

■ ECMWF Report on ENVISAT RA-2 for December 2006 ■

Report on ENVISAT Radar Altimeter - 2 (RA-2) **Wind/Wave Product with Height Information (RA2 WWV 2P)**

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Overview:

Based on the data received during this month, on average, 11730 observations arrived at ECMWF every 6-hour window of which an average of 4670 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 79.64% of the remaining part passed the quality control. As can be seen in Figure 1, there was no data during the following periods (in terms of 6-hour time windows):

- time windows centred at 12:00 UTC on the 7th. and the 9th. of the month,
- time windows from 10:00 UTC on the 13th. till 18:00 UTC on the 15th. of the month (both inclusive),
- time windows centred at 12:00 and 18:00 UTC on the 17th. of the month, and
- time windows centred at 12:00 UTC on the 26th., the 27th., the 28th., the 29th. and the 30th. of the month, and
- time windows centred at 06:00 and 12:00 UTC on the 31st. of the month.

Furthermore, there was some reduction in data volume during several other time windows.

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.



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Quality of Received Data:

For the period covered, the RA-2 Ku-band wave height data are generally of very good quality. The S-band wave height observations, after removing the S-band anomaly related outliers, are of good quality. The quality of wind speed observations is as good as usual. The MWR products, after removing the ice contaminated observations, are generally in good agreement with the model (wet tropo correction is somewhat smaller than the model). **The S-band significant wave height is lower than usual after the implementation of the IPF 5.03.**

Backscatter:

- ENVISAT Ku-band $\langle\sigma^0\rangle = 10.954$ dB (with a main peak at 11.1 dB and a secondary peak at 10.6 dB).
- ENVISAT S-band $\langle\sigma^0\rangle = 11.19$ dB (with a main peak at 10.6 dB and a secondary peak at 10.8 dB).

Comparison Summary:

Table 1: Comparison of Surface Wind Speeds:

	RA2 - ECMWF		RA2 - Buoy	
	Bias (m/s)	SI (%)	Bias (m/s)	SI (%)
Global	+ 0.27	14.9	+ 0.13	16.4
Northern Hemisphere	+ 0.52	14.9	+ 0.25	16.7
Tropics	+ 0.18	14.5	- 0.62	10.5
Southern Hemisphere	+ 0.17	14.4	----	----



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

	RA2 (Ku) - WAM		RA2 (Ku) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.11	10.8	0.10	13.4
Northern Hemisphere	0.15	11.0	0.12	13.4
Tropics	0.09	10.1	0.03	11.7
Southern Hemisphere	0.09	10.3	----	----

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

	RA2 (S) - WAM		RA2 (S) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	- 0.11	14.2	- 0.26	15.4
Northern Hemisphere	- 0.14	13.9	- 0.27	15.3
Tropics	- 0.01	17.3	- 0.20	14.1
Southern Hemisphere	- 0.15	11.9	----	----



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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	- 0.012	8.9	- 0.35	9.2
Northern Hemisphere	- 0.011	11.7	- 0.76	11.8
Tropics	- 0.011	6.6	+ 0.68	6.2
Southern Hemisphere	- 0.012	10.9	- 0.85	11.0

Remarks:

- The ENVISAT RA-2 on-board anomaly related to the USO which started on the 13th. March 2006 (at ~17:40 UTC) does not have any impact on the wind and wave products. *Note that this remark applies to the instrument while configured to Side A (i.e. before 11:00 UTC on the 15th. of May 2006 and after 13:20 UTC on the 21st. of June 2006).*
- It is important to note that additional and stricter quality control criteria were used to eliminate the impact of “S-Band Anomaly” on S-Band significant wave height and the impact of ice (and land) contamination on MWR products. Therefore, most of the outliers used to exist in Figures 26-29 and 38-45 and extremely high scatter index values in Figures 37, 46 and 47 have been eliminated. This is reflected in reduced scatter index values in Tables 3 and 4.



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- 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.
- **The rain flag is responsible for the rejection of 4% of the data this month. The rain flag did not show any high activity during the whole 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 wind 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 ECMWF model. ENVISAT wind speed product is now about 27 cm/s higher than the model for this month. On the other hand, it is about 12 cm/s **higher** than the buoy measurements. The upper limit of the algorithm is 21.3 m/s.
- The Ku-band significant wave heights are higher by about 4.2% when compared to WAM results (4.6% in the NH, 4.8% in Tropics and 3.7% in SH) over the whole month. This is visually clear in the scatter plots of Figures 22-25 (Ku-band - WAM comparisons) and can be inferred from the symmetric slope values of same scatter plots. On the other hand, the RA-2 Ku-band wave heights are about 2.6% higher than buoy wave heights as can be seen in Figures 30-32 (Ku-band - buoy comparison).
- As a result of the additional quality control criteria of limiting the difference between the backscatter coefficient values from Ku- and S-band altimeters, most of the outliers (due to the well-known RA-2 S-band anomaly) in the scatter plots of S-band versus wave model significant wave height (Figures 26-29) were eliminated.
- The S-band overestimates significant wave heights at low sea states forming a tail in the scatter plots similar to ERS altimeter (see Figures 26-29 and 33-35).
- The S-band significant wave height product is lower than the model except for conditions with low sea state dominance; i.e. the Northern Hemisphere during the summer and the Tropics.



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- **After the operational implementation of the ENVISAT Altimetry Instrument Processing Facility (IPF) Version 5.03 on the 19th. of September 2006, S-band significant wave height was about 3-4% (~10 cm) lower than usual.**
- **As can be seen in Figure 48, the ratio between Ku-band and S-band wave heights this month was between 1.02 and 1.06 (following the IPF Ver. 5.03 processing chain on the 19th. of September 2006).** It is important to notice the seasonal variation for this ratio with low values of about 0.92-0.94 (0.96 in 2006) reached during June to August and high values around 1.0 (1.02 in 2005-2006) during December to April. This seasonal cycle seems to be related to the S-Band overestimation of low wave height (see Figures 26-29 and 33-35).
- Stricter quality control and the use of the model sea ice information eliminate most of the usual 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). The scatter index values are now much smaller than before.
- **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 always there, it becomes very clear in the rather long-period scatter plots. No specific condition or geographical location could be associated with this behaviour. The additional quality control criteria mentioned above did not help much to eliminate this kind of outliers. This issue is still under investigation.**
- While the MWR derived TCWV is now in good agreement with the model counterpart (MWR TCWV is slightly smaller than the model in the Extra Tropics), 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.



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- ENVISAT RA-2 Ku-band significant wave height and ASAR Wave Mode Level 1b data as well as Jason altimeter significant wave height data are assimilated in the ECMWF wave model.
- There was no ECMWF model change during this month. The current operational IFS cycle is CY31R1 (since 12 September 2006).

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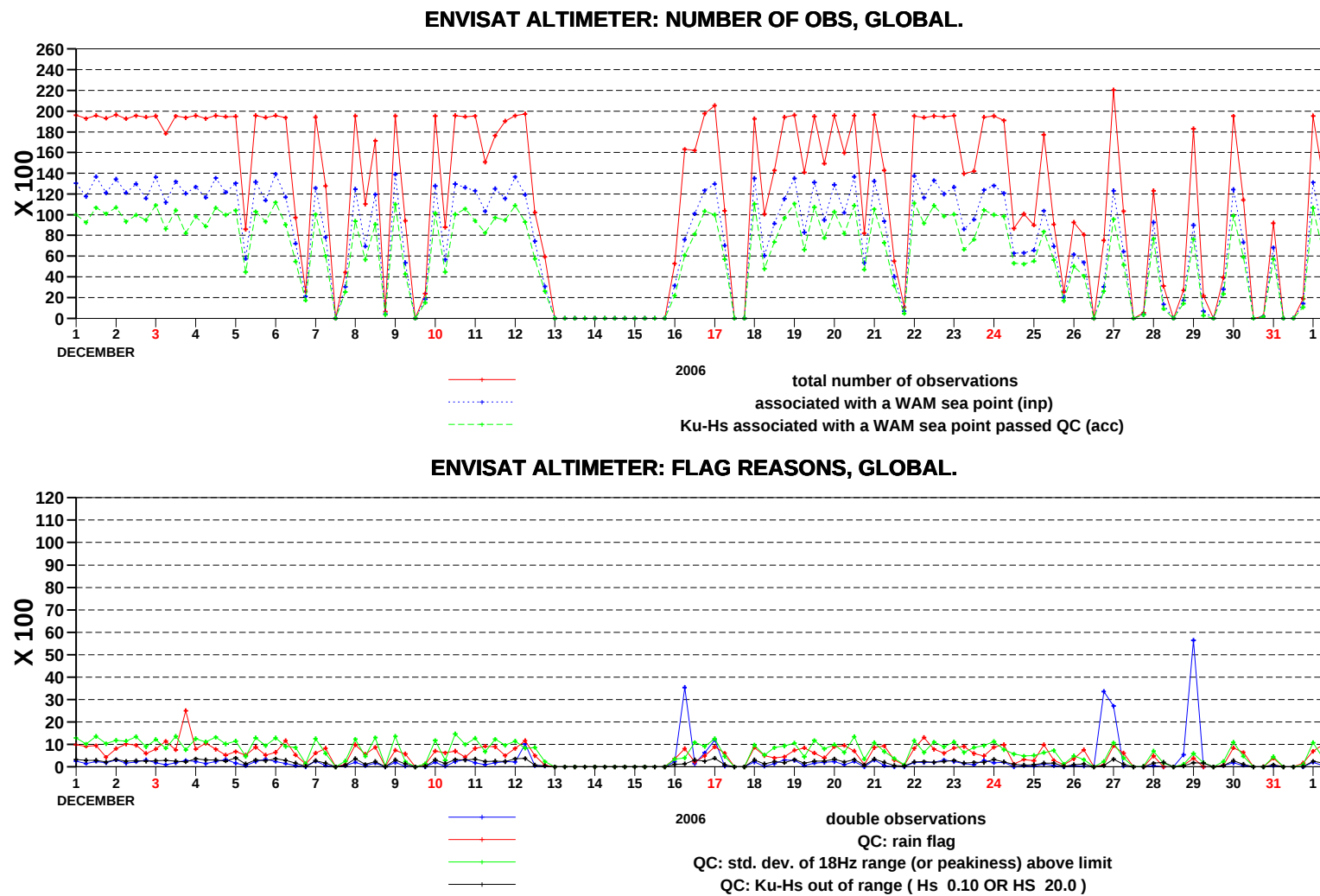


Figure 1: Time series of data reception for ENVISAT Altimeter data for December 2006

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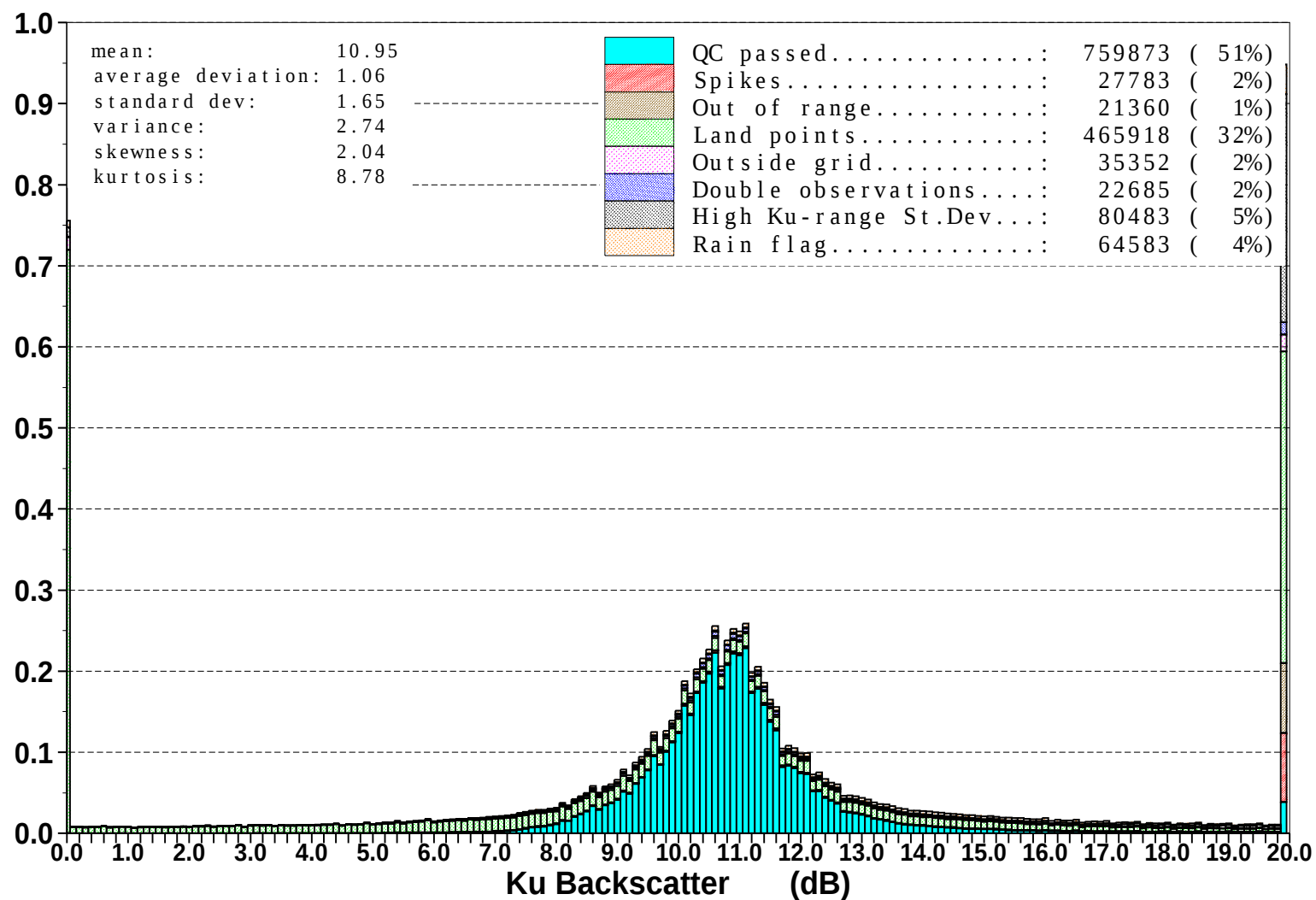


Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for December 2006

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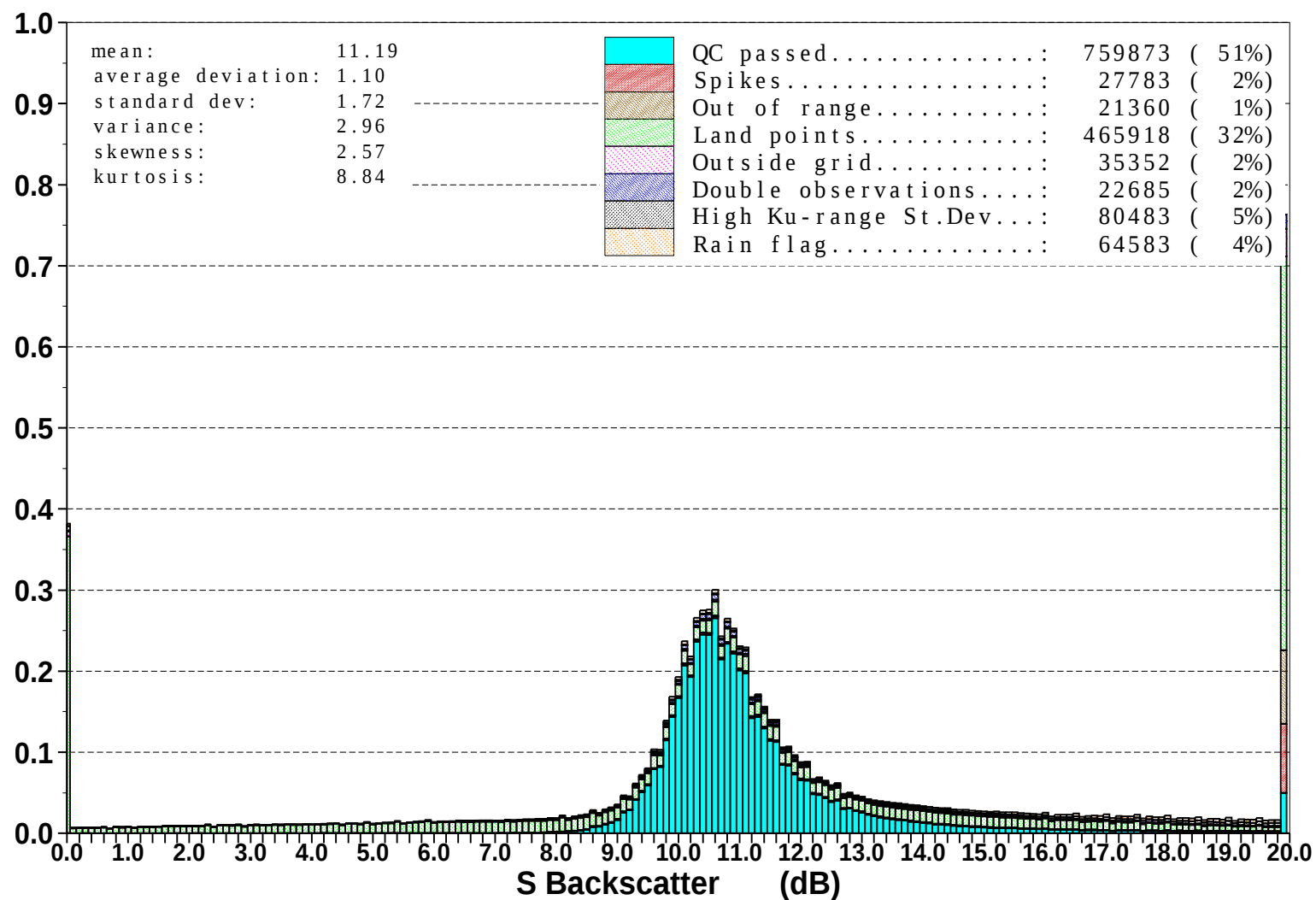


Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for December 2006

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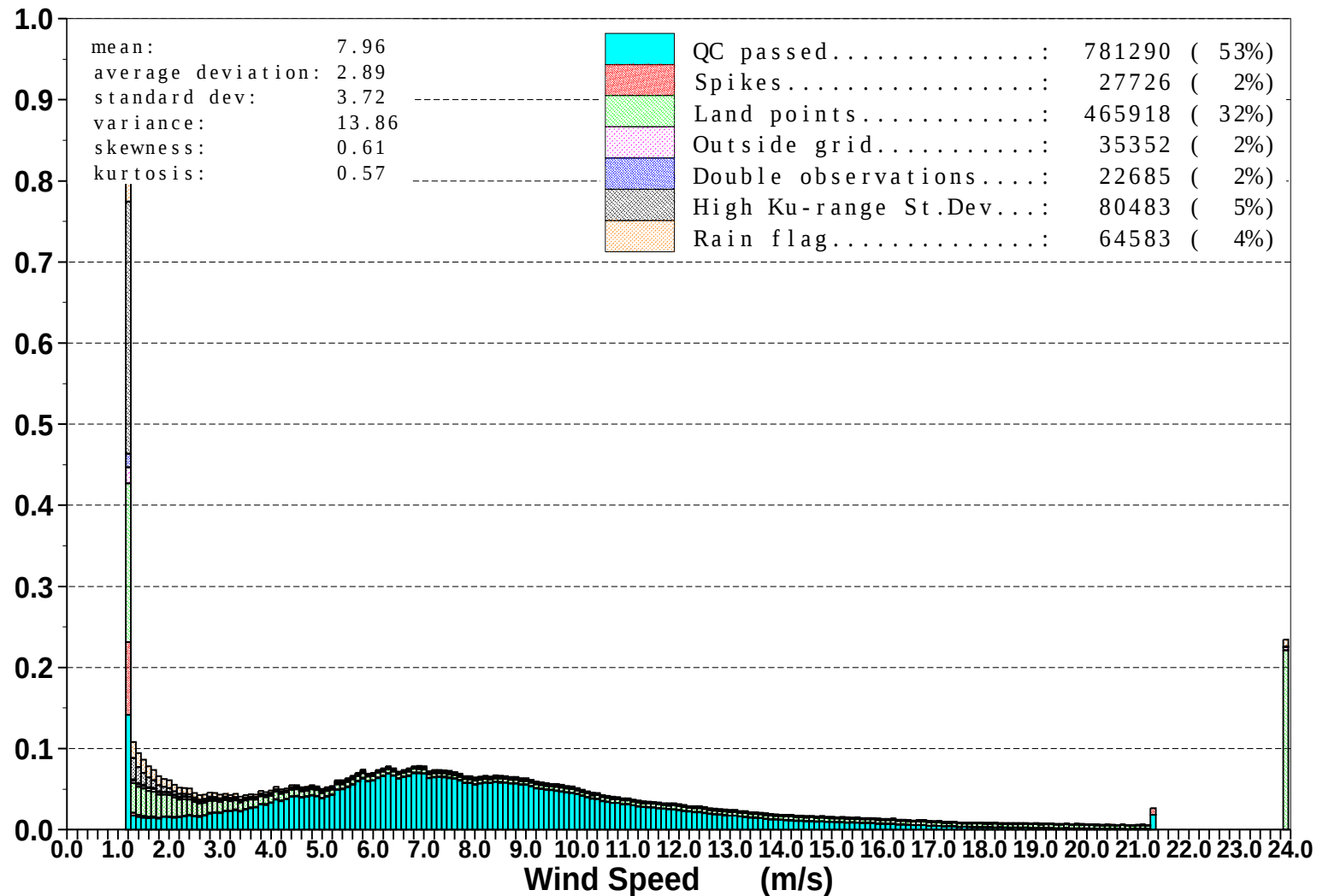


Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for December 2006

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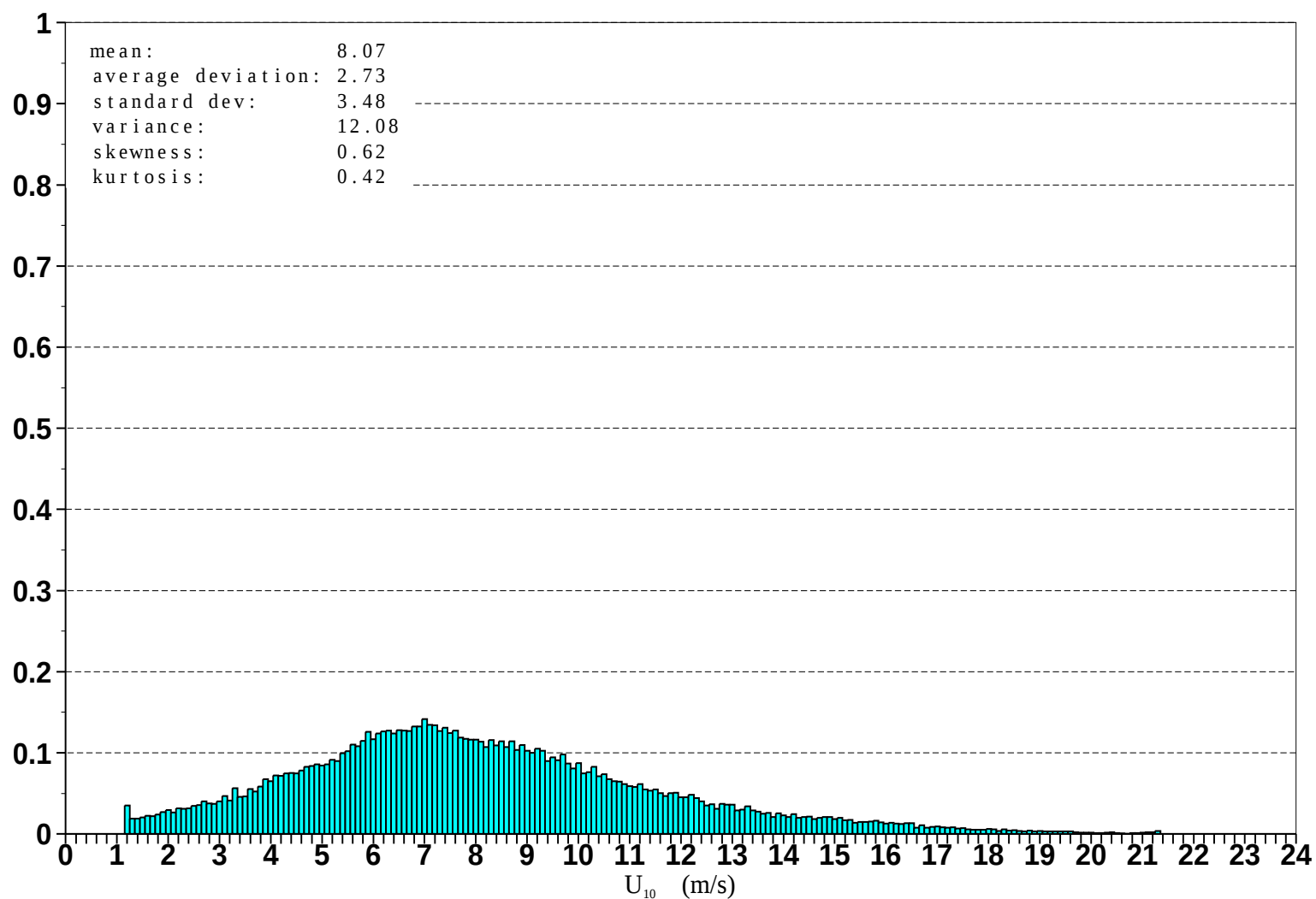


Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for December 2006



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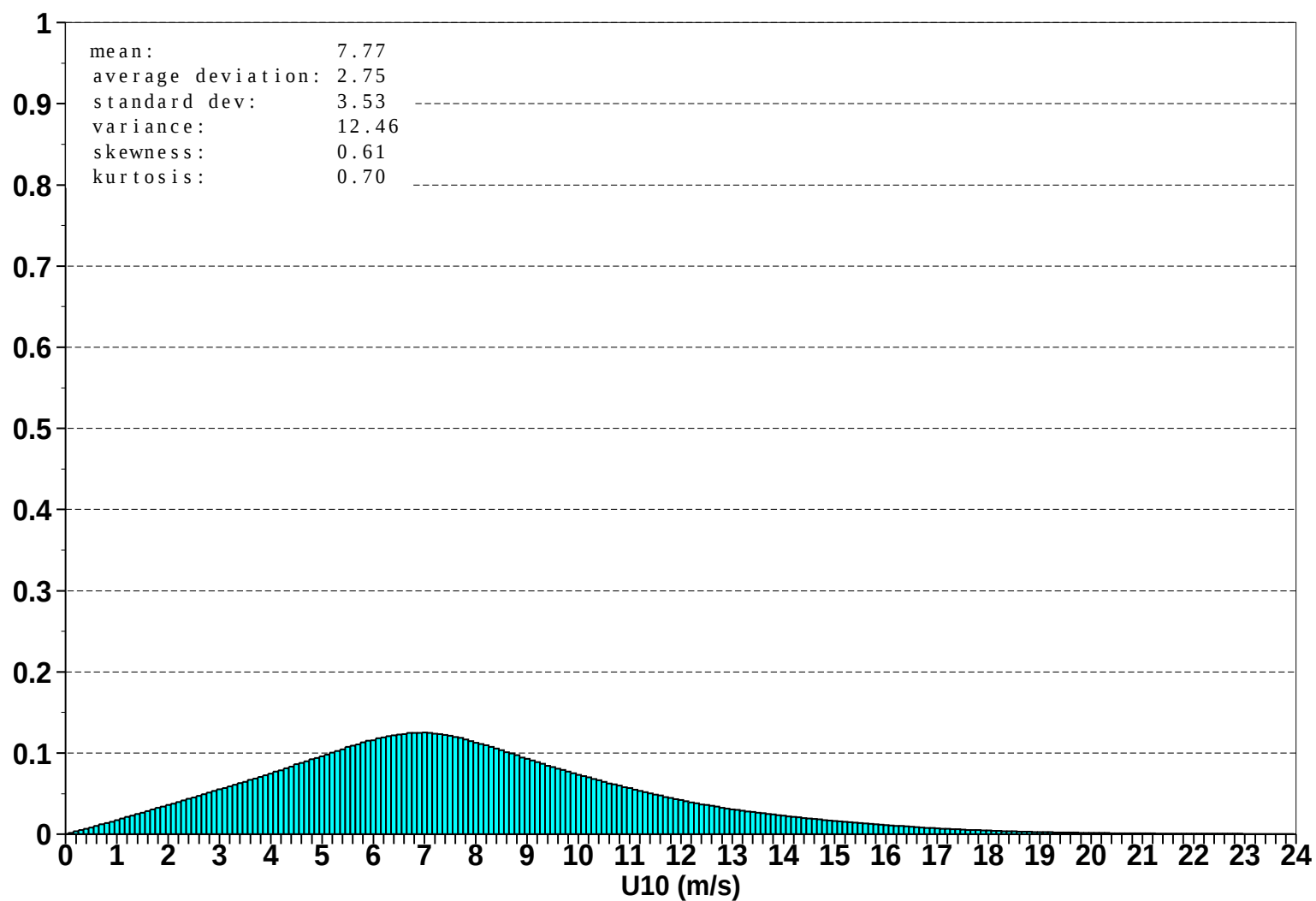


Figure 6: Global distribution of ECMWF Analysis ocean surface wind speeds for December 2006

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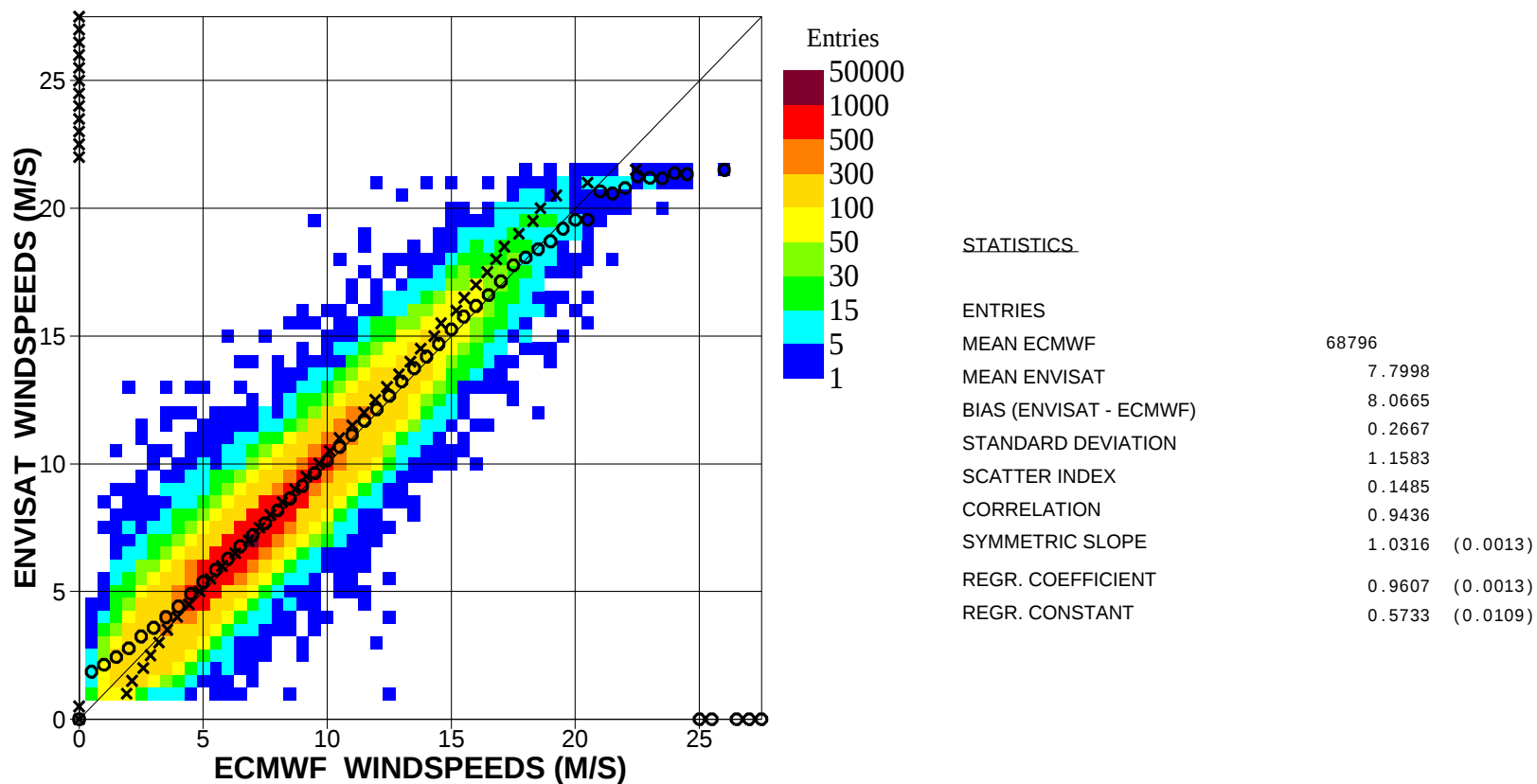


Figure 7. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2006 (Global)

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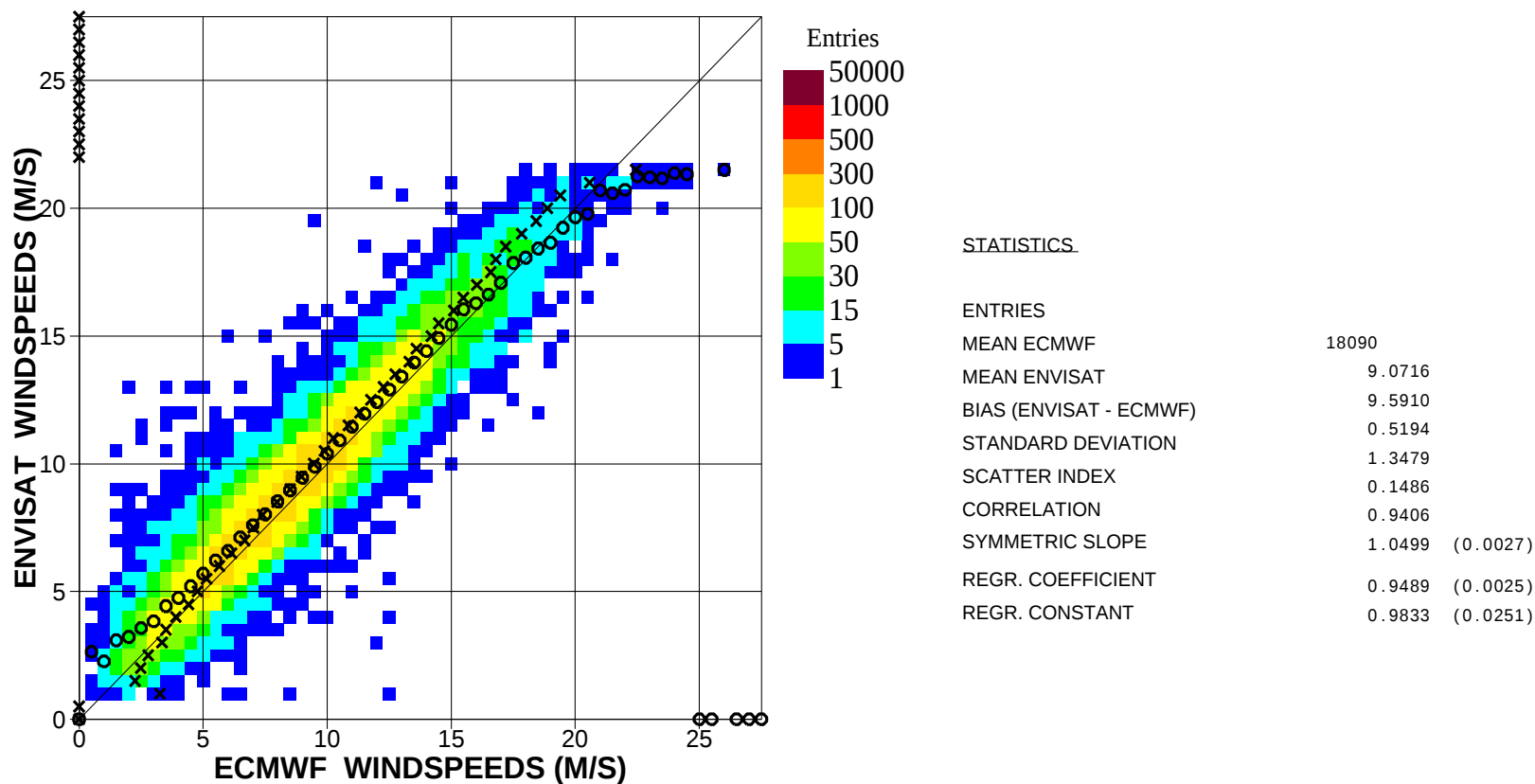


Figure 8. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2006 (N.Hem.)

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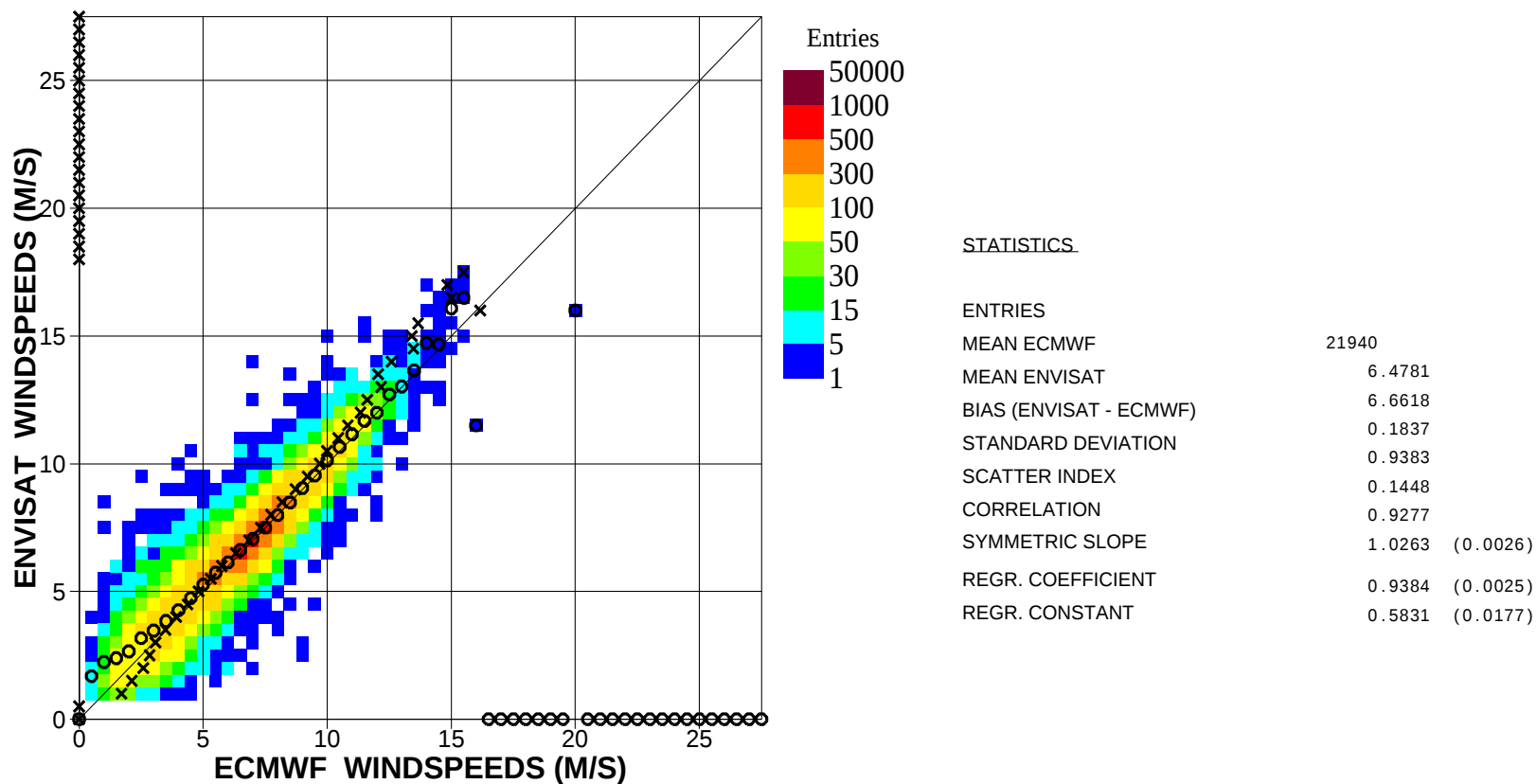


Figure 9. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2006 (Tropics)

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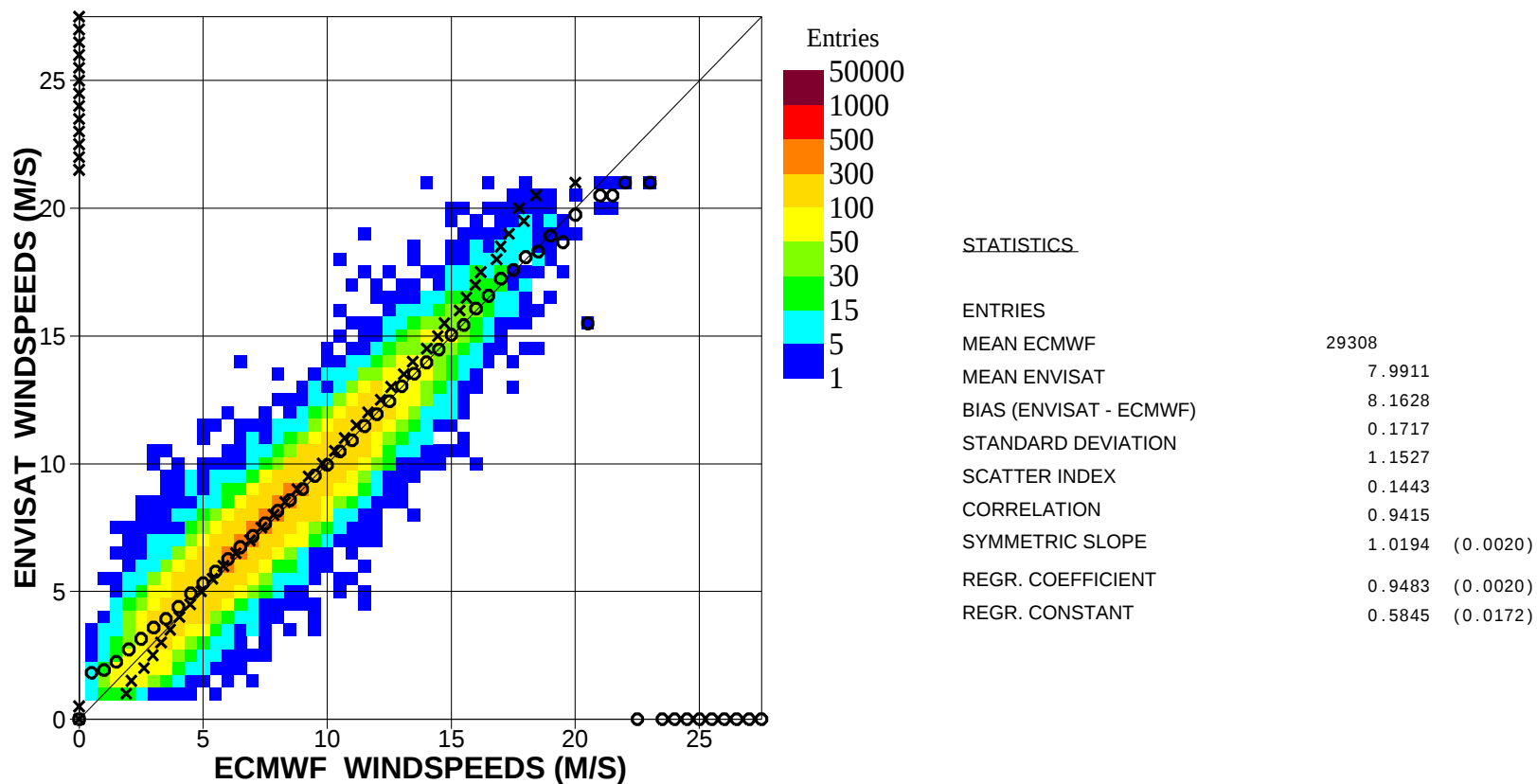


Figure 10. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2006 (S.Hem.)

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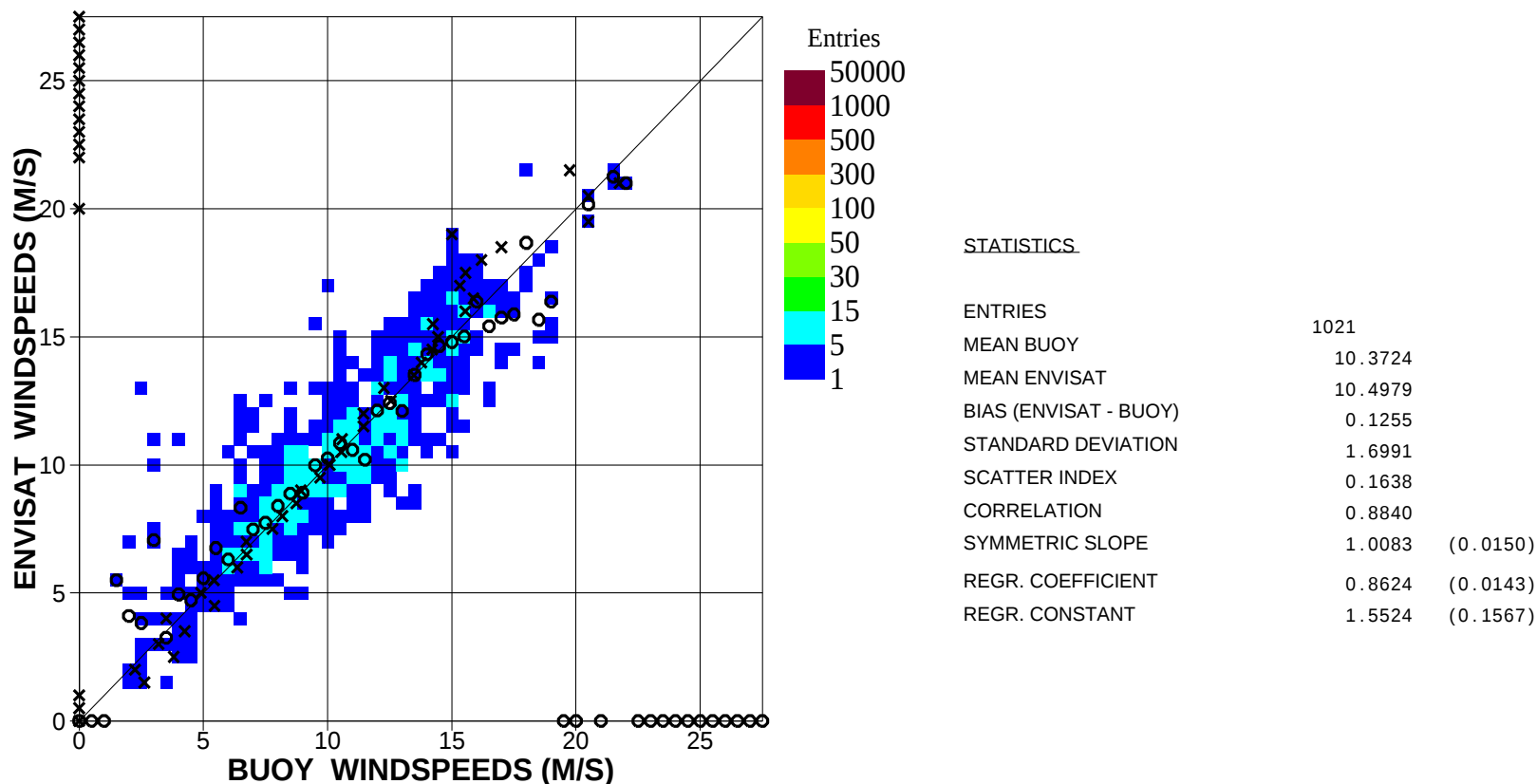


Figure 11. Comparison between ENVISAT Altimeter and buoy wind speeds for December 2006 (Global)

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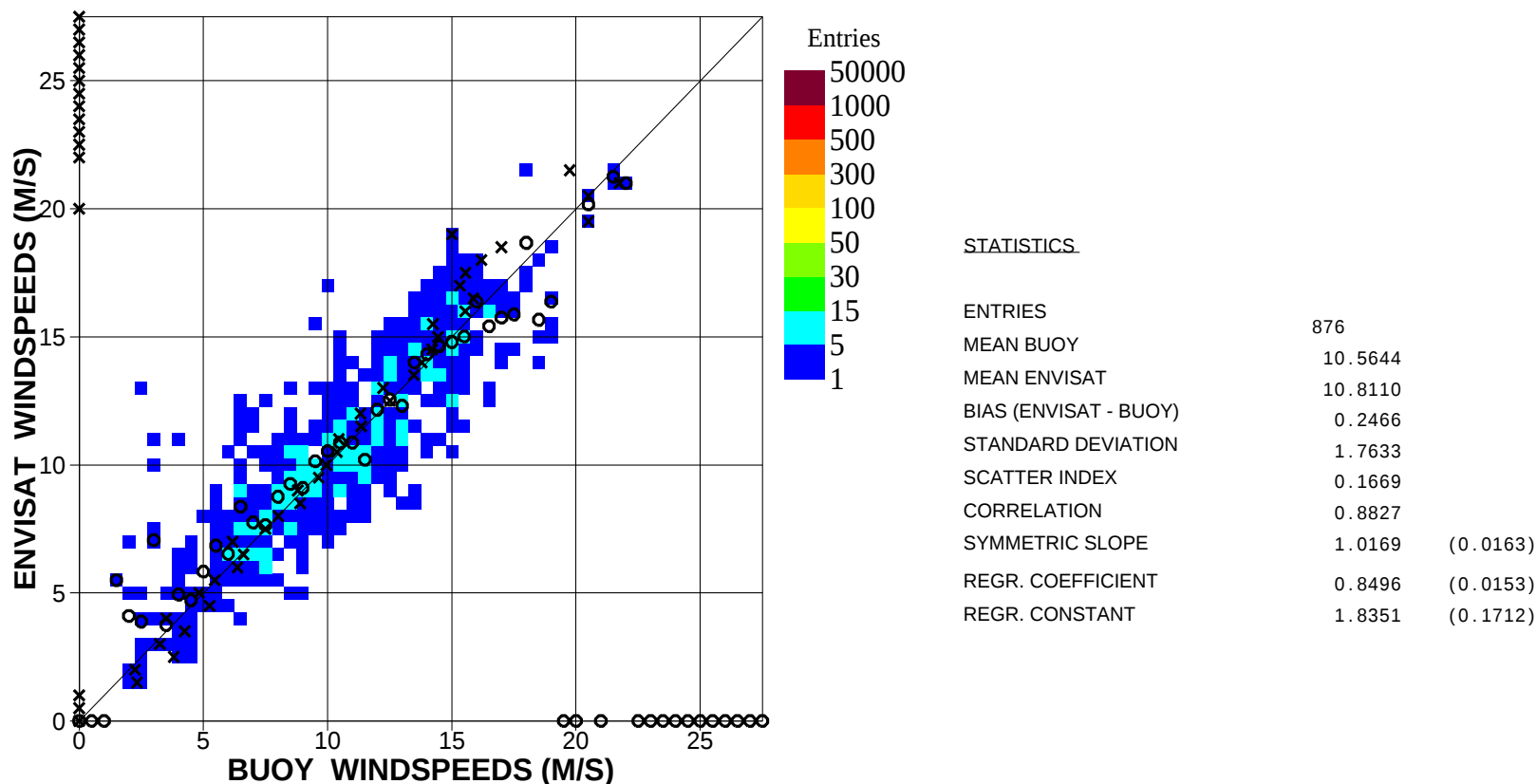


Figure 12. Comparison between ENVISAT Altimeter and buoy wind speeds for December 2006 (N.Hem.)

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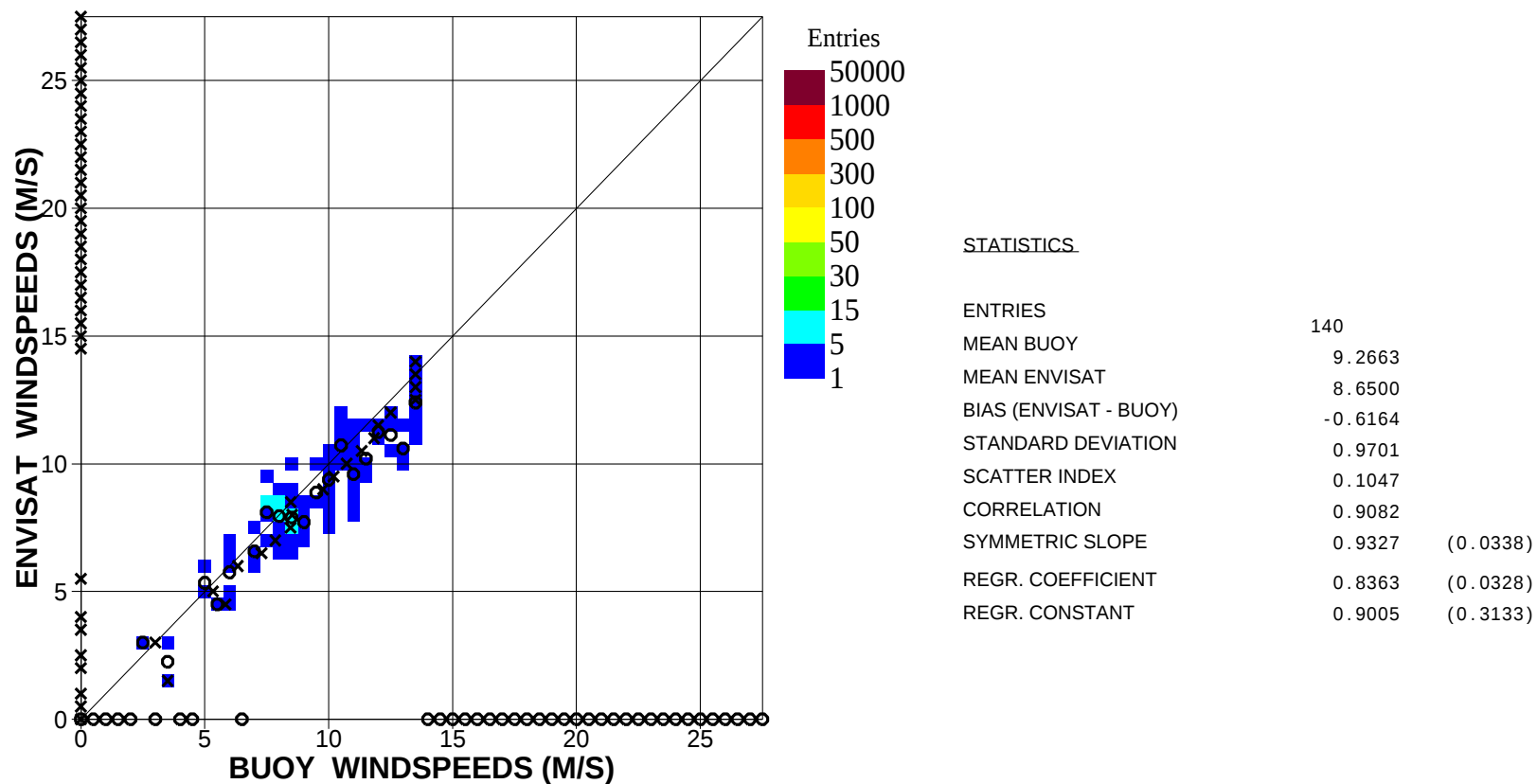


Figure 13. Comparison between ENVISAT Altimeter and buoy wind speeds for December 2006 (Tropics)

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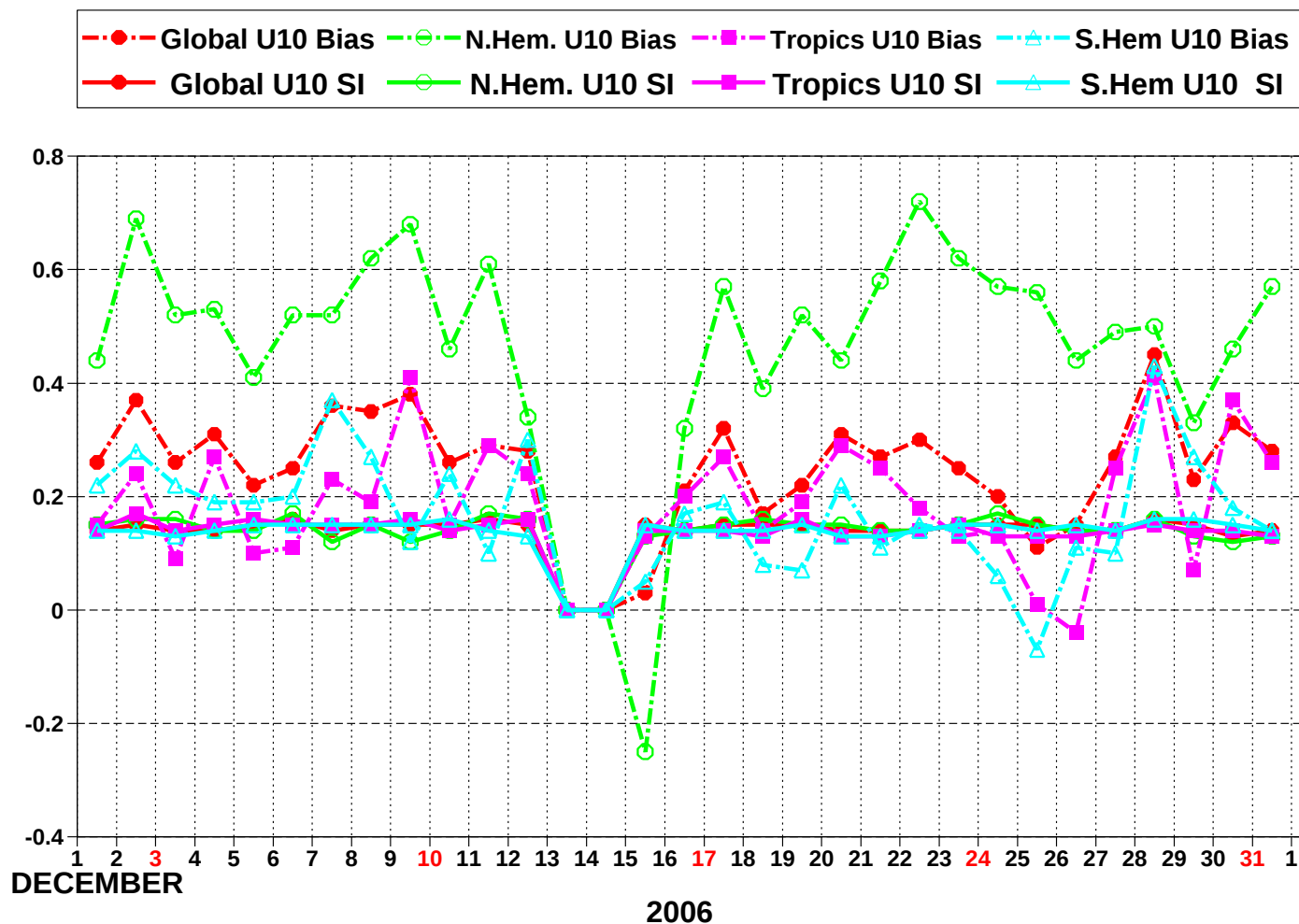


Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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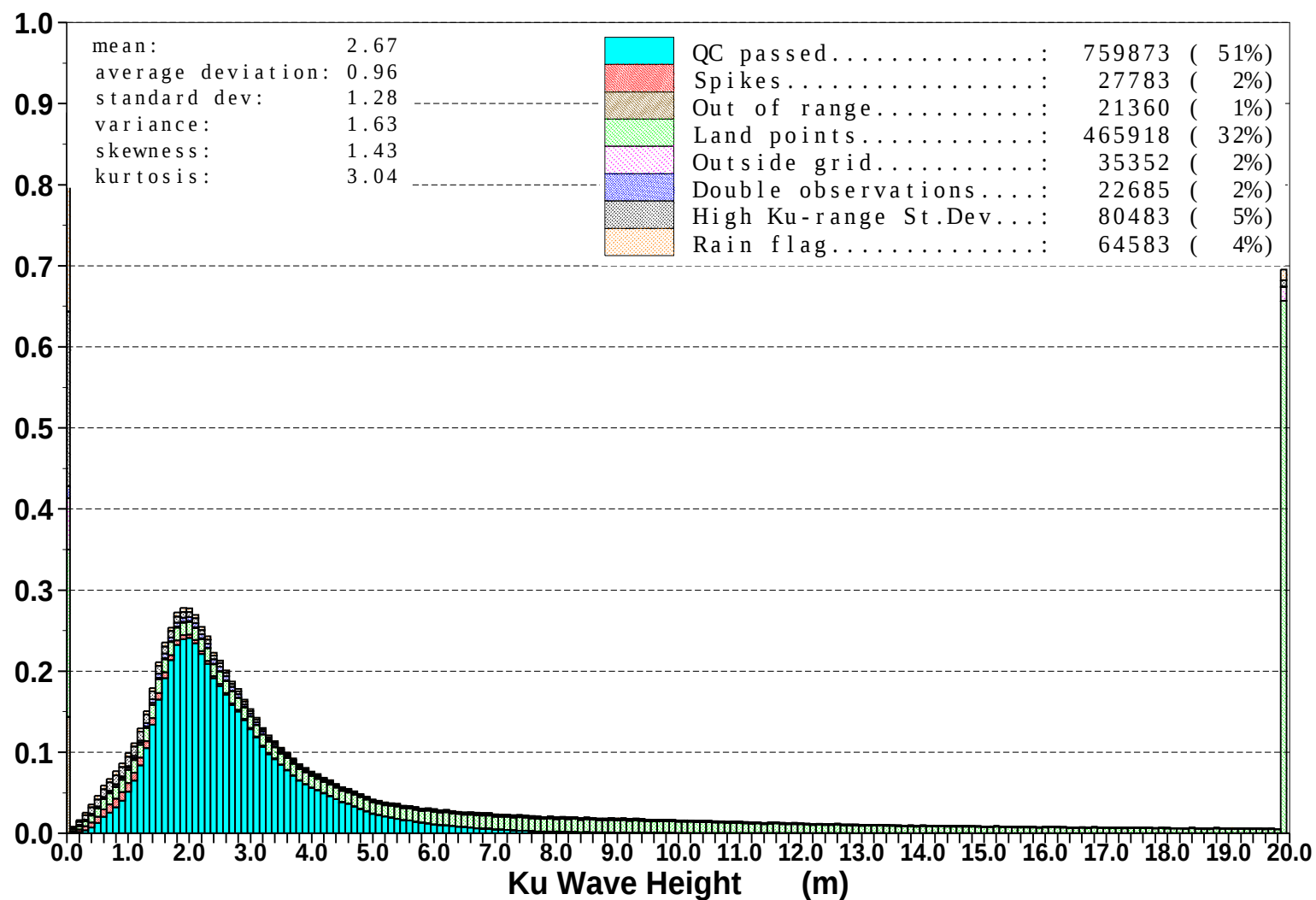


Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for December 2006

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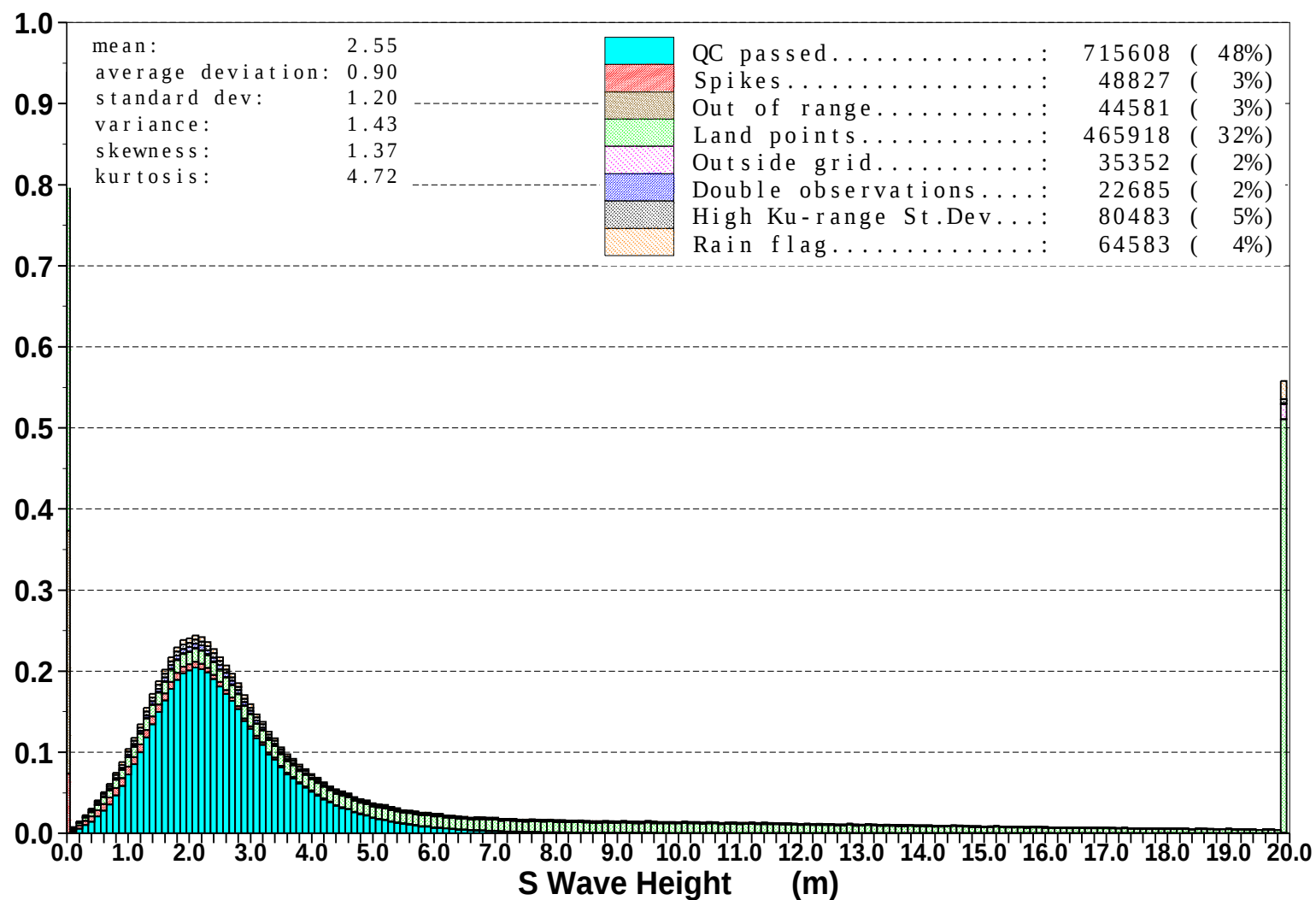


Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for December 2006

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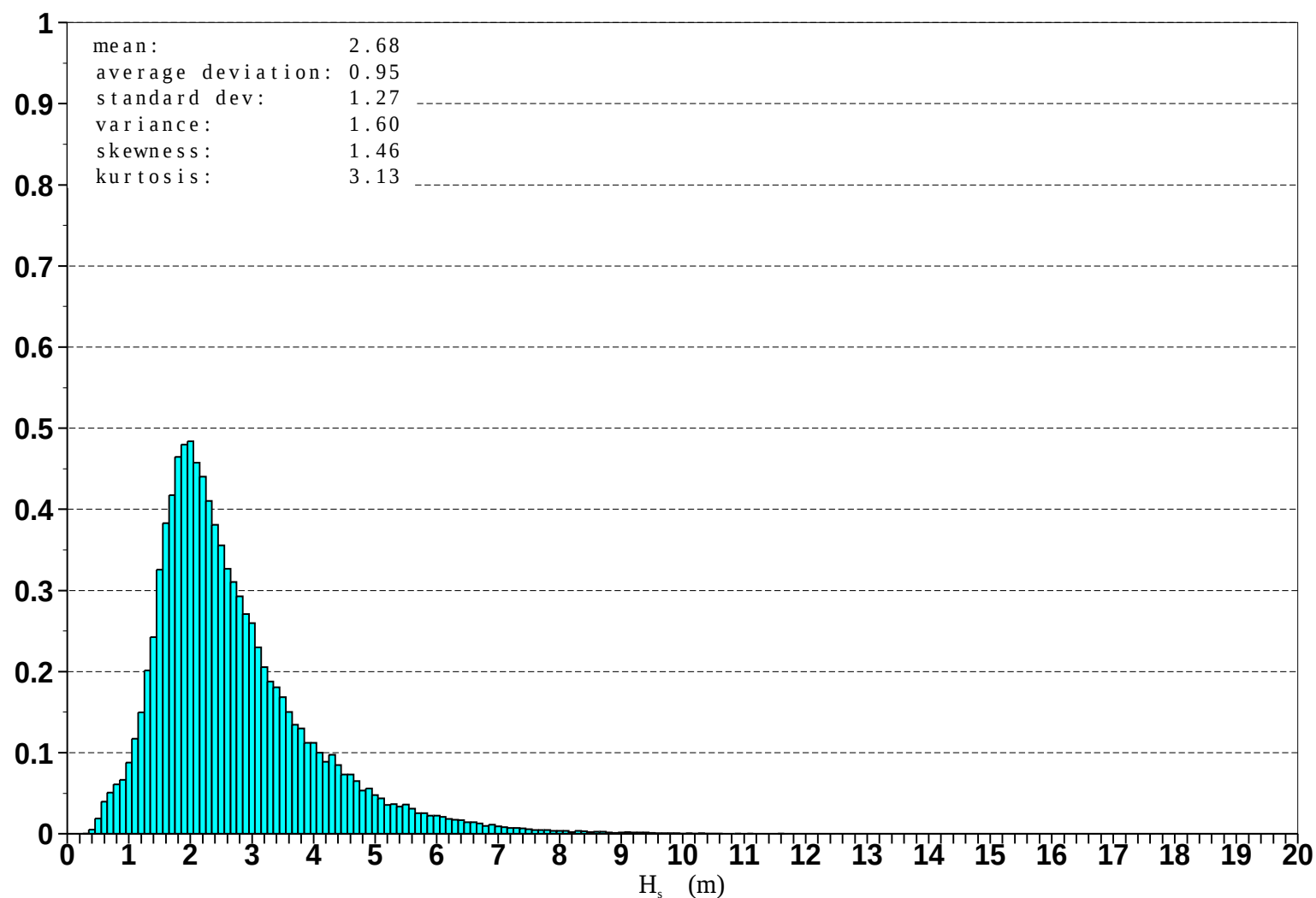


Figure 17: Distribution of ENVISAT Altimeter Ku-Band Wave Heights after Along-Track Averaging for December 2006



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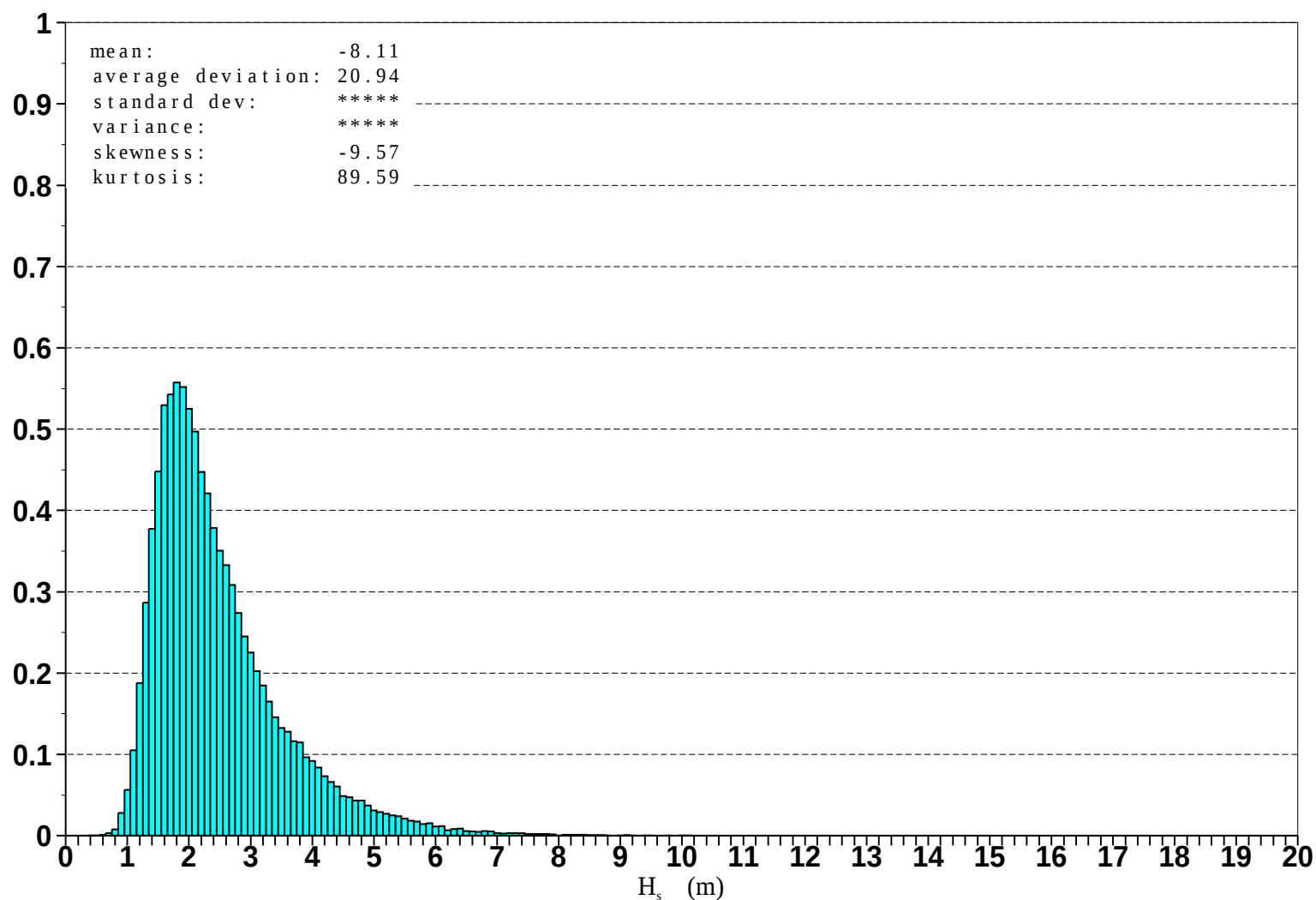


Figure 18: Distribution of ENVISAT Altimeter S-Band Wave Heights after Along-Track Averaging for December 2006



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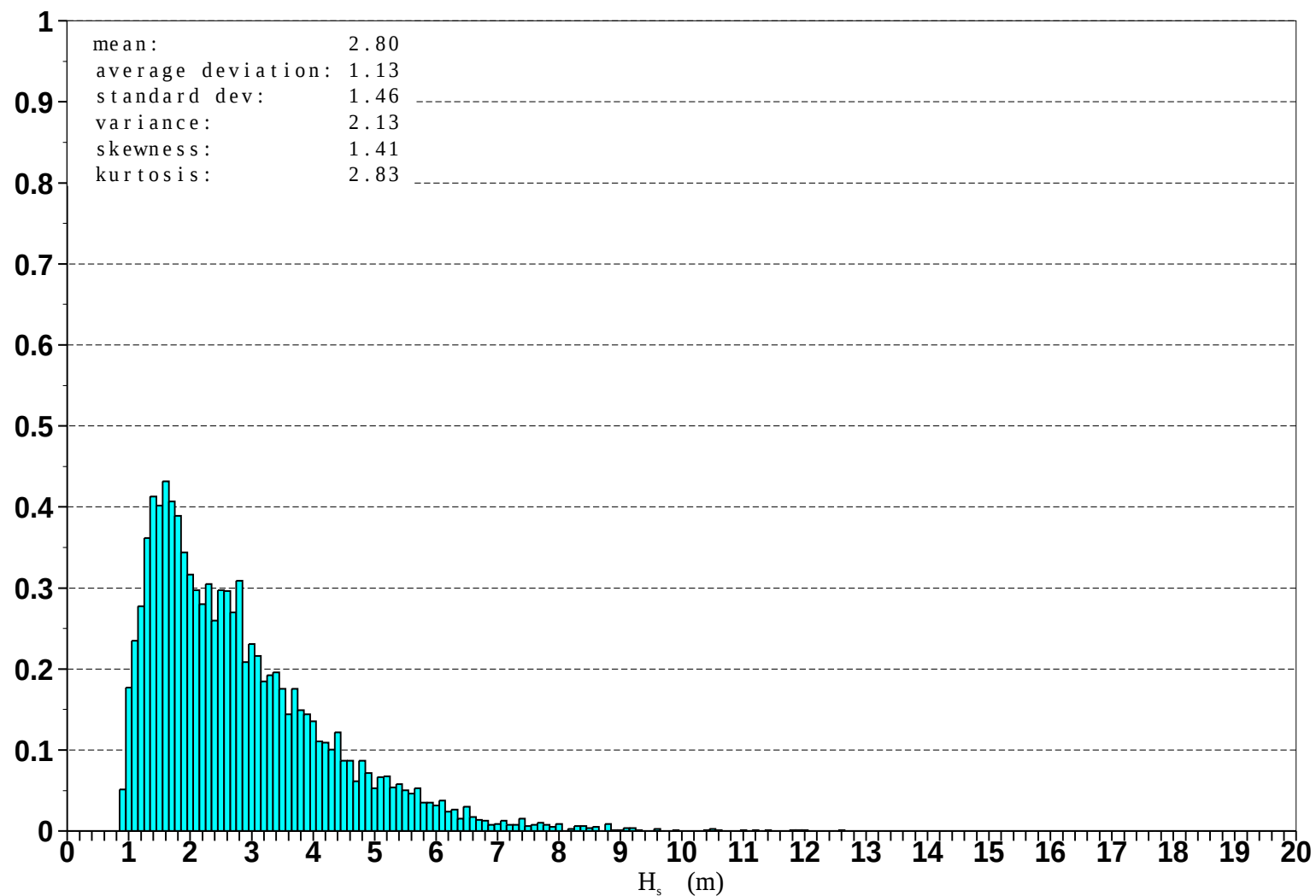
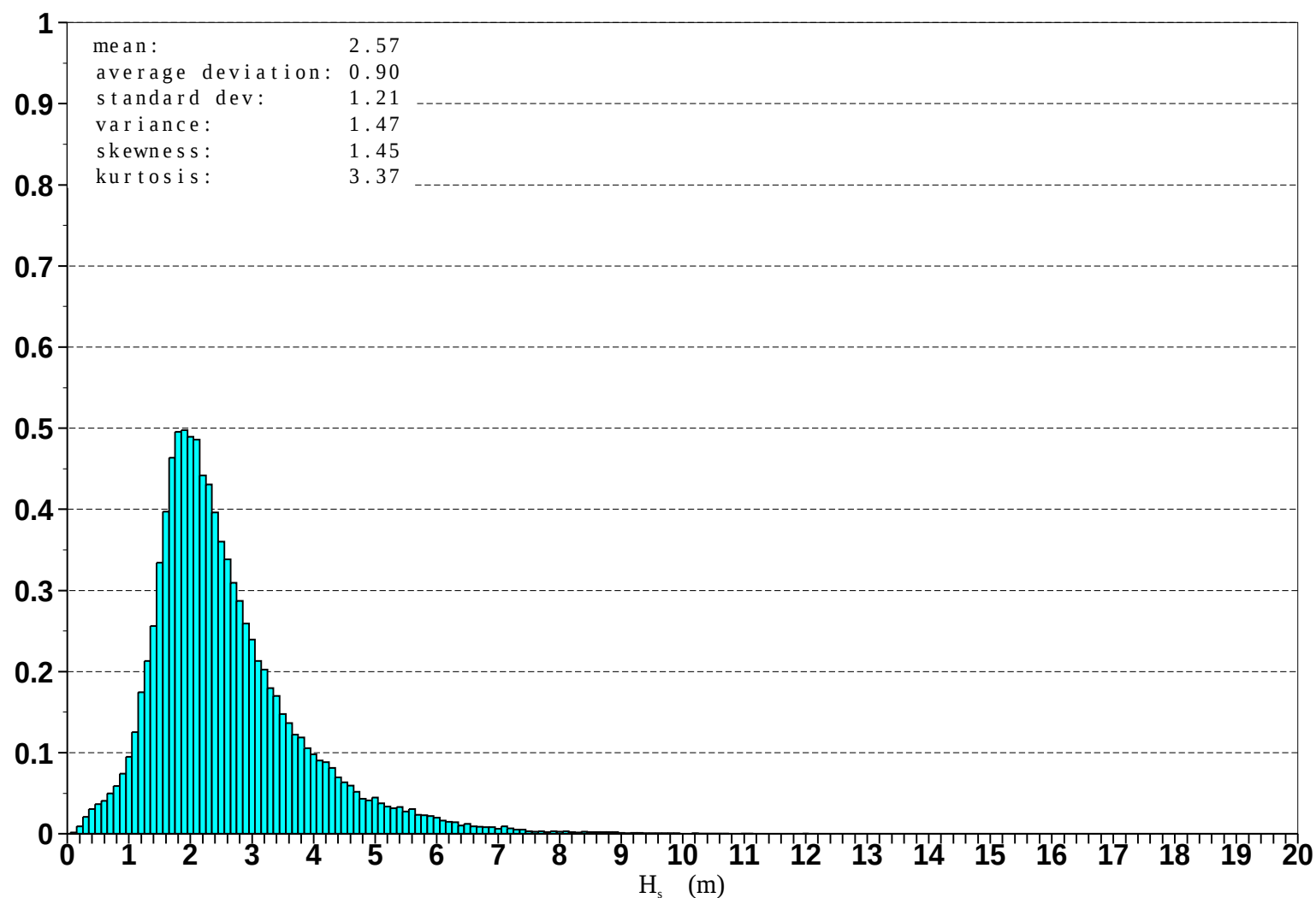


Figure 19: Distribution of ERS-2 Altimeter Wave Heights after Along-Track Averaging for December 2006

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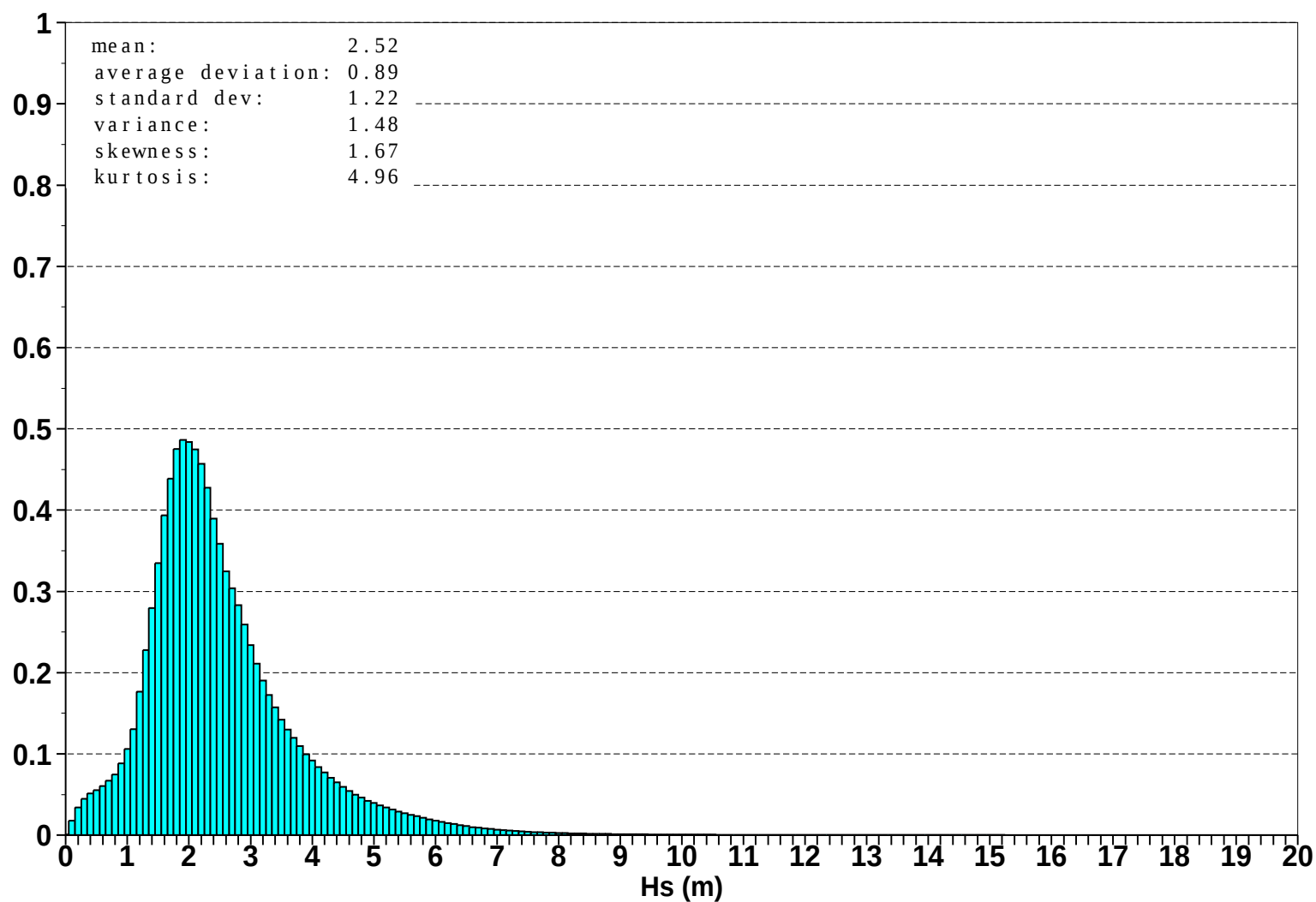


Figure 20: Global distribution of ECMWF First-Guess wave heights for December 2006



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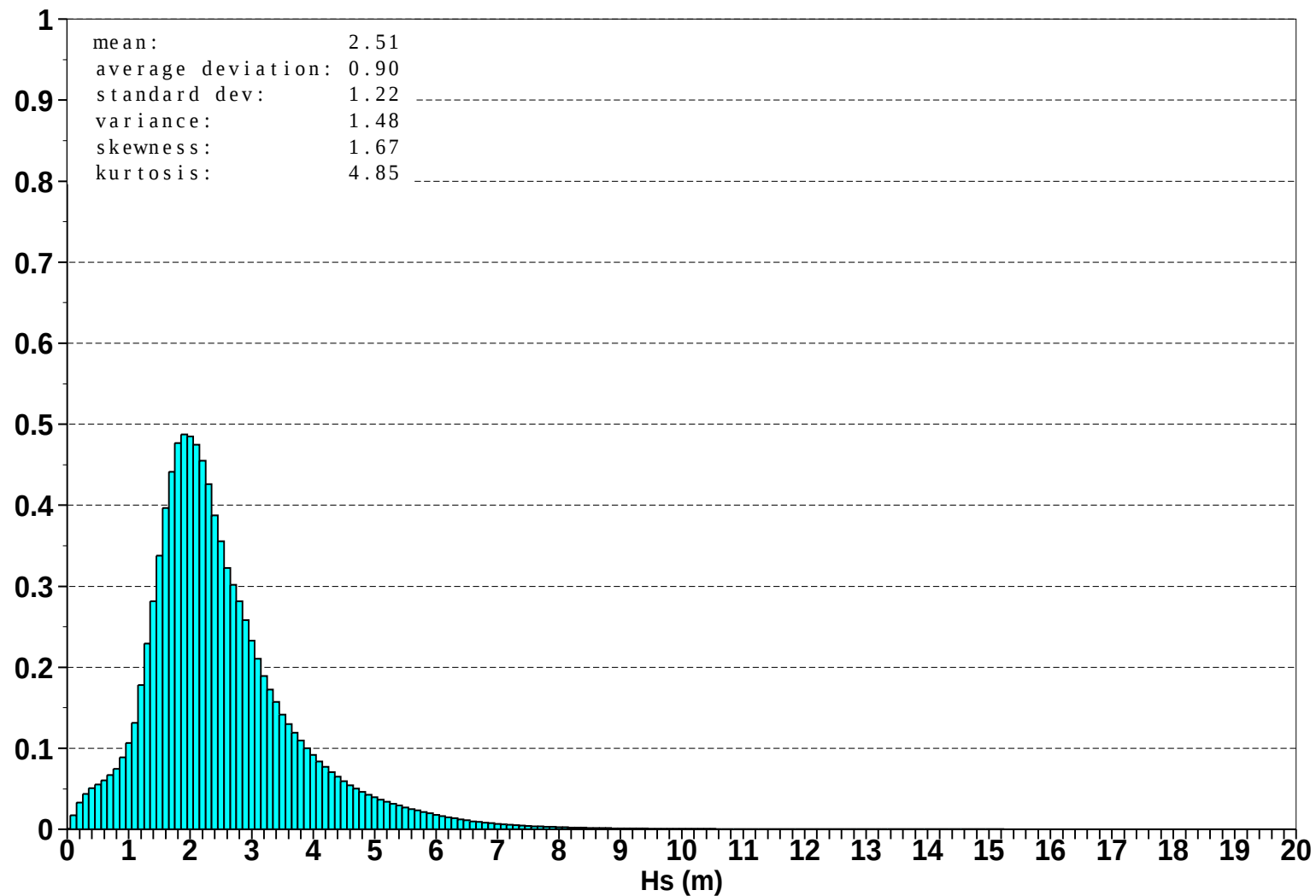


Figure 21: Global distribution of ECMWF Analysis wave heights for December 2006

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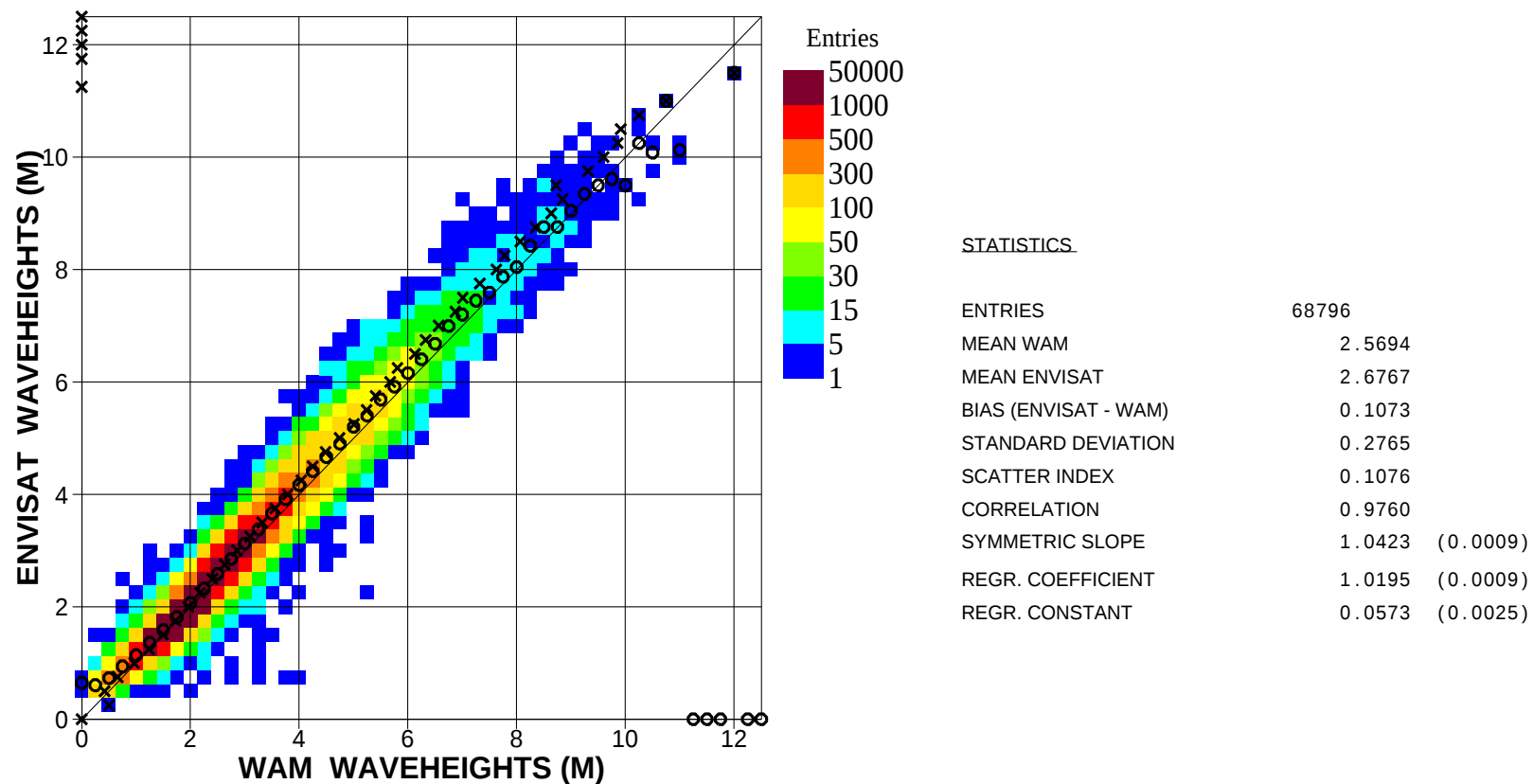


Figure 22. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2006 (Global)

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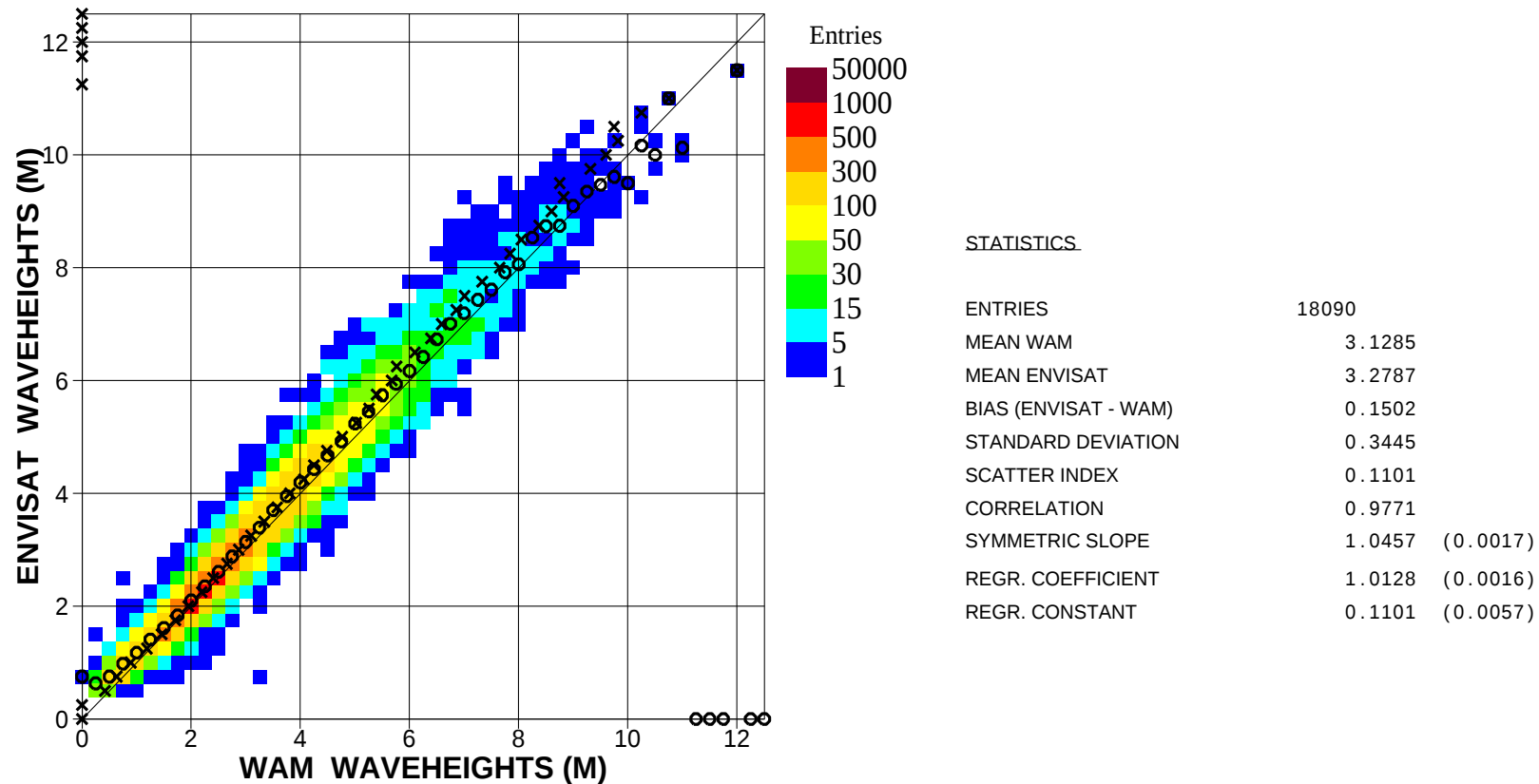


Figure 23. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2006 (N.Hem.)

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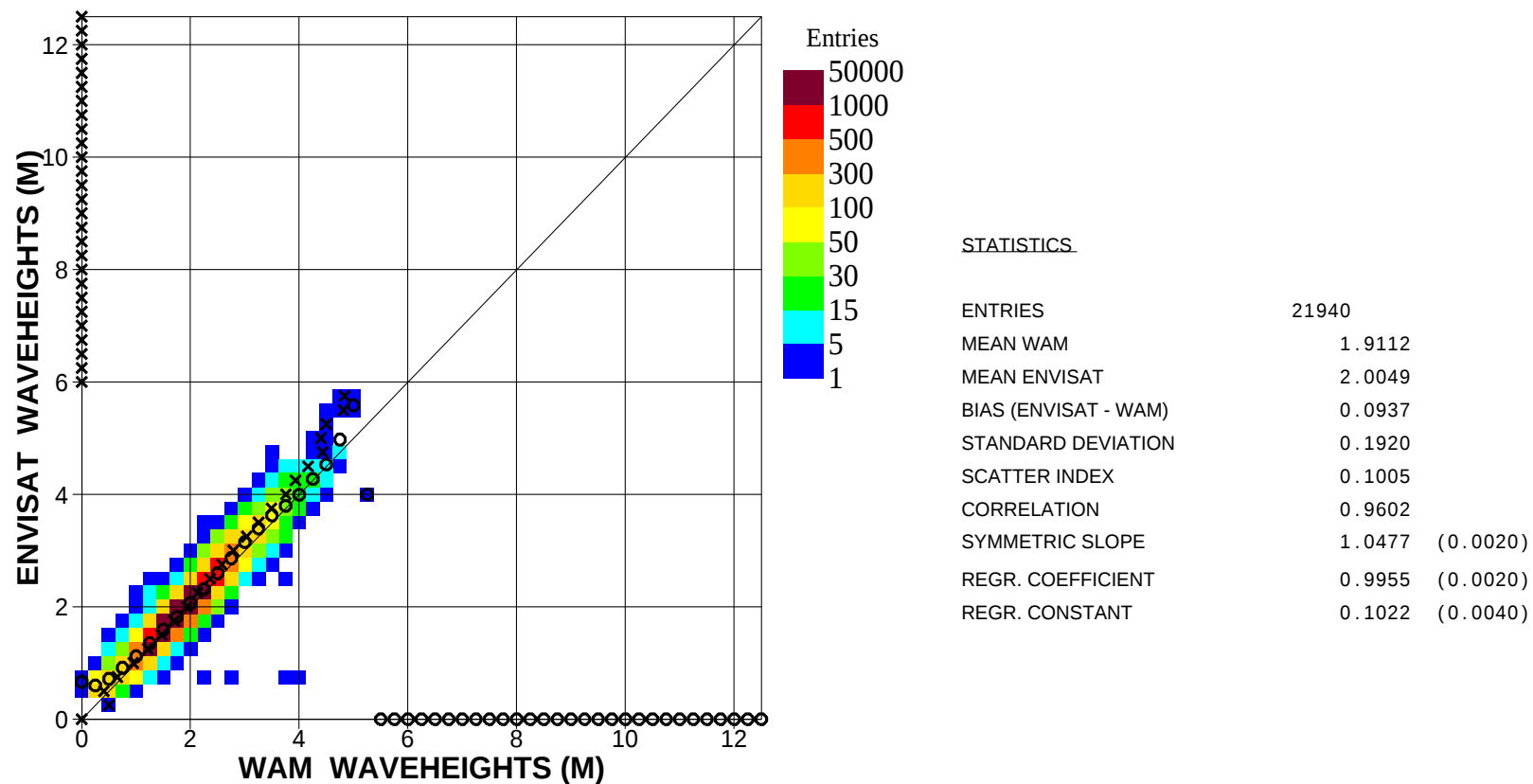


Figure 24. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2006 (Tropics)

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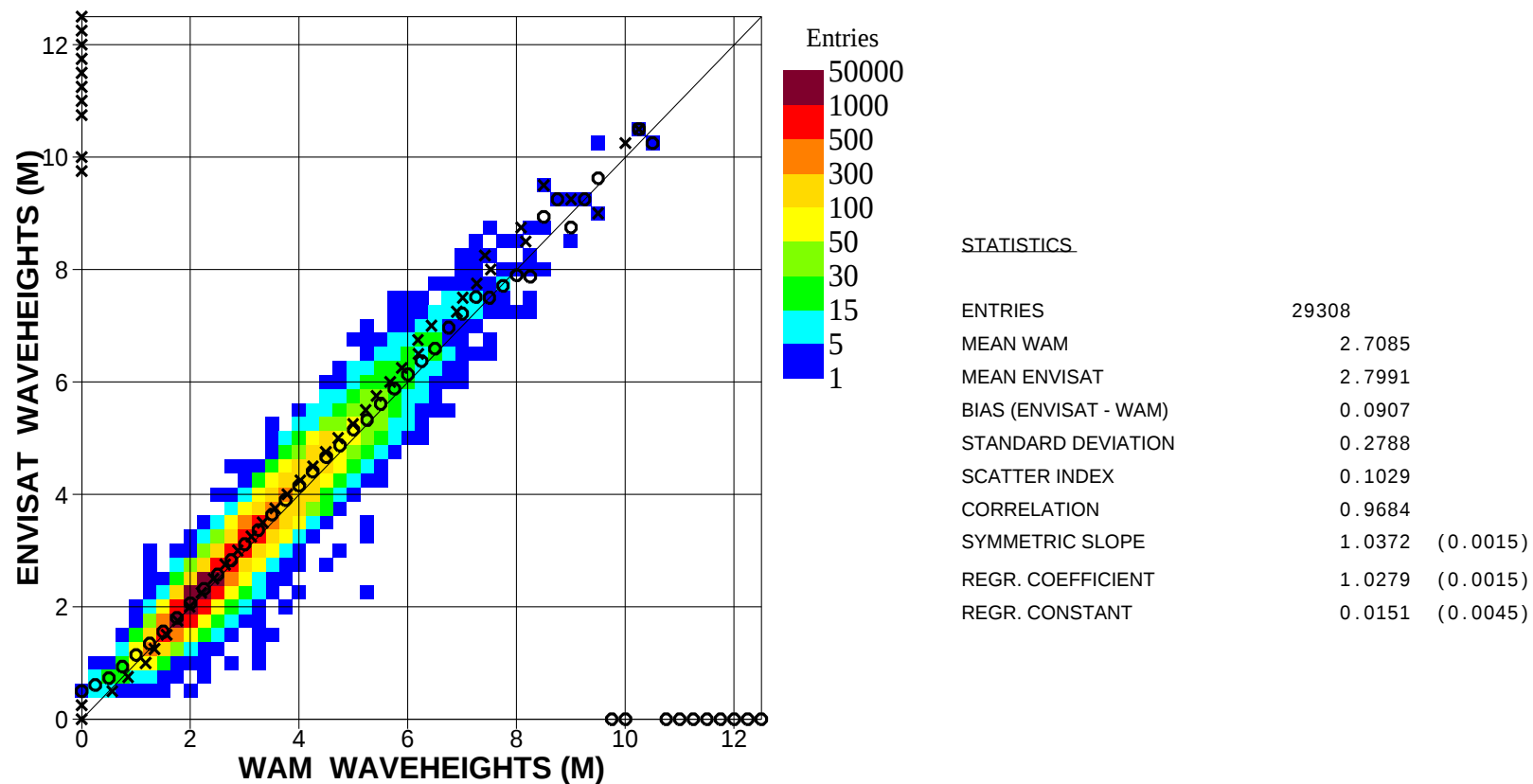


Figure 25. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2006 (S.Hem.)

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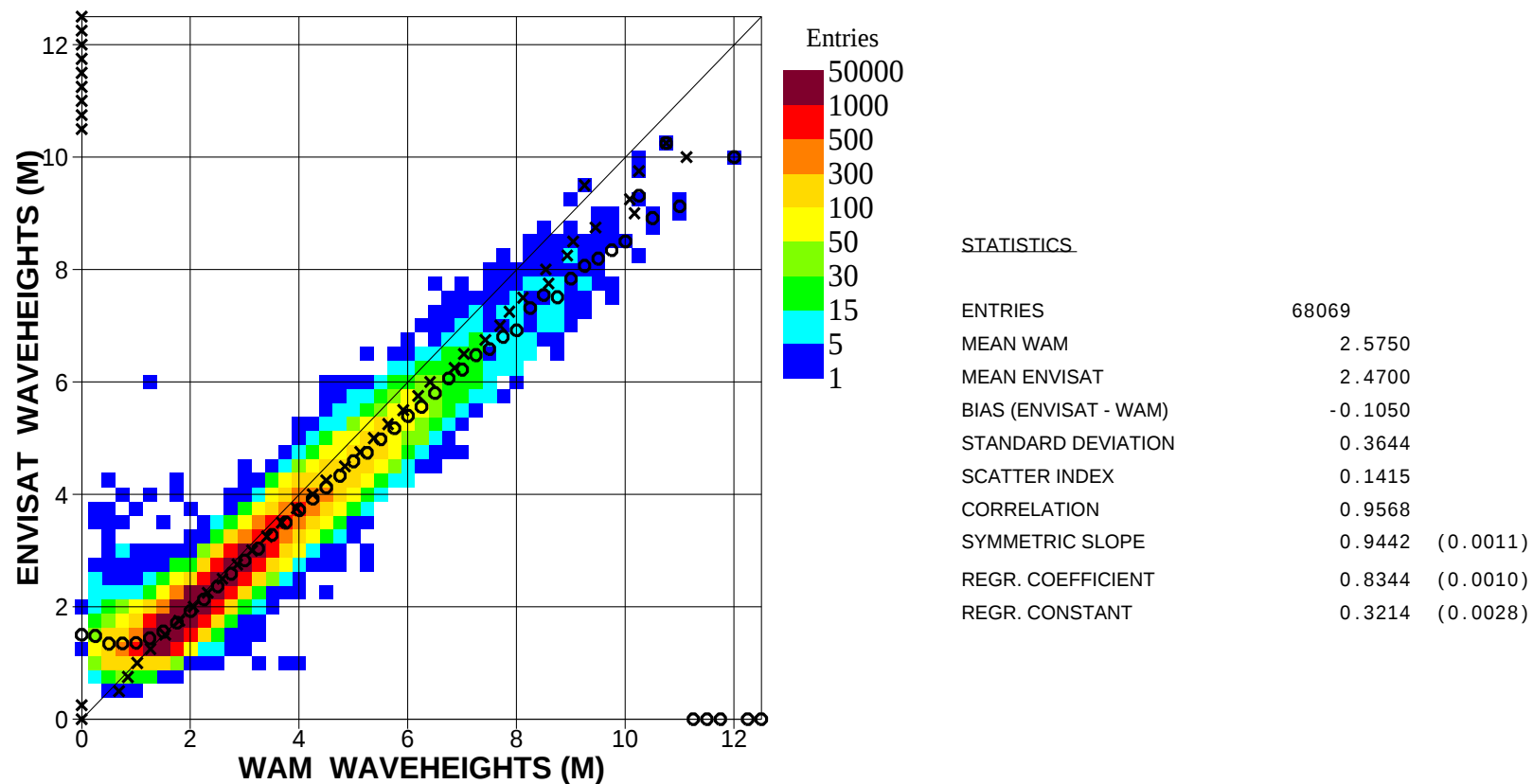


Figure 26. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2006 (Global)

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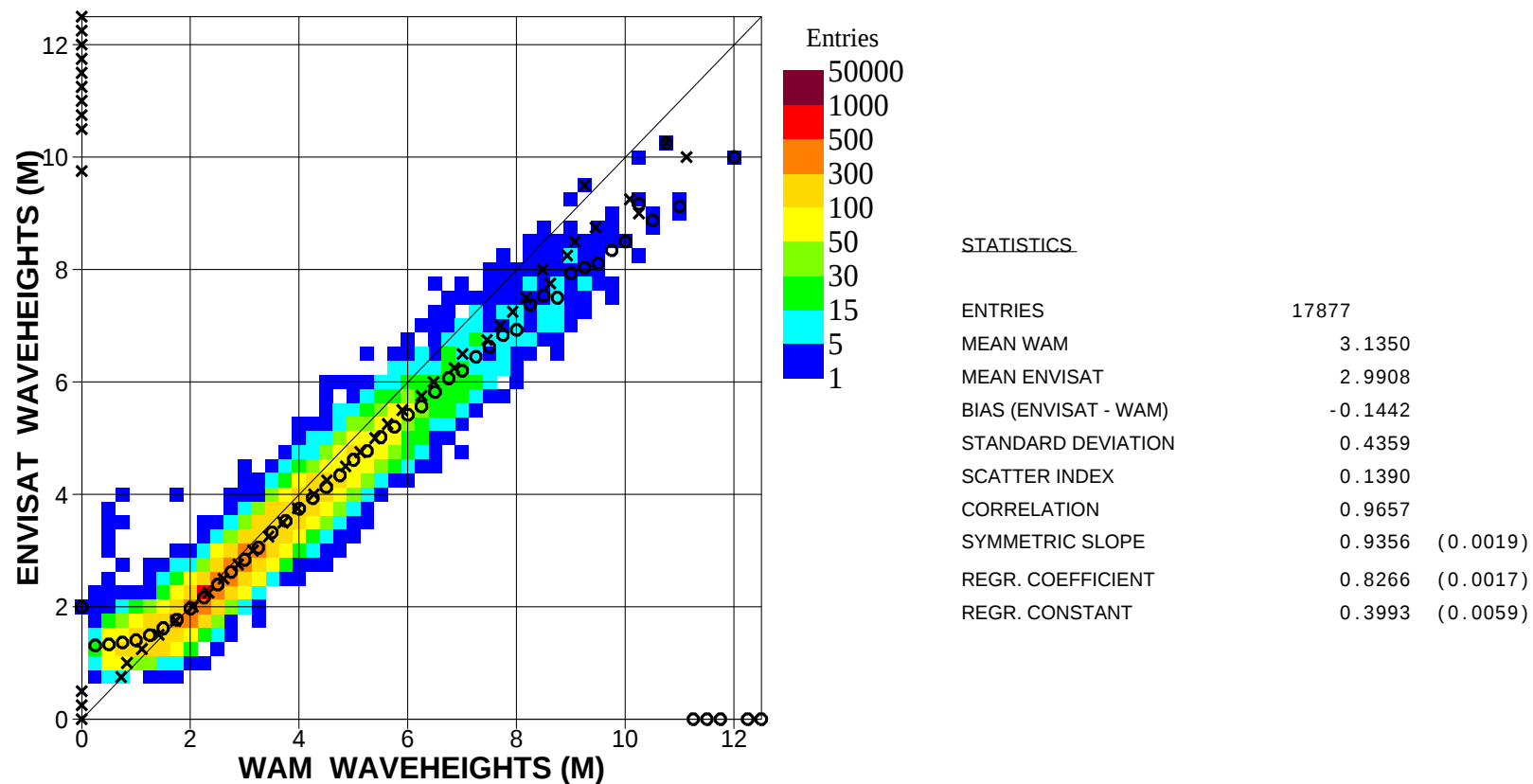


Figure 27. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2006 (N.Hem.)

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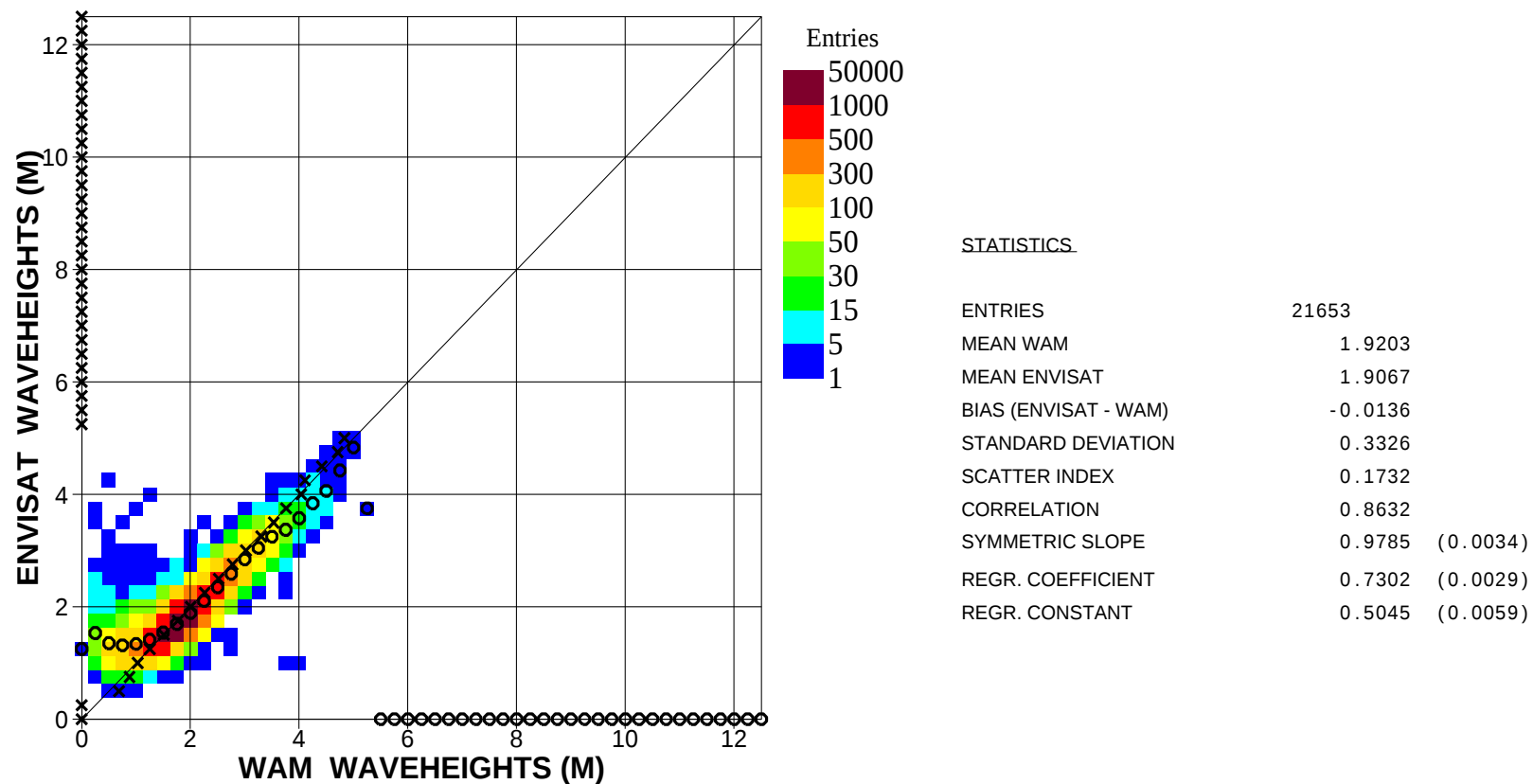


Figure 28. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2006 (Tropics)

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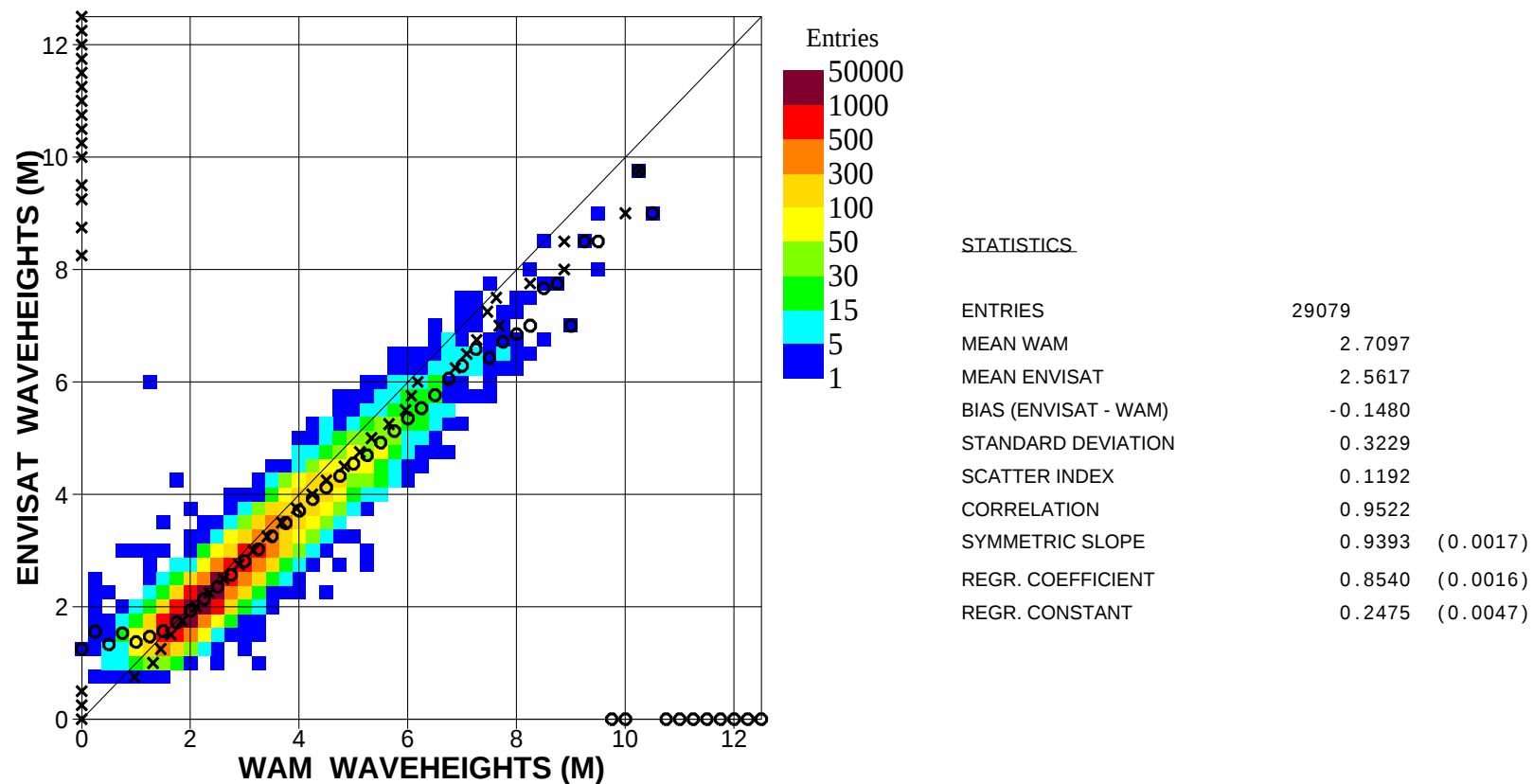


Figure 29. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2006 (S.Hem.)

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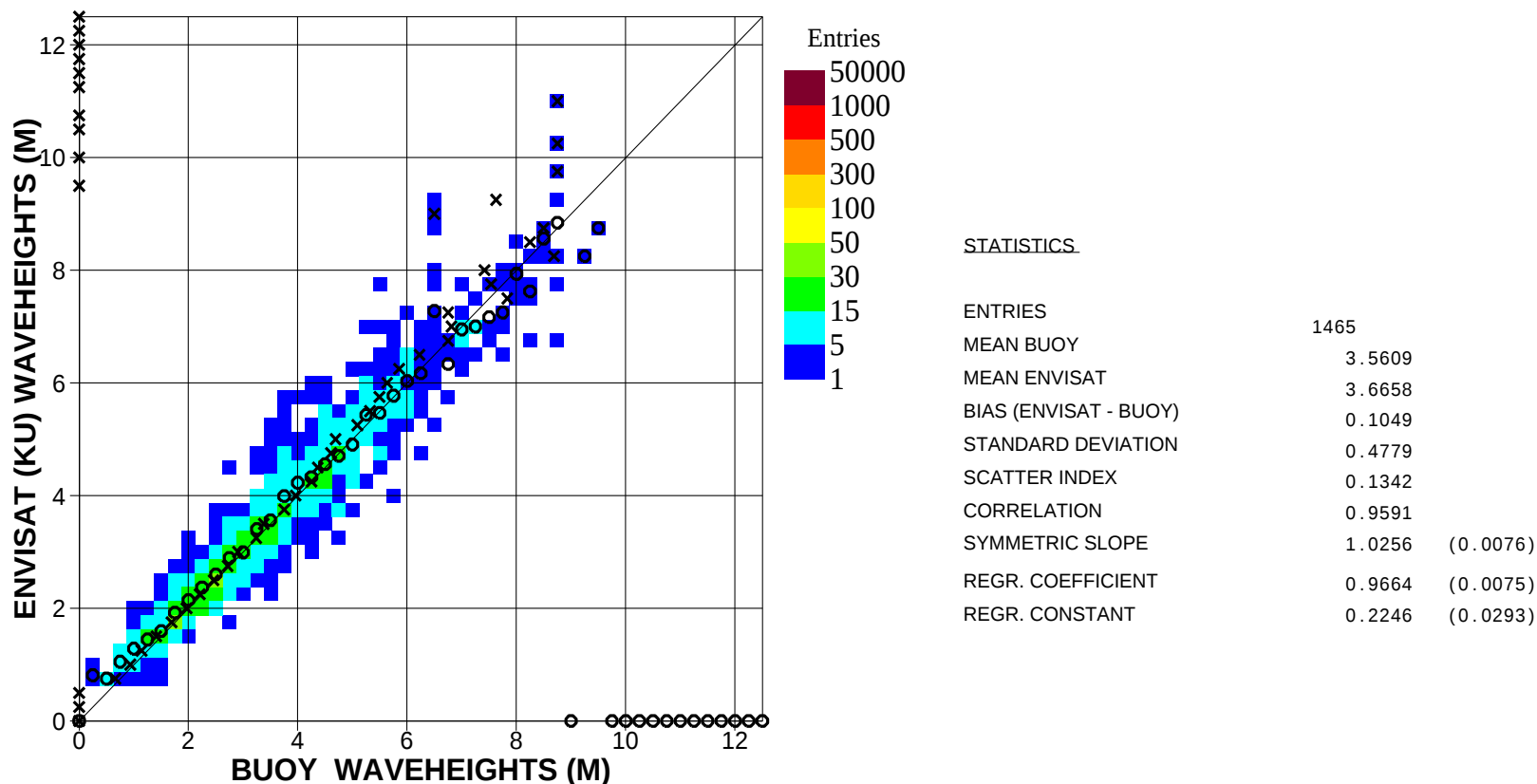


Figure 30. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for December 2006 (Global)

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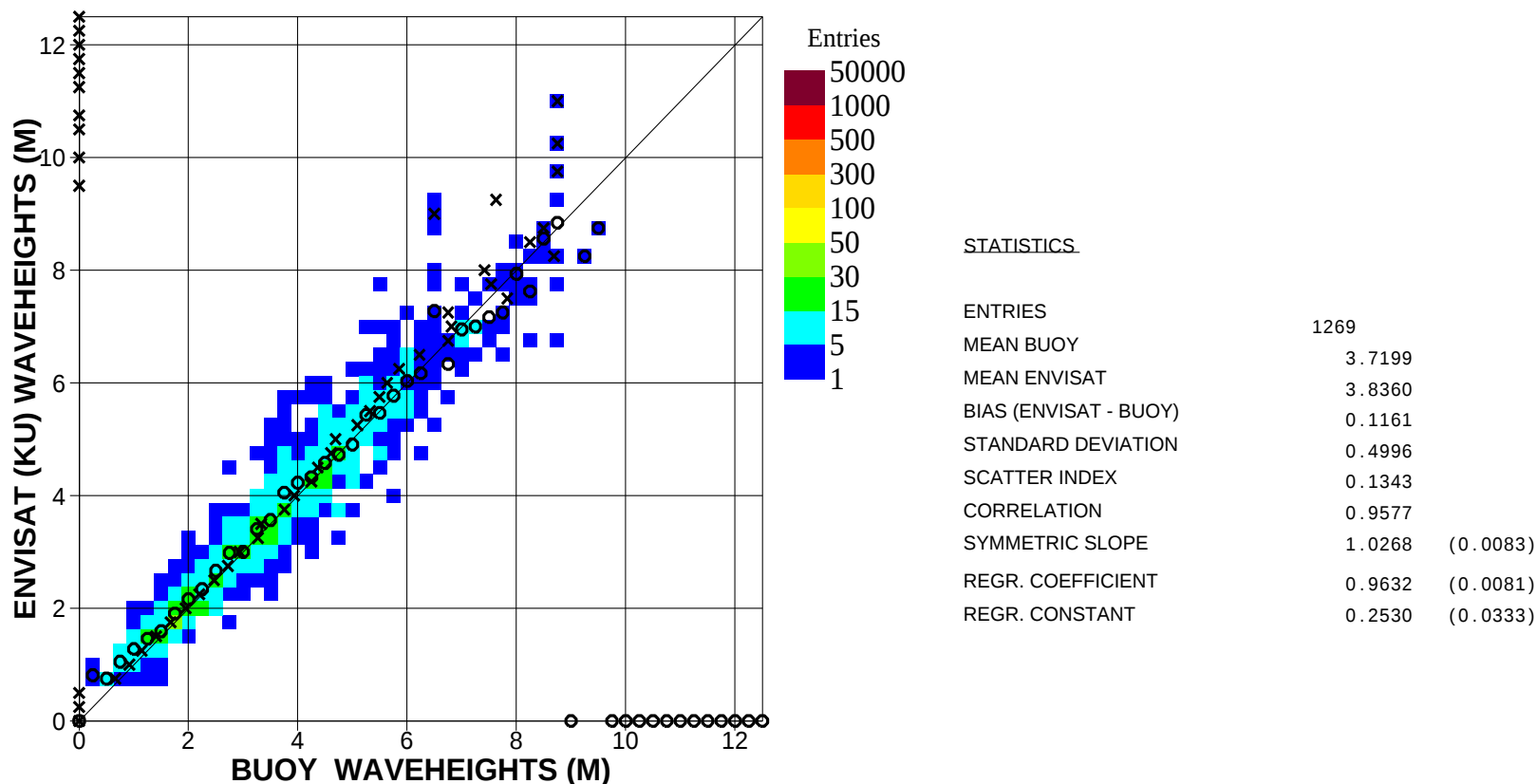


Figure 31. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for December 2006 (N.Hem.)

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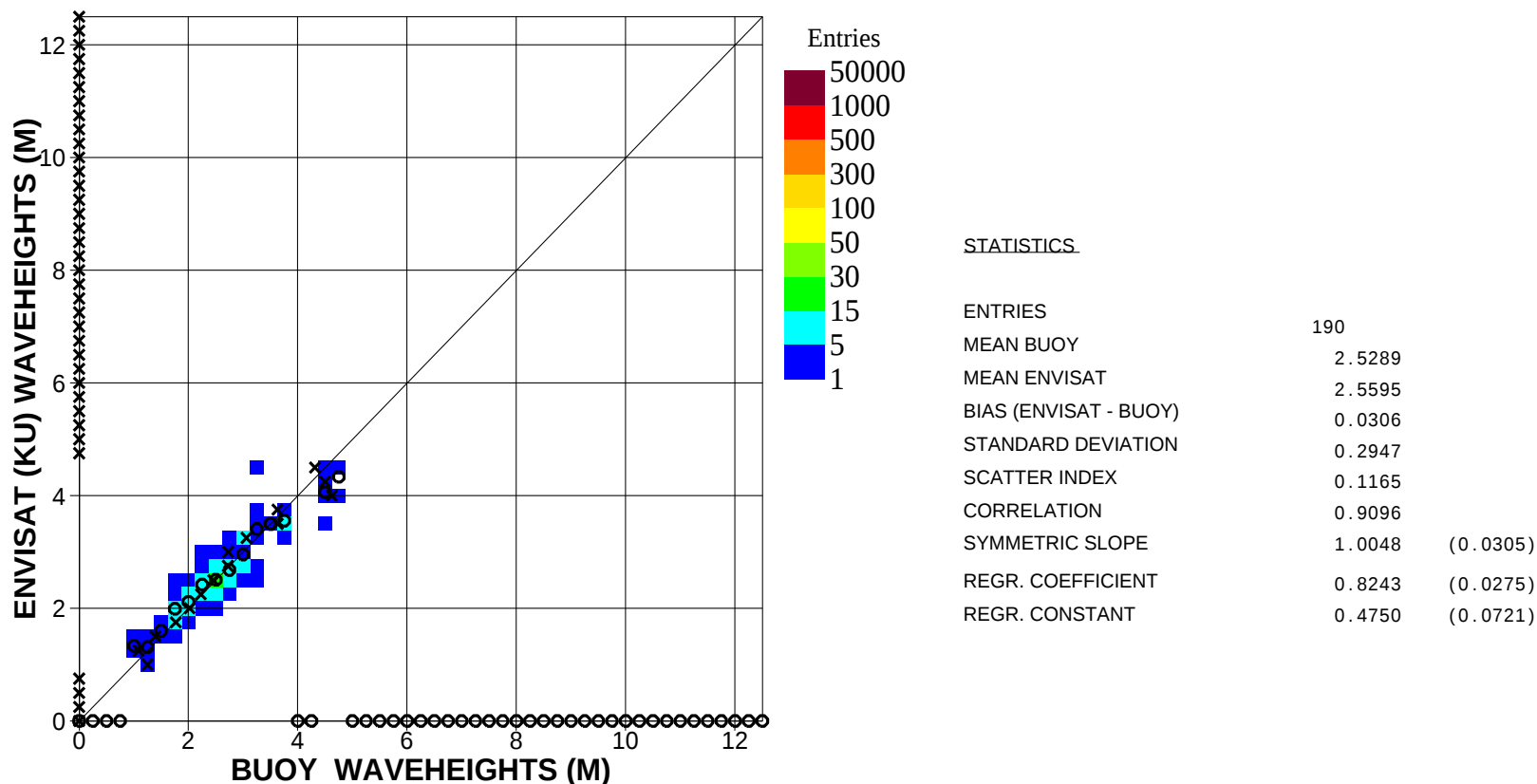


Figure 32. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for December 2006 (Tropics)

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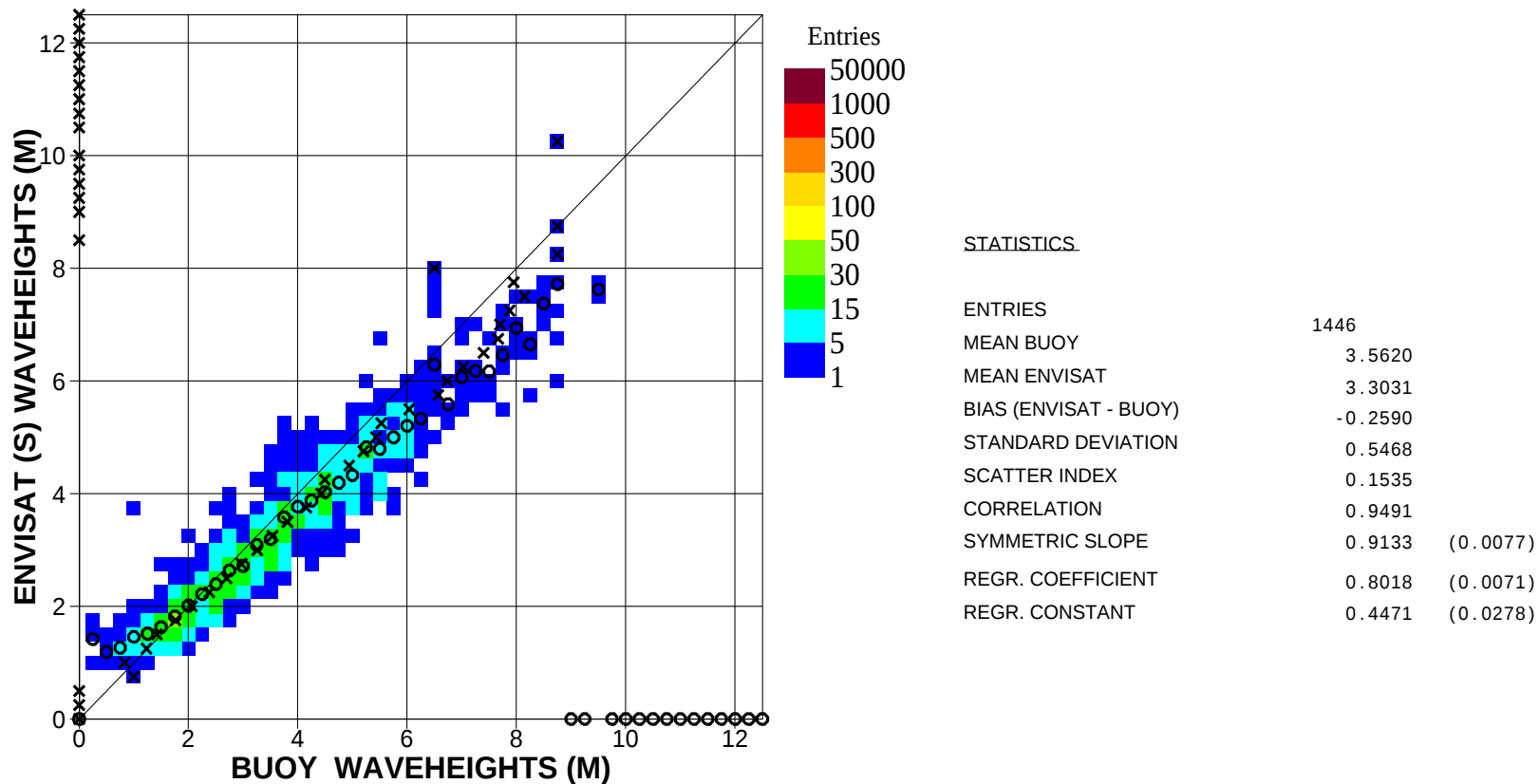


Figure 33. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for December 2006 (Global)

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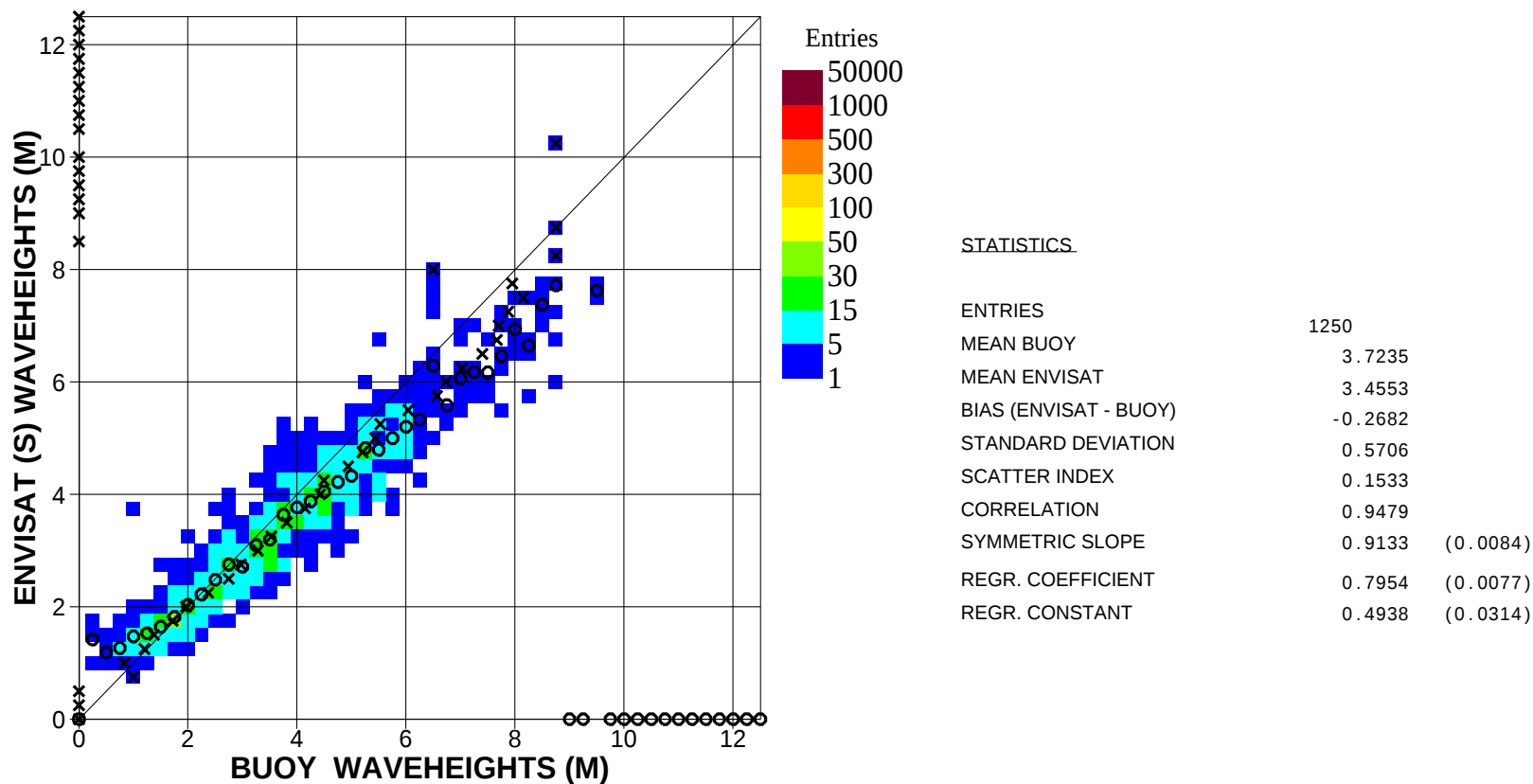


Figure 34. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for December 2006 (N.Hem.)

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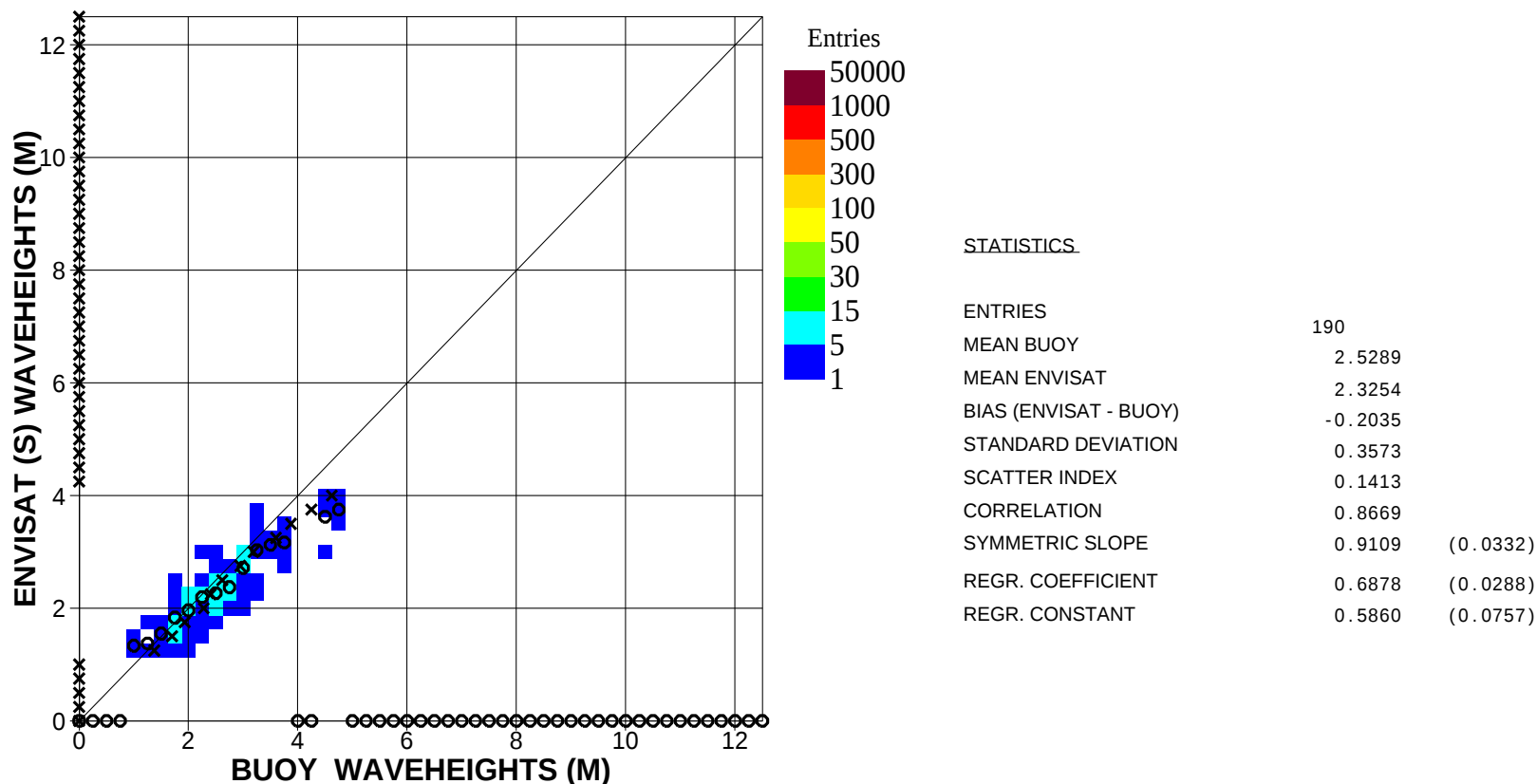


Figure 35. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for December 2006 (Tropics)

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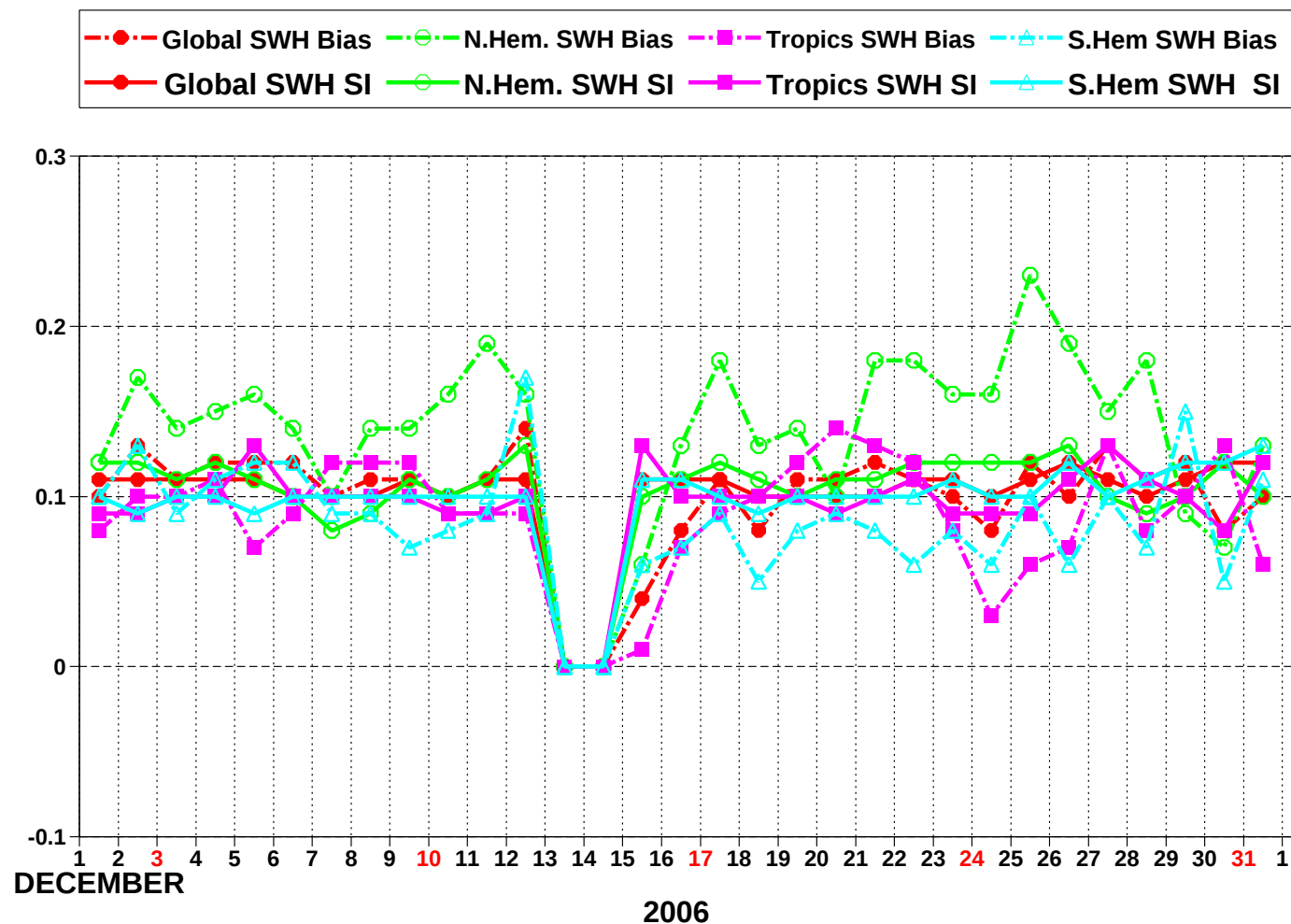


Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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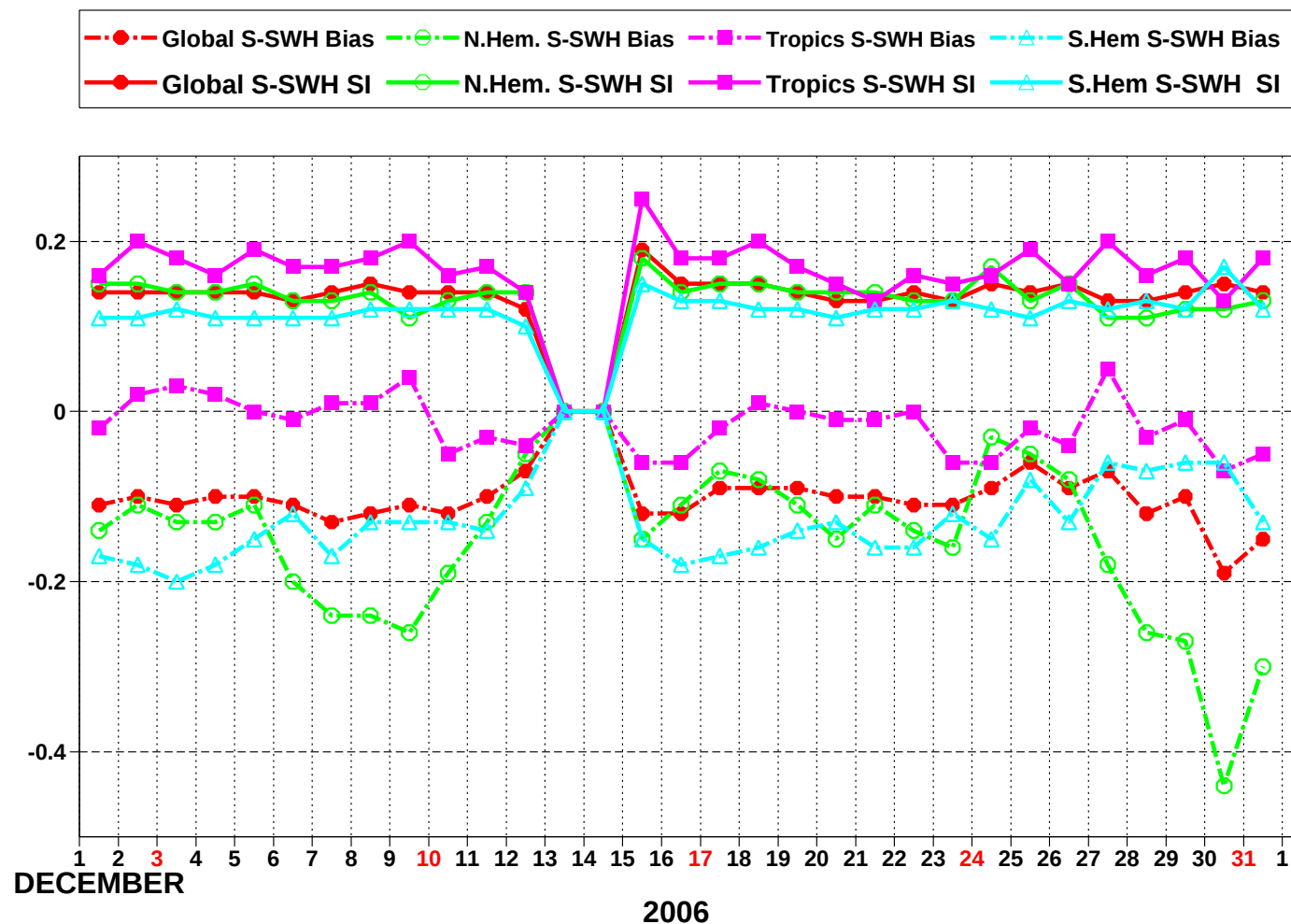


Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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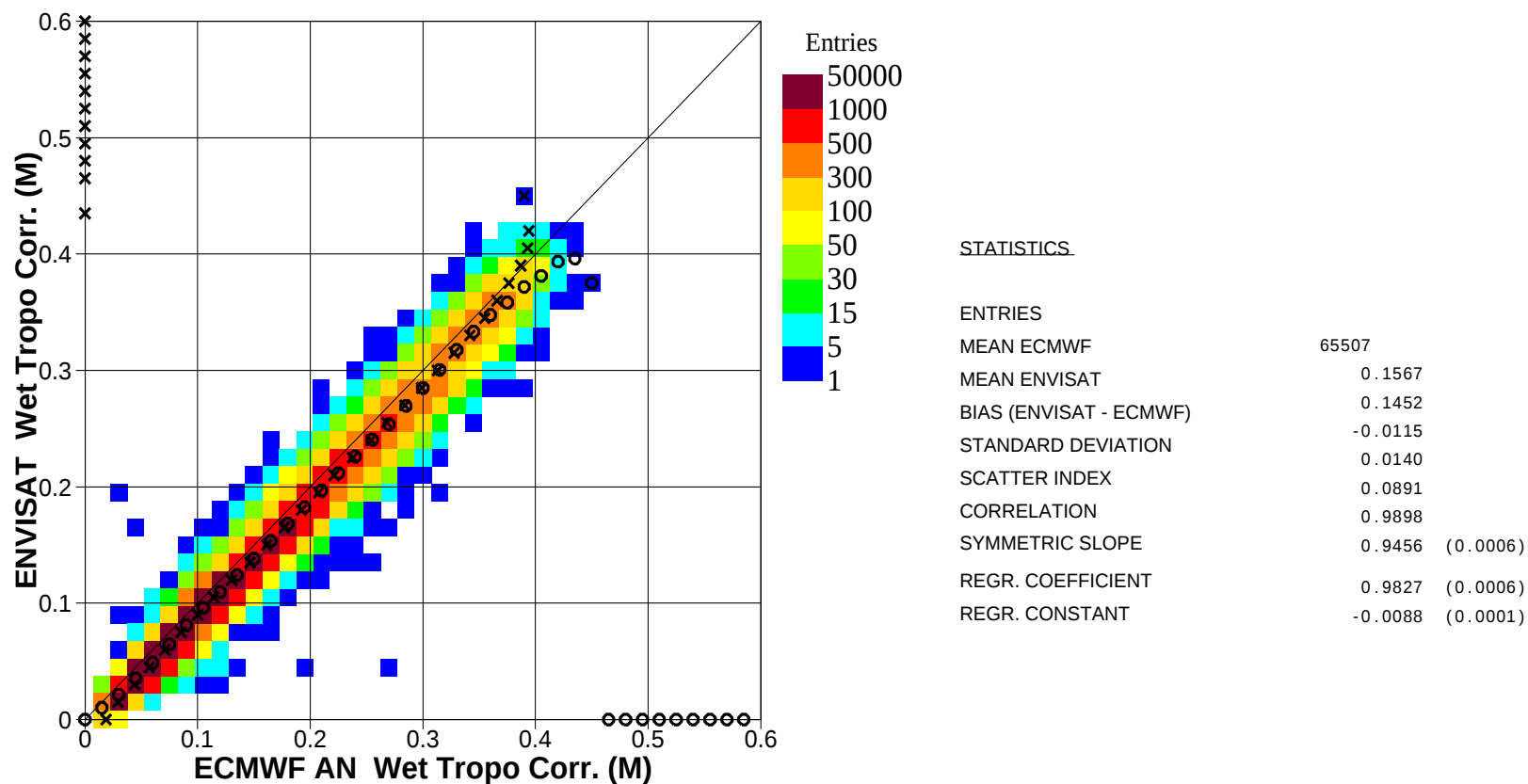


Figure 38. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2006 (Global)

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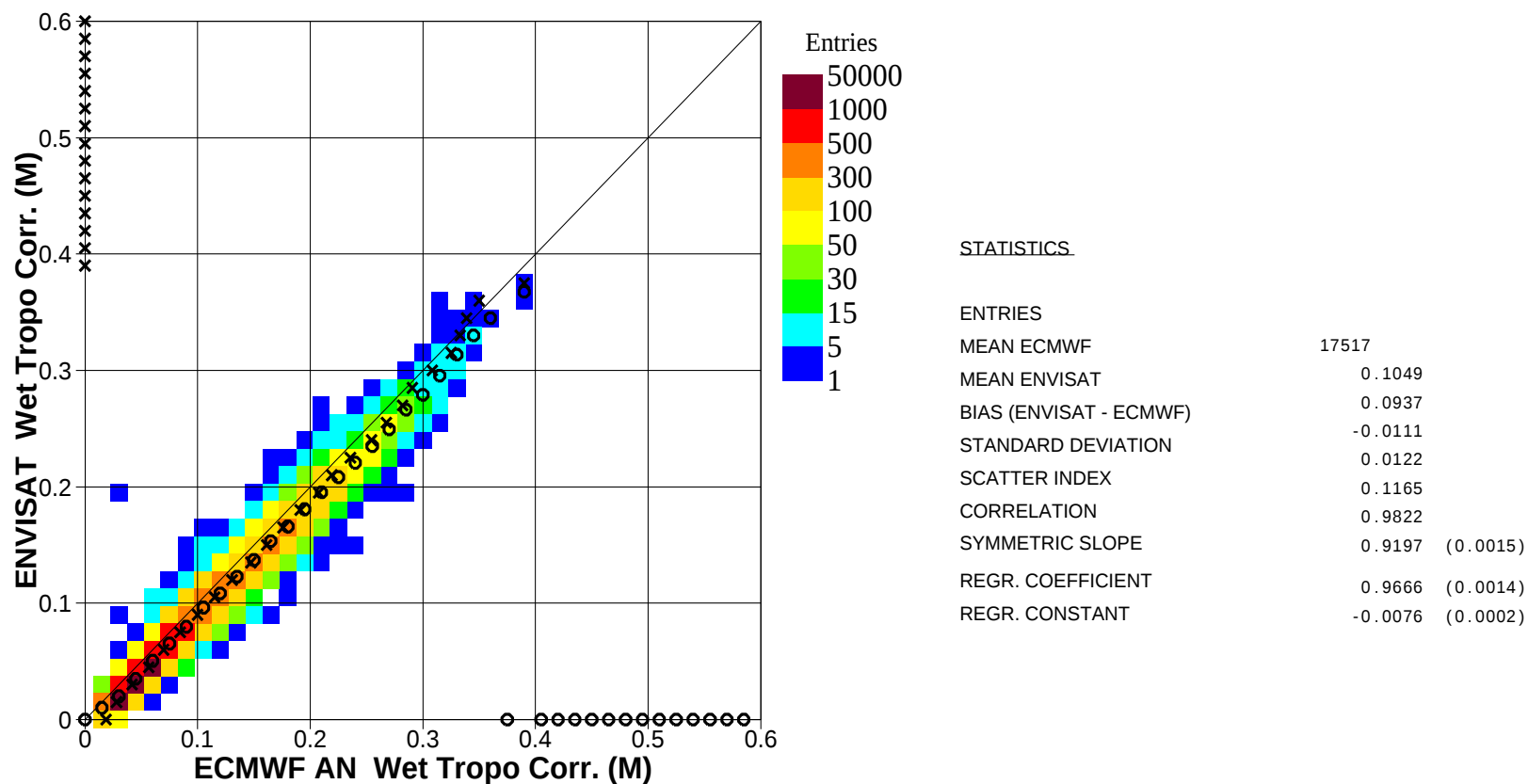


Figure 39. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2006 (N.Hem.)

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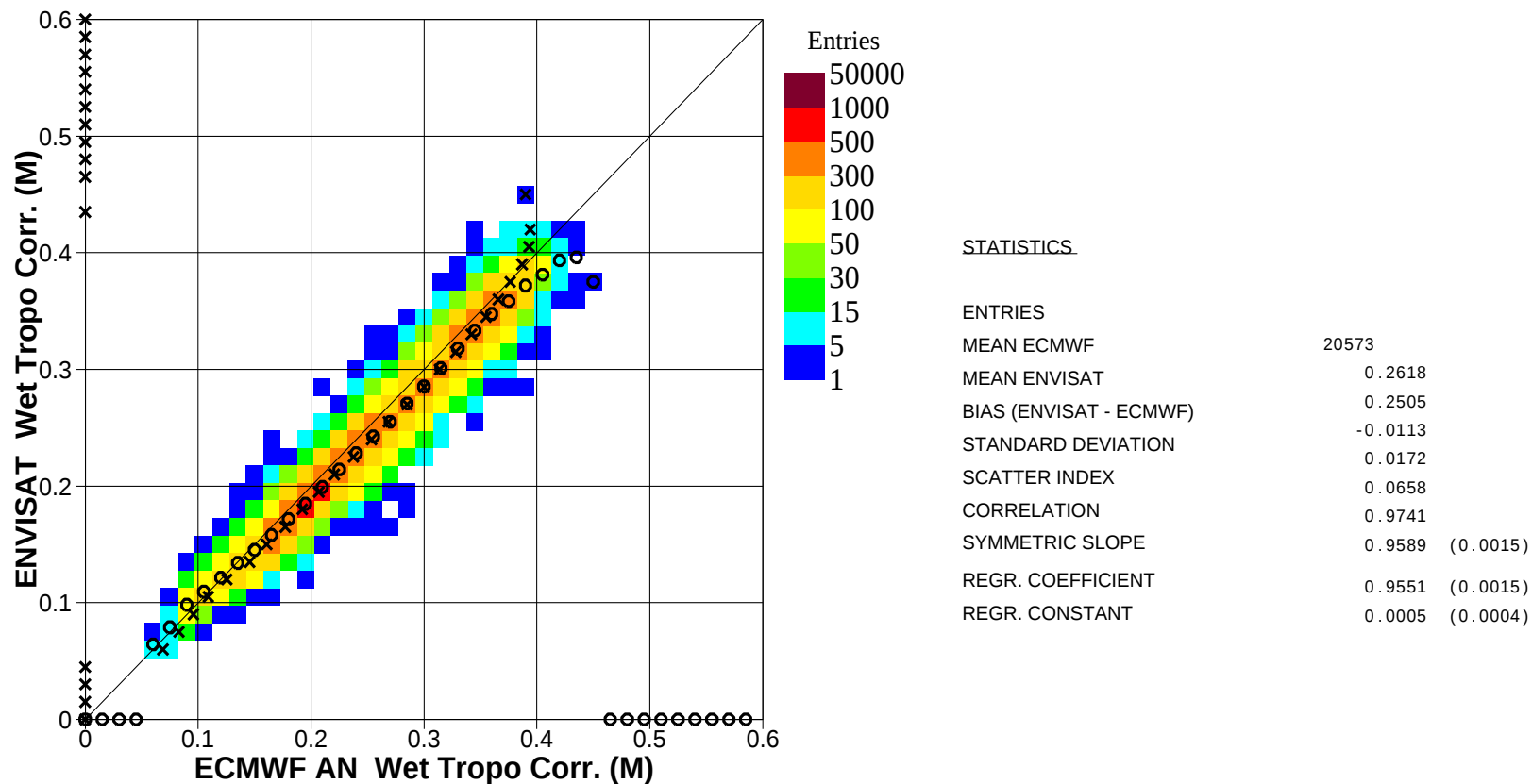


Figure 40. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2006 (Tropics)

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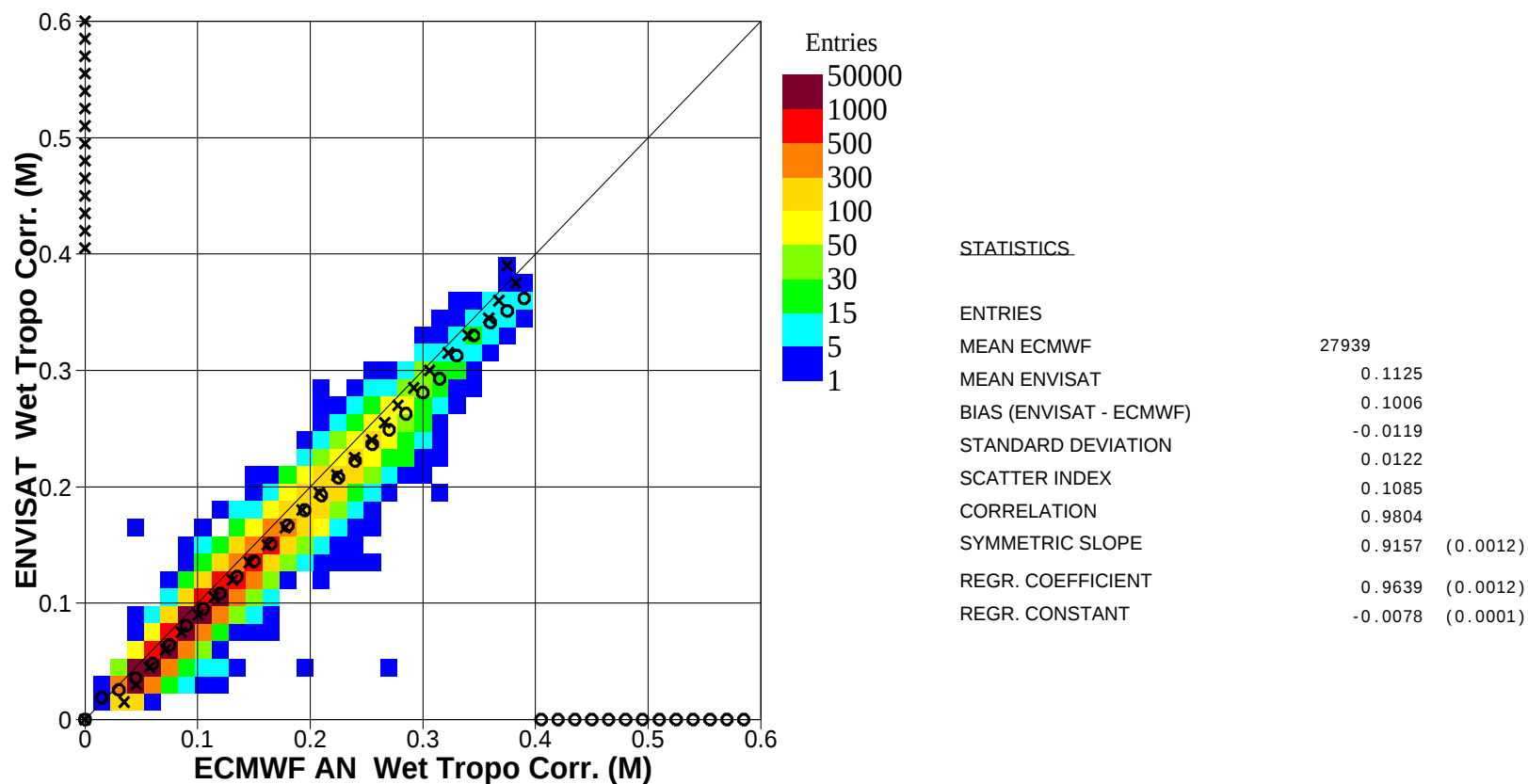


Figure 41. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2006 (S.Hem.)

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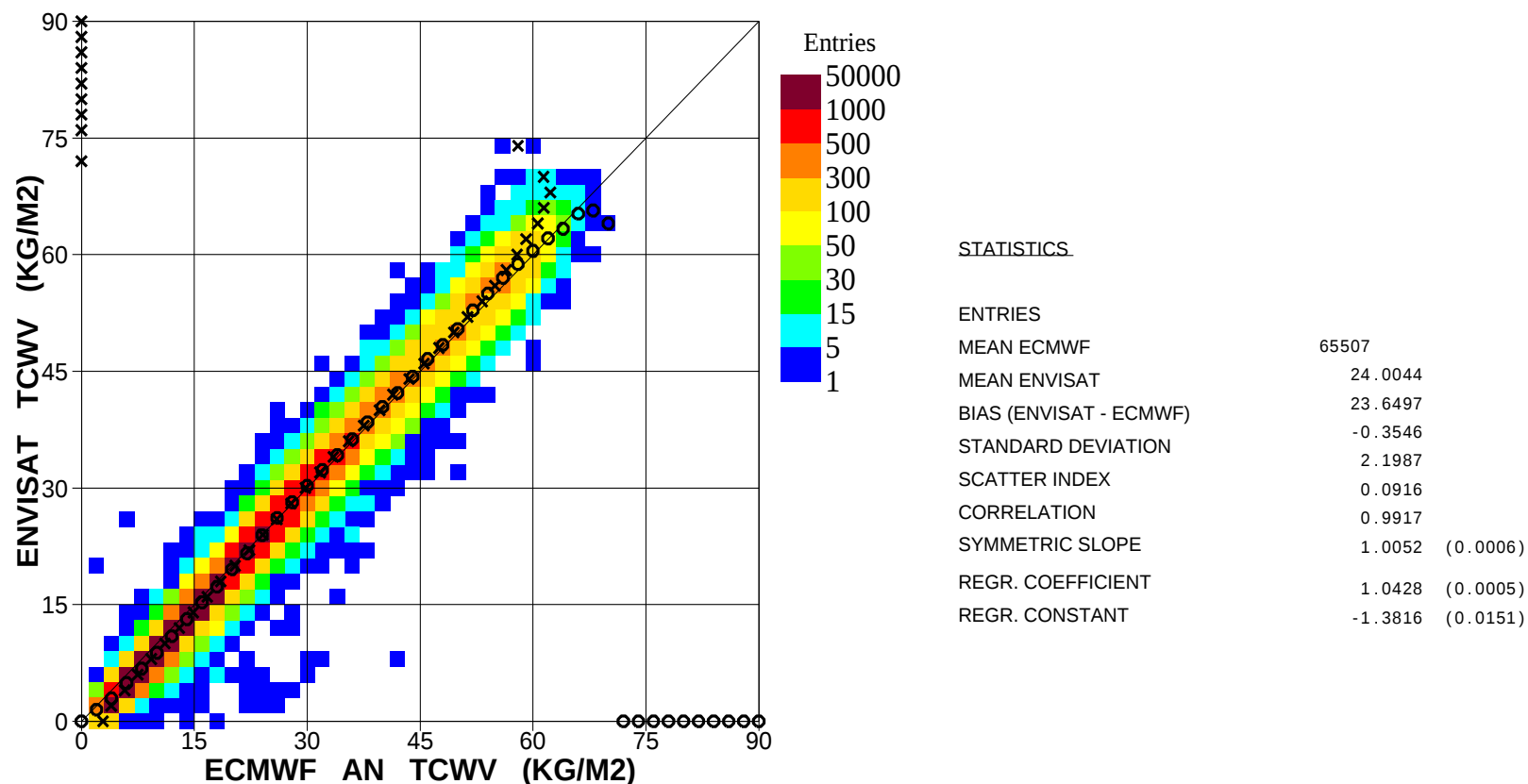


Figure 42. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for December 2006 (Global)

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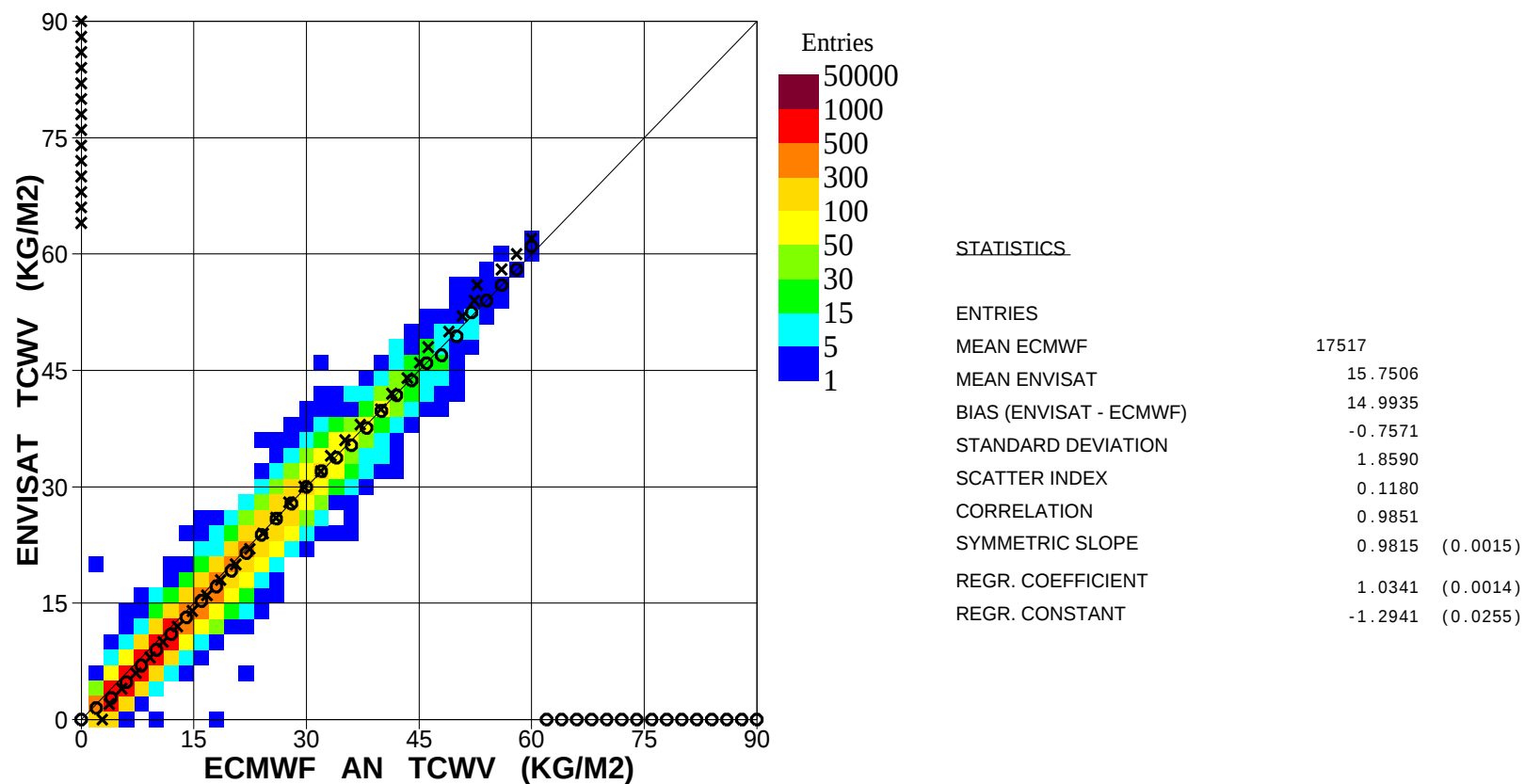


Figure 43. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for December 2006 (N.Hem.)

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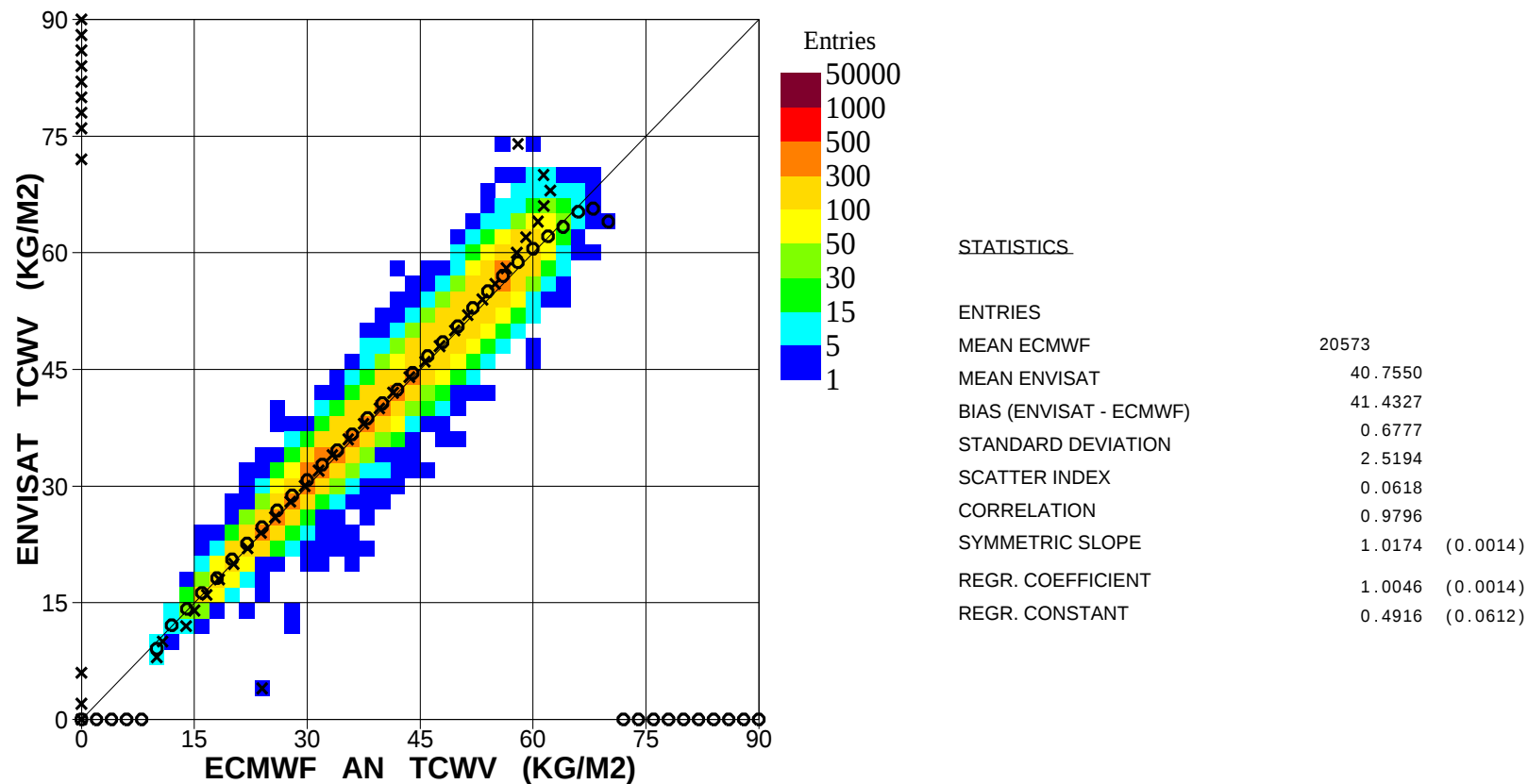


Figure 44. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for December 2006 (Tropics)

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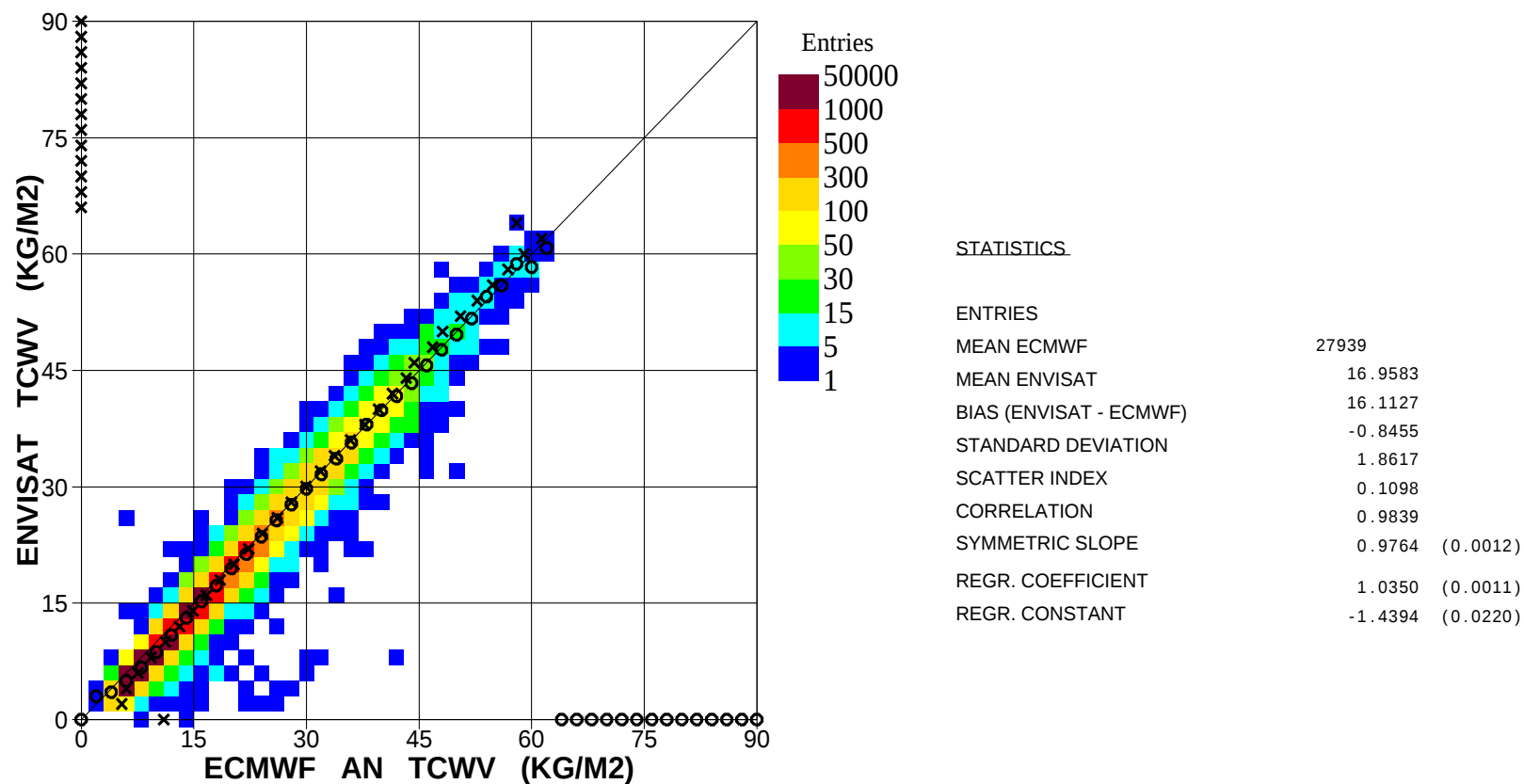


Figure 45. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for December 2006 (S.Hem.)

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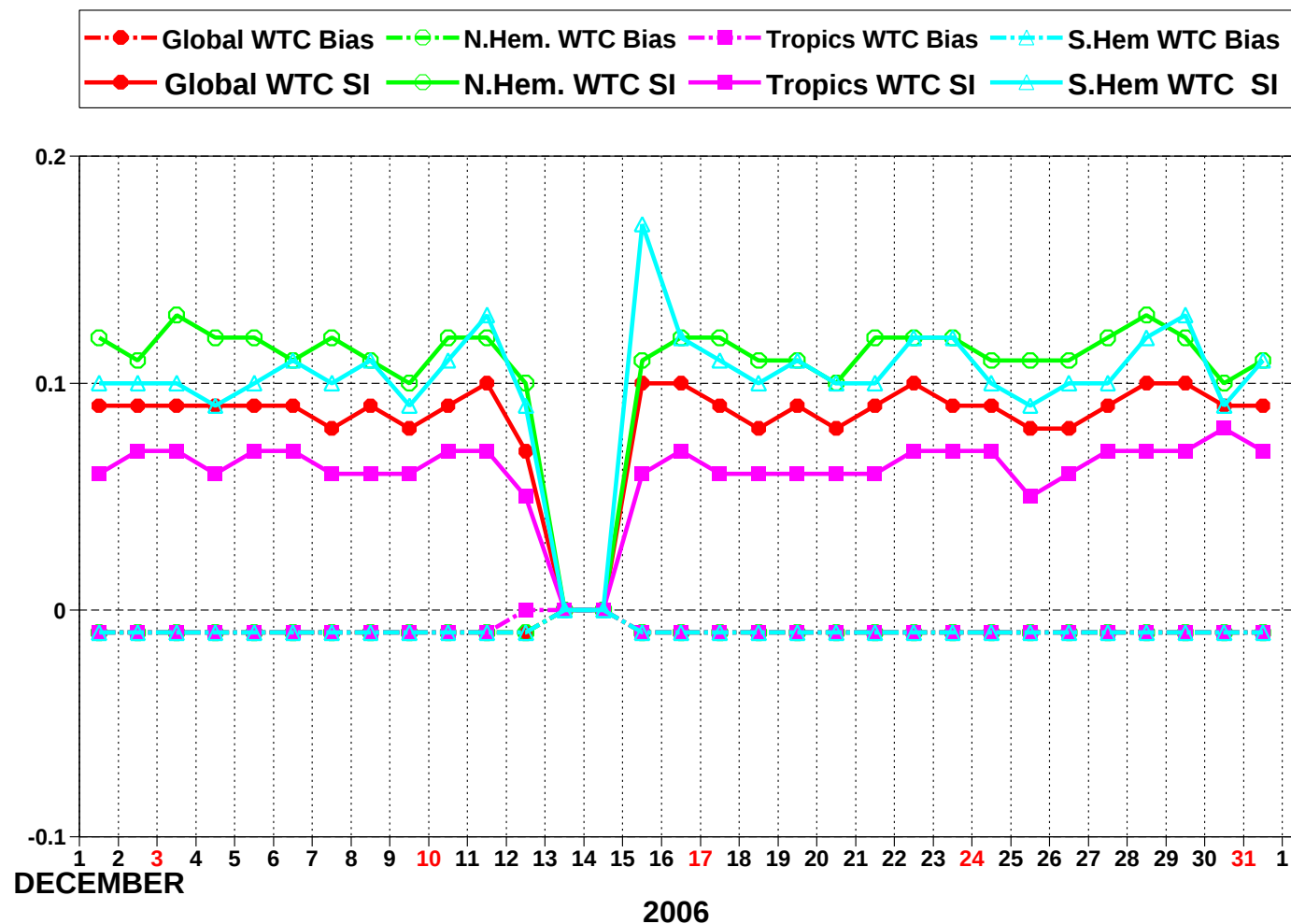


Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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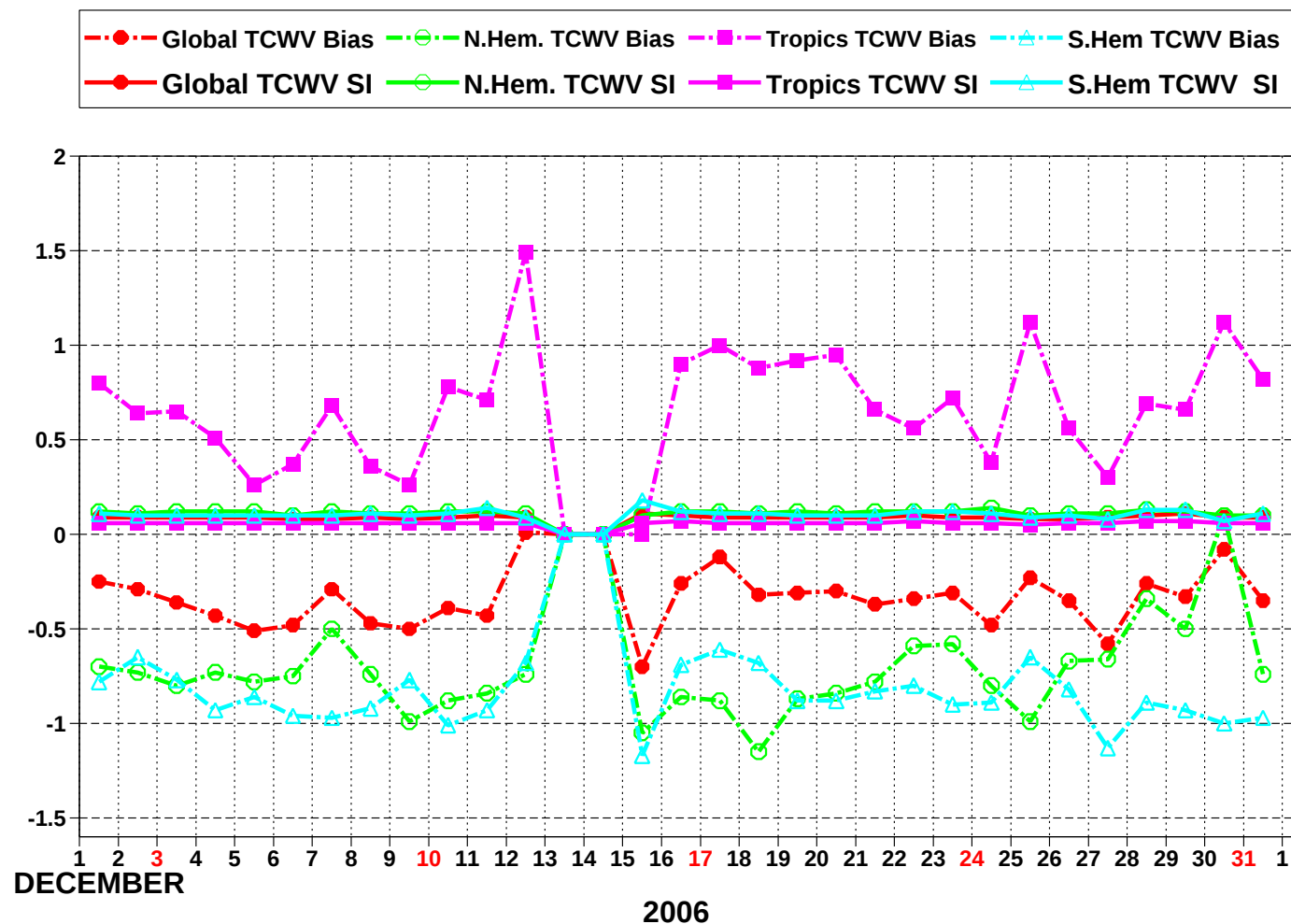


Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

■ ECMWF Report on ENVISAT RA-2 for December 2006 ■

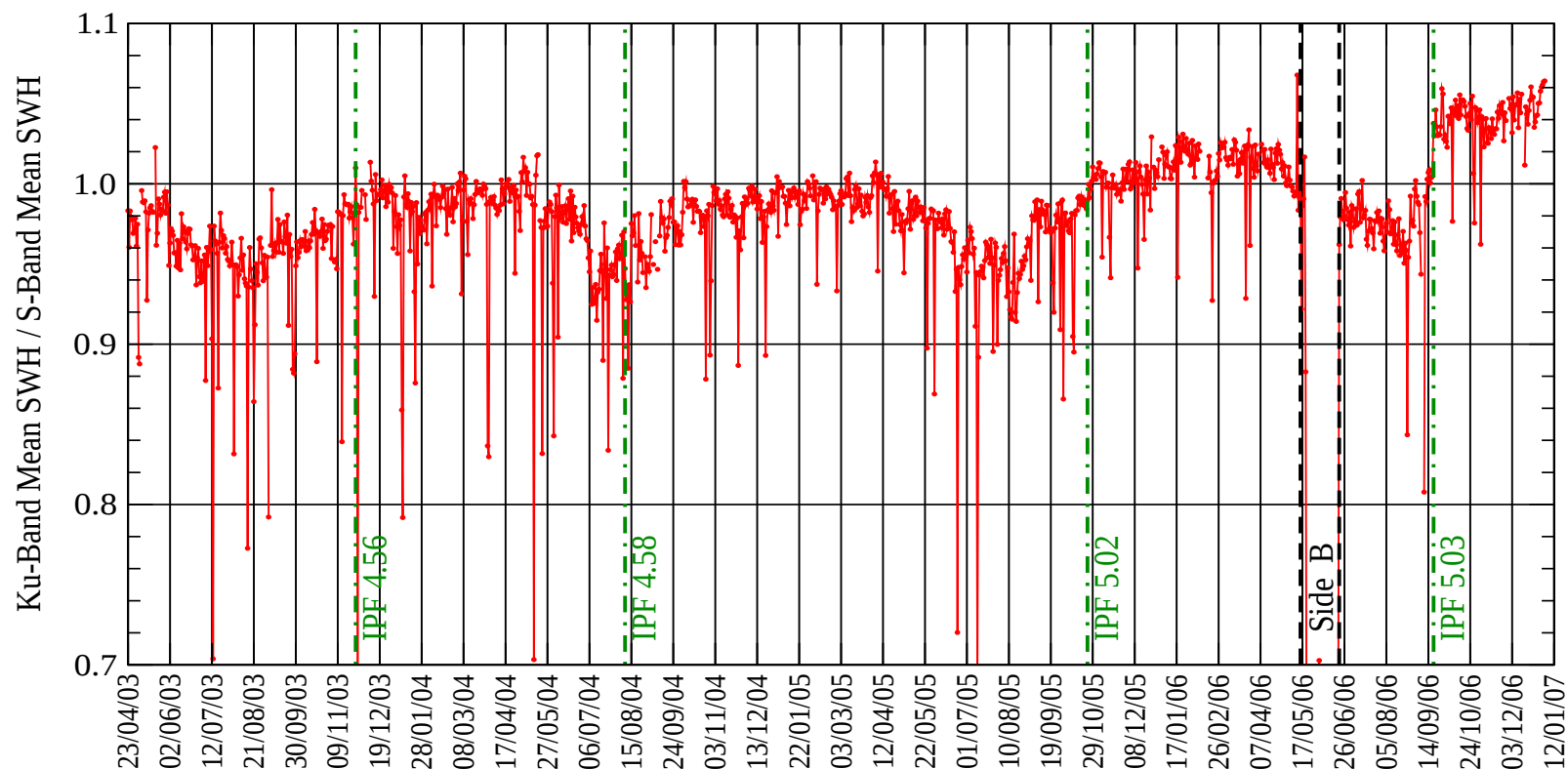


Figure 48: Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 23rd. of April 2003.