

■ ECMWF Report on ENVISAT RA-2 for December 2004 ■

Report on ENVISAT Radar Altimeter - 2 (RA-2)

Wind/Wave Product with Height Information (RA2 WWV 2P)

By: *Saleh Abdalla*

Date: *11 January 2005*

Overview:

Based on the data received during this month, on average, 16416 observations arrived at ECMWF every 6-hour window of which an average of 6668 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 78.61% 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 1:

- Time windows centred at 00:00 on the 10th., the 11th. and the 12th. of the month.
- Time window centred at 06:00 on the 27th. of the month.

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

- Time windows centred at 00:00 on the 1st., the 17th. and the 28th. of the month.



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- Time windows centred at 06:00 on the 3rd., the 9th., the 10th., the 11th., the 12th., the 15th., the 17th. and the 25th. of the month.
- Time windows centred at 12:00 on the 1st. and the 17th. of the month.

Although it seems that full nominal coverage was attained for most of the month, there are several gaps due to late conversion of PDS files into bufr at ESRIN site (00:00 UTC on the 10th., the 11th. and the 12th. of the month). Note that we are talking about the raw data which we downloaded in “bufr” 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 more than last month. 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), 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 $\langle\sigma_0\rangle = 11.03$ dB (with a single peak at ~ 11.1 dB with a tendency to have two secondary peaks at 10.6 dB and 11.3 dB).
- ENVISAT RA-2 S-Band $\langle\sigma_0\rangle = 11.31$ dB (with a single peak at ~ 10.6 dB with a tendency to have several secondary peaks especially at 10.1 dB and 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	- 0.08	16.9	- 0.05	16.3
Northern Hemisphere	+ 0.26	16.4	+ 0.03	16.5
Tropics	- 0.27	18.1	- 0.75	10.3
Southern Hemisphere	- 0.15	15.7	----	----

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

	RA2 (Ku) - WAM		RA2 (Ku) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.11	12.3	0.08	13.2
Northern Hemisphere	0.21	13.0	0.08	13.2
Tropics	0.02	11.0	0.06	11.8
Southern Hemisphere	0.11	11.2	----	----



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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	0.08	20.3	- 0.08	15.8
Northern Hemisphere	0.09	15.7	- 0.08	15.9
Tropics	0.09	27.2	- 0.05	13.7
Southern Hemisphere	0.06	19.7	----	----

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	14.0	- 0.53	16.0
Northern Hemisphere	- 0.009	27.6	- 0.58	24.6
Tropics	- 0.012	6.7	+ 0.57	6.7
Southern Hemisphere	- 0.015	17.3	- 1.28	25.0

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Remarks:

- There was no related ECMWF model changes this month (current operational cycle is CY28R4).
- 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 the rejection of most of the data on the 18th., the 20th. and the 21st. 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), as usual.
- 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 about 1% 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 is more than that during the last month (less outliers in the Northern Hemisphere). Most of those outliers occurred on the 18th., the 20th. and the 21st. of the month (Figure 37) when there was over-active rain flagging.
- The ratio between Ku-band and S-band wave heights varied between ~0.97 to ~1.00 as can be seen in Figure 48 (there are few days with lower ratio values coinciding with the extreme *RA-2 S-band anomaly* events).

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- 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. The sea-ice flag associated with the MWR products is not included in the current bufr template. This will be treated soon.
- 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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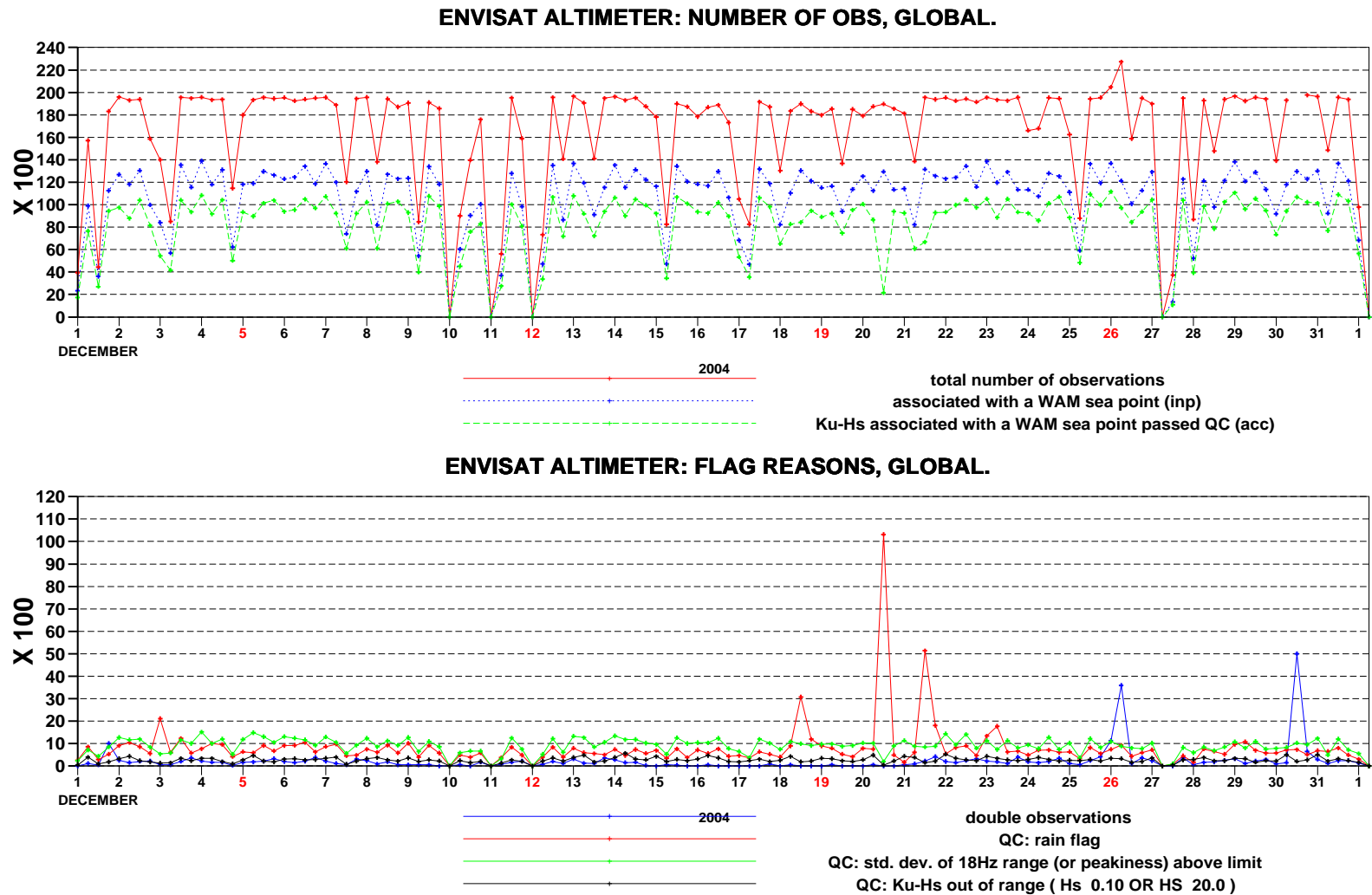


Figure 1: Time series of data reception for ENVISAT Altimeter data for December 2004

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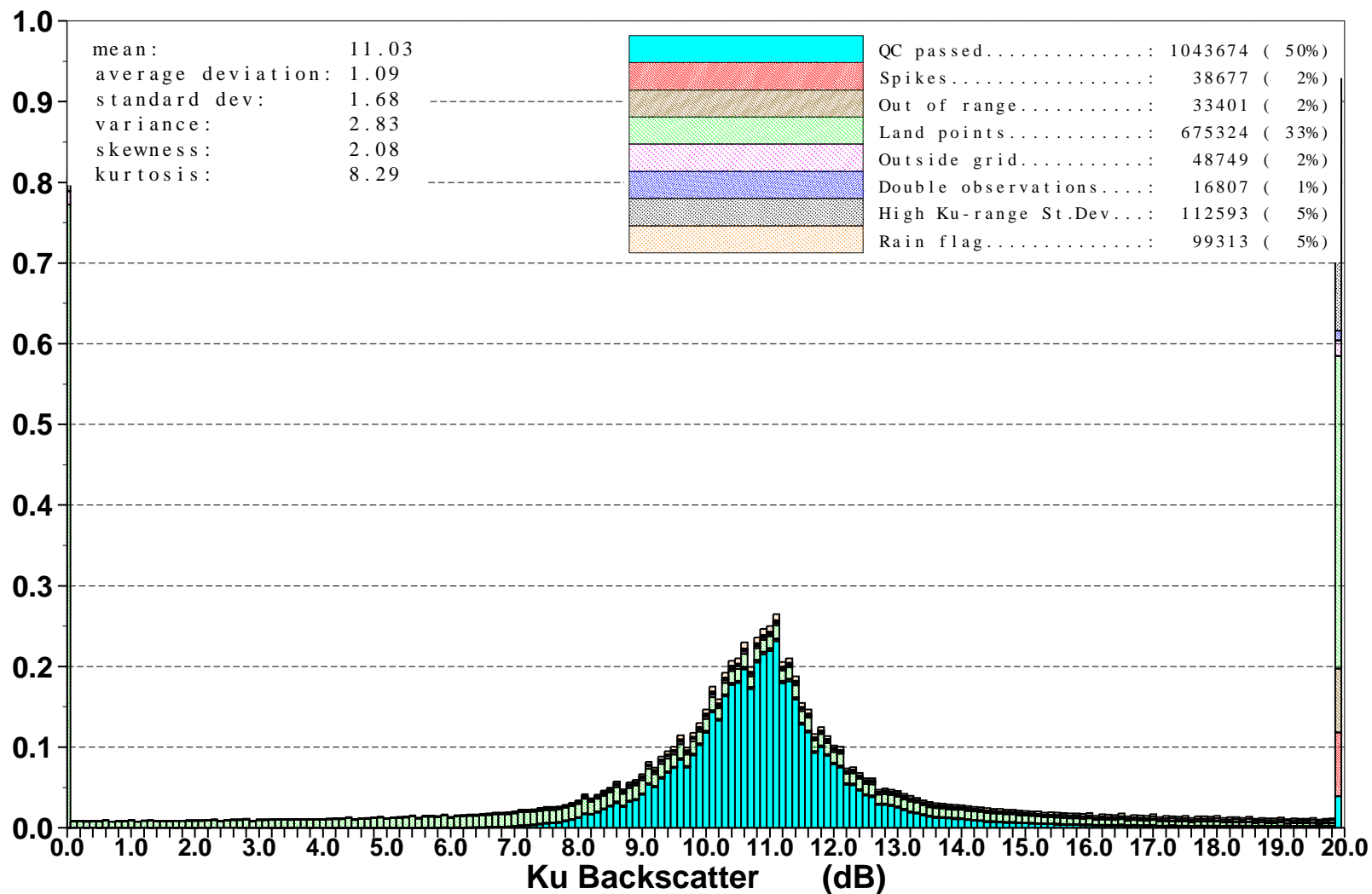


Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for December 2004

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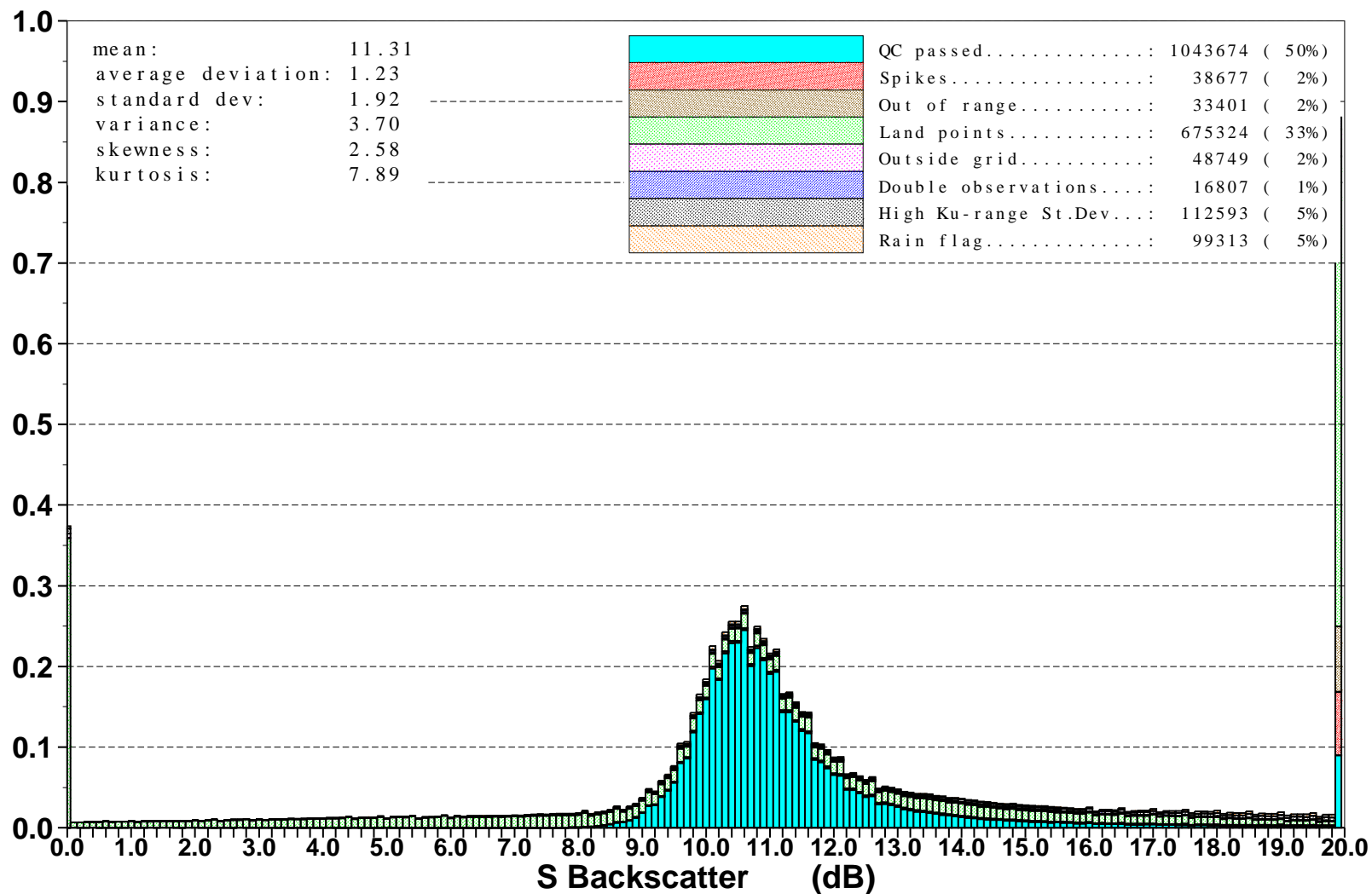


Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for December 2004

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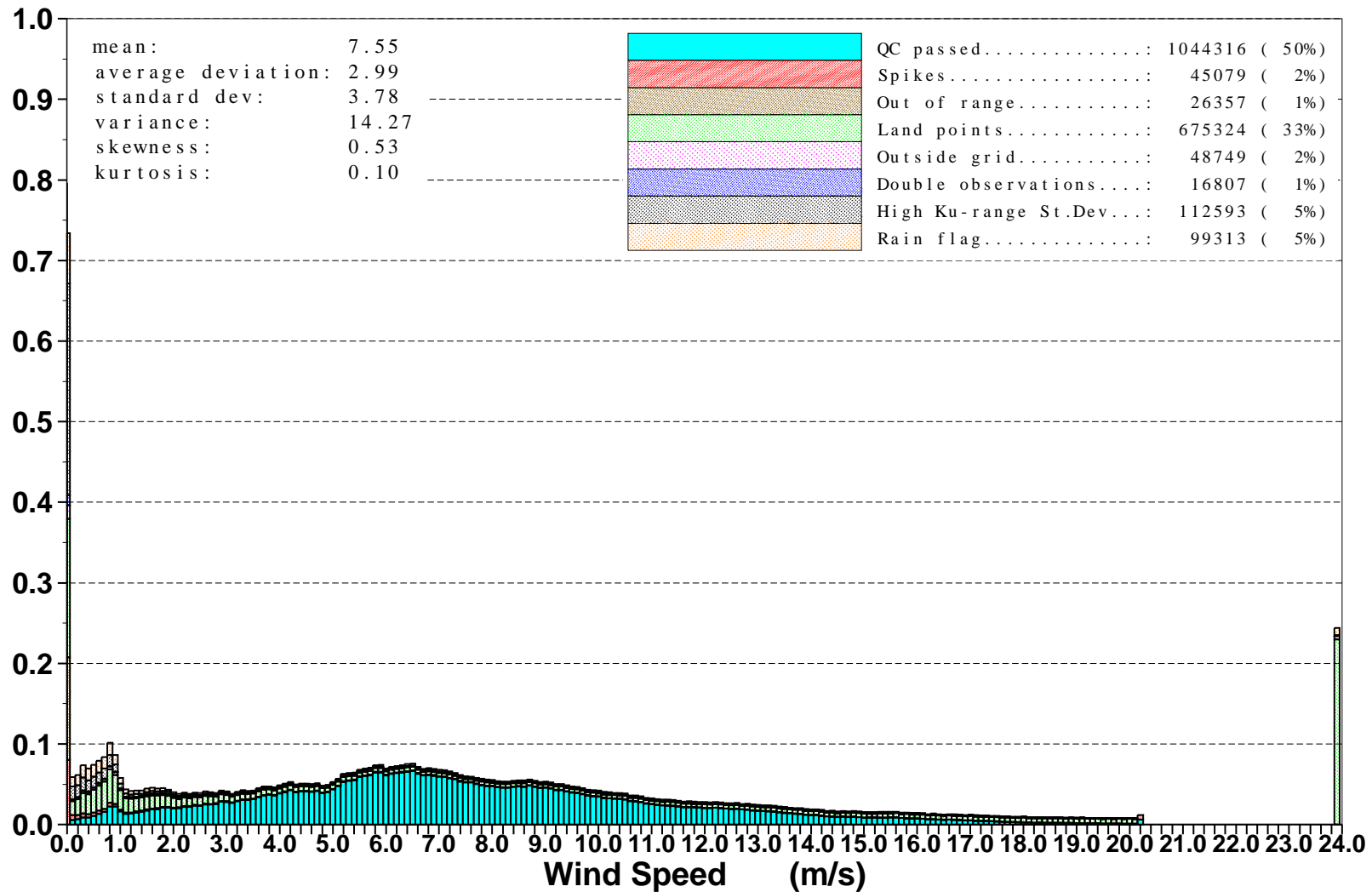


Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for December 2004



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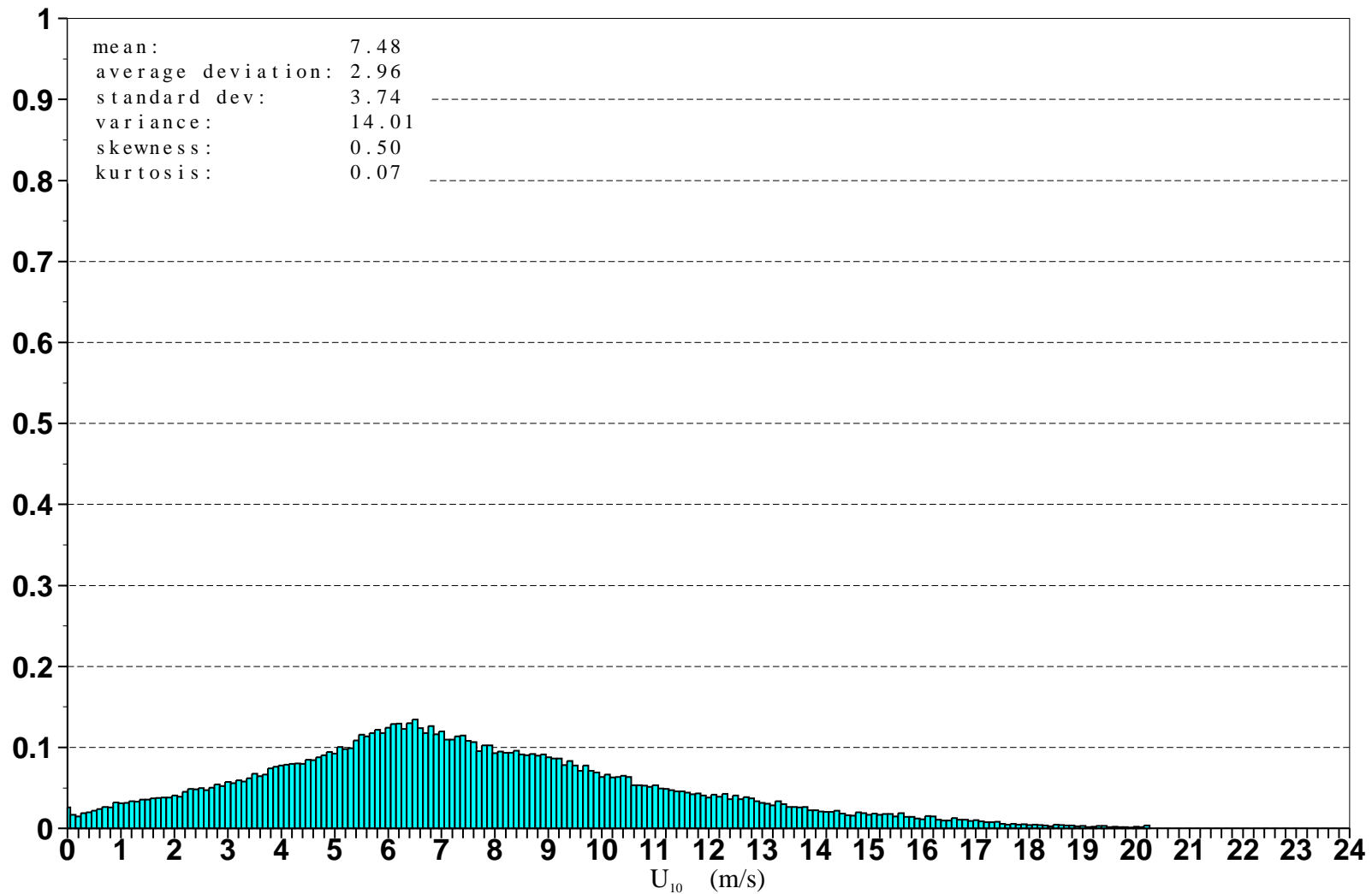


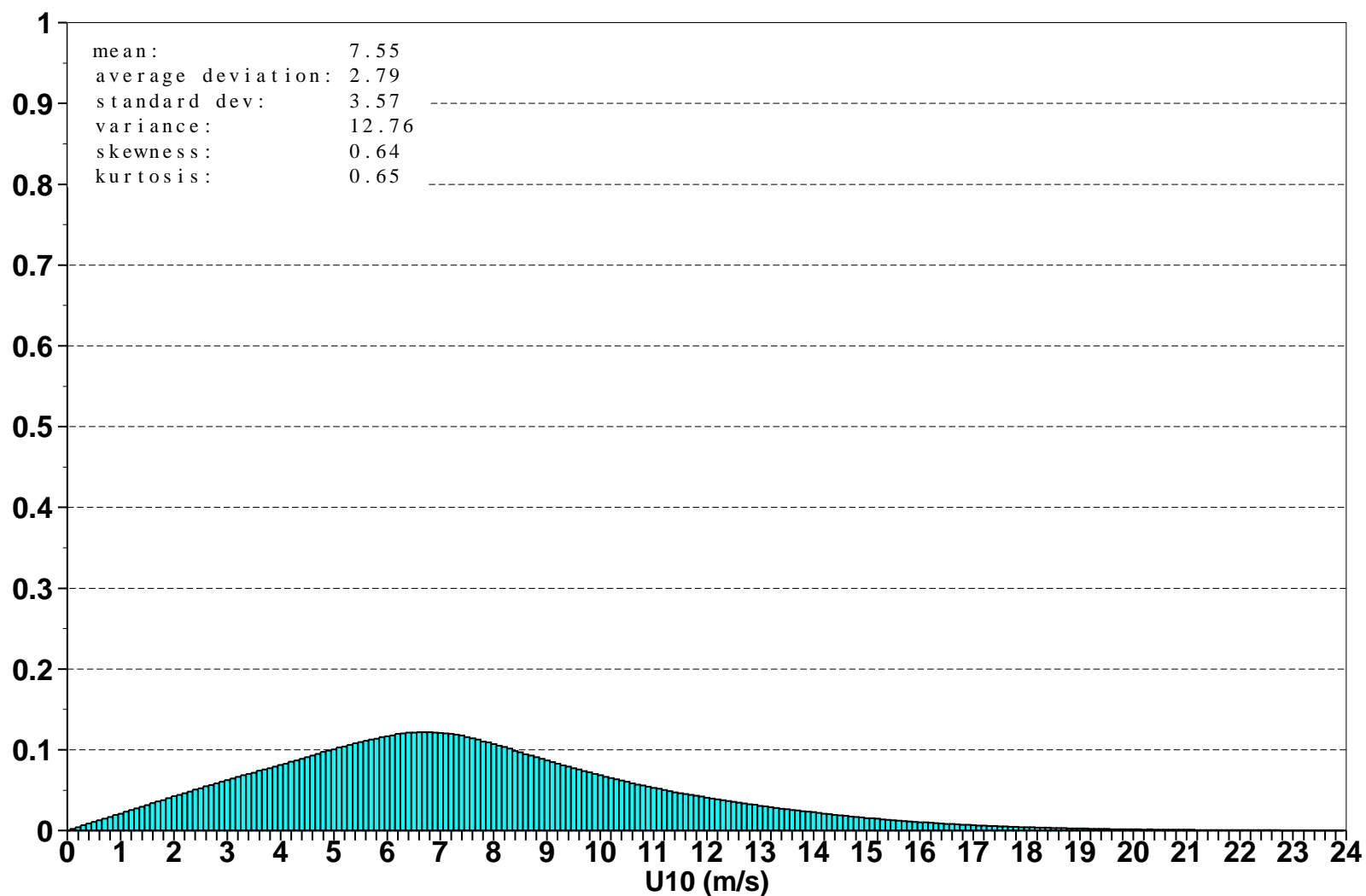
Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for December 2004



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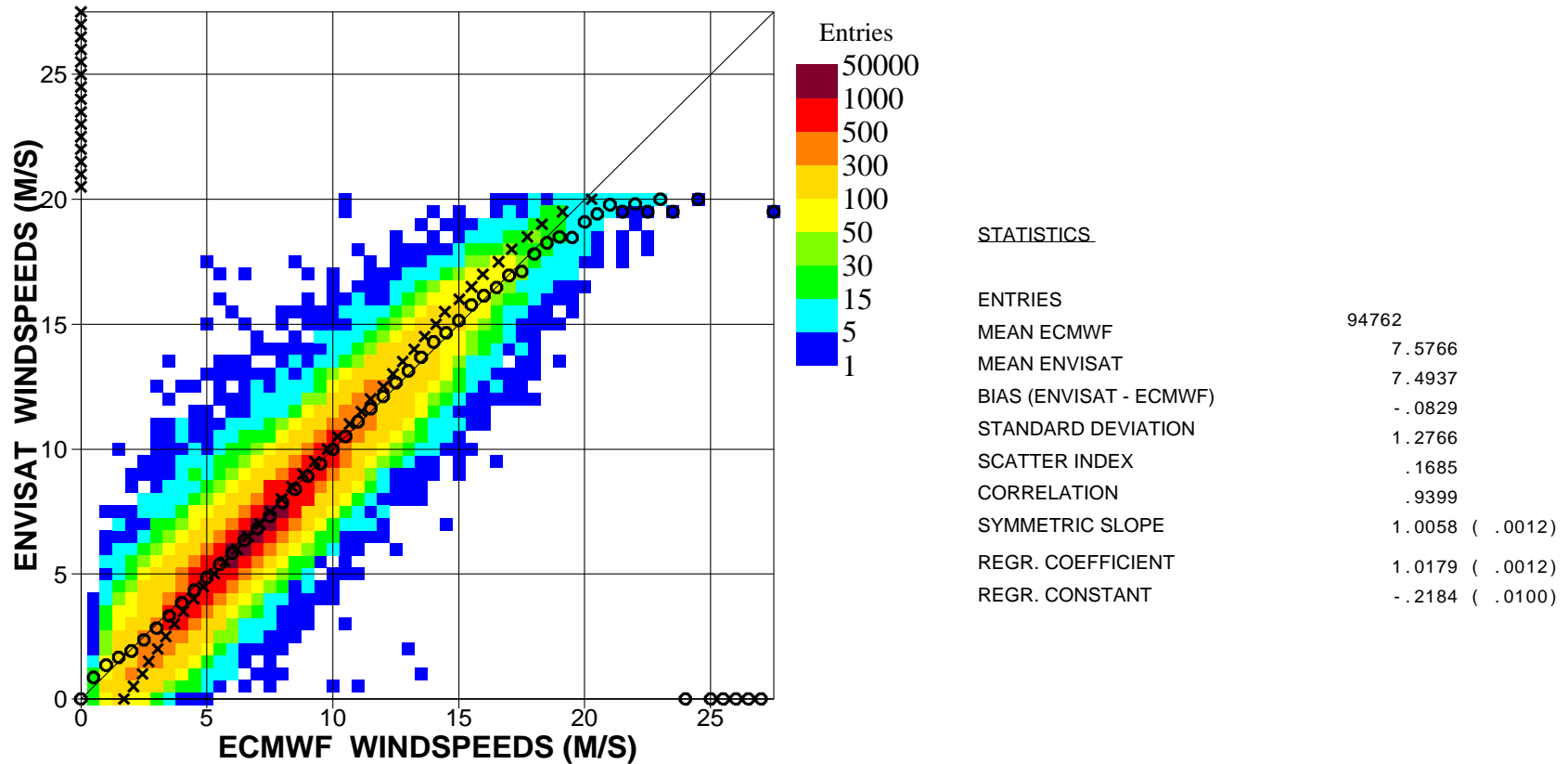


Figure 7. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2004 (Global)

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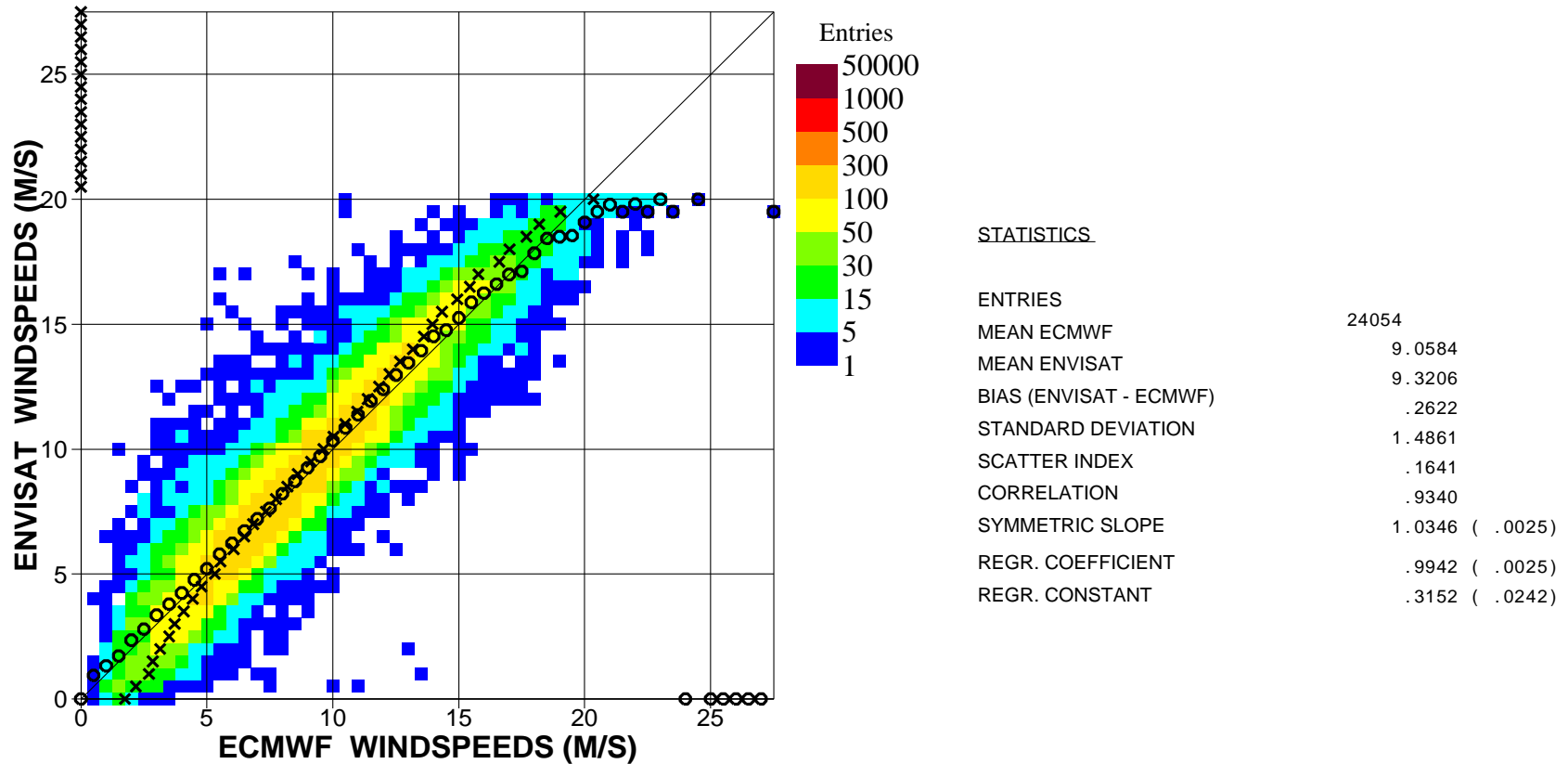


Figure 8. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2004 (N.Hem.)

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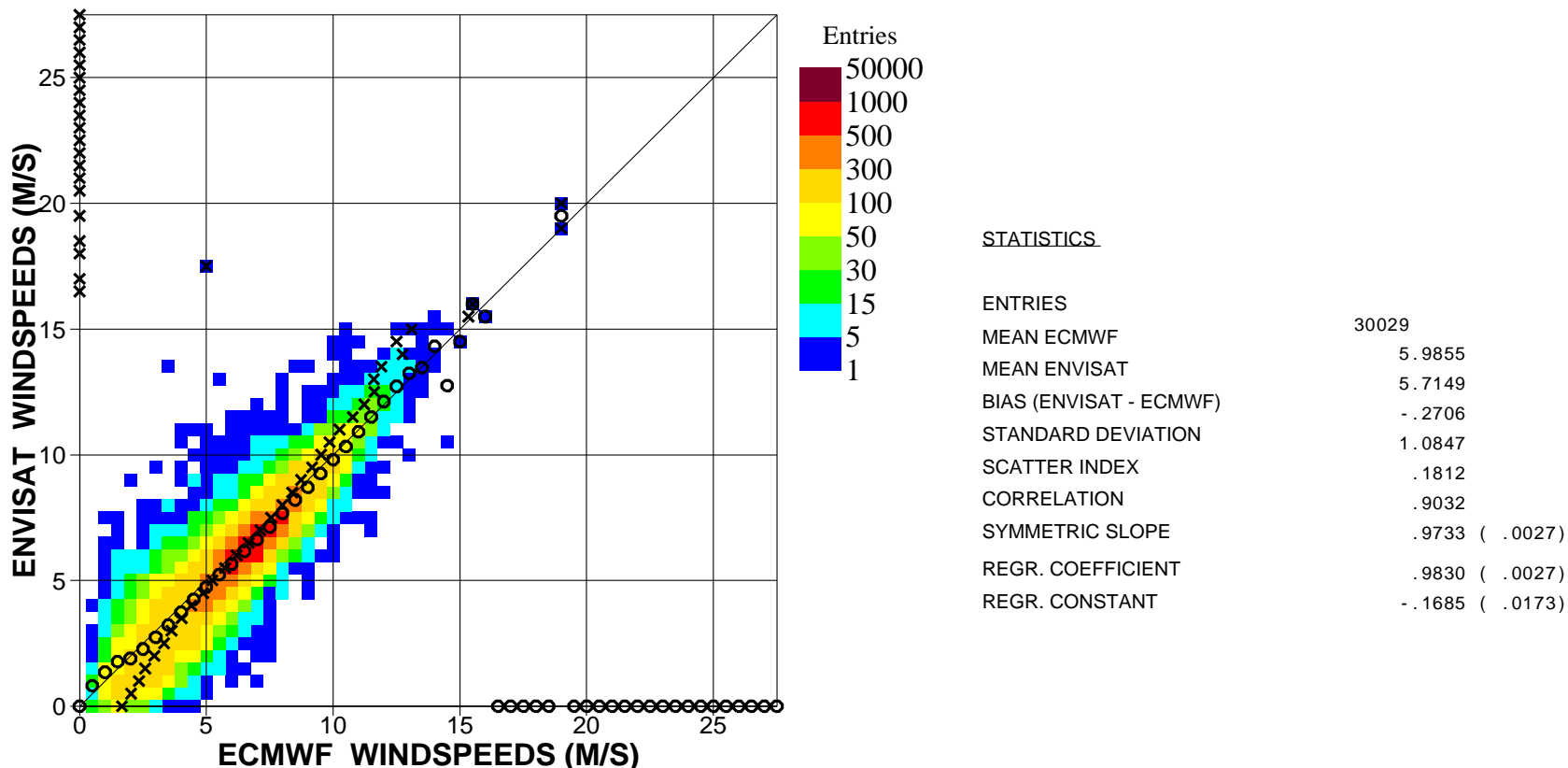
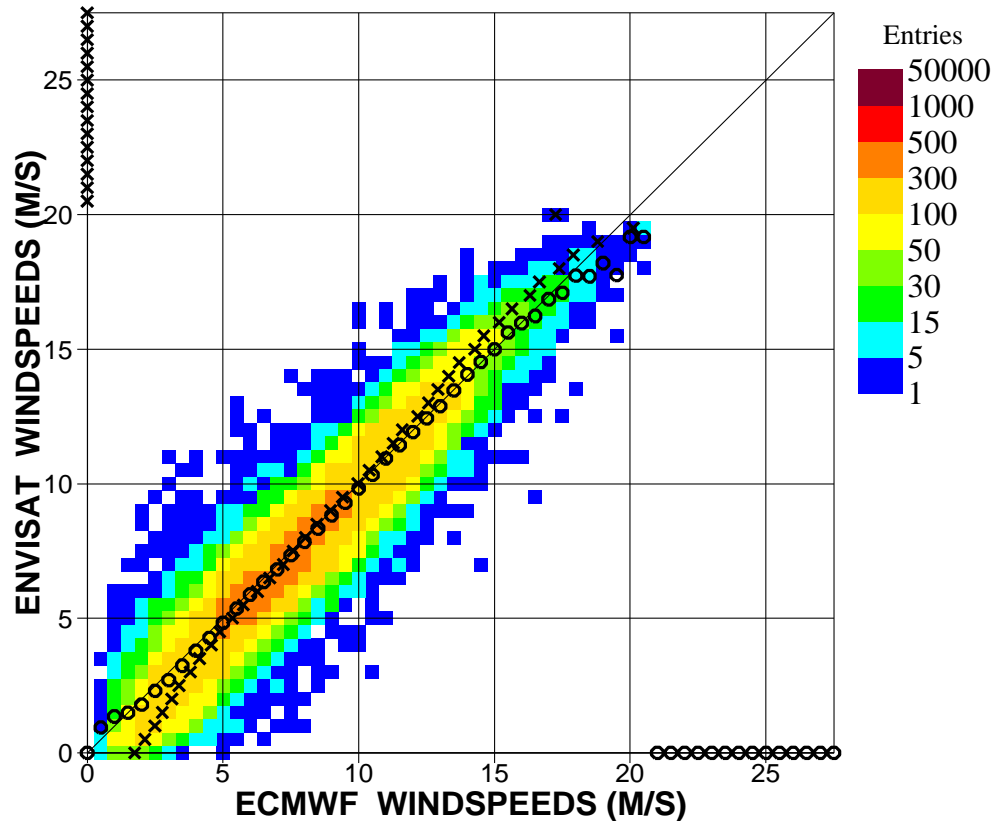


Figure 9. Comparison between ENVISAT Altimeter and ECMWF wind speeds for December 2004 (Tropics)

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STATISTICS

ENTRIES	41417
MEAN ECMWF	7.8582
MEAN ENVISAT	7.7074
BIAS (ENVISAT - ECMWF)	- .1509
STANDARD DEVIATION	1.2307
SCATTER INDEX	.1566
CORRELATION	.9403
SYMMETRIC SLOPE	.9959 (.0018)
REGR. COEFFICIENT	1.0103 (.0018)
REGR. CONSTANT	-.2317 (.0154)

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

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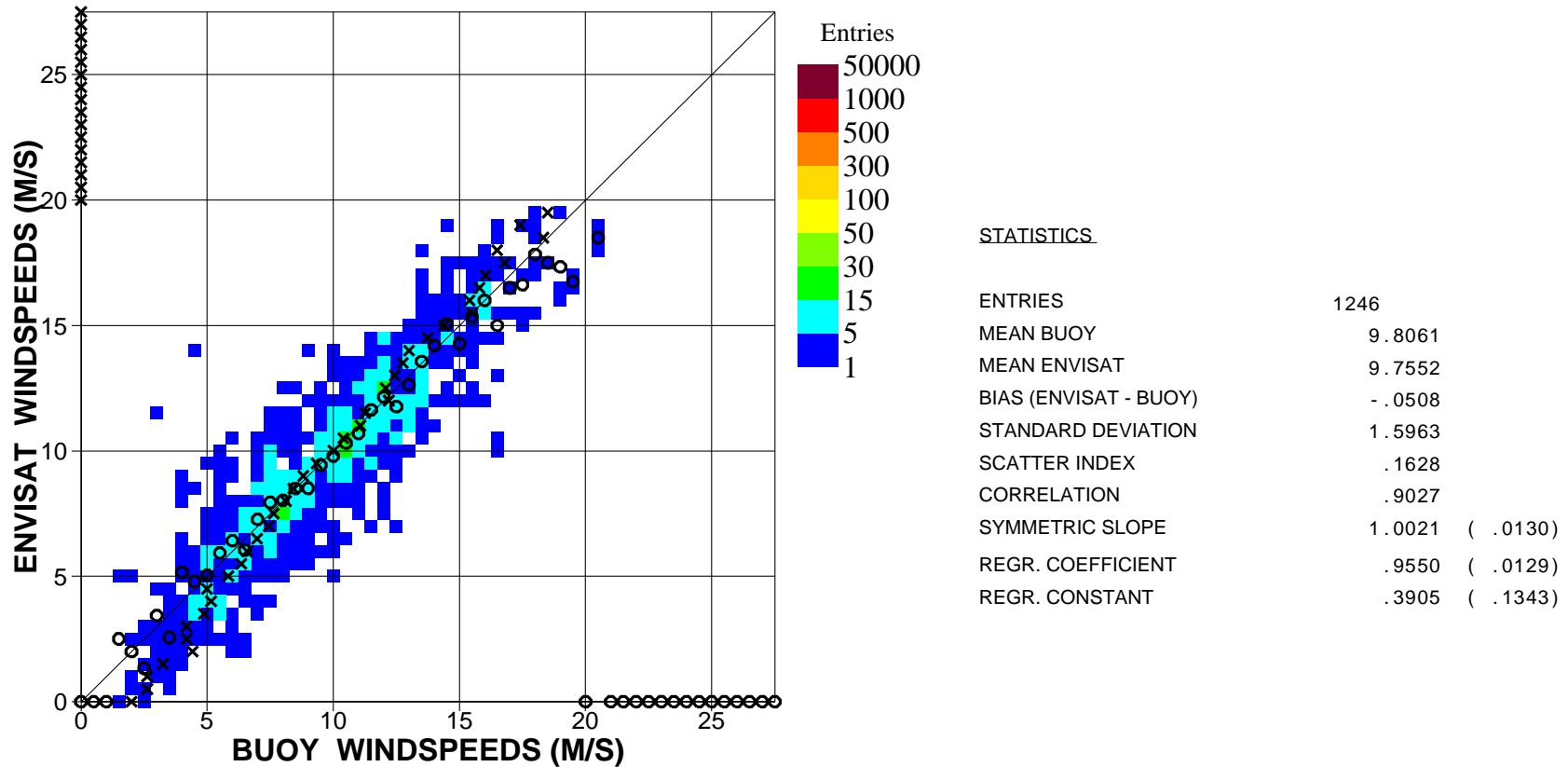


Figure 11. Comparison between ENVISAT Altimeter and buoy wind speeds for December 2004 (Global)

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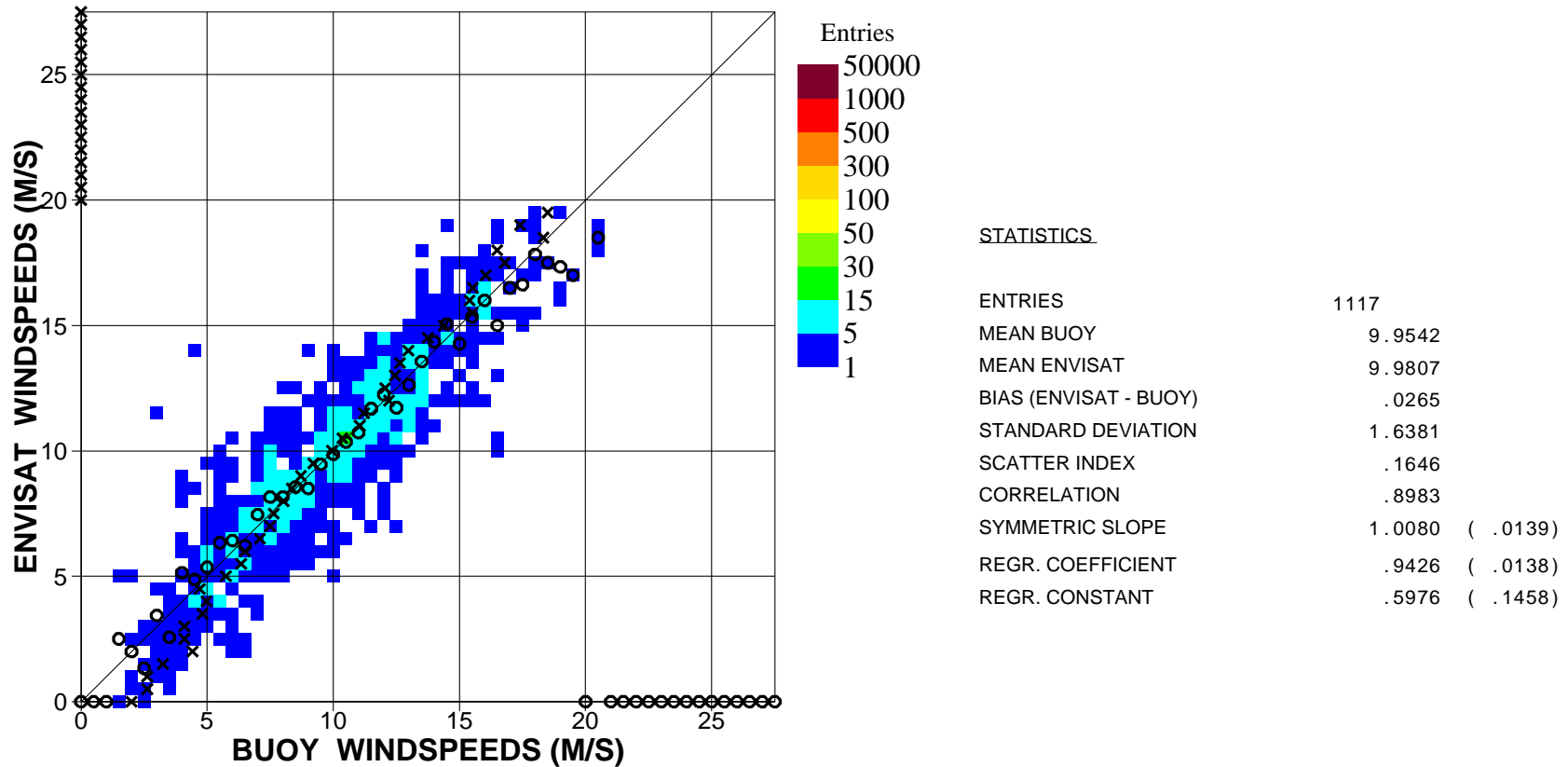


Figure 12. Comparison between ENVISAT Altimeter and buoy wind speeds for December 2004 (N.Hem.)

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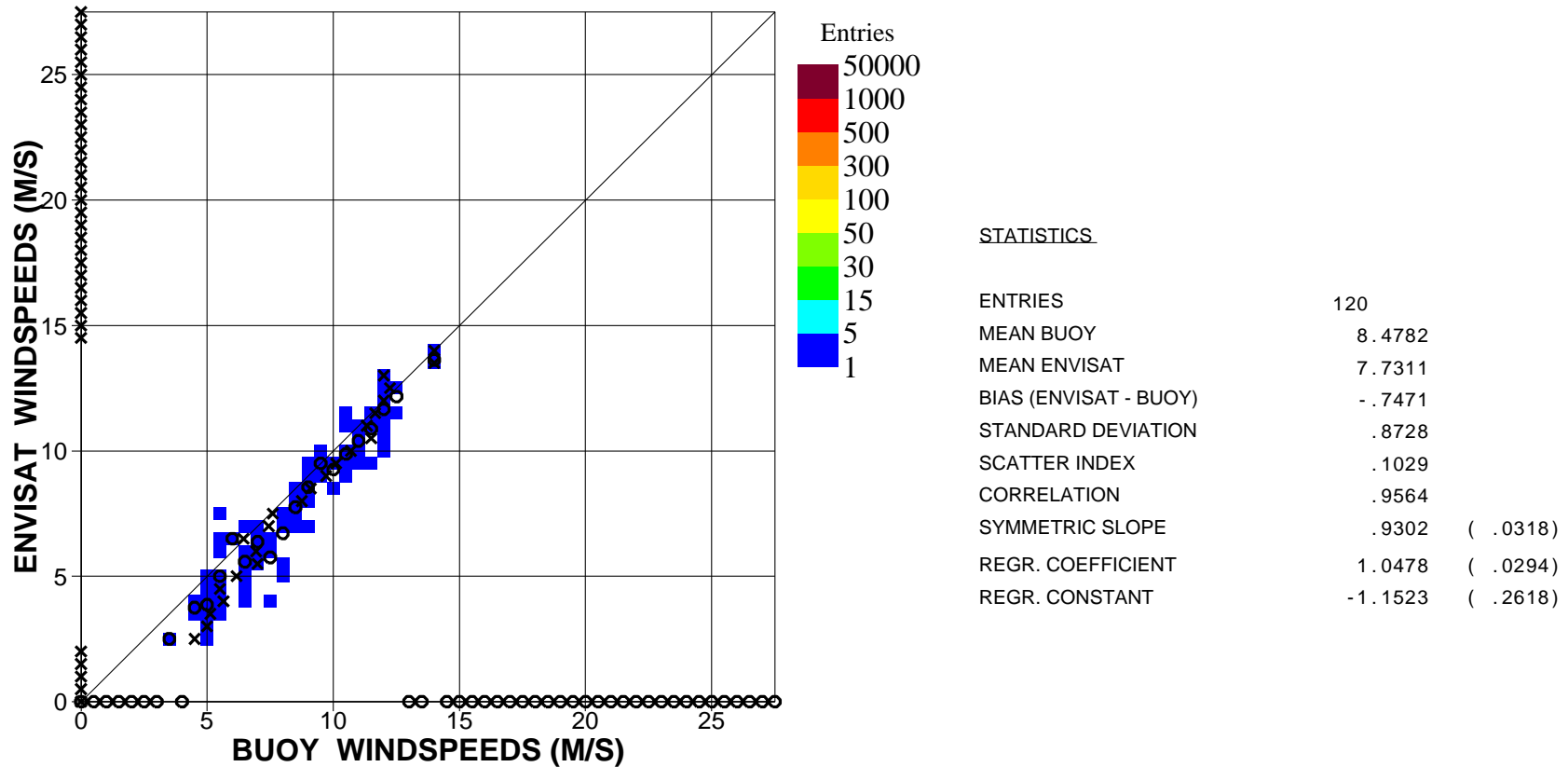


Figure 13. Comparison between ENVISAT Altimeter and buoy wind speeds for December 2004 (Tropics)

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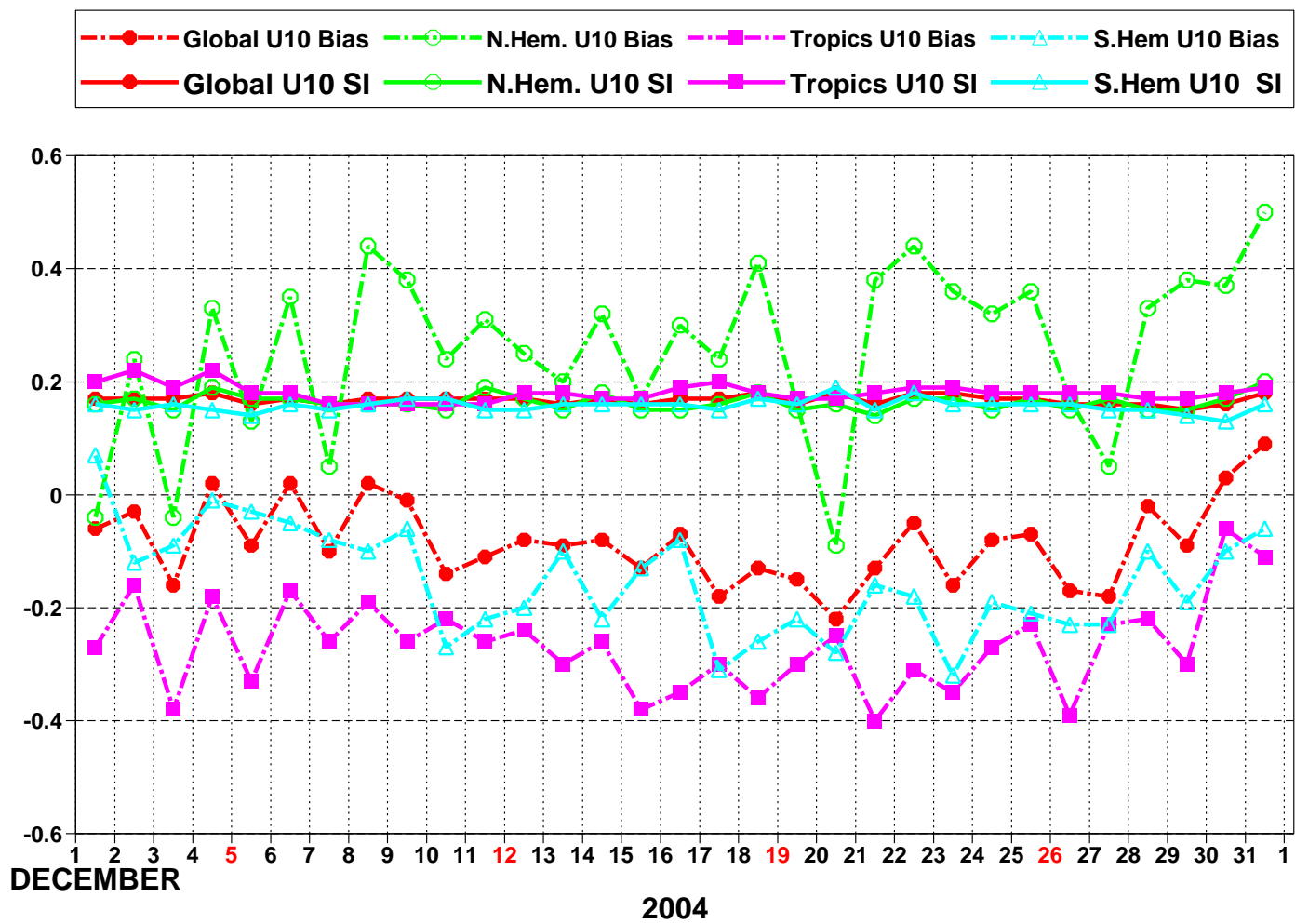


Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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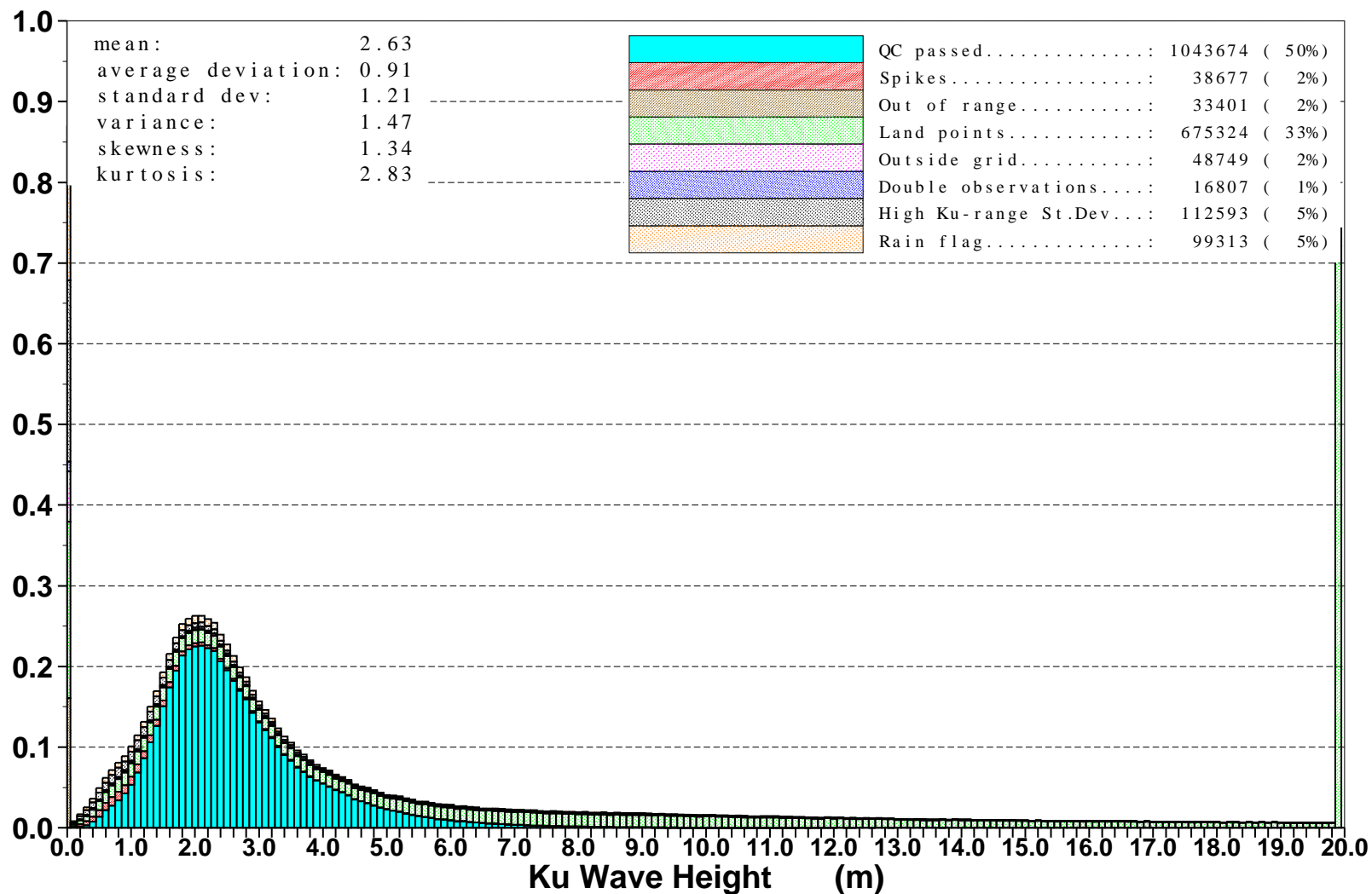


Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for December 2004

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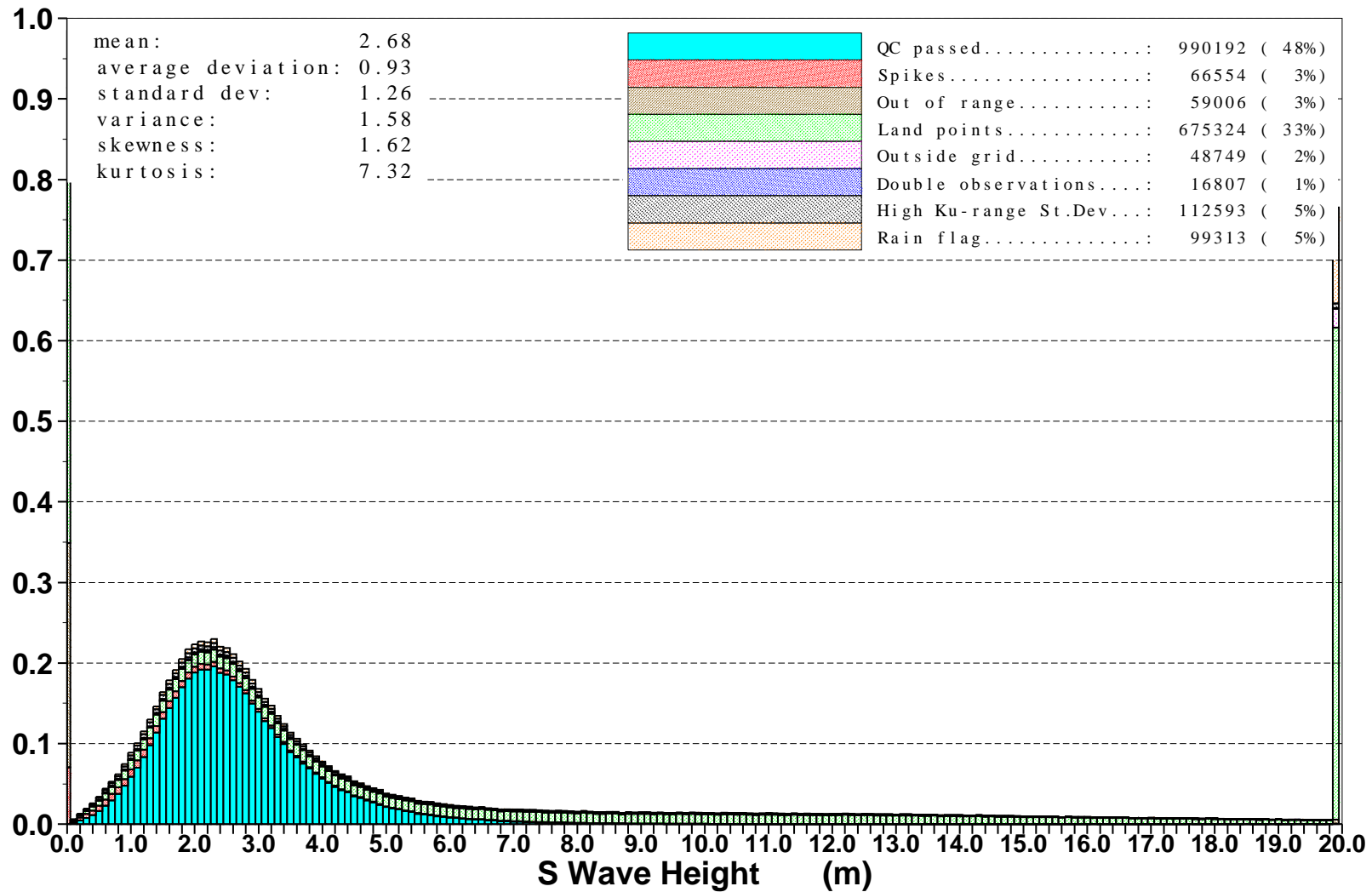


Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for December 2004

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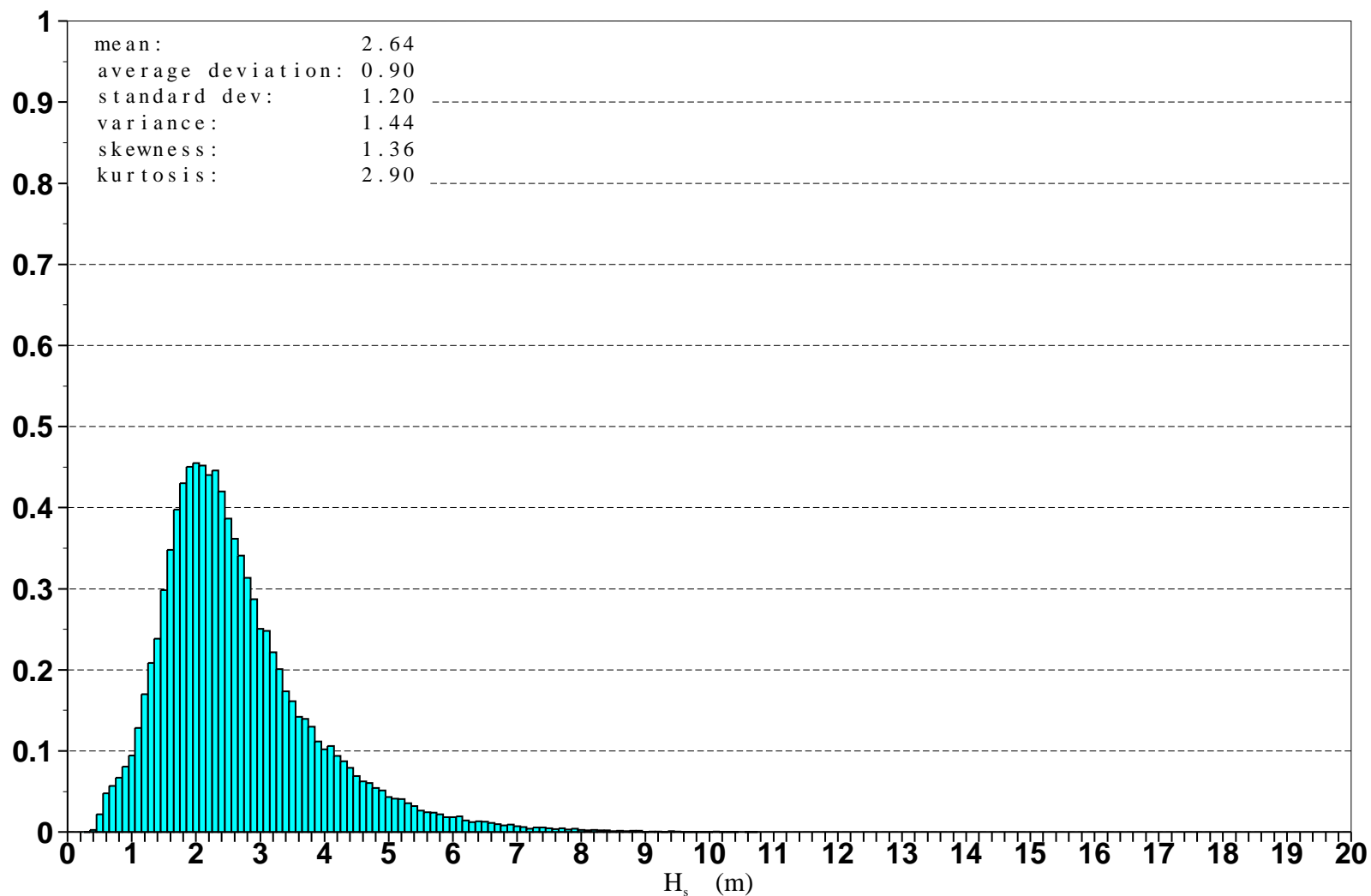


Figure 17: Distribution of ENVISAT Altimeter Ku-Band Wave Heights after Along-Track Averaging for December 2004

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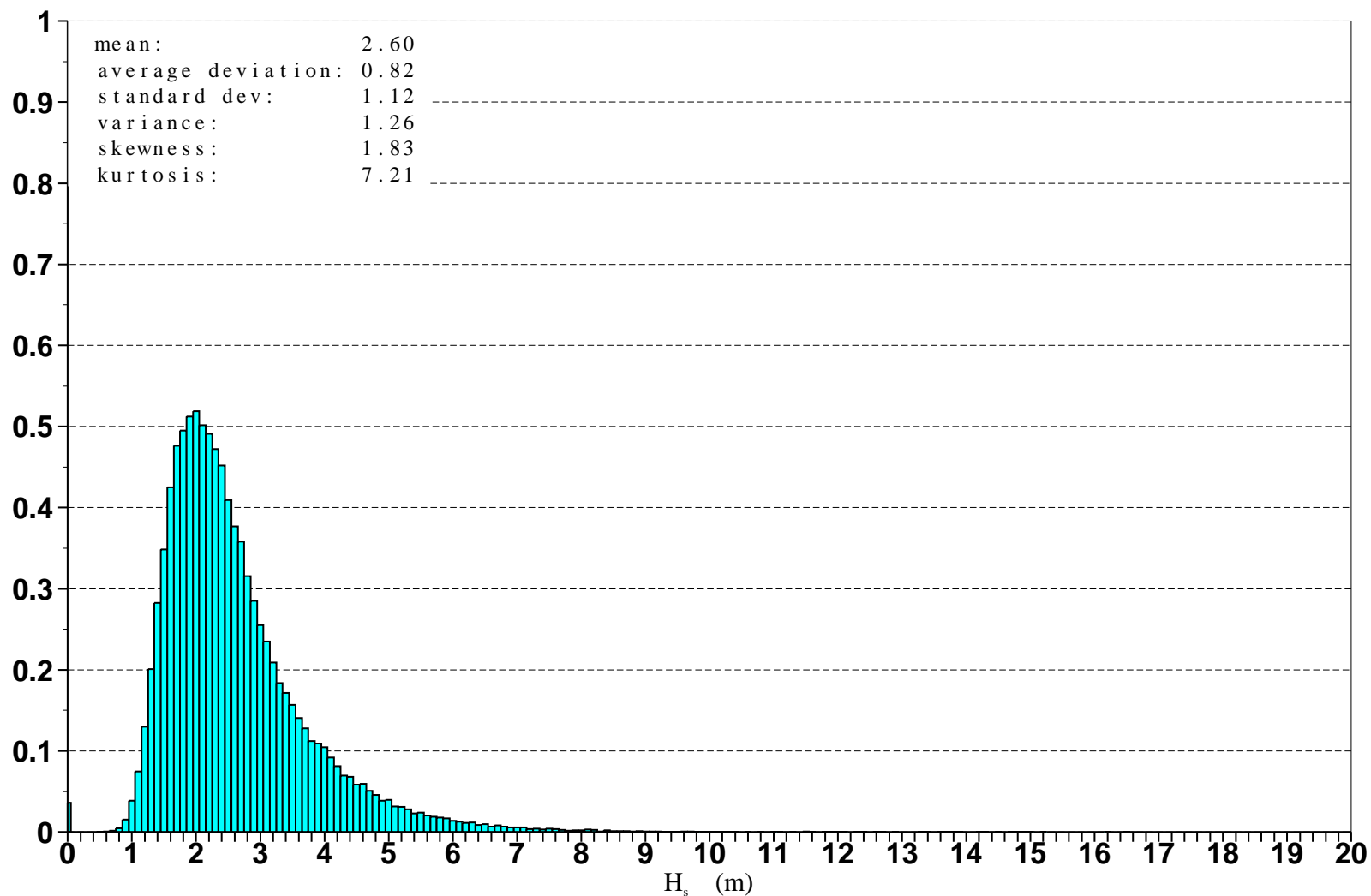


Figure 18: Distribution of ENVISAT Altimeter S-Band Wave Heights after Along-Track Averaging for December 2004



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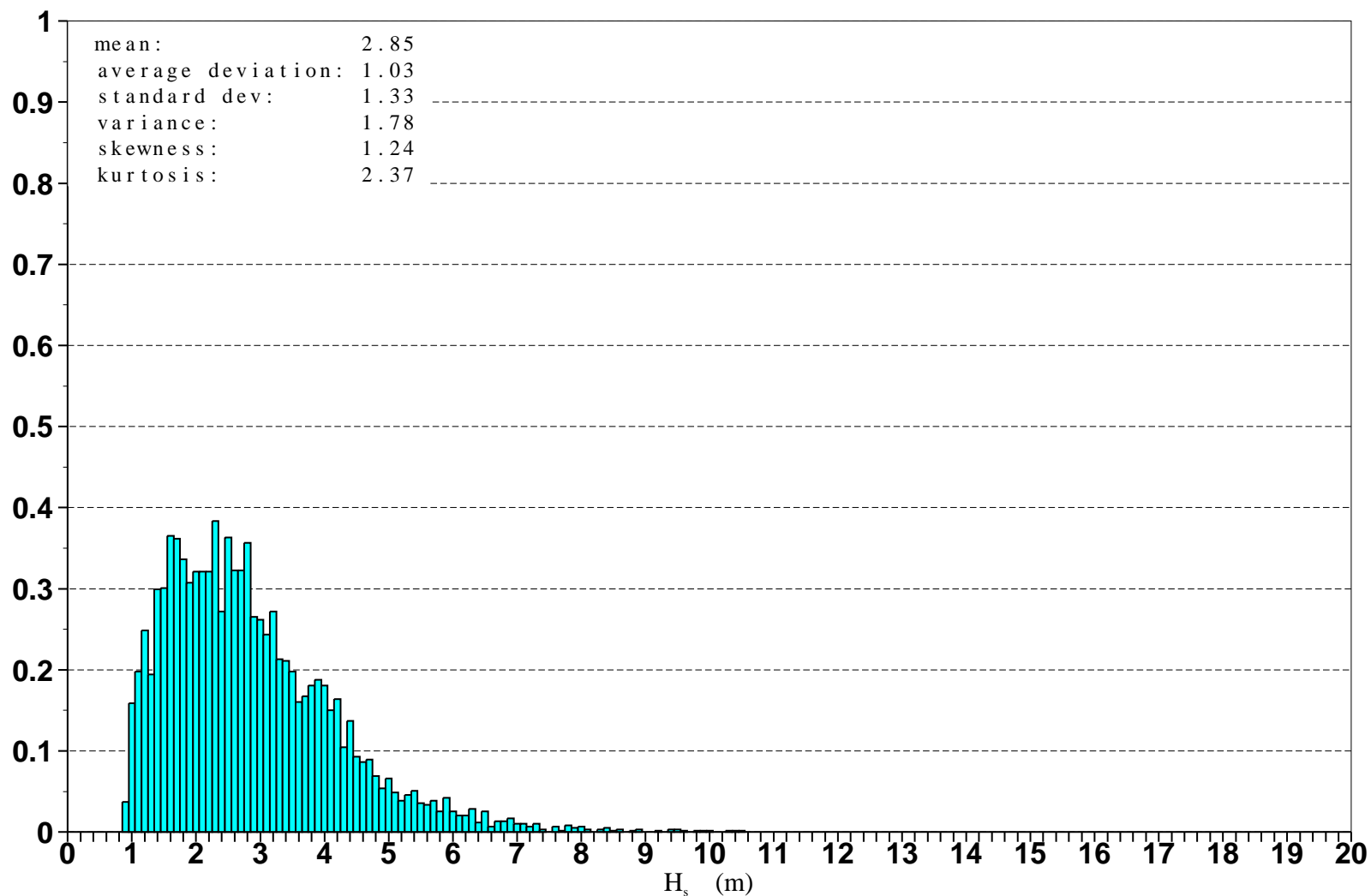


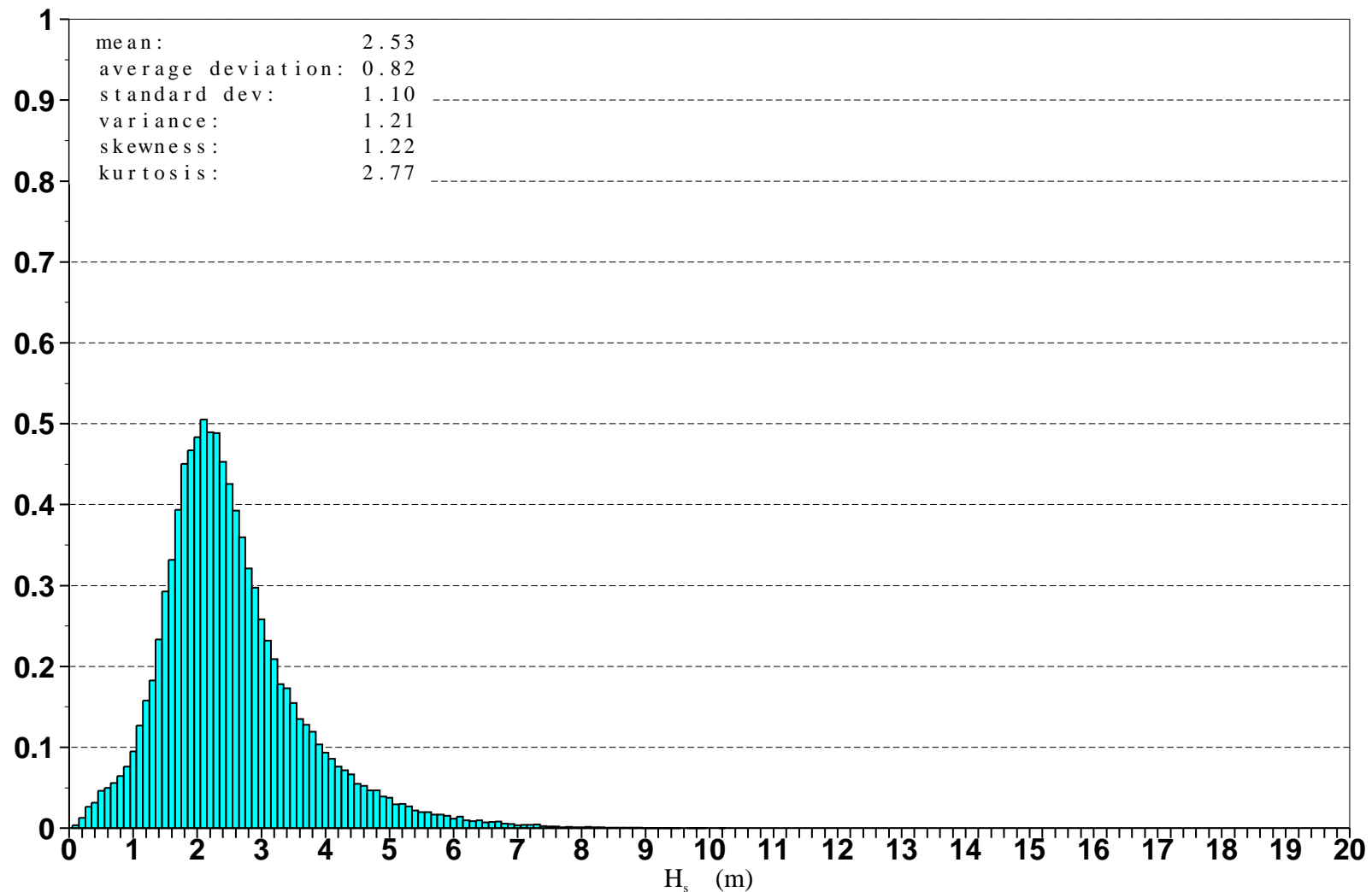
Figure 19: Distribution of ERS-2 Altimeter Wave Heights after Along-Track Averaging for December 2004



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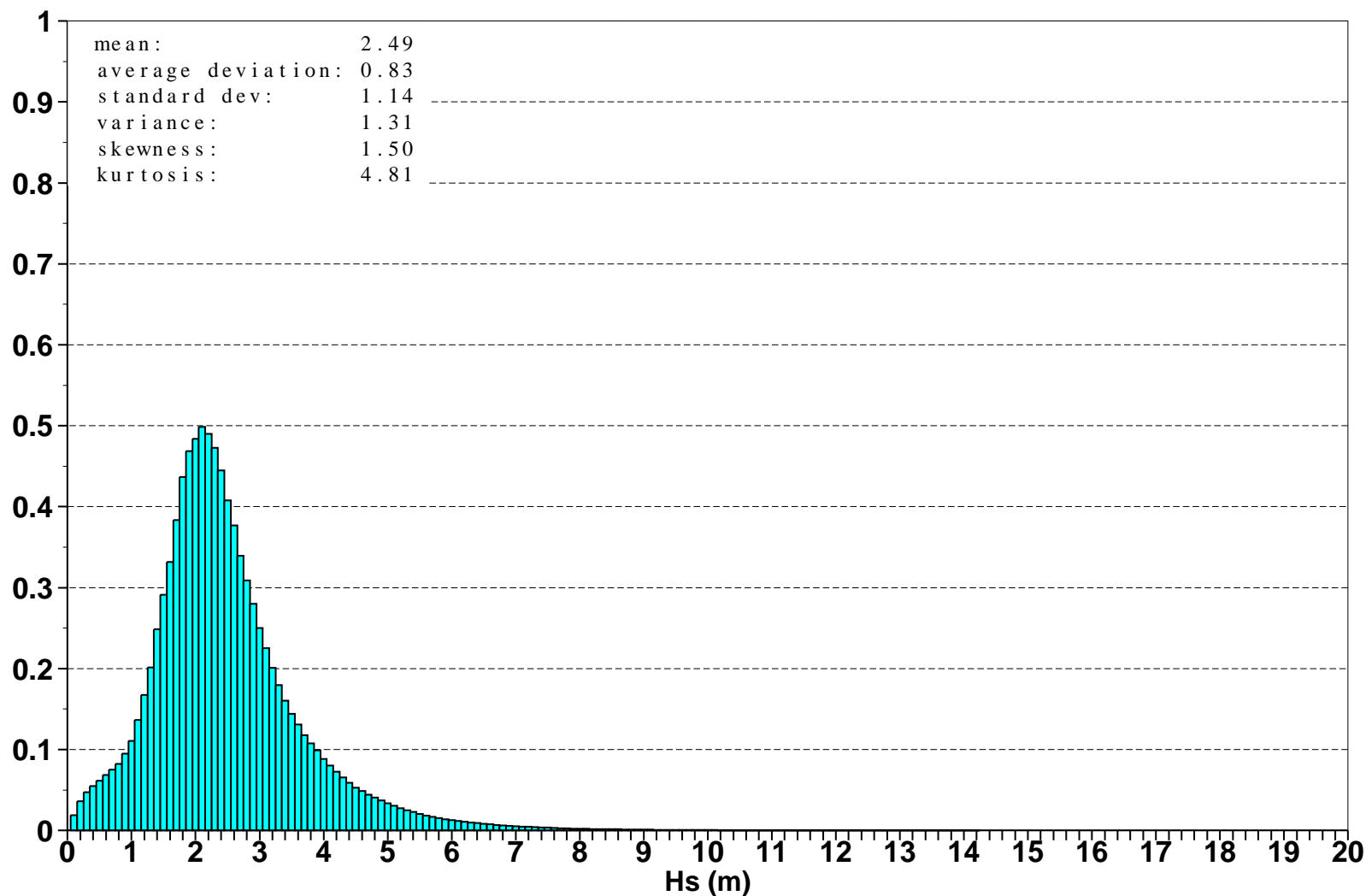


Figure 20: Global distribution of ECMWF First-Guess wave heights for December 2004



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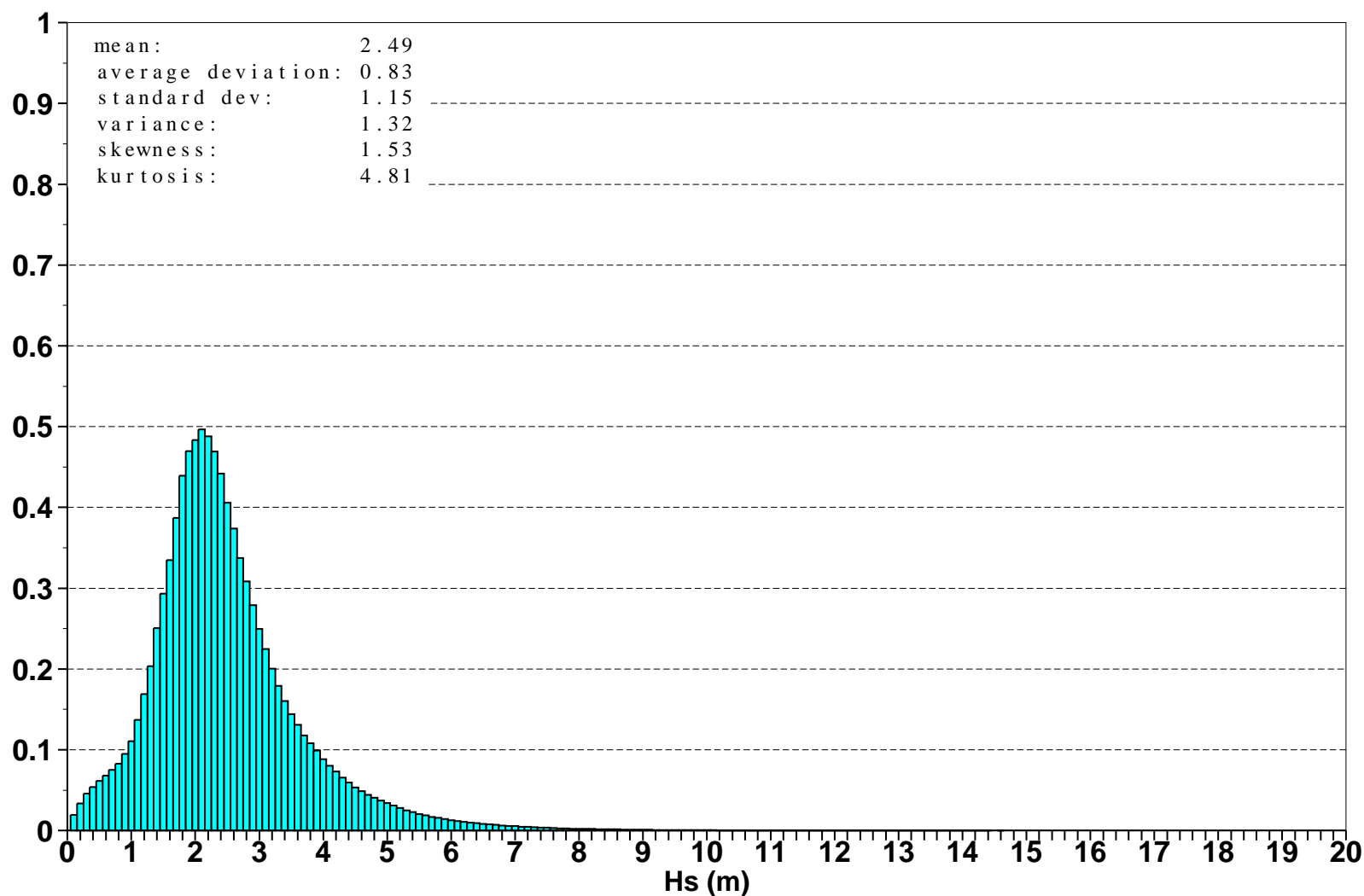


Figure 21: Global distribution of ECMWF Analysis wave heights for December 2004



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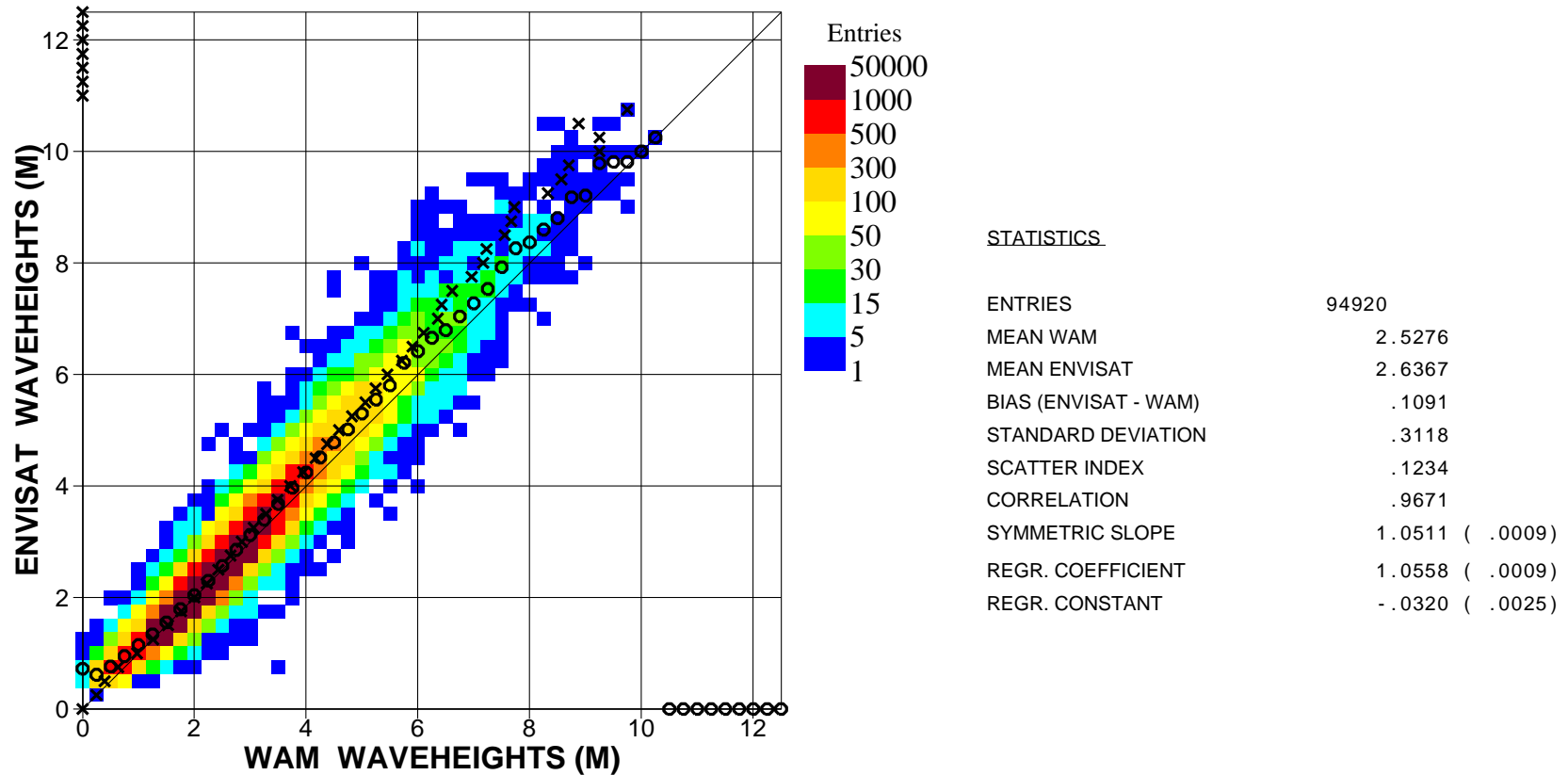


Figure 22. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2004 (Global)

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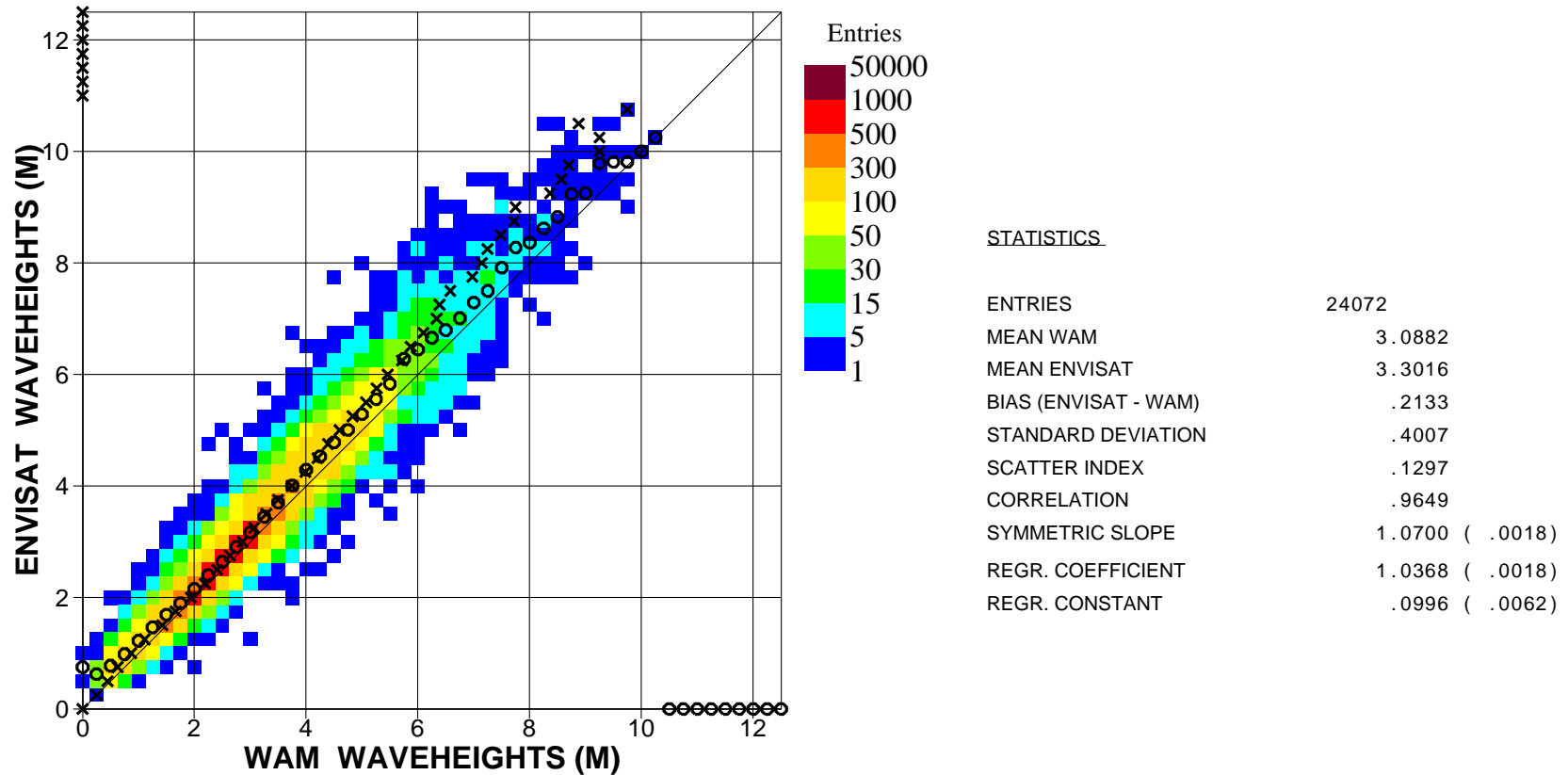


Figure 23. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2004 (N.Hem.)

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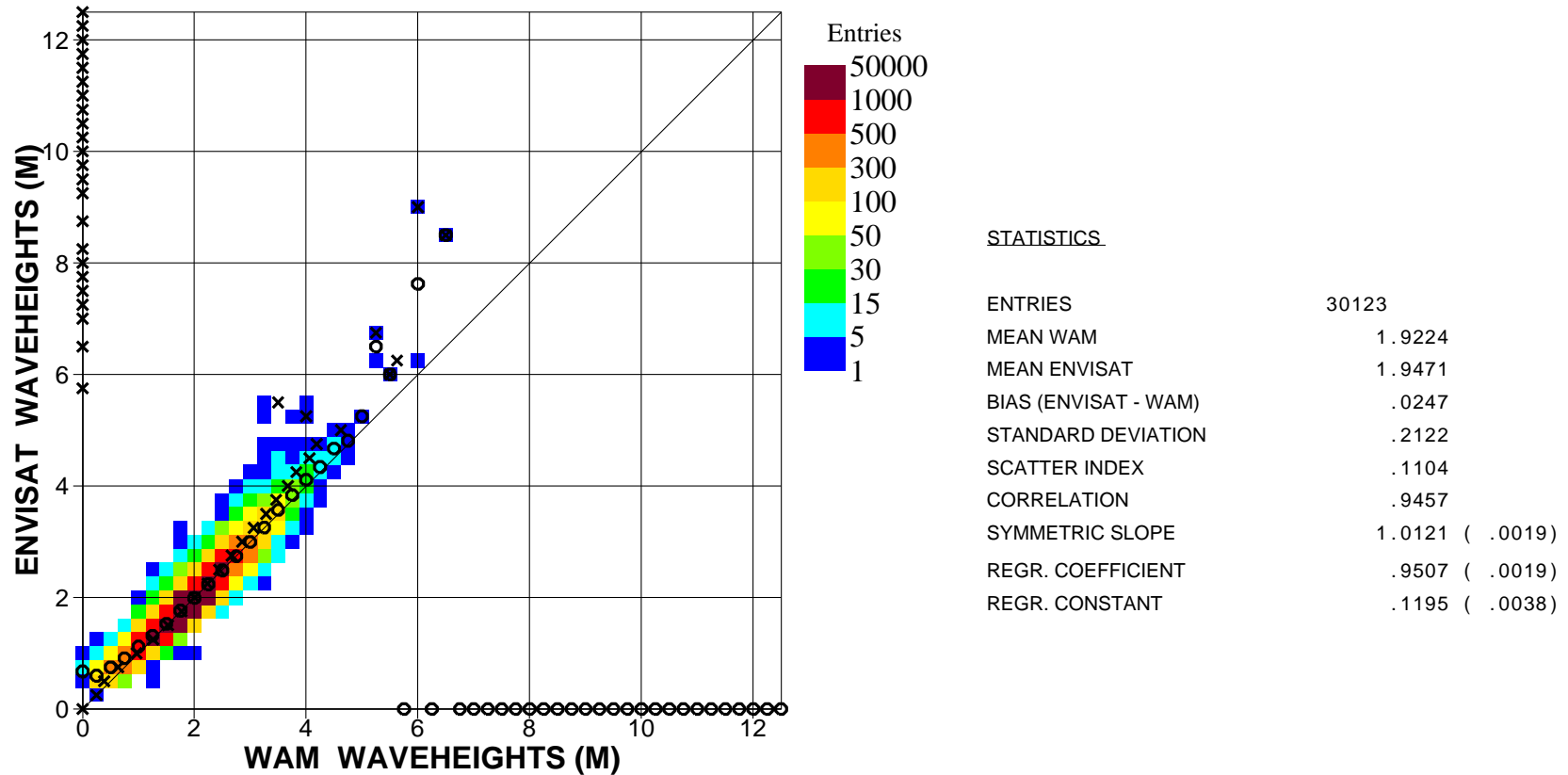


Figure 24. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2004 (Tropics)

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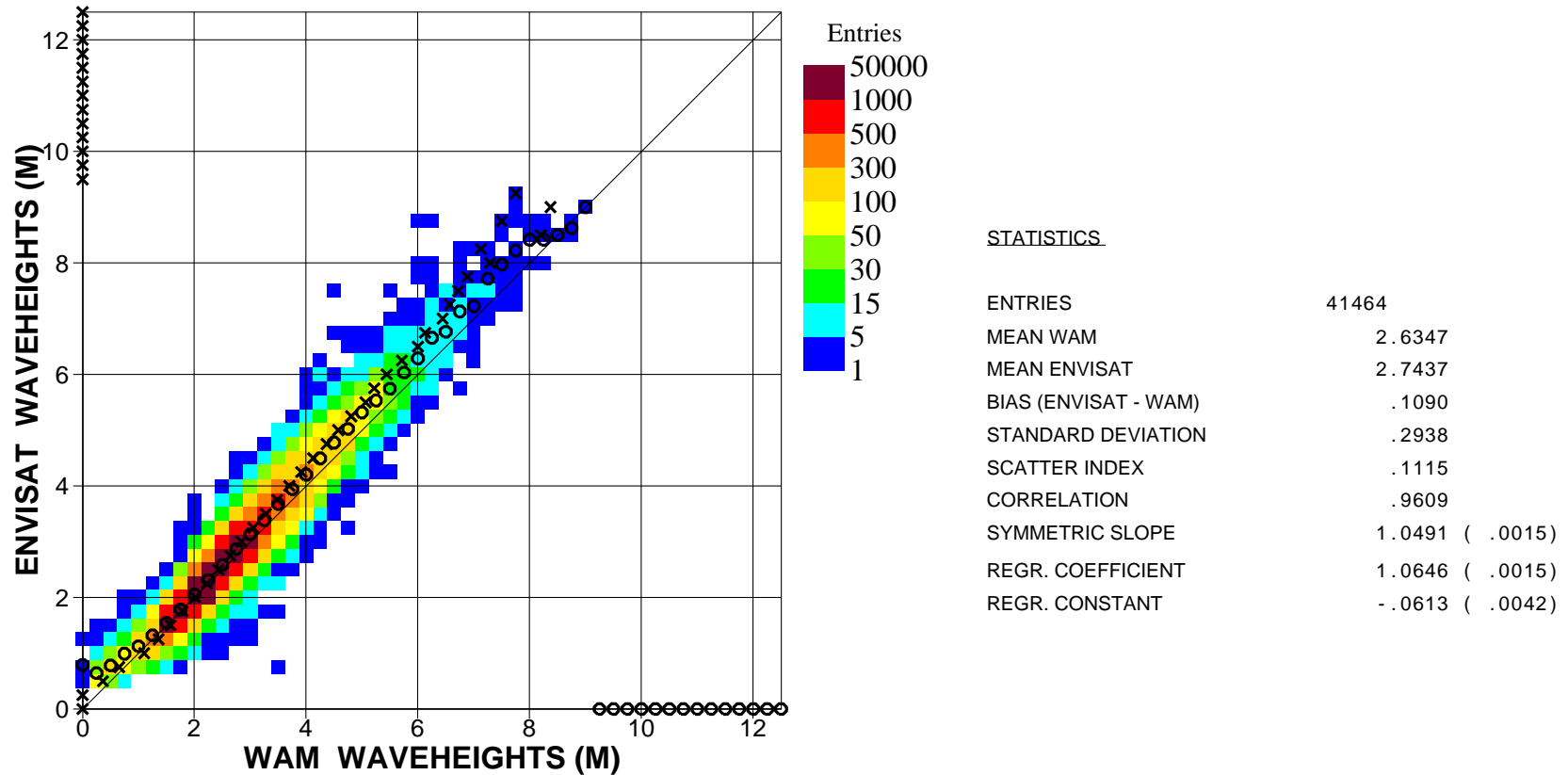


Figure 25. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for December 2004 (S.Hem.)

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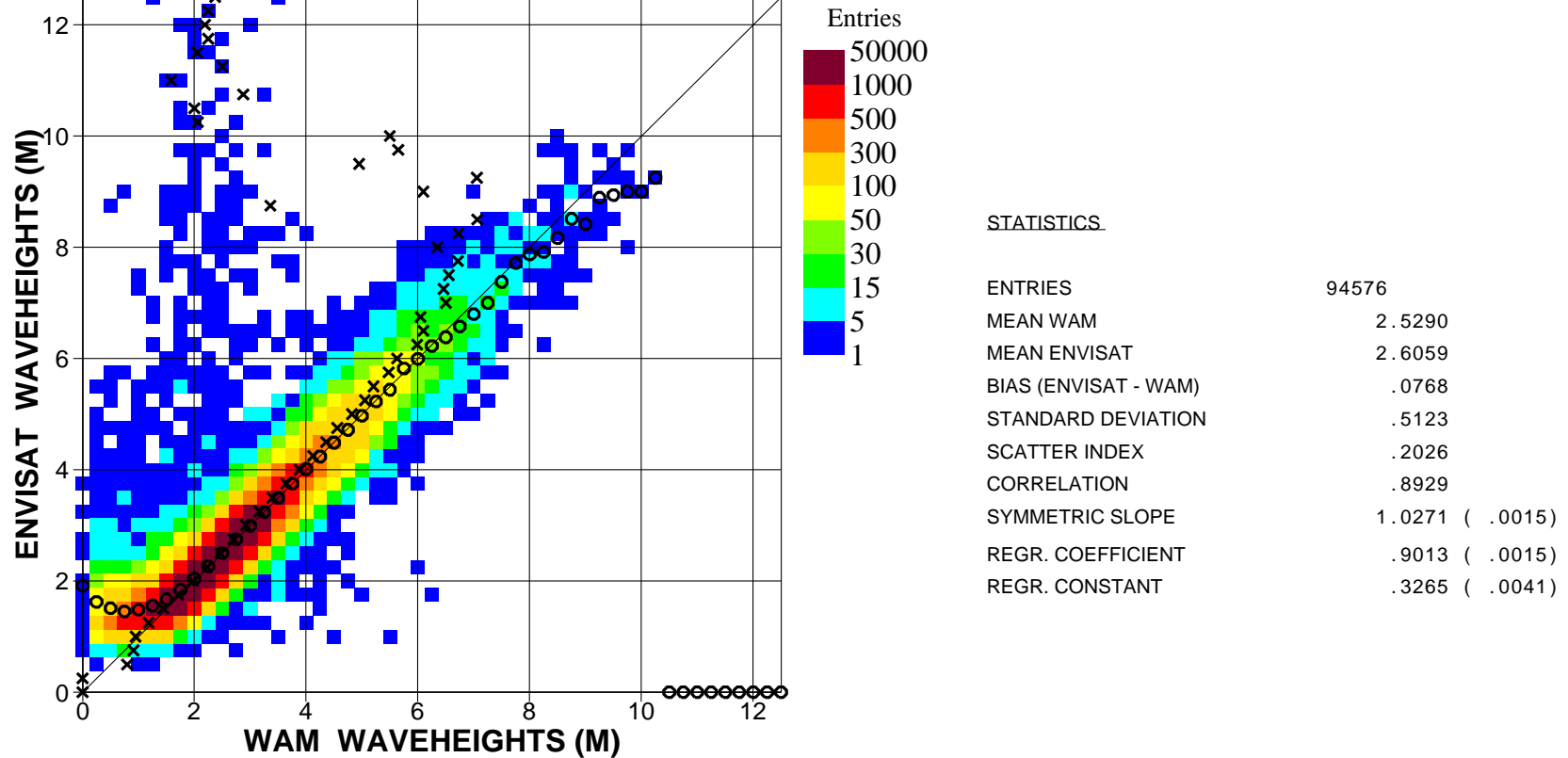


Figure 26. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2004 (Global)

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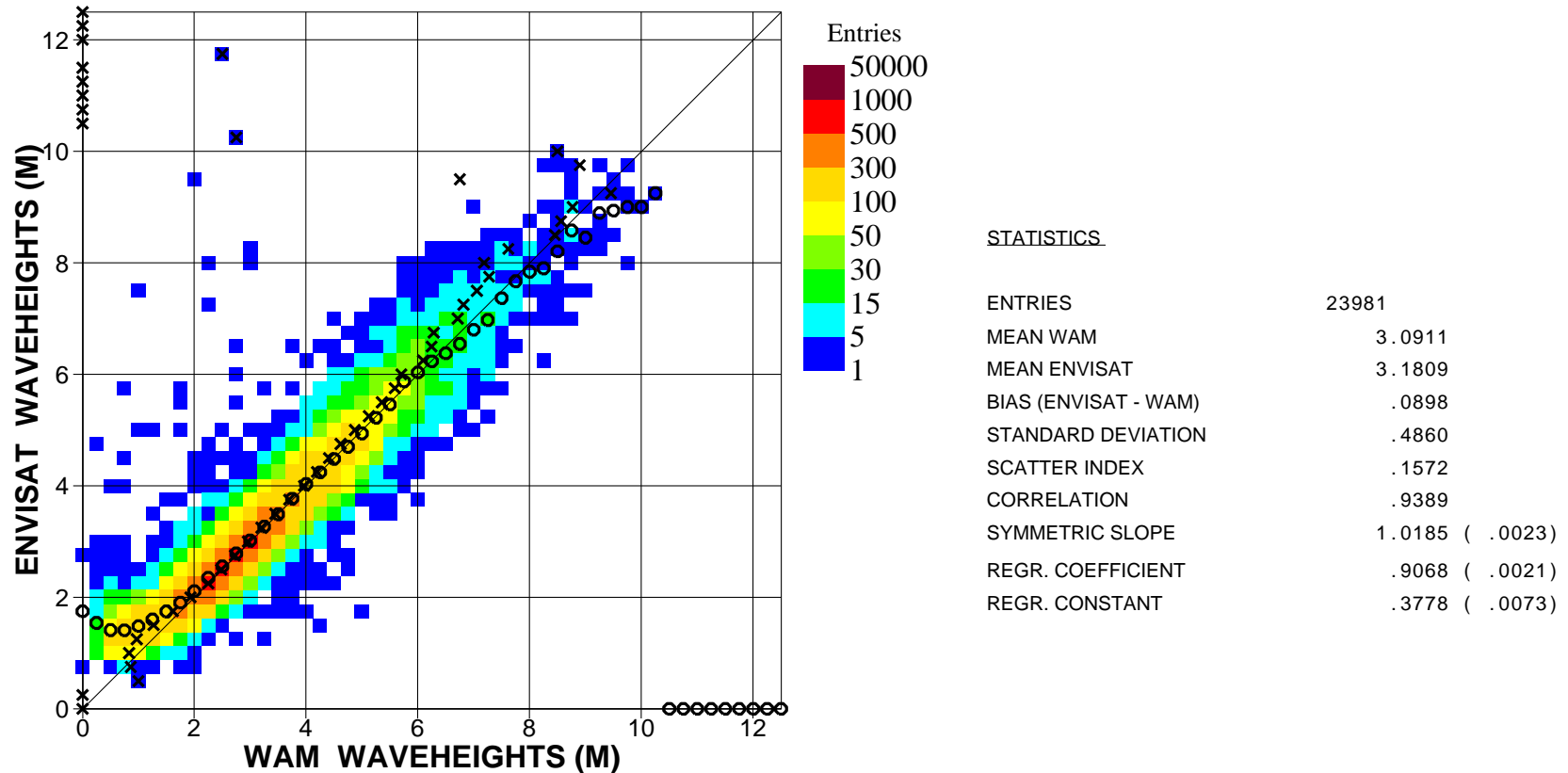


Figure 27. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2004 (N.Hem.)

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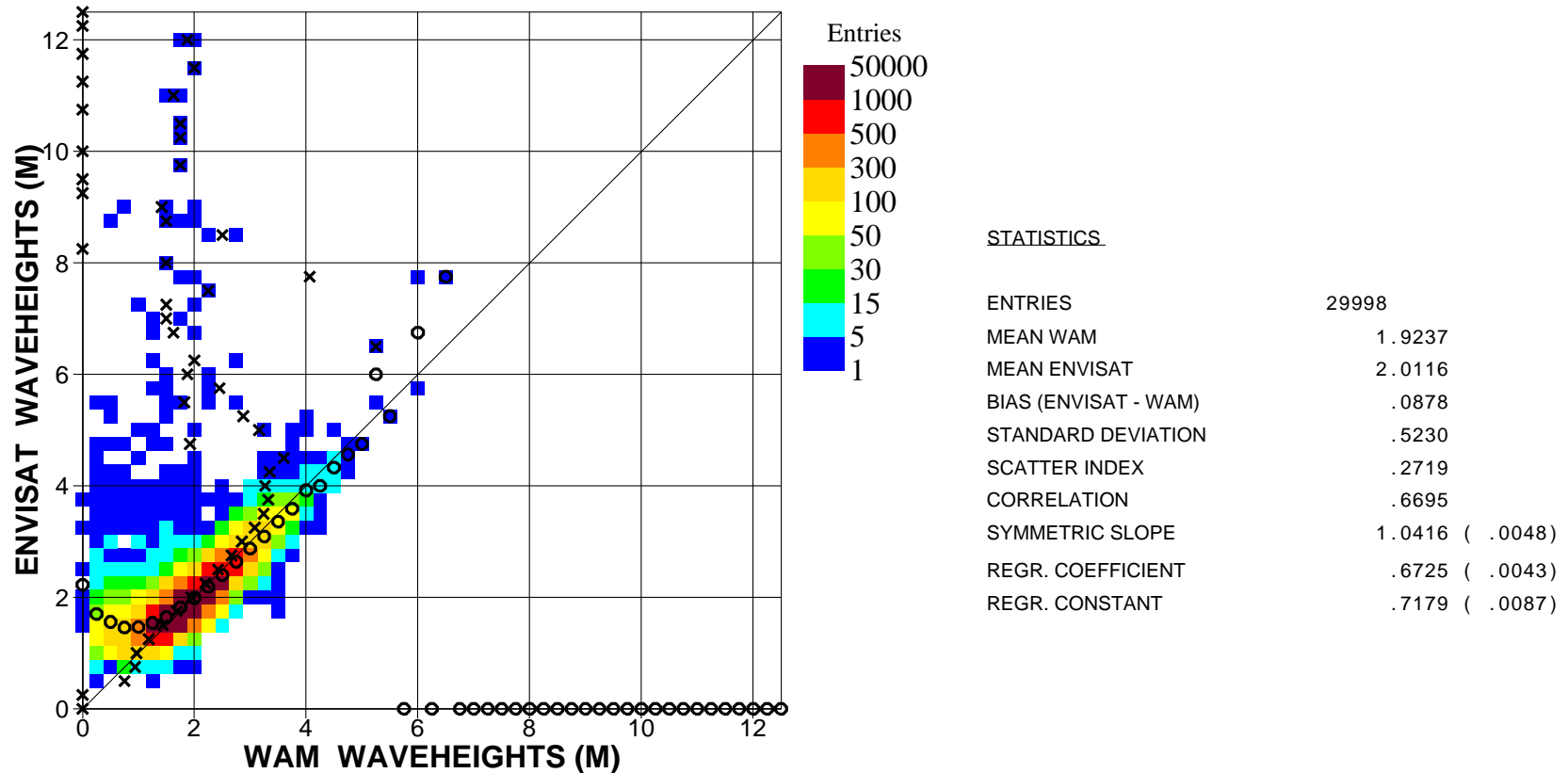


Figure 28. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2004 (Tropics)

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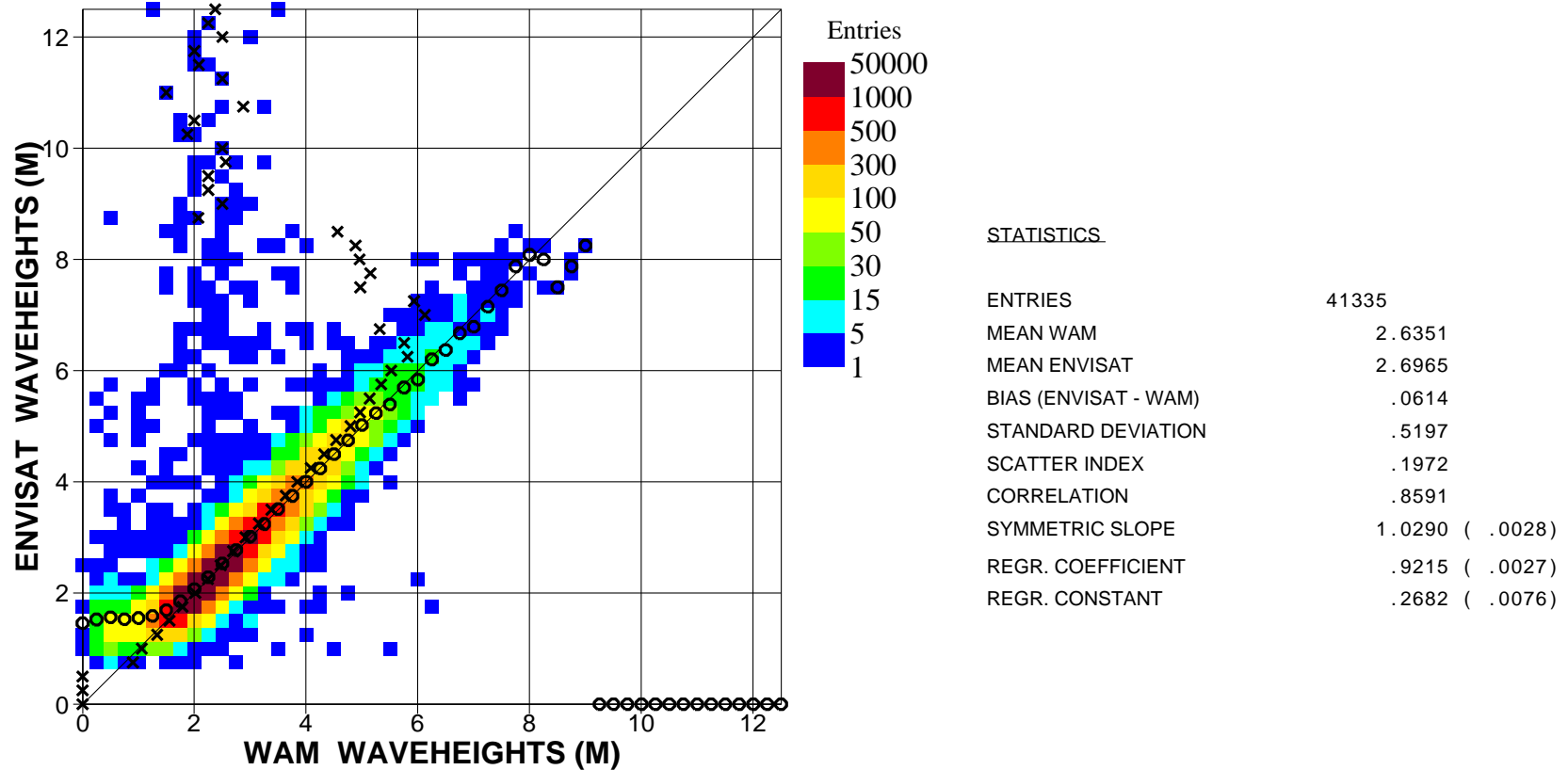


Figure 29. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for December 2004 (S.Hem.)

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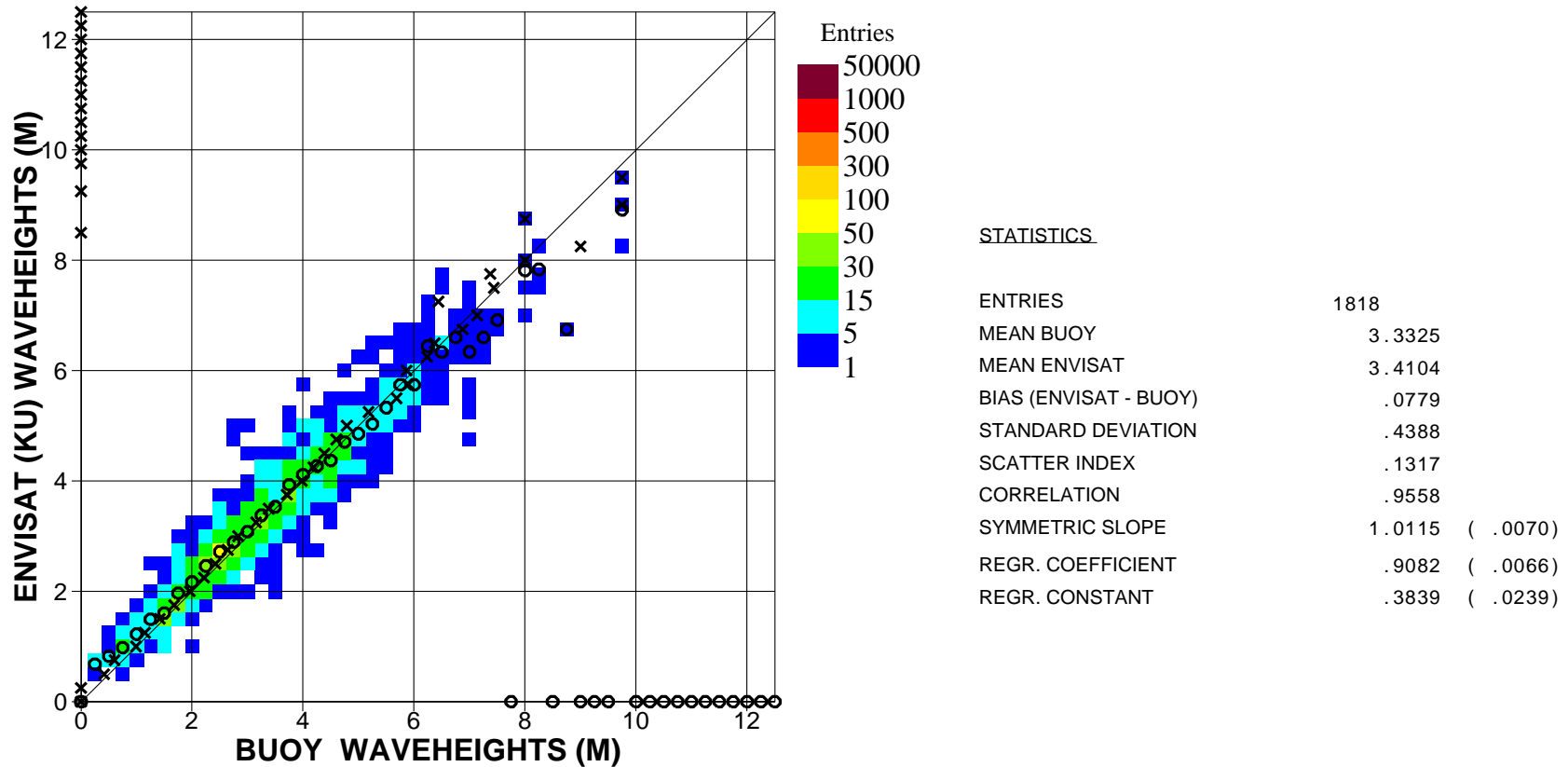


Figure 30. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for December 2004 (Global)

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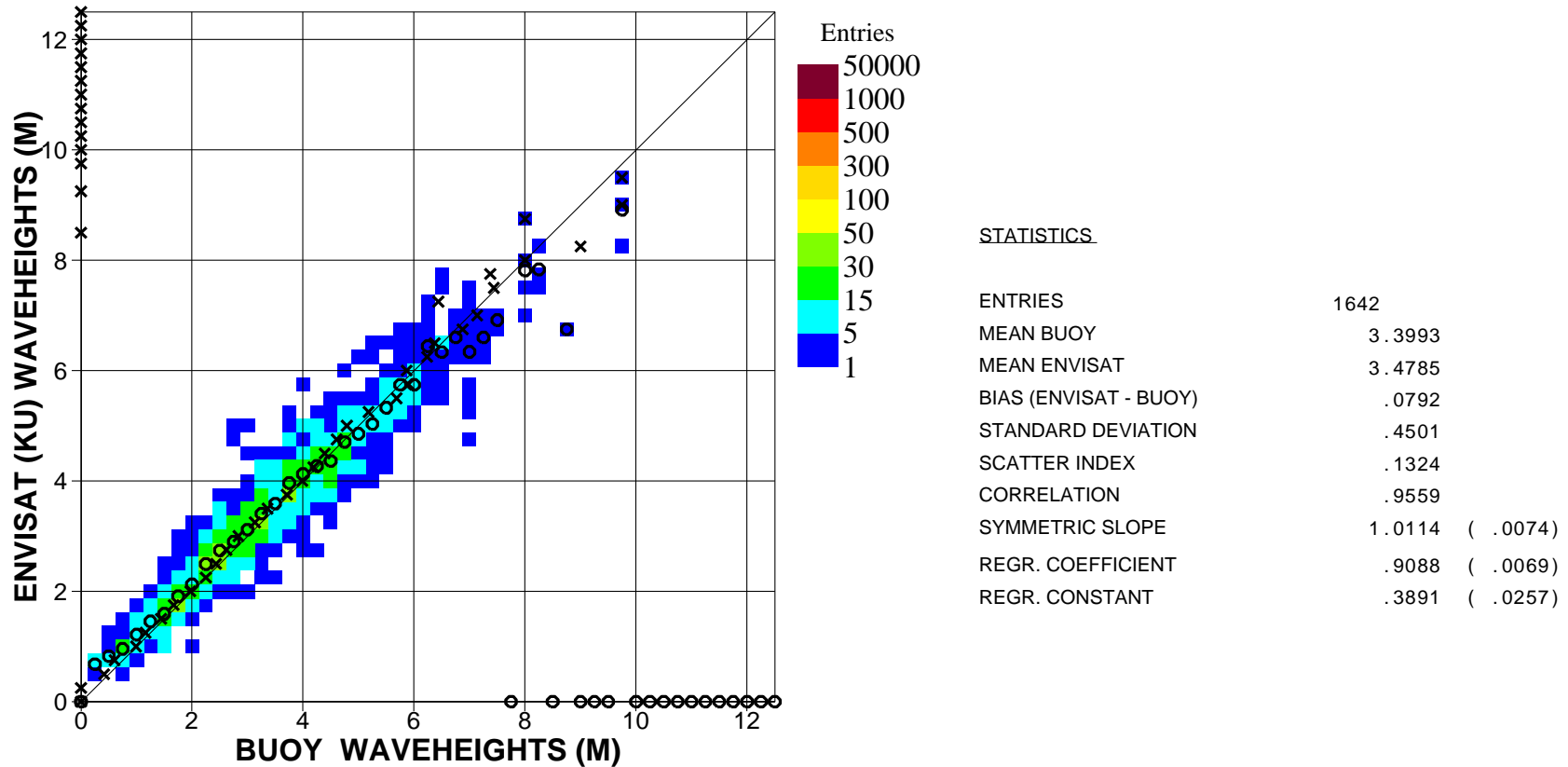


Figure 31. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for December 2004 (N.Hem.)

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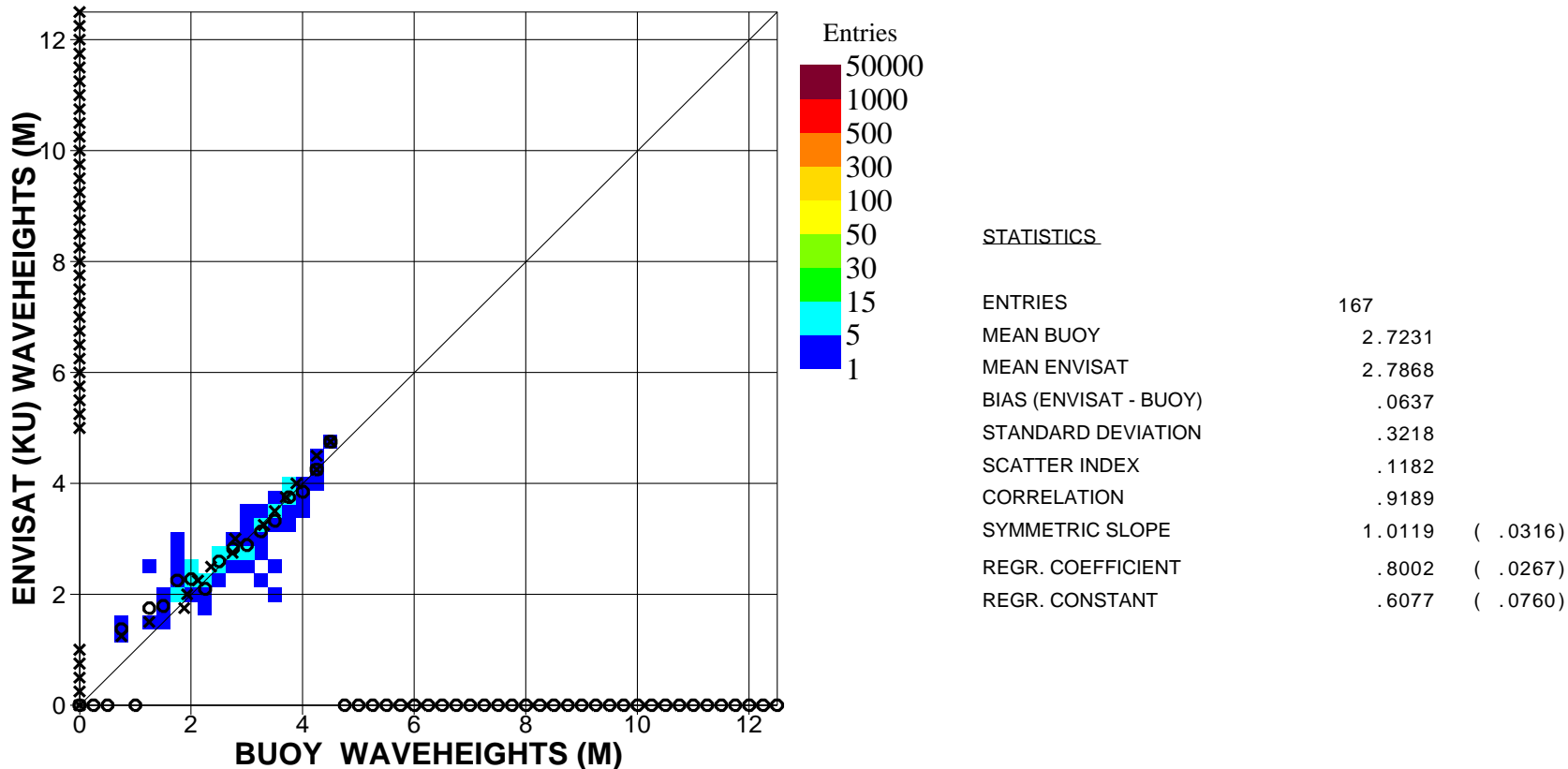


Figure 32. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for December 2004 (Tropics)

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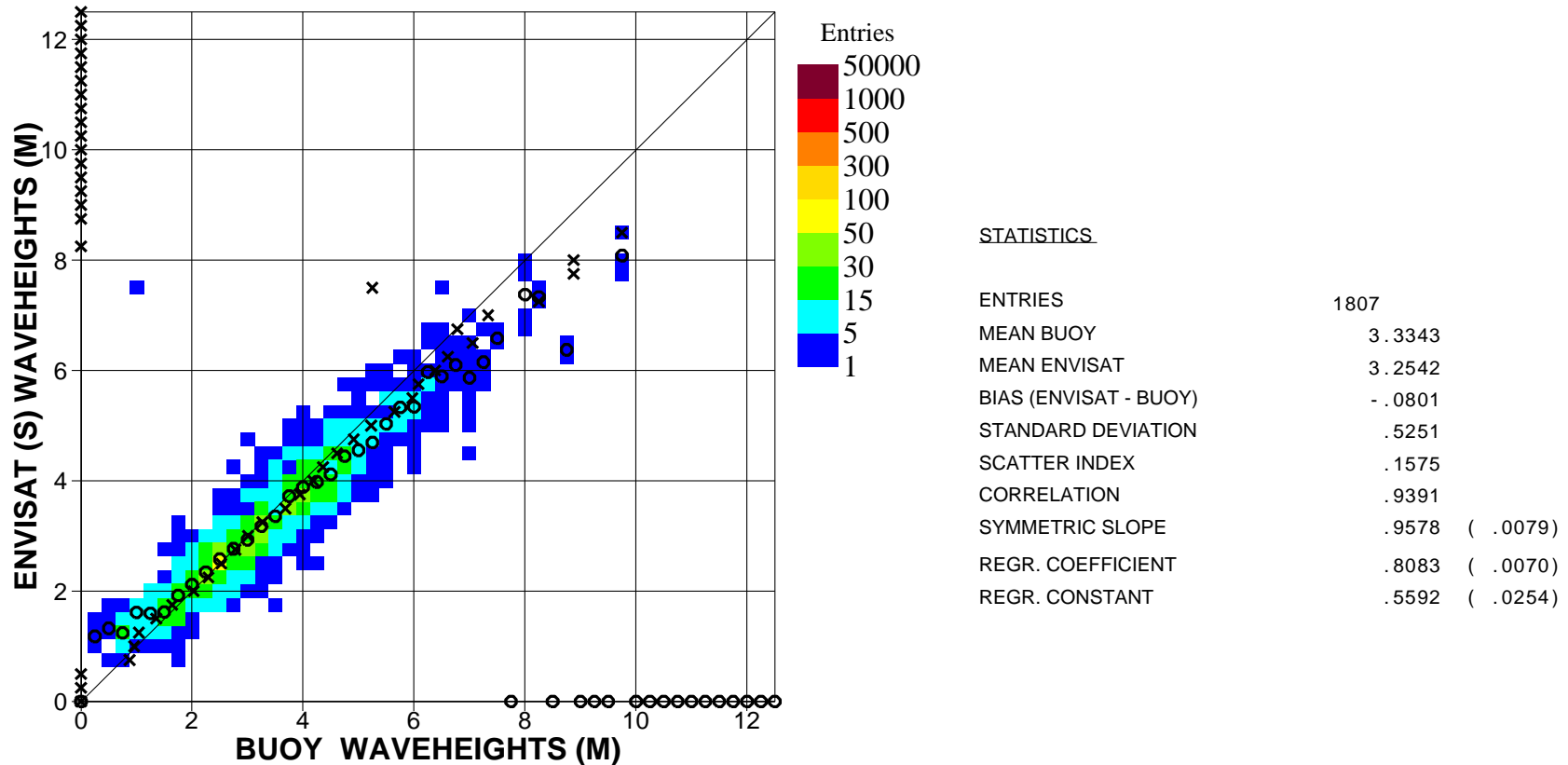


Figure 33. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for December 2004 (Global)

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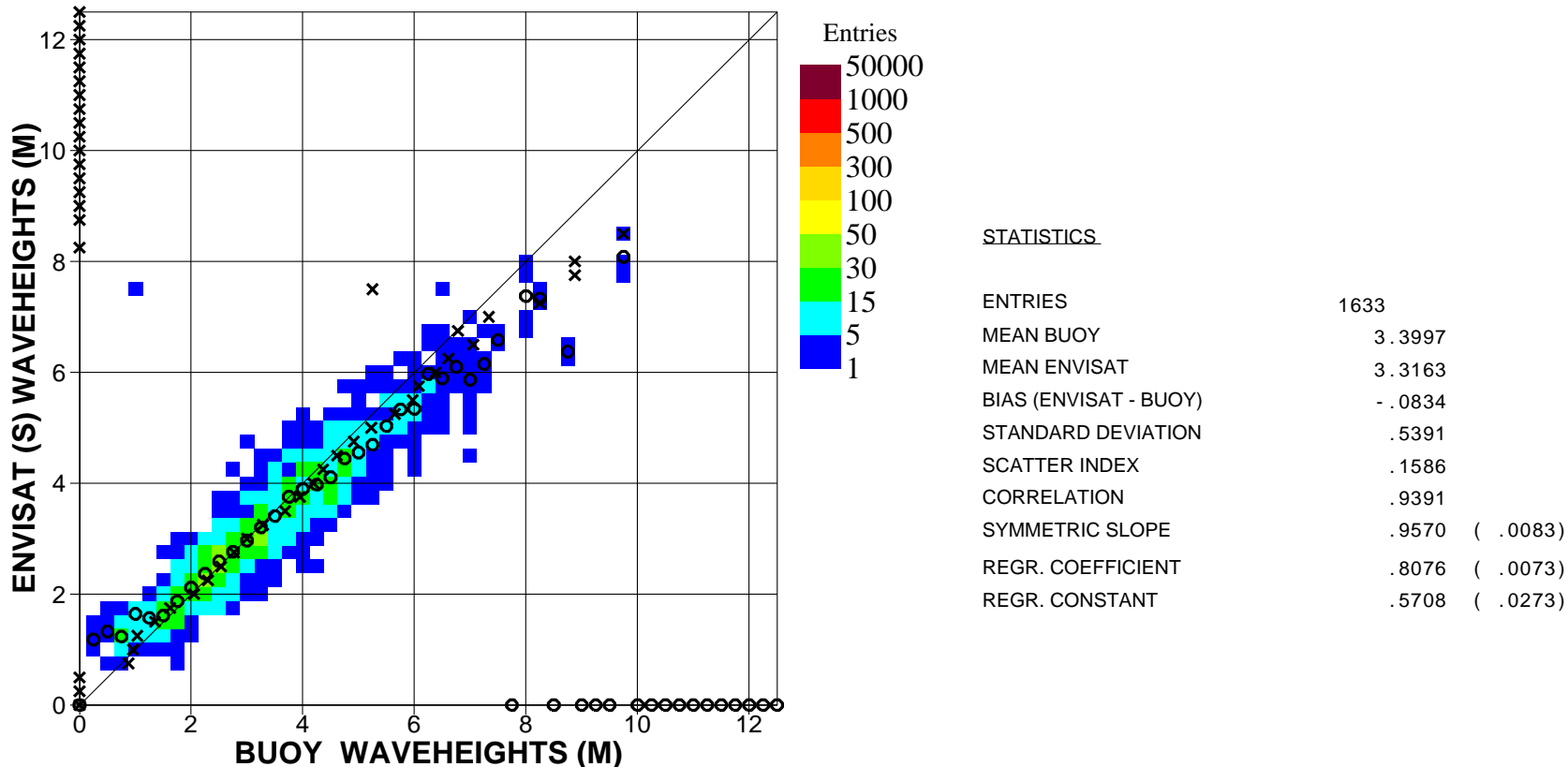


Figure 34. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for December 2004 (N.Hem.)

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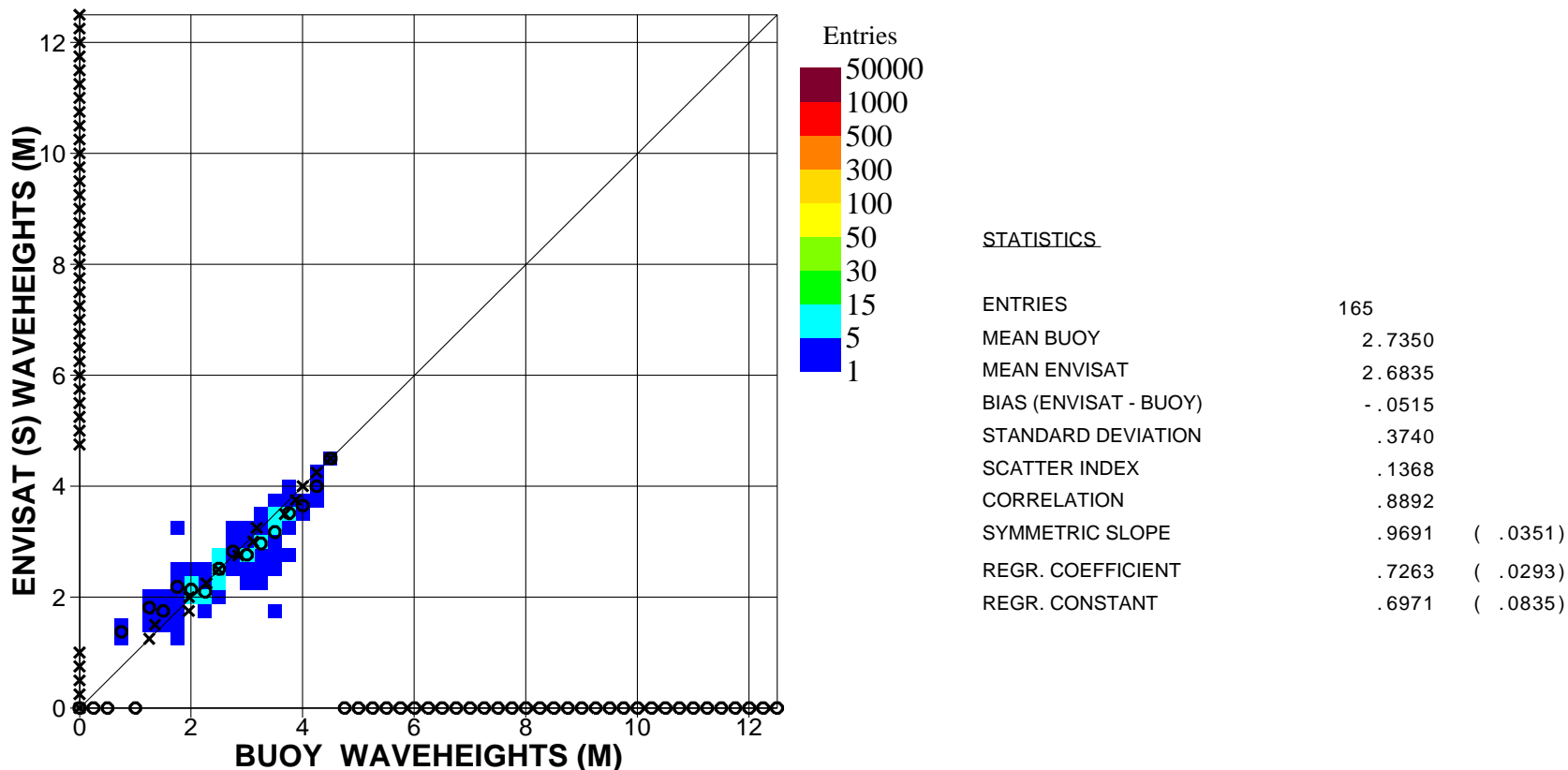


Figure 35. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for December 2004 (Tropics)

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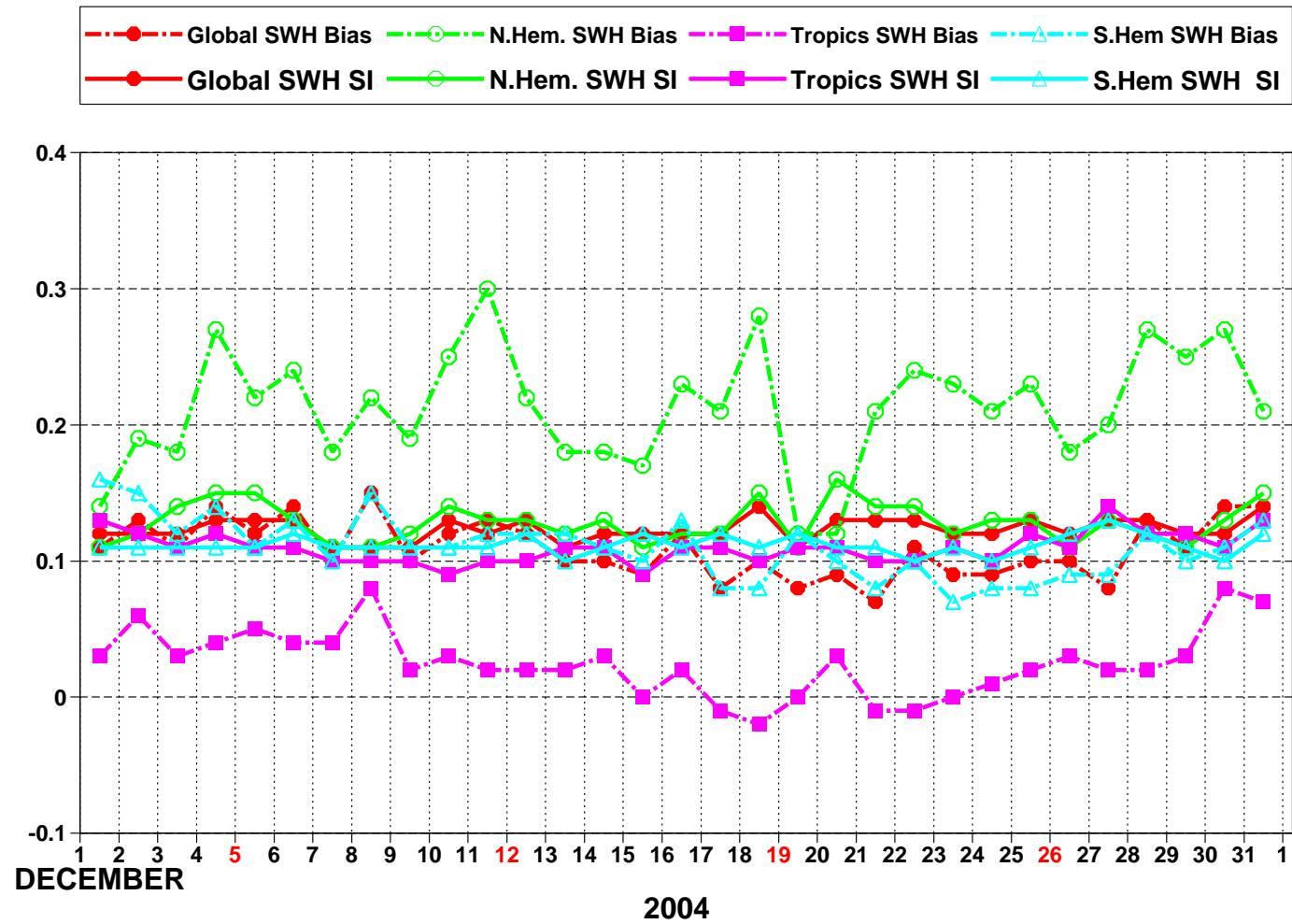


Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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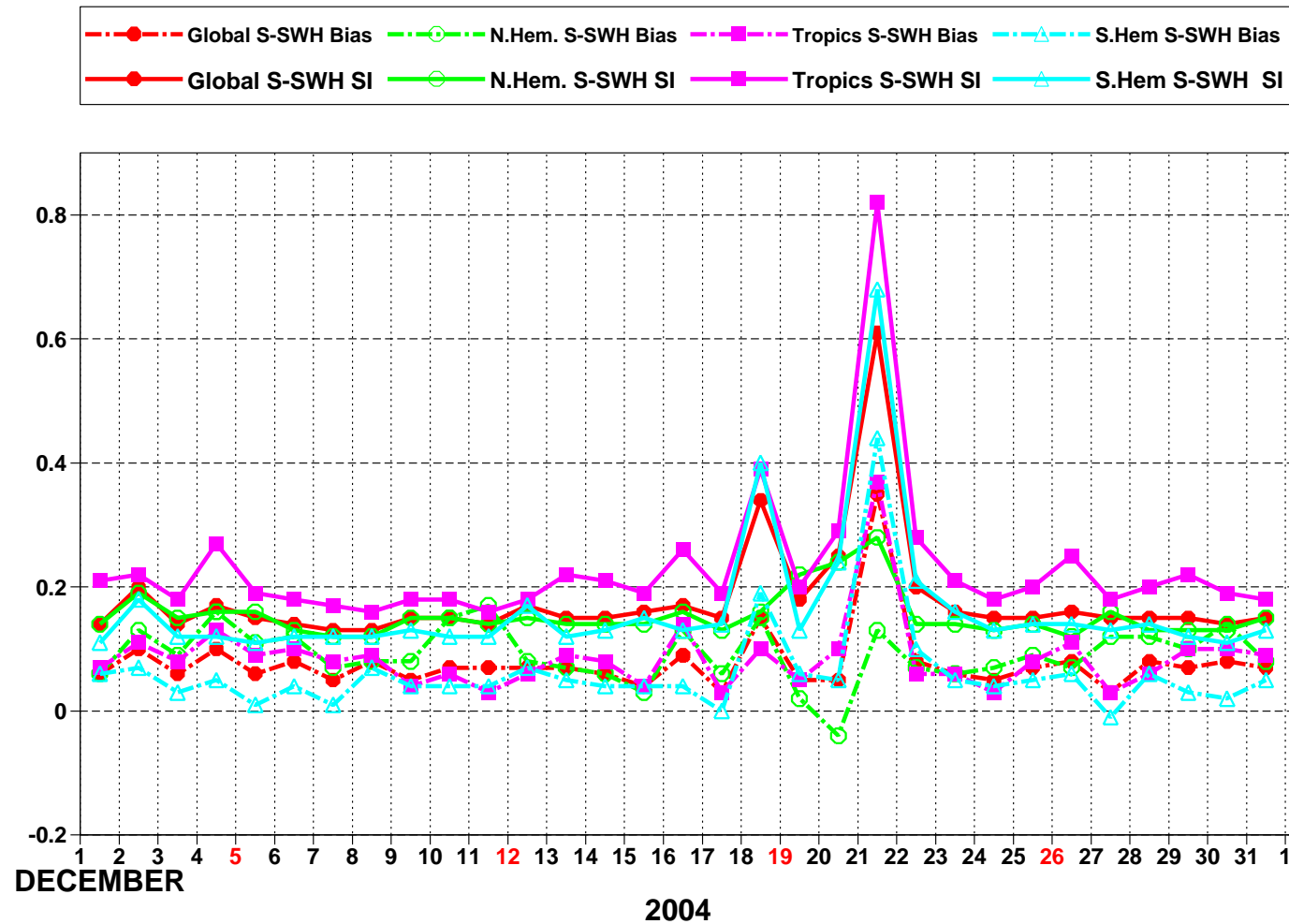


Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)



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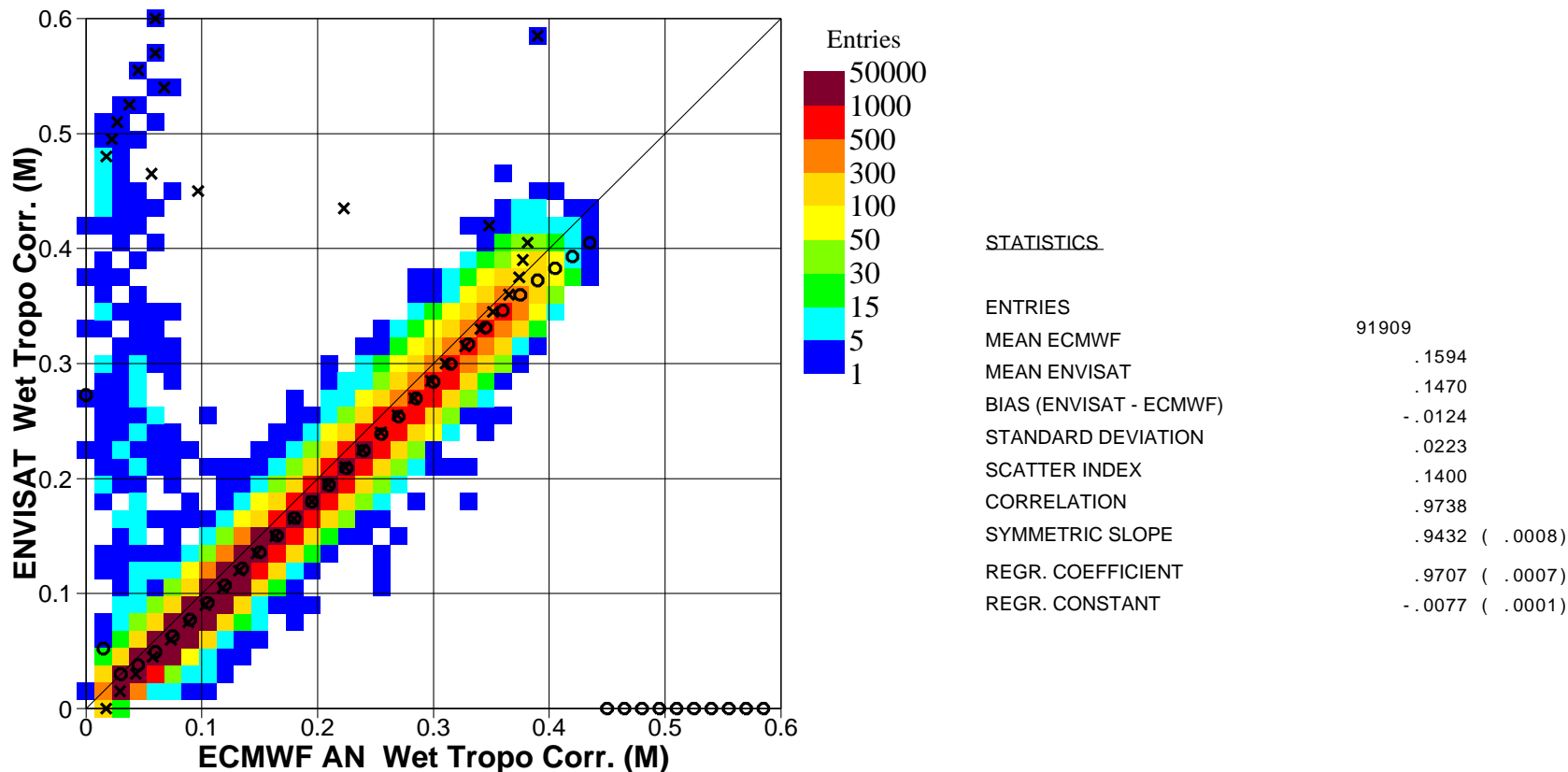


Figure 38. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2004 (Global)

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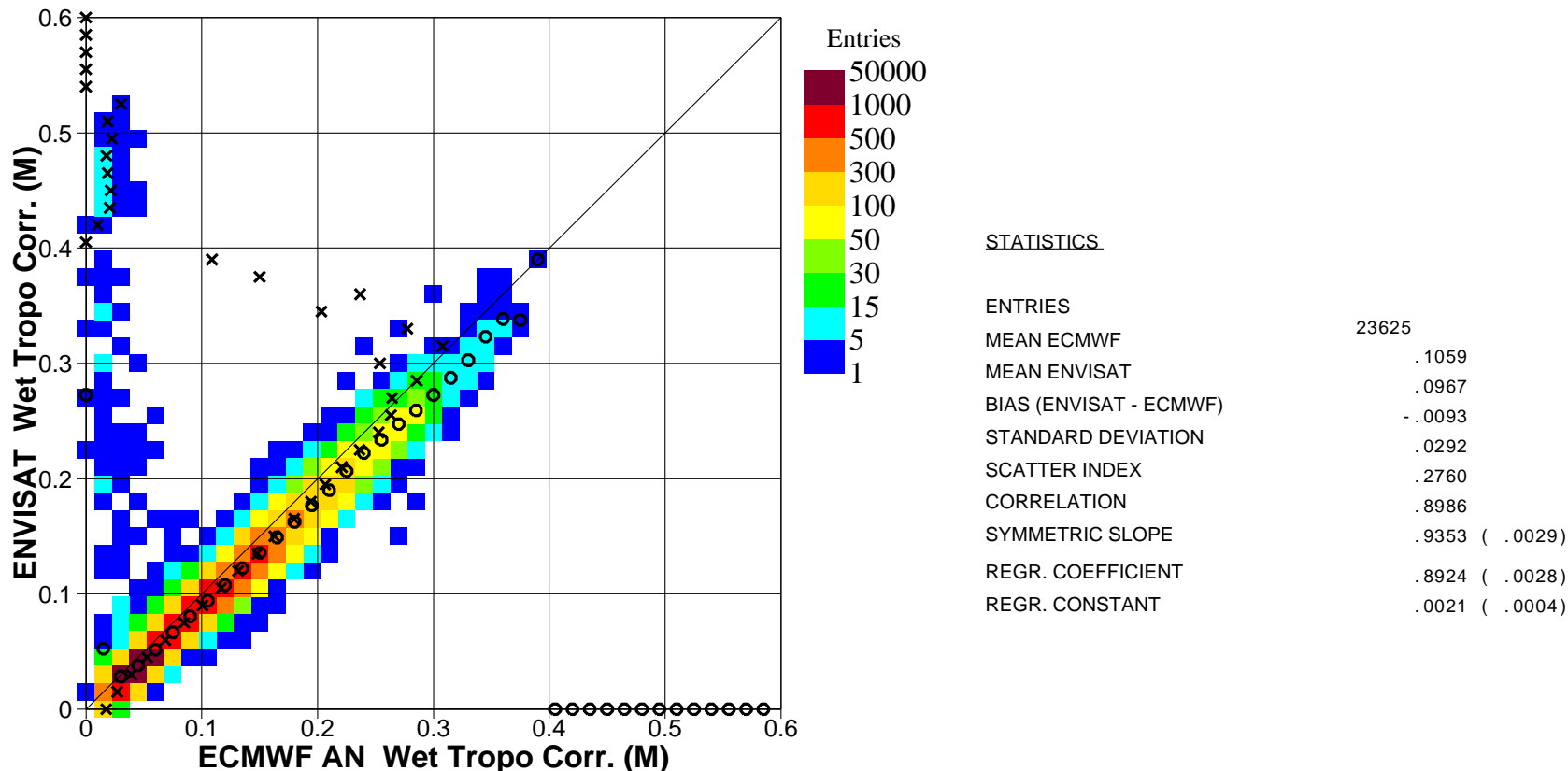
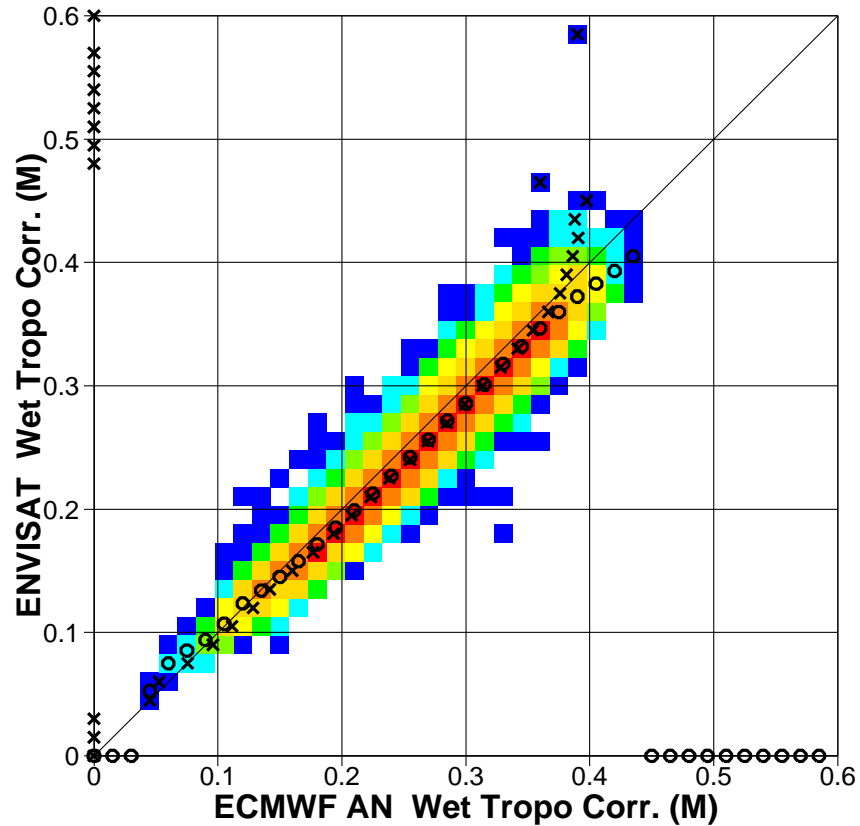


Figure 39. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2004 (N.Hem.)

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STATISTICS

ENTRIES	28936
MEAN ECMWF	.2635
MEAN ENVISAT	.2519
BIAS (ENVISAT - ECMWF)	-.0115
STANDARD DEVIATION	.0176
SCATTER INDEX	.0669
CORRELATION	.9712
SYMMETRIC SLOPE	.9584 (.0014)
REGR. COEFFICIENT	.9567 (.0014)
REGR. CONSTANT	-.0001 (.0004)

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

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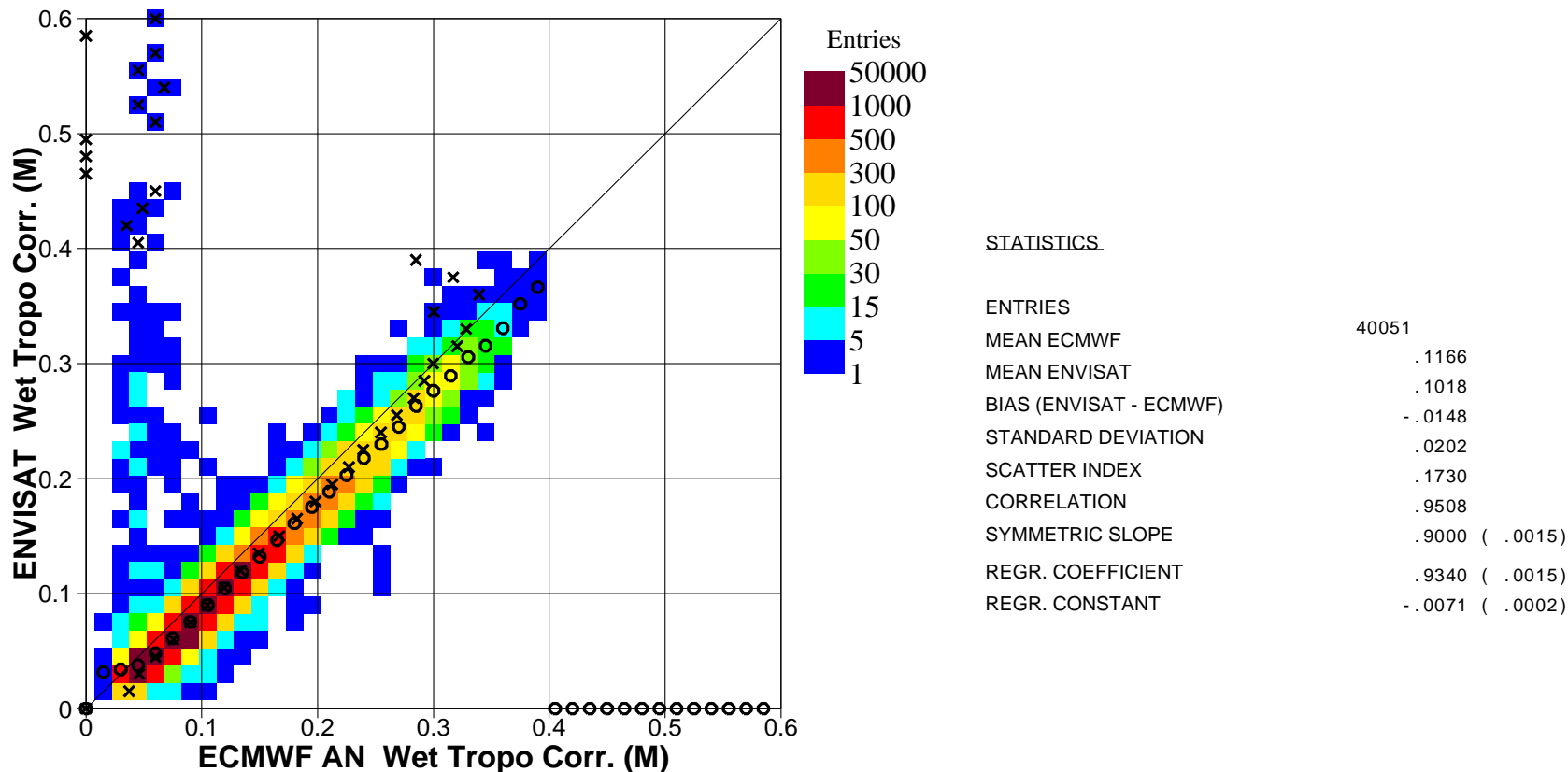


Figure 41. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for December 2004 (S.Hem.)

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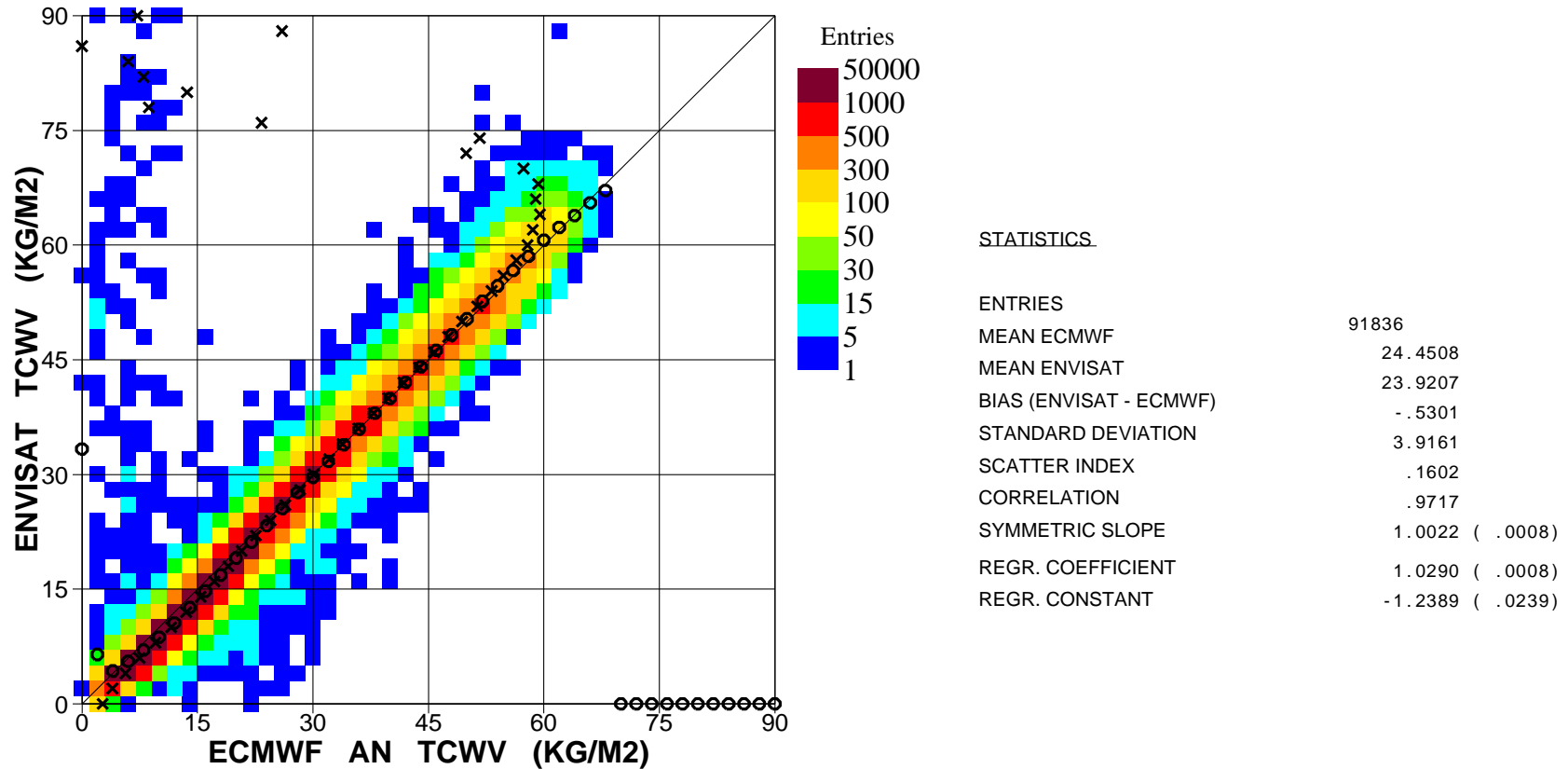


Figure 42. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for December 2004 (Global)

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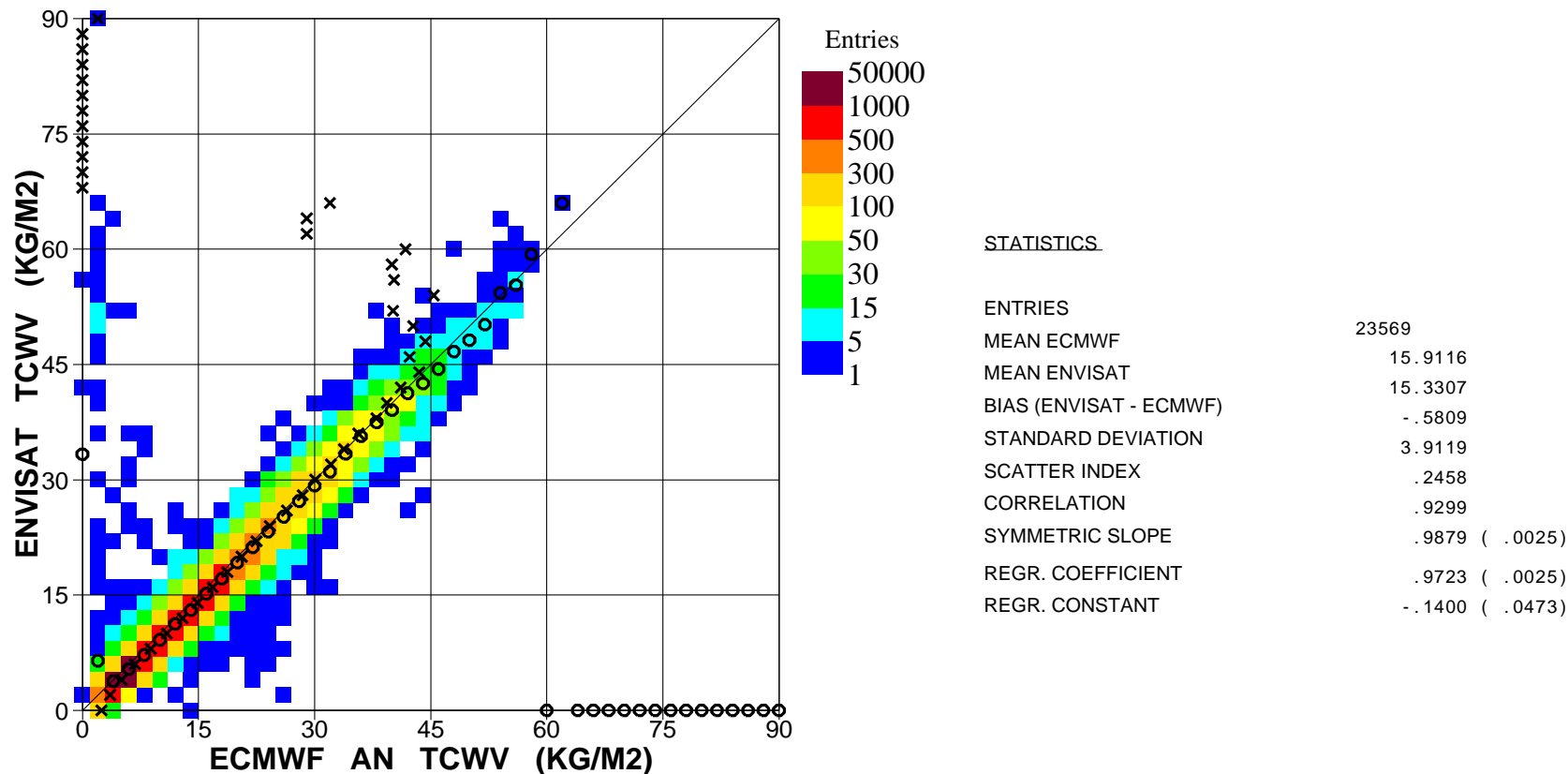
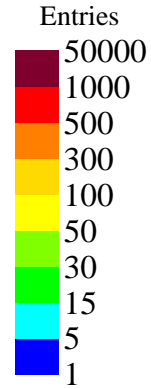
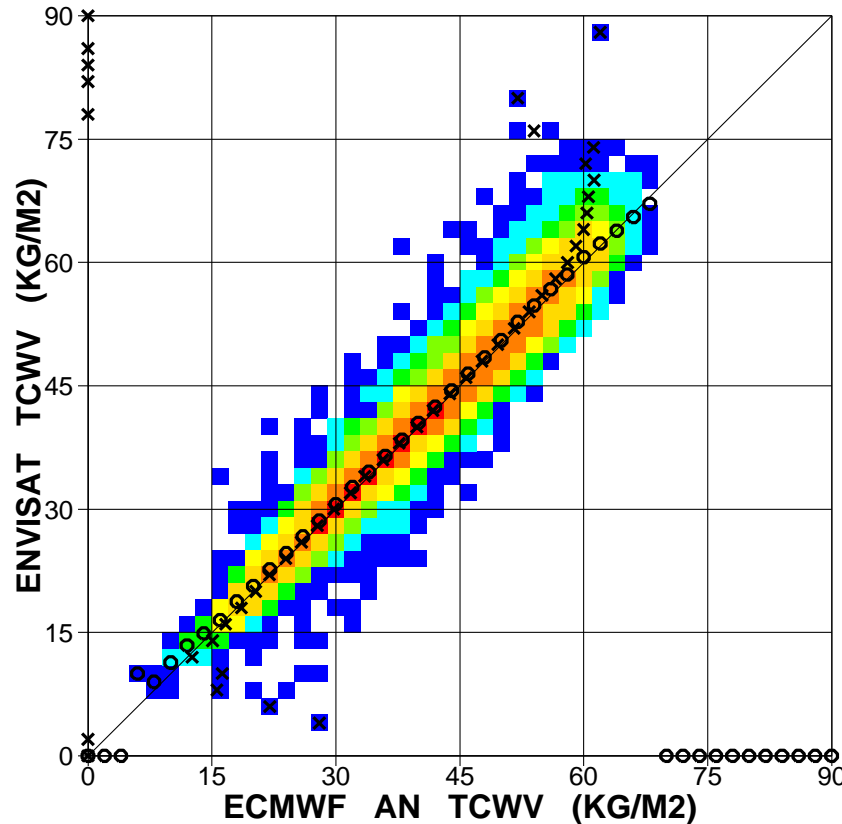


Figure 43. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for December 2004 (N.Hem.)

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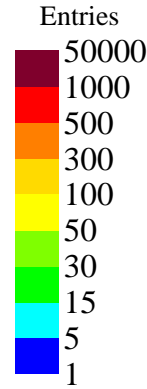
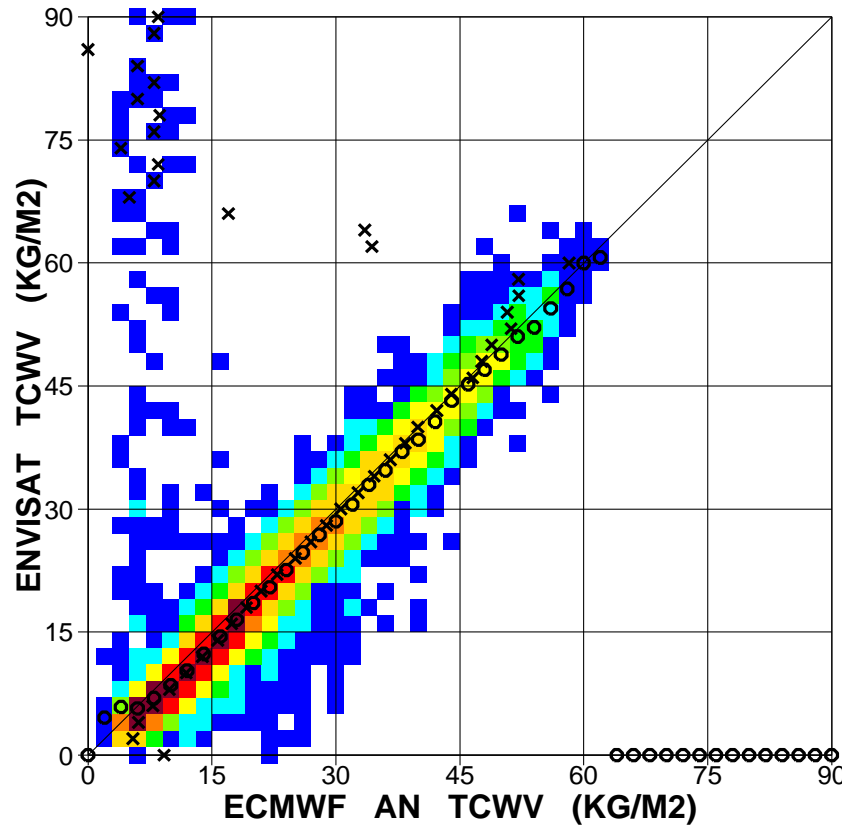
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MEAN ECMWF	41.0907
MEAN ENVISAT	41.6566
BIAS (ENVISAT - ECMWF)	.5659
STANDARD DEVIATION	2.7504
SCATTER INDEX	.0669
CORRELATION	.9744
SYMMETRIC SLOPE	1.0148 (.0014)
REGR. COEFFICIENT	1.0010 (.0014)
REGR. CONSTANT	.5261 (.0581)

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

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STATISTICS

ENTRIES	40034
MEAN ECMWF	17.5827
MEAN ENVISAT	16.3030
BIAS (ENVISAT - ECMWF)	-1.2797
STANDARD DEVIATION	4.4022
SCATTER INDEX	.2504
CORRELATION	.9169
SYMMETRIC SLOPE	.9682 (.0022)
REGR. COEFFICIENT	.9910 (.0022)
REGR. CONSTANT	-1.1219 (.0438)

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

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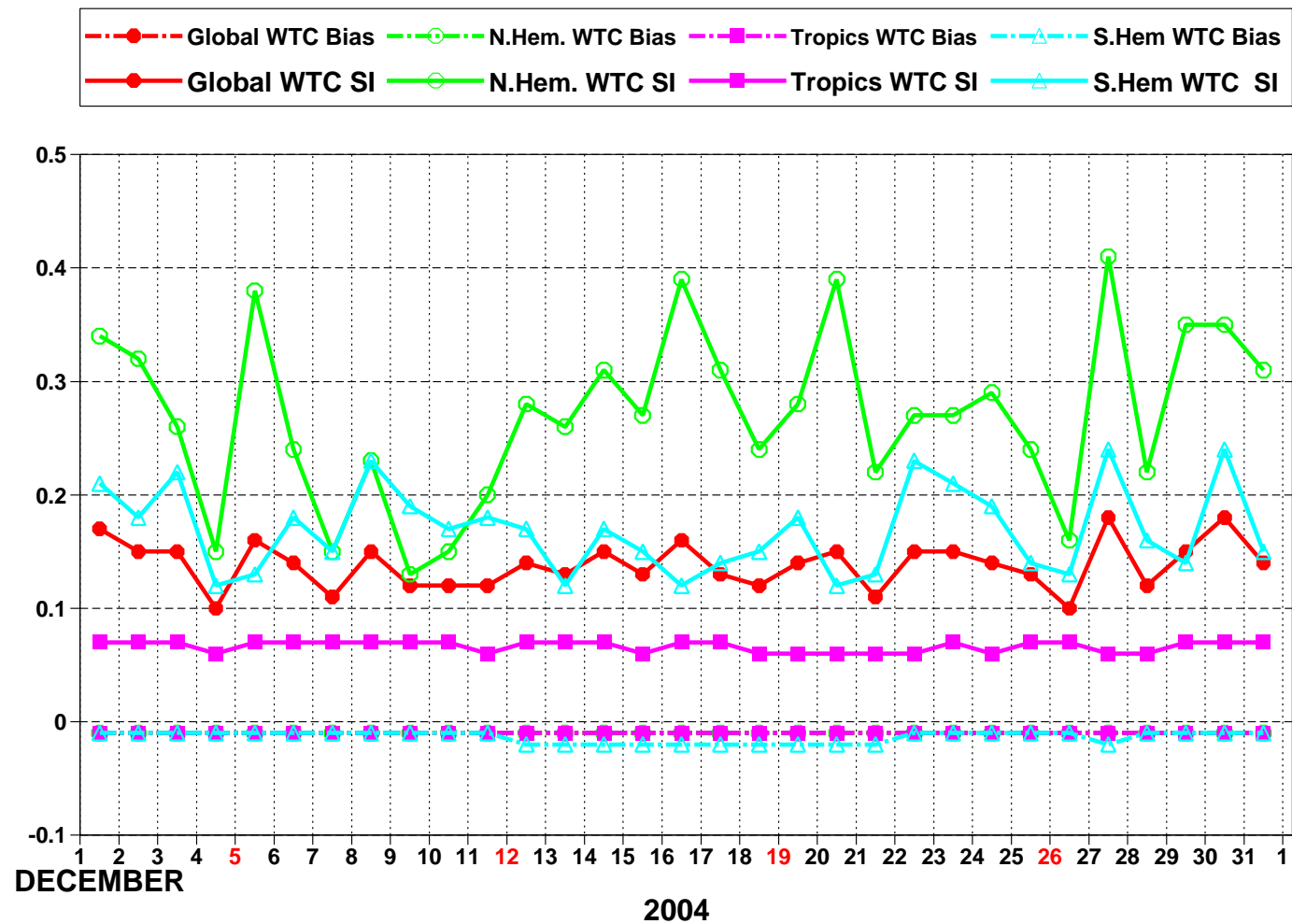


Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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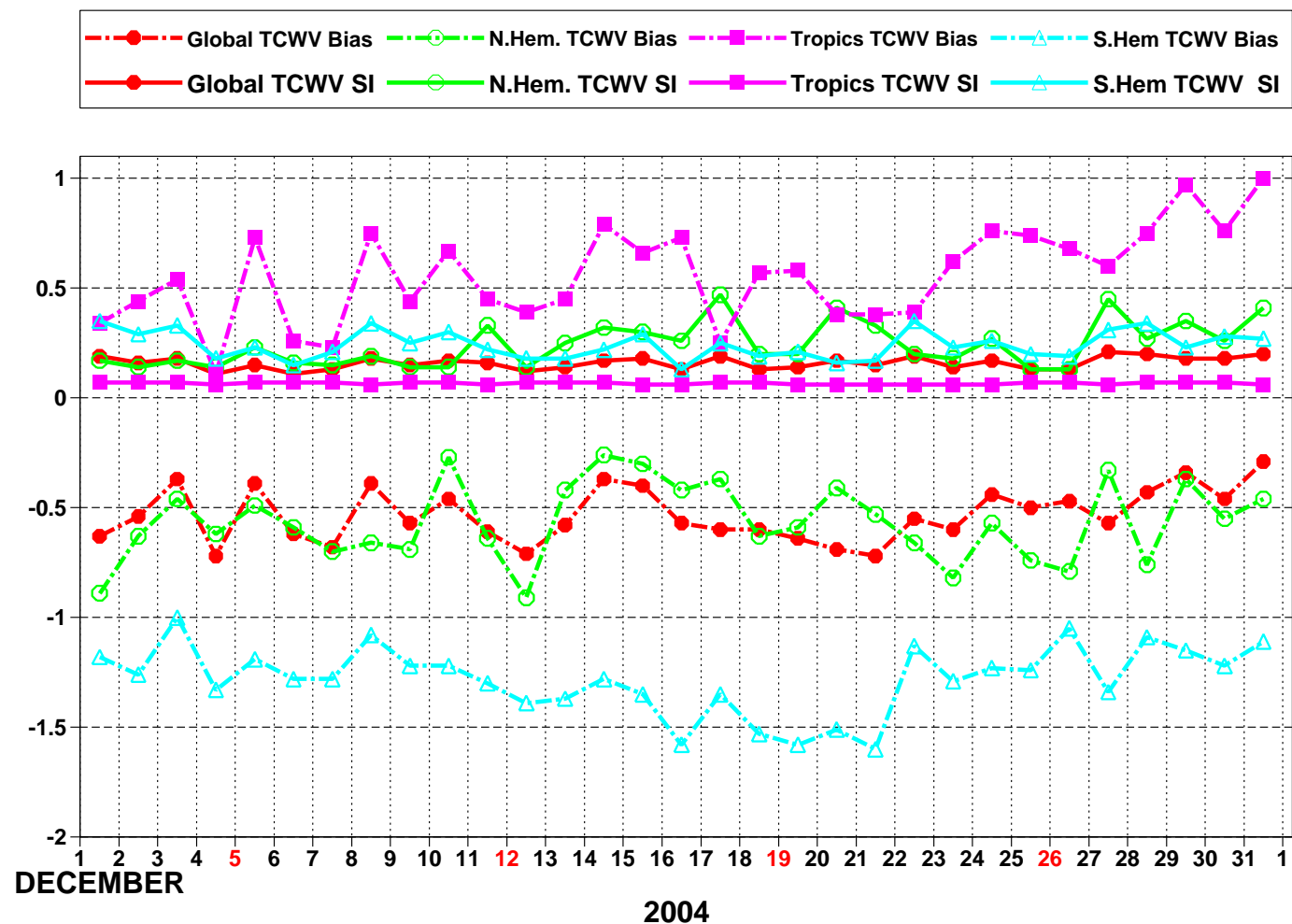


Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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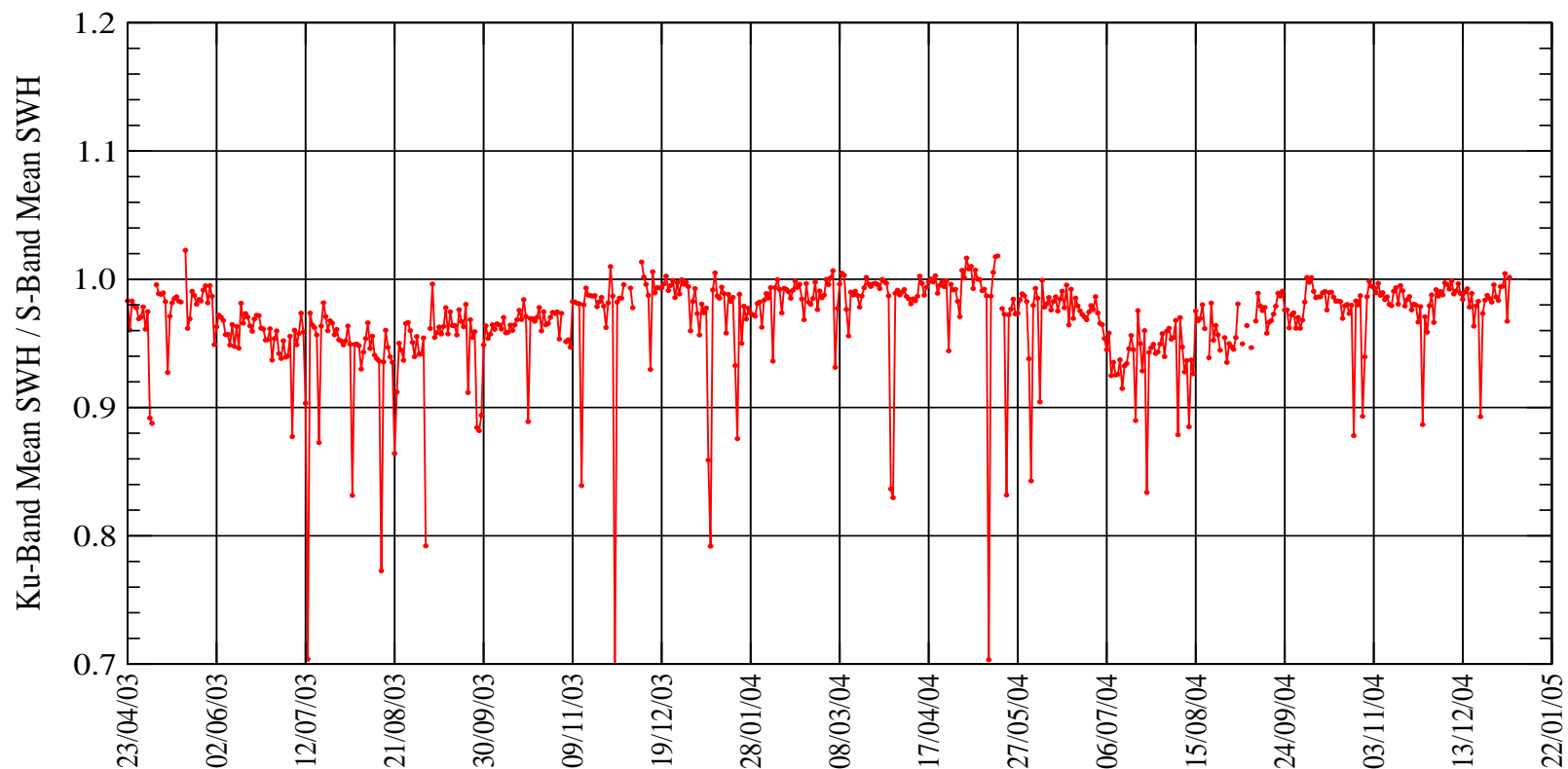


Figure 48. Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 23rd. of April 2003.



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