

# ■ ECMWF Report on ENVISAT RA-2 for August 2004 ■

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

**By:** *Saleh Abdalla*

**Date:** *21 September 2004*

### Overview:

Based on the data received during this month, on average, 14957 observations arrived at ECMWF every 6-hour window of which an average of 6065 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 77.61% of the remaining part passed the quality control. There was no data during the following periods (in terms of 6-hour time-windows; all times are in UTC) as can be seen in Figure 49:

- Time windows centred at 00:00 on the 2nd. and the 9th. of the month.
- Time windows from 00:00 on the 10th. till 06:00 on the 11th. of the month except for time window 12:00 on the 12th.
- Time windows centred at 12:00 on the 21st. and the 22nd. of the month.
- Time windows centred at 12:00 and 18:00 on the 29th. of the month.

On the other hand, there was significant reduction in data volume during the following periods:



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- Time window centred at 06:00 on the 1st. of the month.
- Time windows centred at 00:00 and 06:00 on the 8th. of the month.
- Time windows centred at 06:00 and 18:00 on the 9th., the 21st. and the 22nd. of the month.
- Time windows centred at 12:00 and 18:00 on the 19th., the 20th. and the 26th. of the month.
- Time window 12:00 on the 27th. of the month.

Full nominal coverage was attained most of the month. Unfortunately, the “MWR L2 Processing Flag” started to become missing for about 42% of the data since the beginning of the second week of August 2004. The pre-processing software interpreted such data records as “corrupt” and therefore did not include them in analysis. Therefore the amount of data used in the operational analysis can be seen in Figure 1. This bug was spotted and a correction will be implemented soon. Note that we are talking about the raw data which we downloaded in “buf” format before they were processed.

## **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 number of outliers. The quality of wind speed observations is good. Apart from the few outliers, MWR products are generally fine and in good agreement with the model (wet tropo correction is somewhat smaller than the model).

## **Backscatter:**

- ENVISAT RA-2 Ku-Band  $\langle\sigma_0\rangle = 11.24$  dB (with a single peak at  $\sim 11.1$  dB).
- ENVISAT RA-2 S-Band  $\langle\sigma_0\rangle = 11.55$  dB (with a single rather broad peak at  $\sim 10.6$  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	-0.30	17.5	-1.10	19.4
Northern Hemisphere	-0.74	19.4	-1.17	20.0
Tropics	-0.44	17.2	-0.65	14.8
Southern Hemisphere	+0.14	14.9	----	----

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

	RA2 (Ku) - WAM		RA2 (Ku) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.12	13.7	0.10	16.8
Northern Hemisphere	0.10	17.8	0.10	17.7
Tropics	0.05	12.7	0.02	8.5
Southern Hemisphere	0.18	11.7	----	----

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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	0.12	23.6	0.25	30.7
Northern Hemisphere	0.27	34.2	0.28	31.8
Tropics	0.08	25.8	-0.09	11.7
Southern Hemisphere	0.03	18.0	----	----

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 <sup>2</sup> )	SI (%)
Global	-0.012	15.4	-0.55	16.0
Northern Hemisphere	-0.013	19.1	-0.72	17.7
Tropics	-0.011	6.5	+0.58	6.7
Southern Hemisphere	-0.013	25.6	-1.29	31.0

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## Remarks:

- The “MWR L2 Processing Flag” started to become missing for about 42% of the time since the beginning of the second week of August 2004. The pre-processing software interpreted such data records as “corrupt” and therefore did not include them in the analysis.
- There was no ECMWF model changes during the reporting period.
- 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.
- Although the rain flag is only responsible for the rejection of 5% of the data this month, it was responsible for rejection of most of the data on the 7th., the 12th., and the 14th. of the month (lower panel of Figure 49).
- The wind speed data are in good agreement with the wave model and buoy data except for very low wind speeds (below ~ 4 m/s) and for high wind speeds (20 m/s and above).
- The wind speed algorithm needs some adjustments both in the low wind regime (below ~ 4 m/s) and more importantly for the very high wind regime (20 m/s and above) as can be concluded from the scatter plots in Figures 7-13 and from comparing the histograms in Figures 5 and 6. Furthermore, the wind speed histogram of Figure 4 indicates that wind speeds around and below 1 m/s may not be optimal.
- There is a trend for Ku-band wave heights to be slightly overestimated by about 5% when compared to WAM results. 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 higher than buoy wave heights by about 4% 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

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number of outliers is similar to last month. Most of those outliers occurred on the 7th., the 12th., and the 14th. of the month (Figure 37) when there was over-active rain flagging.

- The ratio between Ku-band and S-band wave heights varied between  $\sim 0.92$  to  $\sim 0.98$  as can be seen in Figure 48.
- 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).
- 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 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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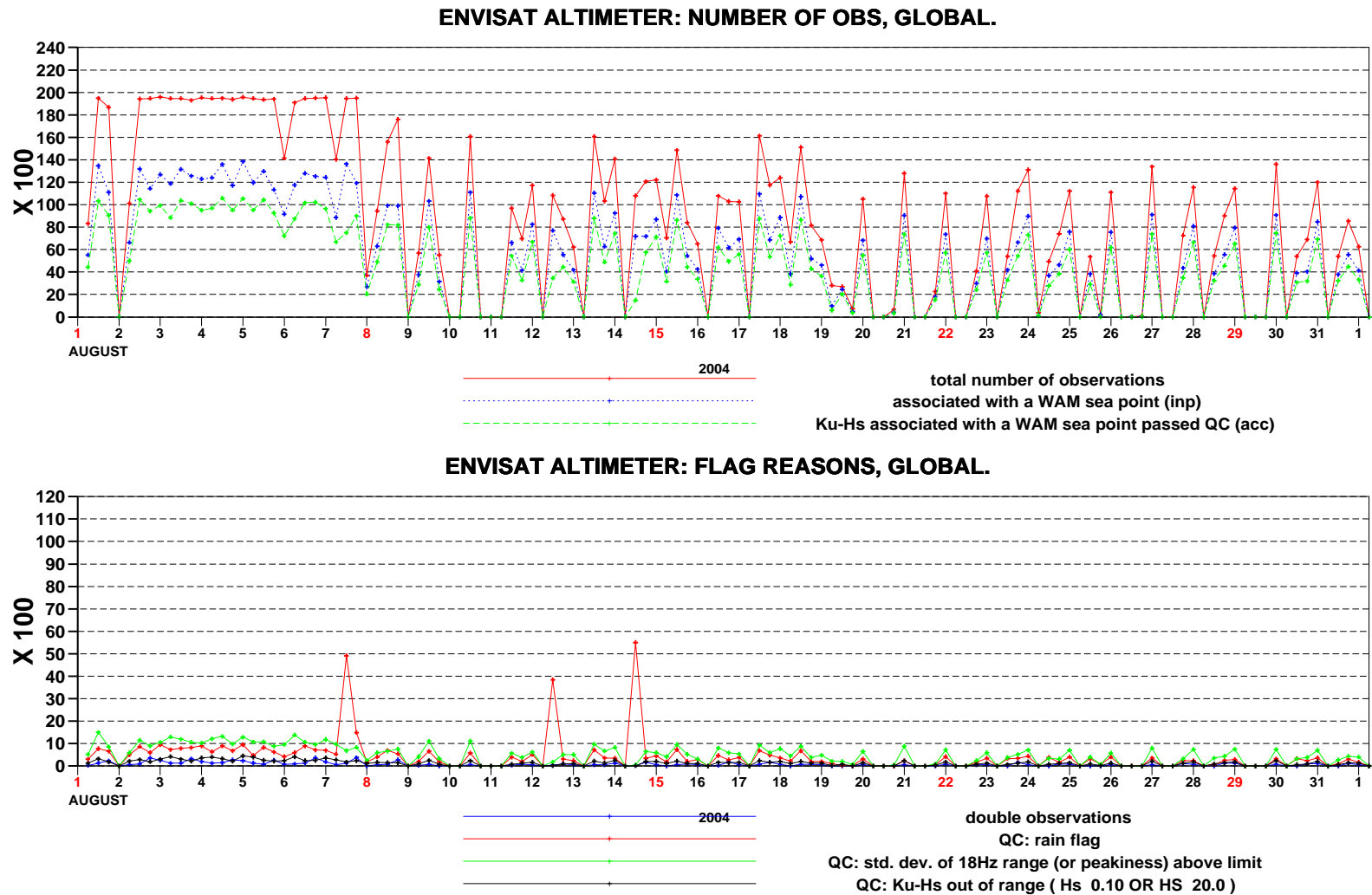


Figure 1: Time series of data reception for ENVISAT Altimeter data for August 2004

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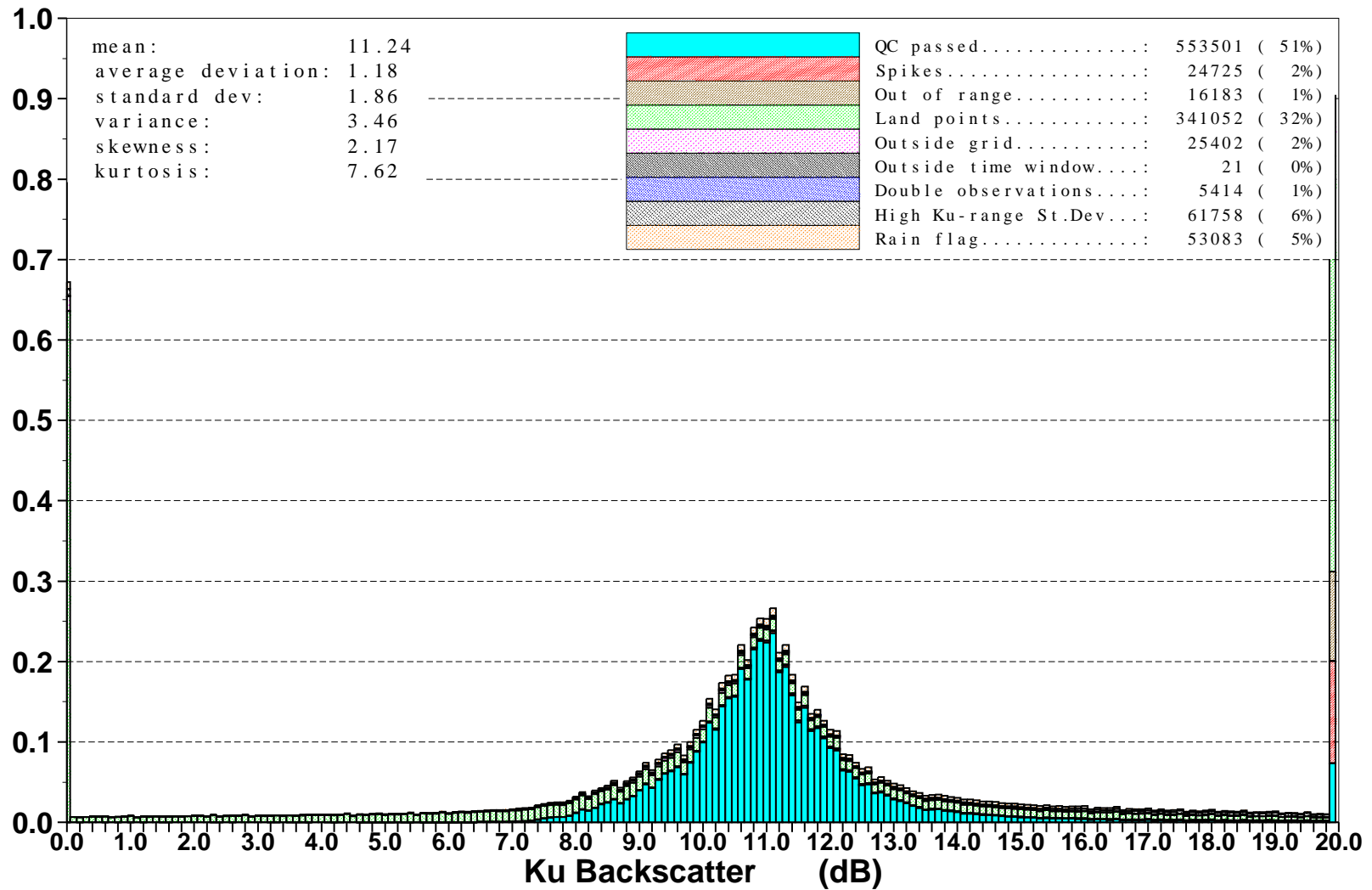


Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for August 2004



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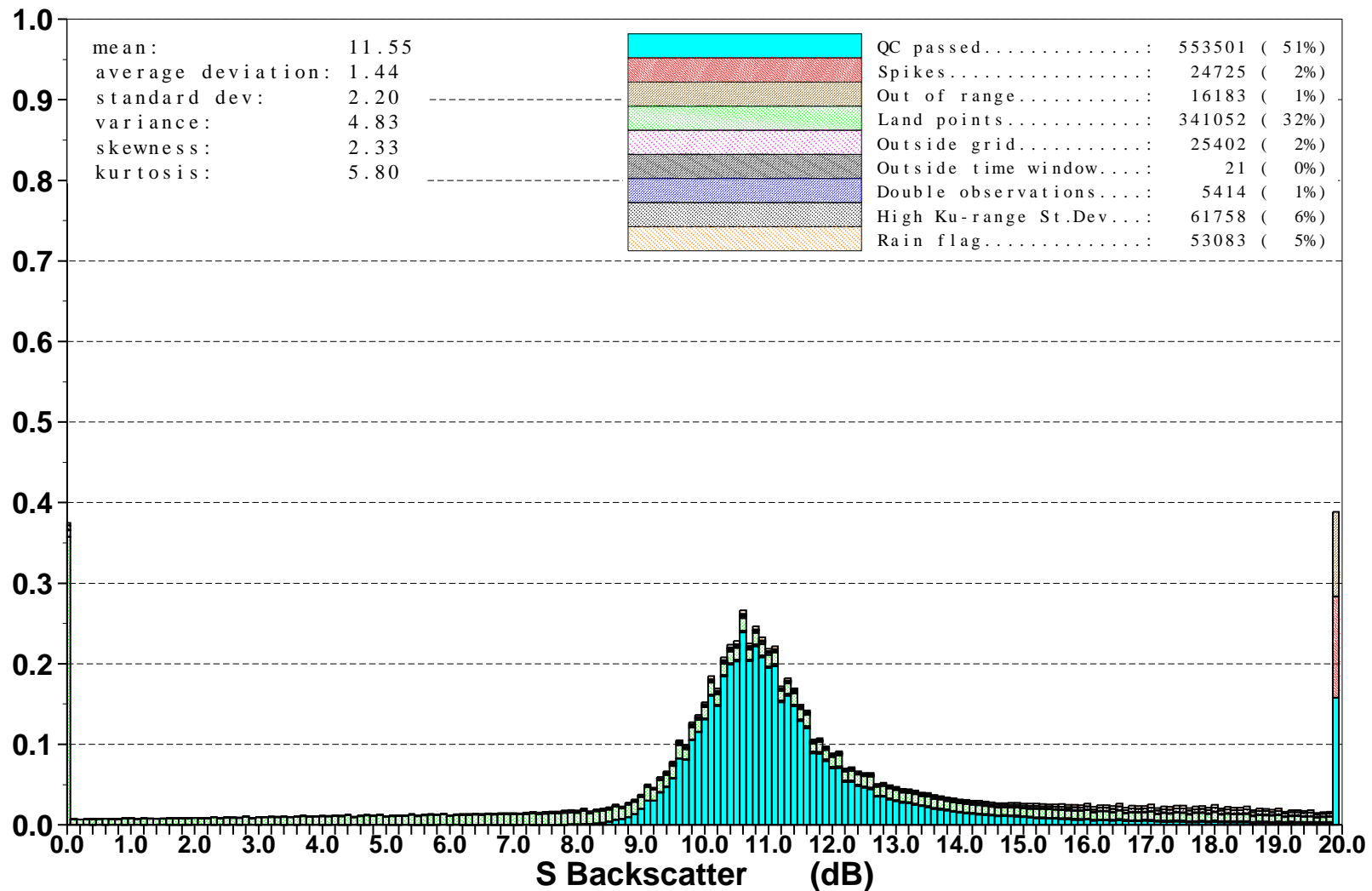


Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for August 2004



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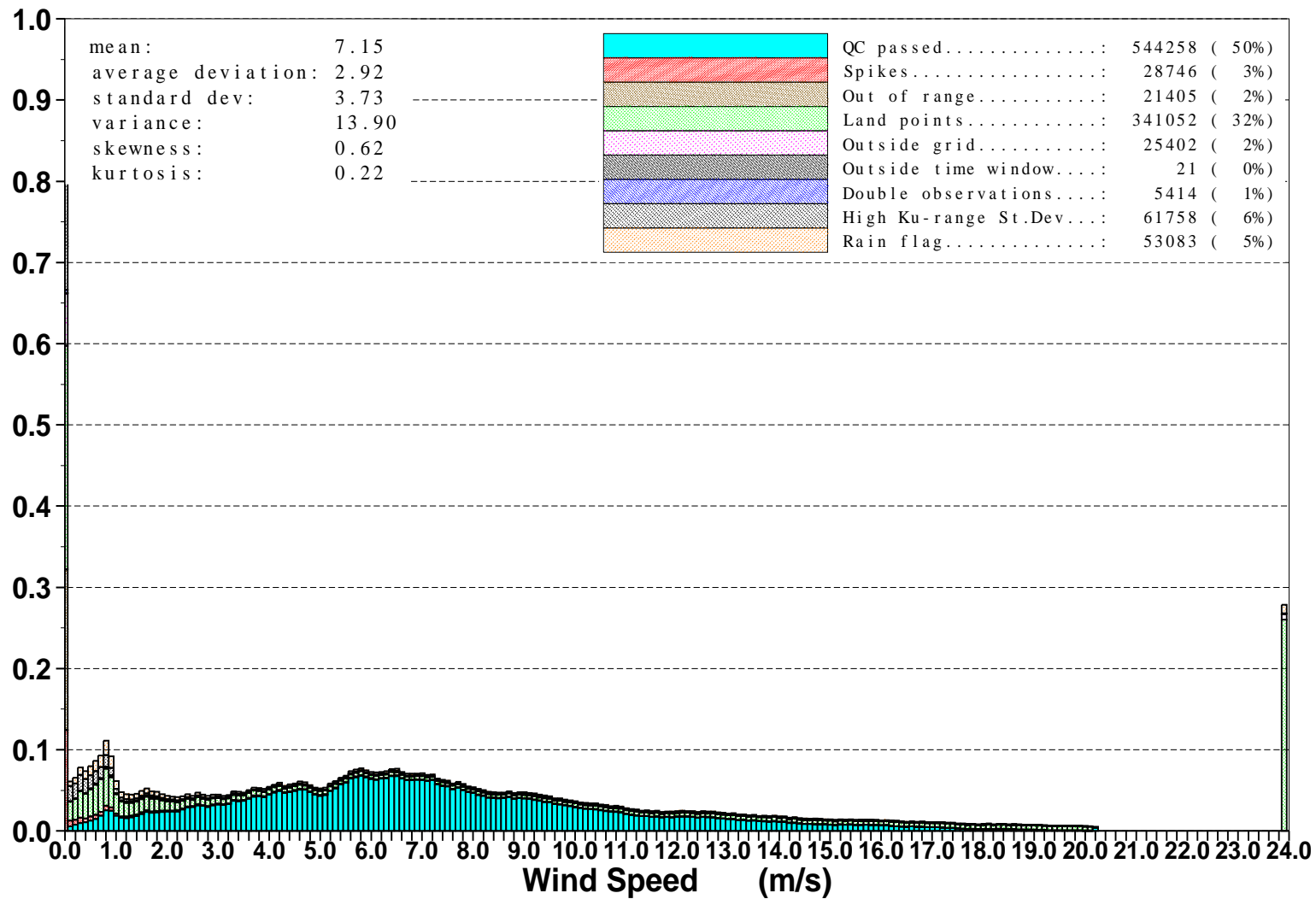


Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for August 2004

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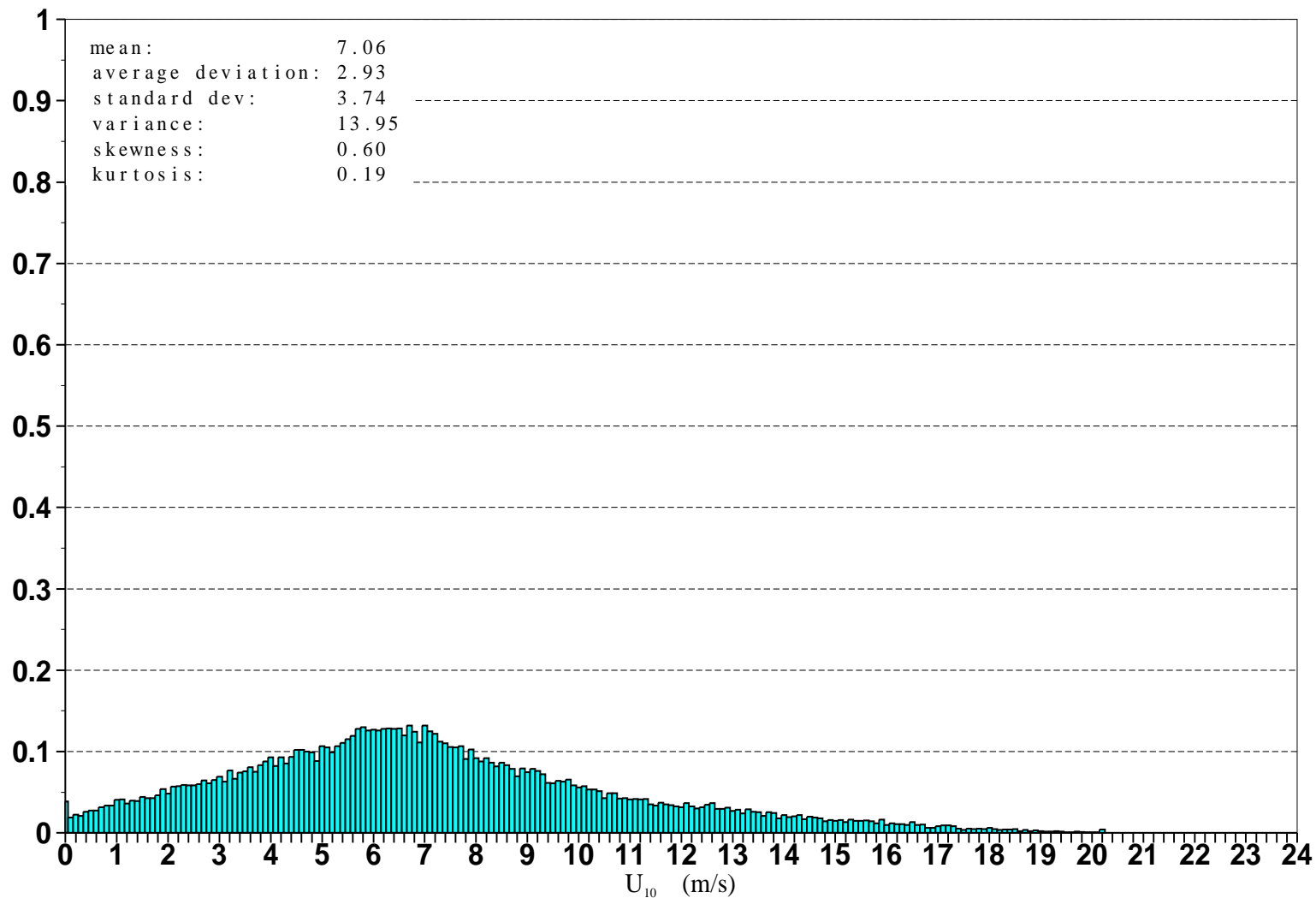


Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for August 2004



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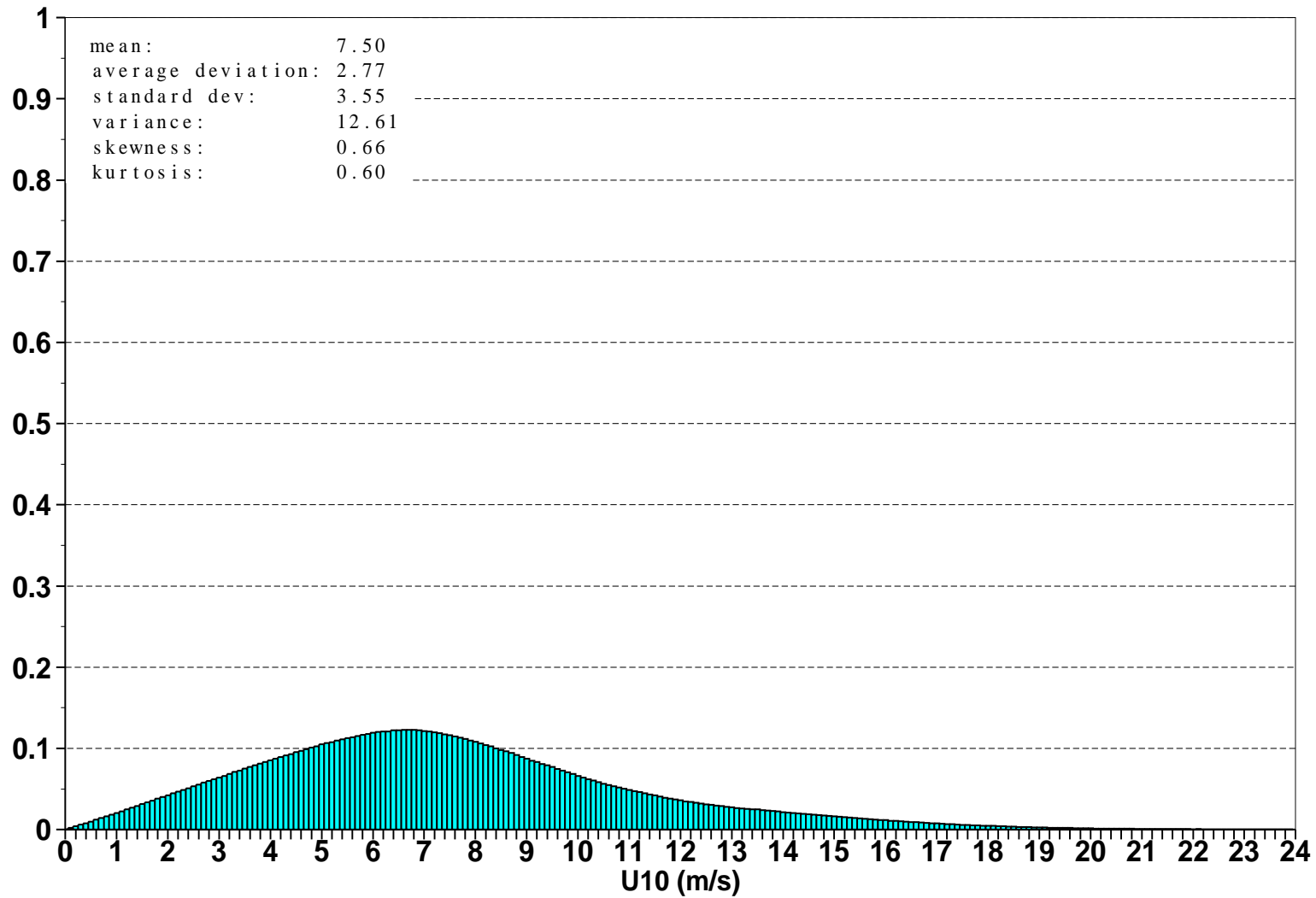


Figure 6: Global distribution of ECMWF Analysis ocean surface wind speeds for August 2004



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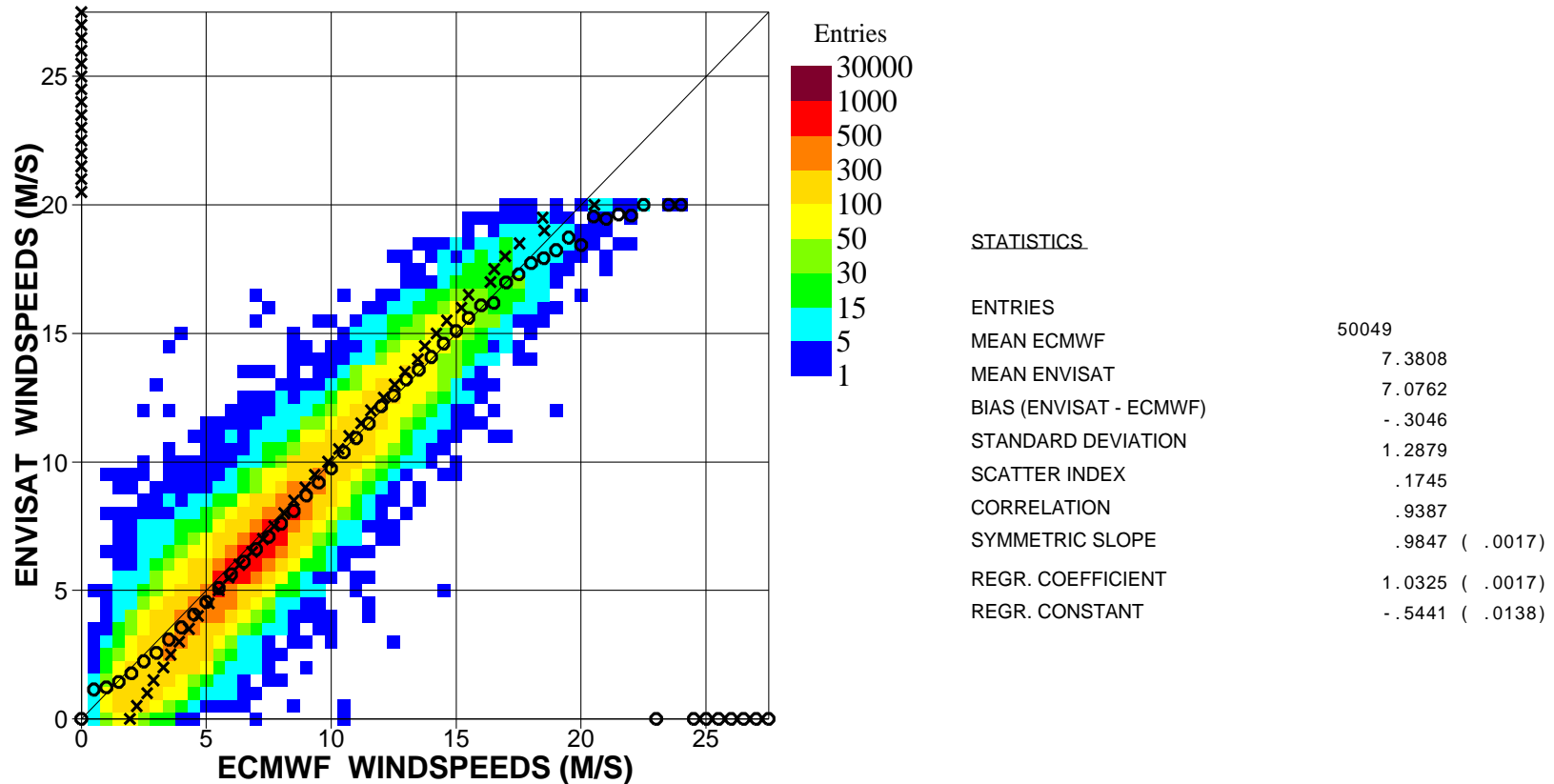


Figure 7. Comparison between ENVISAT Altimeter and ECMWF wind speeds for August 2004 (Global)

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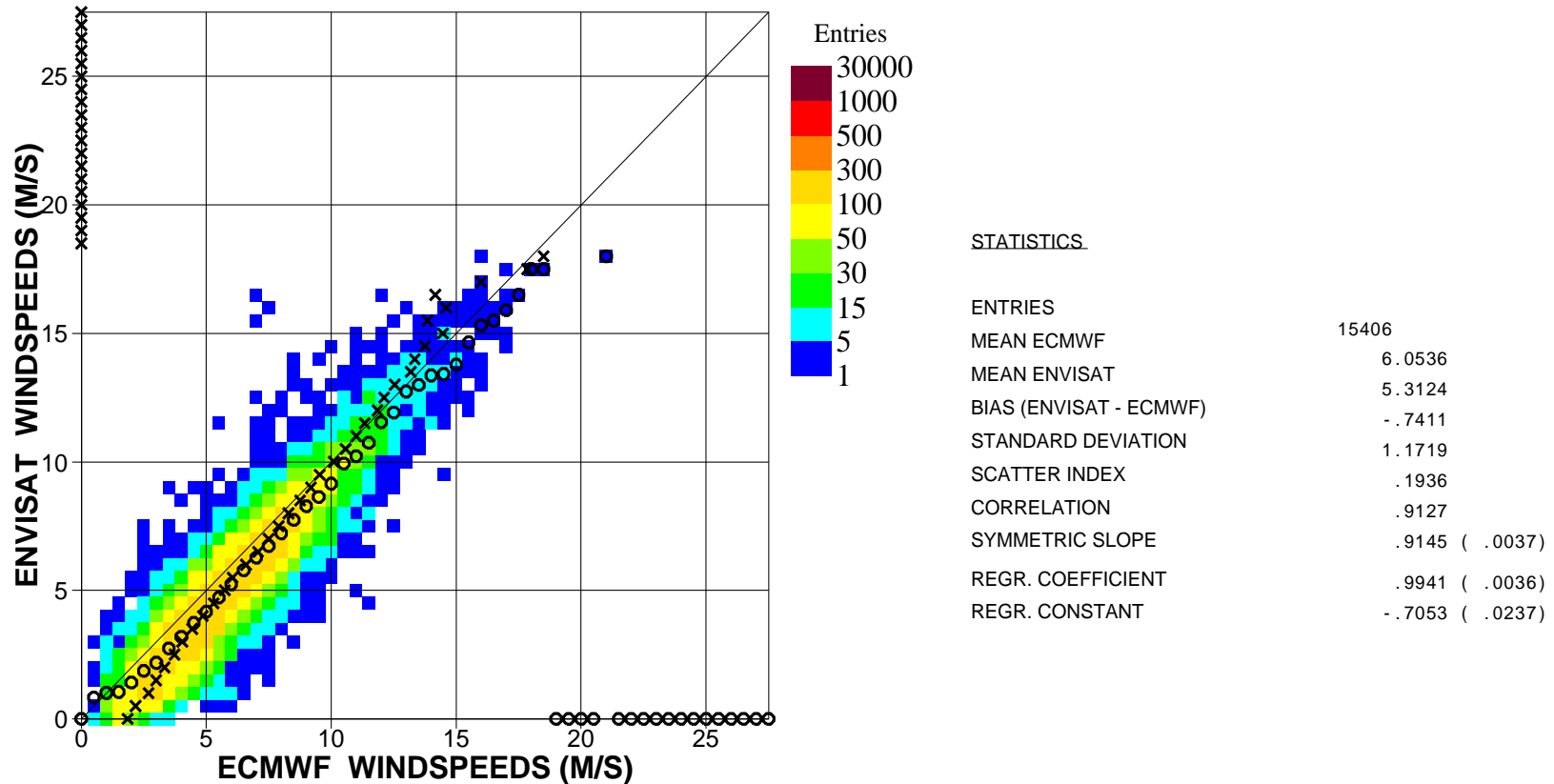


Figure 8. Comparison between ENVISAT Altimeter and ECMWF wind speeds for August 2004 (N.Hem.)

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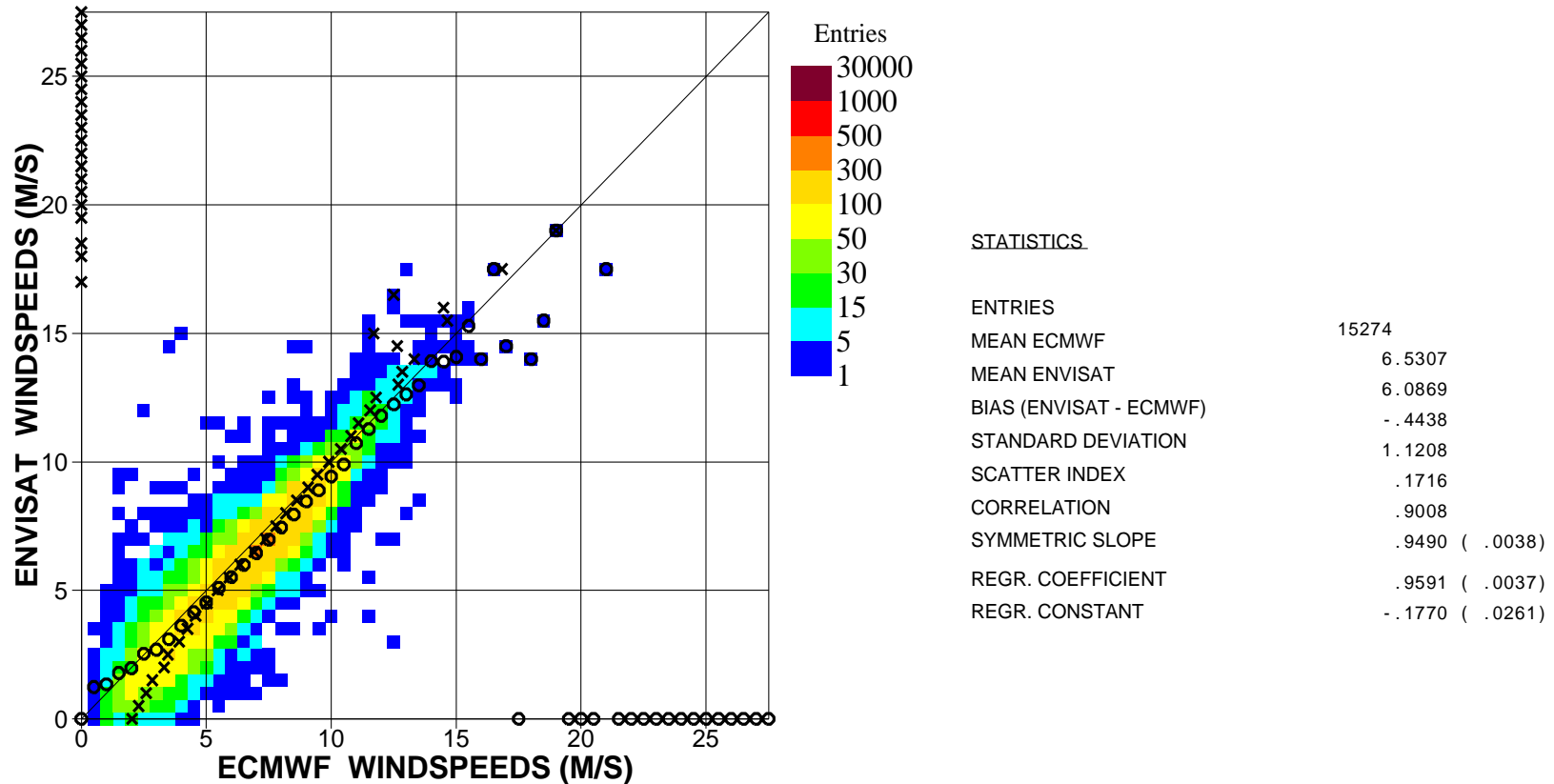


Figure 9. Comparison between ENVISAT Altimeter and ECMWF wind speeds for August 2004 (Tropics)

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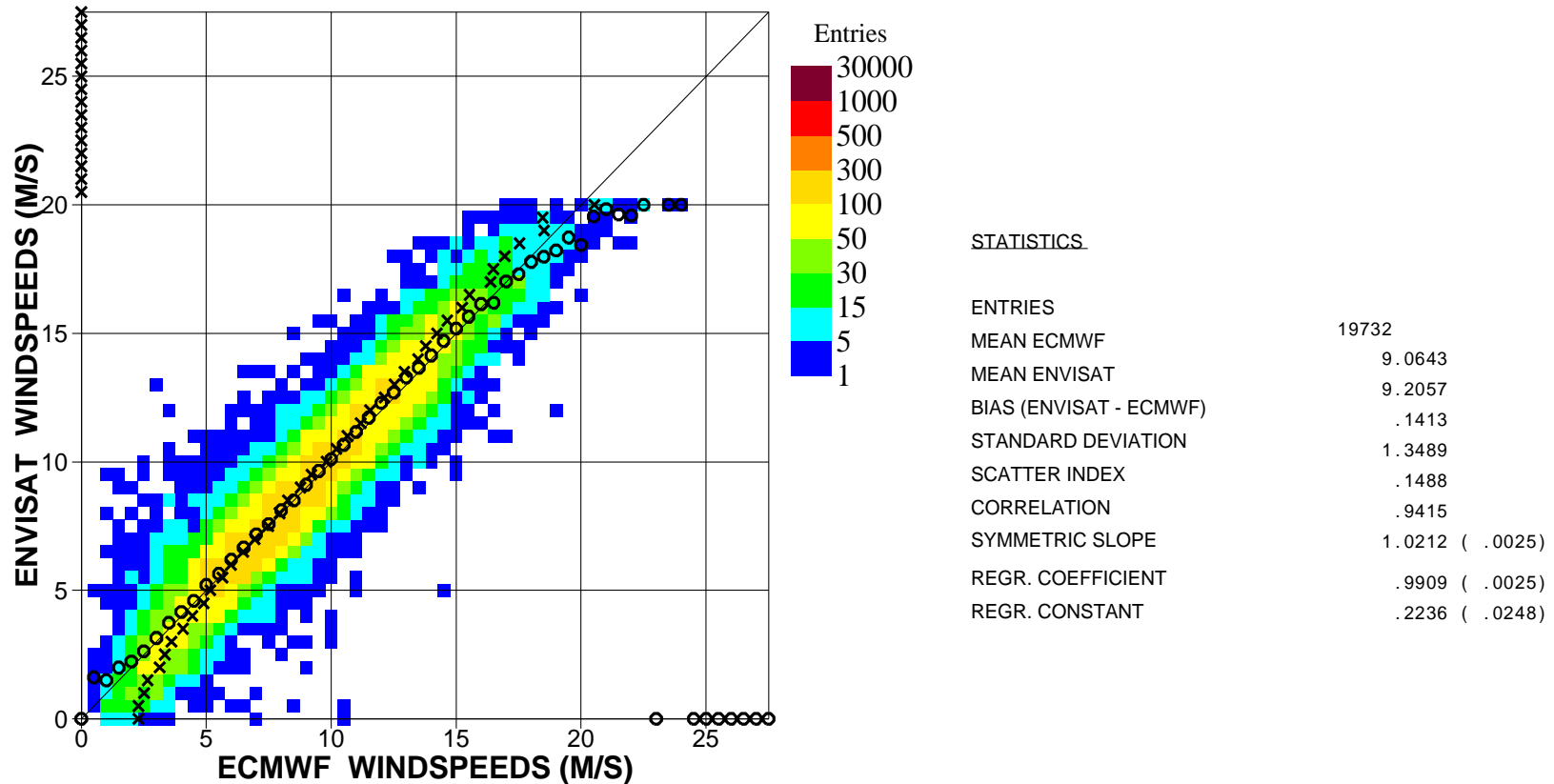


Figure 10. Comparison between ENVISAT Altimeter and ECMWF wind speeds for August 2004 (S.Hem.)

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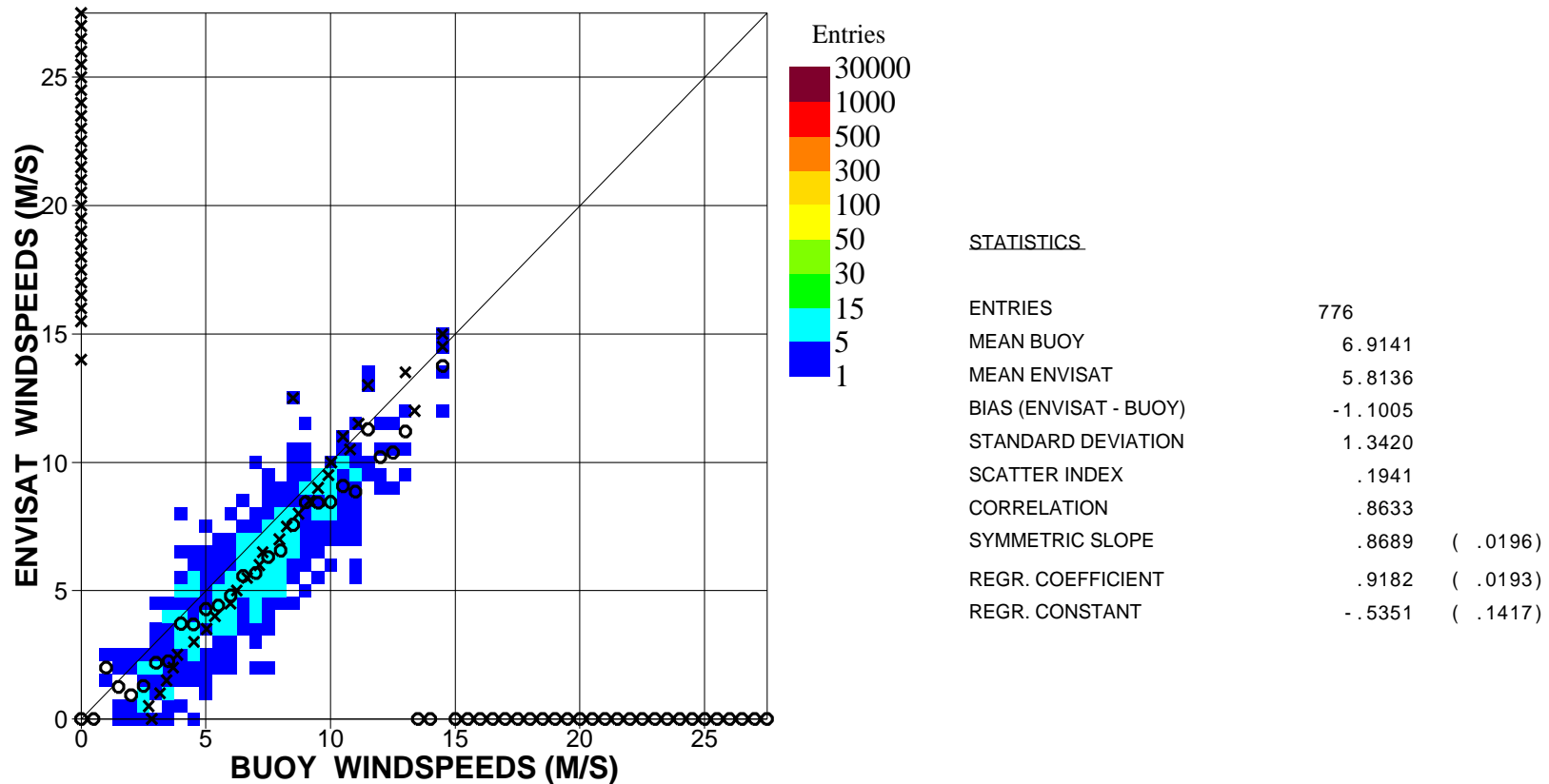


Figure 11. Comparison between ENVISAT Altimeter and buoy wind speeds for August 2004 (Global)

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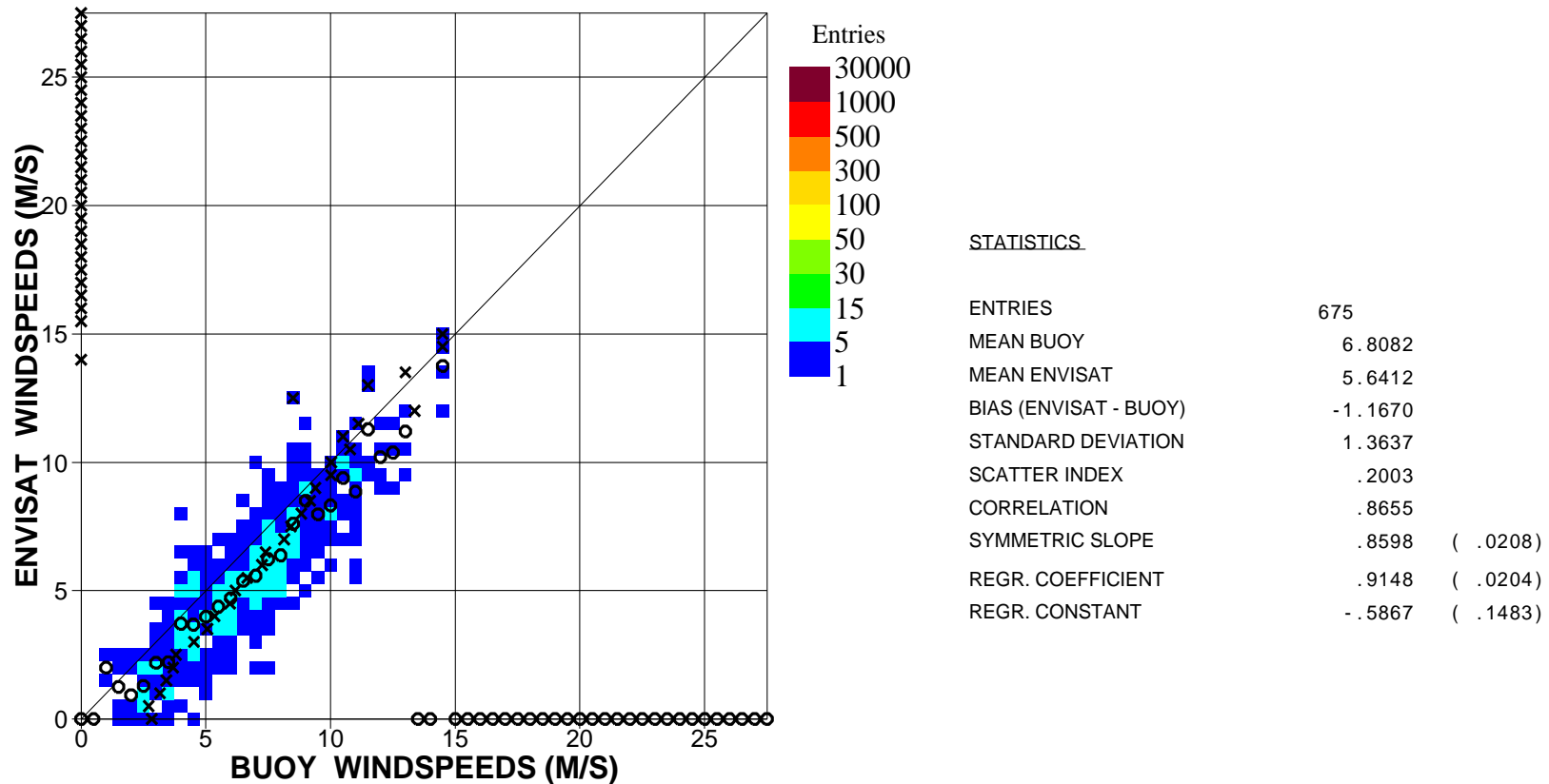


Figure 12. Comparison between ENVISAT Altimeter and buoy wind speeds for August 2004 (N.Hem.)

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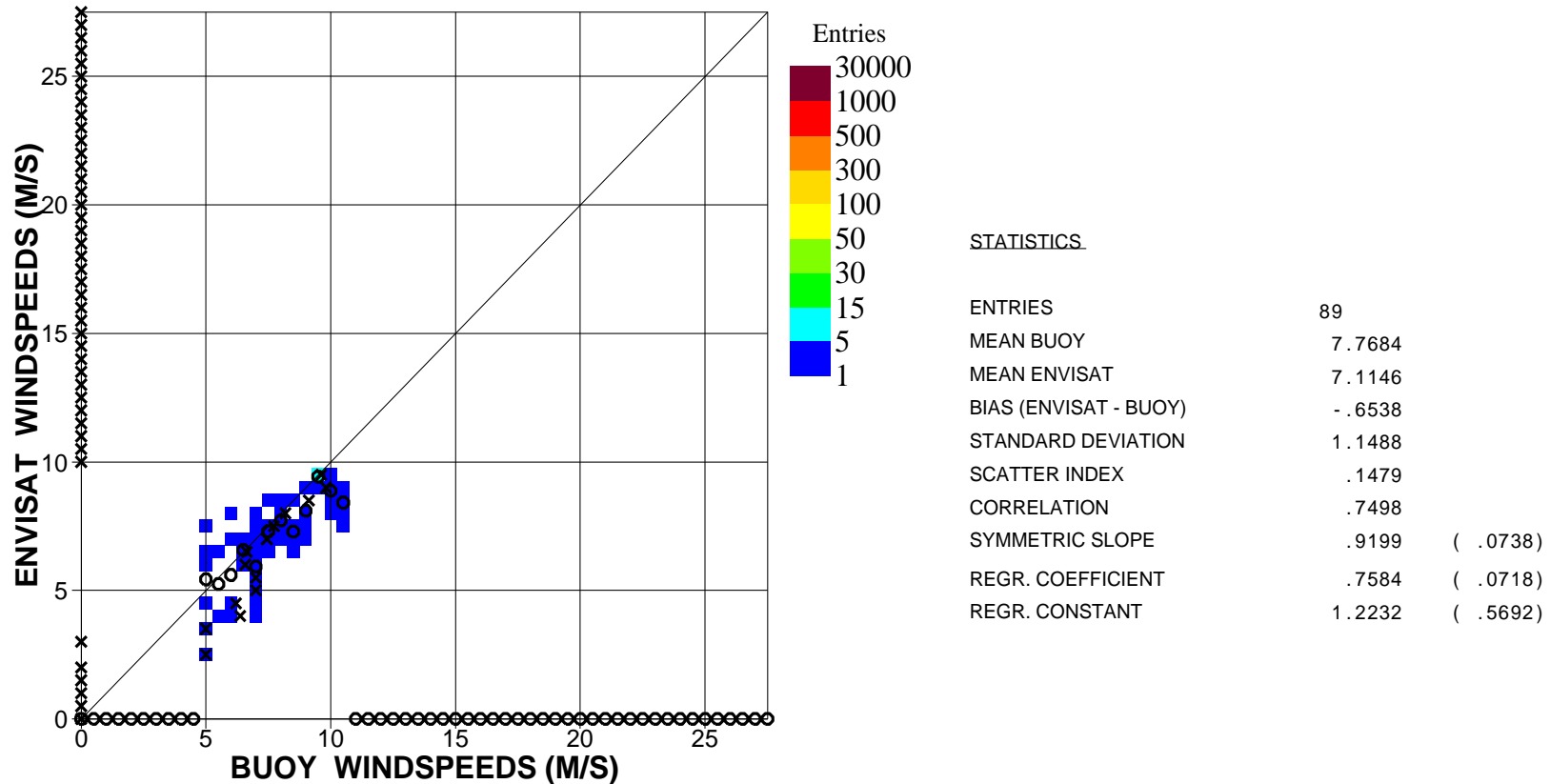


Figure 13. Comparison between ENVISAT Altimeter and buoy wind speeds for August 2004 (Tropics)

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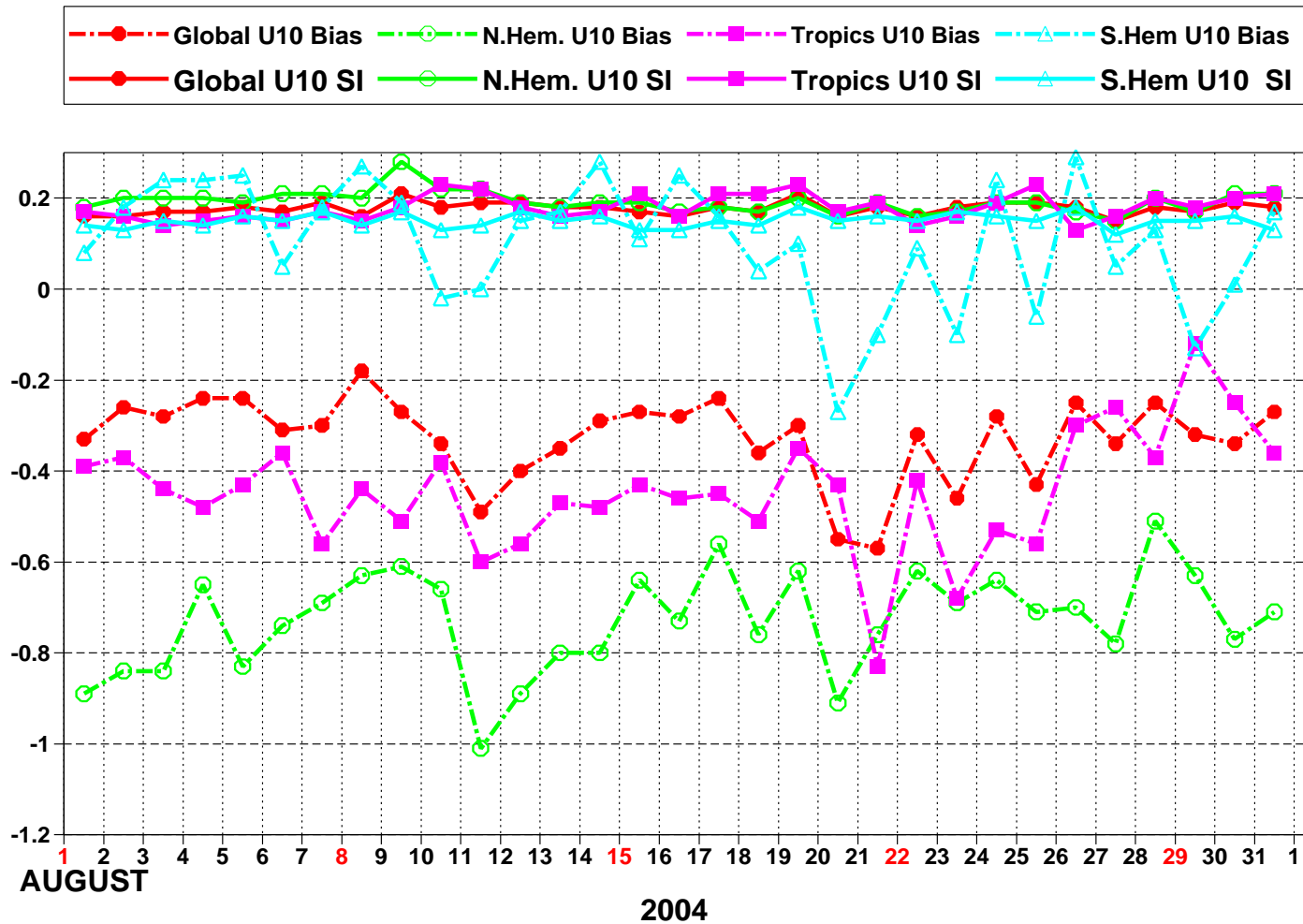


Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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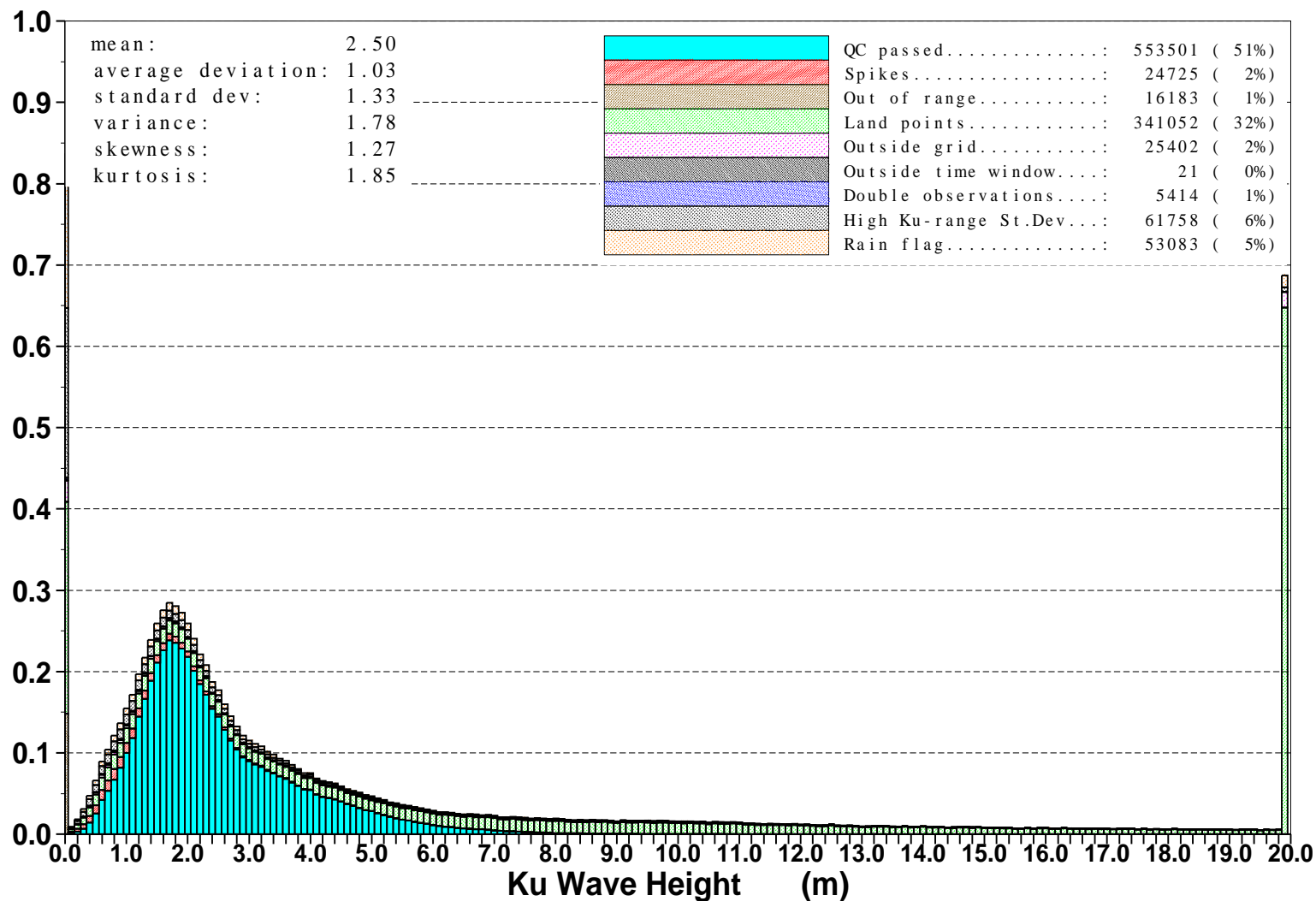


Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for August 2004

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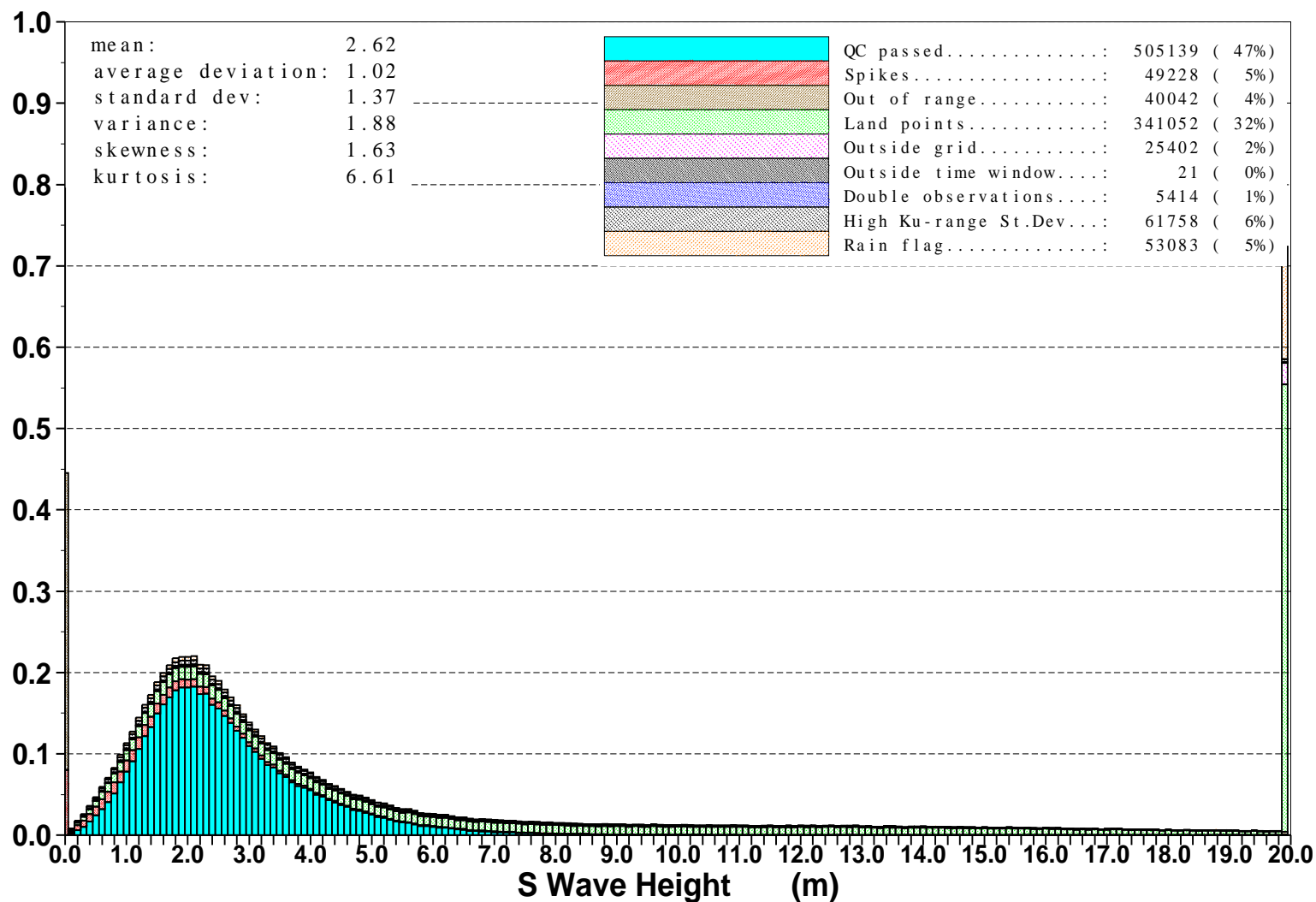
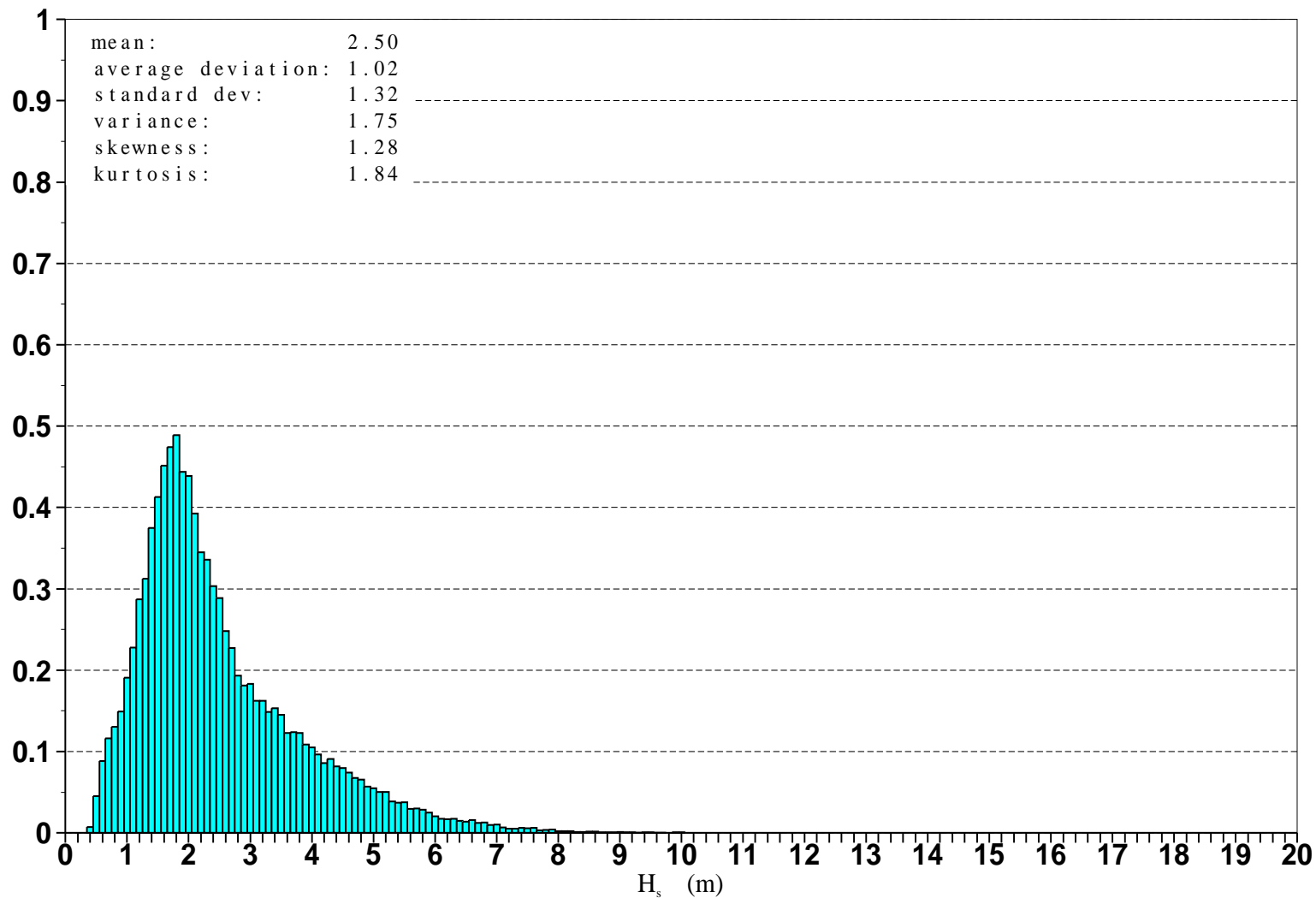


Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for August 2004



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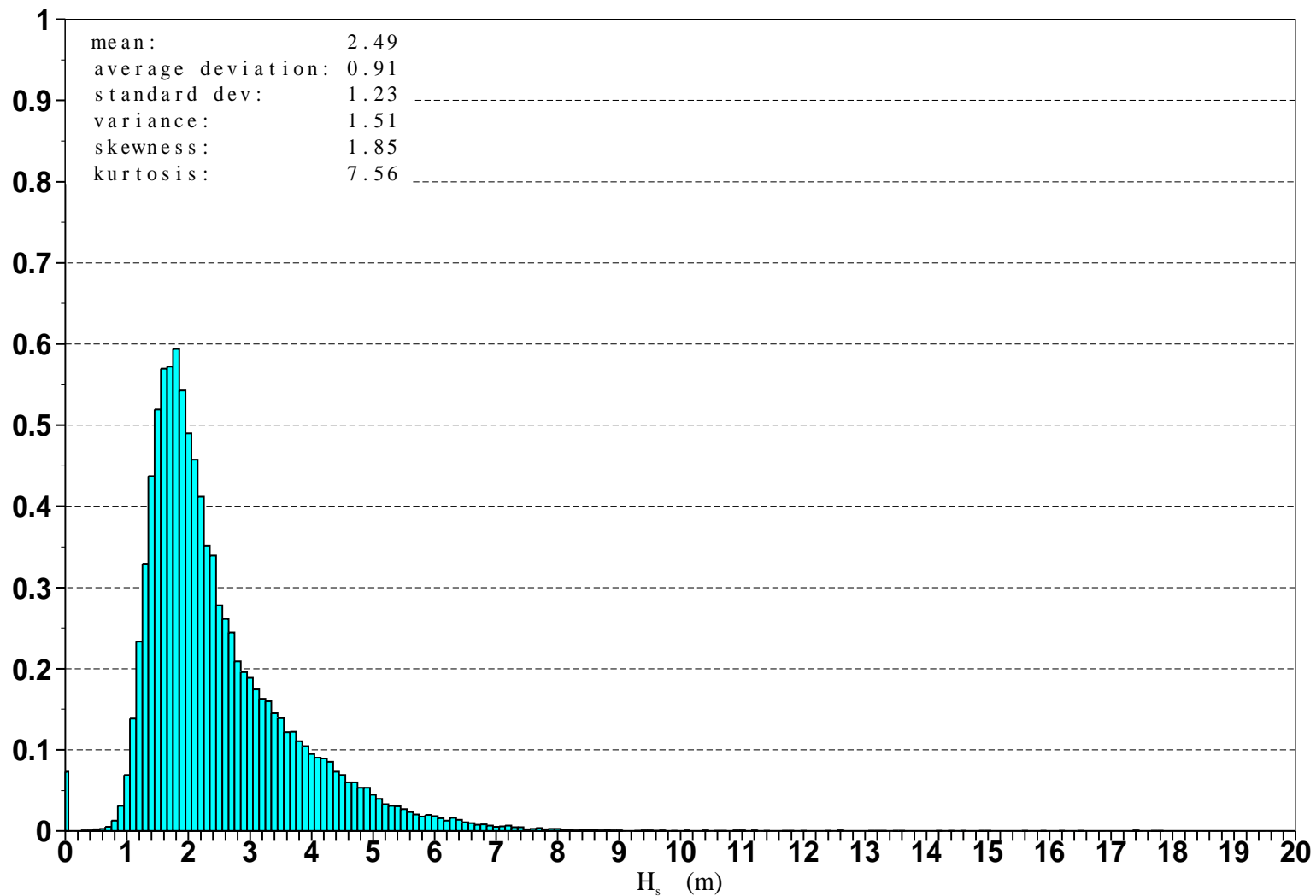


Figure 18: Distribution of ENVISAT Altimeter S-Band Wave Heights after Along-Track Averaging for August 2004



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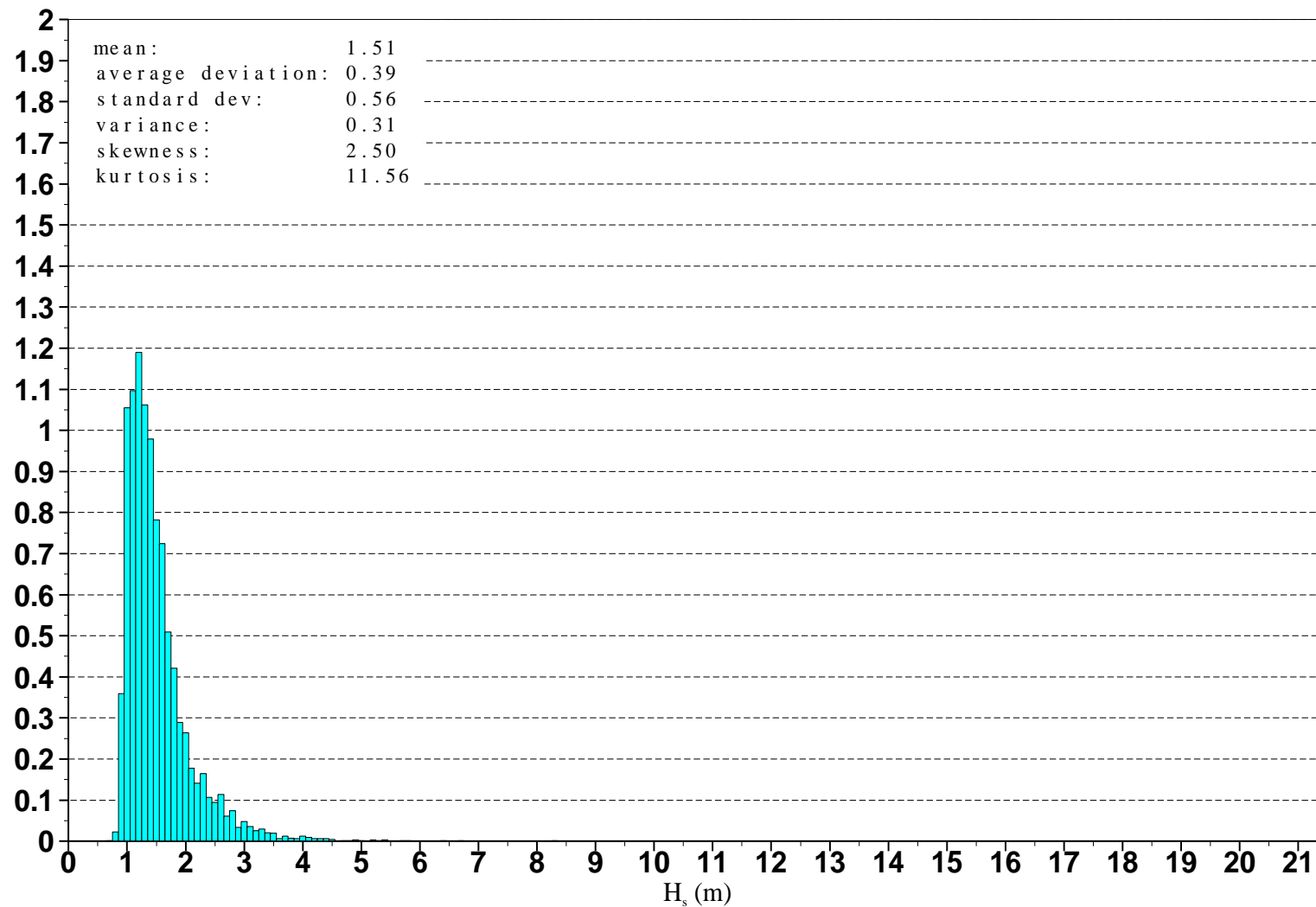


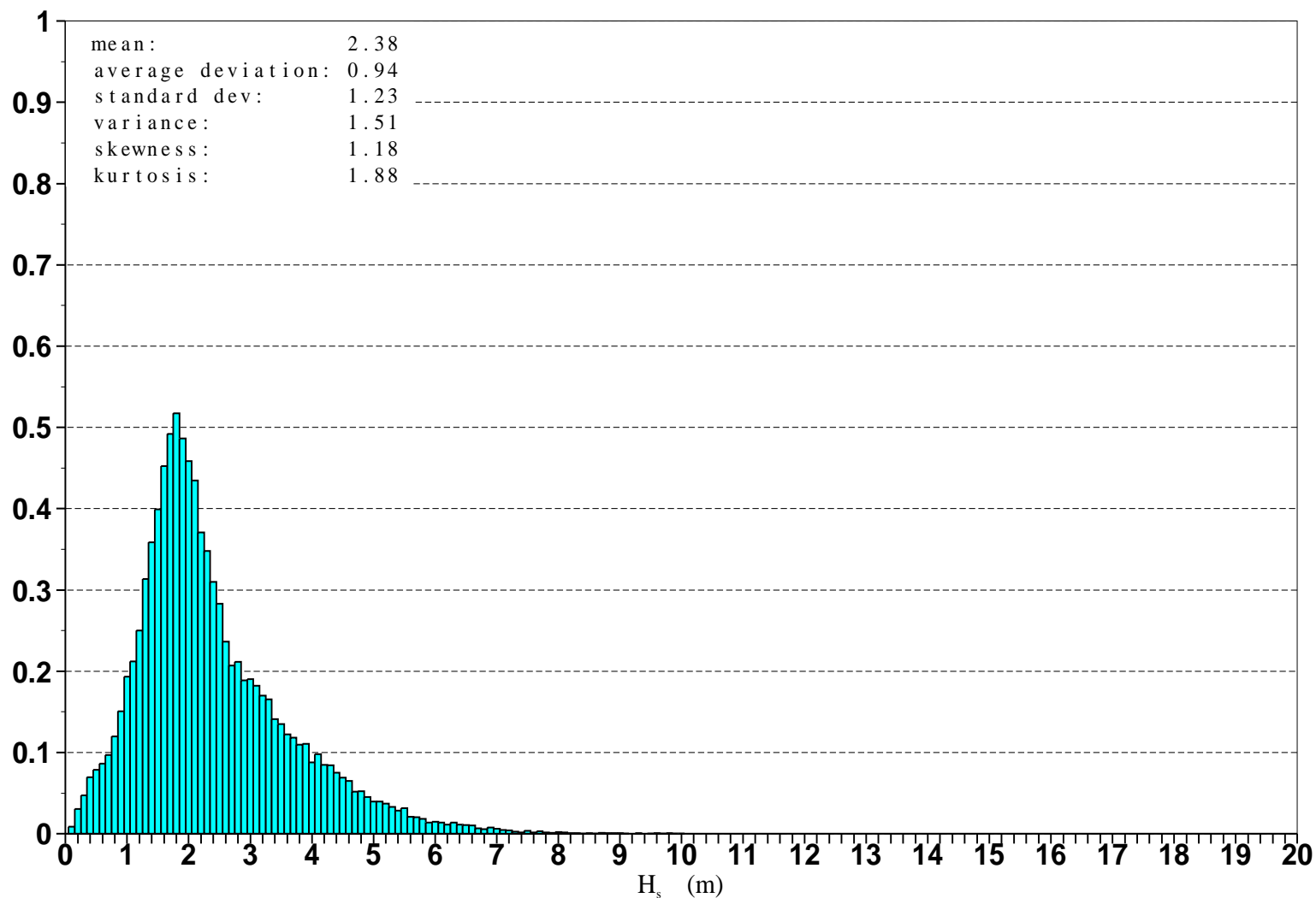
Figure 15: Distribution of ERS-2 Altimeter wave heights after along track averaging for August 2004



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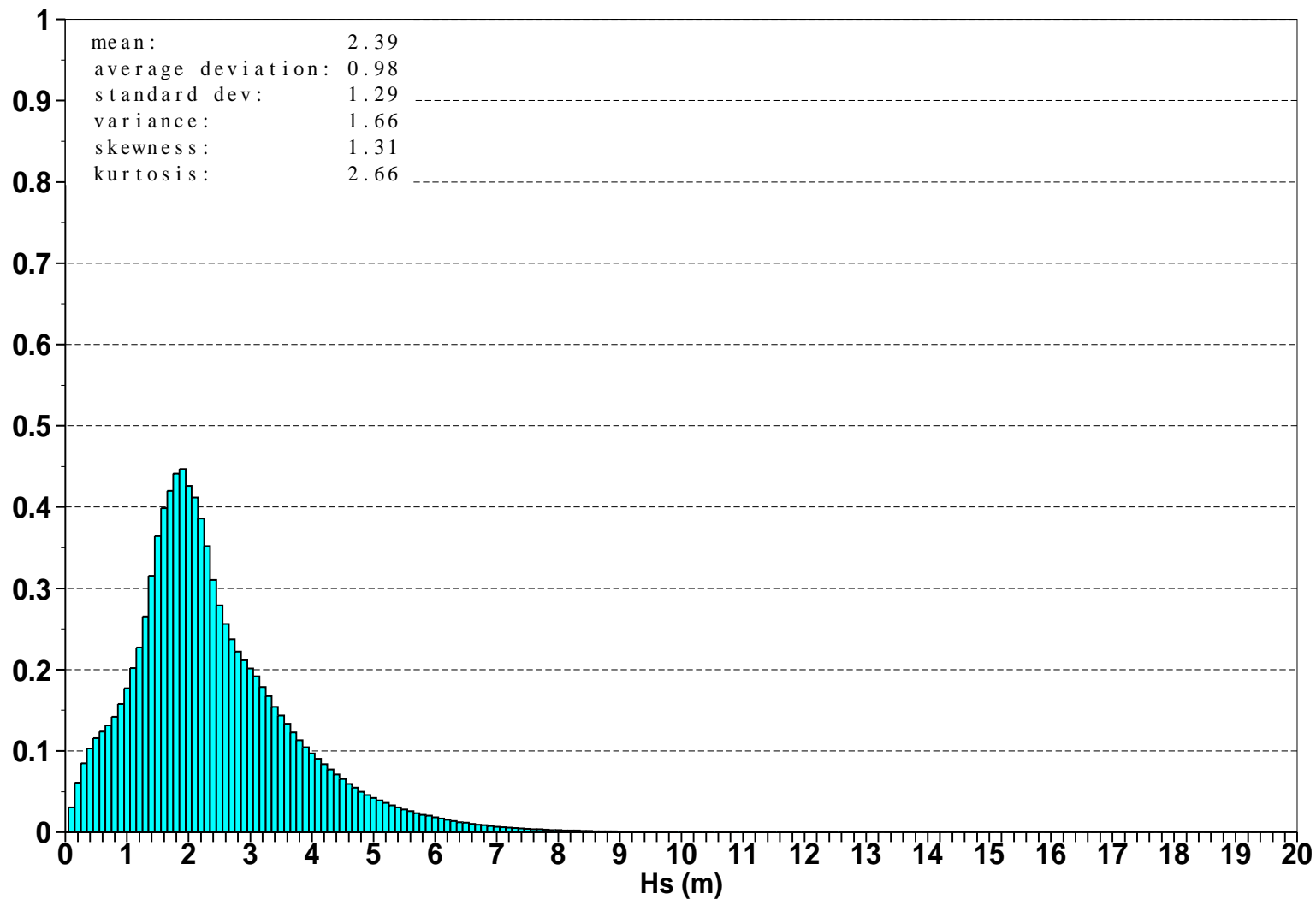


Figure 20: Global distribution of ECMWF First-Guess wave heights for August 2004

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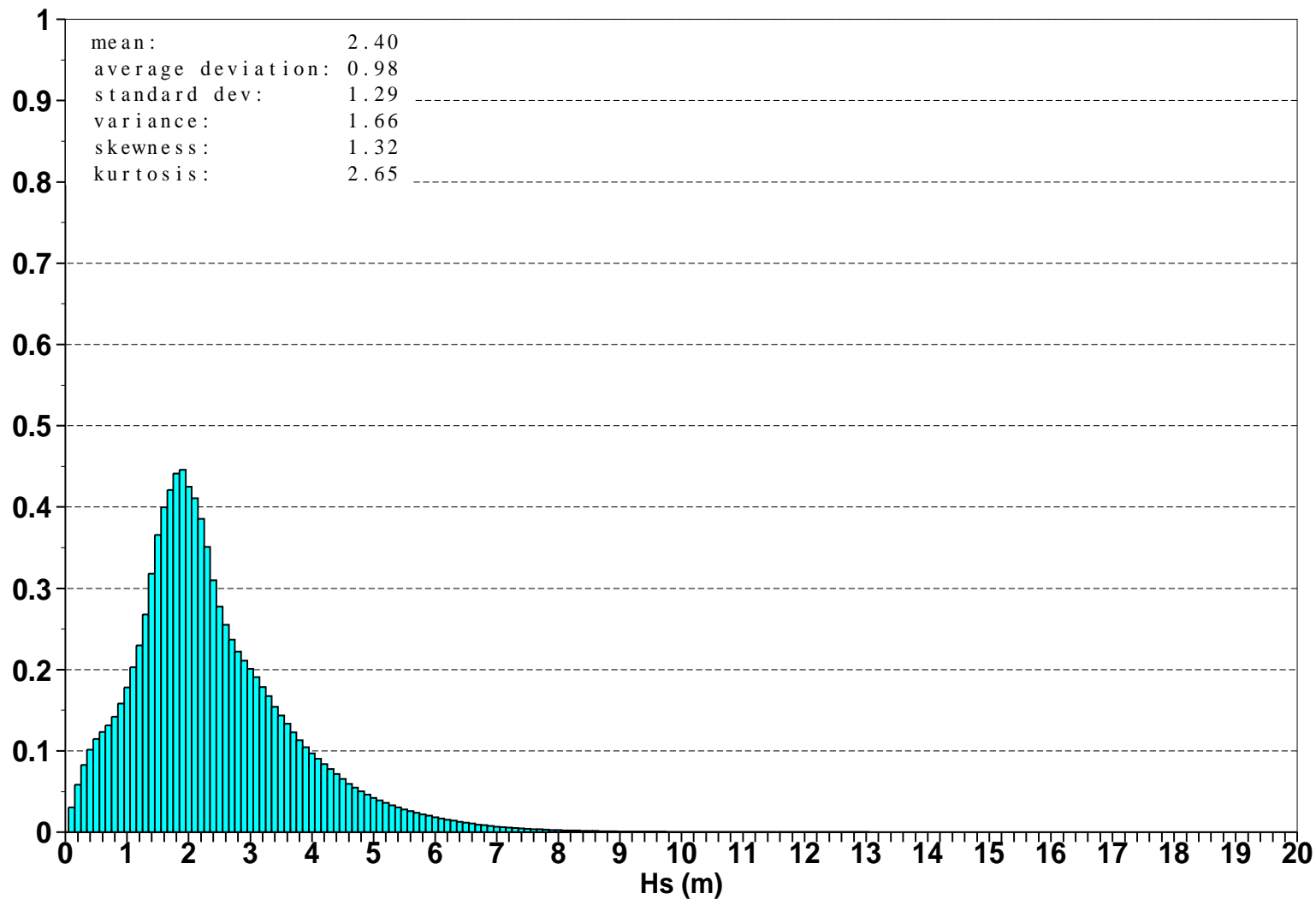


Figure 21: Global distribution of ECMWF Analysis (using ERS-2 data) wave heights for August 2004



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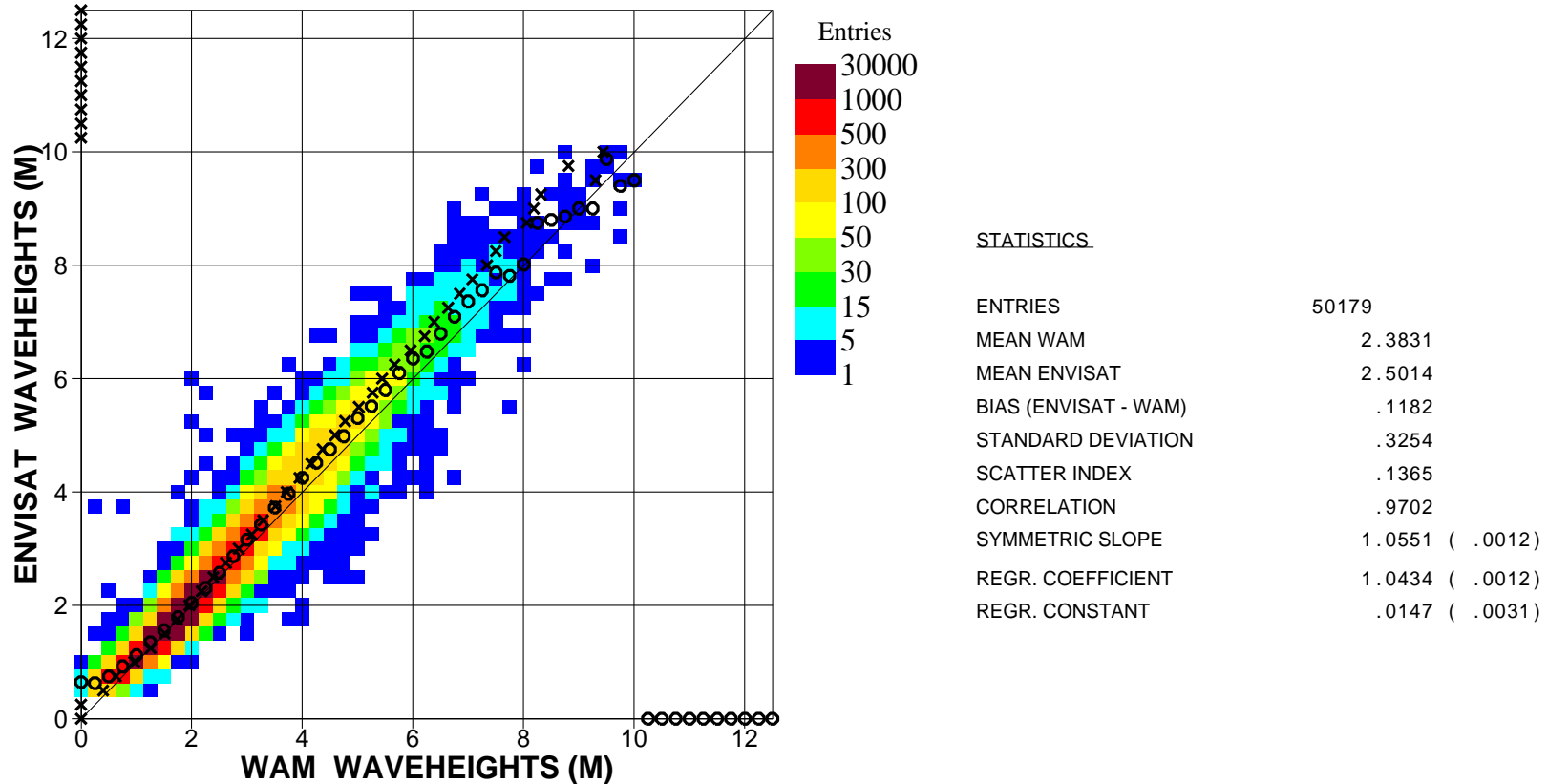


Figure 22. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for August 2004 (Global)

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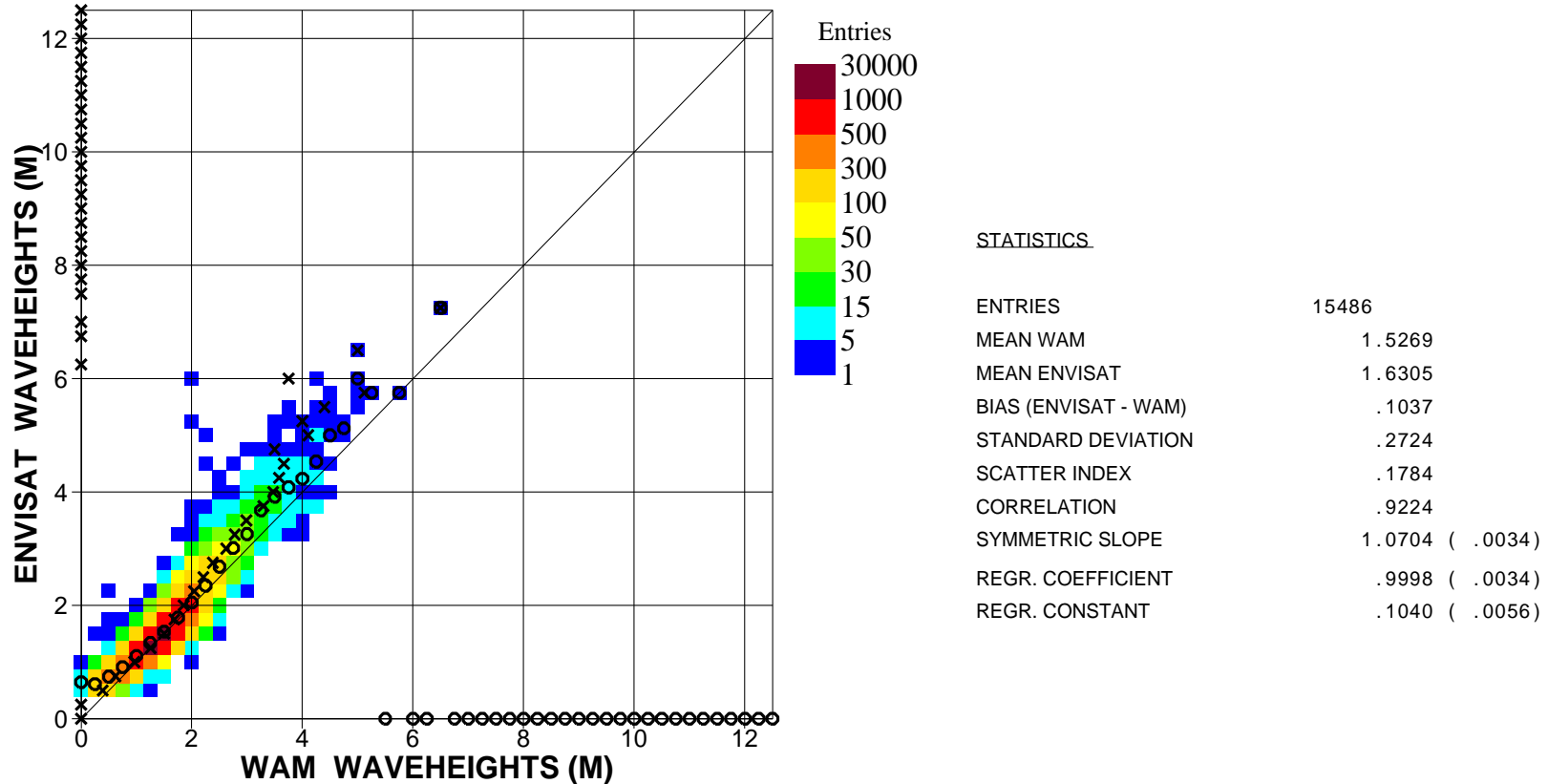


Figure 23. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for August 2004 (N.Hem.)

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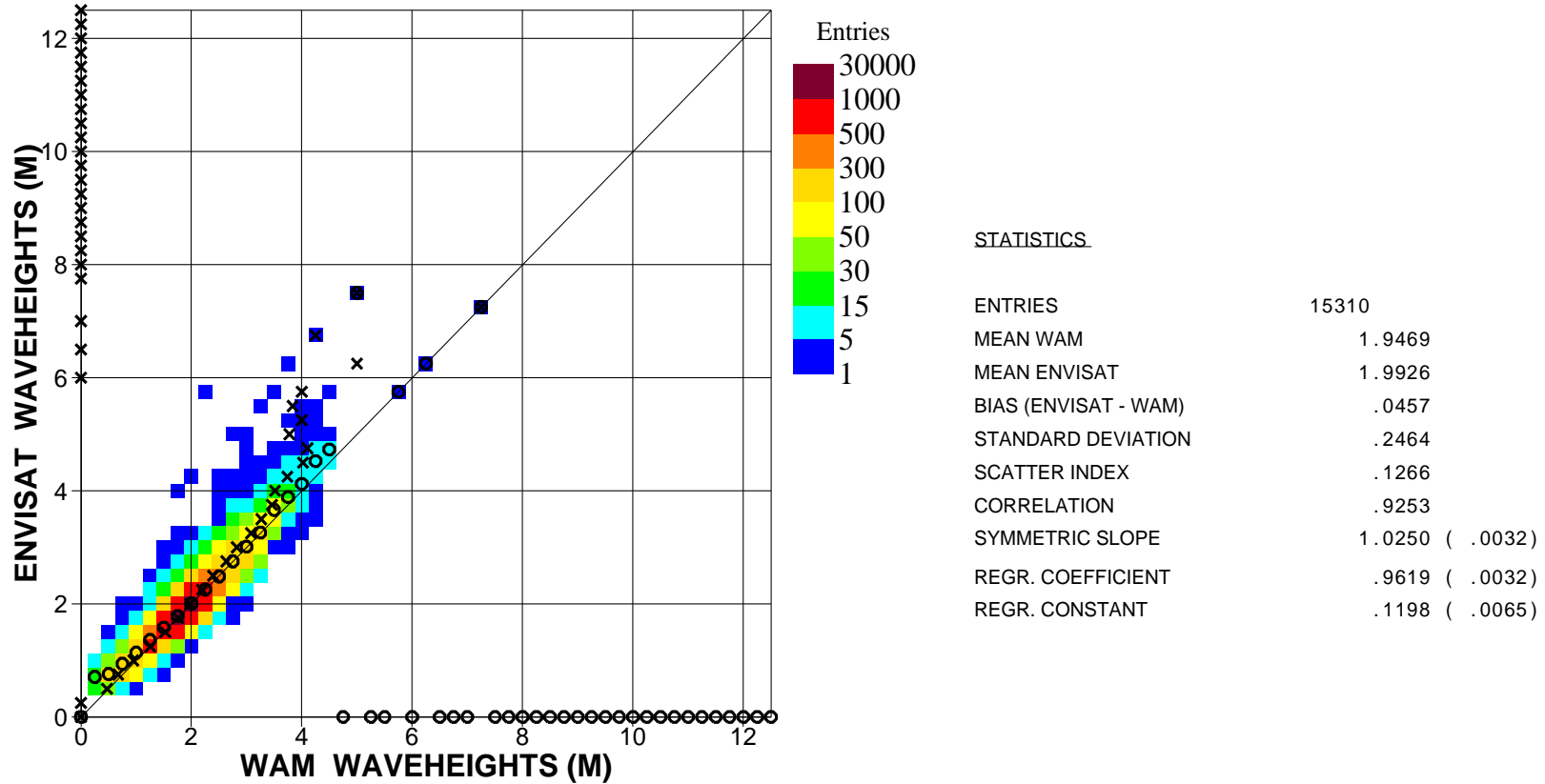


Figure 24. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for August 2004 (Tropics)

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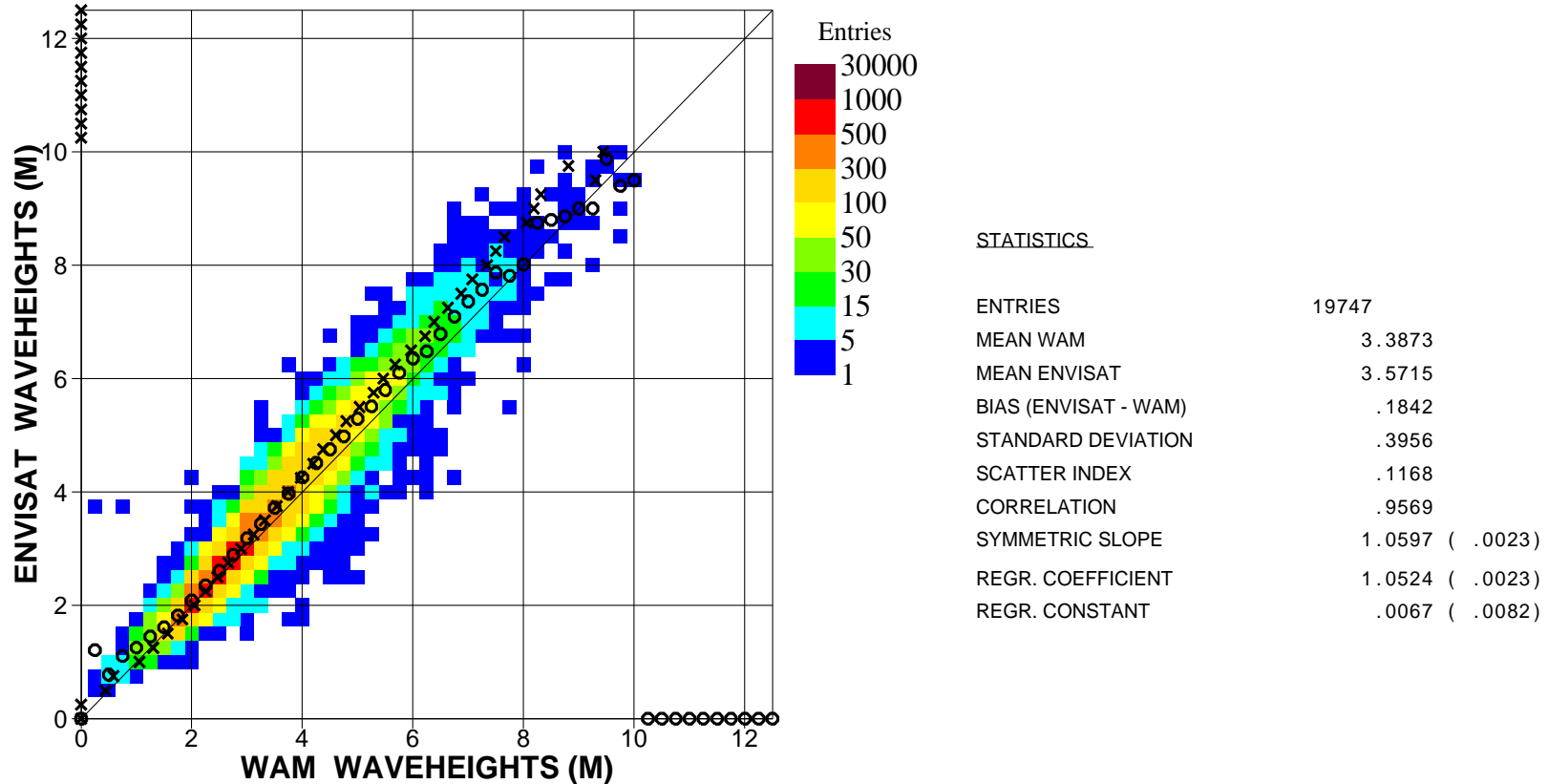


Figure 25. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for August 2004 (S.Hem.)

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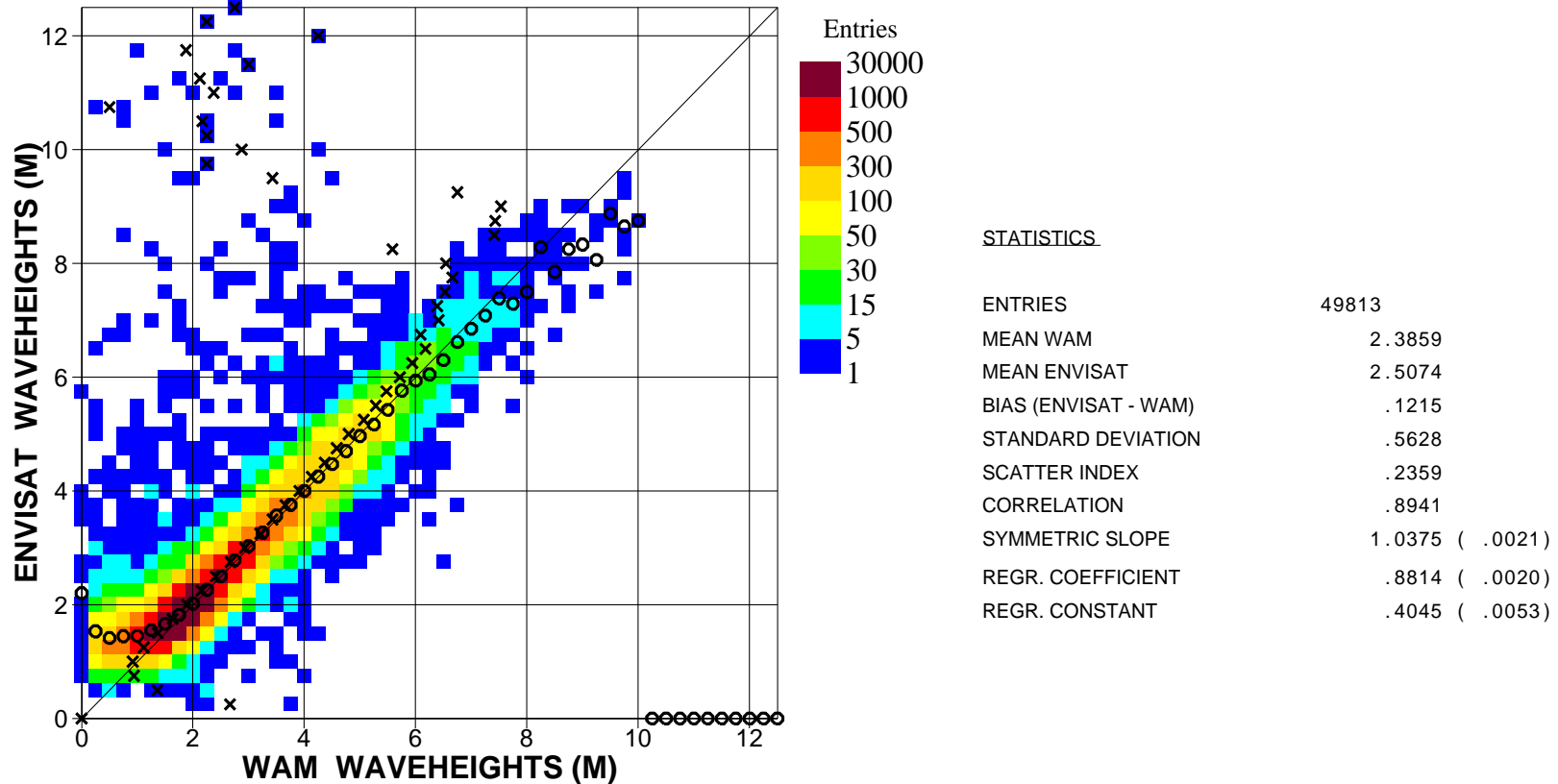


Figure 26. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for August 2004 (Global)

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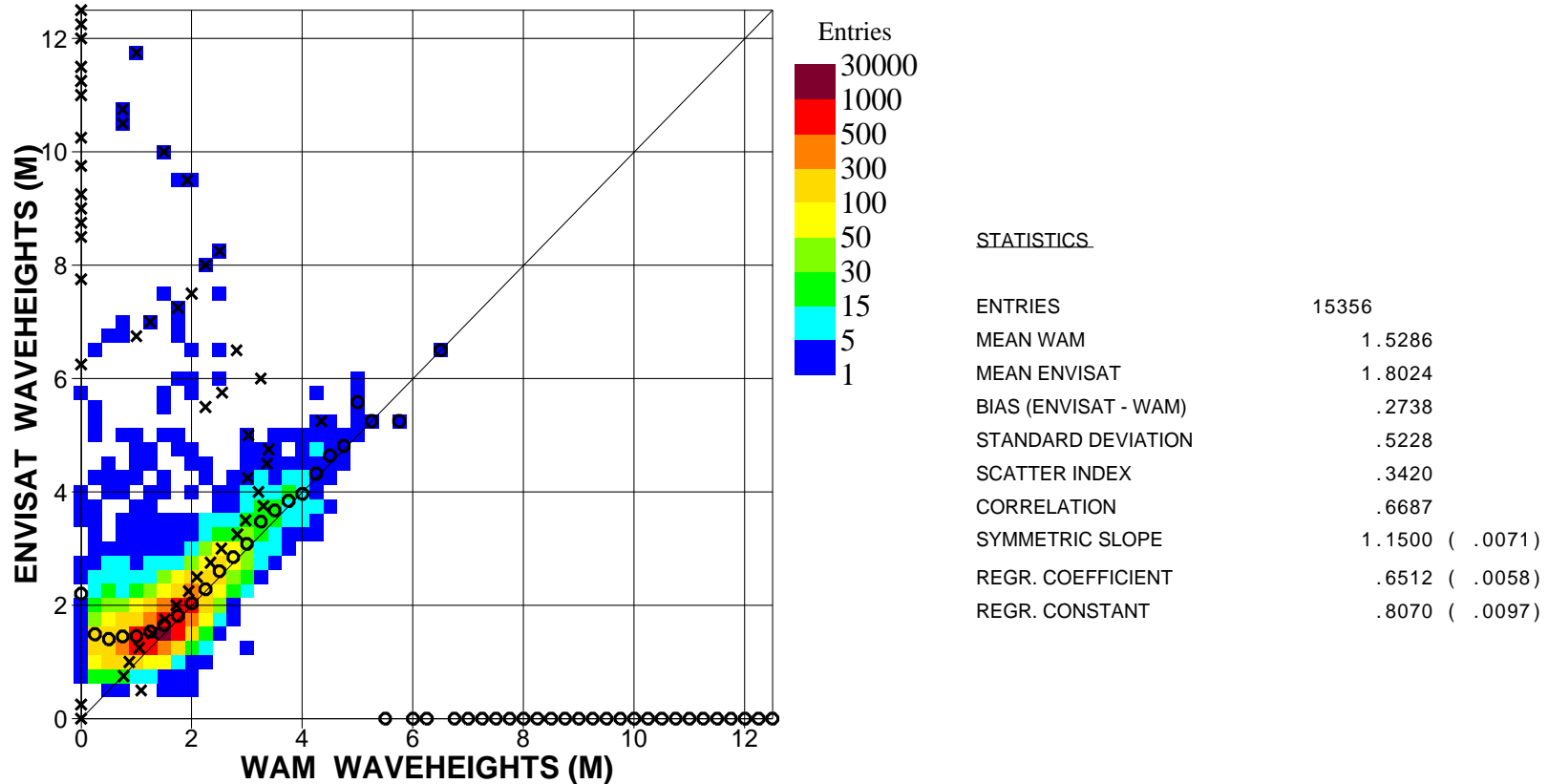


Figure 27. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for August 2004 (N.Hem.)

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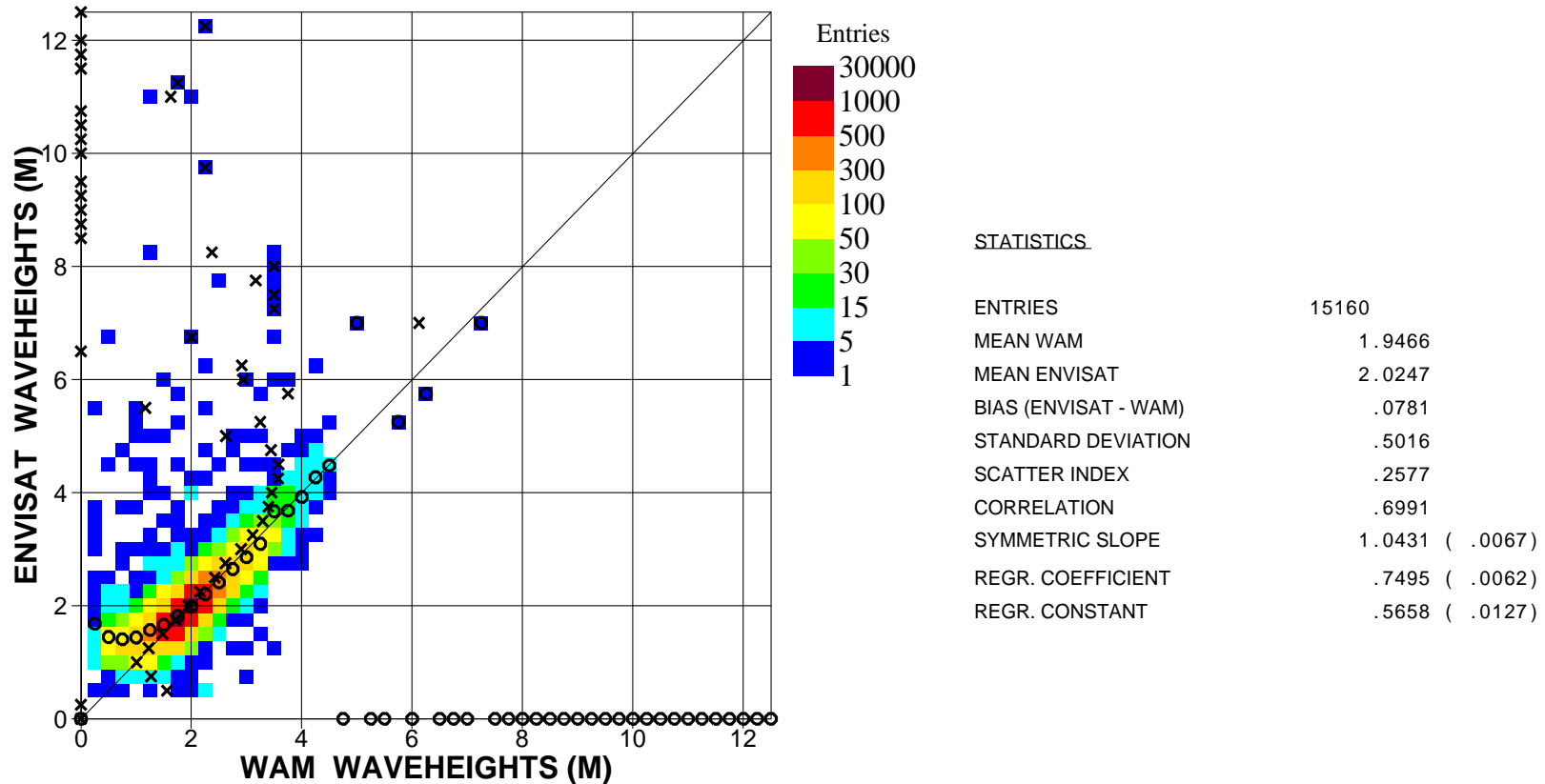


Figure 28. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for August 2004 (Tropics)

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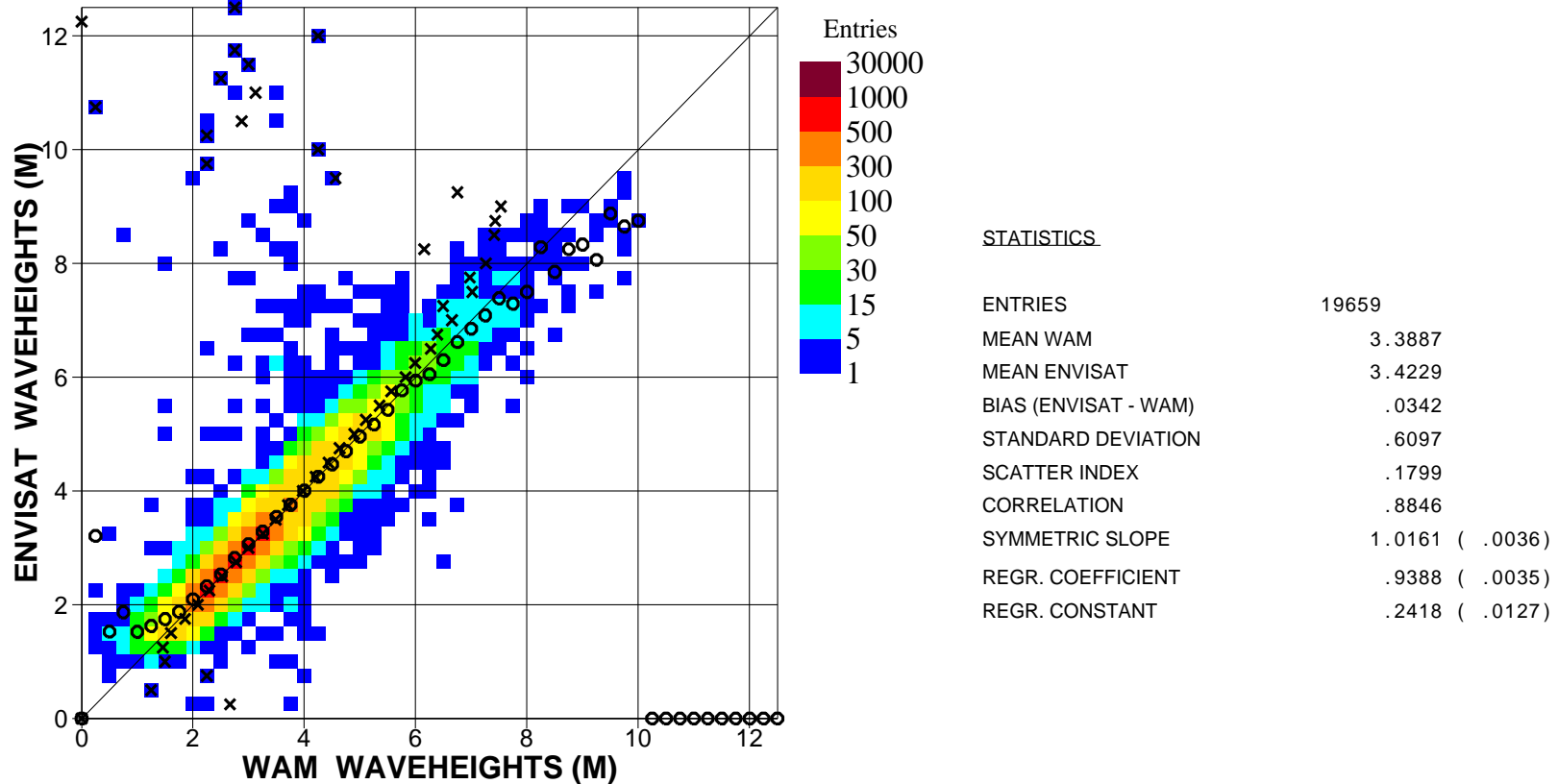


Figure 29. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for August 2004 (S.Hem.)

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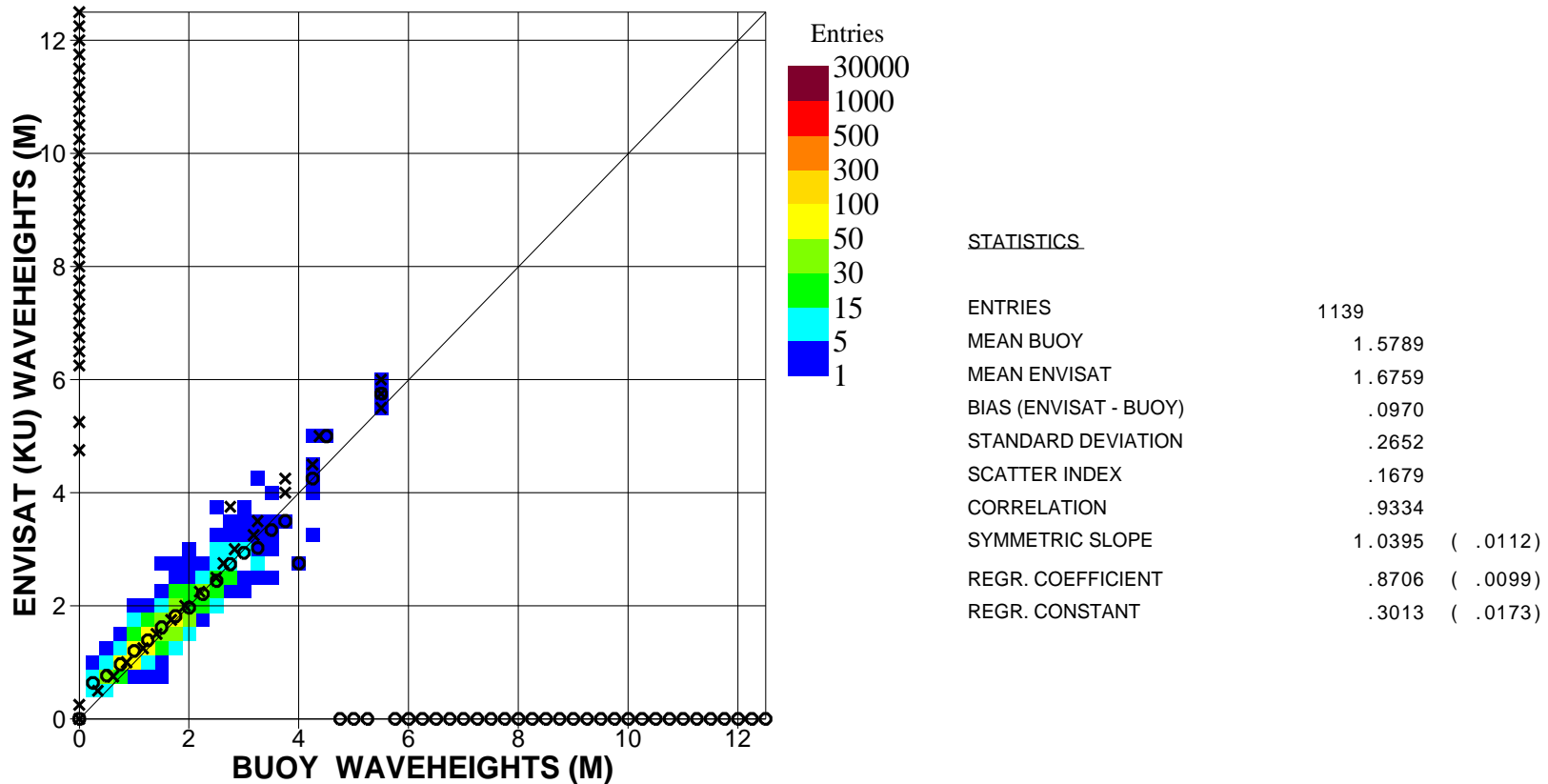


Figure 30. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for August 2004 (Global)

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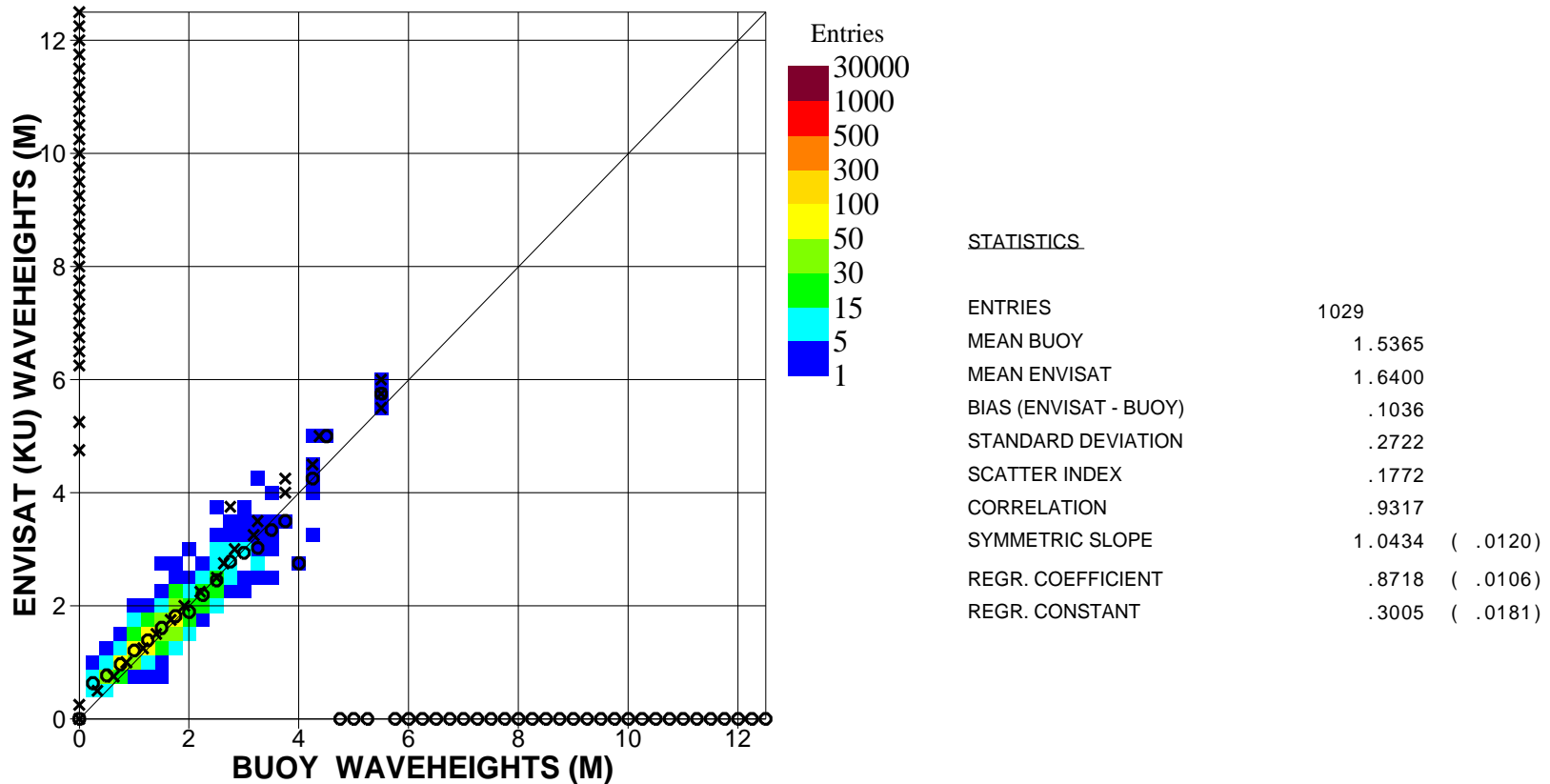


Figure 31. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for August 2004 (N.Hem.)

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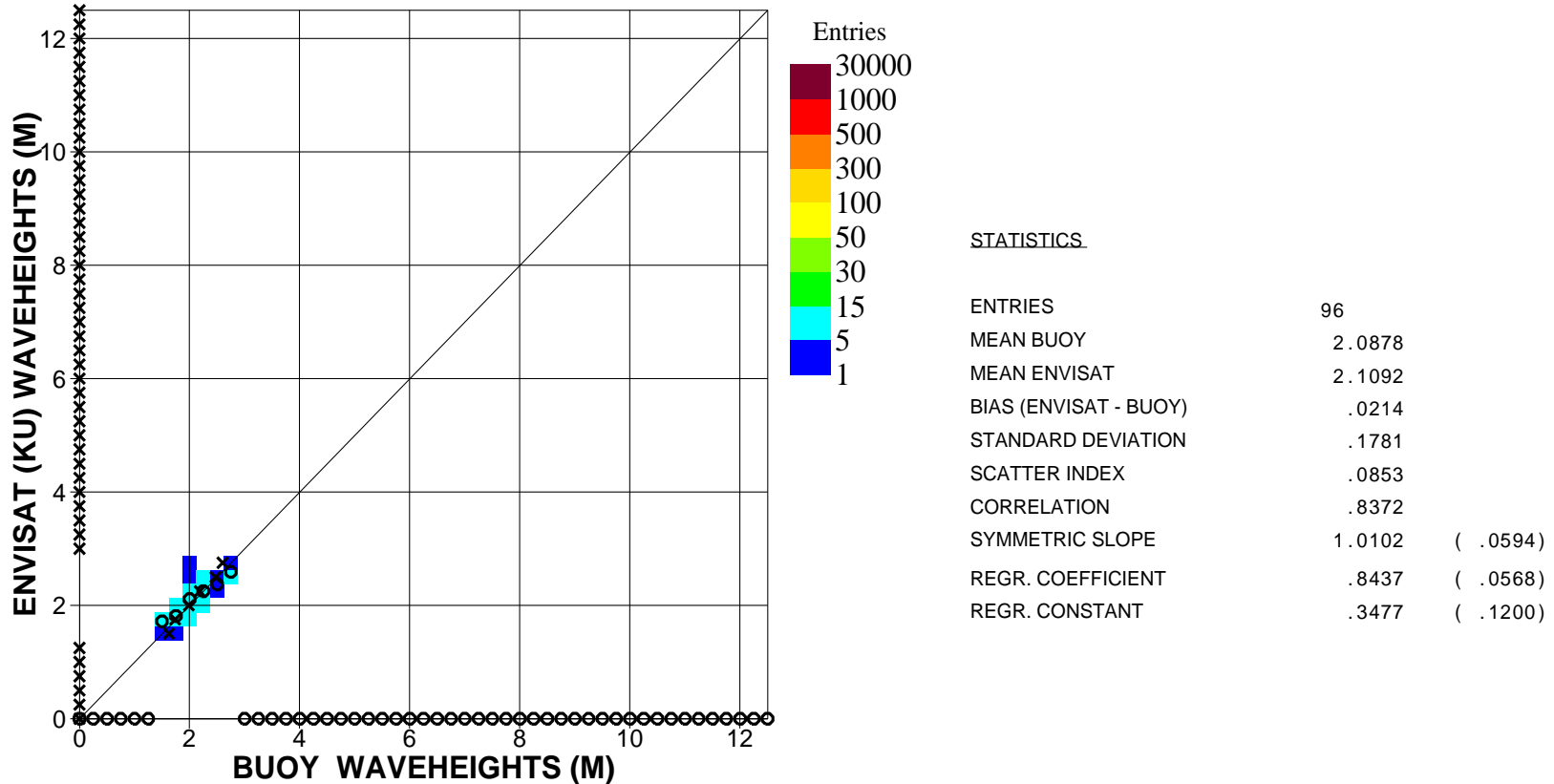


Figure 32. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for August 2004 (Tropics)

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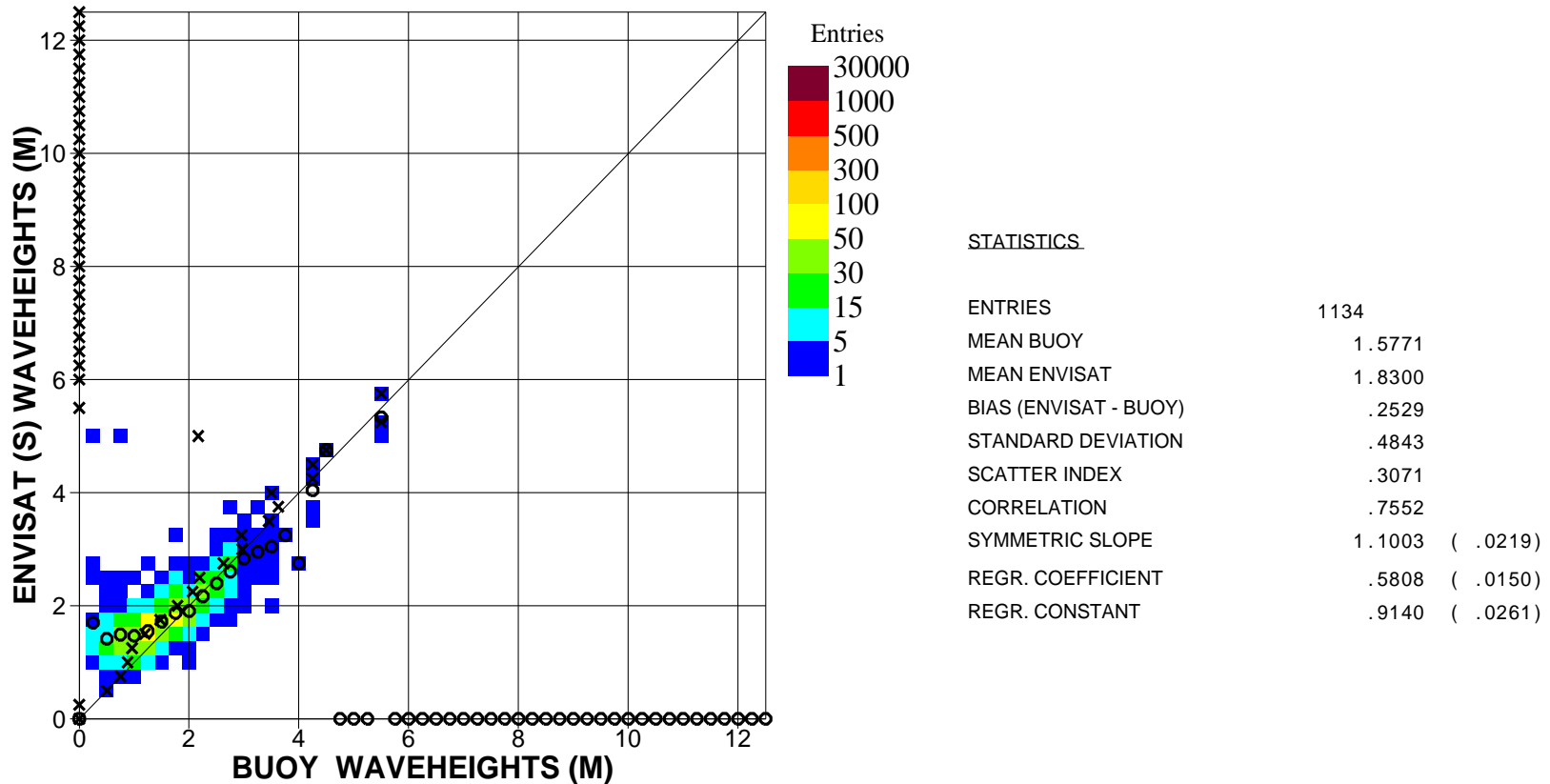


Figure 33. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for August 2004 (Global)

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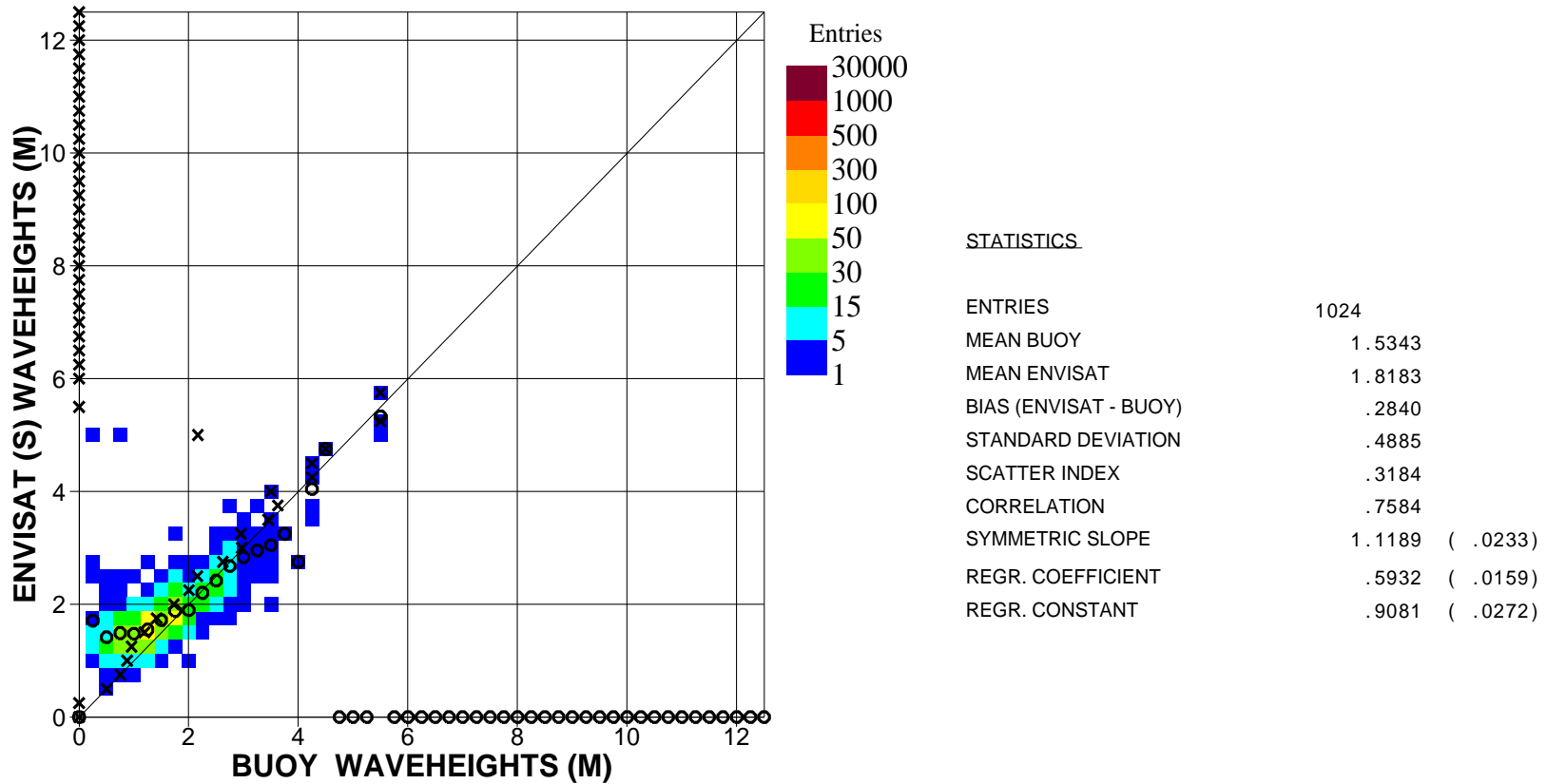


Figure 34. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for August 2004 (N.Hem.)

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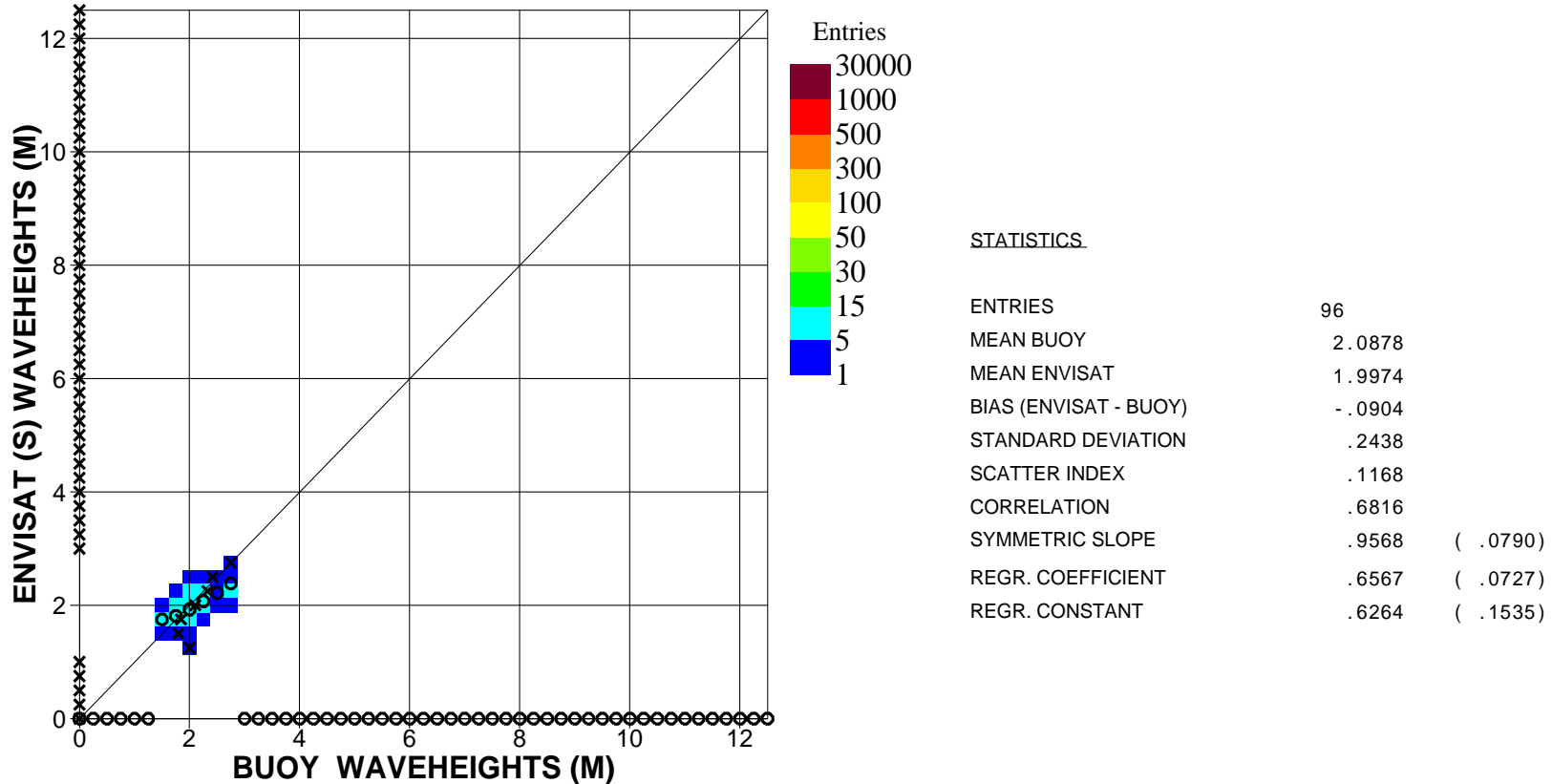


Figure 35. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for August 2004 (Tropics)

# ECMWF Report on ENVISAT RA-2 for August 2004

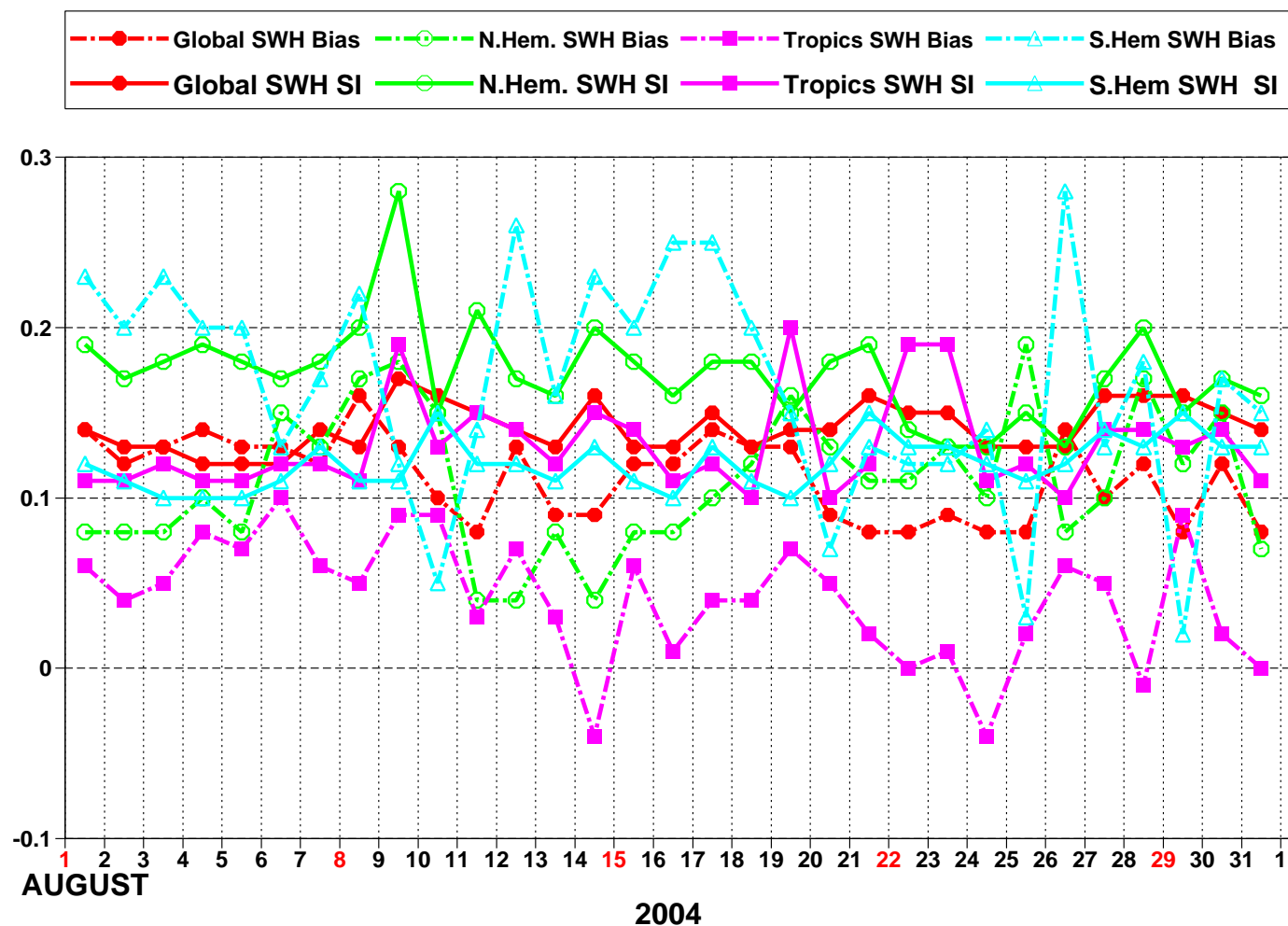


Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM\_FG) and scatter index (SI)

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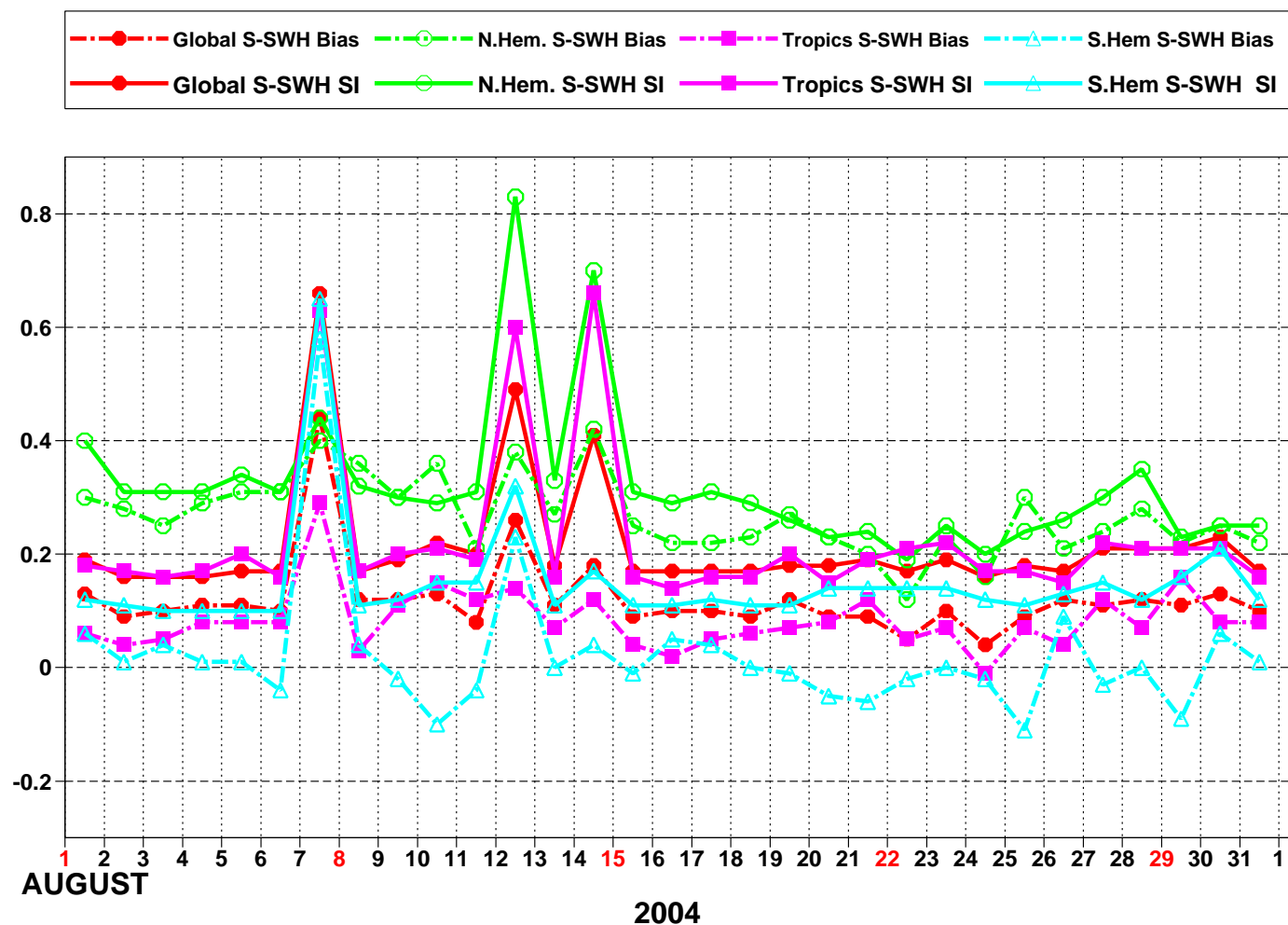


Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM\_FG) and scatter index (SI)



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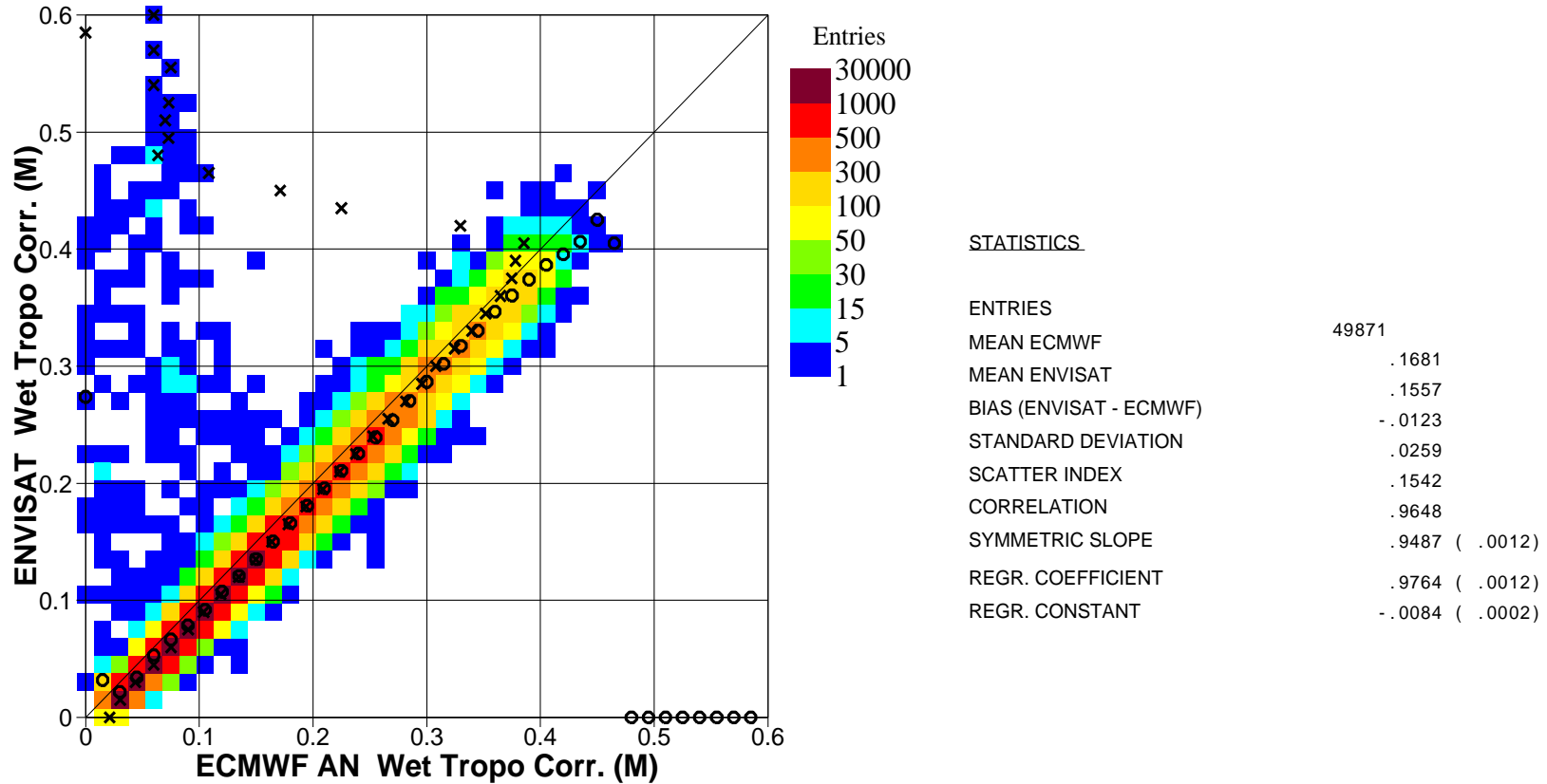


Figure 38. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for August 2004 (Global)

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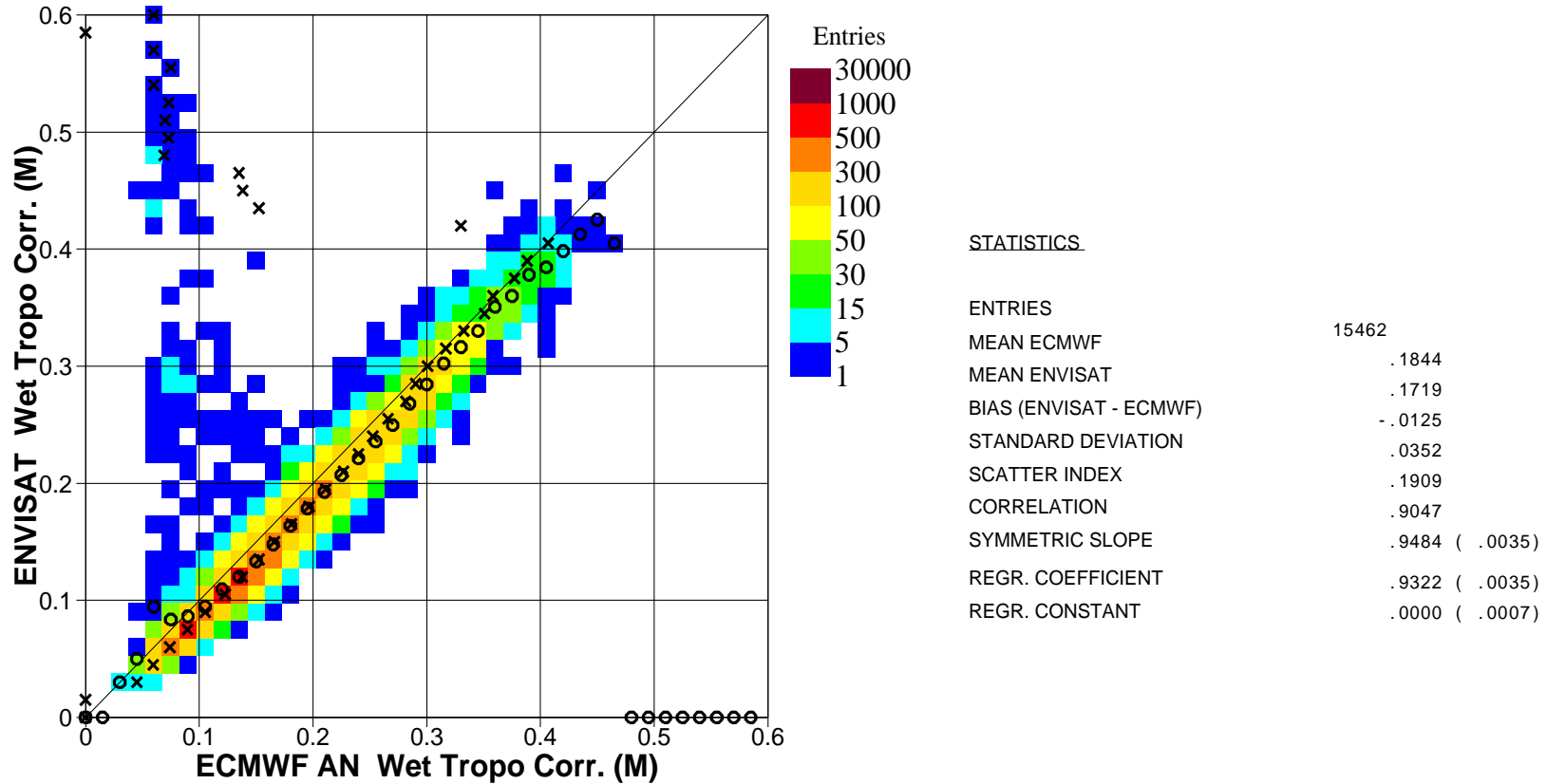


Figure 39. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for August 2004 (N.Hem.)



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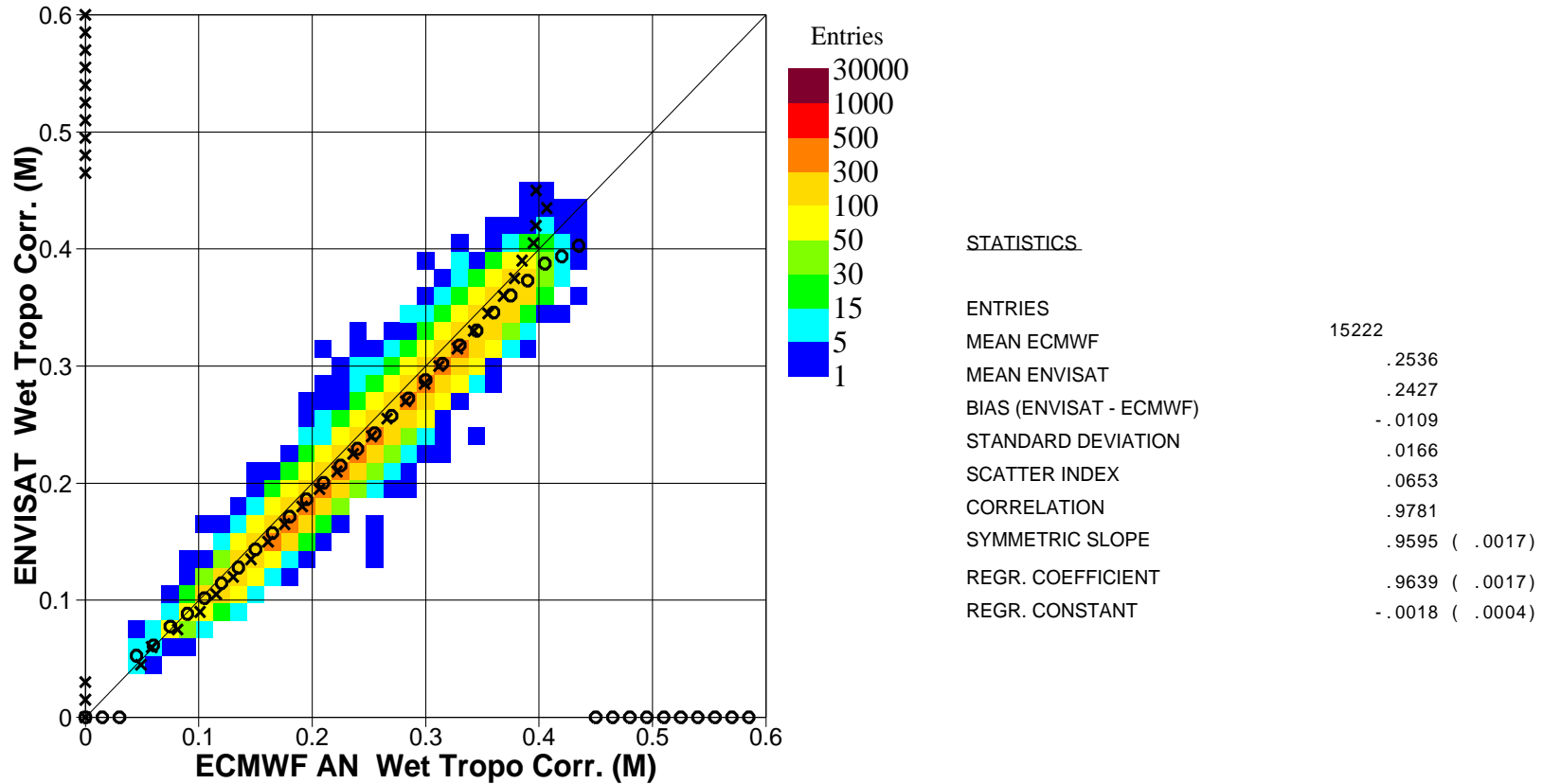


Figure 40. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for August 2004 (Tropics)

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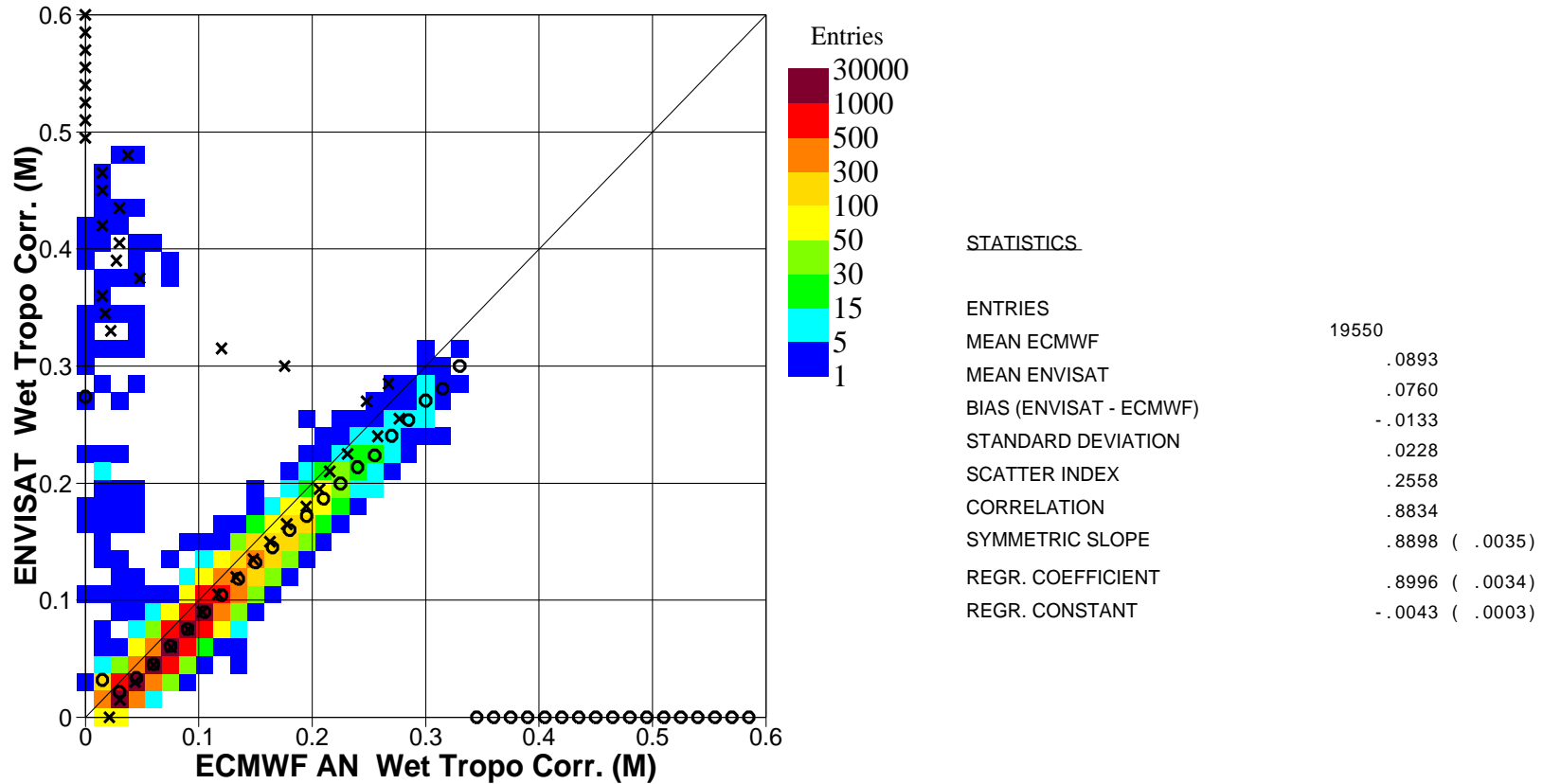


Figure 41. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for August 2004 (S.Hem.)

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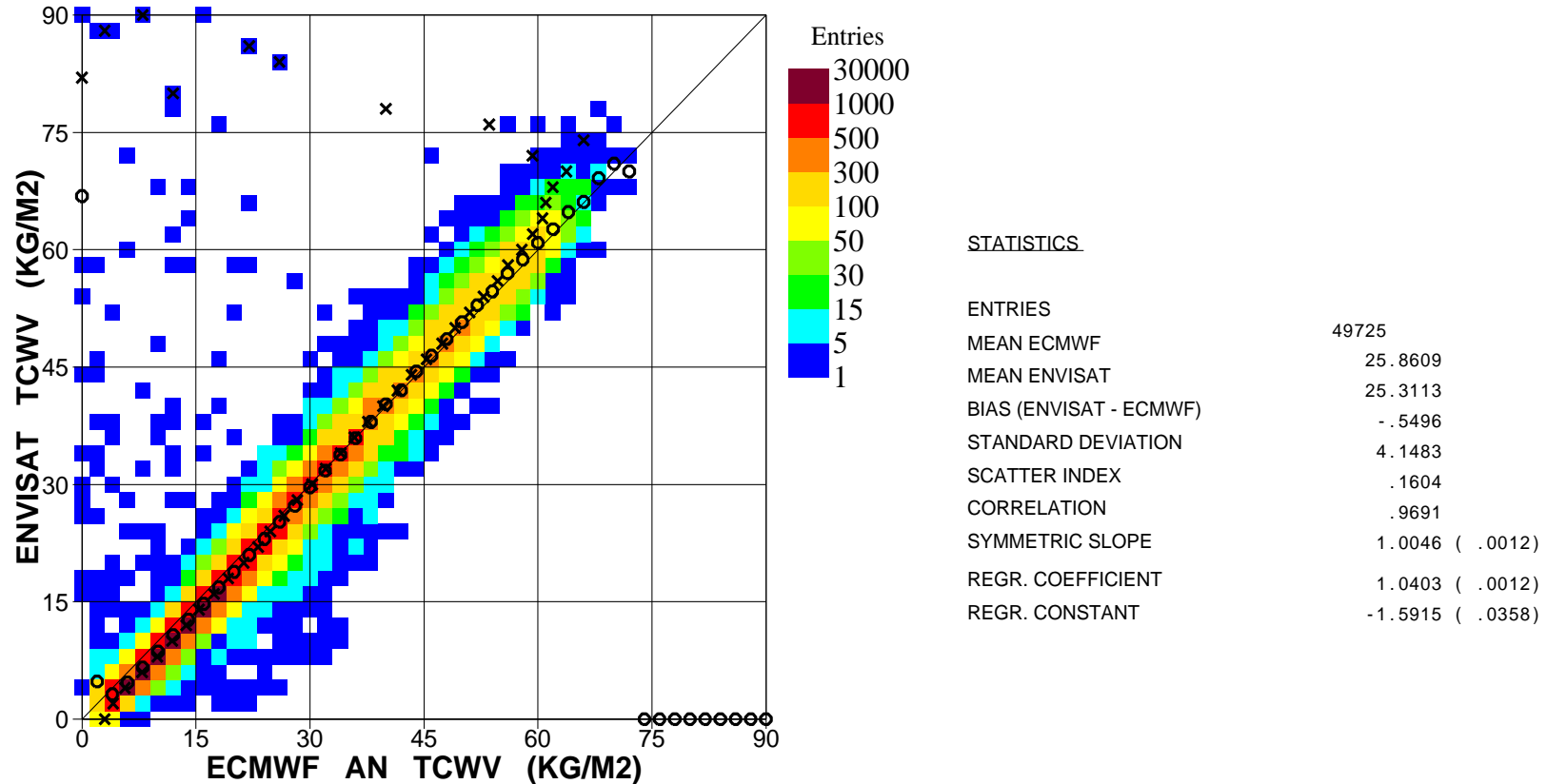


Figure 42. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for August 2004 (Global)

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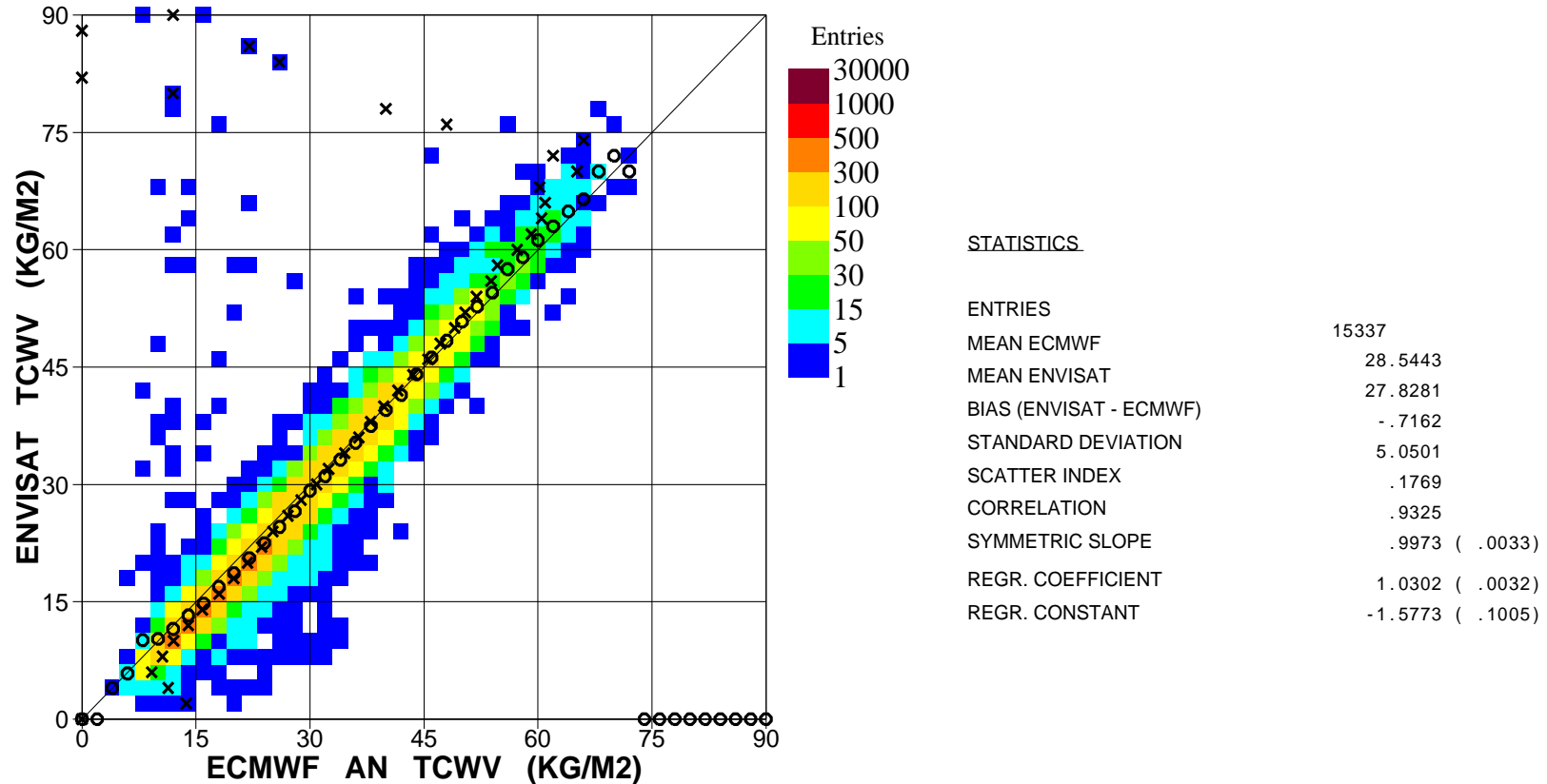


Figure 43. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for August 2004 (N.Hem.)

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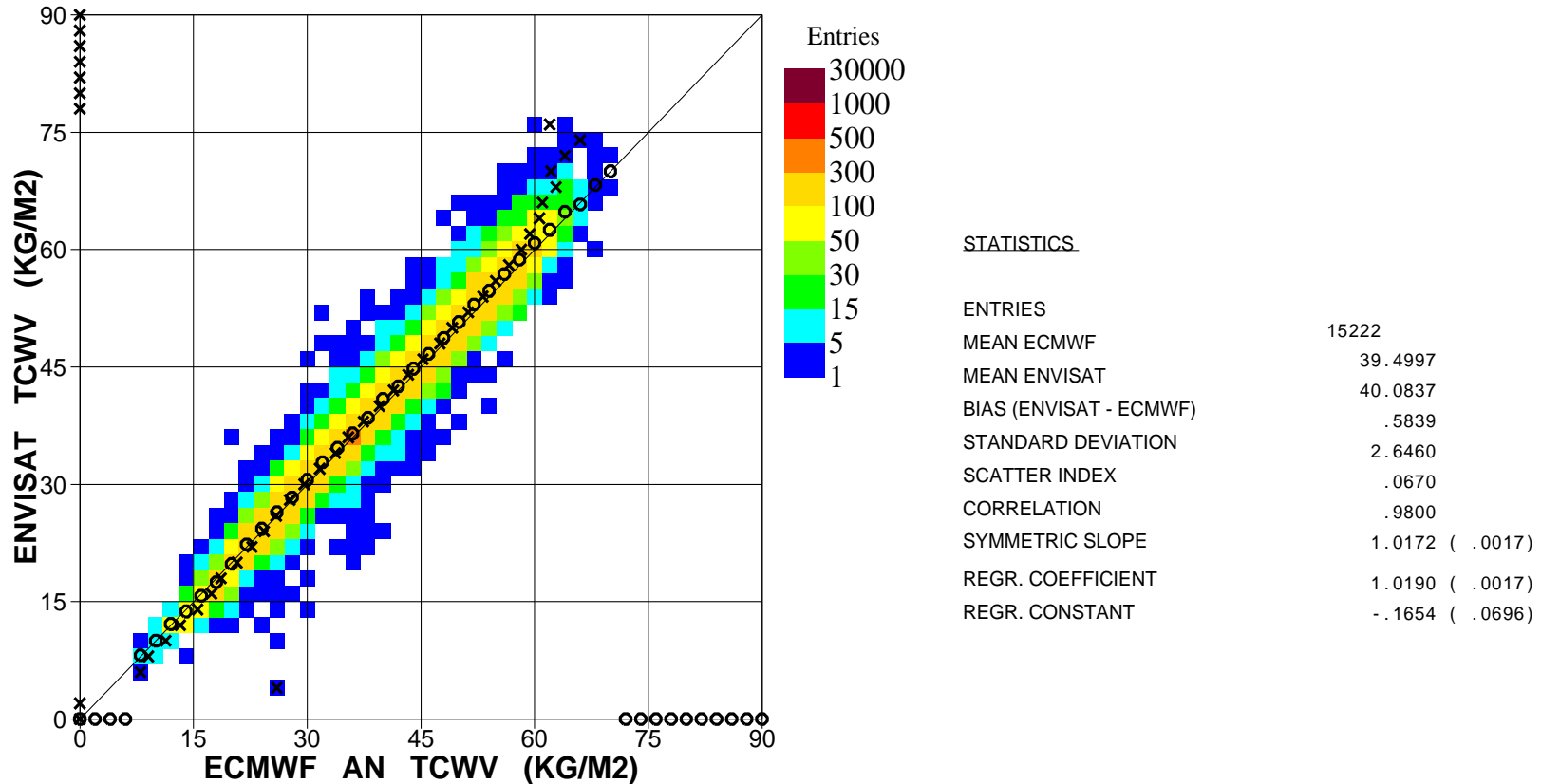
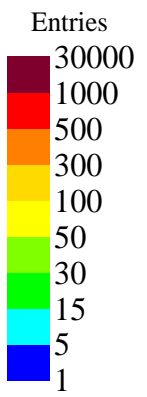
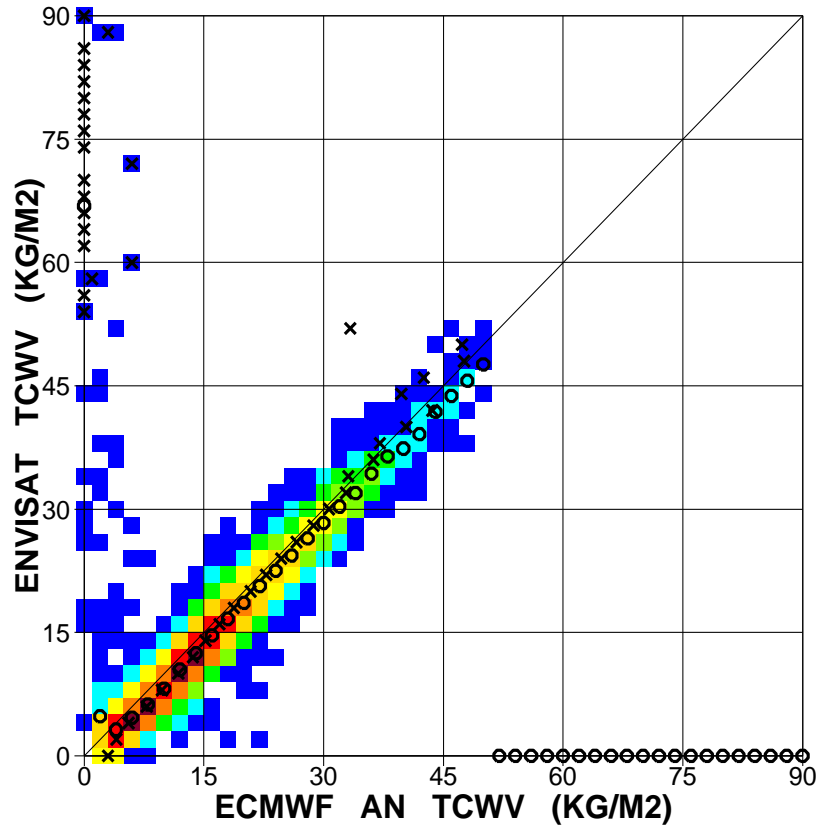


Figure 44. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for August 2004 (Tropics)

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STATISTICS.

ENTRIES	19529
MEAN ECMWF	13.2357
MEAN ENVISAT	11.9490
BIAS (ENVISAT - ECMWF)	-1.2867
STANDARD DEVIATION	4.1086
SCATTER INDEX	.3104
CORRELATION	.8611
SYMMETRIC SLOPE	.9547 ( .0041)
REGR. COEFFICIENT	.9558 ( .0040)
REGR. CONSTANT	-.7013 ( .0610)

Figure 45. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for August 2004 (S.Hem.)

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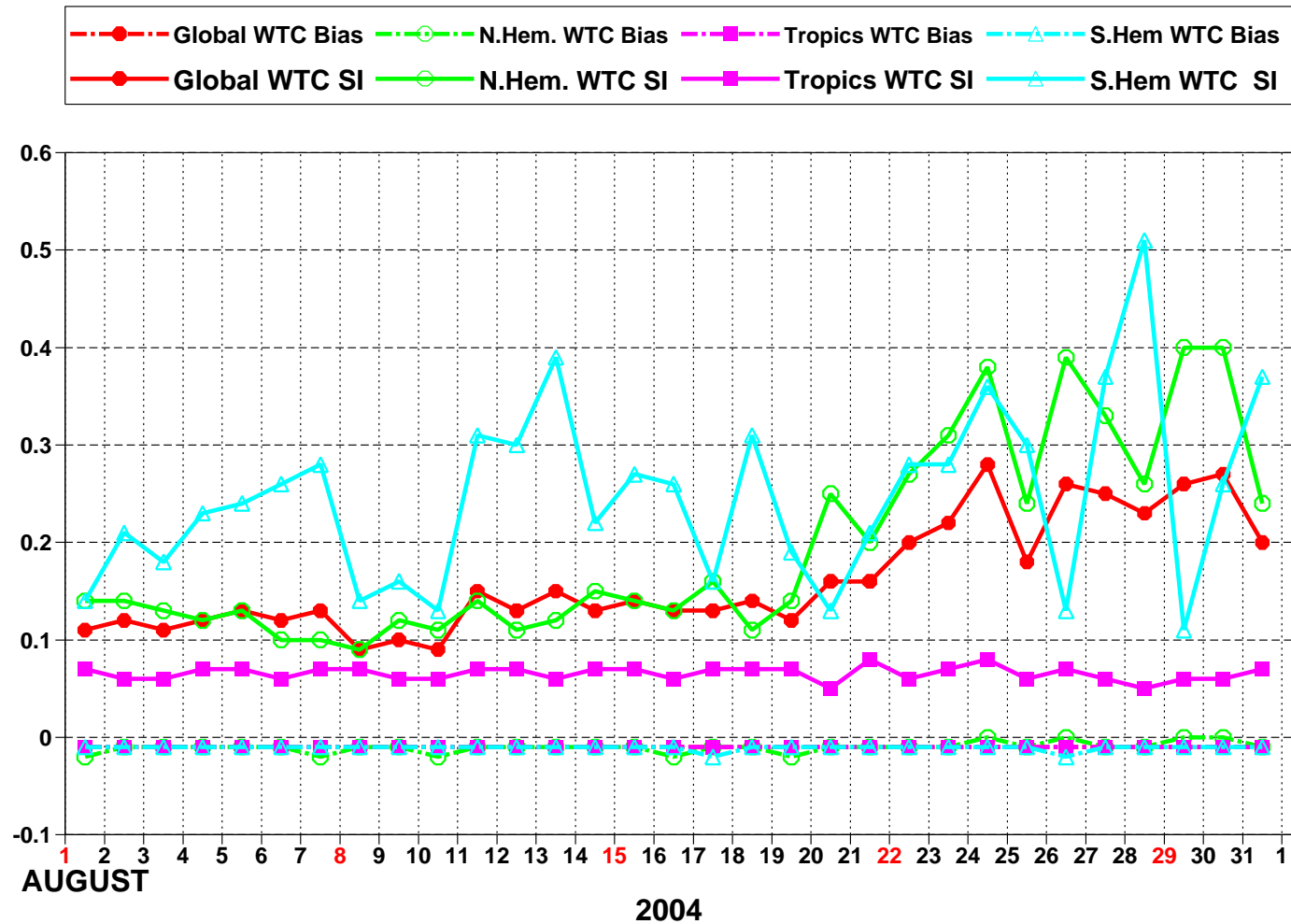


Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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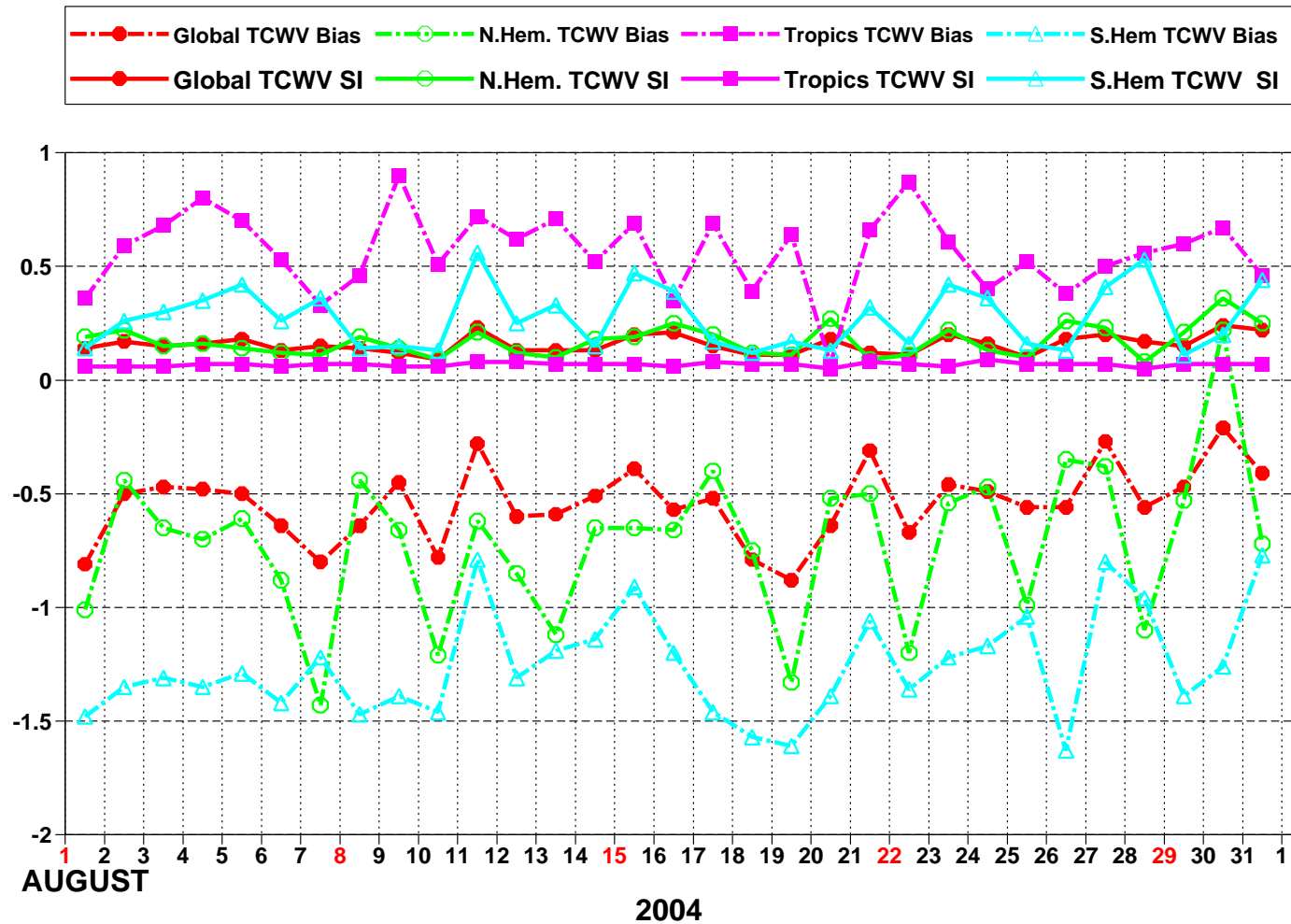


Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)



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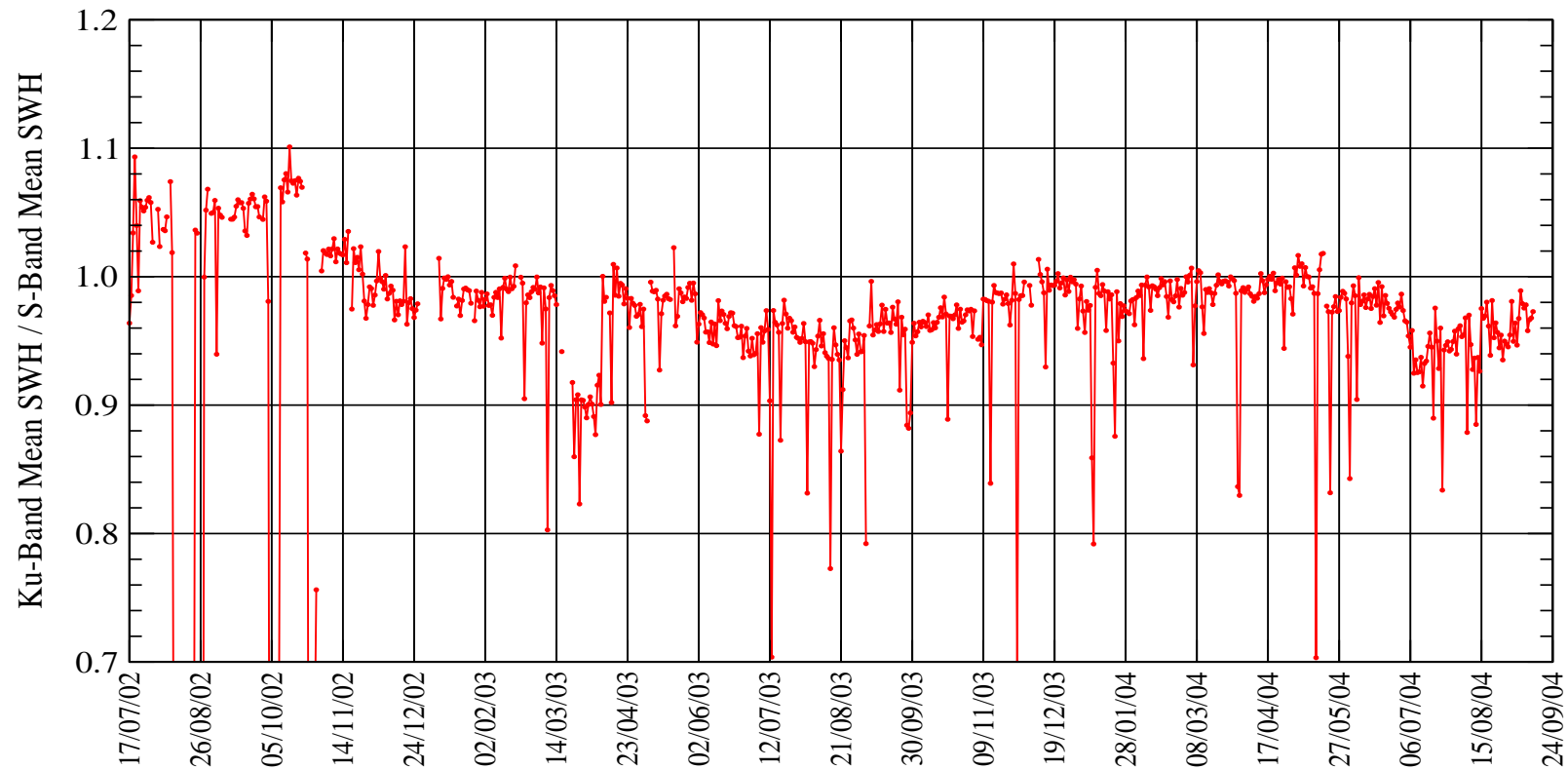


Figure 48. Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 18th. of July 2002.



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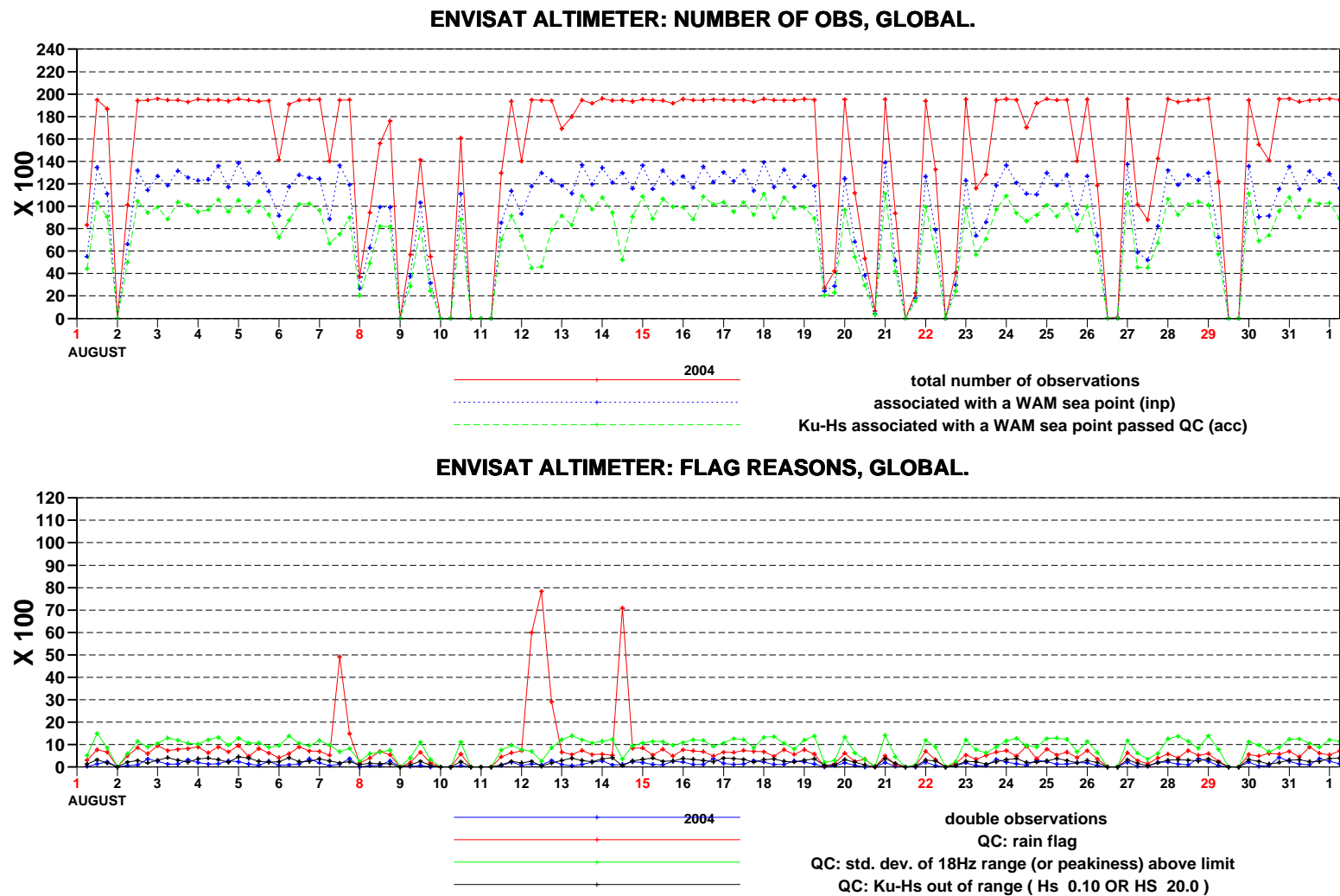


Figure 49: Correct time series of data reception for ENVISAT Altimeter data for August 2004