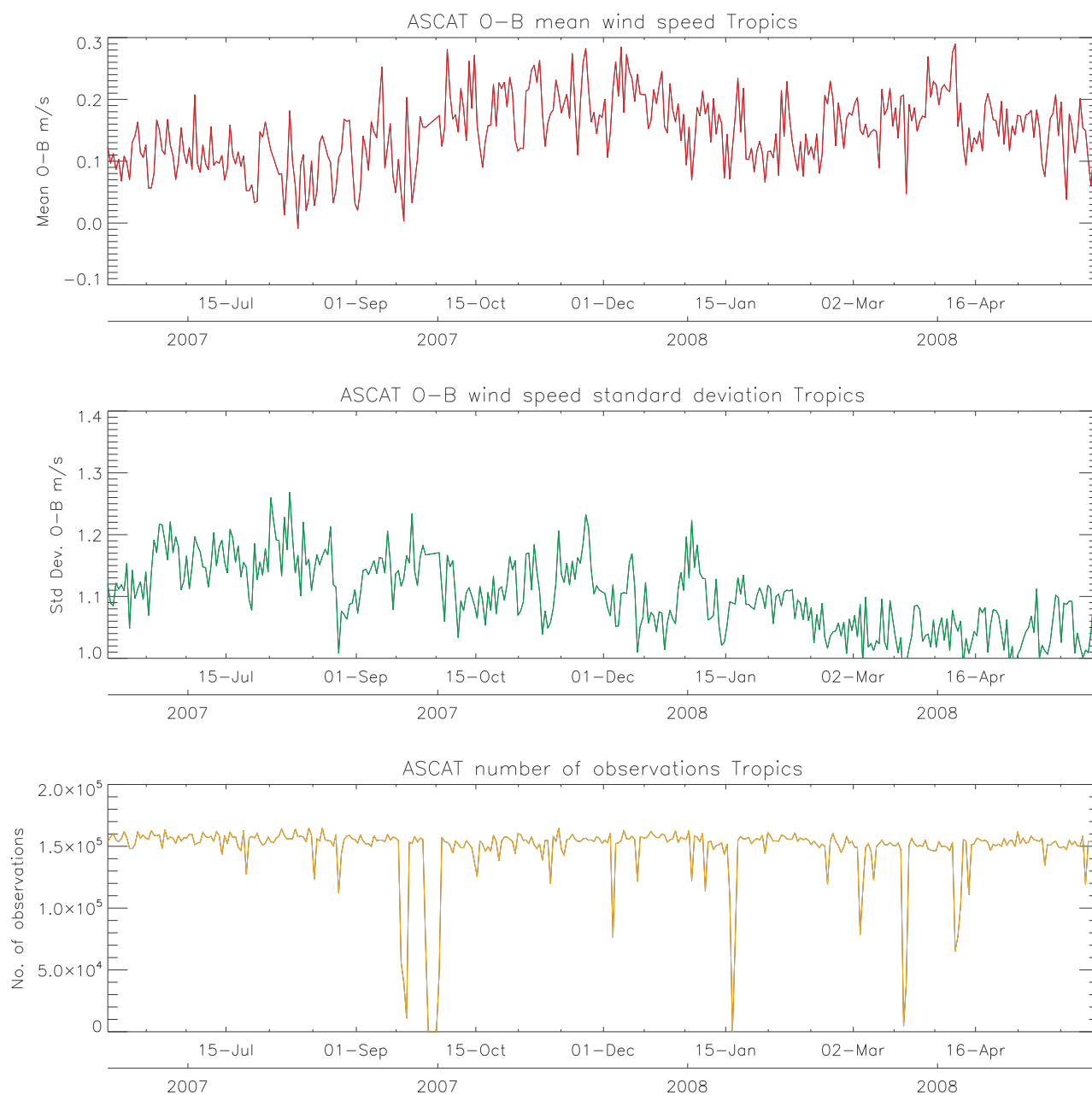


Figure 4a. ASCAT wind speed statistics for the tropics. The standard deviation in O-B wind speed falls throughout the year. It is tempting to see a step change reduction in standard deviation just before 1 December after ASCAT and IASI went operational in the Met Office global forecast system.

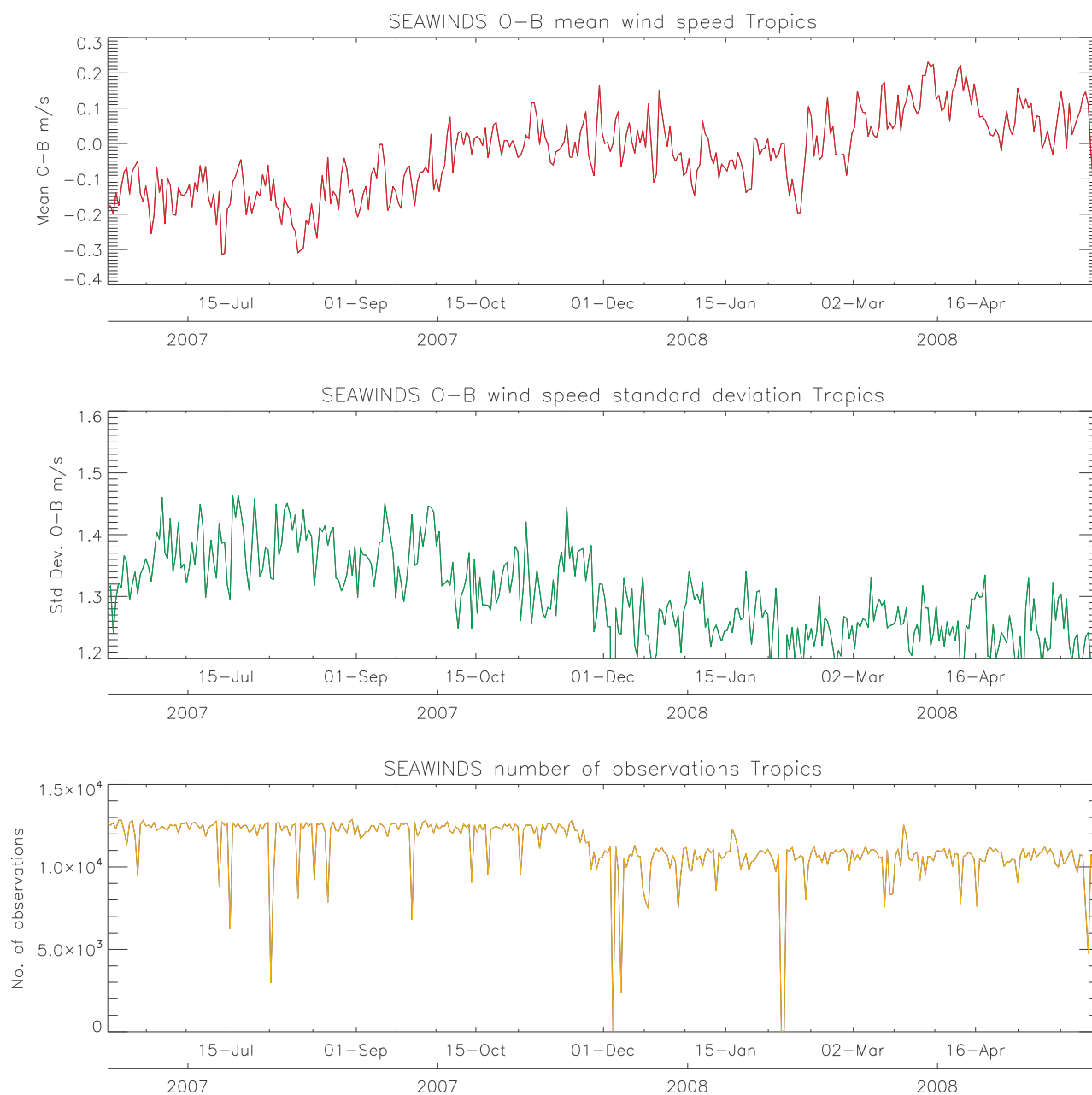


Figure 4b. SEAWINDS wind speed statistics for the tropics. The standard deviation in the O-B wind speed undergoes a step change reduction just before 1 December when ASCAT and IASI became operationally assimilated in the Met Office global forecast system.

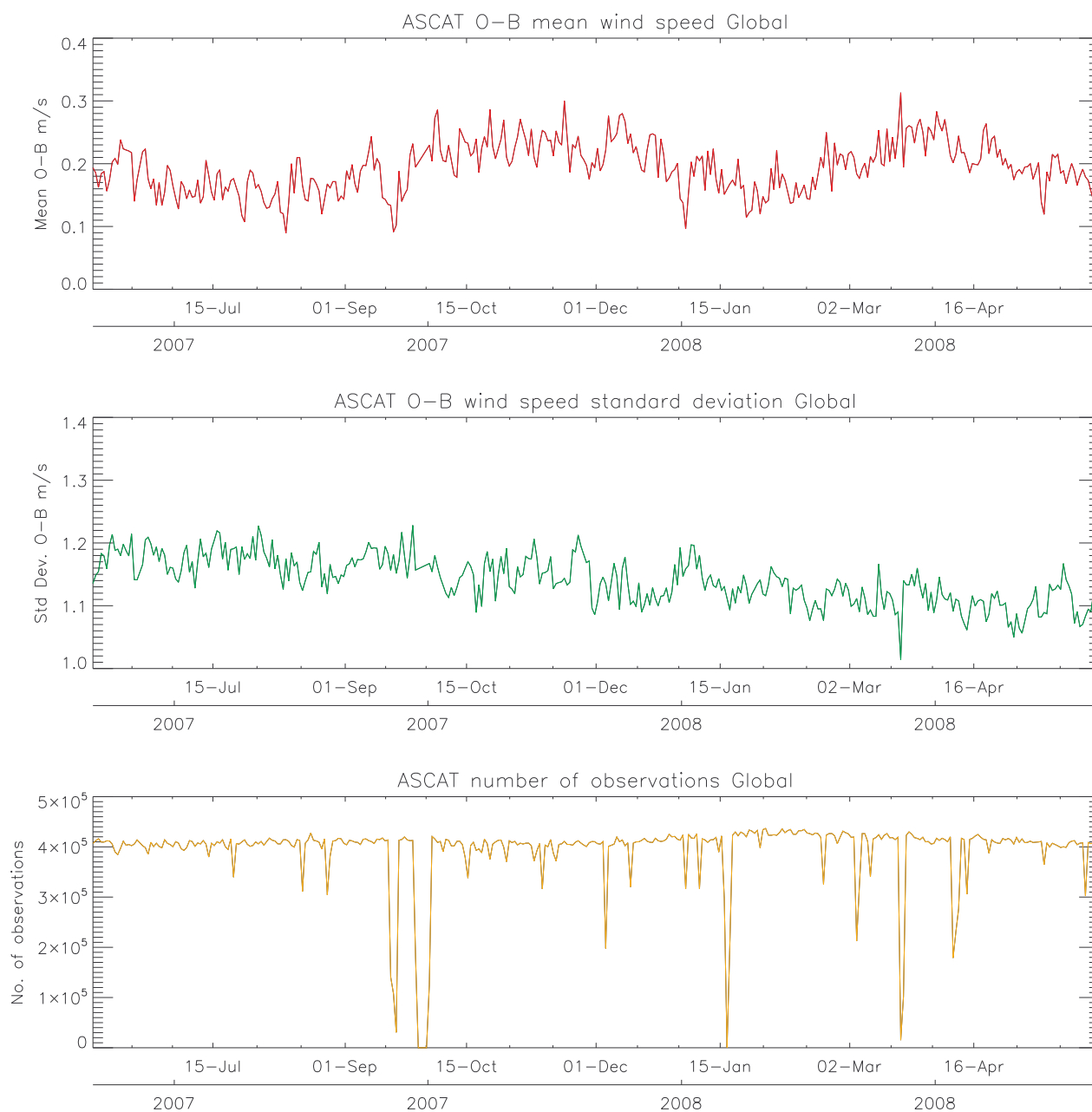


Figure 5a. ASCAT wind speed statistics for all latitudes. The standard deviation in O-B wind speed falls steadily throughout the year.

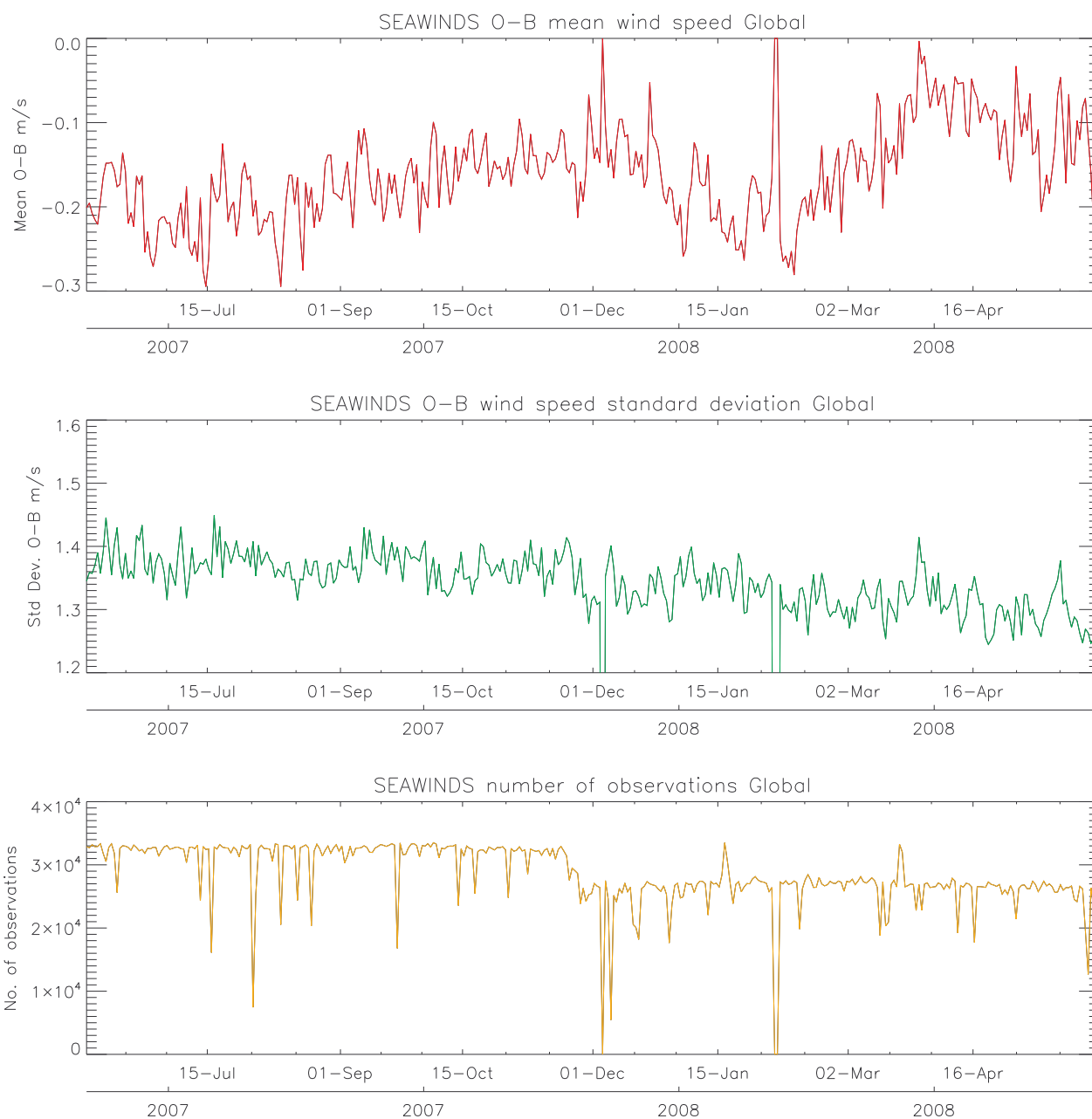


Figure 5b. SEAWINDS wind speed statistics for all latitudes. The standard deviation in O-B wind speed falls steadily throughout the year by a similar amount to ASCAT.

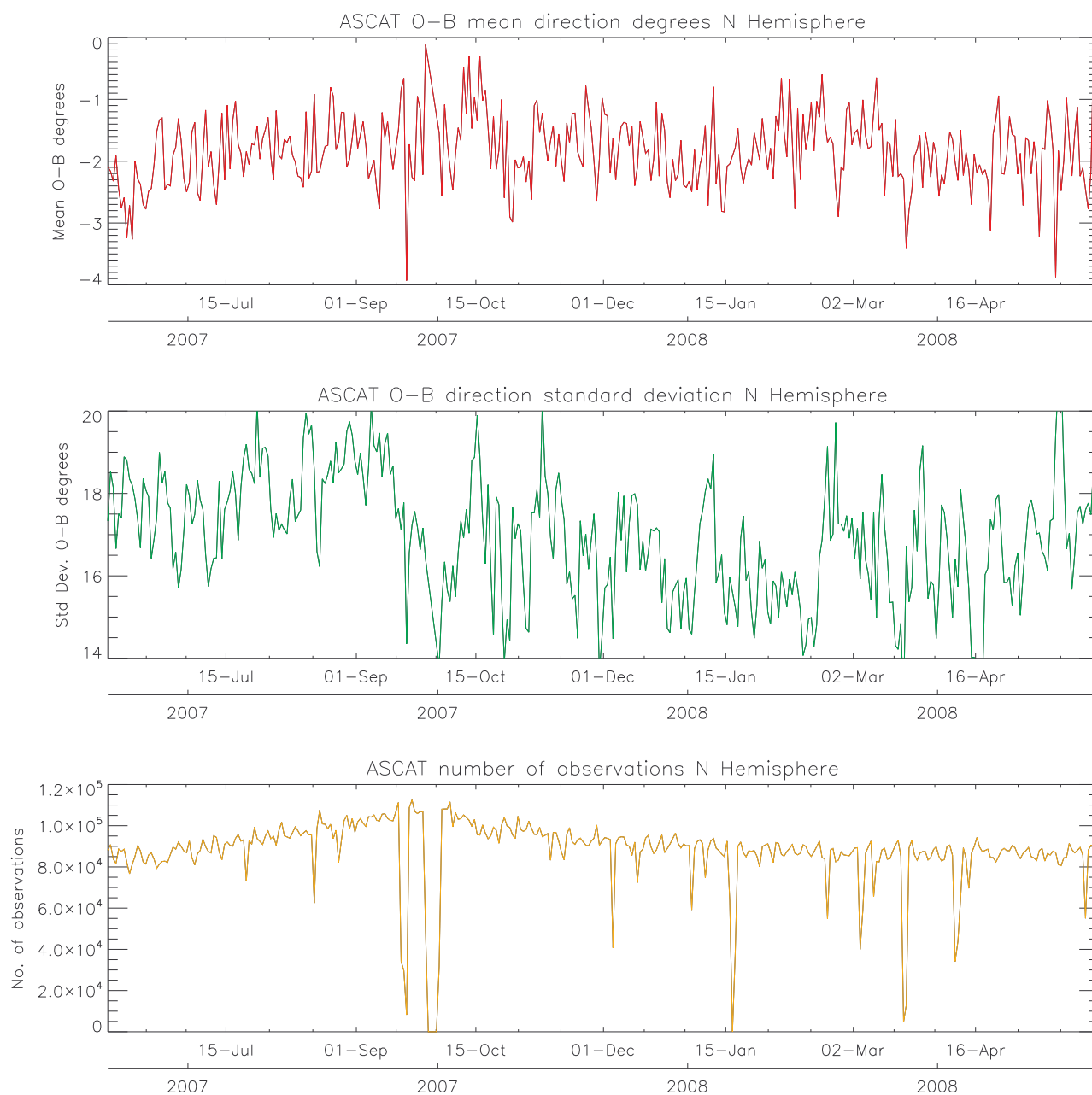


Figure 6a. ASCAT wind direction statistics for northern hemisphere

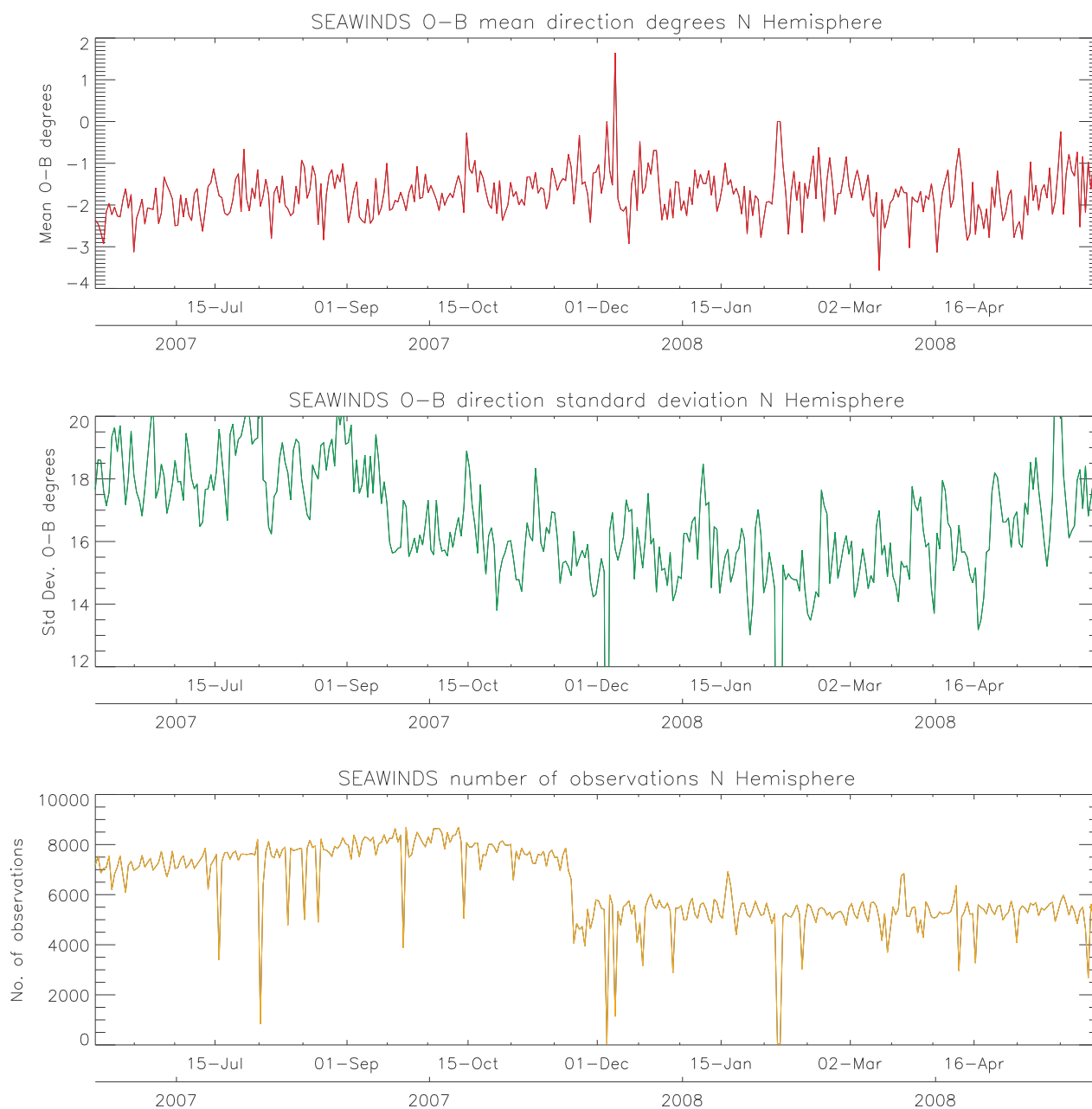


Figure 6b. SEAWINDS wind direction statistics for northern hemisphere

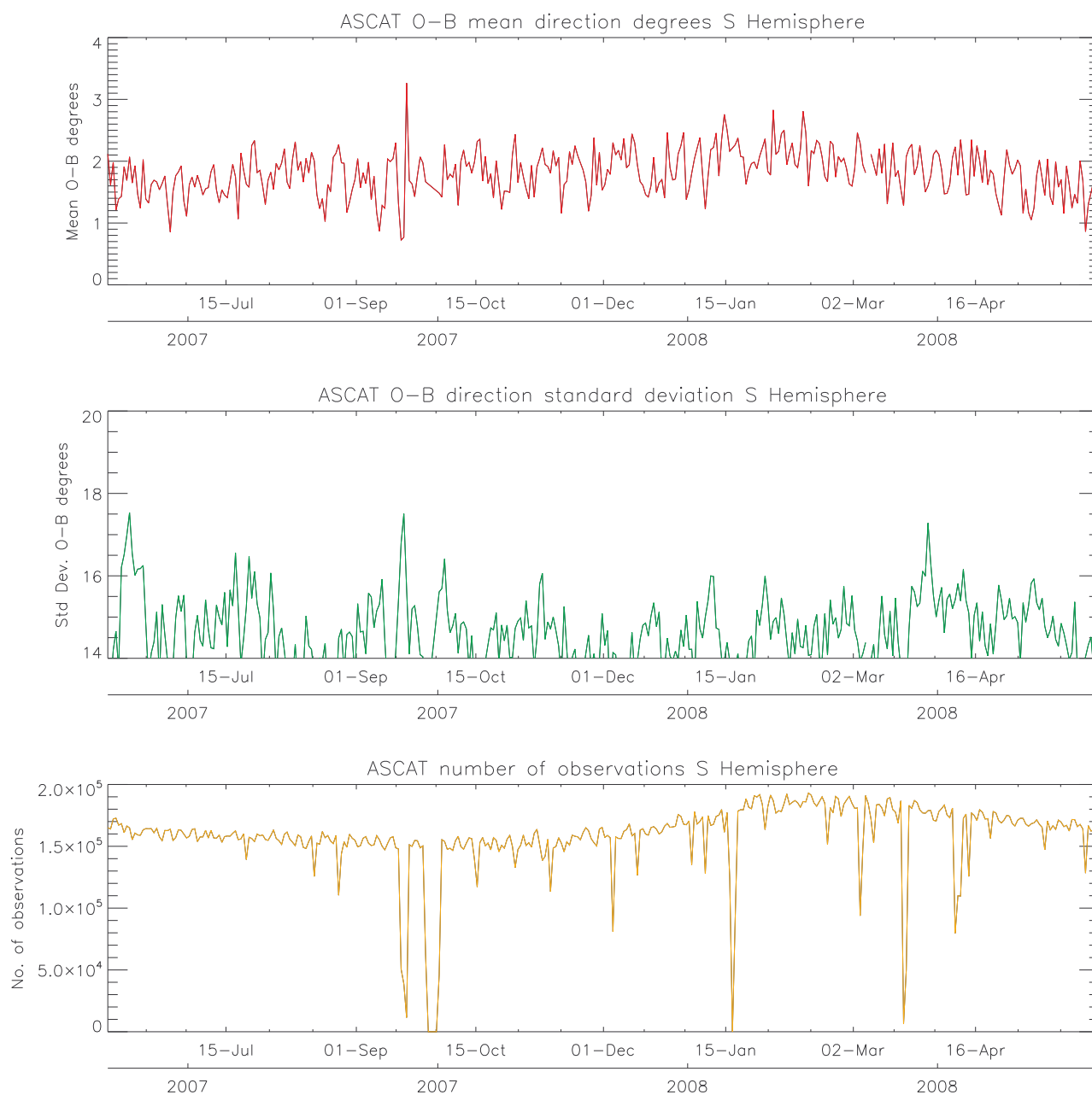


Figure 7a. ASCAT wind direction statistics for southern hemisphere

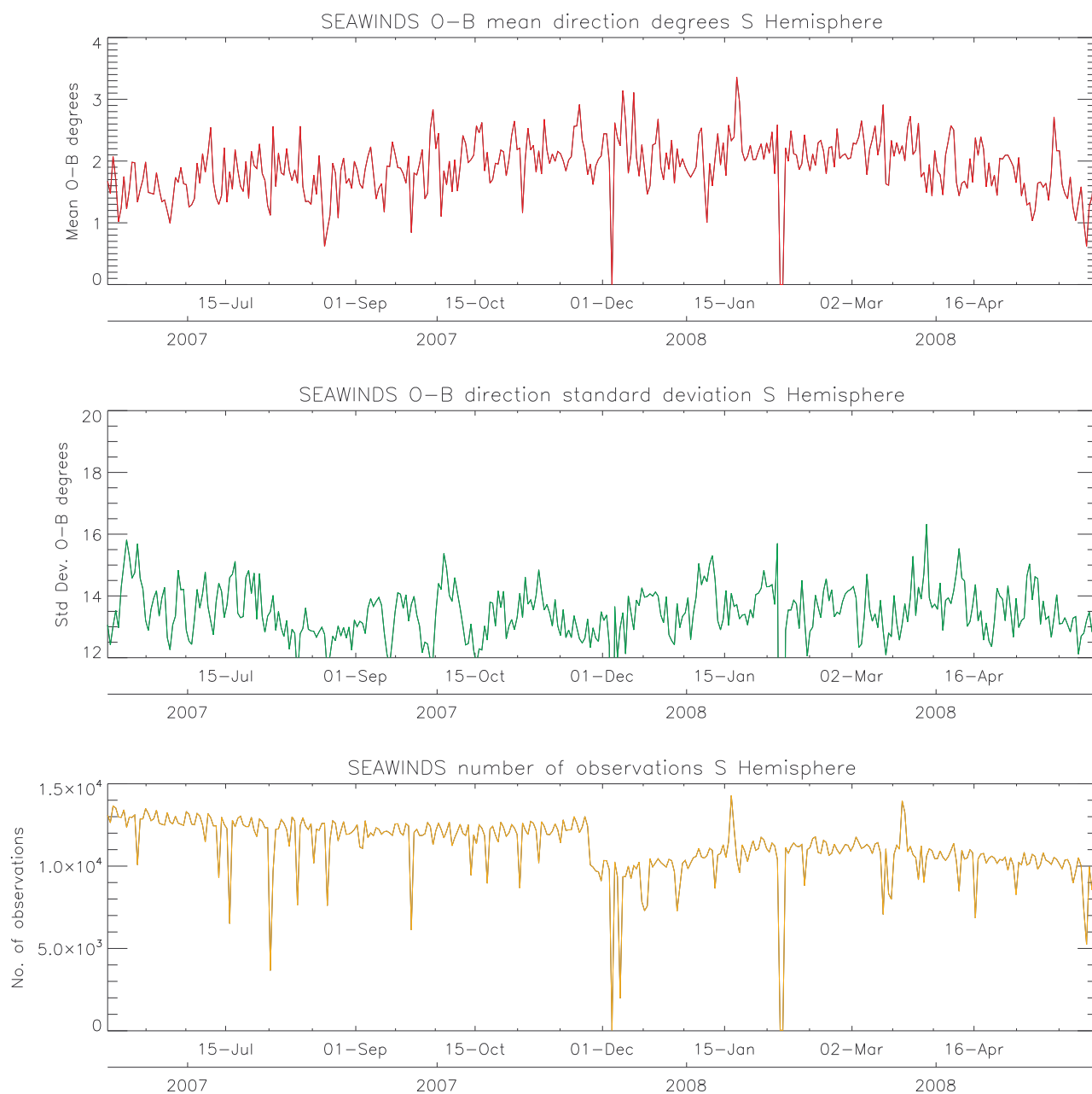


Figure 7b. SEAWINDS wind direction statistics for southern hemisphere

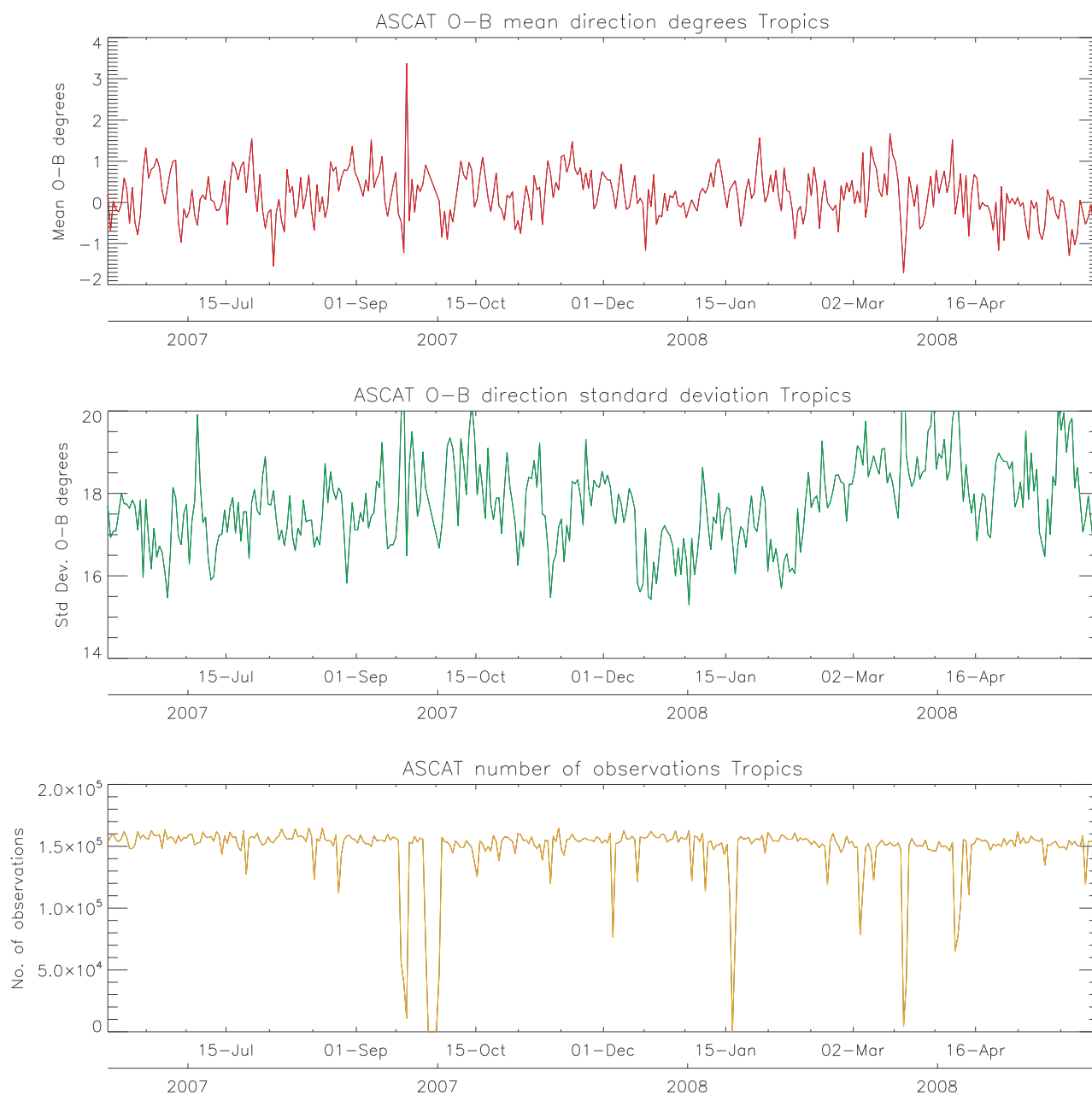


Figure 8a. ASCAT wind direction statistics for the tropics

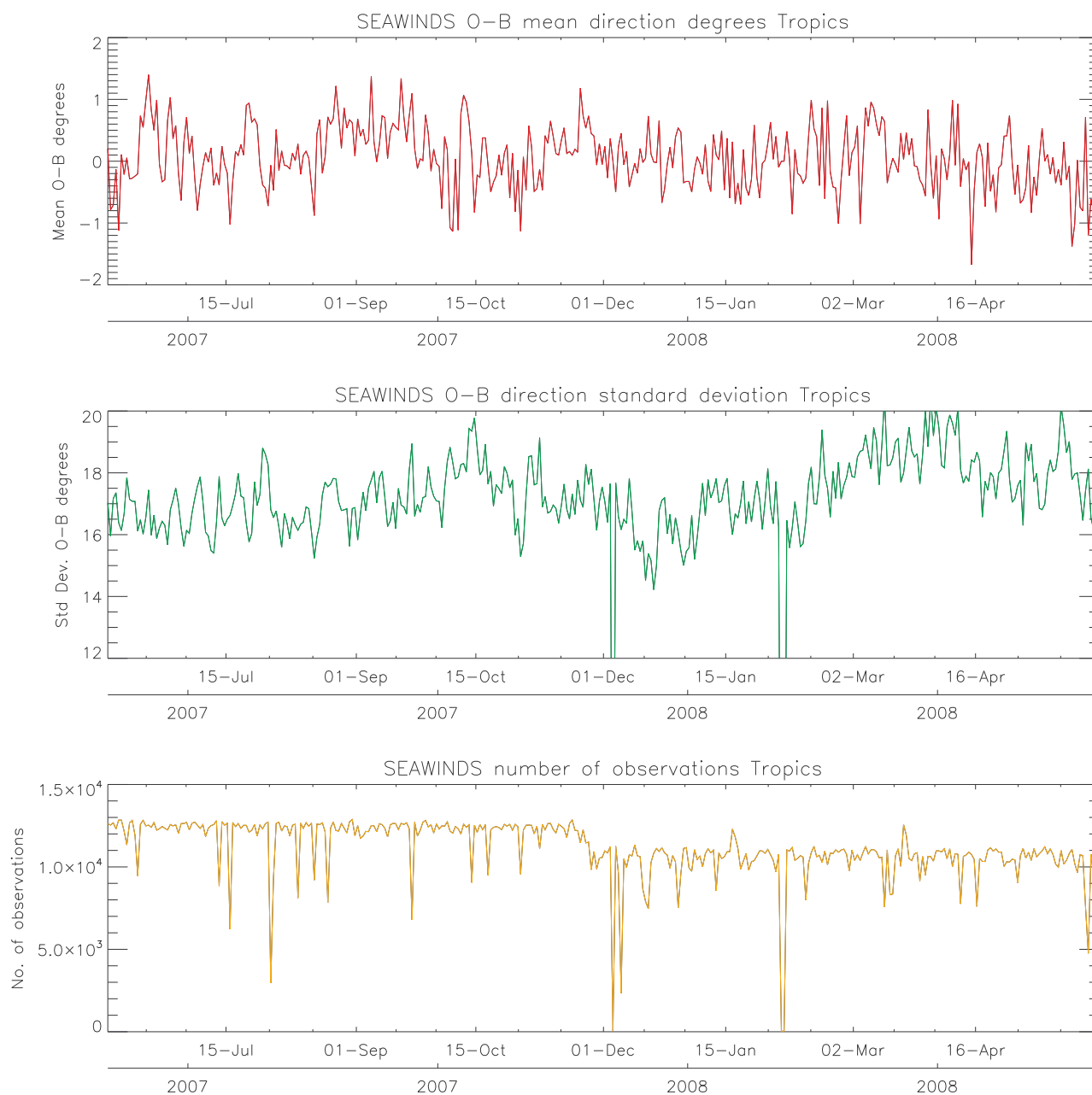


Figure 8b. SEAWINDS wind direction statistics for the tropics

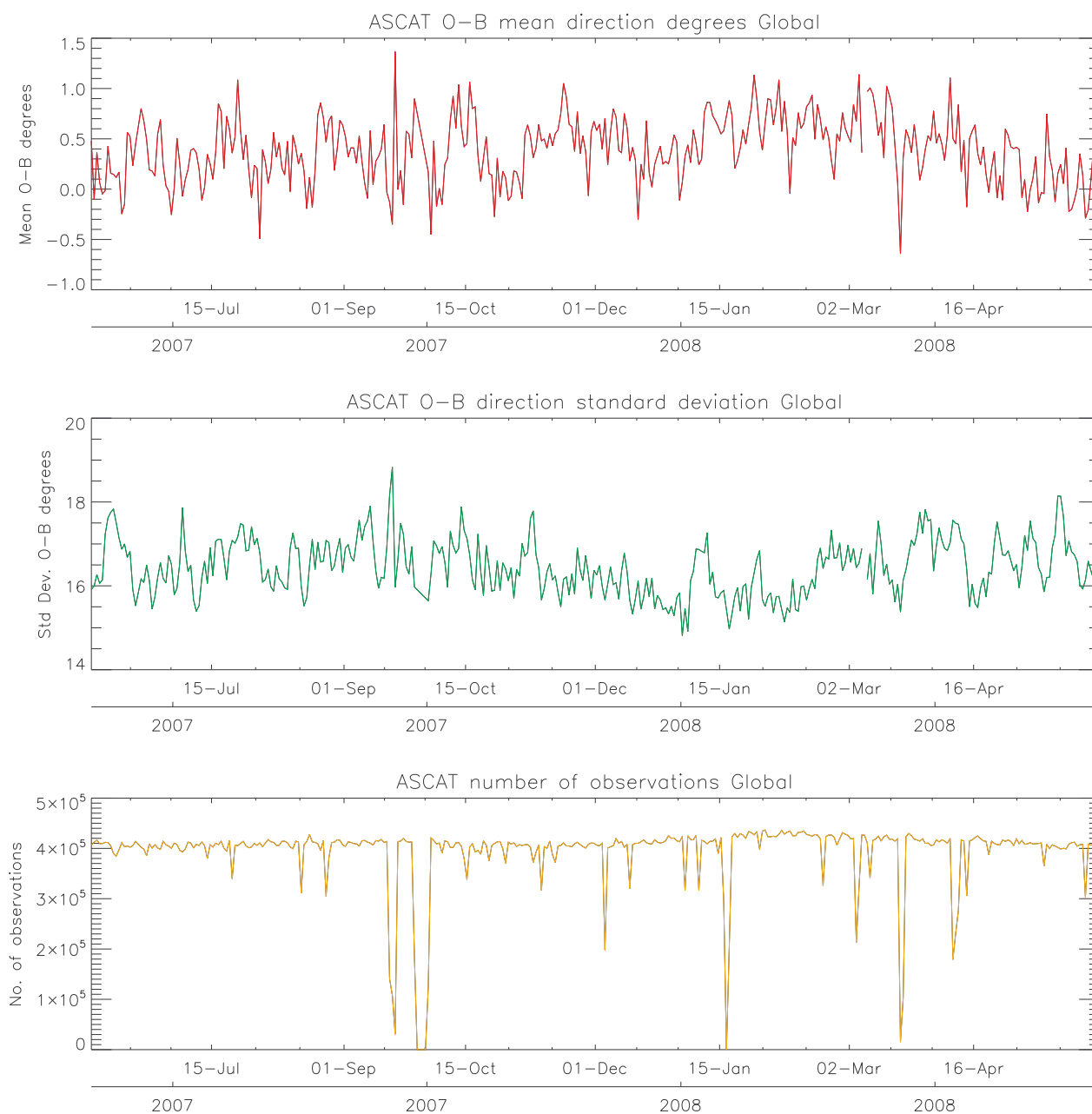


Figure 9a. ASCAT wind direction statistics for all latitudes

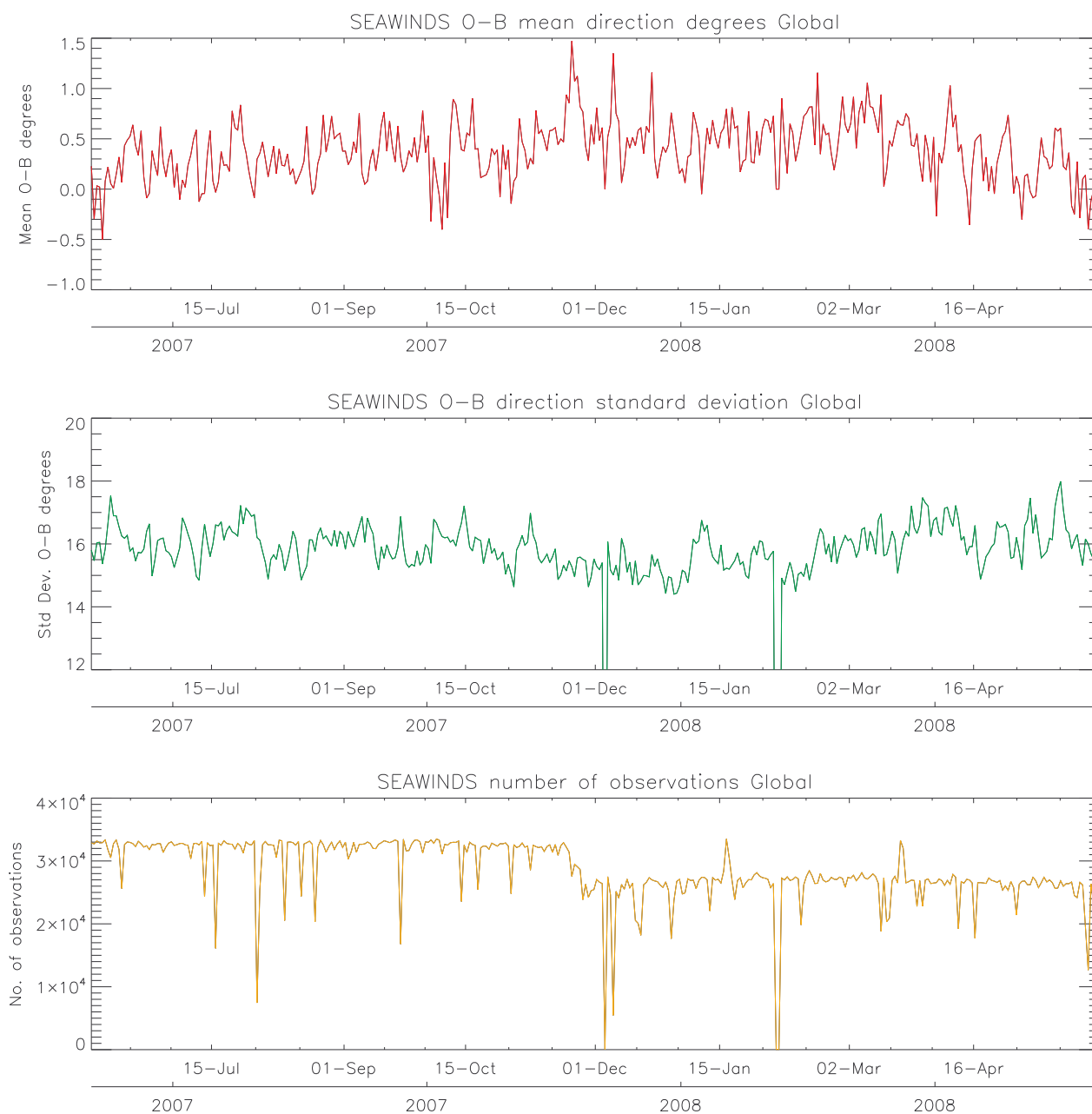


Figure 9b. SEAWINDS wind direction statistics for all latitudes

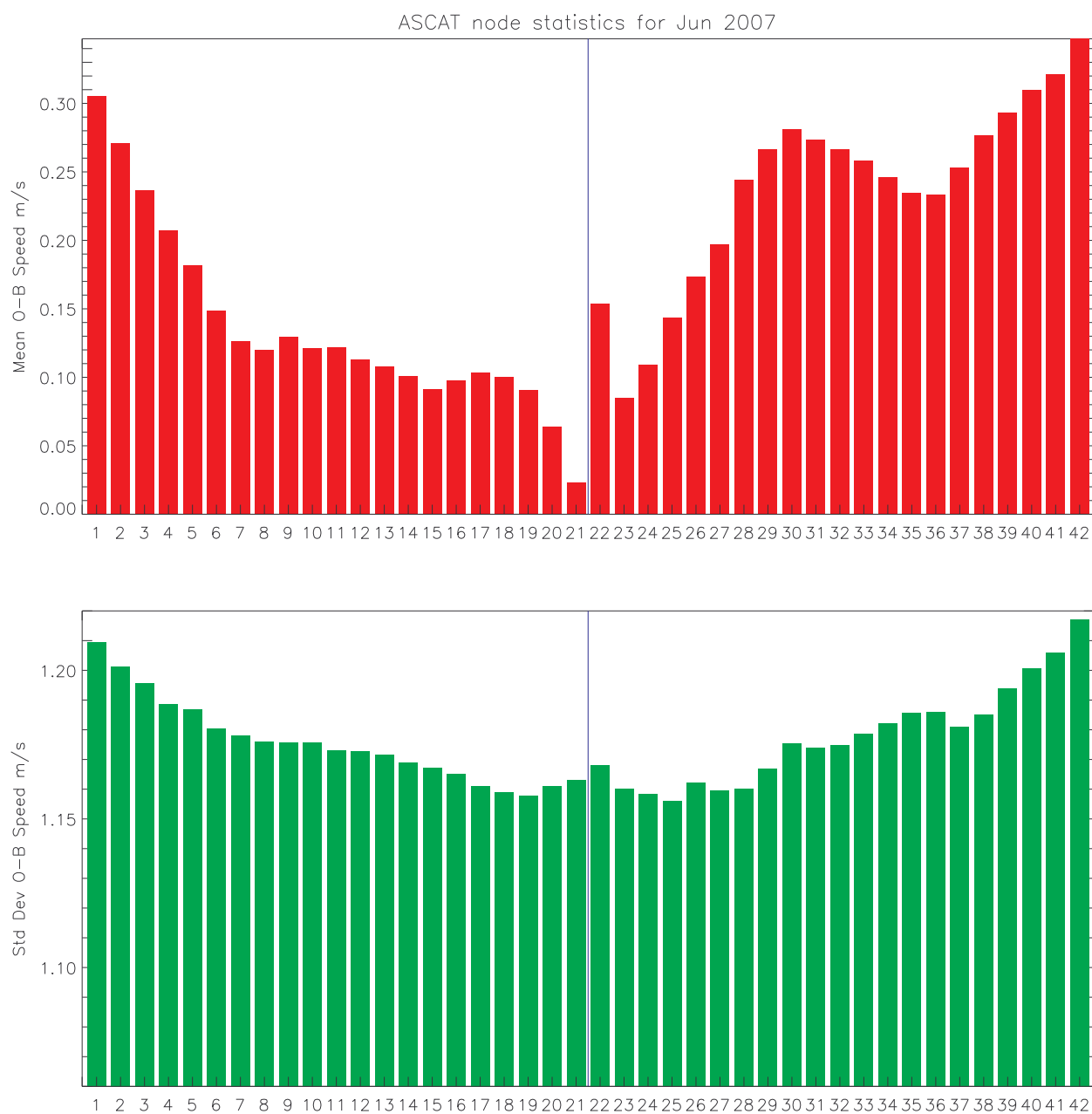


Figure 10a. ASCAT O-B speed statistics for June 2007.

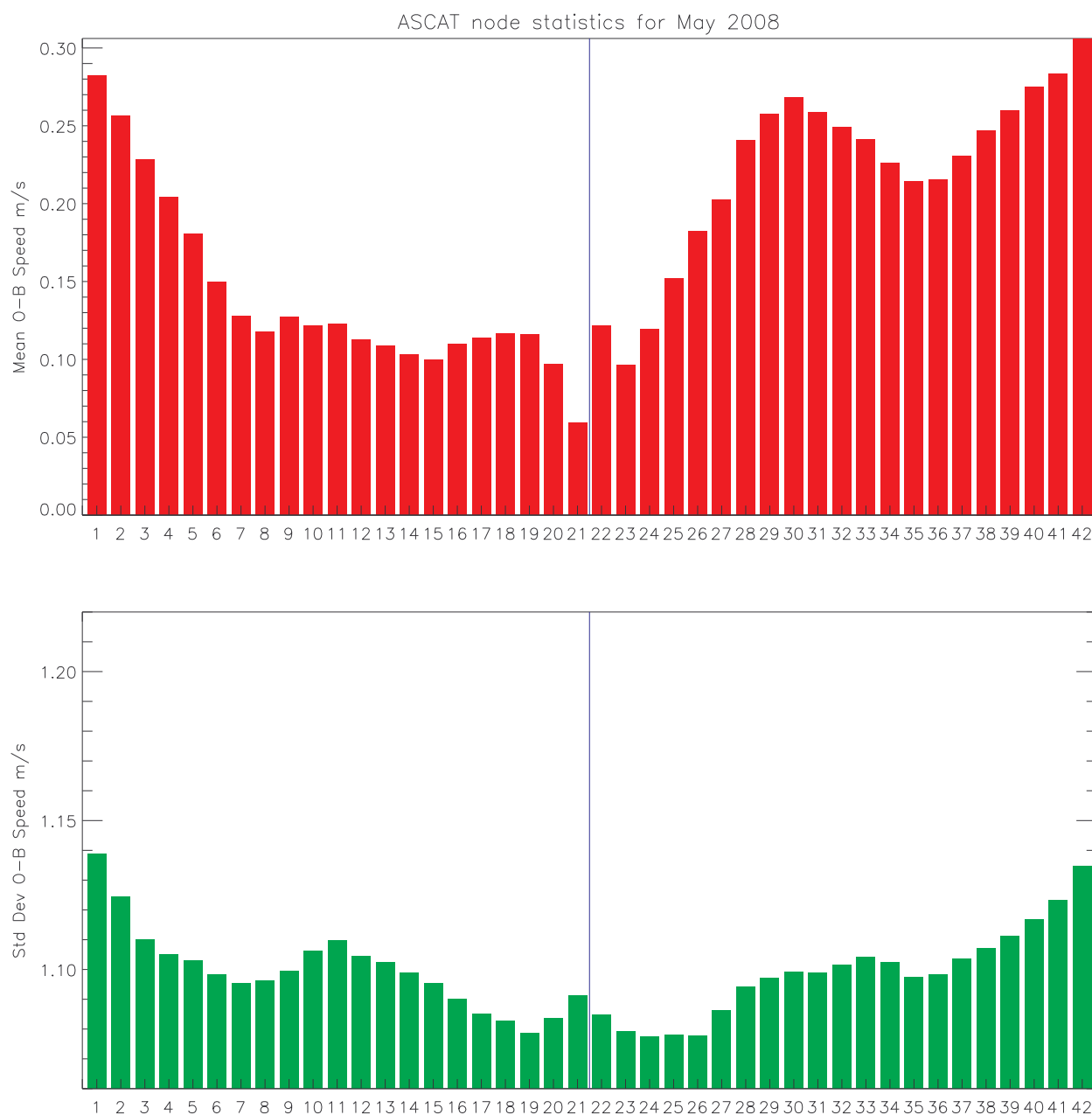


Figure 10b. ASCAT O-B speed statistics for May 2008. The cross-track shape of the O-B wind speed is very similar in May 2008 to that for June 2007. The standard deviation in O-B wind speed is reduced across the swath for from June 2007, which is consistent with the time series information in figure 5a.

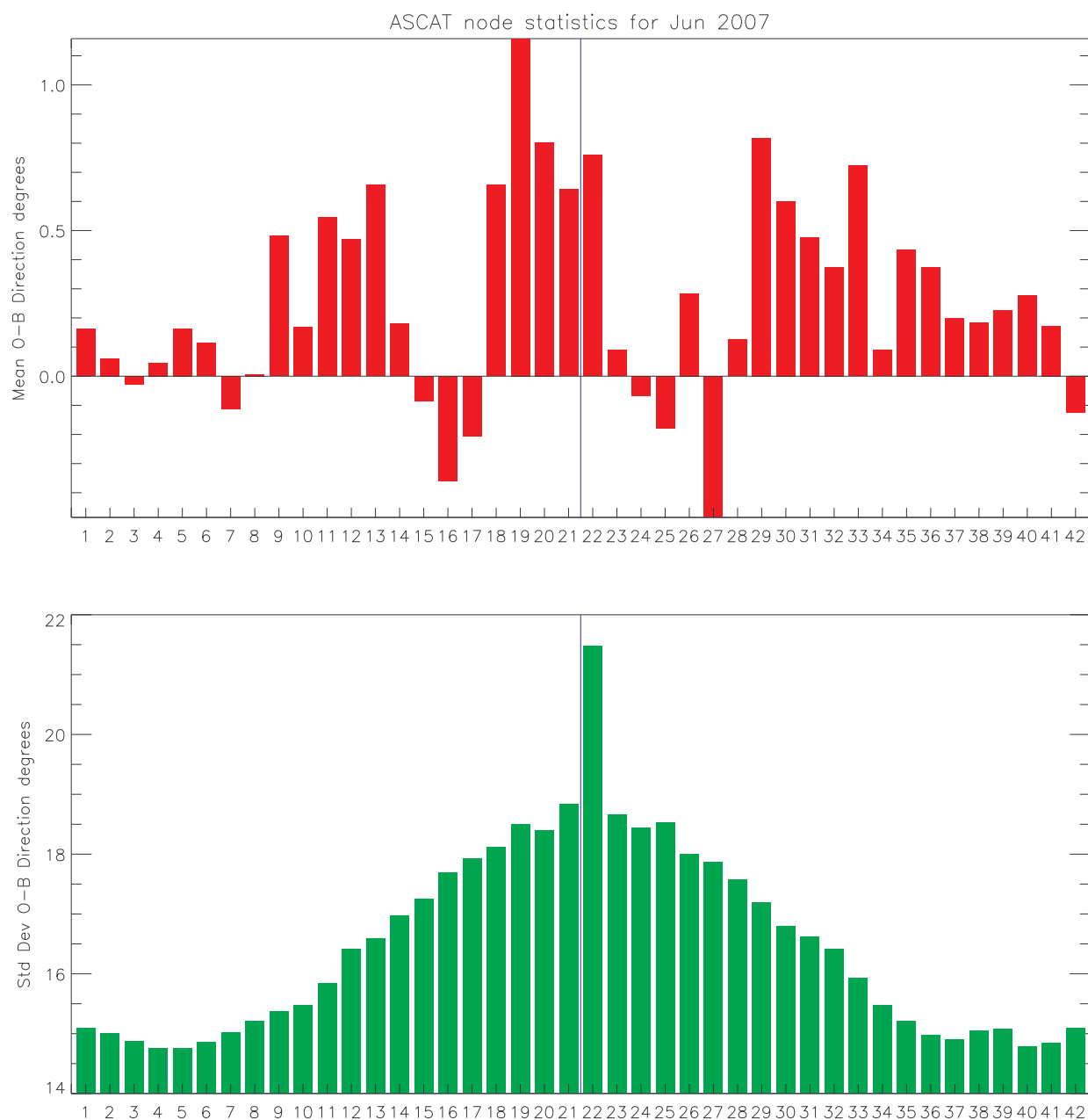


Figure 10c. ASCAT O-B direction statistics for June 2007. The standard deviation in O-B wind direction for node 22 is anomalously high compared to the values for neighbouring nodes.

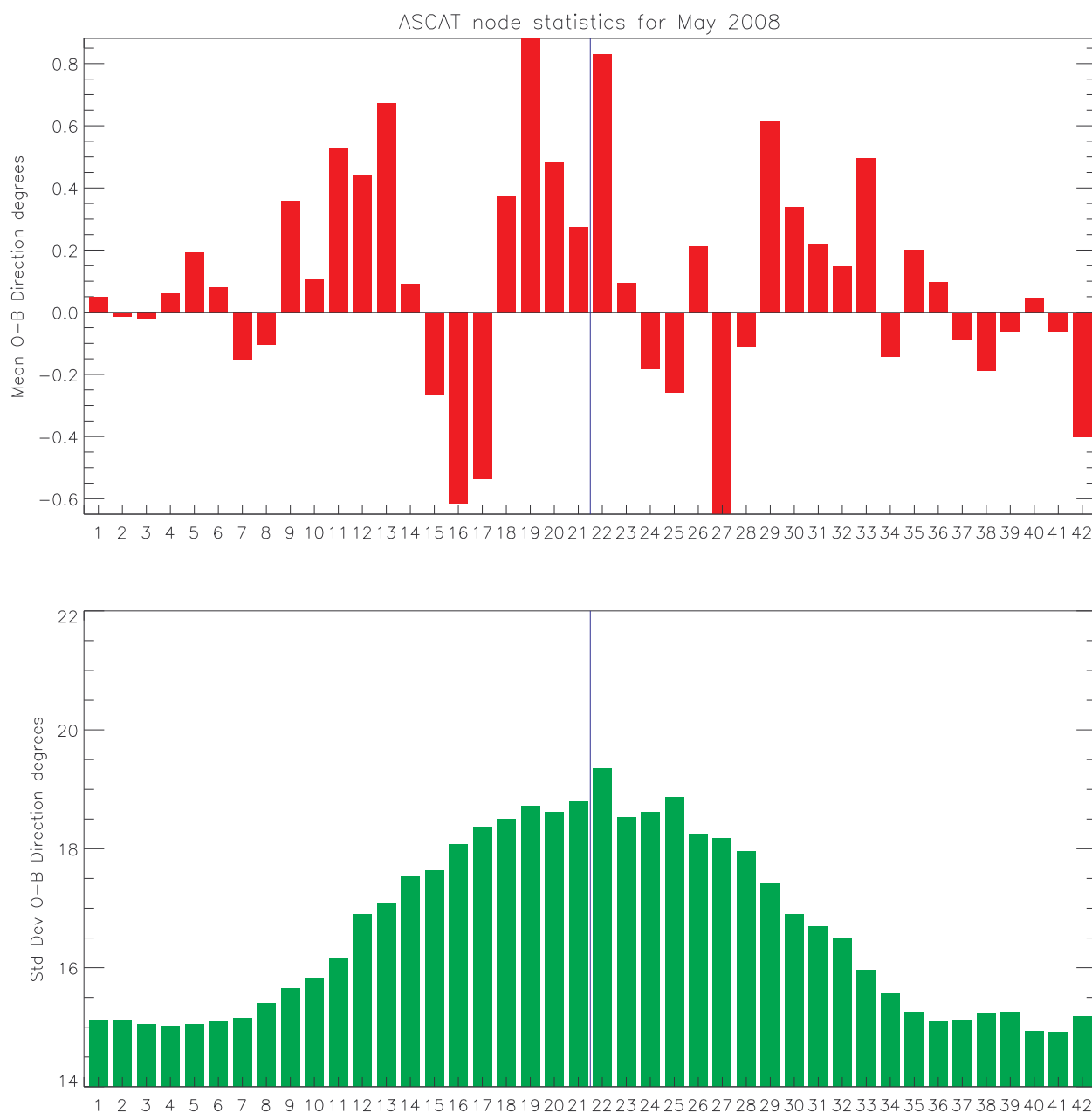
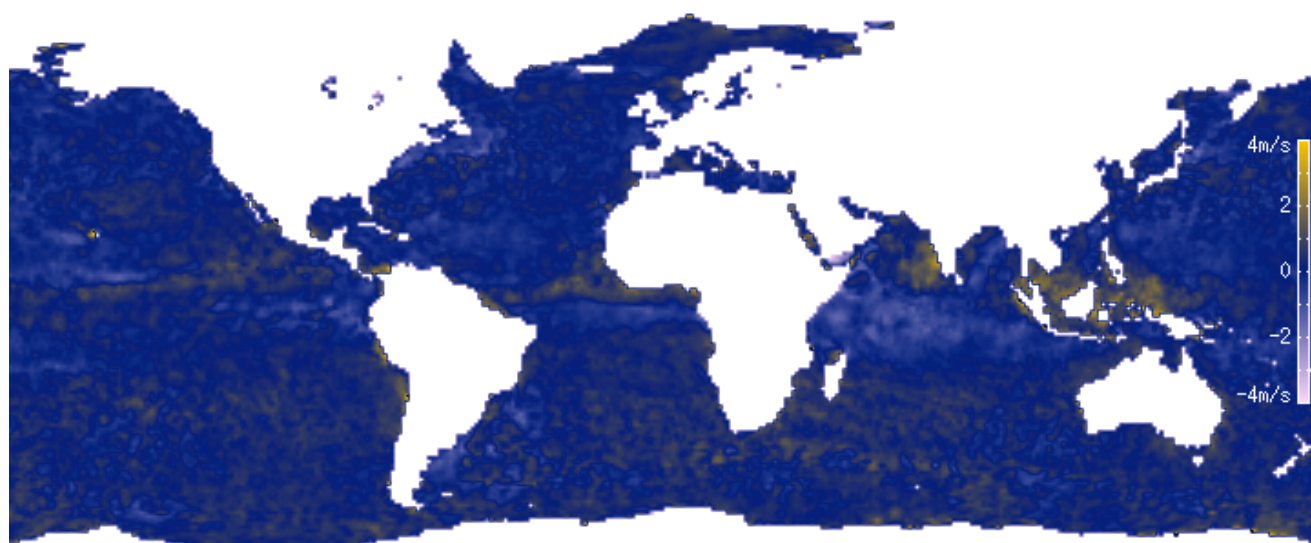
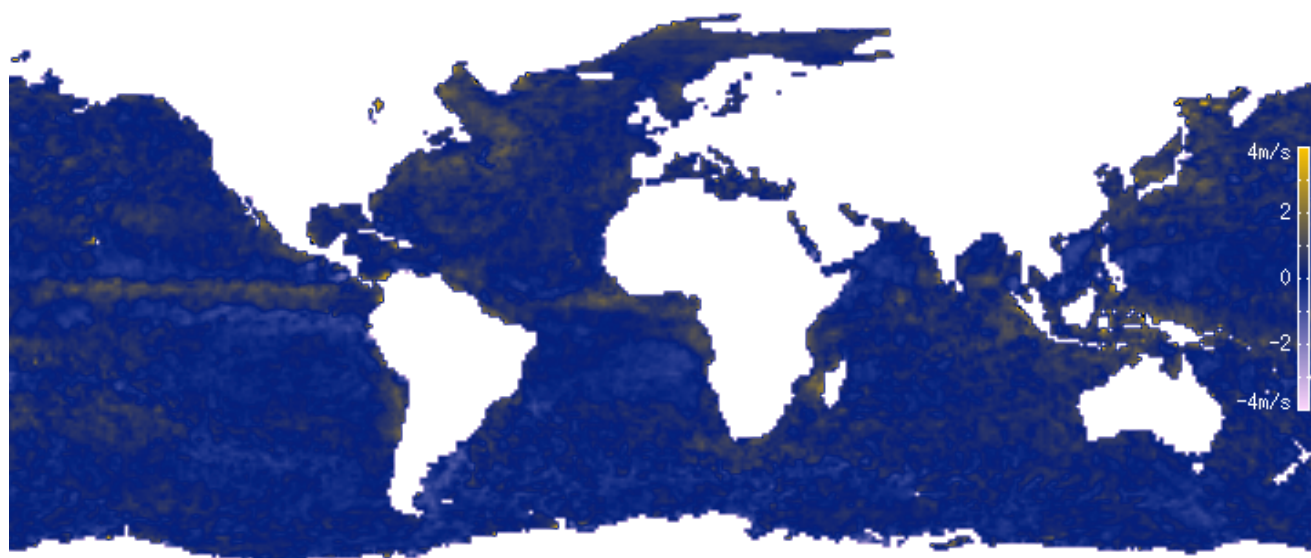


Figure 10d. ASCAT O-B direction statistics for May 2008. The standard deviation in O-B wind direction for node 22 is now much more consistent with the values for neighbouring nodes due to processing enhancements implemented at KNMI during October 2007.



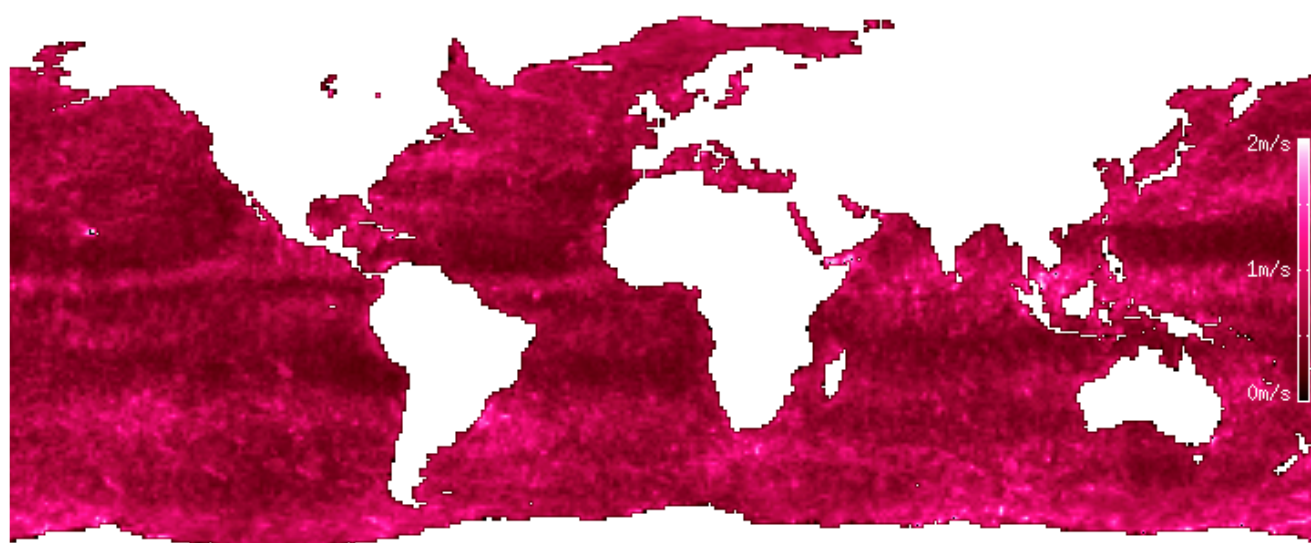
Mean ASCAT O-B Wind Speed m/s : Jun 2007

Figure 11a. Mean O-B wind speed for June 2007. Model winds look to be too low off the western coast of South America, west coast of India and in the Indonesian region.



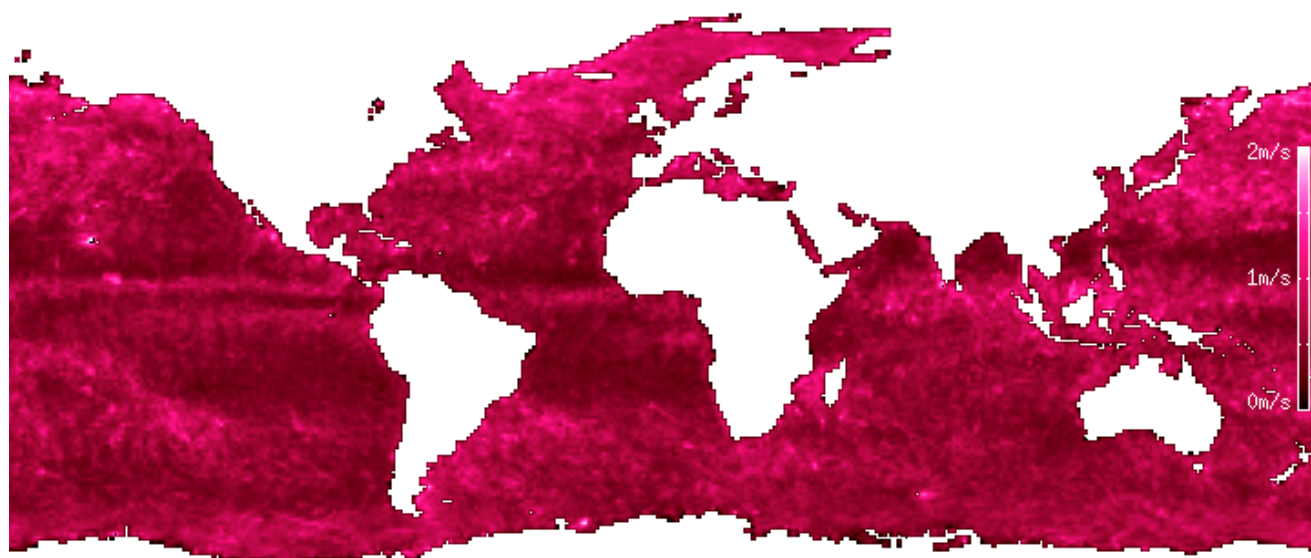
Mean ASCAT O-B Wind Speed m/s : Dec 2007

Figure 11b. Mean O-B wind speed for December 2007.



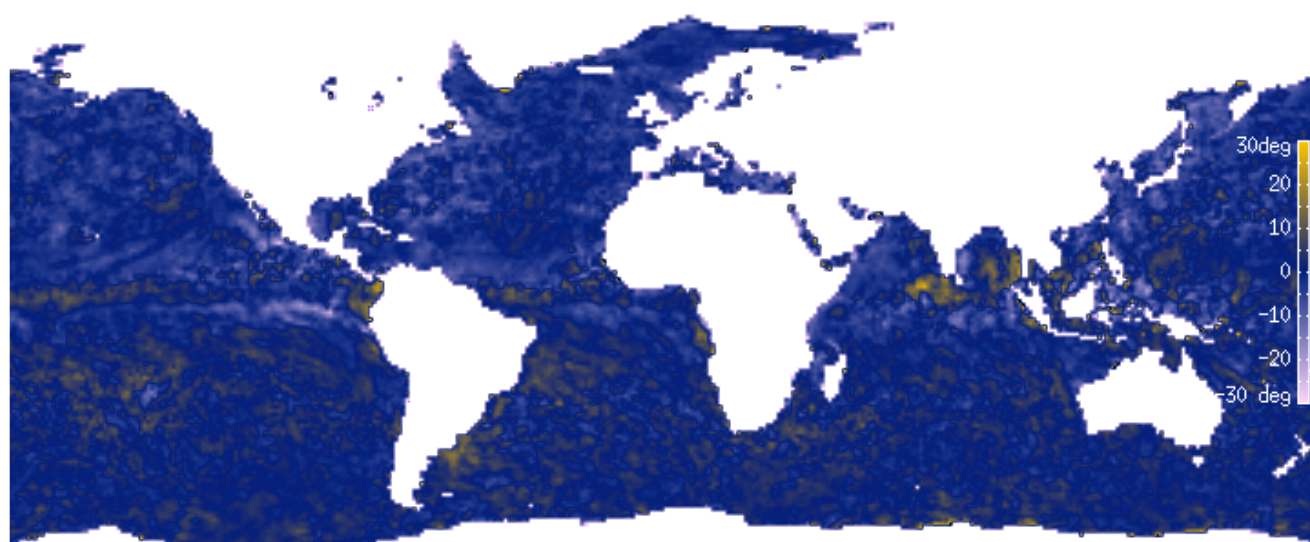
Std Dev ASCAT O-B Wind Speed m/s : Jun 2007

Figure 11c. Standard deviation O-B wind speed for June 2007. High variability can be observed in O-B wind speed in the Gulf of Aden and in the Indonesian region.



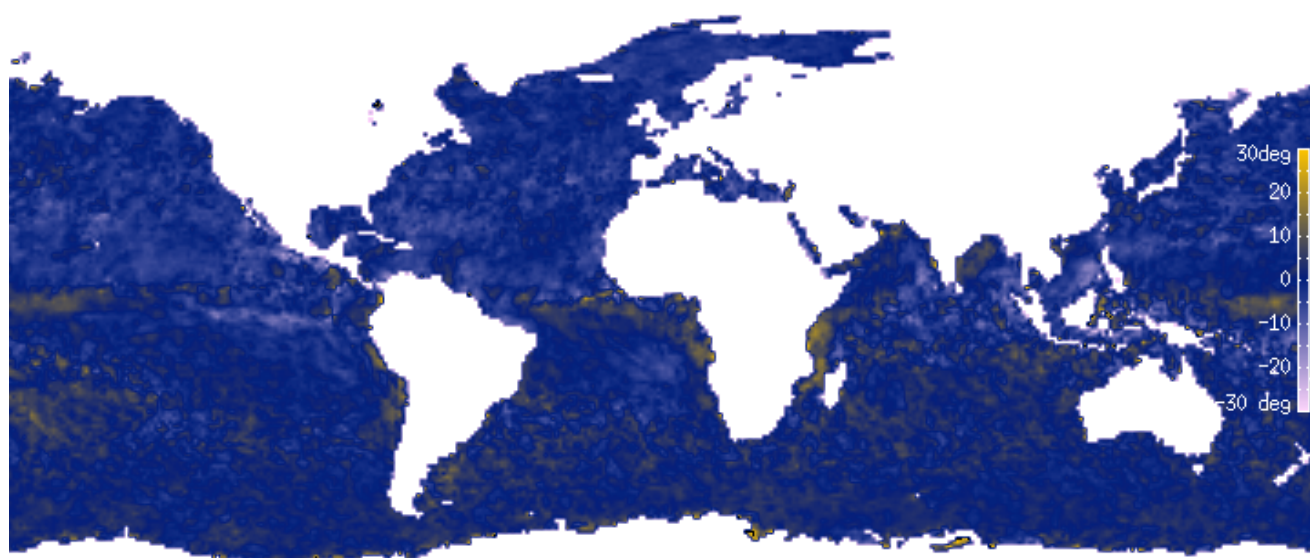
Std Dev ASCAT O-B Wind Speed m/s : Dec 2007

Figure 11d. Standard deviation O-B wind speed for December 2007.



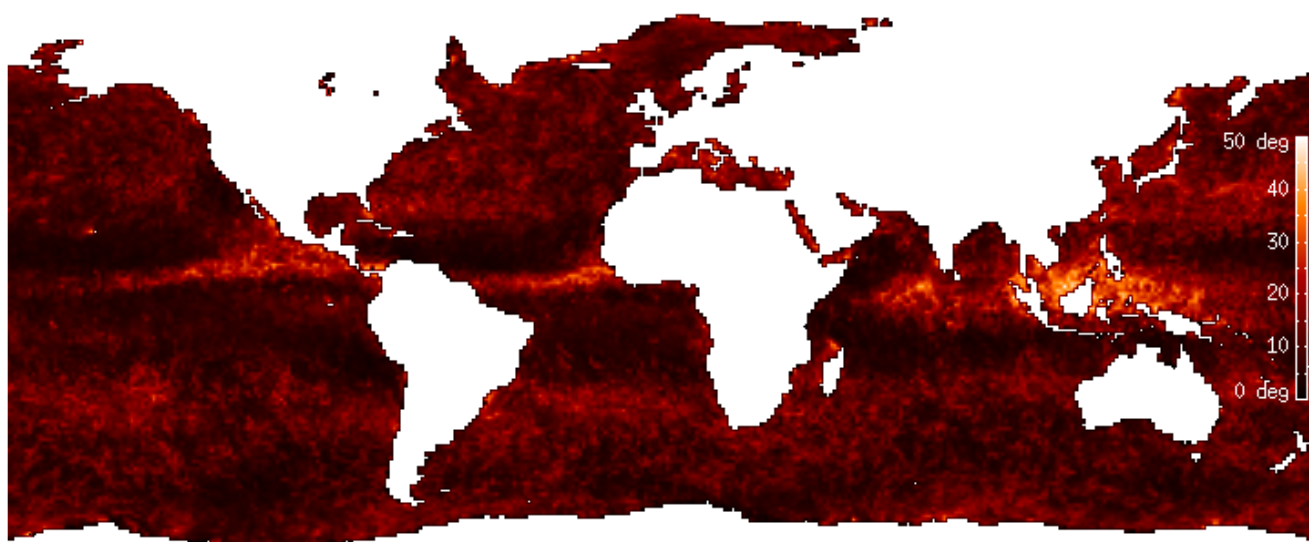
Mean ASCAT O-B Wind Direction degrees ; Jun 2007

Figure 12a. Mean O-B wind direction for June 2007. Larger wind direction biases are observed off the coast of south west India and off the north west coast of South America.



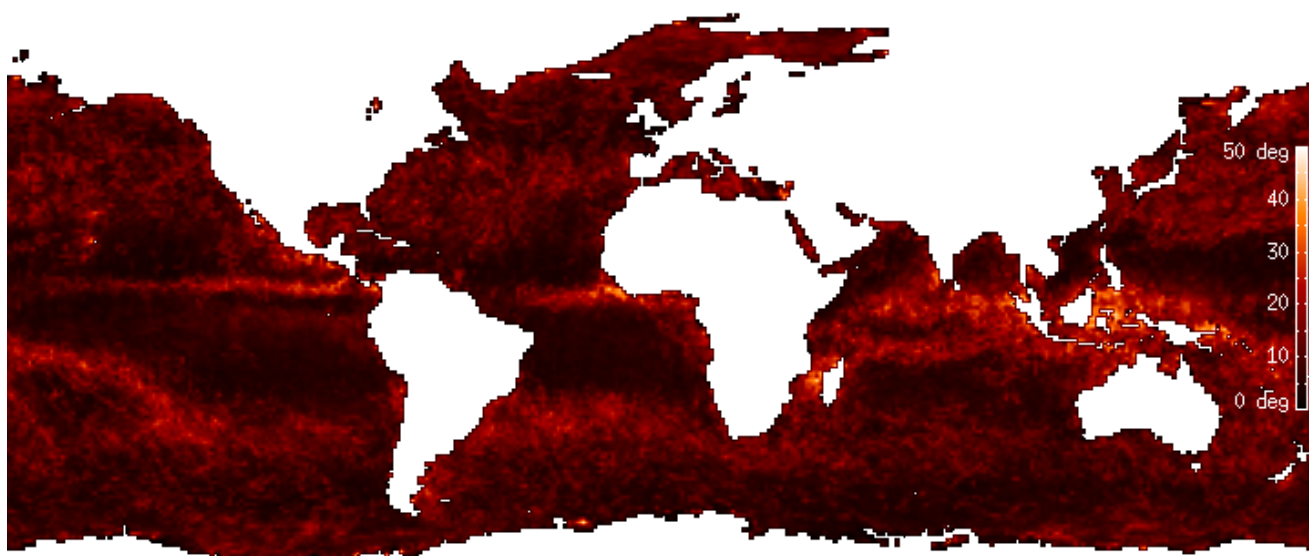
Mean ASCAT O-B Wind Direction degrees ; Dec 2007

Figure 12b. Mean O-B wind direction for December 2007.



Std Dev ASCAT O-B Wind degrees ; Jun 2007

Figure 12c. Standard deviation O-B wind direction for June 2007. High standard deviations in O-B wind direction are visible in the Indonesian region, off the south west coast of India and across the intertropical convergence zone.



Std Dev ASCAT O-B Wind degrees ; Dec 2007

Figure 12d. Standard deviation O-B wind direction for December 2007.