

■ ECMWF Report on ENVISAT RA-2 for November 2005 ■

Report on ENVISAT Radar Altimeter - 2 (RA-2) Wind/Wave Product with Height Information (RA2_WWV_2P)

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Date: *6 January 2006*

Overview:

Based on the data received during this month, on average, 17507 observations arrived at ECMWF every 6-hour window of which an average of 7739 observations were rejected initially because of one of the following reasons: being over land, being outside model domain, being a double observation or flagged for rain contamination. On average 72.13% of the remaining part passed the quality control. As can be seen in Figure 1, there was no data gaps during the whole month. However, there was significant reduction in data volume during the following periods (in terms of 6-hour time-windows; all times are in UTC):

- time window centred at 06:00 on the 1st., the 2nd., the 3rd., the 7th., the 11th., the 12th. and the 13th. of the month,
- time window centred at 18:00 on the 8th. of the month,
- time windows centred at 00:00 and 06:00 on the 14th. of the month,
- time windows centred at 06:00 on the 18th. of the month.



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Note that we are talking about the raw data which we downloaded in “bufr” format before they were processed. Most of data loss was due to delays in the availability of data files on ESA ftp servers.

Quality of Received Data:

For the period covered, the RA-2 Ku-band wave height data are generally of good quality. The S-band wave height observations show a small number of outliers. The quality of wind speed observations is good. Apart from a number of outliers (which seem to be due ice contamination and should be rejected), the MWR products are generally fine and in good agreement with the model (wet tropo correction is somewhat smaller than the model).

The rain flag was quite active this month especially during the last 11 days of the month.

Backscatter:

- ENVISAT Ku-band $\langle \sigma_0 \rangle = 11.08$ dB (with a main peak at 11.1 dB and a secondary peak at 10.6 dB).
- ENVISAT S-band $\langle \sigma_0 \rangle = 11.34$ dB (with a main peak at 10.6 dB and a secondary peak at 10.8 dB).



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Comparison Summary:

Table 1: Comparison of Surface Wind Speeds:

	RA2 - ECMWF		RA2 - Buoy	
	Bias (m/s)	SI (%)	Bias (m/s)	SI (%)
Global	+ 0.28	16.1	- 0.11	17.6
Northern Hemisphere	+ 0.47	16.5	- 0.01	17.5
Tropics	+ 0.19	16.5	- 0.64	16.3
Southern Hemisphere	+ 0.23	15.1	----	----

Table 2: Comparison of Ku-Band Significant Wave Heights:

	RA2 (Ku) - WAM		RA2 (Ku) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.11	11.5	0.10	14.6
Northern Hemisphere	0.17	12.6	0.09	14.5
Tropics	0.06	10.5	0.11	12.8
Southern Hemisphere	0.11	10.5	----	----



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Table 3: Comparison of S-Band Significant Wave Heights:

	RA2 (S) - WAM		RA2 (S) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.04	21.9	- 0.01	22.4
Northern Hemisphere	0.08	24.8	- 0.03	22.5
Tropics	0.12	33.4	0.09	17.1
Southern Hemisphere	- 0.05	12.3	----	----

Table 4: Comparison of Wet Tropo Correction and Total Column Water Vapour Values:

	MWR WTC - ECMWF WTC		MWR TCWV - ECMWF TCWV	
	Bias (m)	SI (%)	Bias (kg/m ²)	SI (%)
Global	- 0.011	17.9	- 0.41	18.0
Northern Hemisphere	- 0.010	32.8	- 0.71	27.0
Tropics	- 0.014	6.3	+ 0.19	6.3
Southern Hemisphere	- 0.010	25.4	- 0.65	31.5



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Remarks:

- The NRT RA2/MWR Level 1b and Level 2 IPF version 5.02 processing chain was operationally implemented last month on the 24 October 2005. (Ref: http://earth.esa.int/pcs/envisat/ra2/articles/RA2_MWR_IPF_5.02.html)
- There was no related ECMWF model changes this month (current operational cycle is CY29R2 since 28 June 2005).
- According to the used land sea mask (which is used for the operational WAM run at ECMWF), about one third of all processed data have been collected over land. This value is too large and is caused by not filtering the land records.
- **The rain flag is responsible for the rejection of 9% of the data this month. This value is about twice as during the previous months. There were two major events of over-active rain flagging on the 7th. and the 14th. of the month (lower panel of Figure 1). Furthermore, in addition to several minor events, the flag was rather active during the last 11 days of the month.**
- As a result of the implementation of the IPF version 5.02 processing chain, the wind speed product is now limited to a lower value of 1.18 m/s (Figures 4 and 5). This is an expected result as the algorithm was tailored to fit the model and the buoy wind speeds requiring this type of shift. Further adjustment was not found suitable below this value since there is some doubts about the capability of winds with lower speeds to generate any detectable surface water waves. Irrespective of this, the wind speed histogram of Figure 5 compares well with the model counterpart in Figure 6.
- As can be seen in Table 1 and Figures 7-10, the wind speed data are in good agreement with the wave model with a scatter index reduced by more than 5% compared to previous months. ENVISAT wind speed product is now about 30 cm/s higher than the model. A value supported by the comparison between the model and the in-situ observations. The upper limit of the algorithm is now shifted from 20.0 to 21.3 m/s.
- Although the scatter index between buoy and altimeter wind speeds (Figures 11-13) does not show significant improvement, the bias is clearly reduced.
- After the implementation of IPF ver. 5.02, the mean RA-2 wind speed increased by about 0.5 m/s (Figure 49). Therefore, the bias with respect to the ECMWF model changed sign as seen in Figure 49. Furthermore, the bias values



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in the various sub-regions (NH, SH and Tropics) tend to collapse to each other. The reduction in scatter index after the implementation can be seen in Figure 50.

- There is a trend for Ku-band wave heights to be overestimated by about 4.5% when compared to WAM results (6% in the NH, 3% in Tropics and 4% in SH). This is visually clear in the scatter plots in Figures 22-25 (Ku-band - WAM comparisons) and can be inferred from the symmetric slope values in same scatter plots. On the other hand, the RA-2 Ku-band wave heights are about 2% higher than buoy wave heights as can be seen in Figures 30-32 (Ku-band - buoy comparison).
- The bulk of S-band wave heights are in good agreement with both the WAM and the buoy data apart from a number of outliers (due to the well-known *RA-2 S-band anomaly*) when compared with the model (as can be seen in the scatter plots in Figures 26-29) and to less extent with the buoys (as can be seen in the scatter plots in Figures 33-34). The number of outliers are higher than last month. Most of those outliers occurred on the 7th. and on the 14th./15th. of the month (Figure 37) coinciding with the significant over-active rain flagging events.
- The S-band wave height product is slightly better than last month as compared with the model.
- The ratio between Ku-band and S-band wave heights this month changed between 0.99 and 1.01 with a couple of dips (down to below 0.94) coinciding with the extreme RA-2 S-band anomaly events as can be seen in Figure 48. The new processing chain (IPF ver. 5.02) caused this ratio to increase to slightly above 1.0. It is important to notice the seasonal variation for this ratio with low values (~0.92-0.94) reached during the period from late April to late September and high values (slightly less than 1.0) during the remaining part of the year.
- There is quite a number of outliers in the scatter plots comparing the MWR derived wet tropospheric correction (WTC) and total column water vapour (TCWV) against the ECMWF model in the Northern and Southern Hemisphere (Figures 39, 41, 43 and 45). It seems that these outliers are due to sea-ice contamination. This issue will be treated soon.
- **There is a small cloud of TCWV scatter plot outliers hanging below the main cloud at model values between 20 and 30 kg/m² as can be seen in Figures 42-45. It occurs almost anywhere. Although this type of outliers is**



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always there, it was noticed only when it became clear in the long-period scatter plots. This will be investigated further at a later stage.

- While the MWR derived TCWV is now in good agreement with the model counterpart (MWR TCWV is slightly smaller than the model), the MWR WTC is still consistently smaller (drier) than the model values.
- It is important to stress that one needs to keep in mind when making the comparison between the results presented here for the ENVISAT RA-2 and the results presented in the ERS-2 altimeter reports that the ERS-2 plots and statistics are done for super-observations composed of 30 individual observation, while the plots and statistics here are for super-observations with 11 individual observations. Therefore, it is natural for the RA-2 plots and statistics to show a bit more variability.
- ENVISAT RA-2 Ku-band wave height data and ERS-2 SAR wave data are assimilated in the ECMWF wave model.
- The ERS-2 SAR wave data used for assimilation at ECMWF wave model are now limited to the North Atlantic and the western coast of North America (in addition to the eastern coast of China since late June 2005 and the Southern Ocean since early July 2005) following the failure of the ERS-2 tape recorders in June 2003. Also note that Figure 19 represents the histogram for the covered area only.

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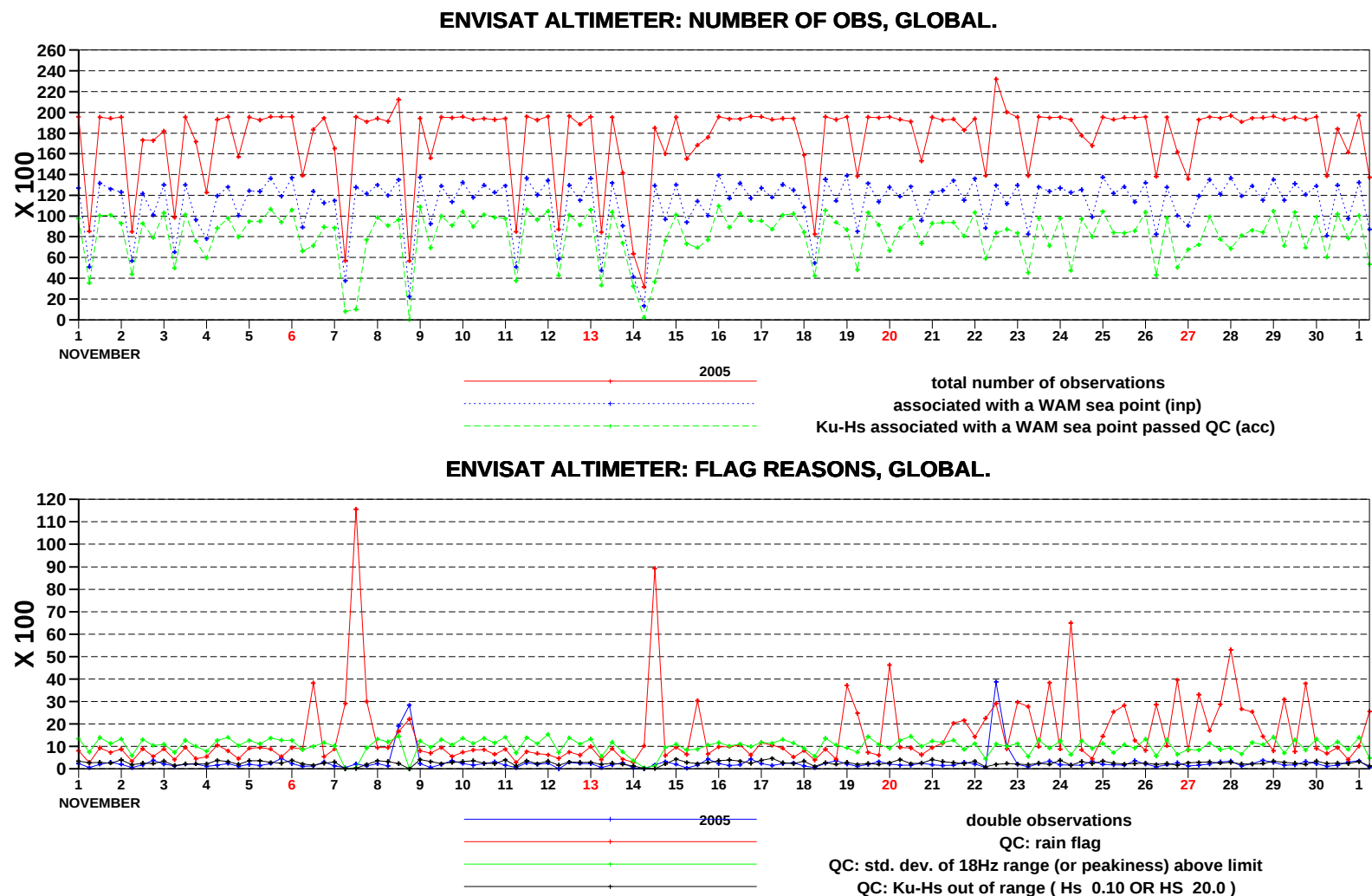


Figure 1: Time series of data reception for ENVISAT Altimeter data for November 2005

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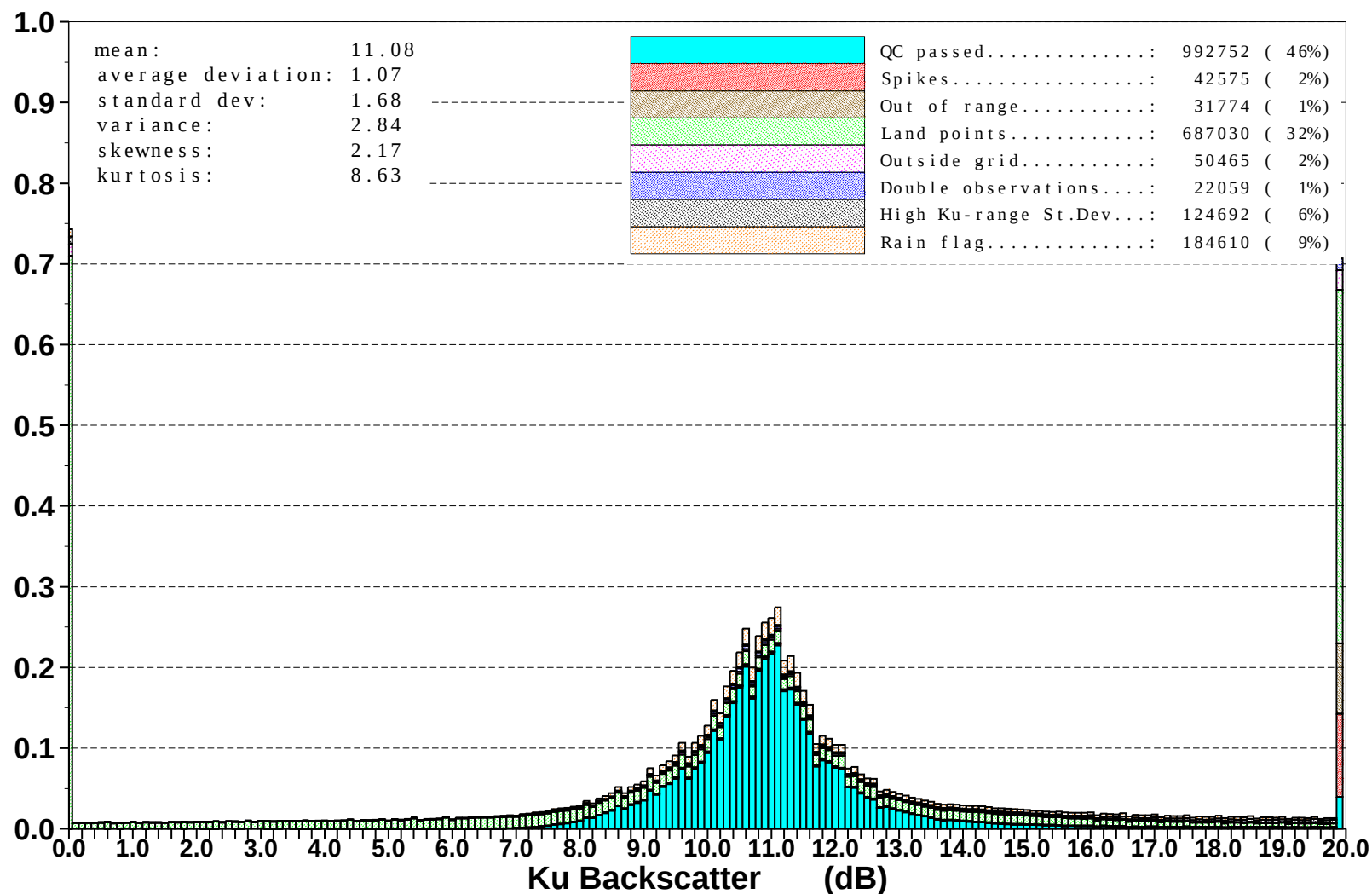


Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for November 2005



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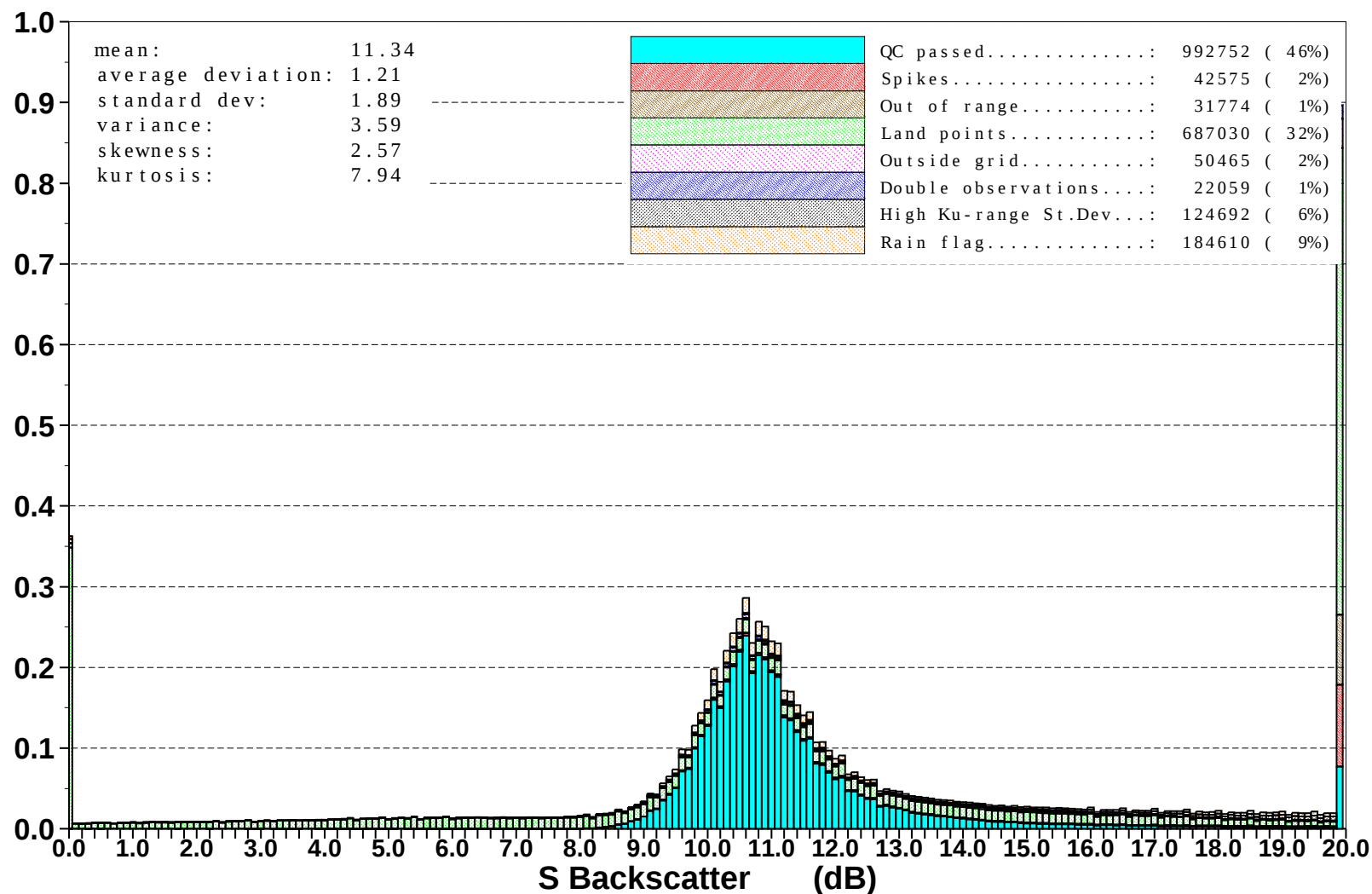


Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for November 2005



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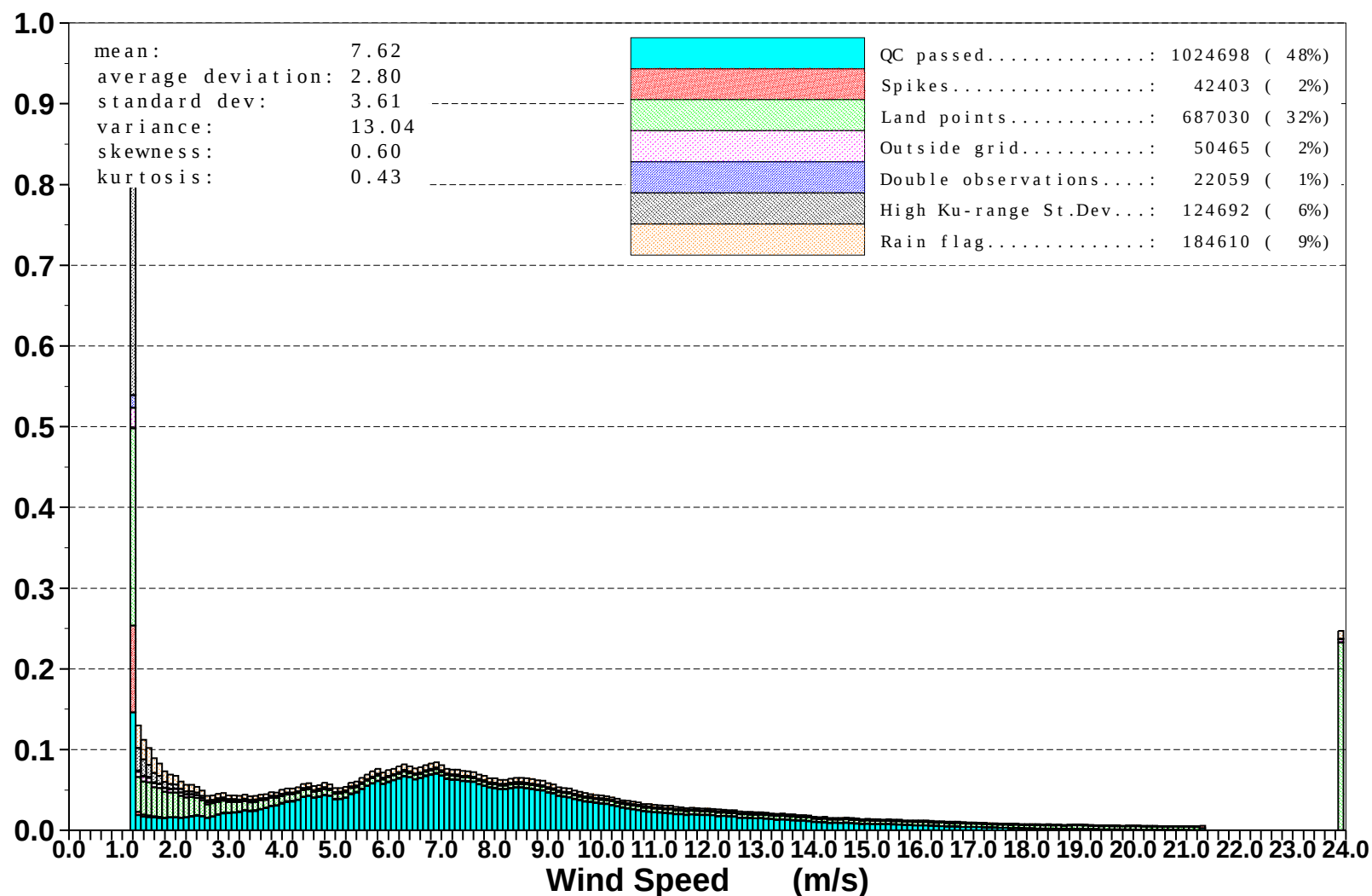


Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for November 2005

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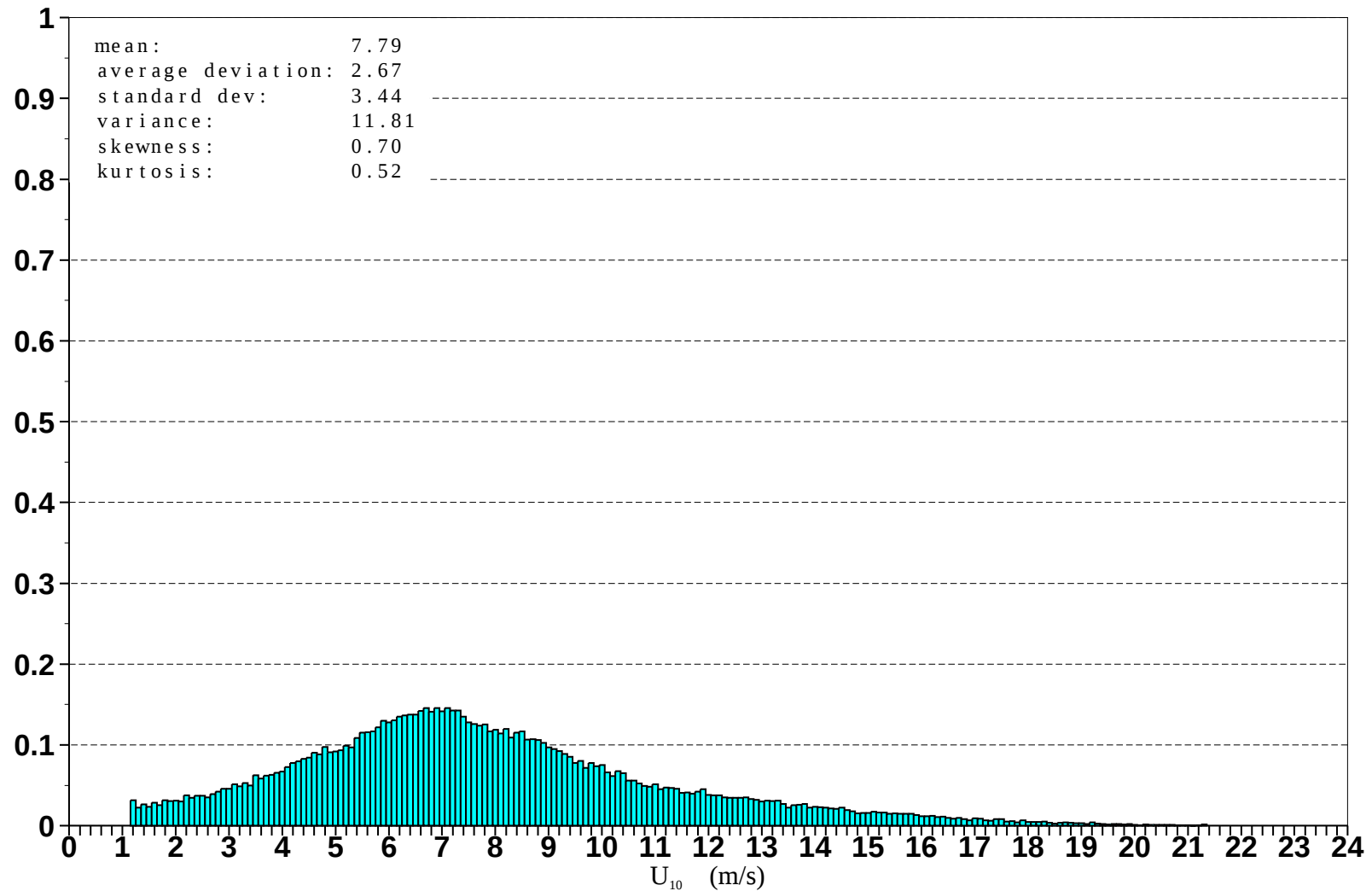


Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for November 2005



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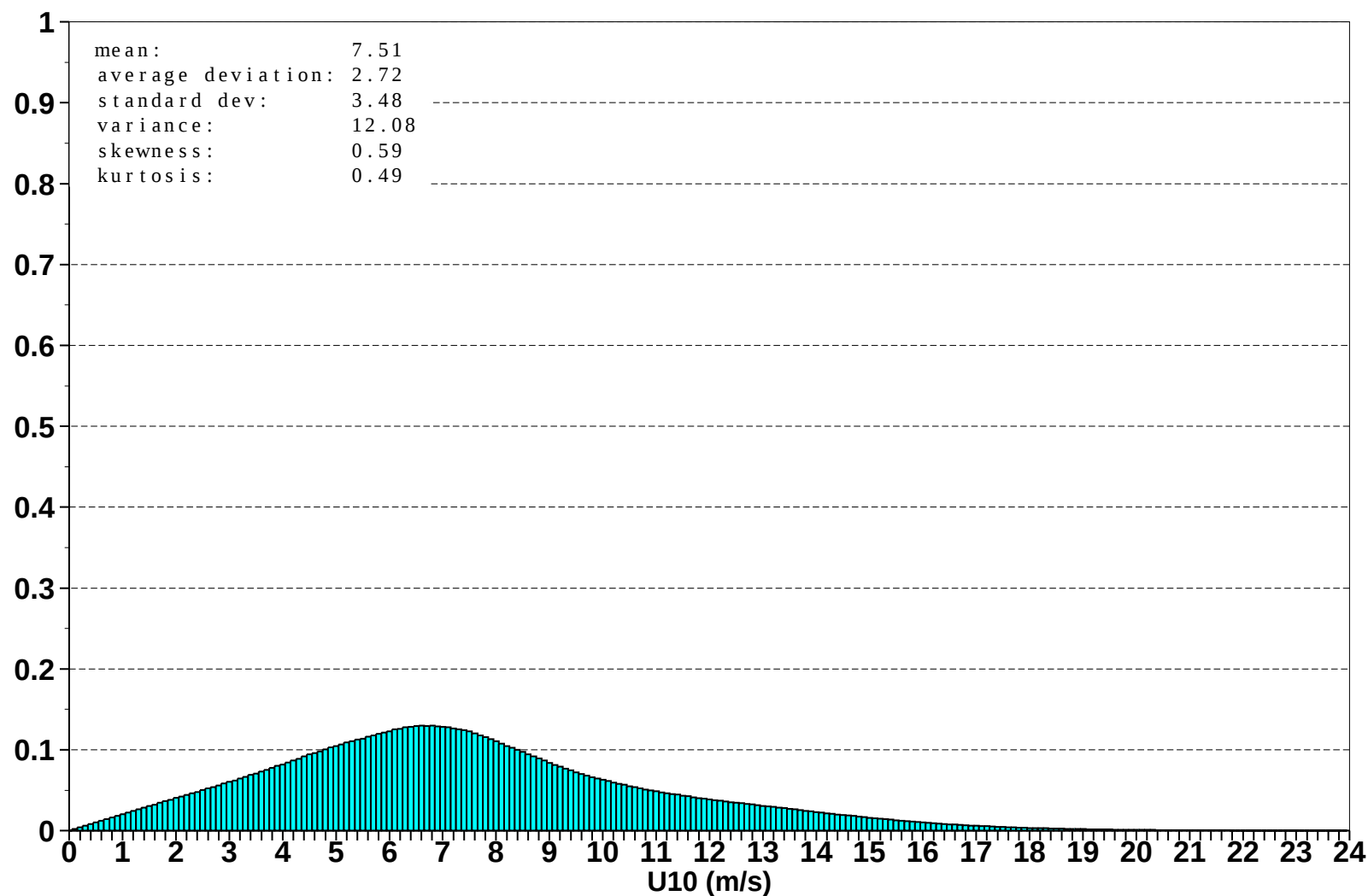


Figure 6: Global distribution of ECMWF Analysis ocean surface wind speeds for November 2005



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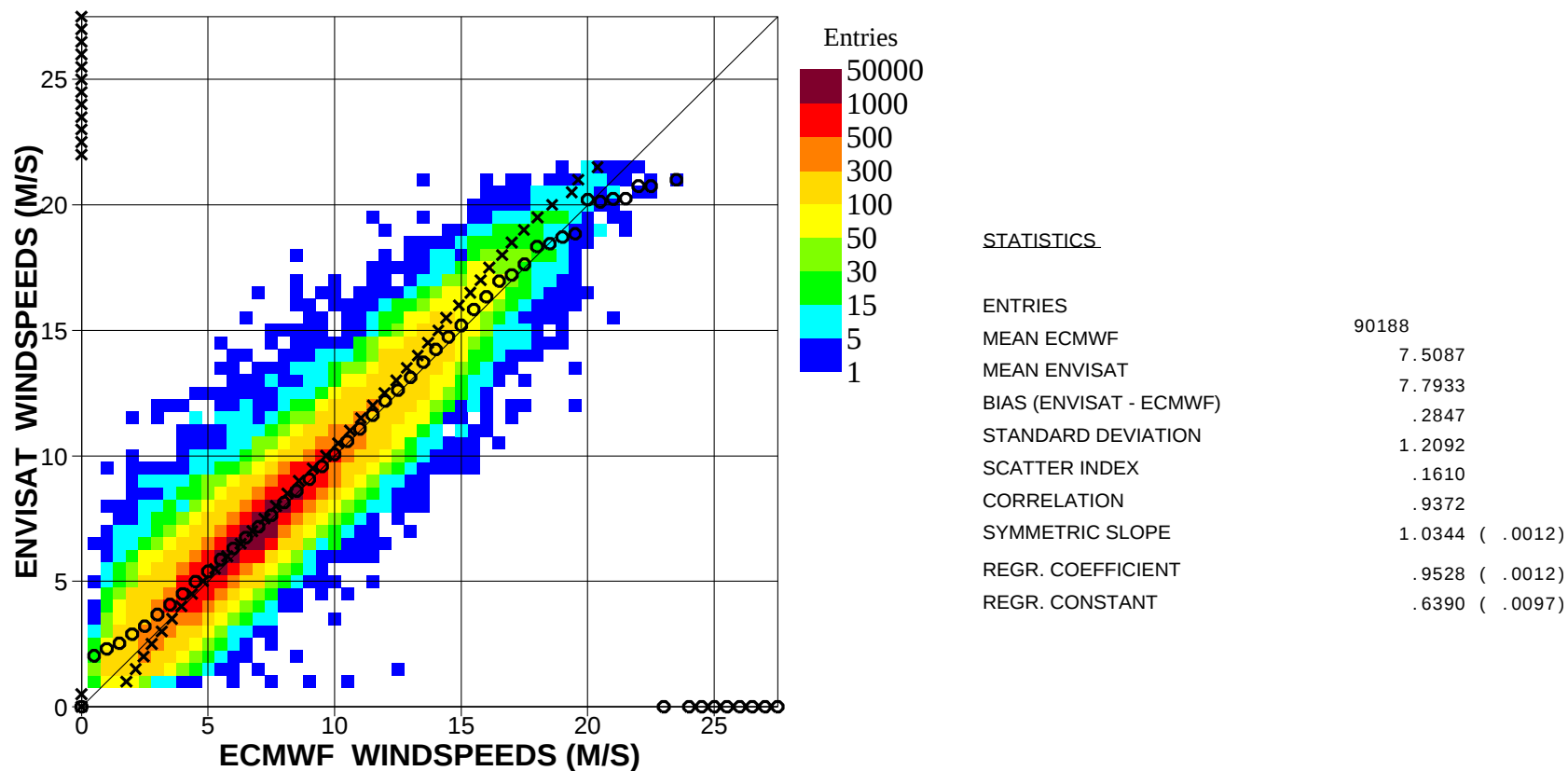


Figure 7. Comparison between ENVISAT Altimeter and ECMWF wind speeds for November 2005 (Global)

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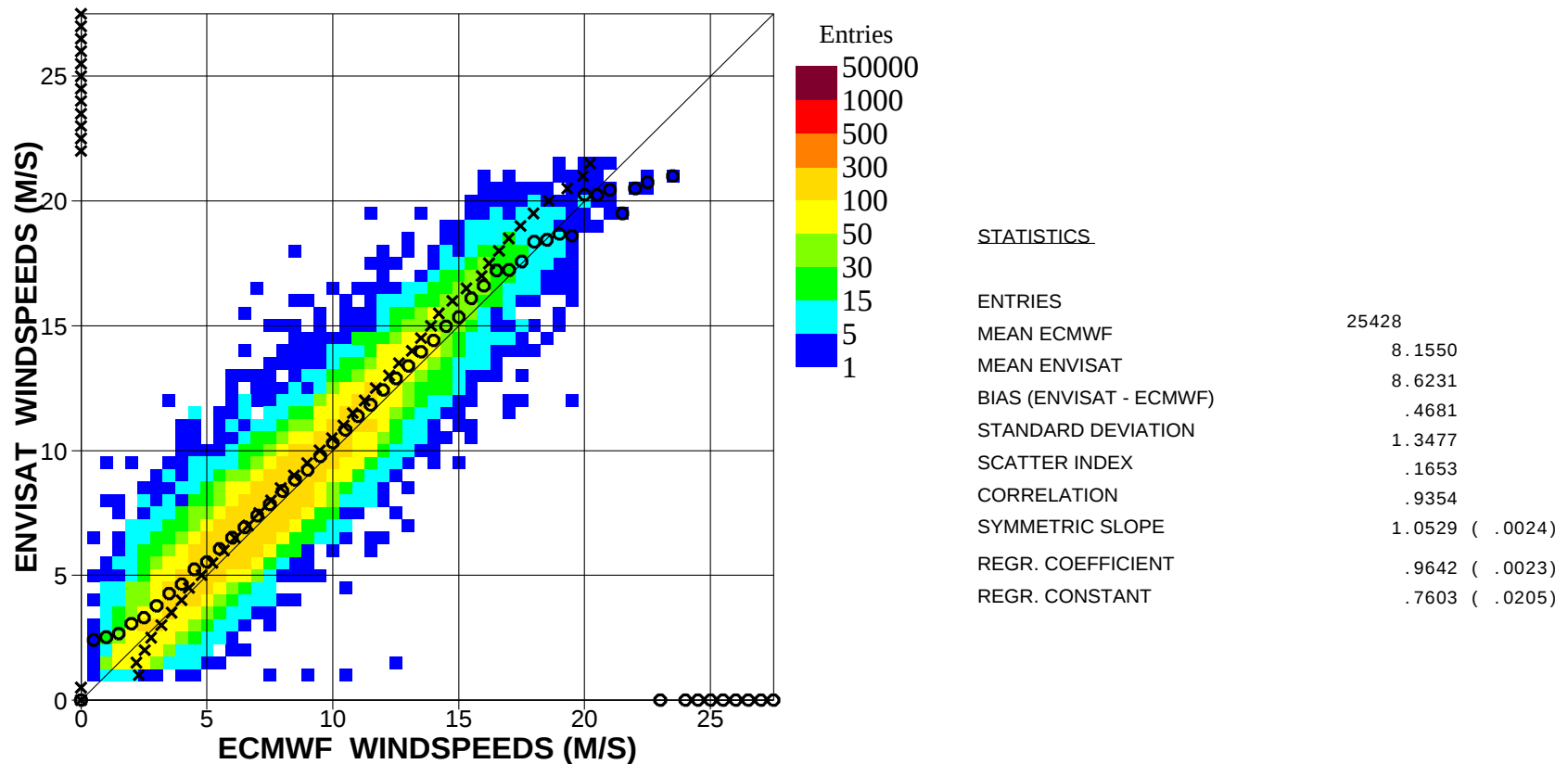


Figure 8. Comparison between ENVISAT Altimeter and ECMWF wind speeds for November 2005 (N.Hem.)

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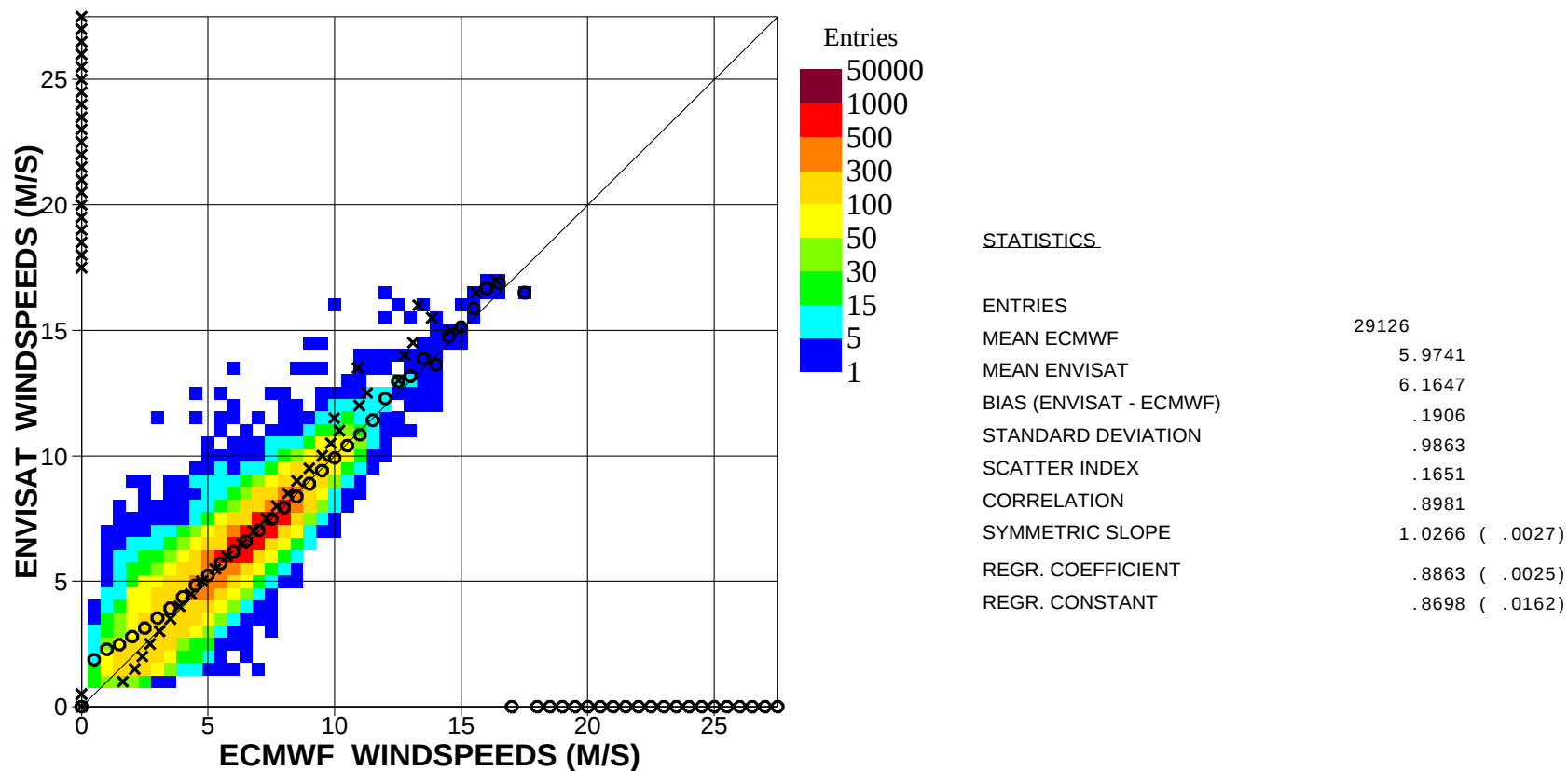


Figure 9. Comparison between ENVISAT Altimeter and ECMWF wind speeds for November 2005 (Tropics)

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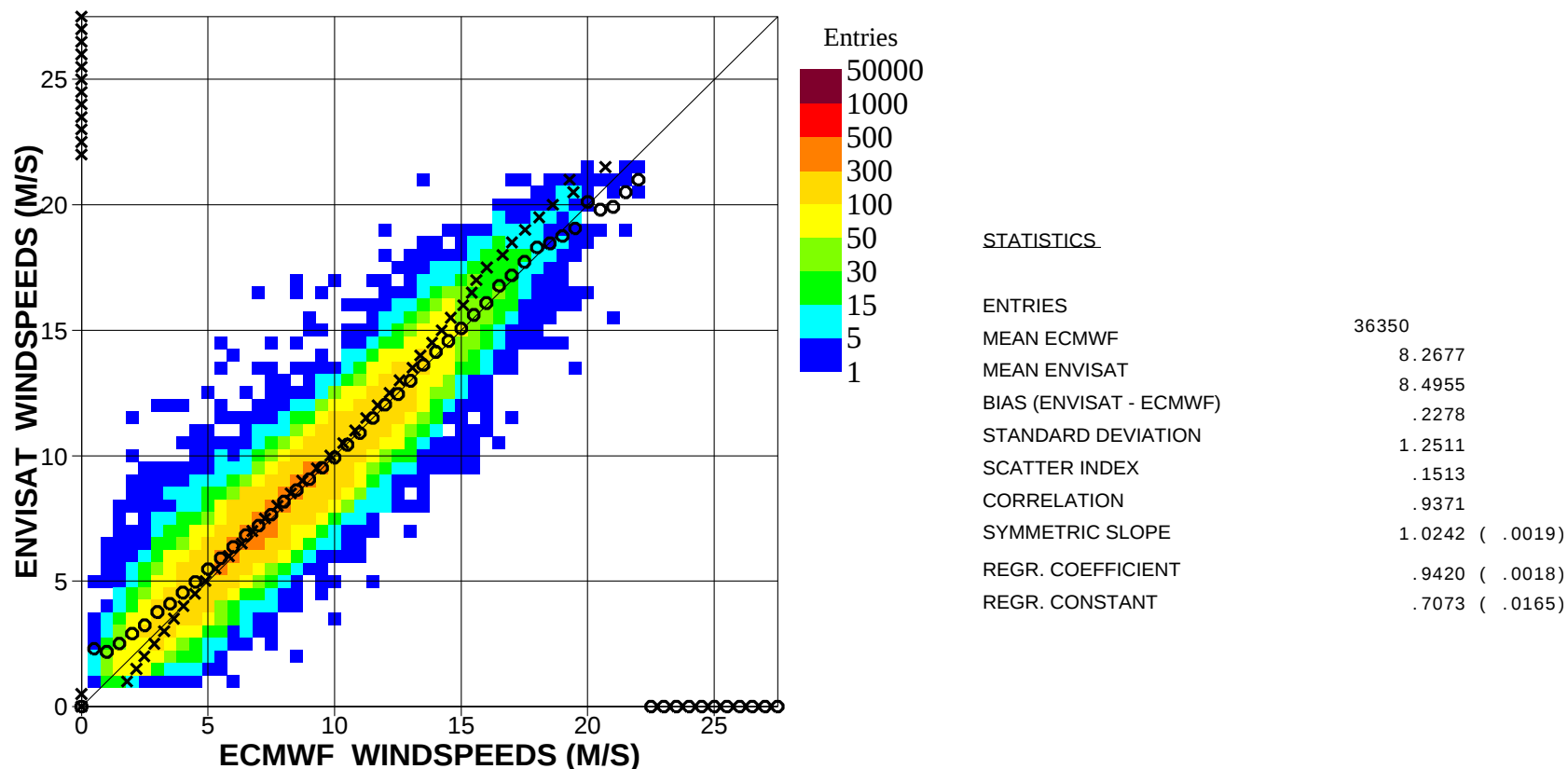


Figure 10. Comparison between ENVISAT Altimeter and ECMWF wind speeds for November 2005 (S.Hem.)

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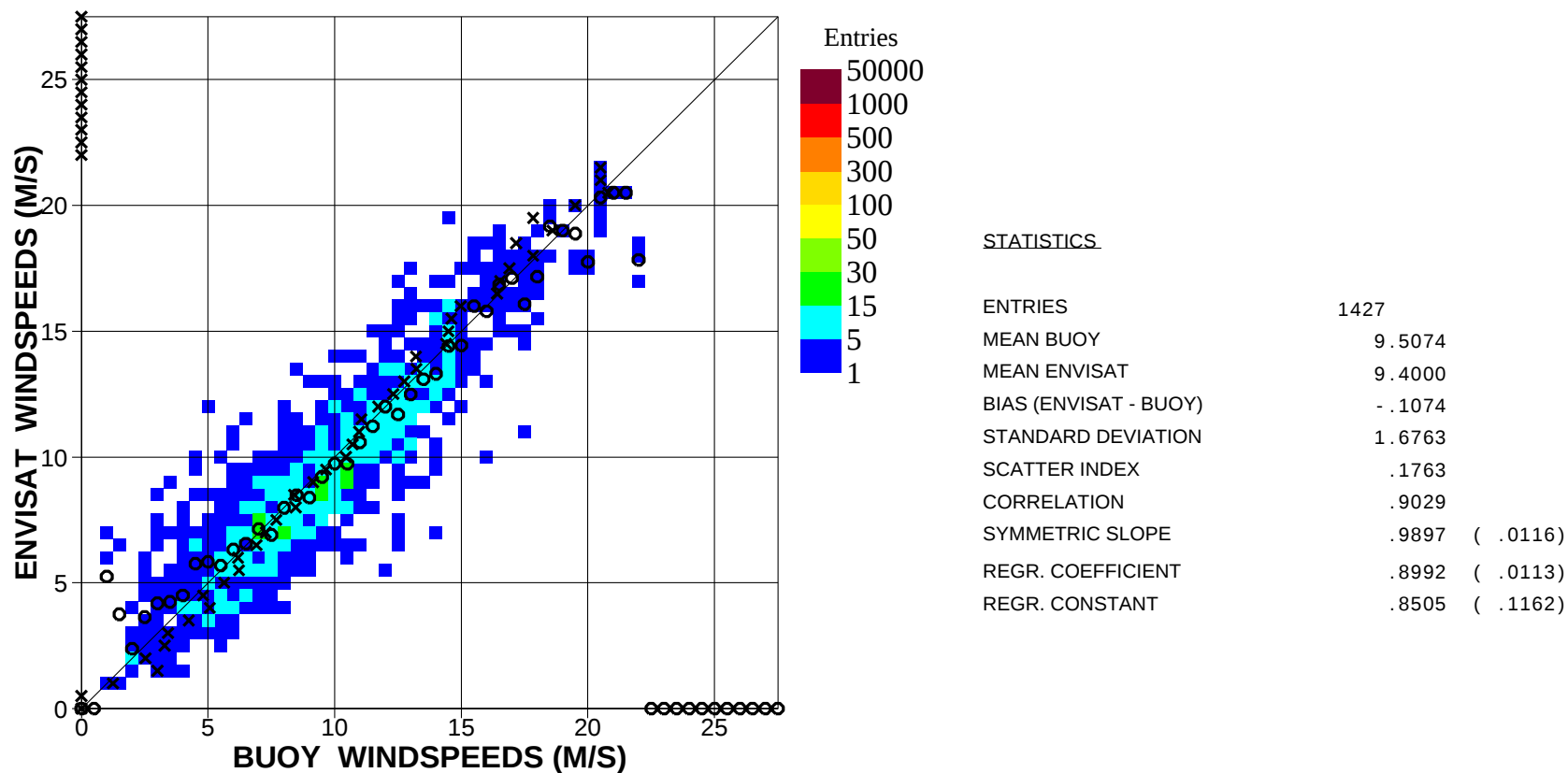


Figure 11. Comparison between ENVISAT Altimeter and buoy wind speeds for November 2005 (Global)

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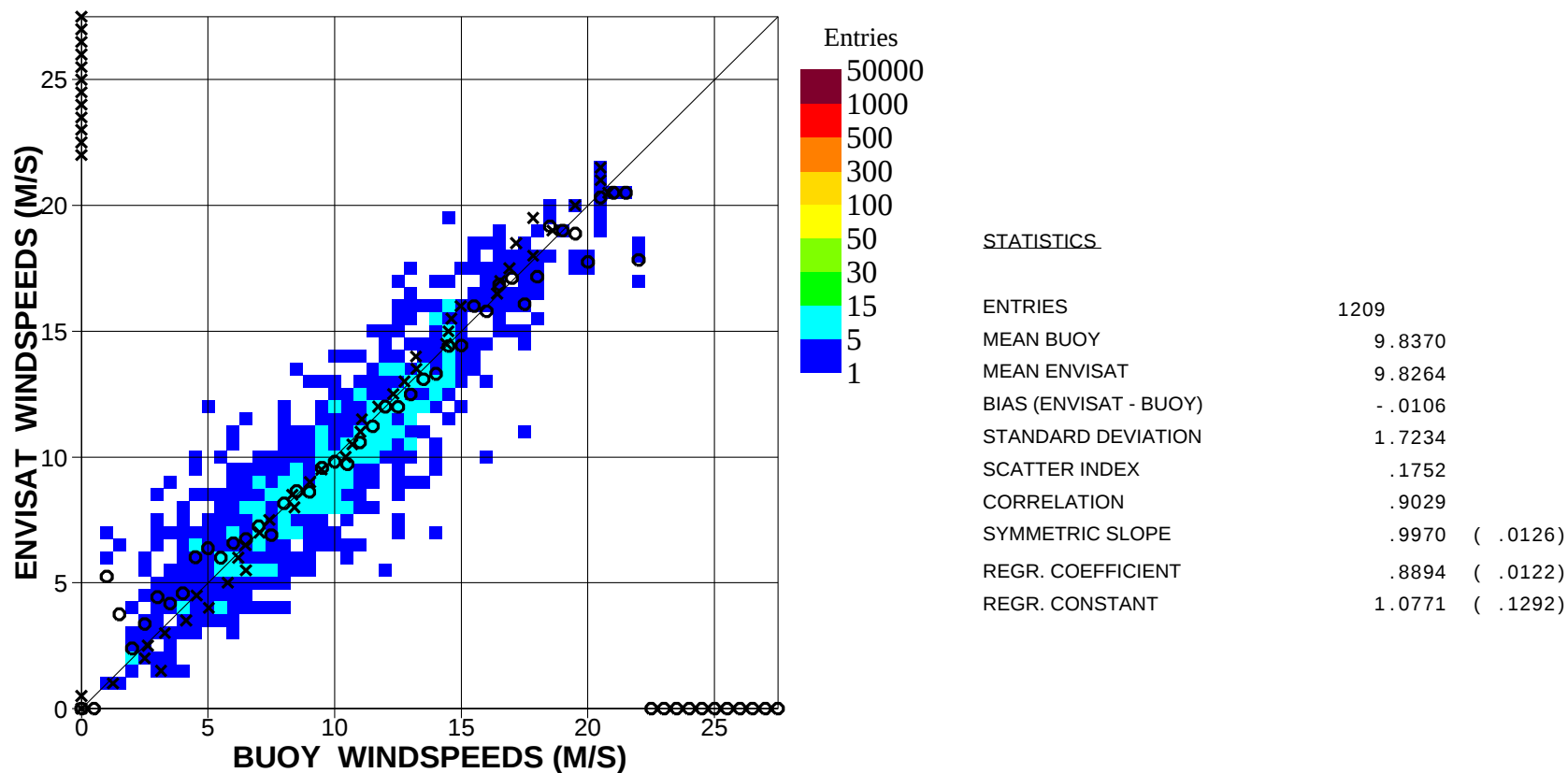


Figure 12. Comparison between ENVISAT Altimeter and buoy wind speeds for November 2005 (N.Hem.)

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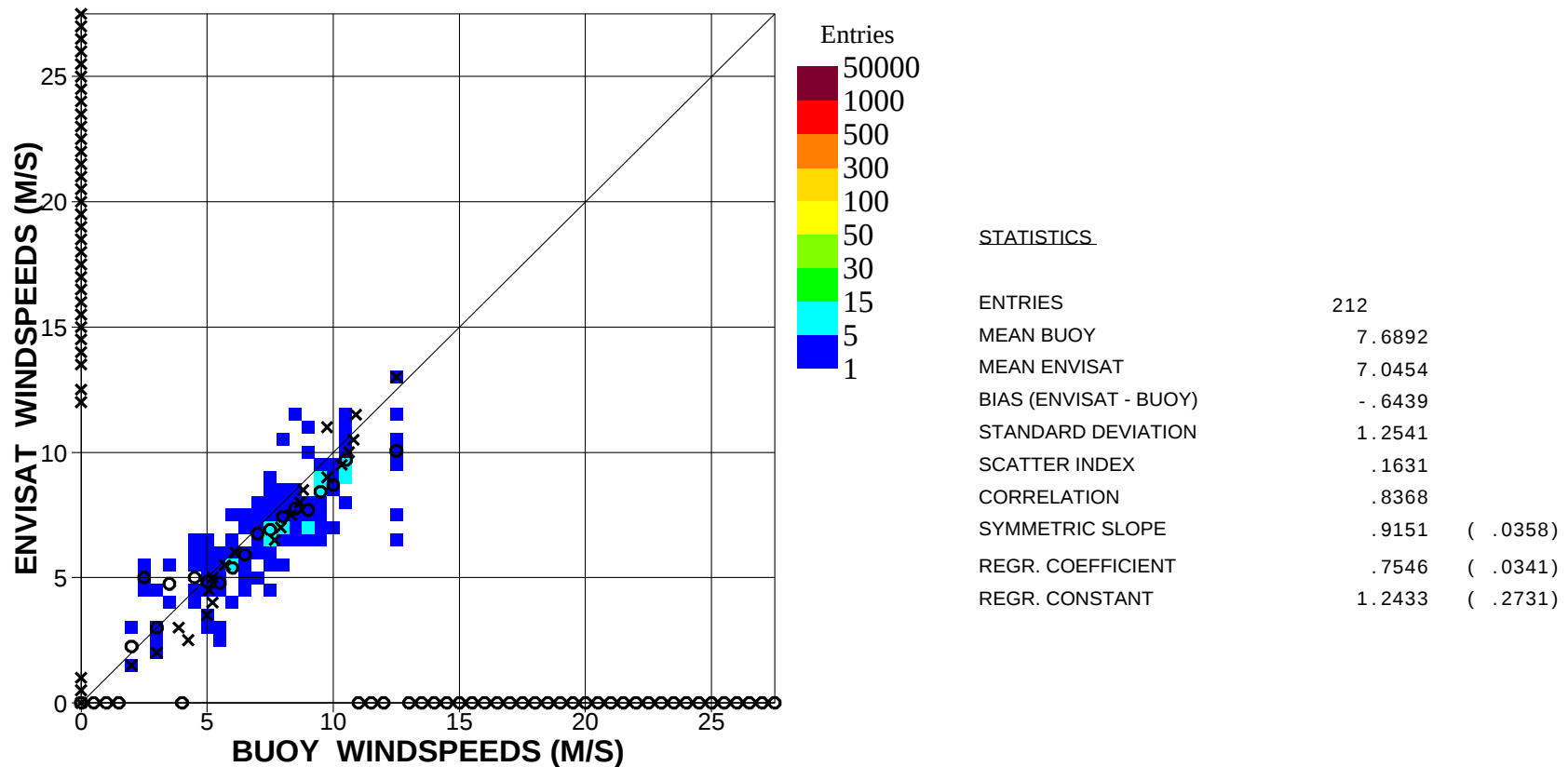


Figure 13. Comparison between ENVISAT Altimeter and buoy wind speeds for November 2005 (Tropics)

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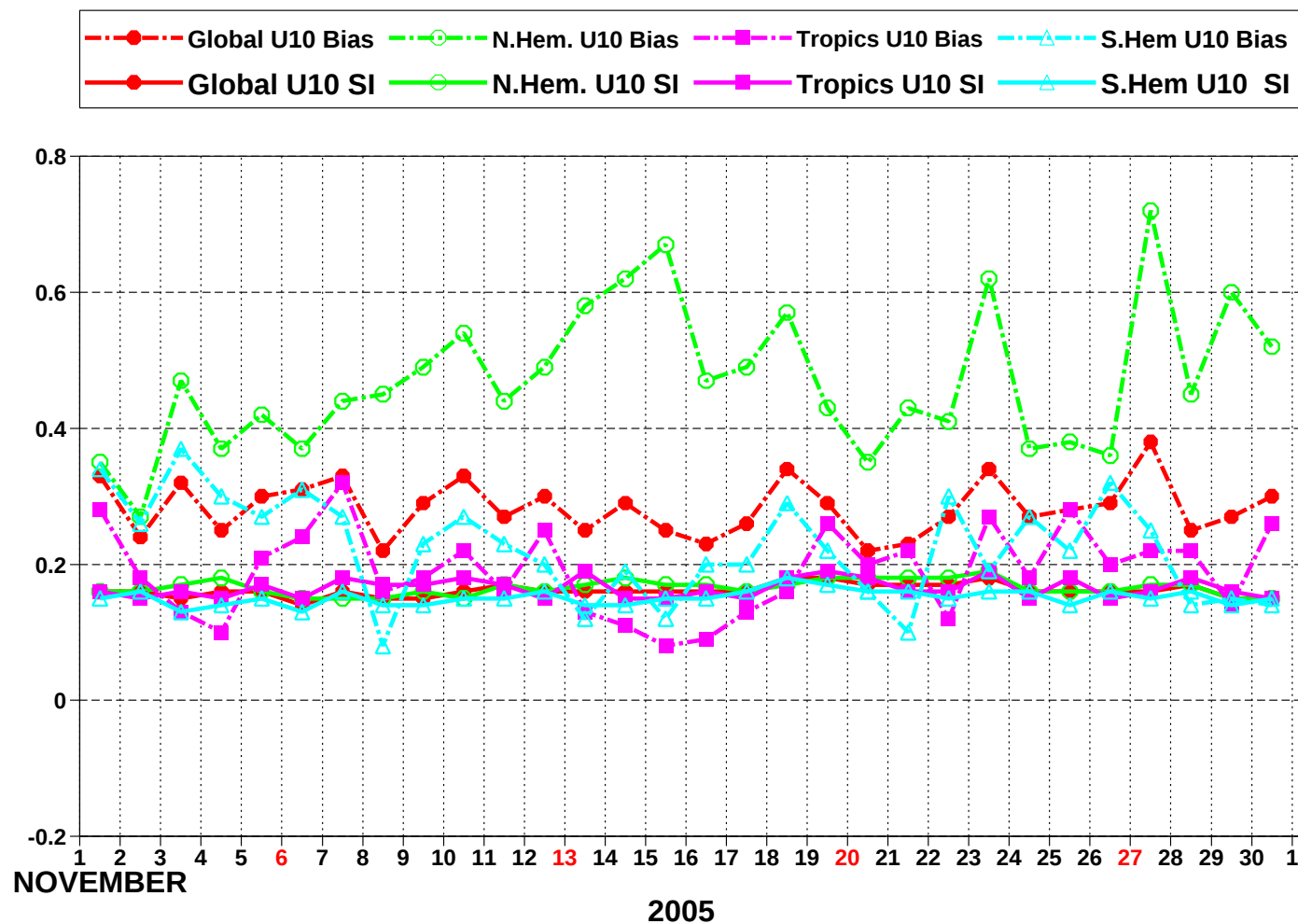


Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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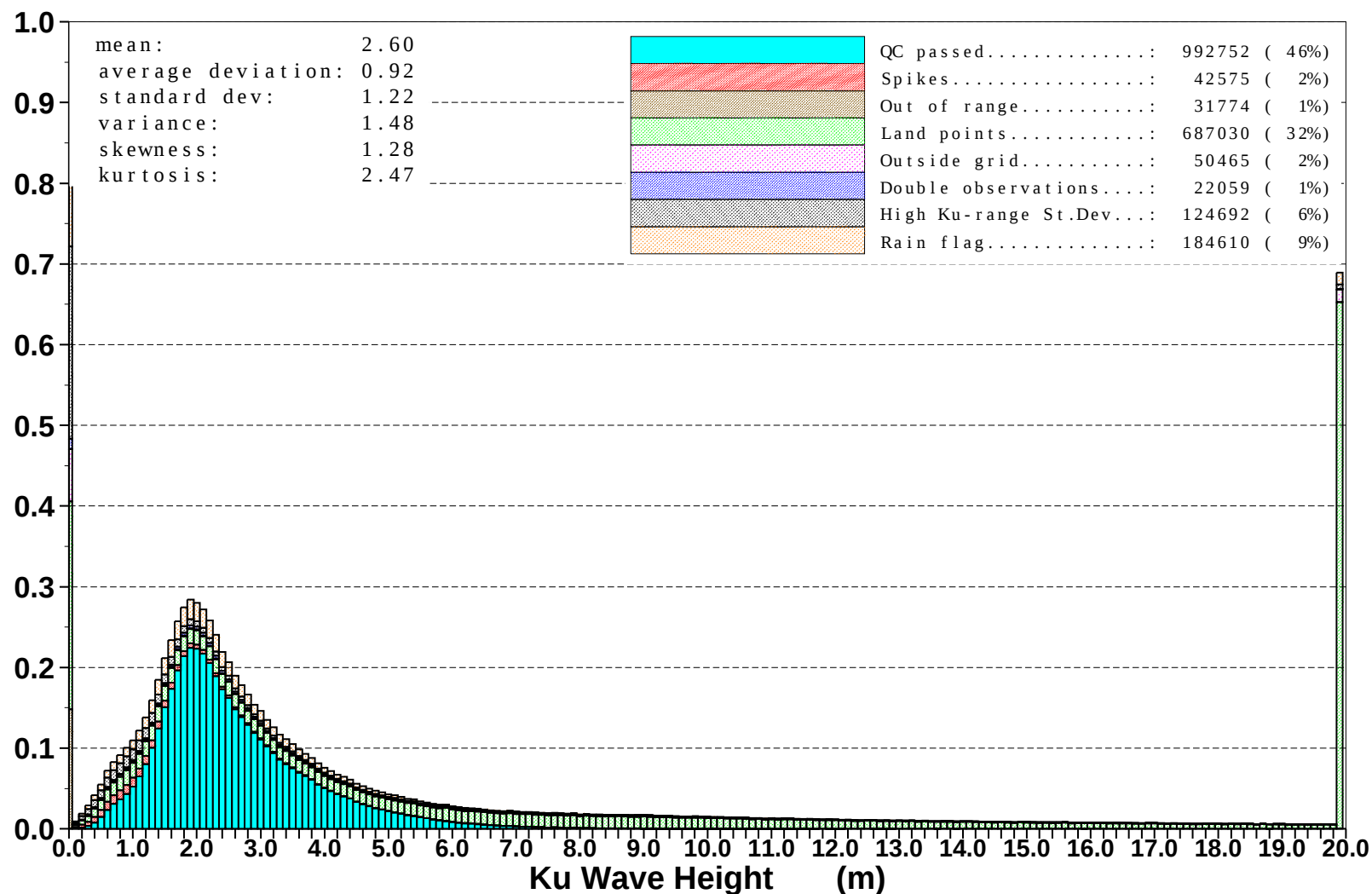


Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for November 2005



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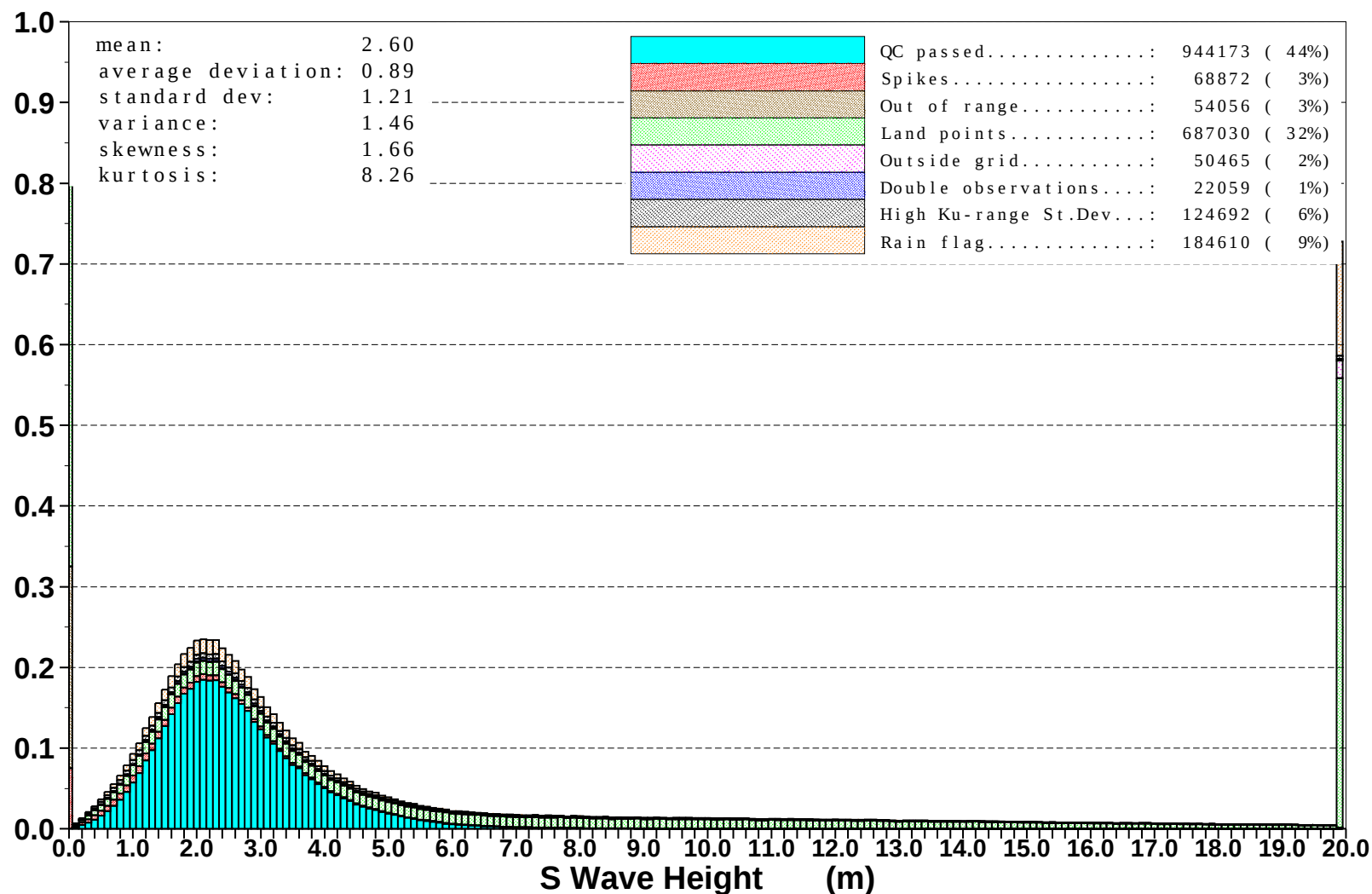


Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for November 2005

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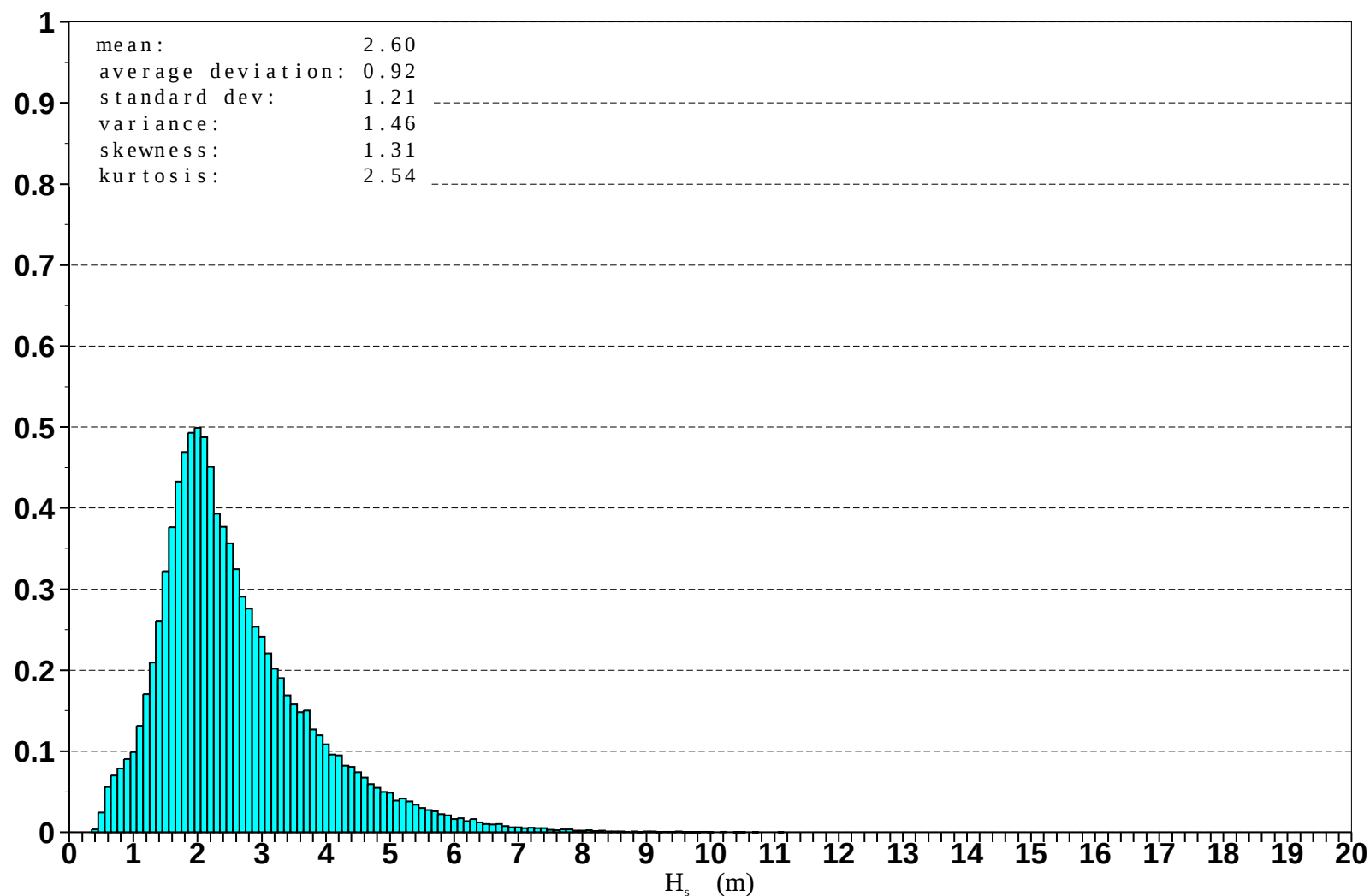


Figure 17: Distribution of ENVISAT Altimeter Ku-Band Wave Heights after Along-Track Averaging for November 2005



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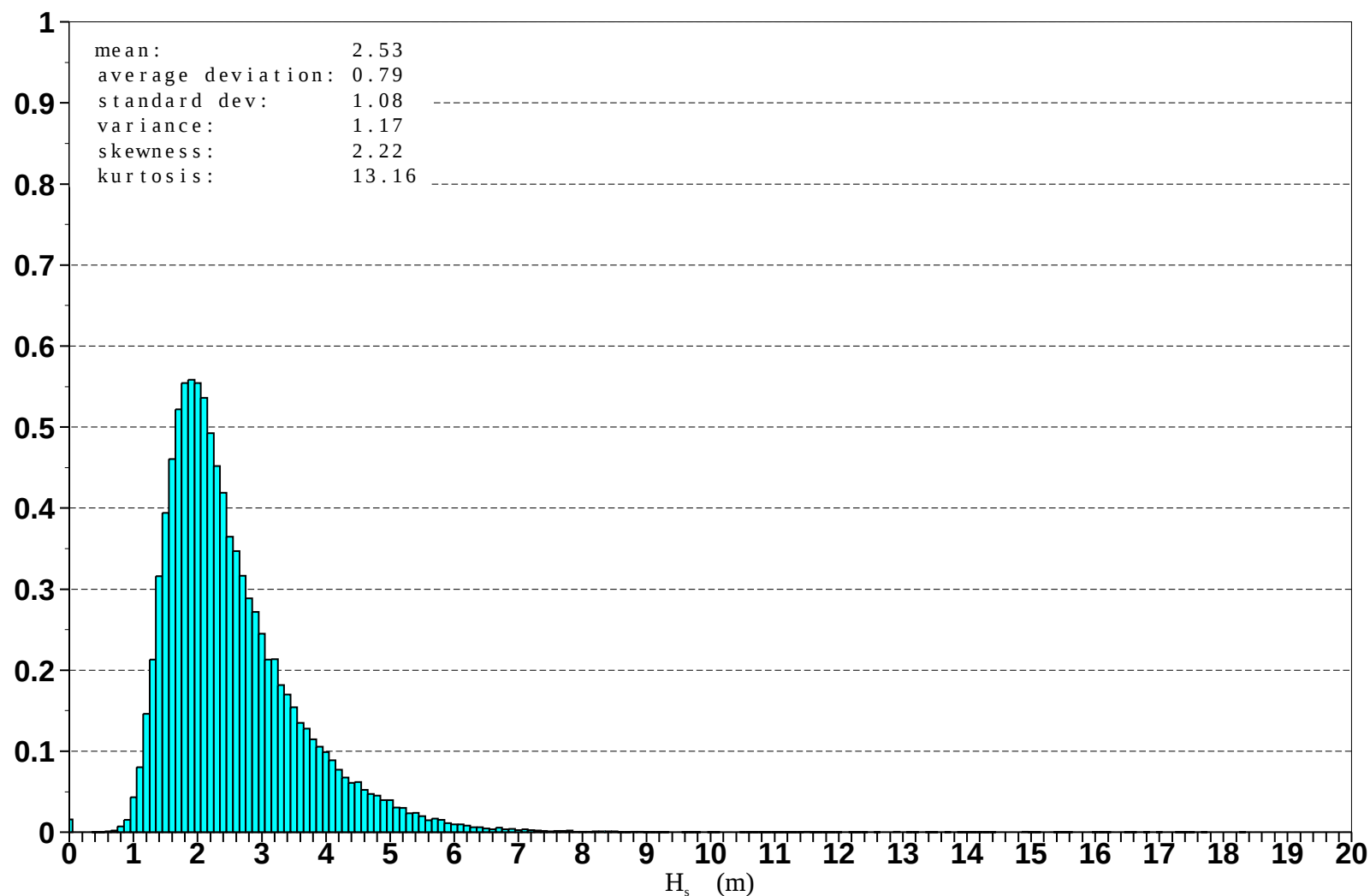


Figure 18: Distribution of ENVISAT Altimeter S-Band Wave Heights after Along-Track Averaging for November 2005



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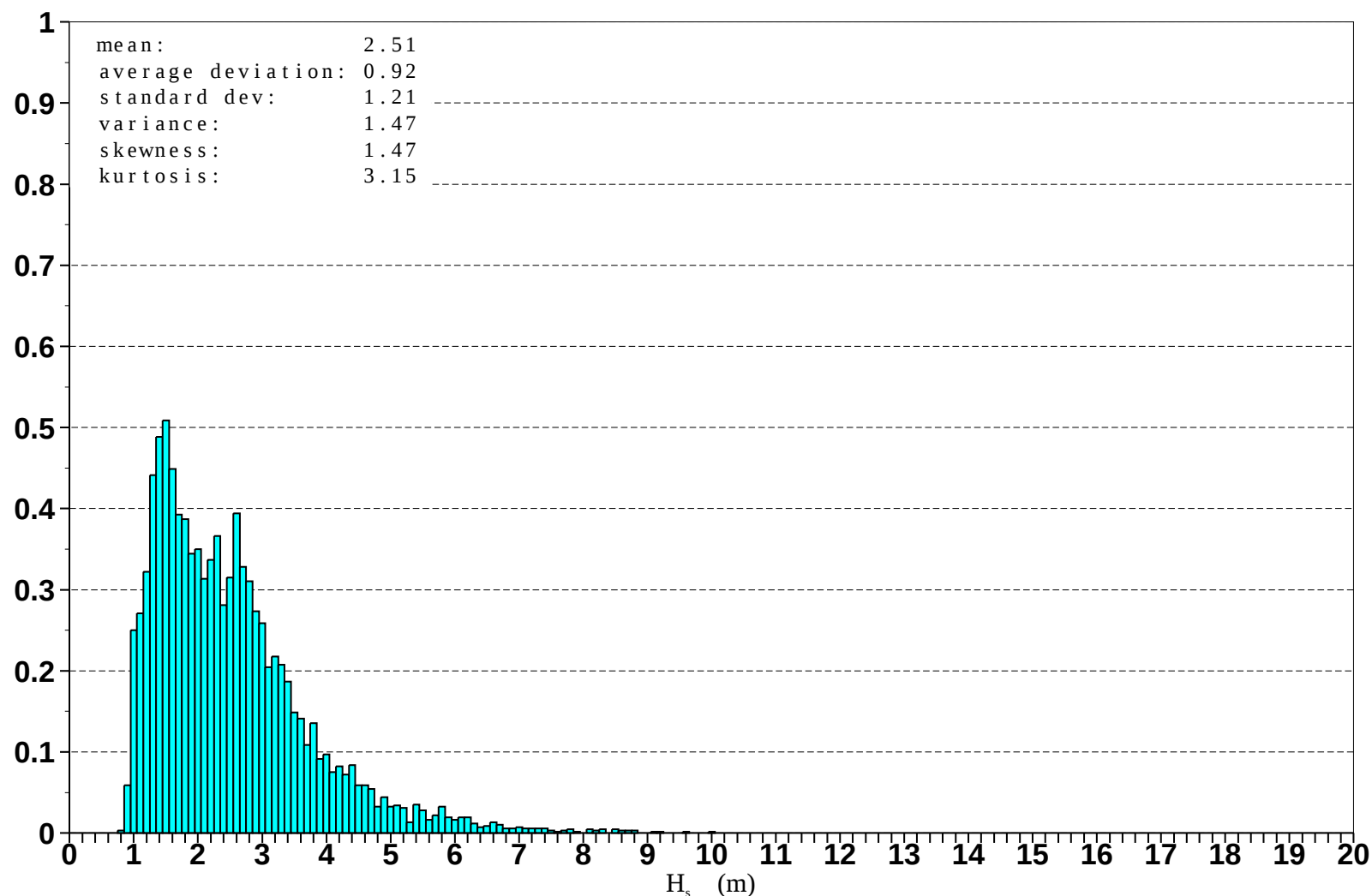


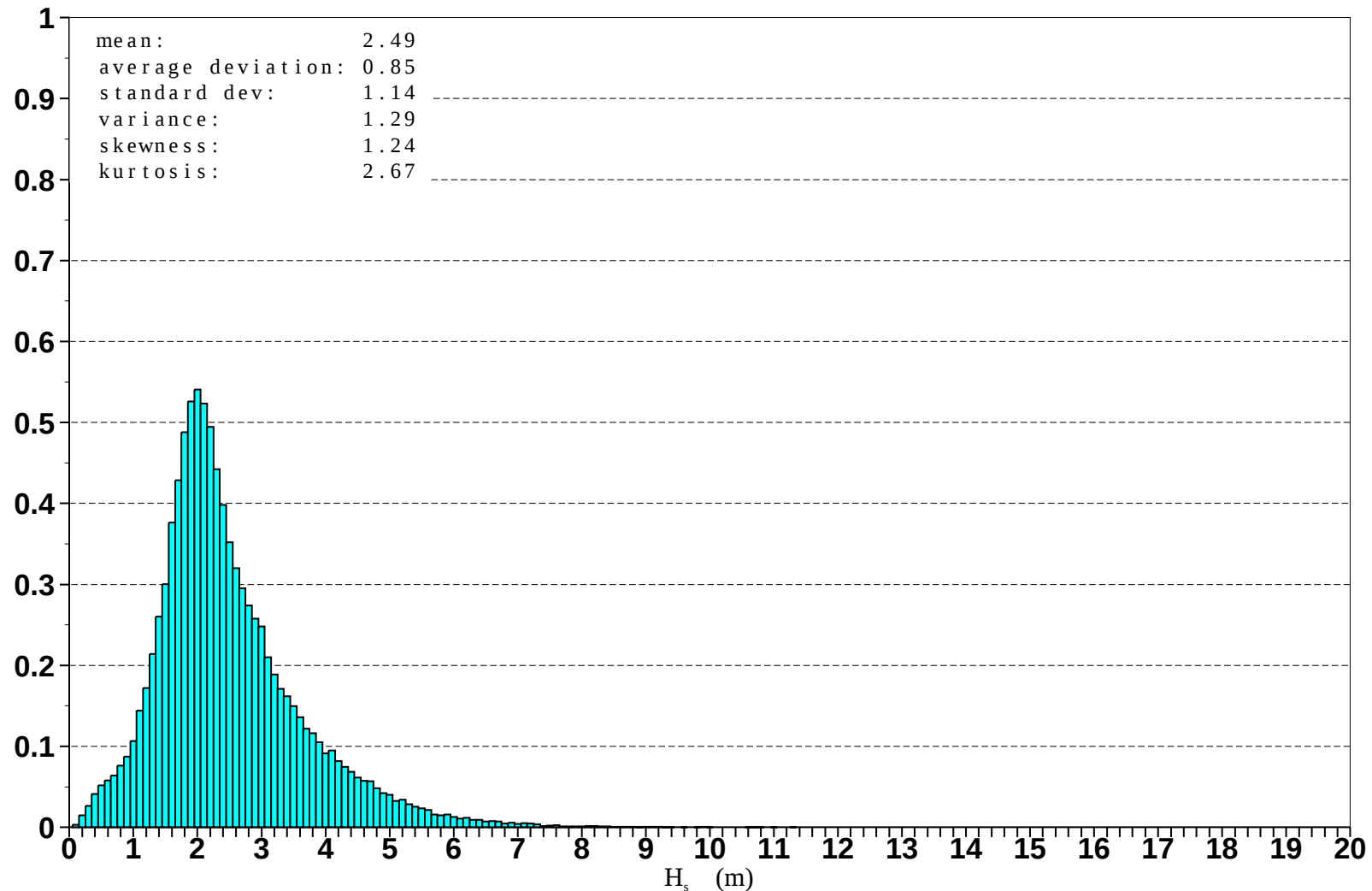
Figure 19: Distribution of ERS-2 Altimeter Wave Heights after Along-Track Averaging for November 2005



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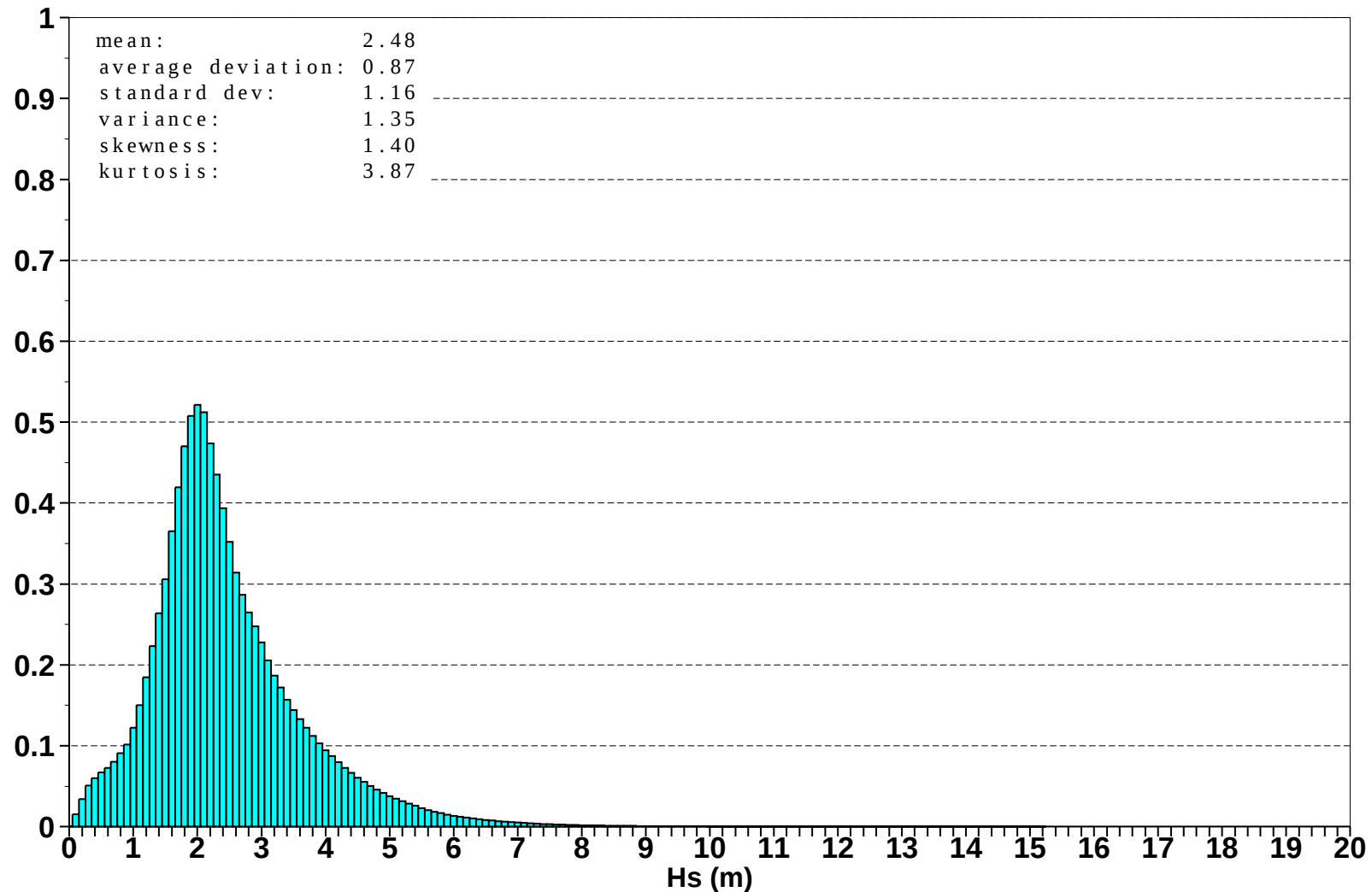


Figure 20: Global distribution of ECMWF First-Guess wave heights for November 2005

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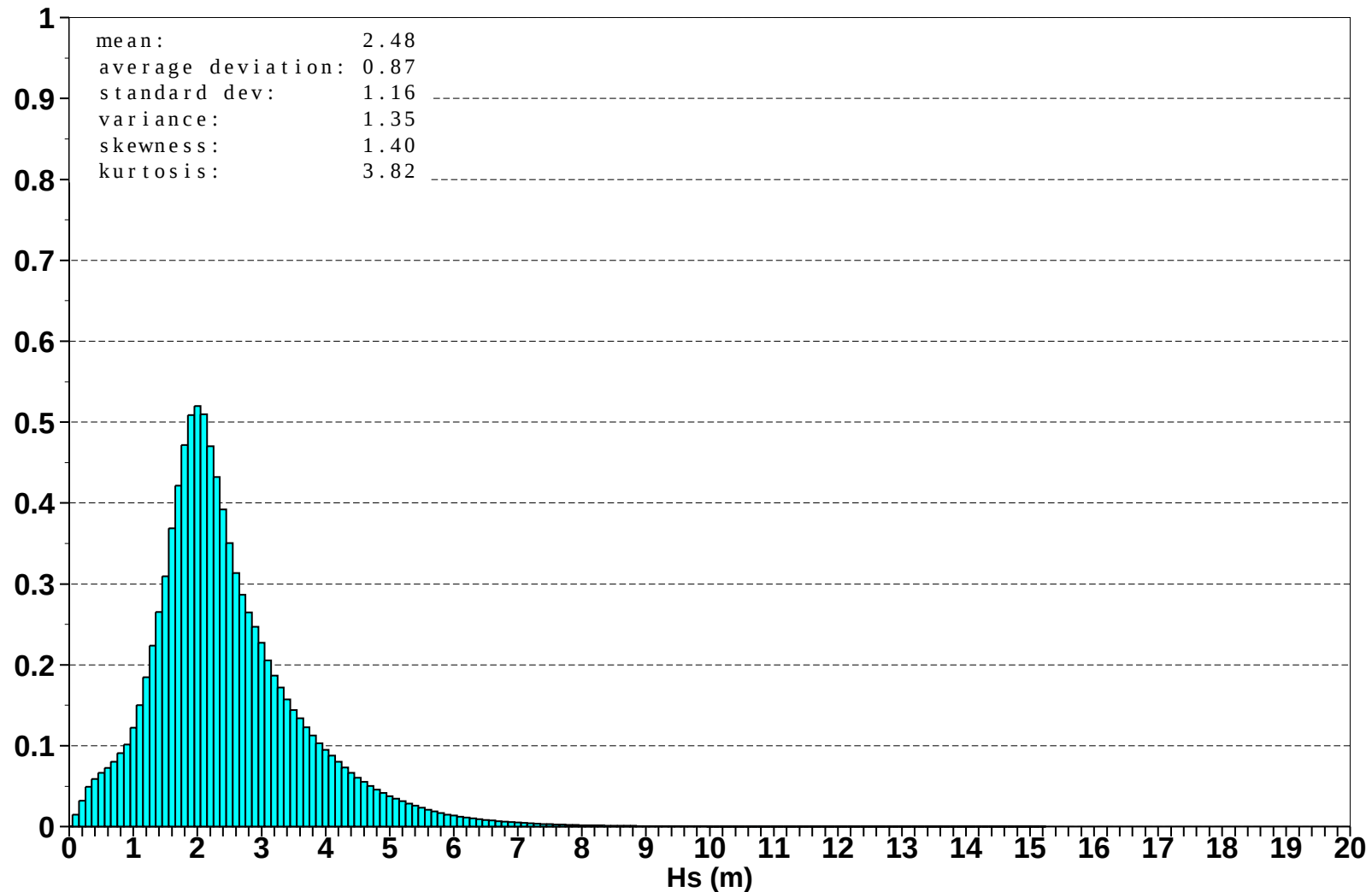


Figure 21: Global distribution of ECMWF Analysis wave heights for November 2005



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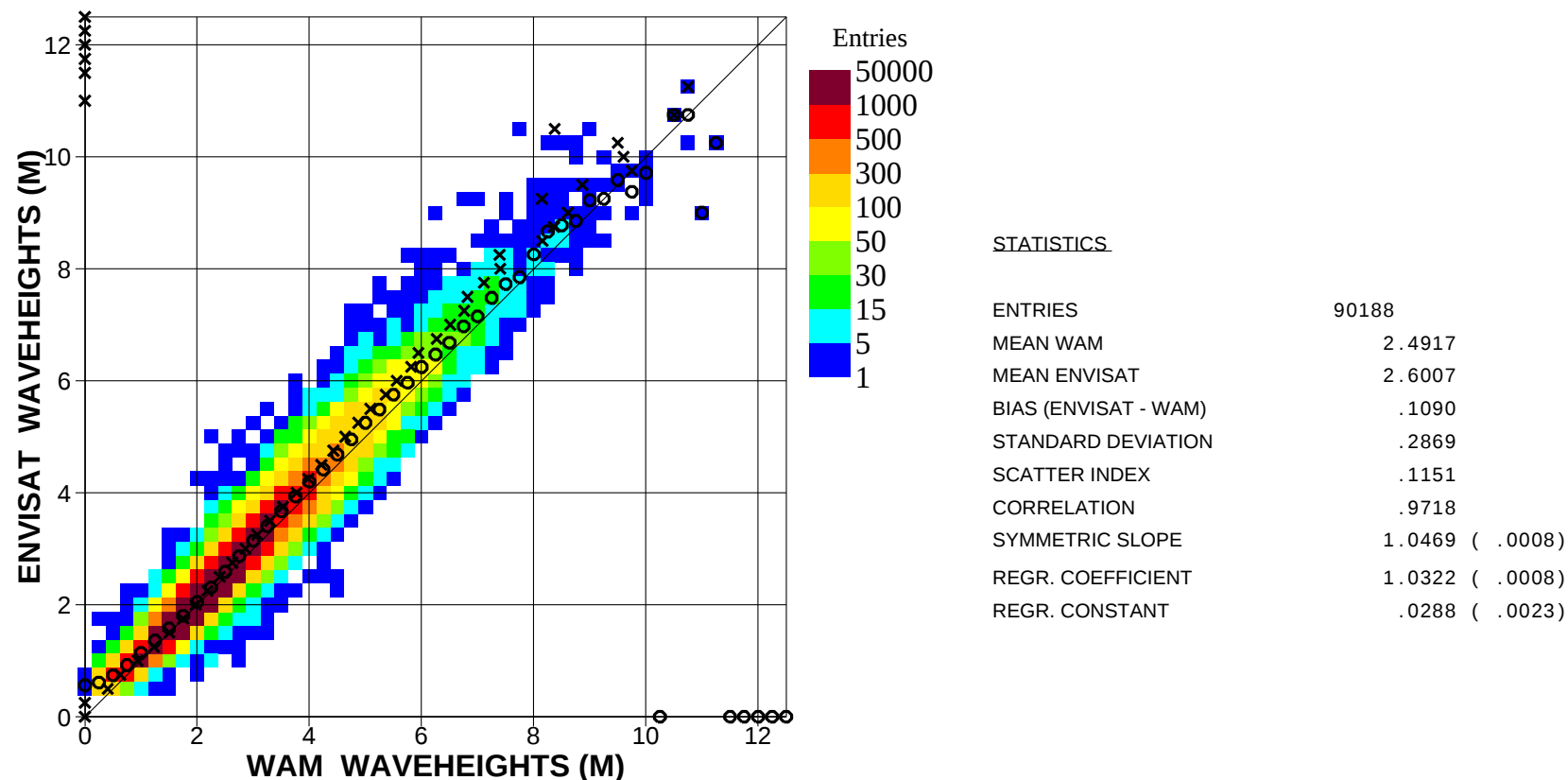


Figure 22. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for November 2005 (Global)

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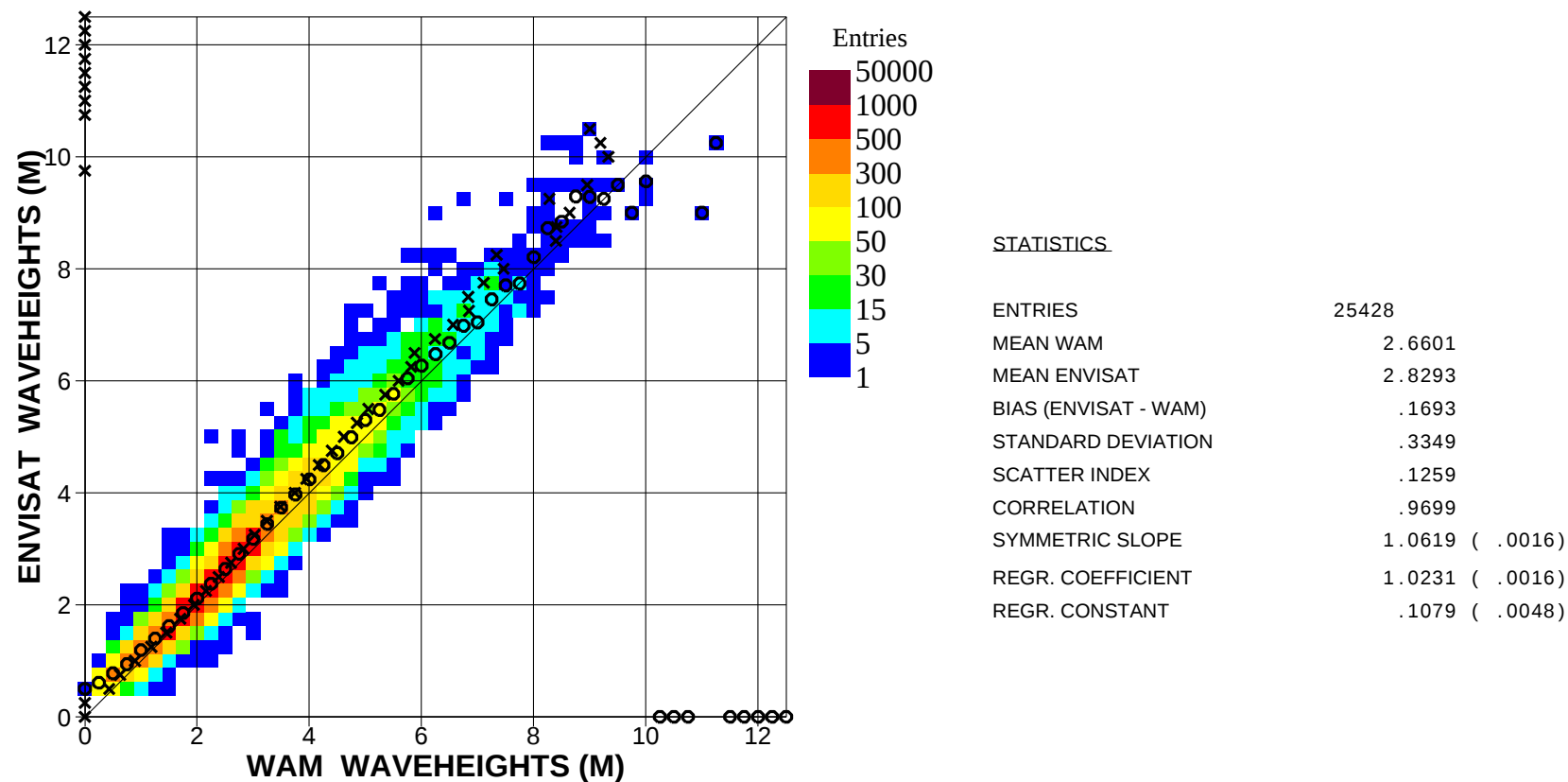


Figure 23. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for November 2005 (N.Hem.)

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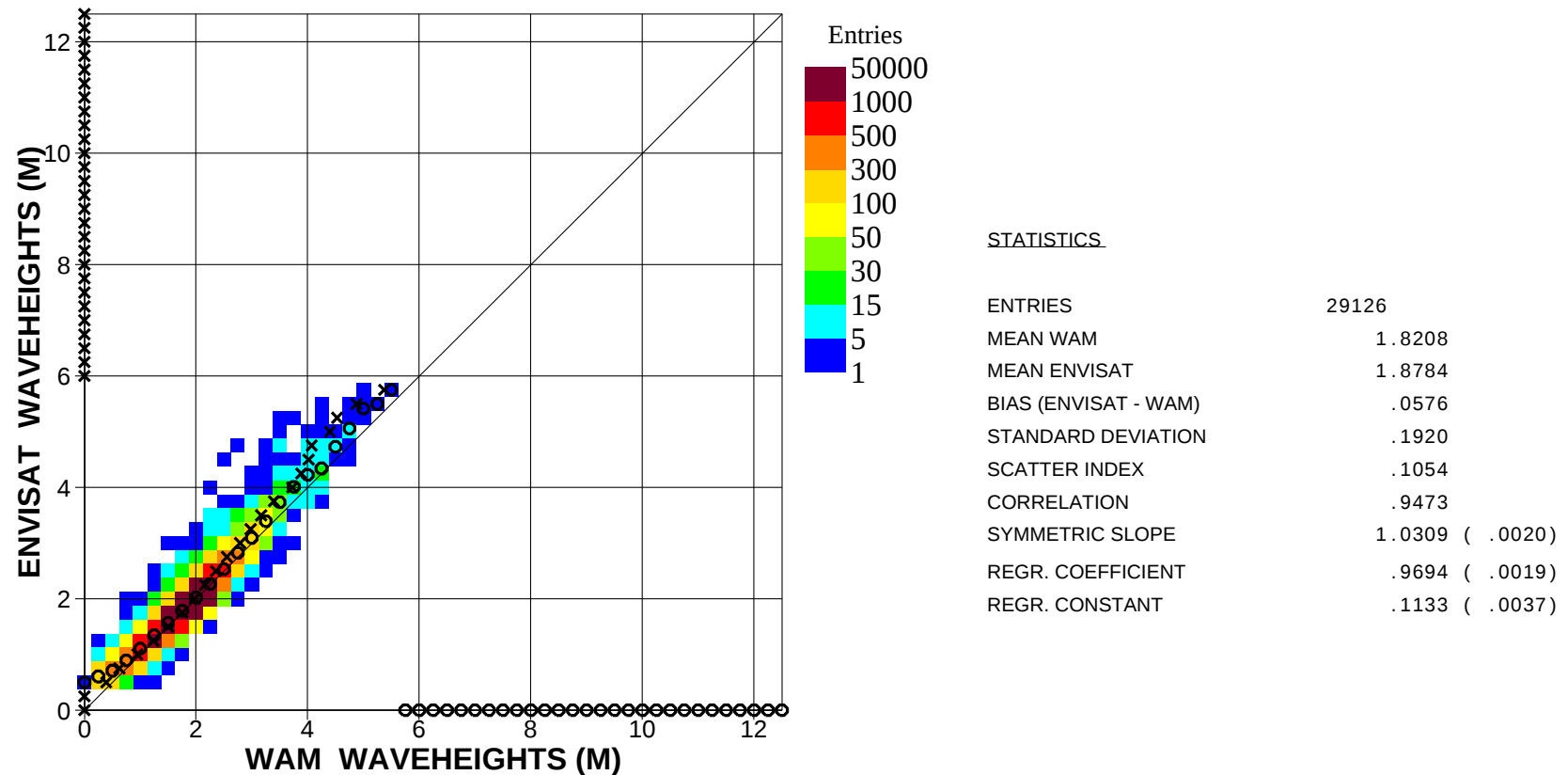


Figure 24. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for November 2005 (Tropics)

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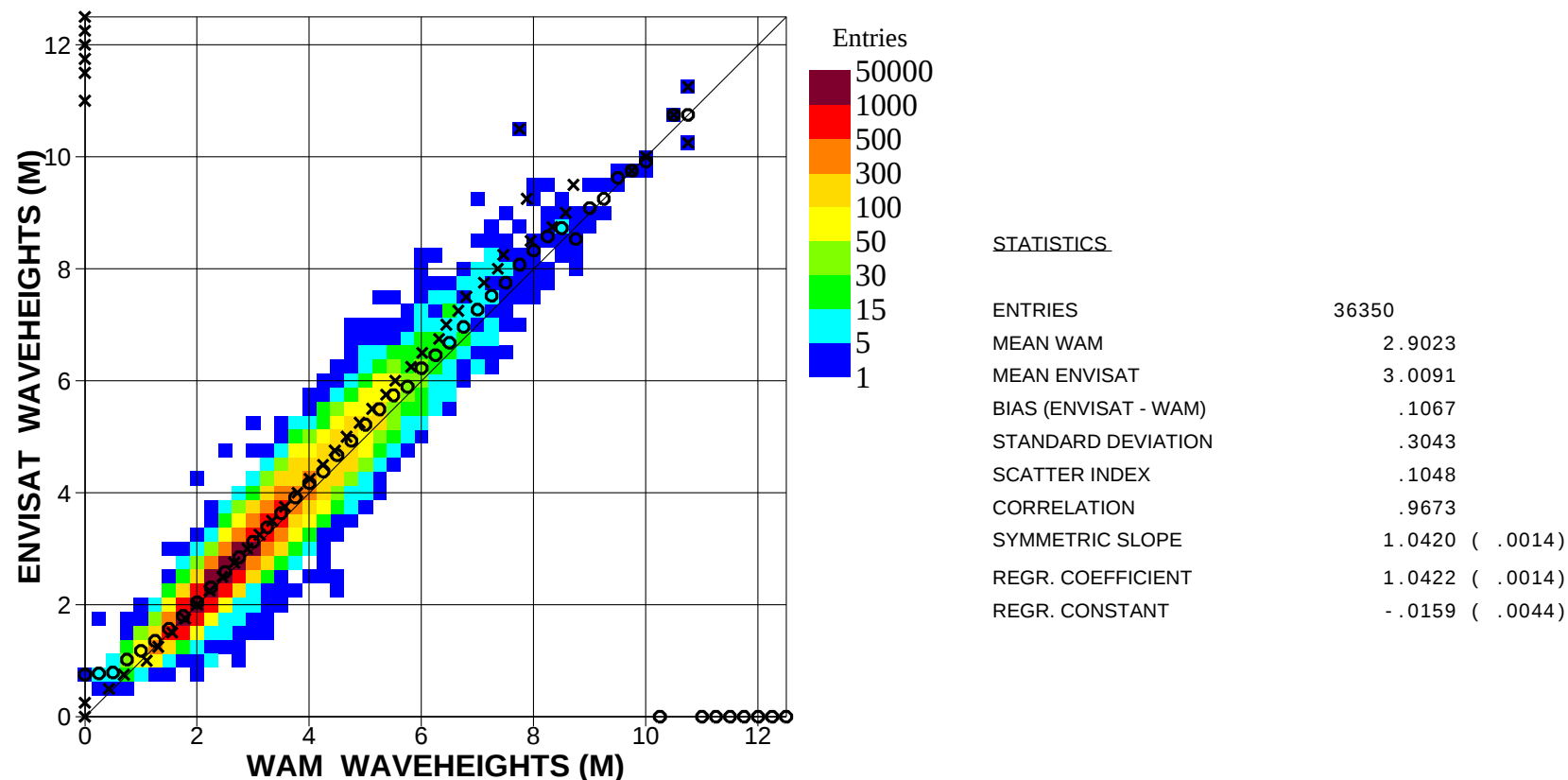


Figure 25. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for November 2005 (S.Hem.)

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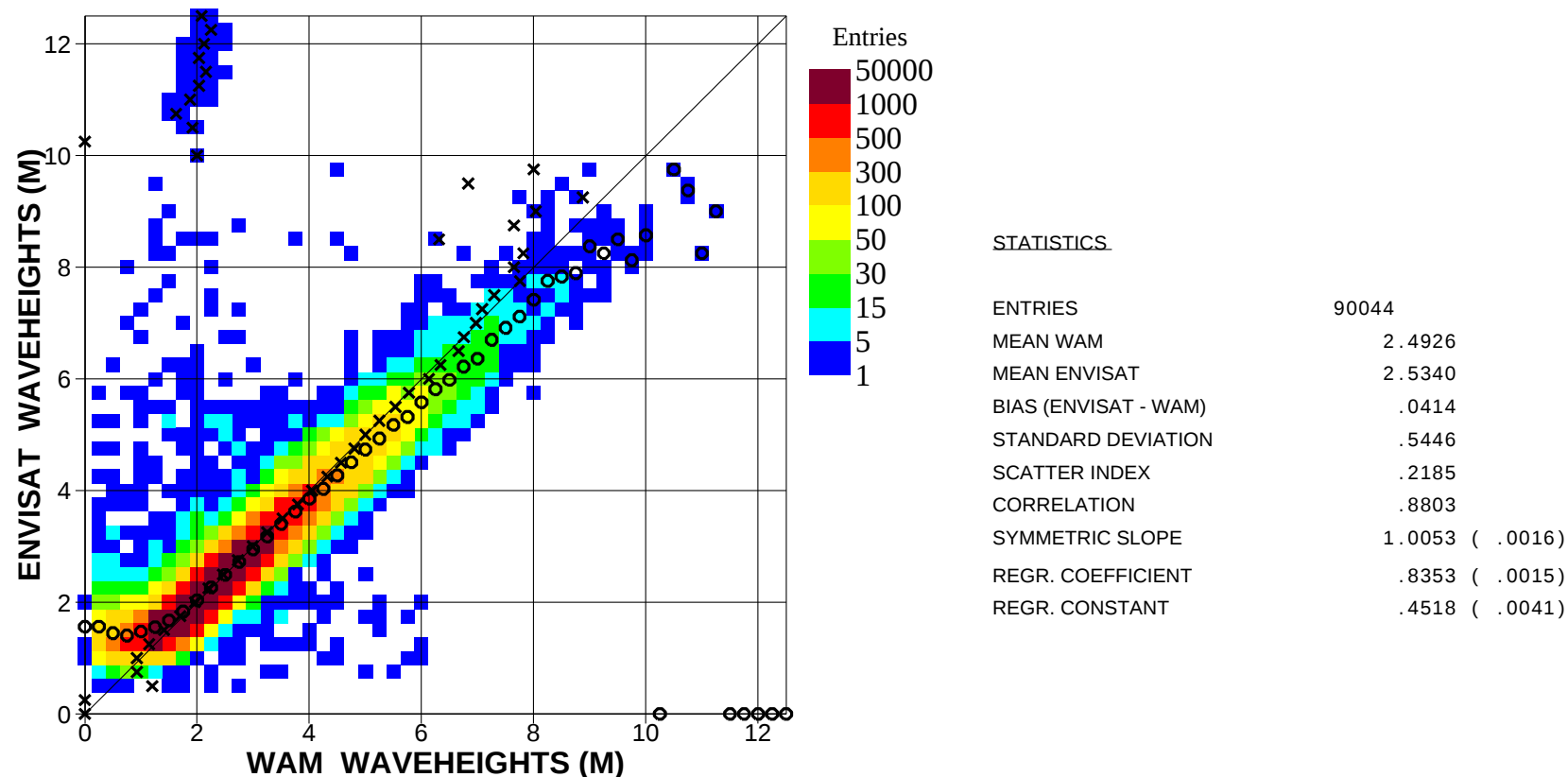


Figure 26. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for November 2005 (Global)

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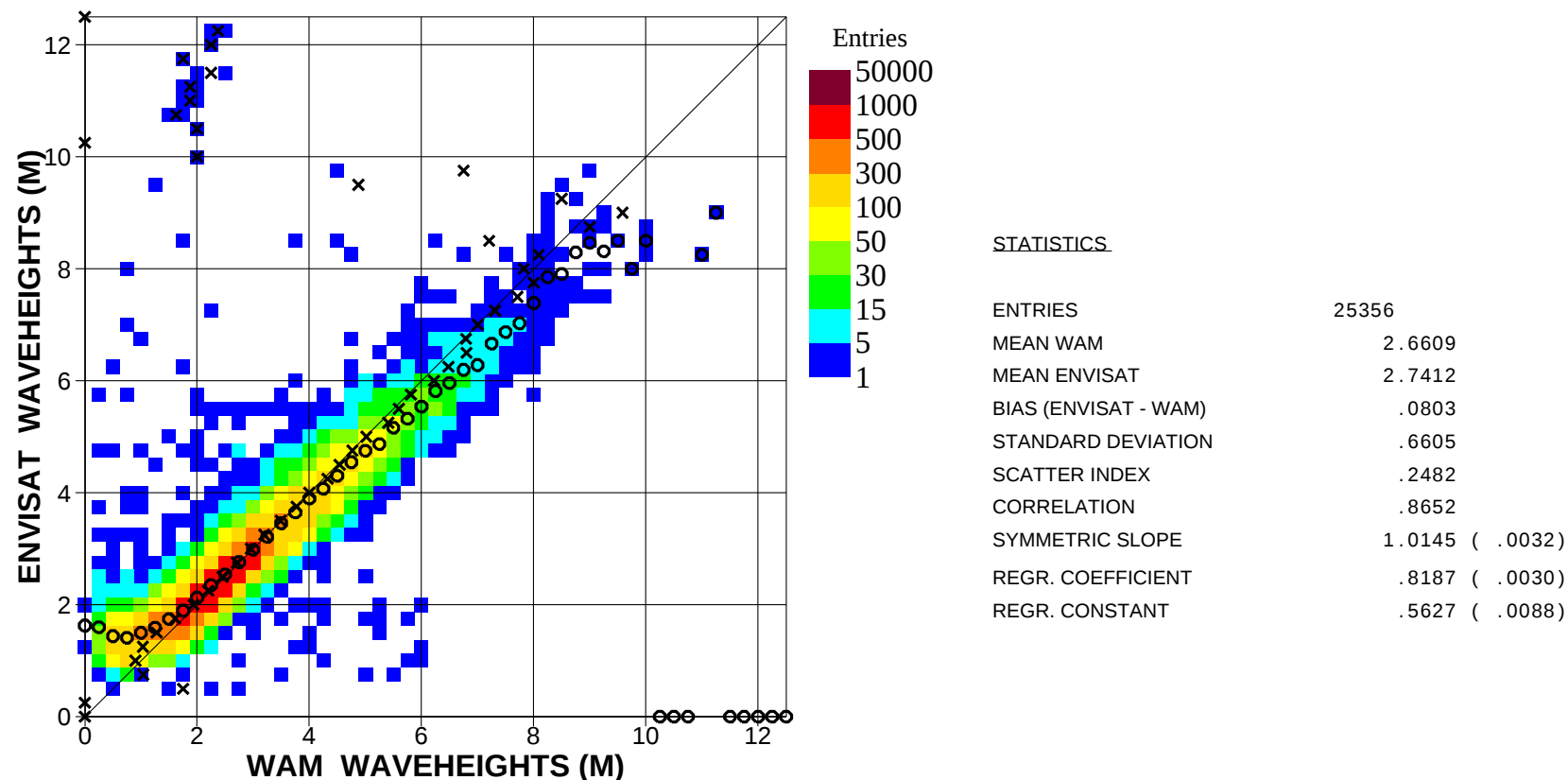


Figure 27. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for November 2005 (N.Hem.)

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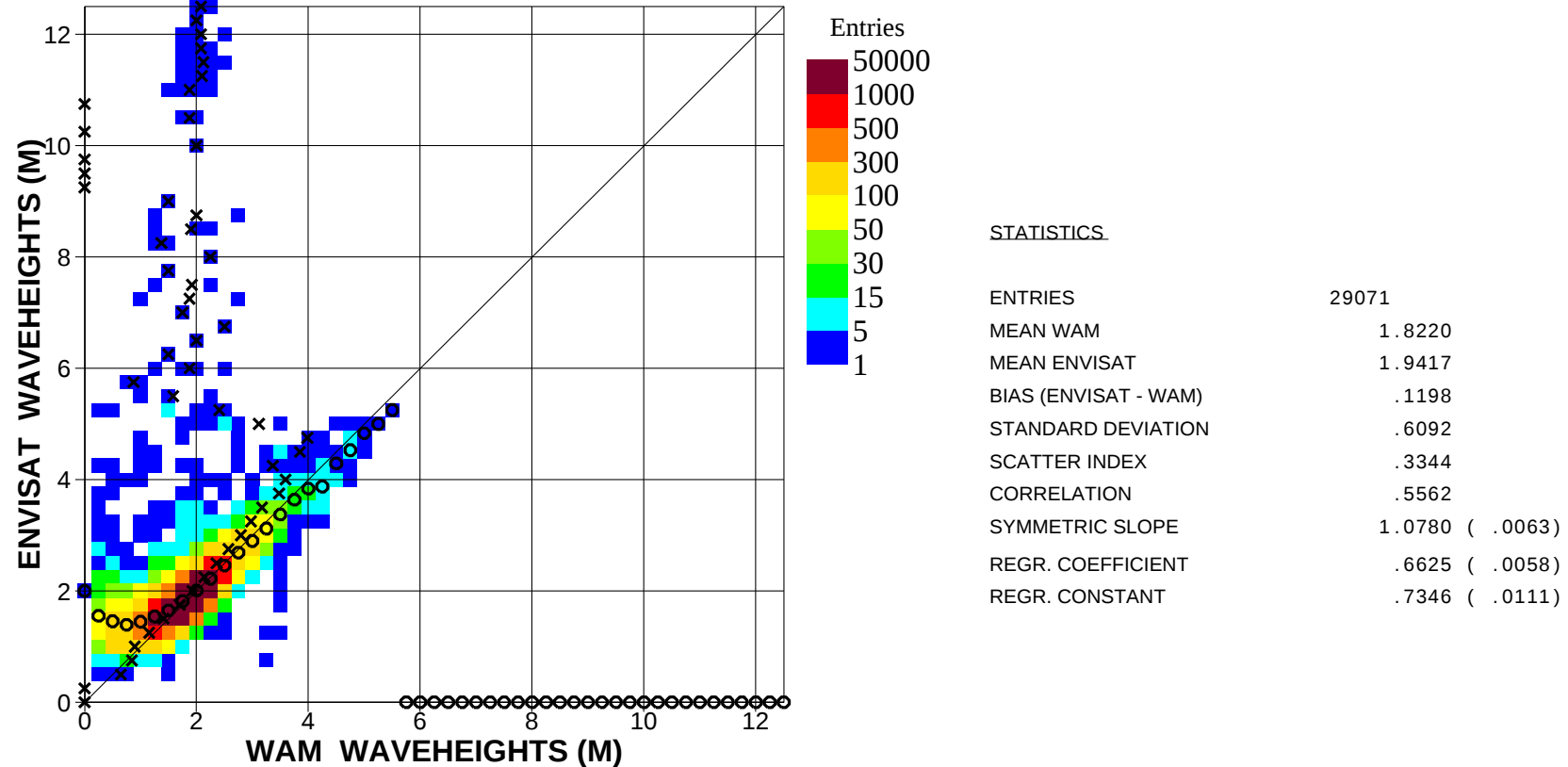


Figure 28. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for November 2005 (Tropics)

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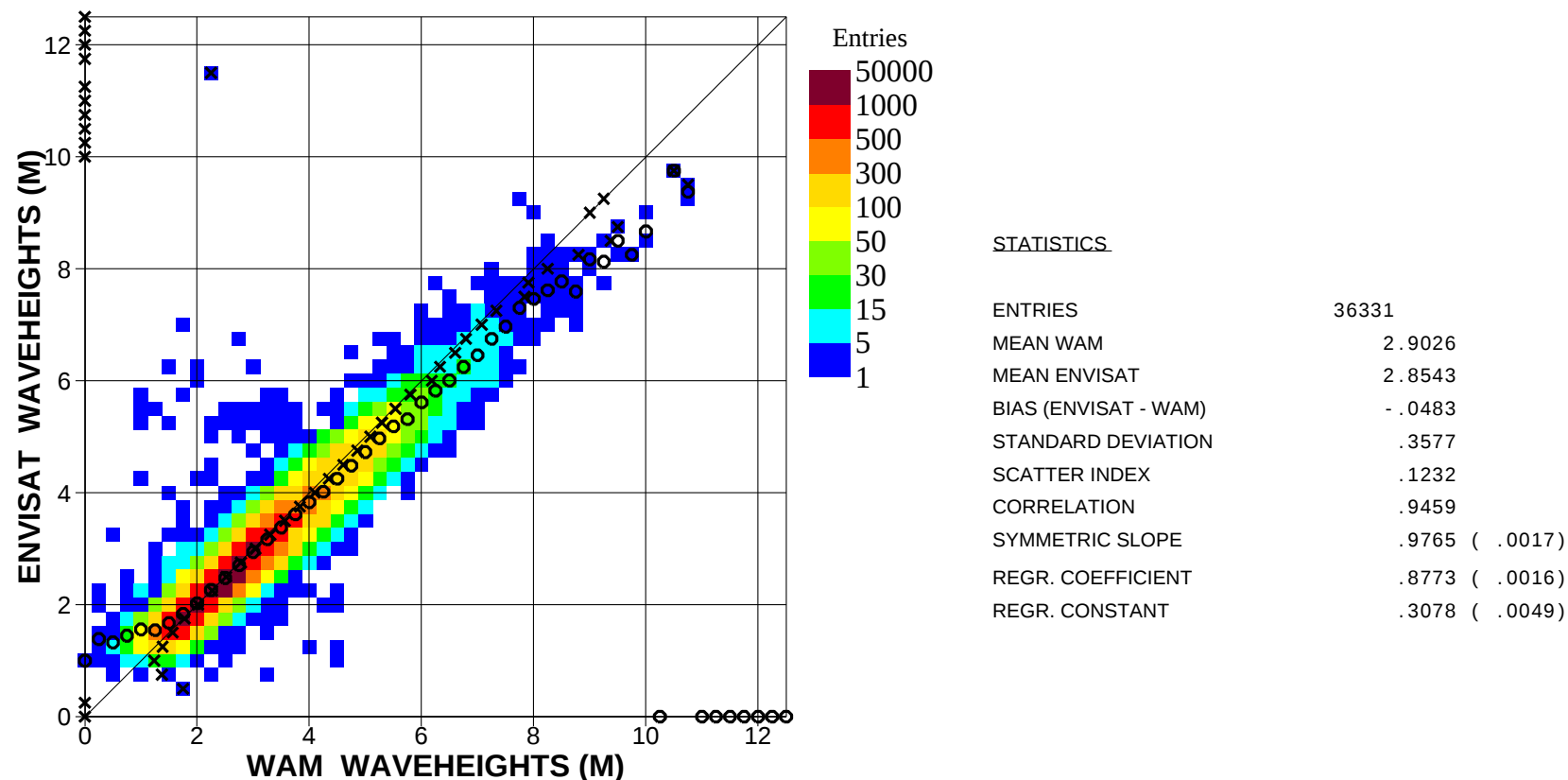


Figure 29. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for November 2005 (S.Hem.)

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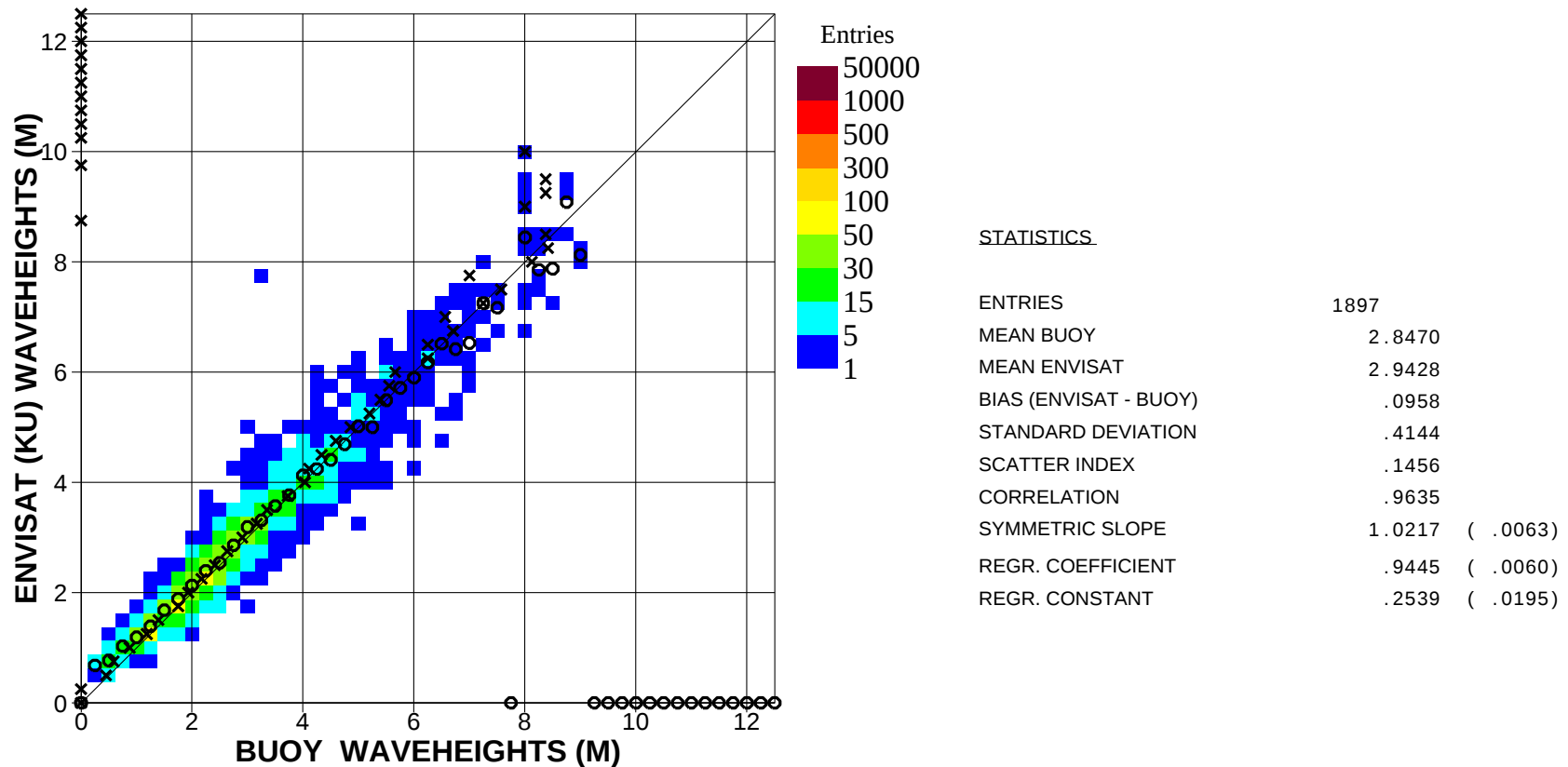


Figure 30. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for November 2005 (Global)

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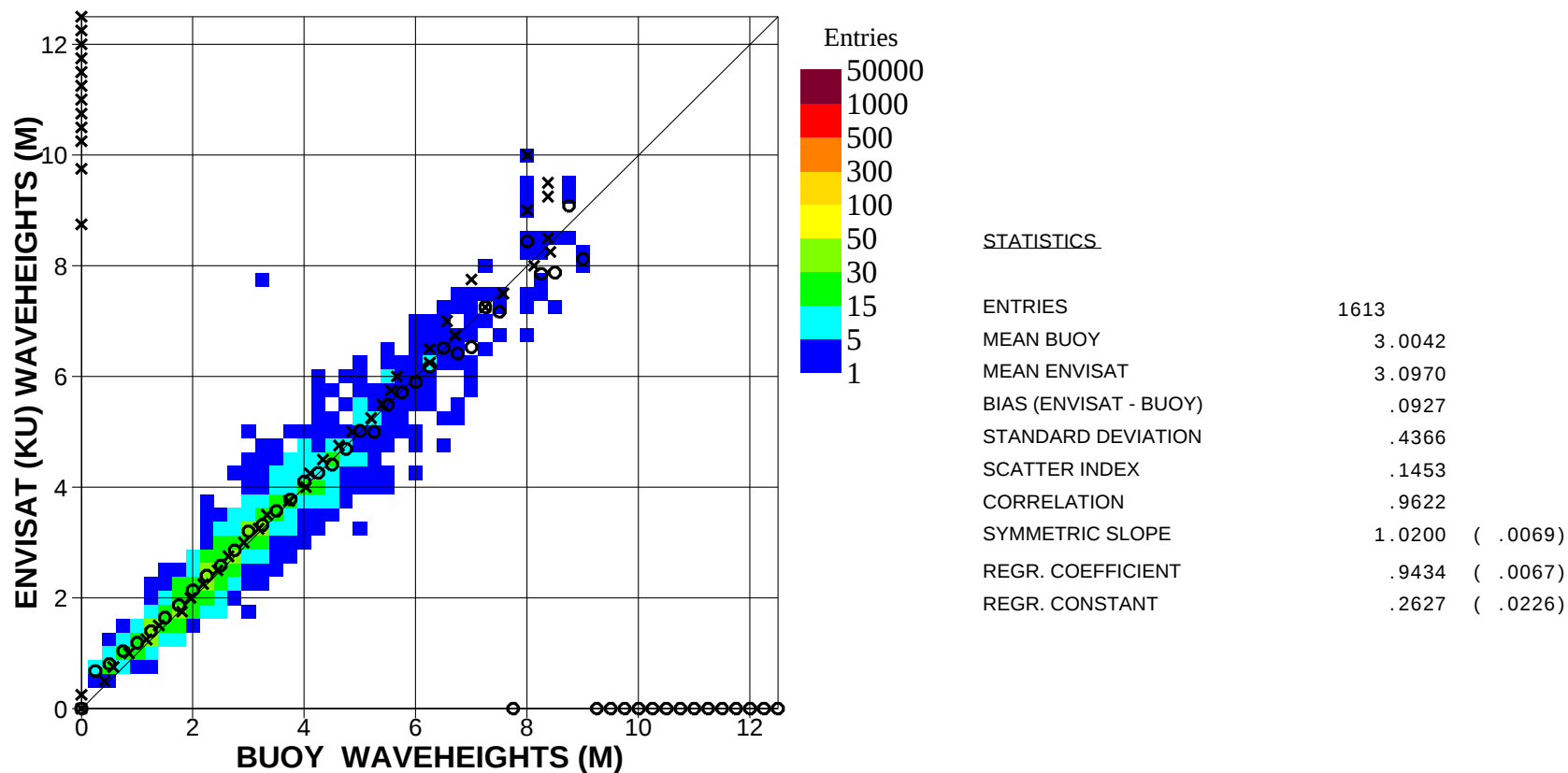


Figure 31. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for November 2005 (N.Hem.)

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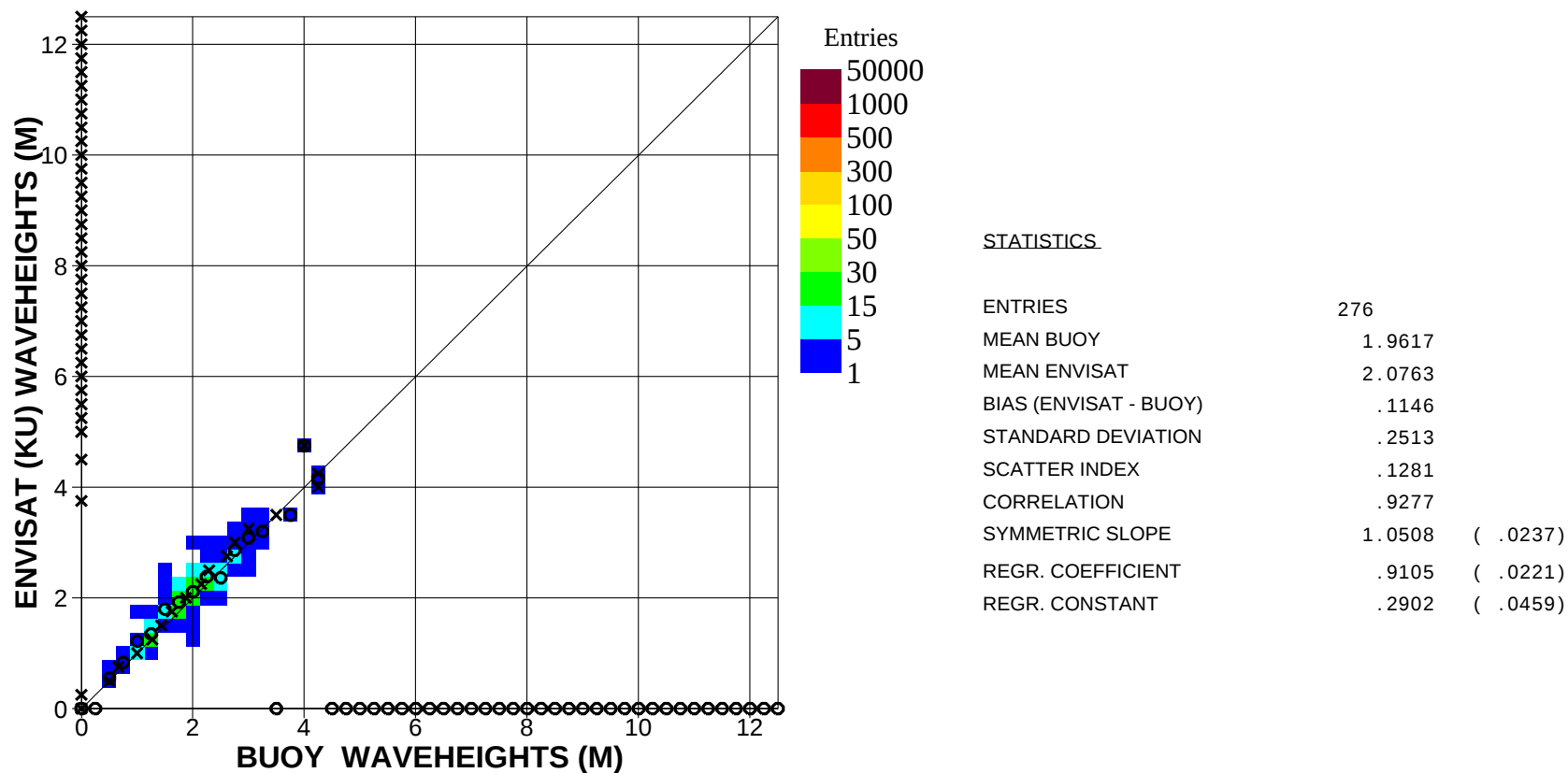


Figure 32. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for November 2005 (Tropics)



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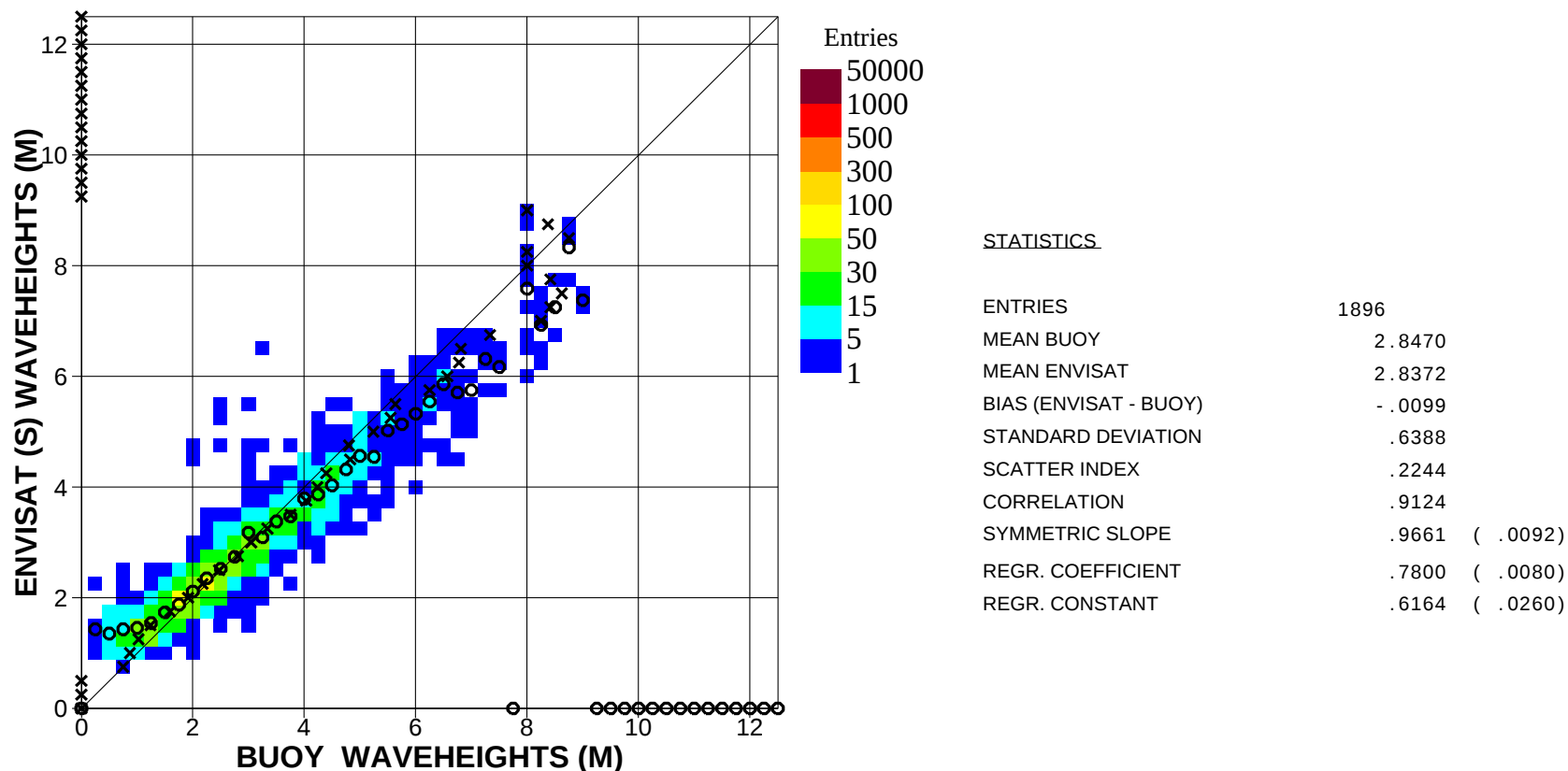


Figure 33. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for November 2005 (Global)

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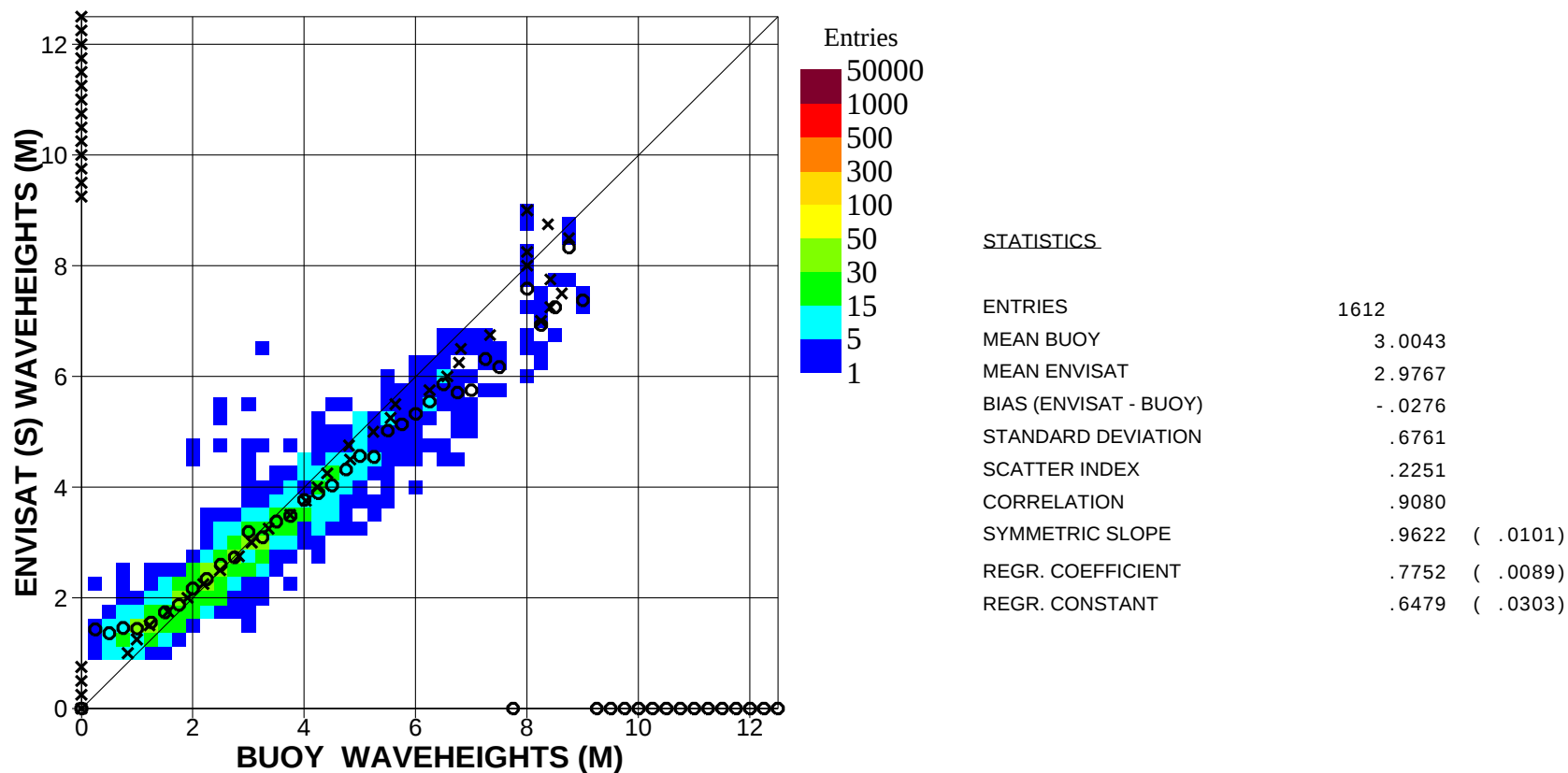


Figure 34. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for November 2005 (N.Hem.)

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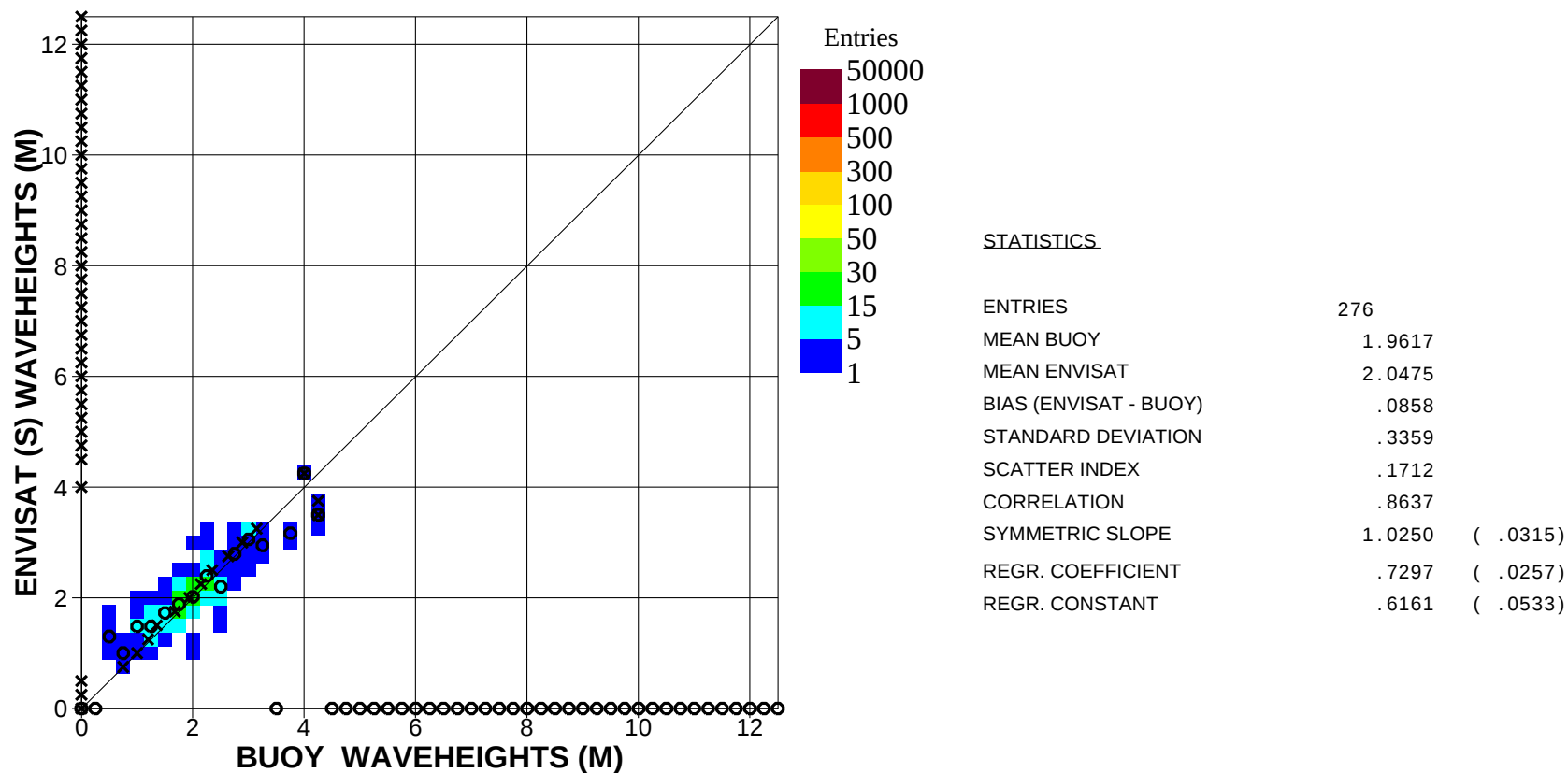


Figure 35. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for November 2005 (Tropics)

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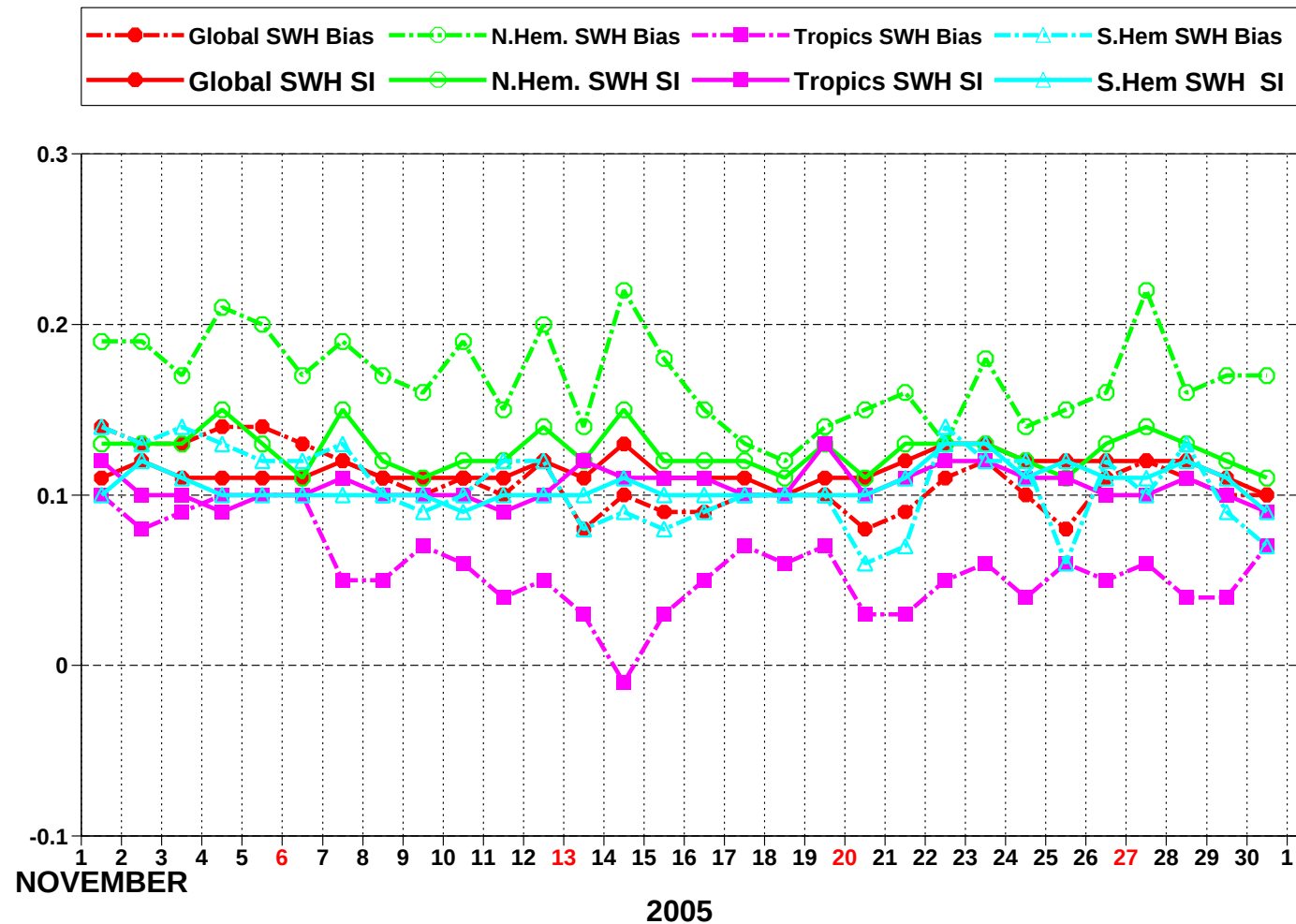


Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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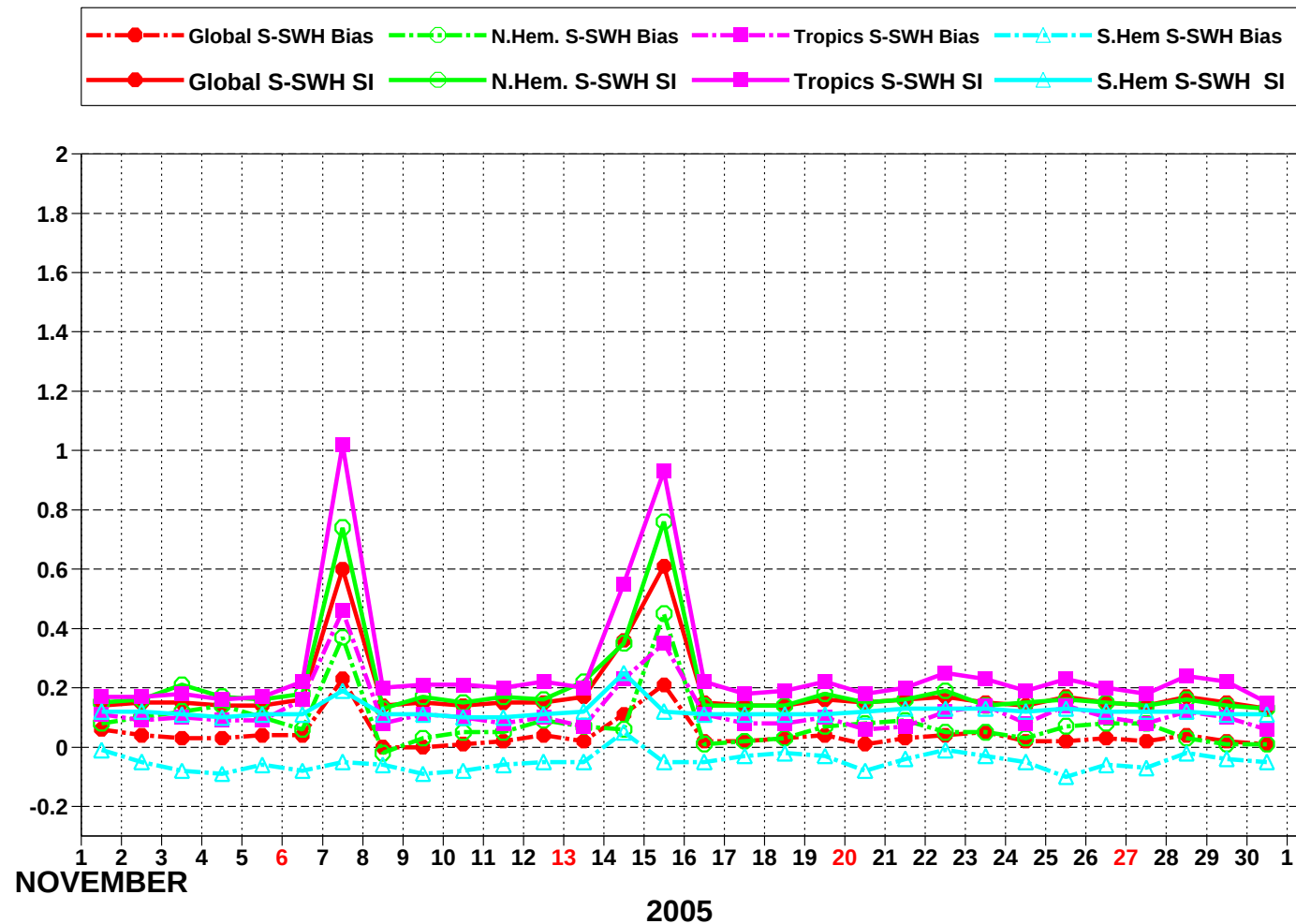


Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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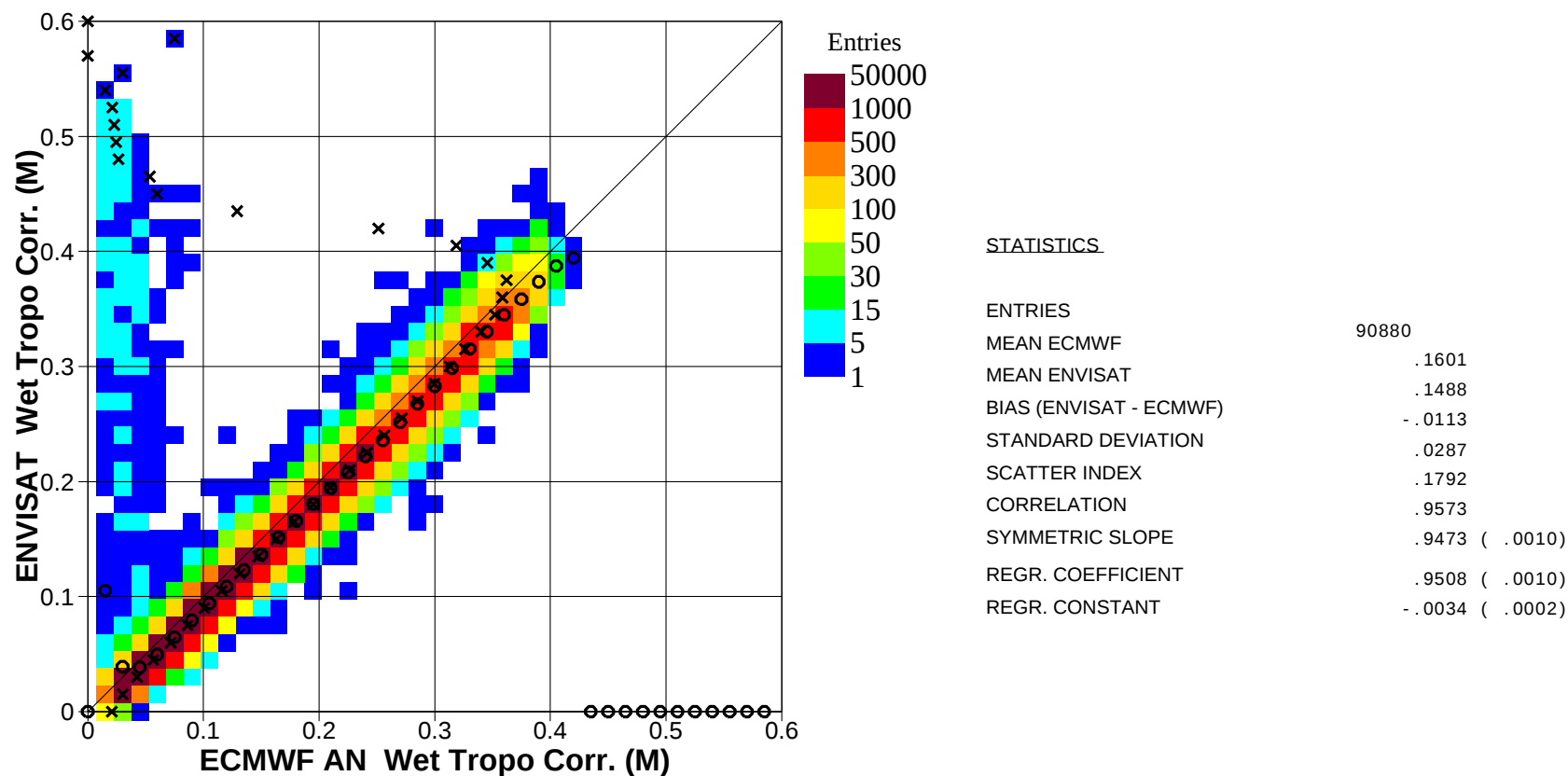


Figure 38. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for November 2005 (Global)

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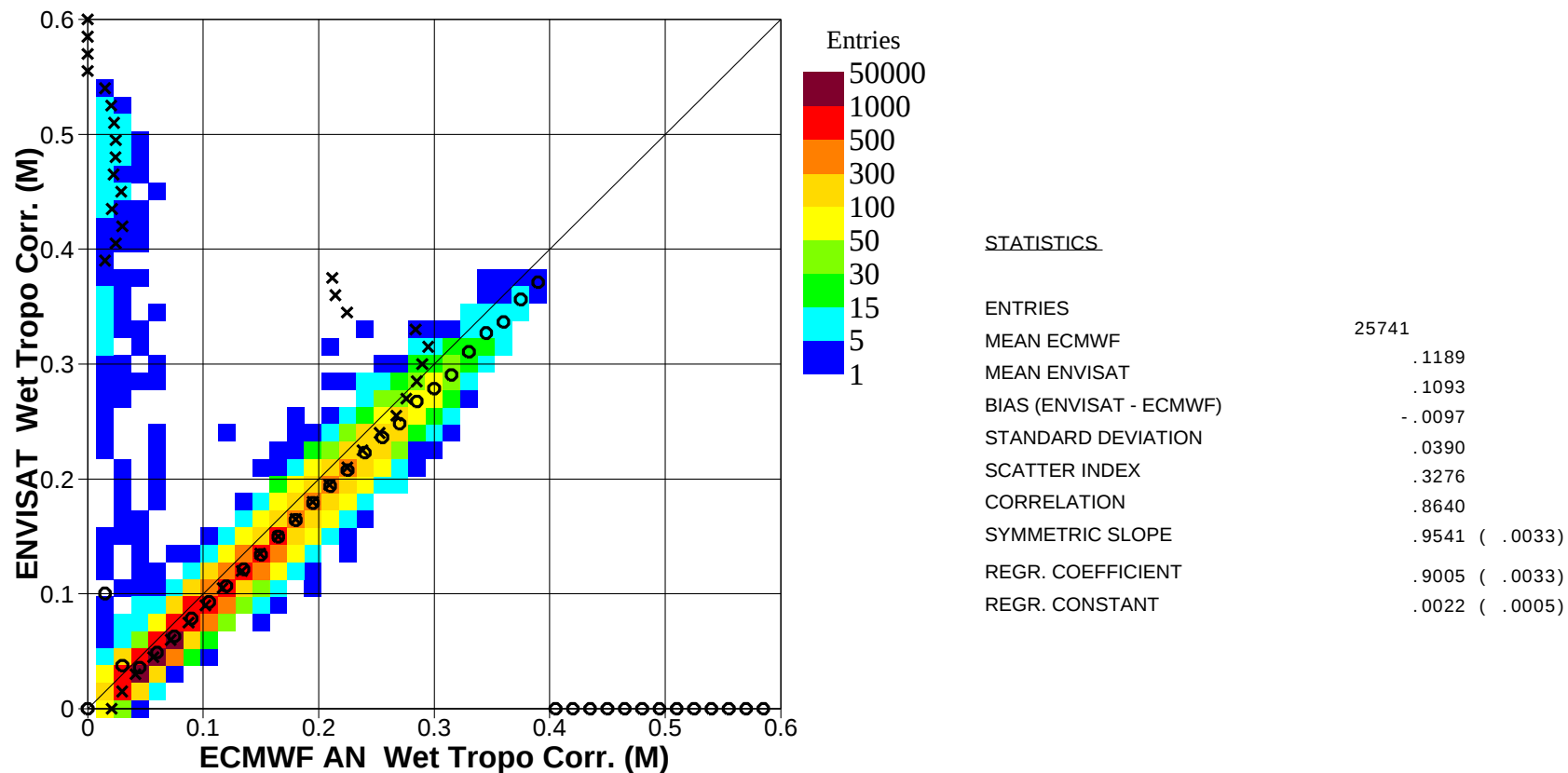


Figure 39. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for November 2005 (N.Hem.)

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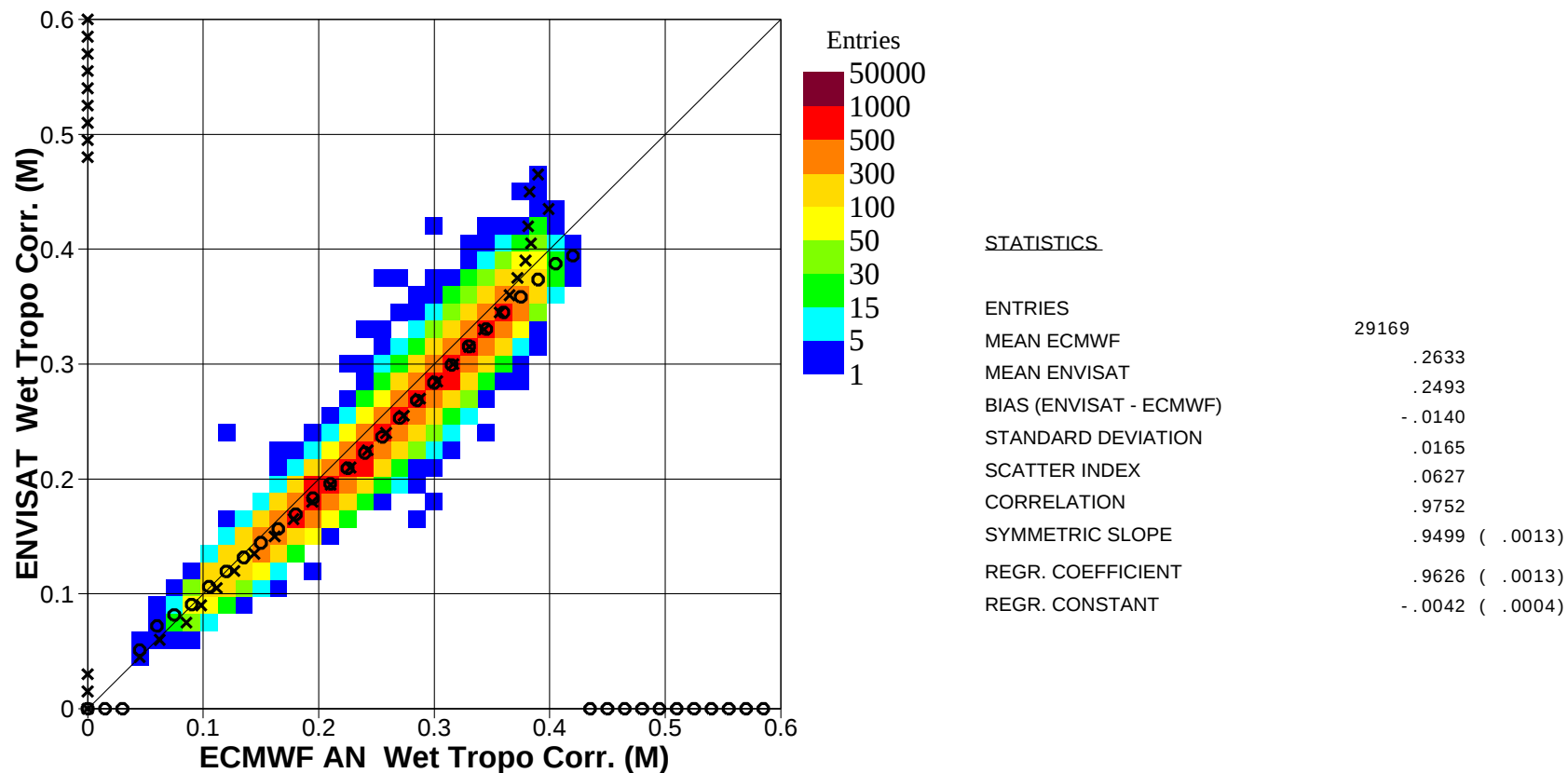


Figure 40. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for November 2005 (Tropics)

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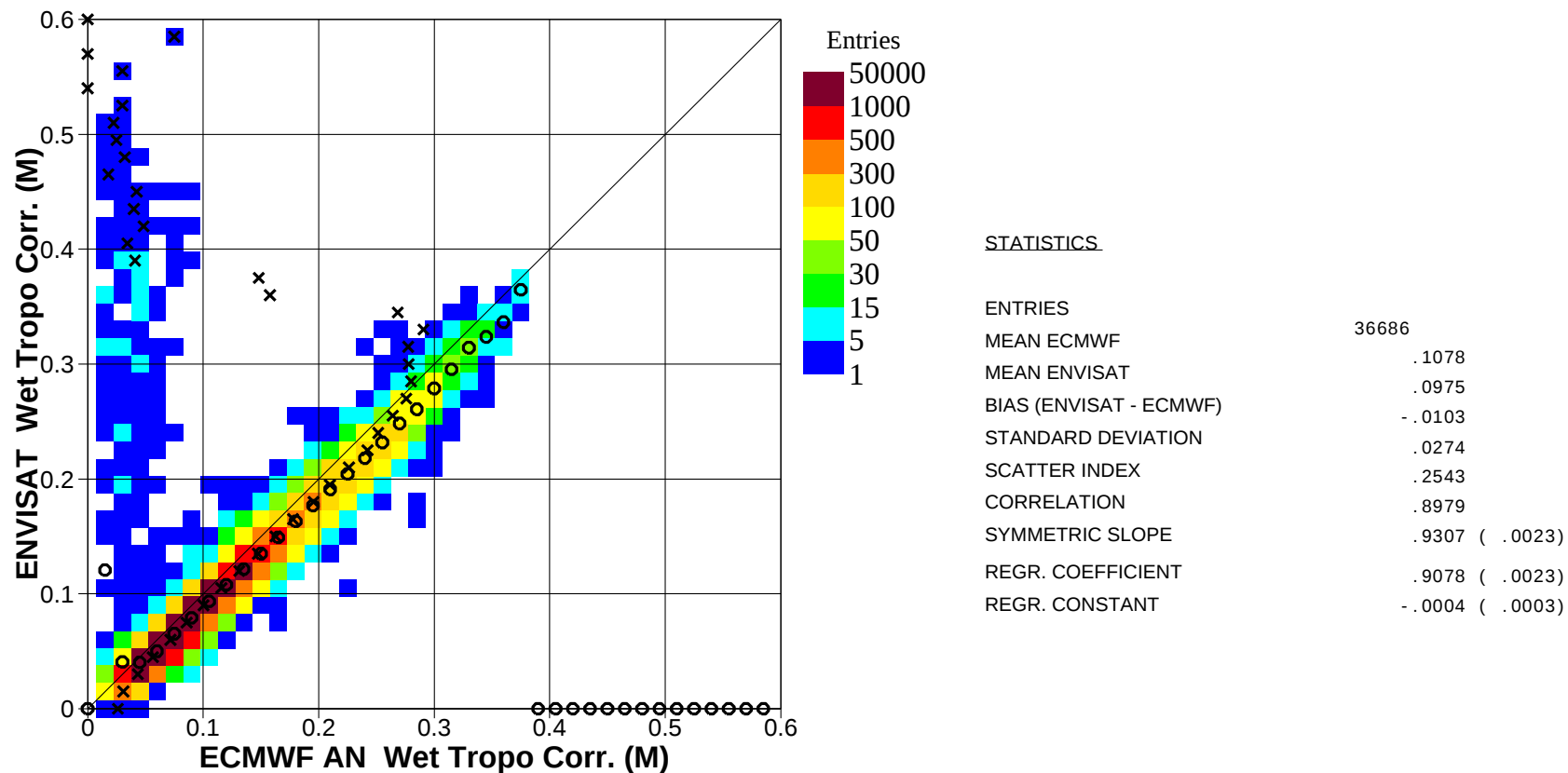


Figure 41. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for November 2005 (S.Hem.)

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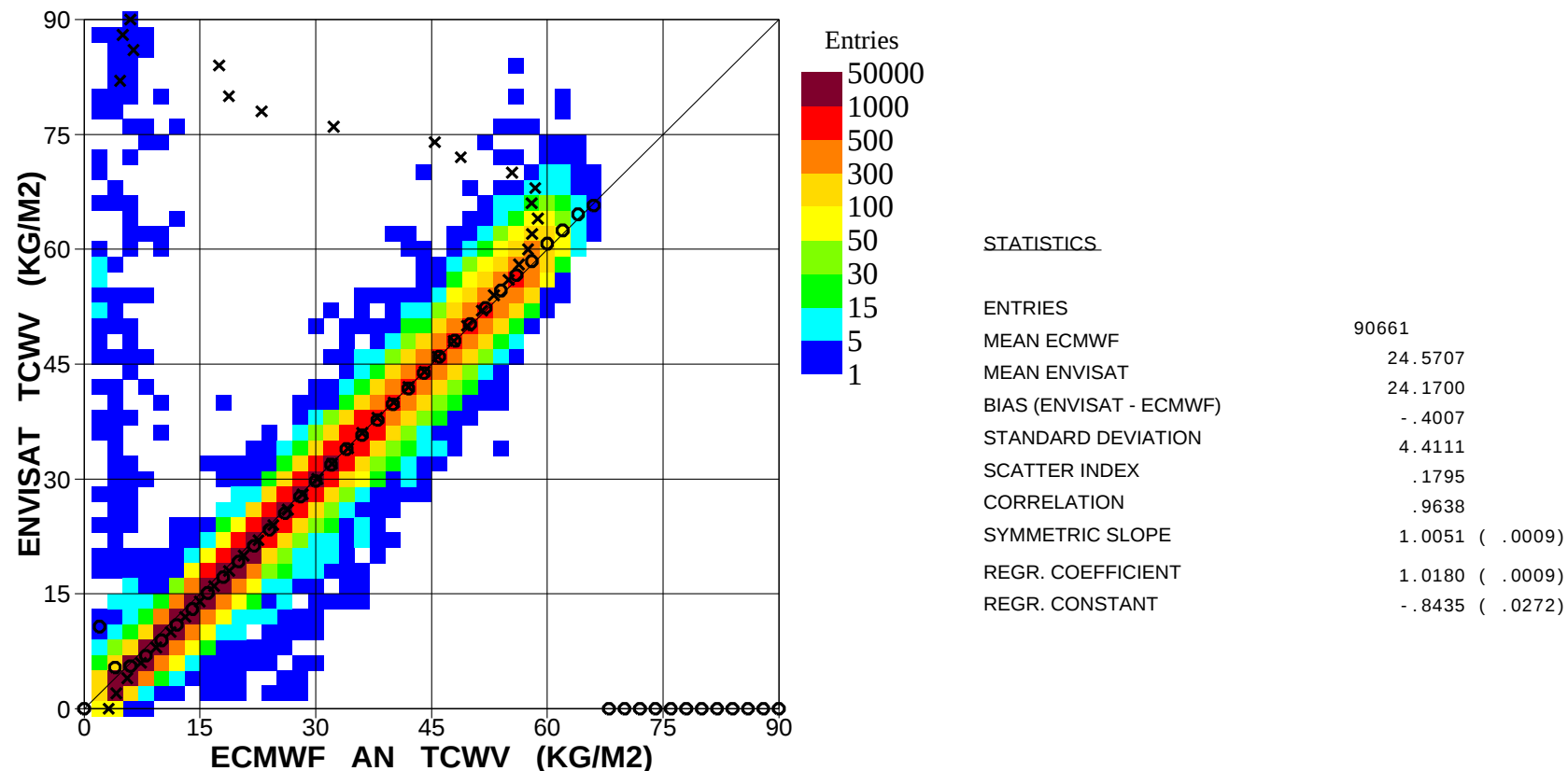


Figure 42. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for November 2005 (Global)

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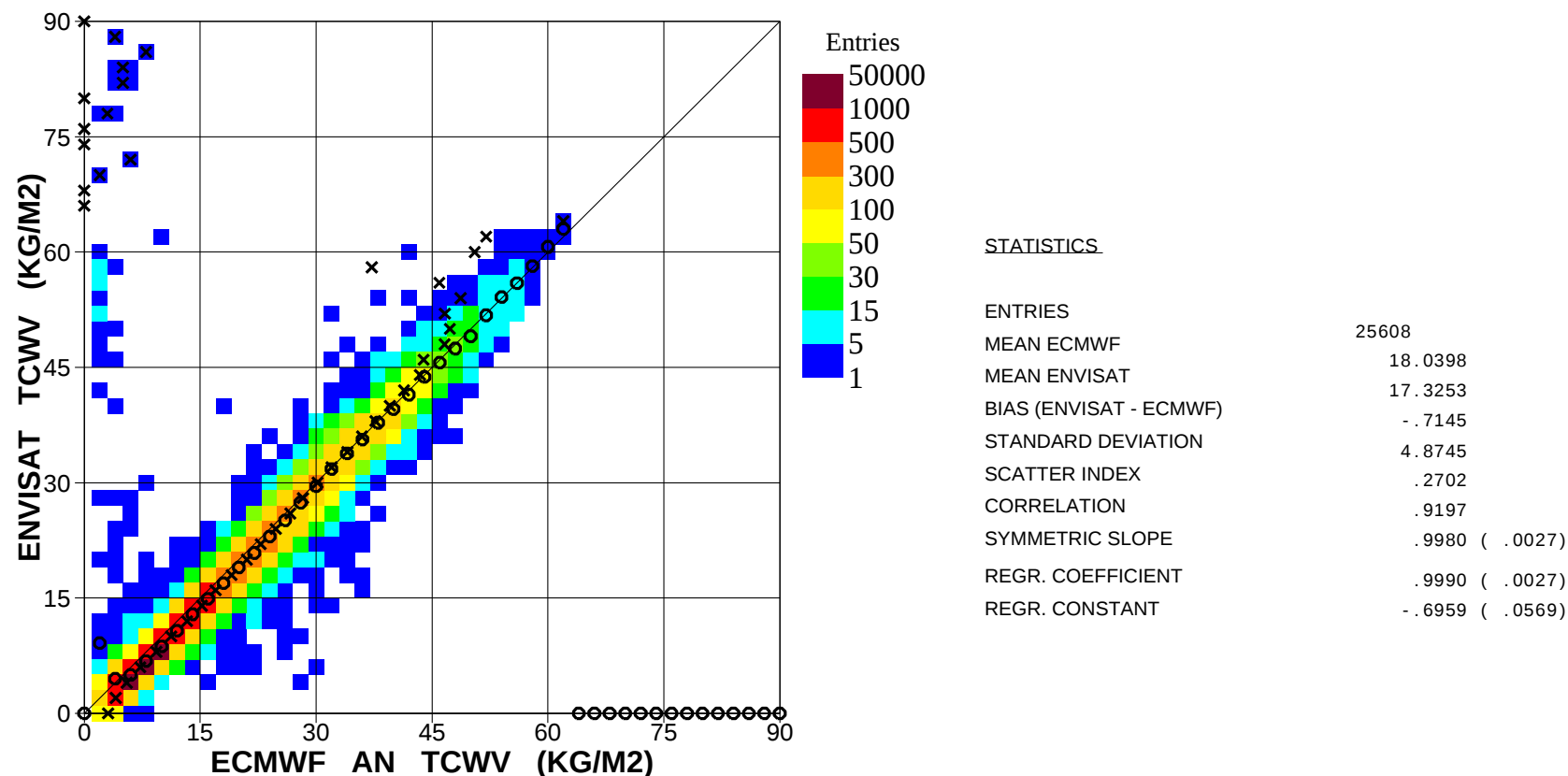


Figure 43. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for November 2005 (N.Hem.)

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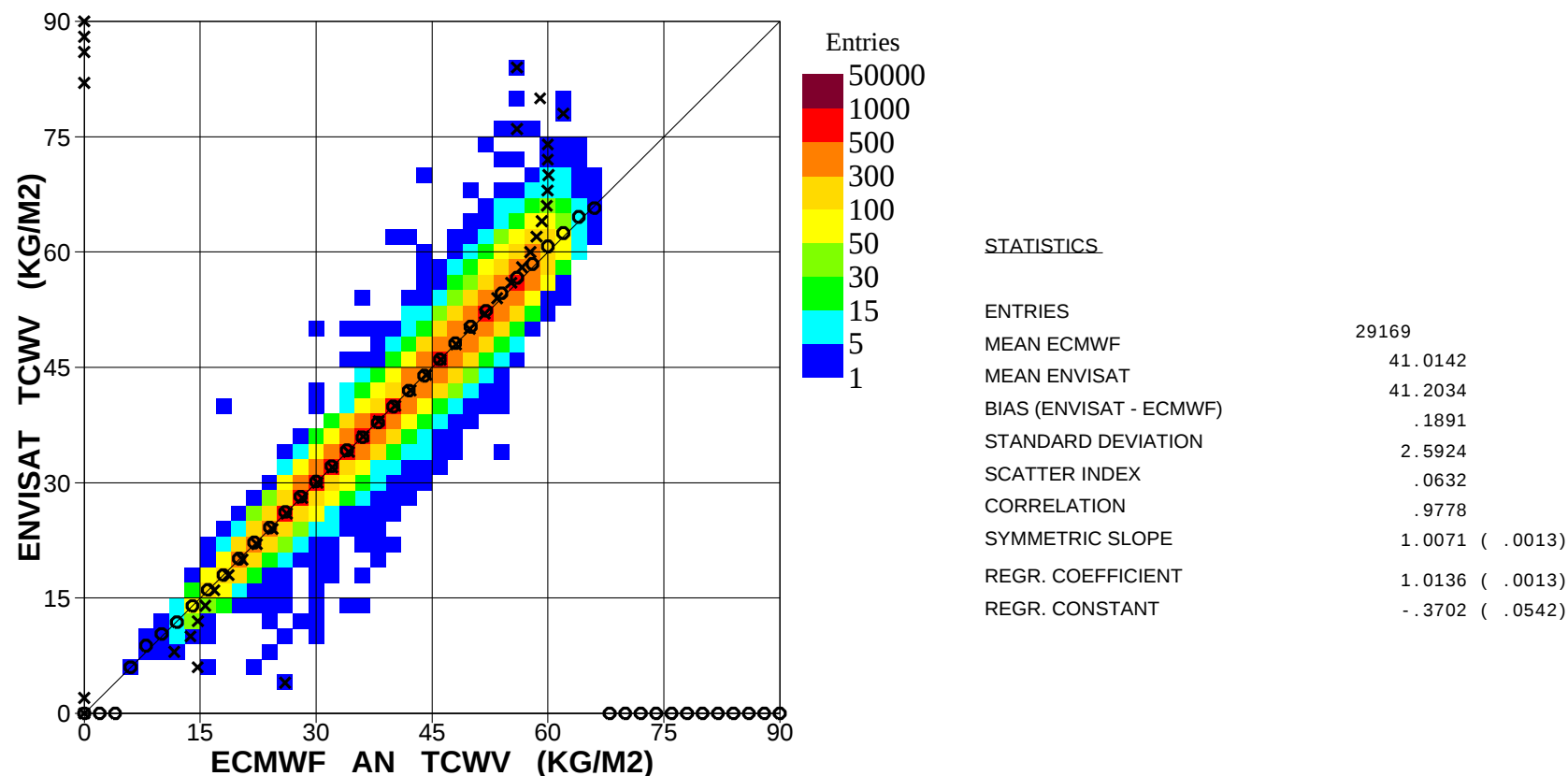


Figure 44. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for November 2005 (Tropics)



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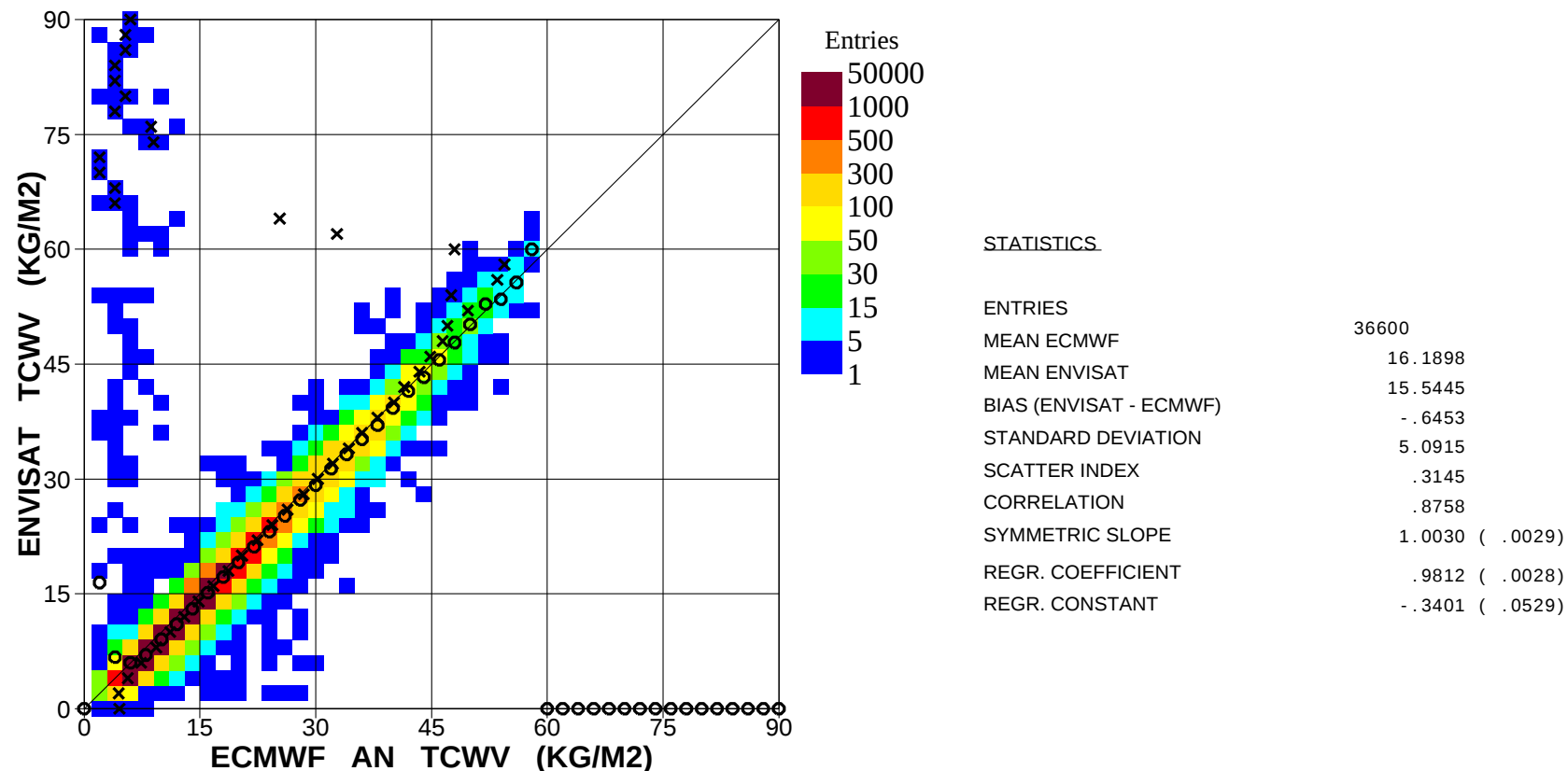


Figure 45. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for November 2005 (S.Hem.)



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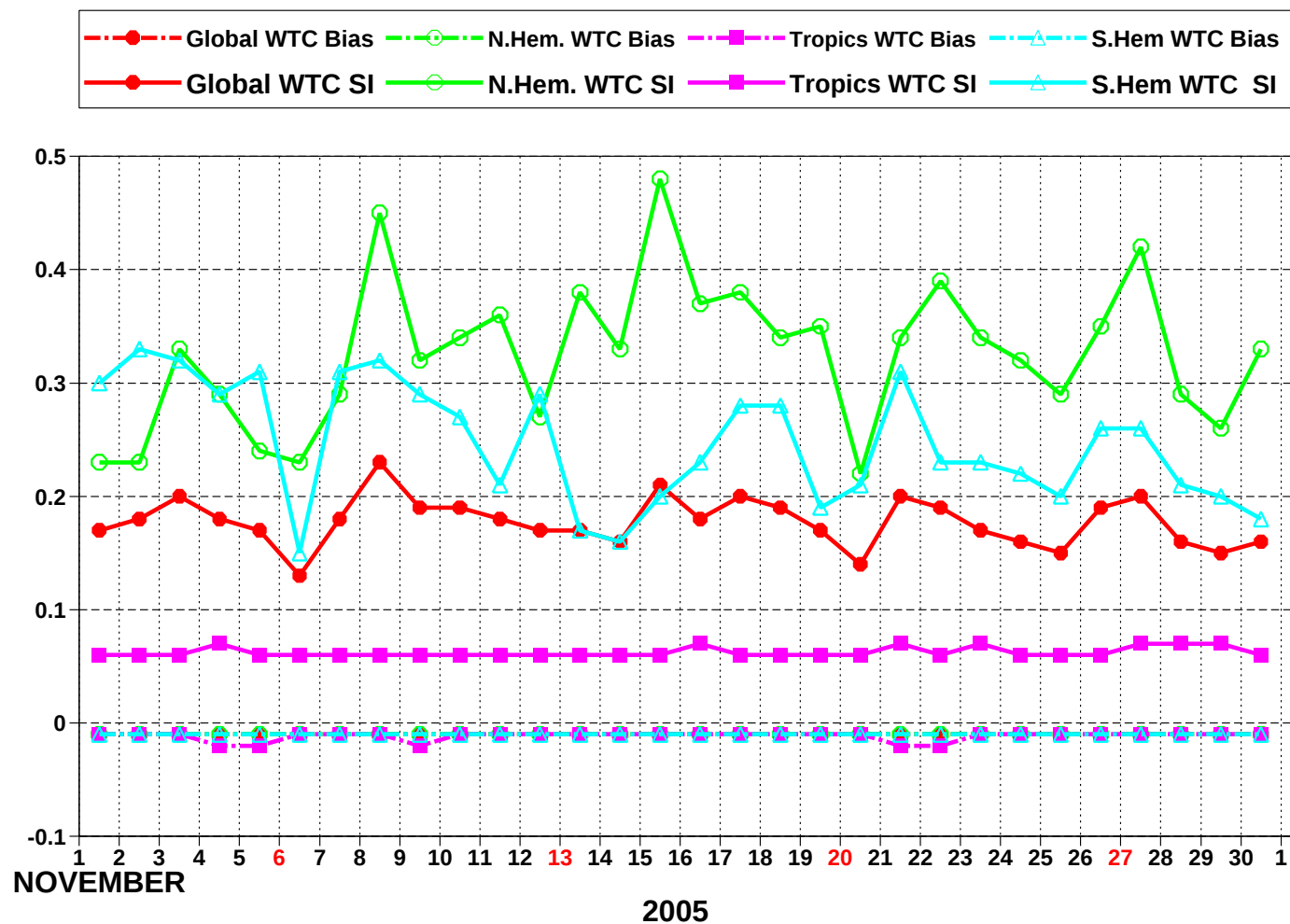


Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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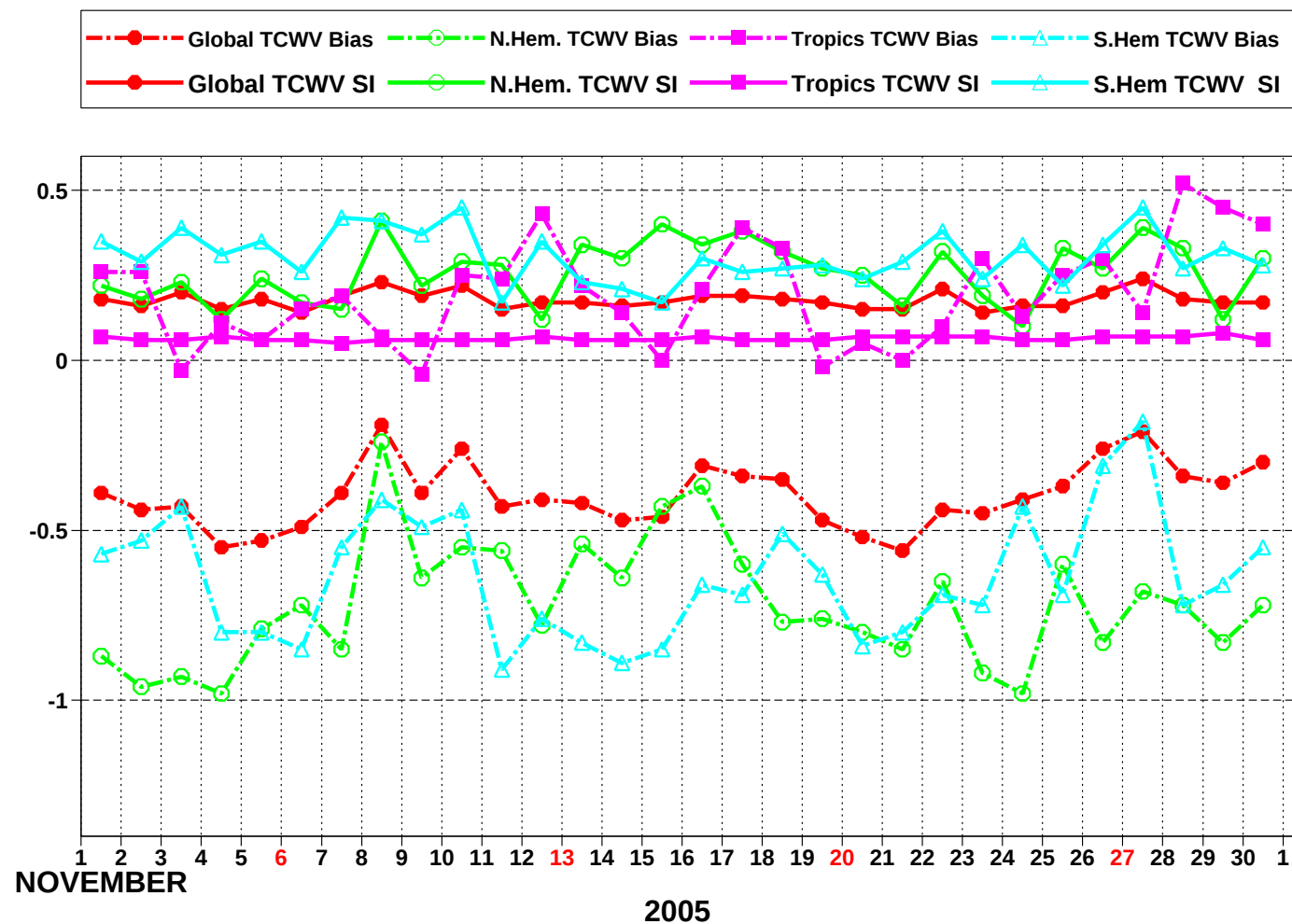


Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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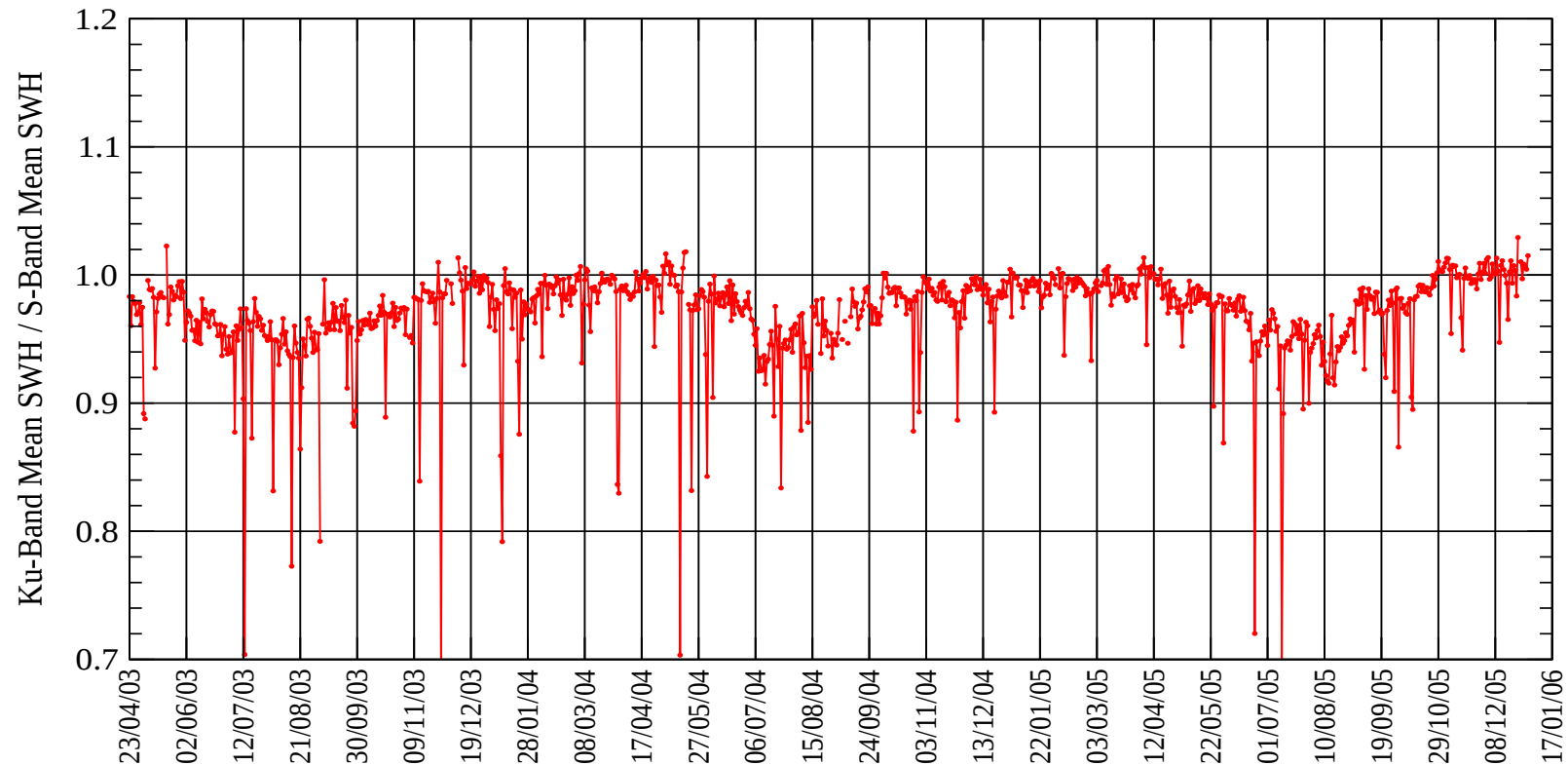


Figure 48: Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 23rd. of April 2003.

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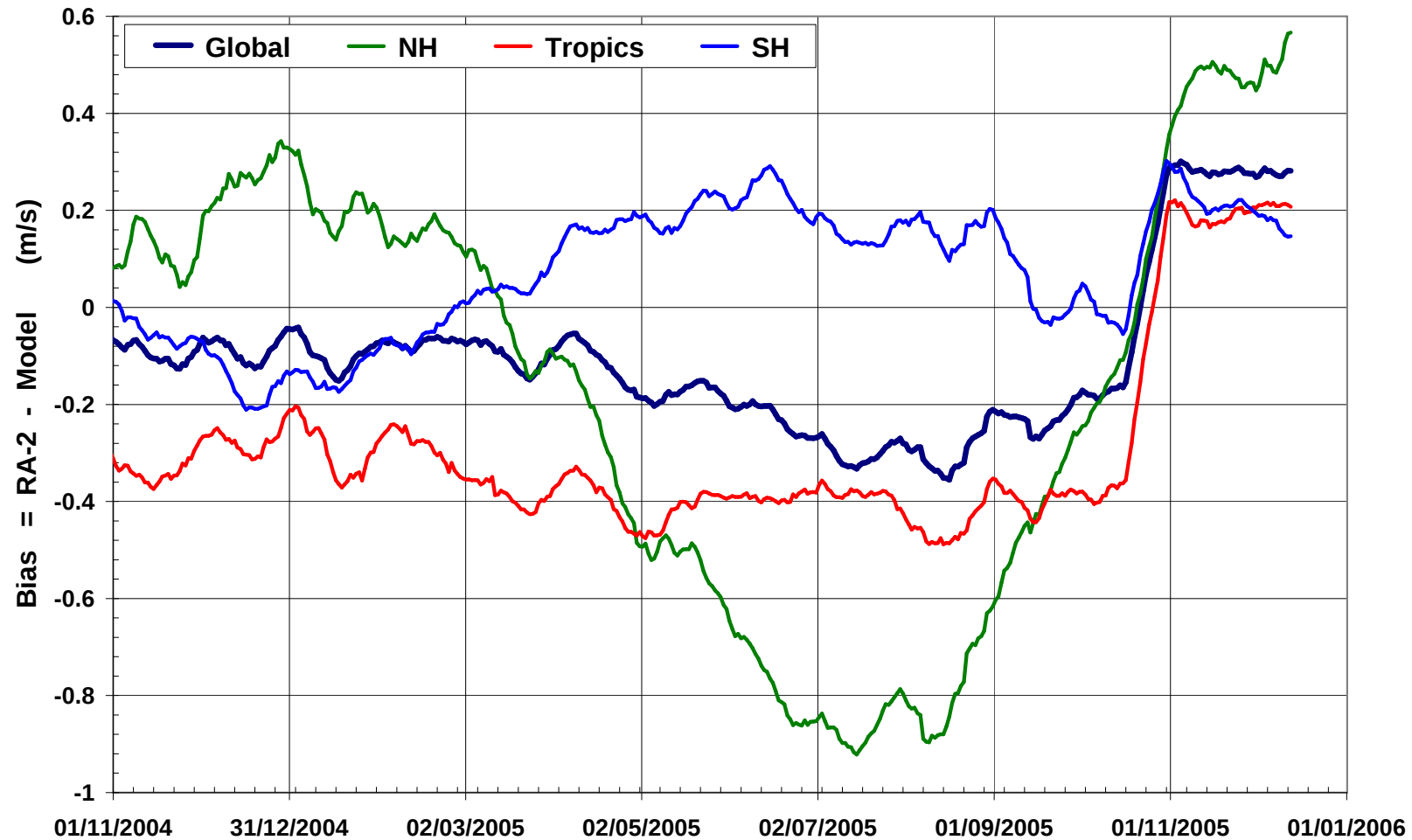


Figure 49: Timeseries of wind speed bias between RA-2 and ECMWF model AN over the last year.

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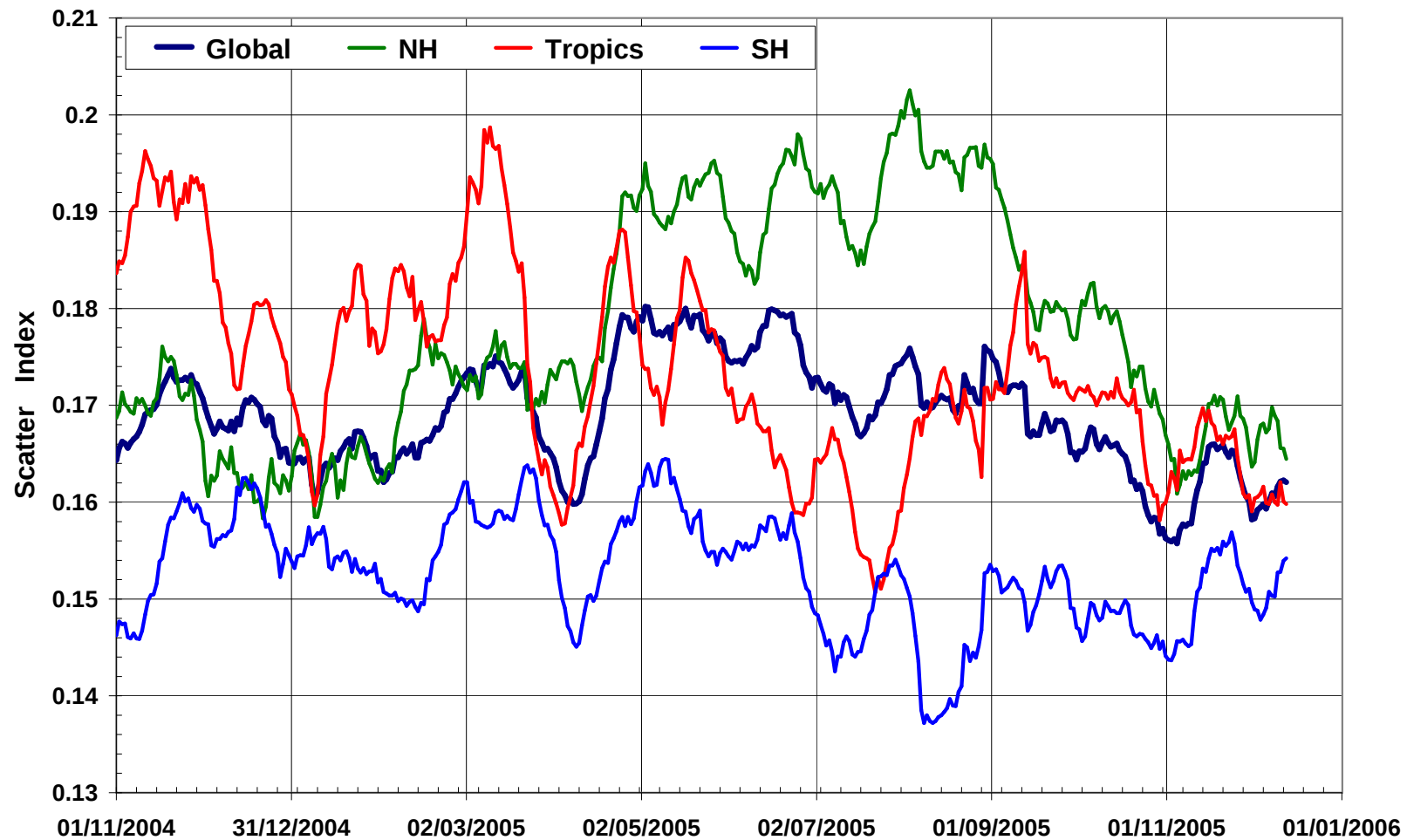


Figure 50: Timeseries of wind speed SI between RA-2 and ECMWF model AN over the last year.

