

# ■ ECMWF Report on ENVISAT RA-2 for April 2003 ■

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

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

**By:** *Saleh Abdalla*

**Date:** *8 May 2003*

#### Overview:

Based on the data received during this month, on average, 9465 (varies between 0 and 22480) observations arrived at ECMWF every 6-hour window of which an average of 3810 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 78.34% 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):

- Data either missing or significantly reduced at midnight everyday.
- From 00:00 to 12:00 on the 9th. of the month.
- At 12:00 on the 15th. of the month.
- From 18:00 on the 24th. to 06:00 on the 25th. of the month.

The time series of the data coverage and some reasons of rejection can be seen in Figure 1. Note that we are talking about the raw data which we downloaded and converted to “bufr” format before they were processed.



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## Quality of Received Data:

For the period covered, the RA-2 Ku-band wave height data are generally of good quality. The quality of S-band wave height observations has been improved considerably this month. The S-band wave heights which were comparable with Ku-band waves after the 7th. of the month started to increase again (see the Remarks Section below). The wind speed observations have been improved since the 7th. of April. Apart from the few outliers, MWR products are generally fine with better agreement with the model (they still somewhat drier than the model). According to the land sea mask we are using, more than one third of processed observations have been collected over land.

## Backscatter:

- ENVISAT RA-2 Ku-Band  $\langle\sigma_0\rangle = 10.54$  dB (with a single rather broad peak at  $\sim 10.8$  dB).
- ENVISAT RA-2 S-Band  $\langle\sigma_0\rangle = 10.21$  dB (with a single rather broad peak at  $\sim 10.8$  dB).

## Comparison Summary:

Table 1: Comparison of Surface Wind Speeds:

	RA2 - ECMWF		RA2 - Buoy	
	Bias (m/s)	SI (%)	Bias (m/s)	SI (%)
Global	1.68	47.0	1.69	52.6
Northern Hemisphere	1.44	47.8	1.78	55.9
Tropics	1.37	59.6	1.65	39.7
Southern Hemisphere	2.01	40.6	----	----

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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	0.16	12.3	0.12	15.0
Northern Hemisphere	0.20	14.0	0.13	15.8
Tropics	0.04	11.5	0.07	7.6
Southern Hemisphere	0.21	10.9	----	----

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

	RA2 (S) - WAM		RA2 (S) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.20	19.2	0.18	19.7
Northern Hemisphere	0.30	26.4	0.19	20.6
Tropics	0.19	27.1	0.09	12.5
Southern Hemisphere	0.15	13.1	----	----



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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 <sup>2</sup> )	SI (%)
Global	-0.024	21.6	-1.70	22.3
Northern Hemisphere	-0.024	41.8	-1.93	43.6
Tropics	-0.017	10.2	-0.10	9.8
Southern Hemisphere	-0.030	27.2	-2.74	28.8

## Remarks:

- For the period covered, the RA-2 Ku-band wave height data are generally of good quality. Since the 9th. of April, S-band wave height and wind speed data are of good quality. Although, the MWR derived quantities have shown significant improvement, a number of outliers when compared against the model still exists.
- According to the used land sea mask (which is used for the operational WAM run at ECMWF), more than one third (34% to be exact) of all processed data have been collected over land. This value is too large compared to that of ERS-2 RA which is usually not more than 13% of the received data.
- Rain flag is only responsible for the rejection of 2% of the data this month.
- The wind speed data have shown significant improvement since the 7th. of April with further improvement on the 9th. of April. RA-2 wind speed data are now in good agreement with the wave model and buoy data except for very low wind speeds (below ~ 4 m/s).

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- **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 (above ~ 20 m/s) as can be concluded from the scatter plots in Figures 7-13 and from comparing the histograms in Figures 5 and 6.**
- Ku-band altimeter is able to see wave heights much smaller than the RA onboard ERS-2 (compare Figure 17 with Figure 19). Thus the concave tail seen in scatter plots of ERS-2 RA-WAM comparisons does not exist in the Ku-band versus WAM scatter plots (Figures 22-25).
- There is a trend for Ku-band wave heights to be slightly overestimated especially when compared to WAM results by about 6.5%. 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 as well as in Figures 30-32 (Ku-band - buoy comparison). It is worthwhile saying that the RA-2 Ku-band wave heights are higher than buoy wave heights by about 1.5%, while ERS-2 altimeter is lower by about 5.5% than the buoy observations.
- The S-band wave heights have been significantly improved since the 9th. of April as can be seen in Figure 37. Now, they are in good agreement with WAM and buoy data. However, there are still a small number of outliers when compared to the model (as can be seen in the scatter plots in Figures 26-29).
- **The S-band wave height values increased, thus the ratio between Ku-band and S-band wave heights decreased, over the period July 2002 to early April 2003 as can be seen in Figures 48-50. This behaviour was handled on the 9th of April bringing the wave heights from both sensors to a comparable level. However, this lasted for few days only. The S-band wave height started to increase gradually compared to Ku-band wave heights as can be clearly seen in Figure 50.**
- There is quite a number of outliers (more than in the last month) 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 tendency of the ECMWF model to have saturation values for both quantities (around 0.4 m for WTC and around 60 kg/m<sup>2</sup> for TCWV) is still existing. We stress that the model behaviour is theoretically more sound.

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- The agreement between the MWR products and the model counterparts has been significantly improved since the 9th. of April. However, there are two points of concern:
  1. The improvement to the TCWV is more significant than that of WTC as can be concluded from the scatter plots in Figures 38-45 (and compare these plots with the corresponding plots from the previous months).
  2. The scatter in MWR products have been increased after the 7th. of April as can be seen in Figures 46 and 47 (more pronounced in the NH). Referring to the corresponding plots from the previous few months, one can see that the scatter was lowest during the period 19 March - 7 April 2003.
- The MWR derived WTC and TCWV tend to be smaller (drier) than ECMWF values for smaller values, then tend to converge towards the ECMWF values at high 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.

## **Comparison Method:**

*A brief description of RA-2 data processing and quality control process together with any special considerations, assumptions and/or data corrections needed while comparing various quantities will go here.*



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Figure 50. 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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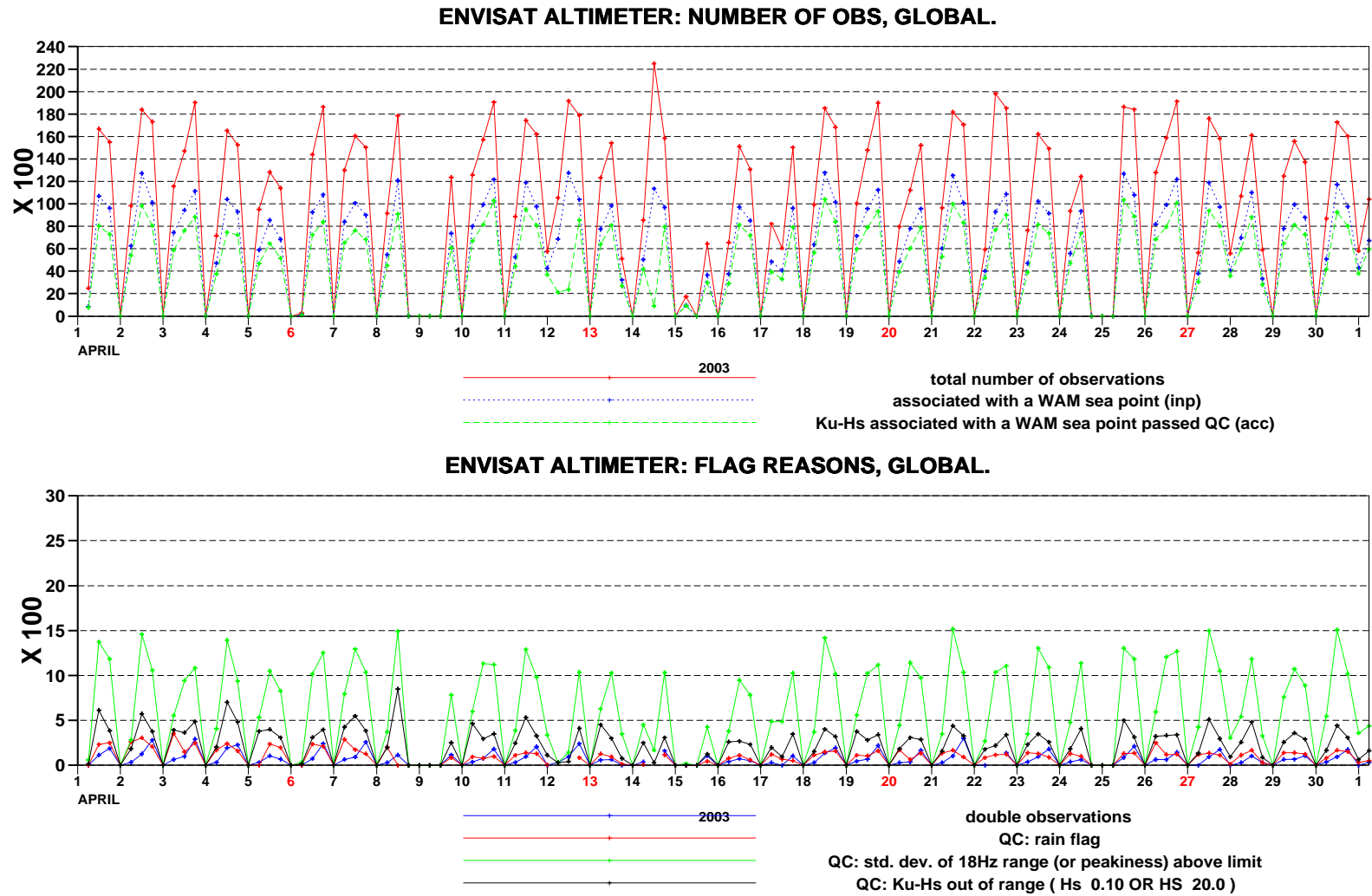


Figure 1: Time series of data reception for ENVISAT Altimeter data for April 2003

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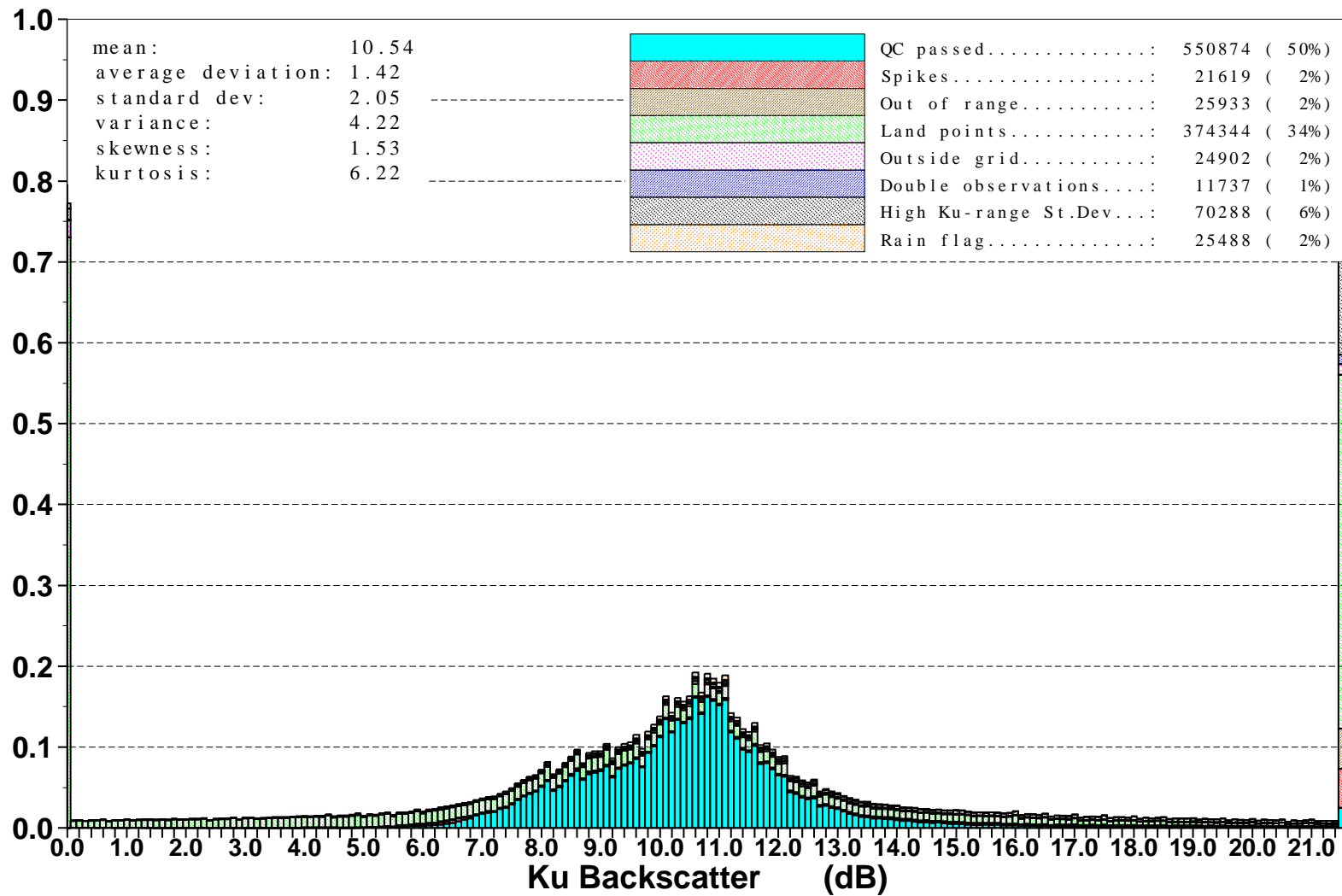


Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for April 2003

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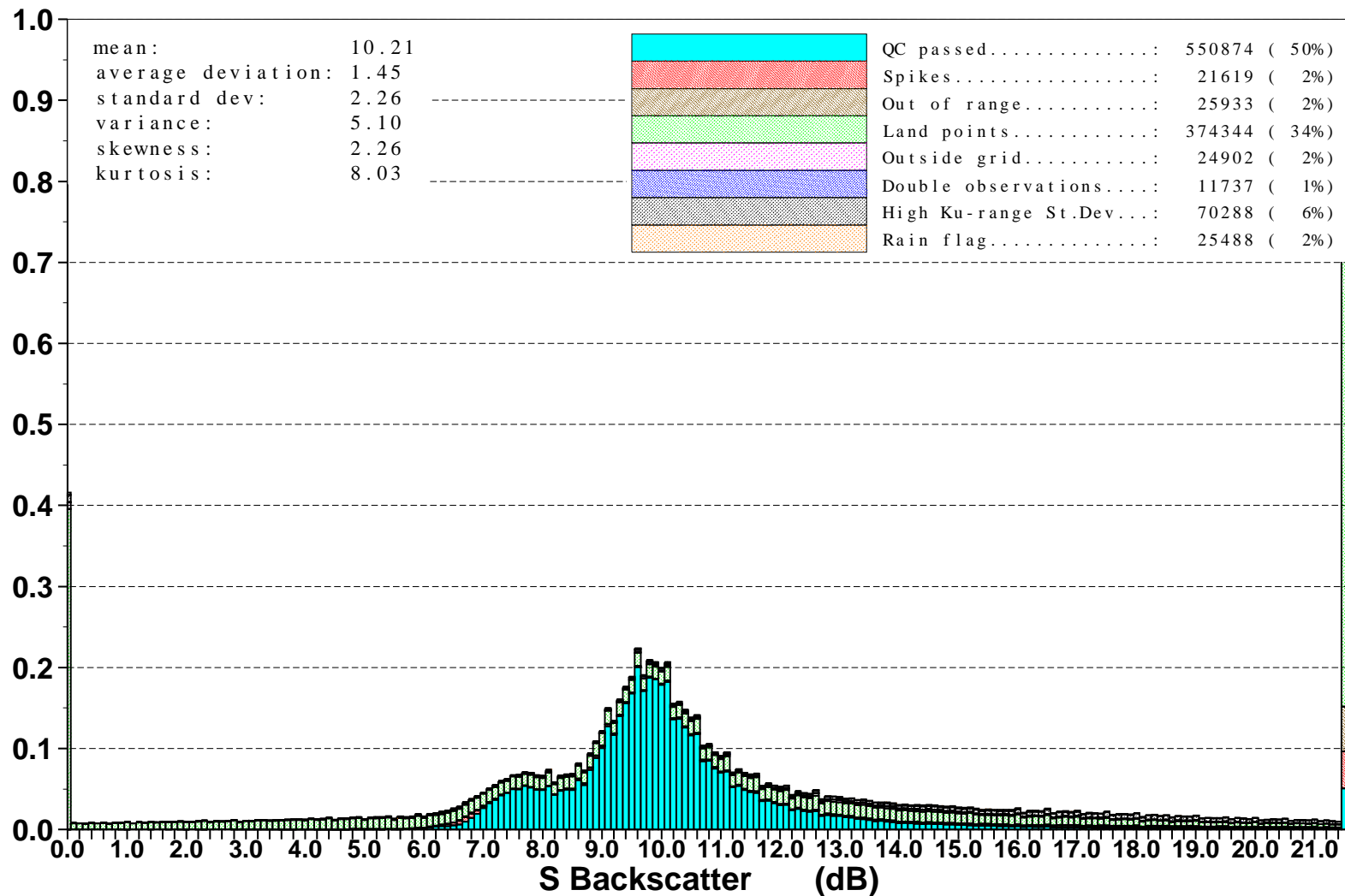


Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for April 2003

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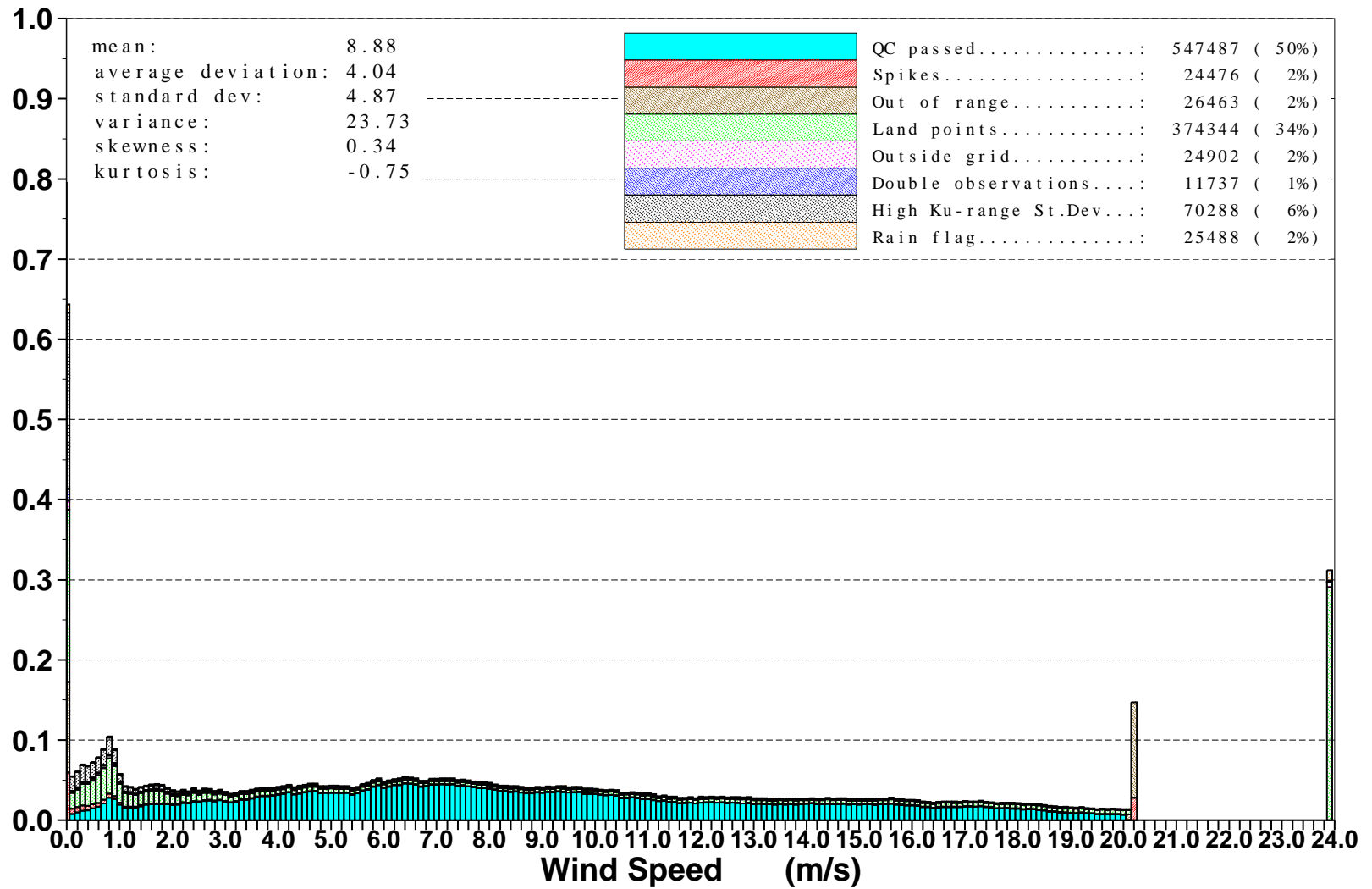


Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for April 2003



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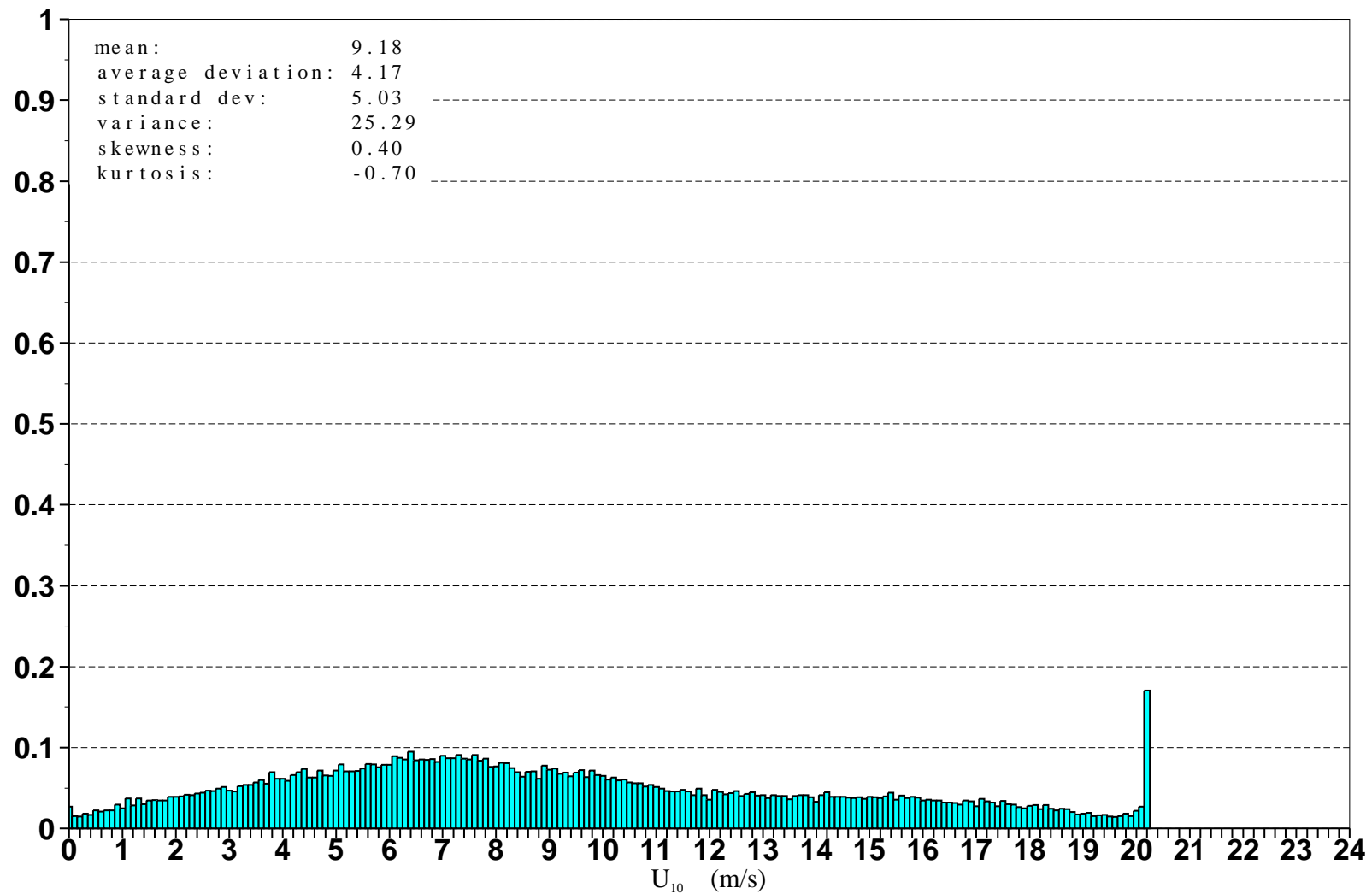


Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for April 2003



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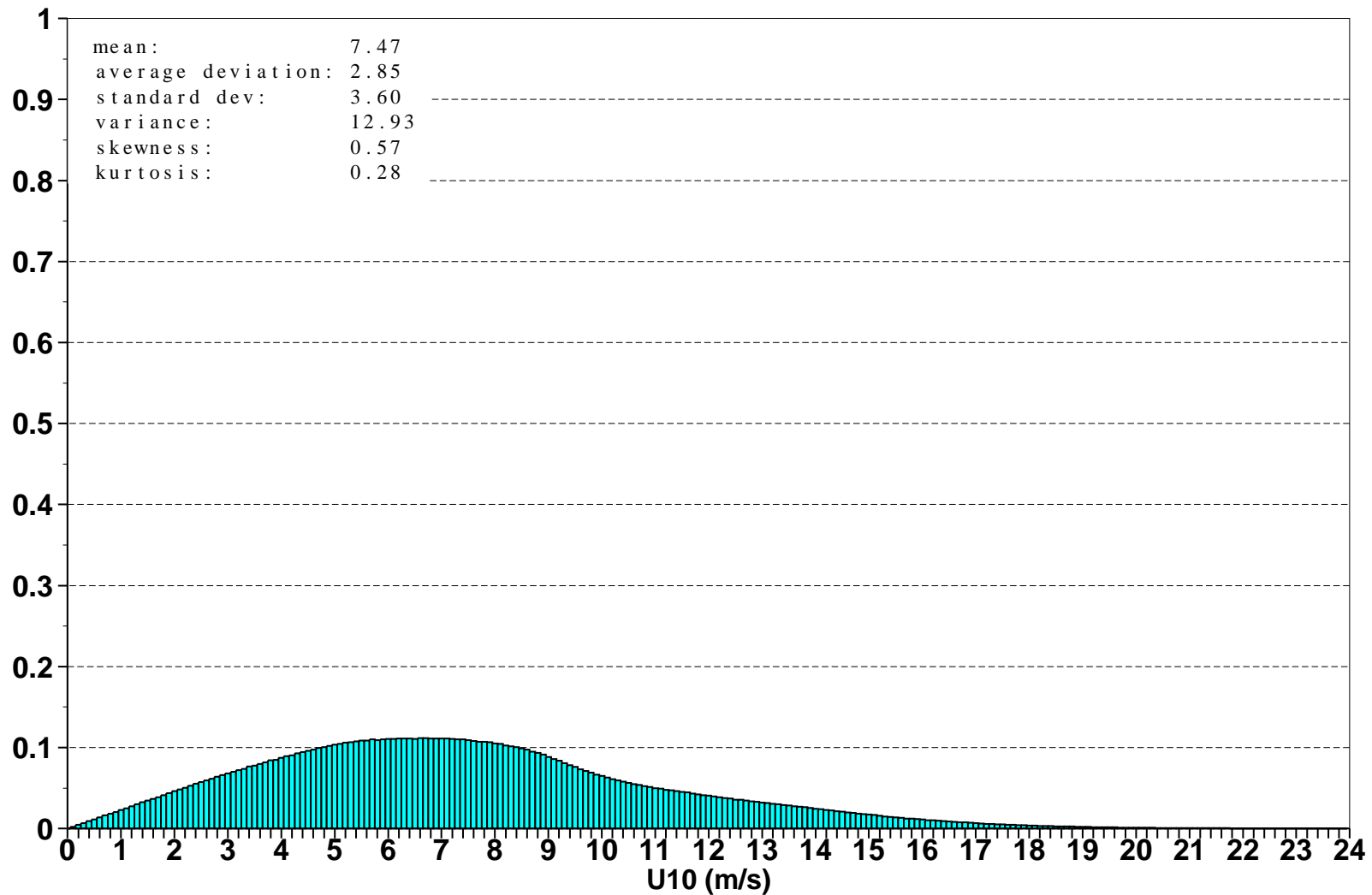


Figure 6: Global distribution of ECMWF Analysis ocean surface wind speeds for April 2003



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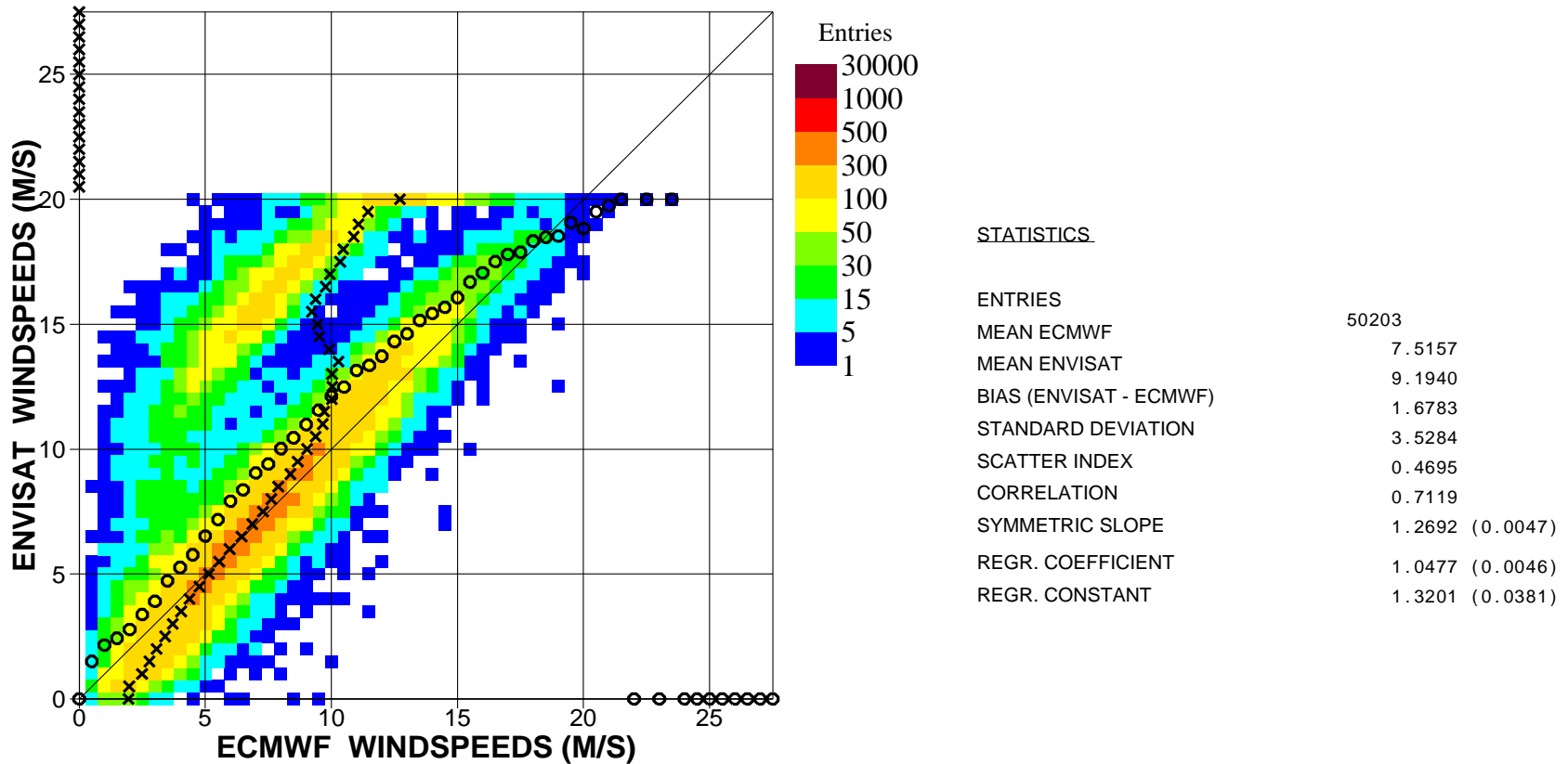


Figure 7. Comparison between ENVISAT Altimeter and ECMWF wind speeds for April 2003 (Global)

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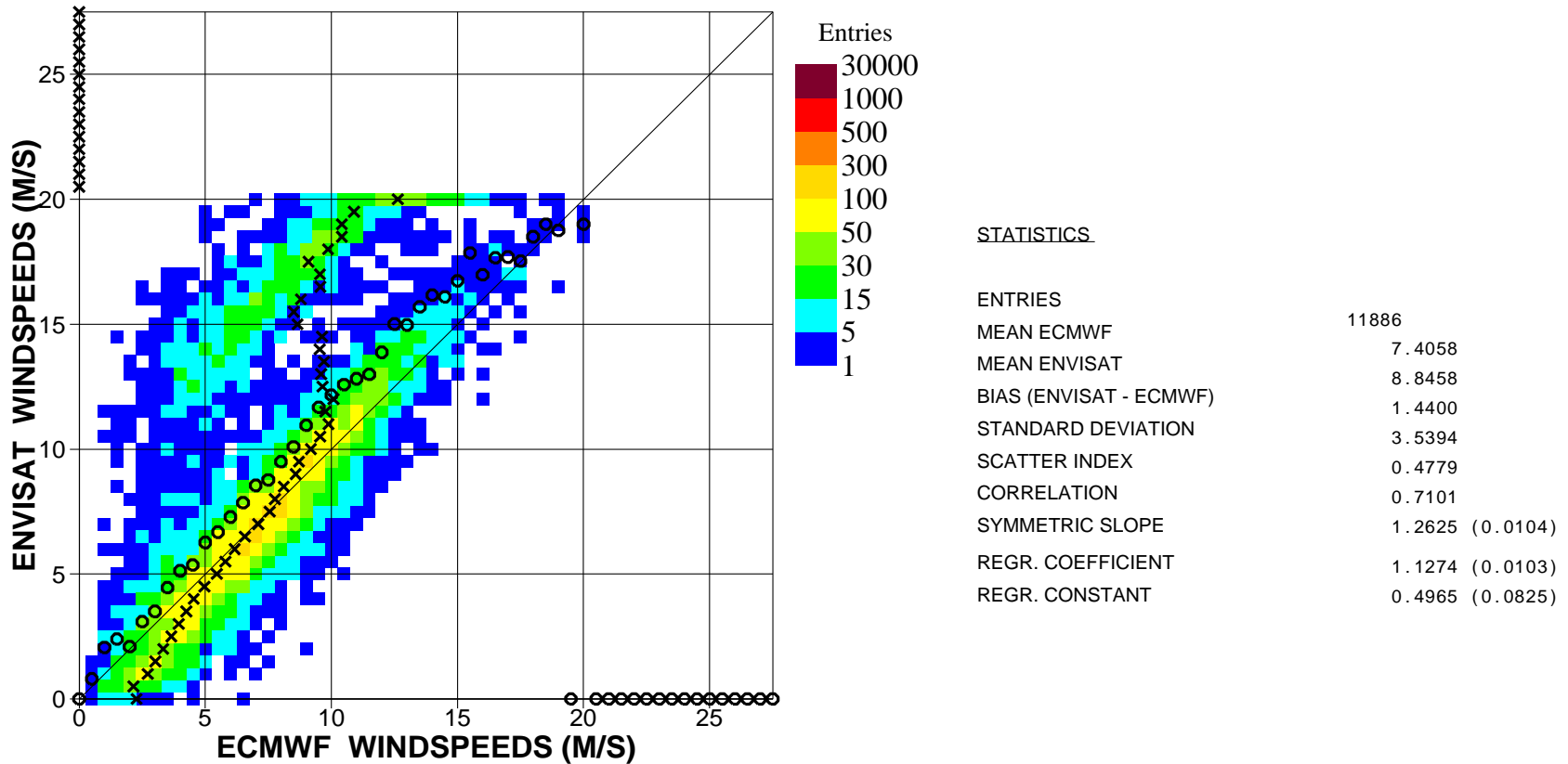


Figure 8. Comparison between ENVISAT Altimeter and ECMWF wind speeds for April 2003 (N.Hem.)

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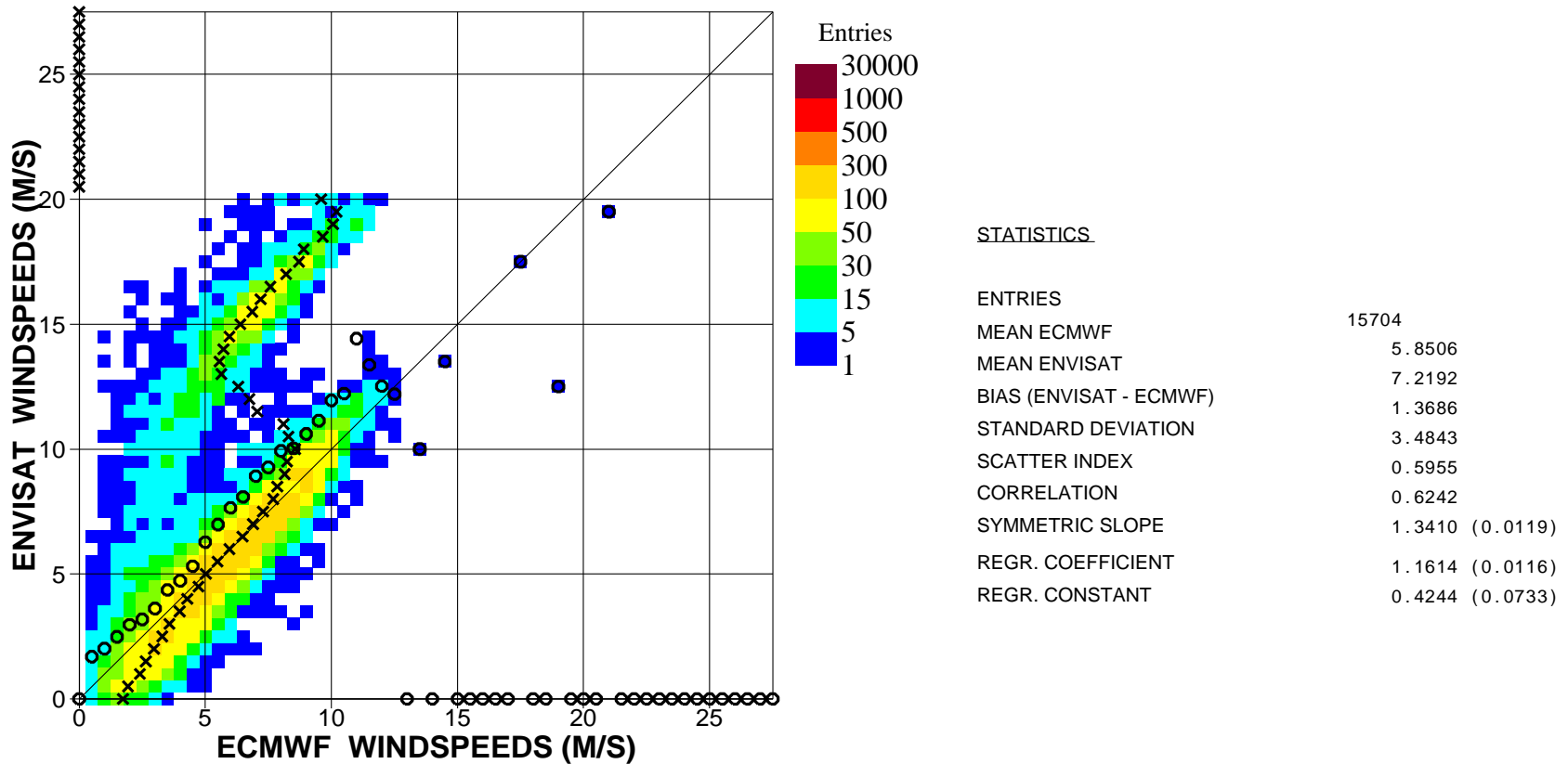


Figure 9. Comparison between ENVISAT Altimeter and ECMWF wind speeds for April 2003 (Tropics)

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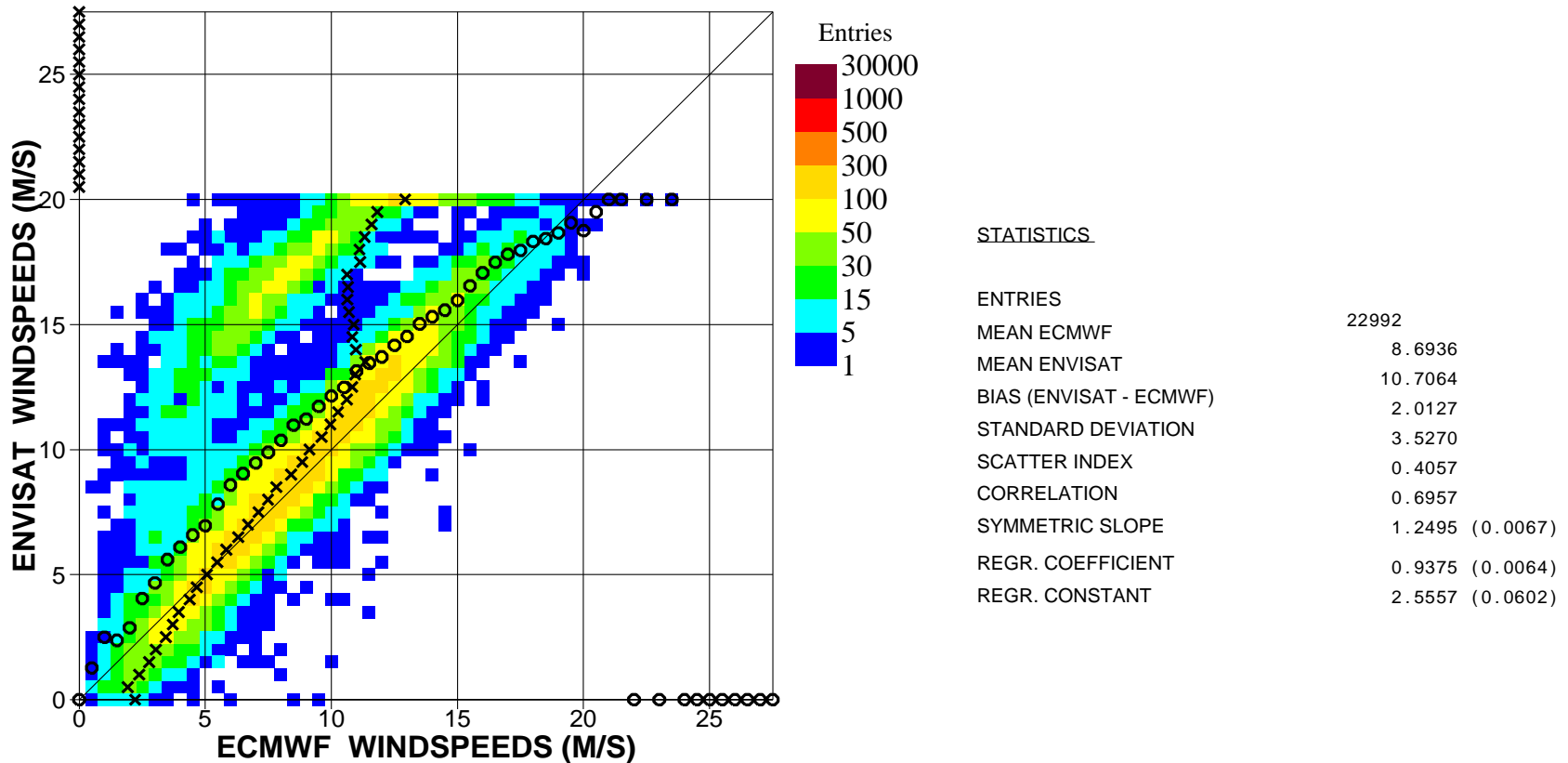


Figure 10. Comparison between ENVISAT Altimeter and ECMWF wind speeds for April 2003 (S.Hem.)

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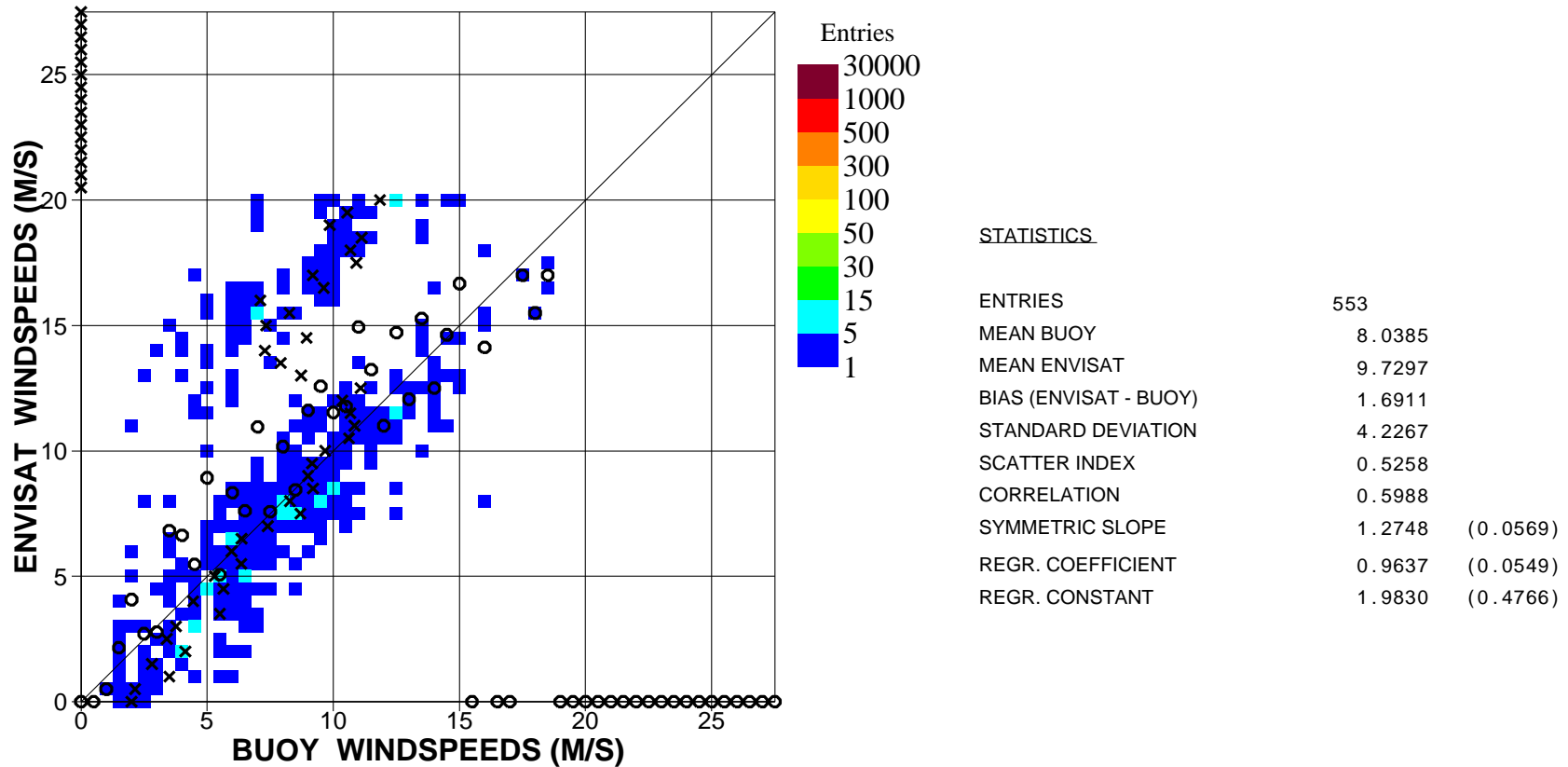


Figure 11. Comparison between ENVISAT Altimeter and buoy wind speeds for April 2003 (Global)

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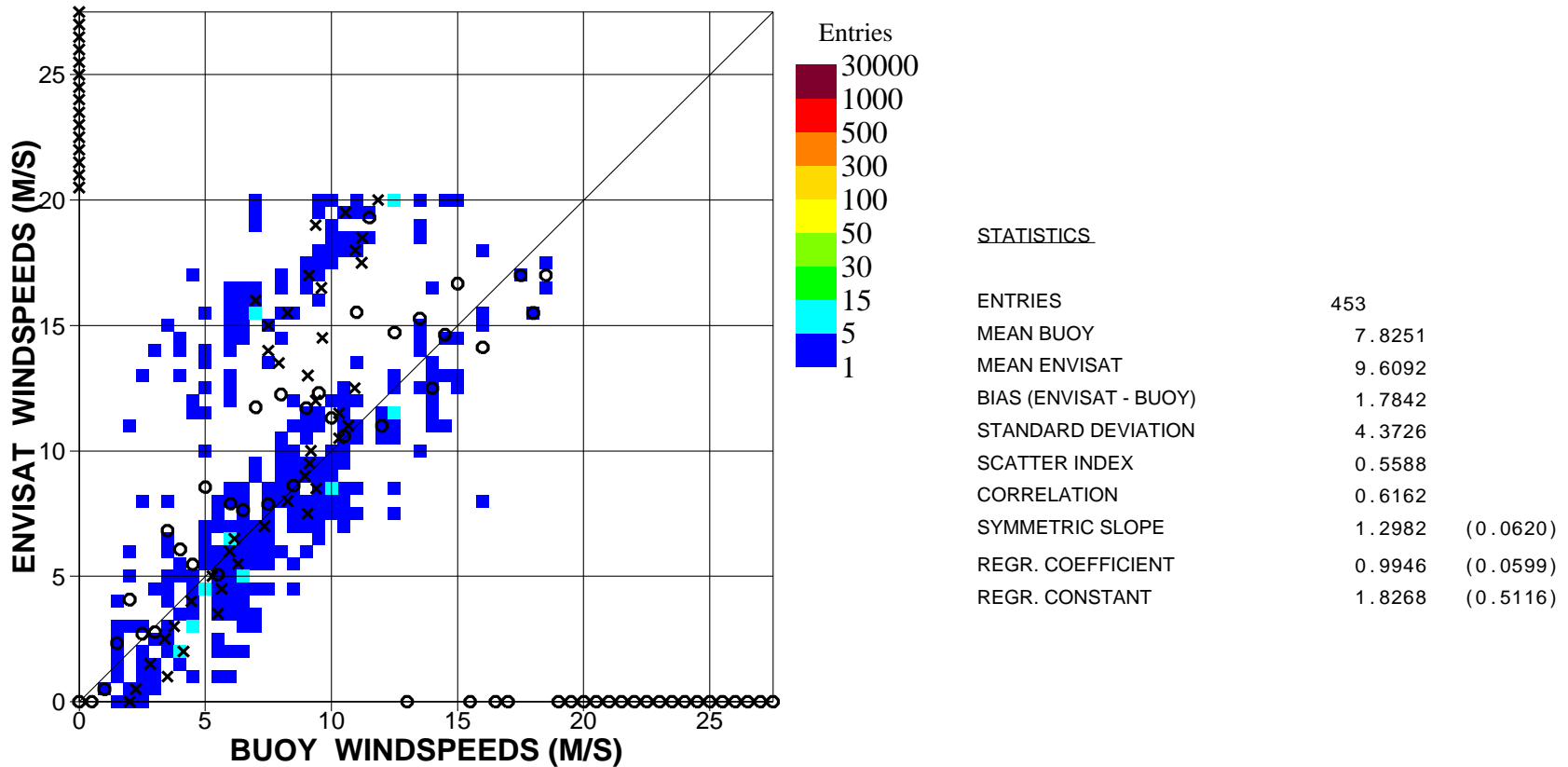


Figure 12. Comparison between ENVISAT Altimeter and buoy wind speeds for April 2003 (N.Hem.)

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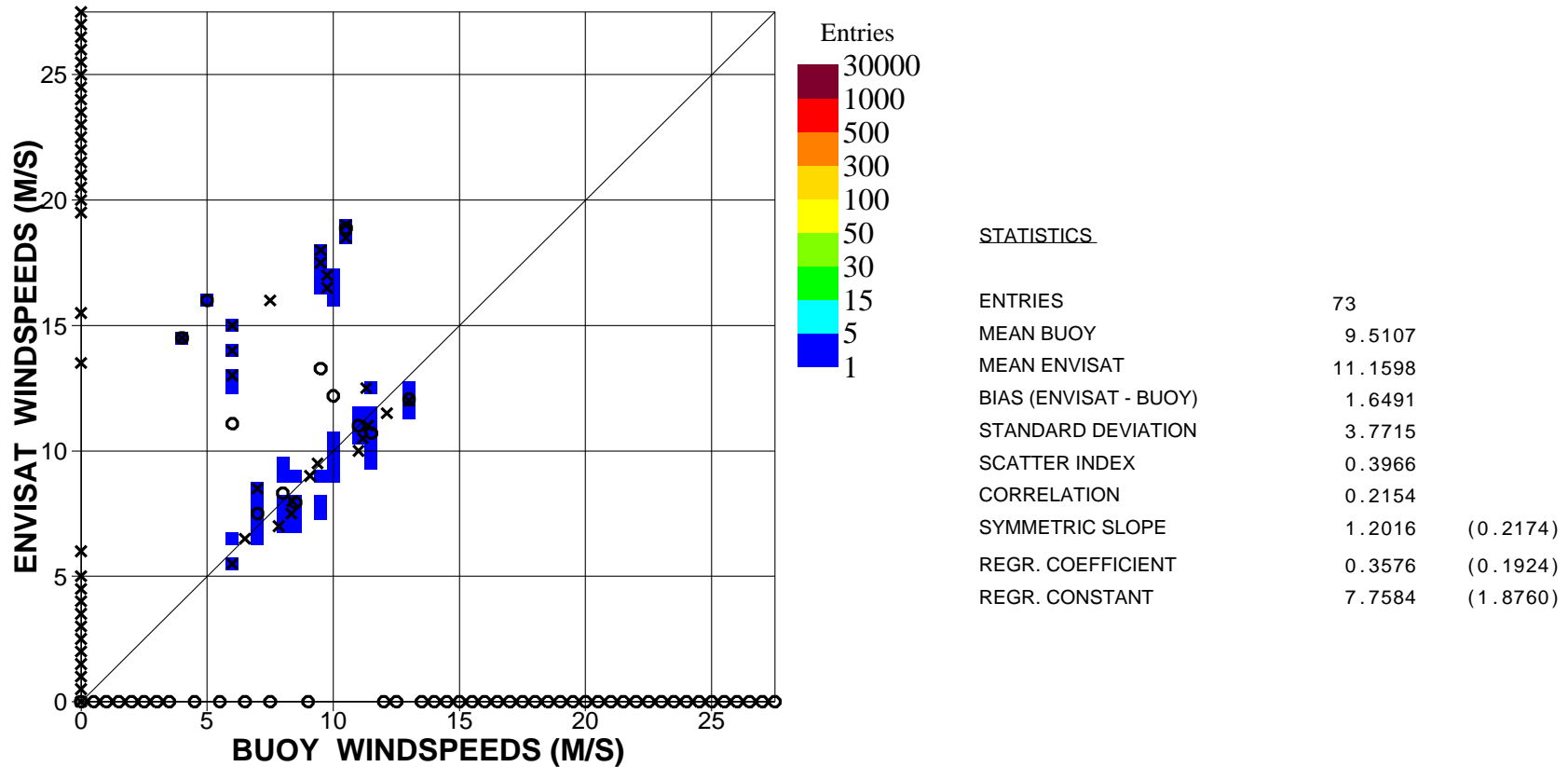


Figure 13. Comparison between ENVISAT Altimeter and buoy wind speeds for April 2003 (Tropics)

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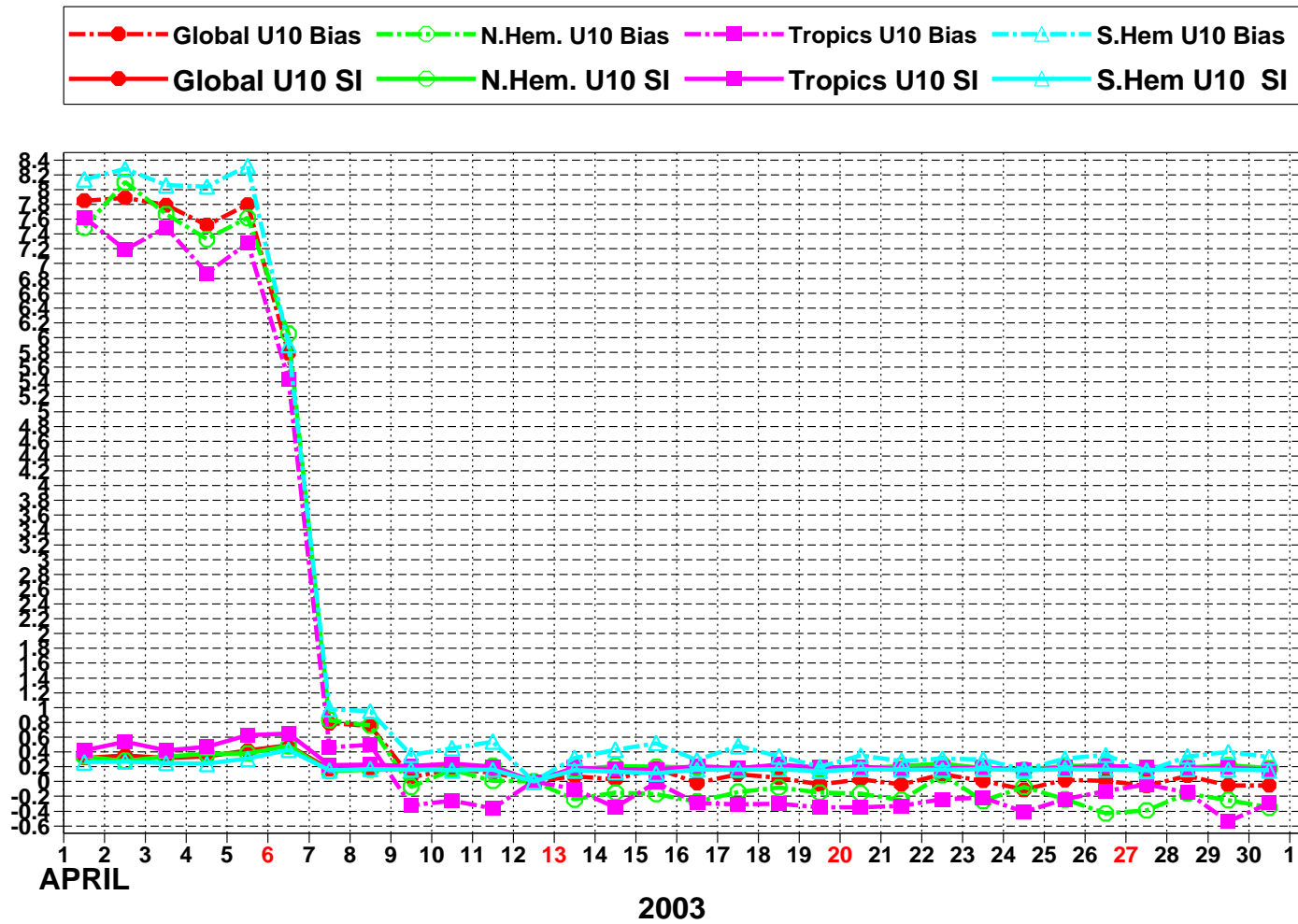


Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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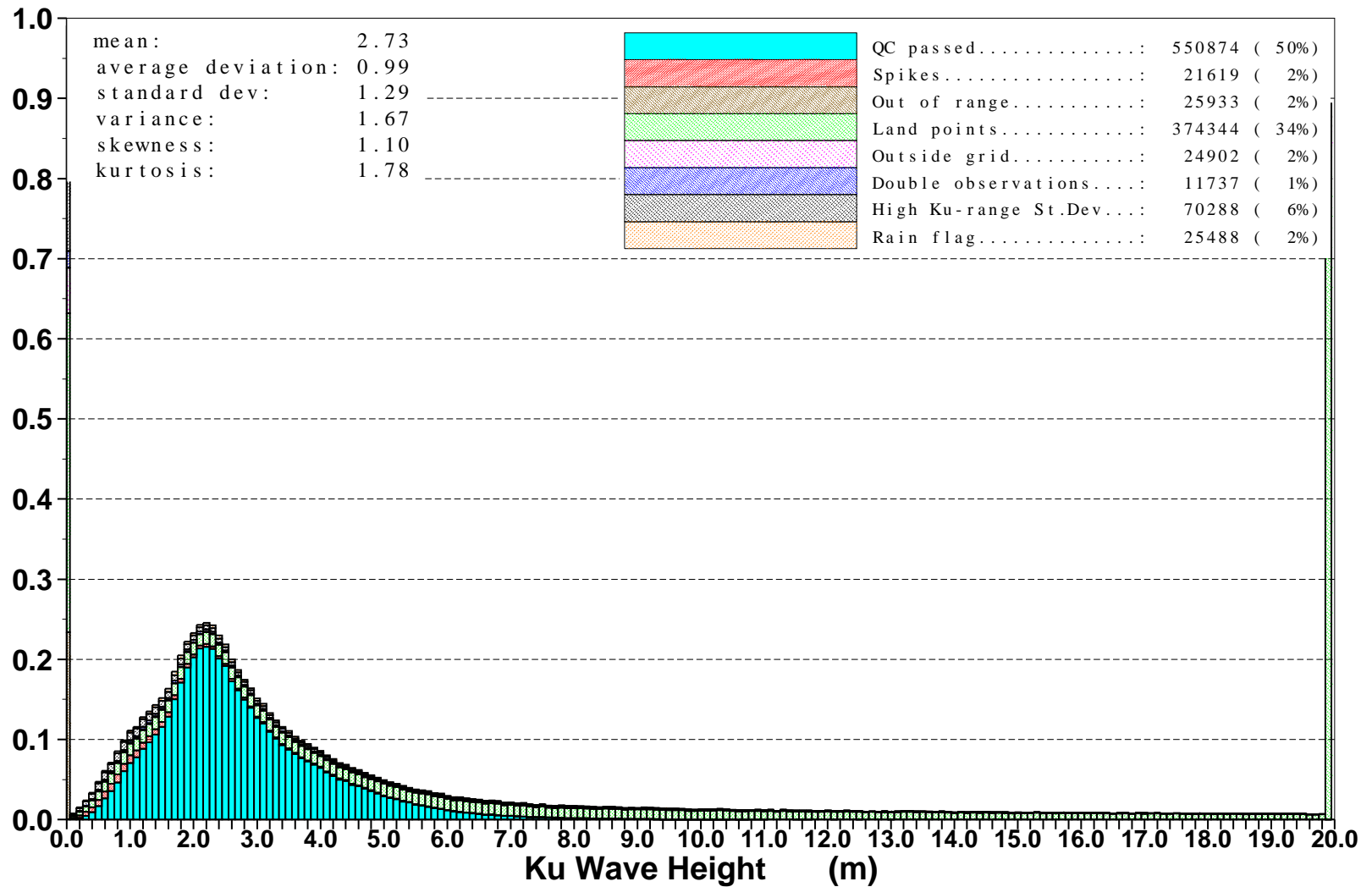


Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for April 2003

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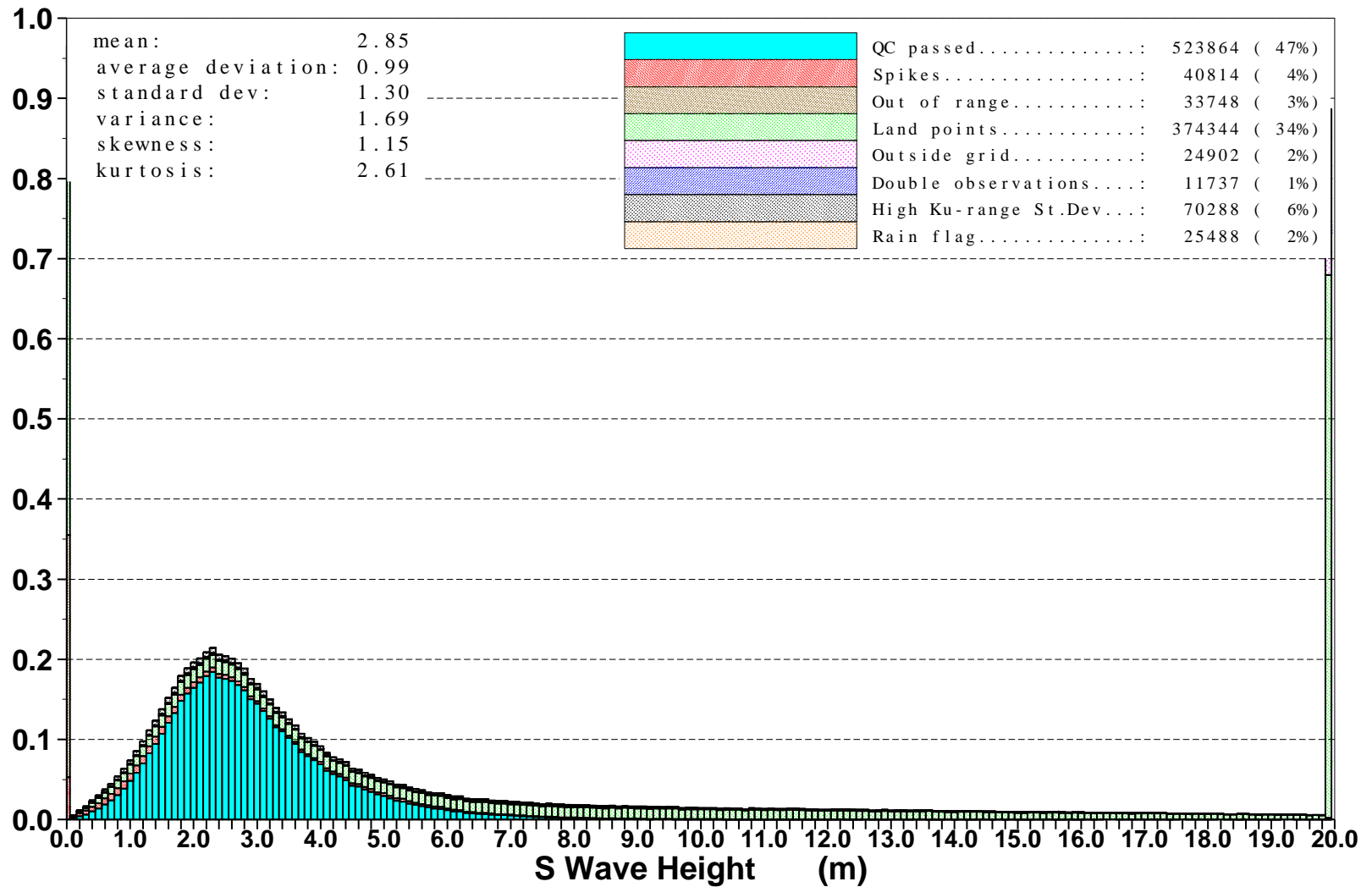
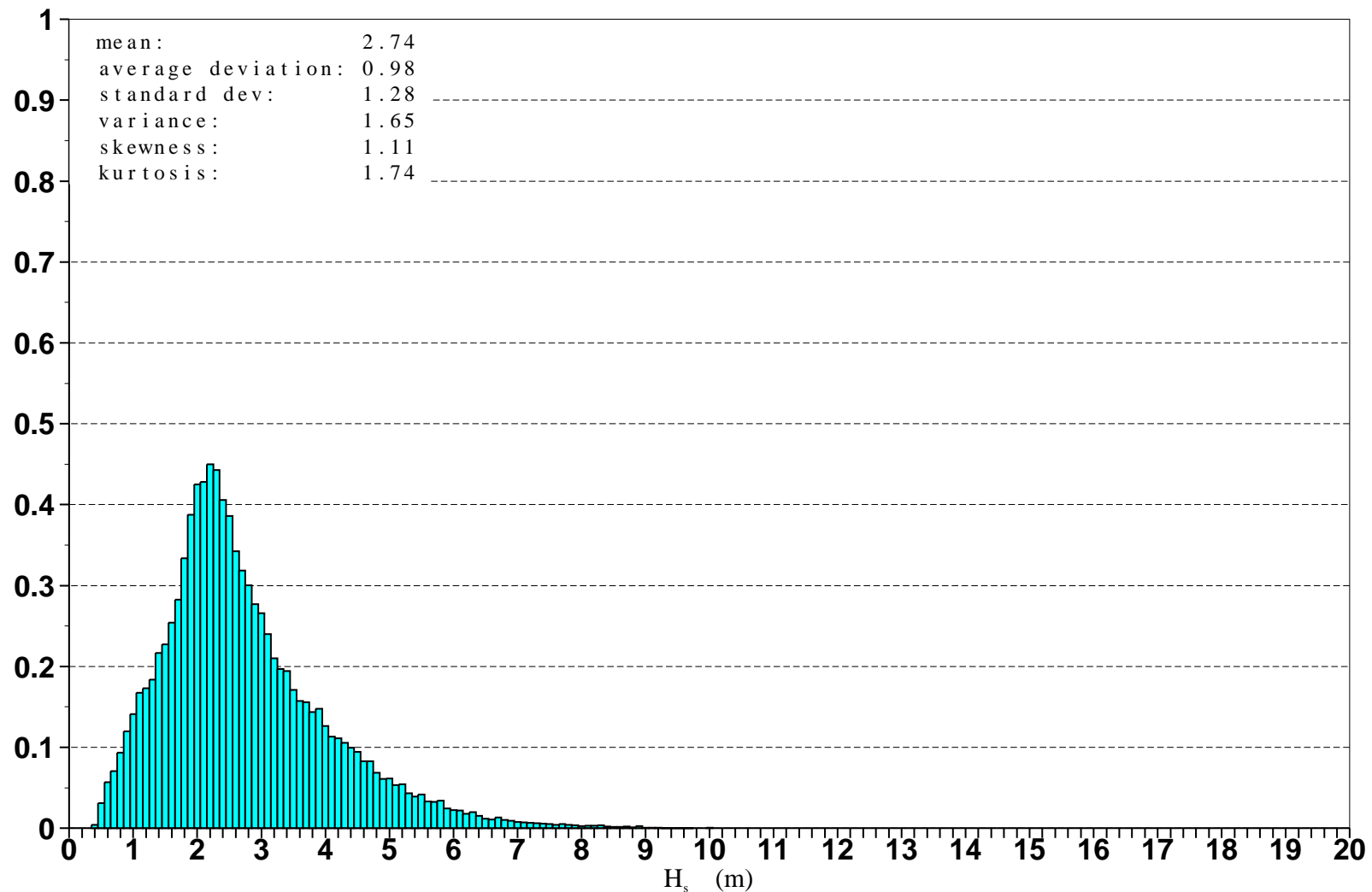


Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for April 2003

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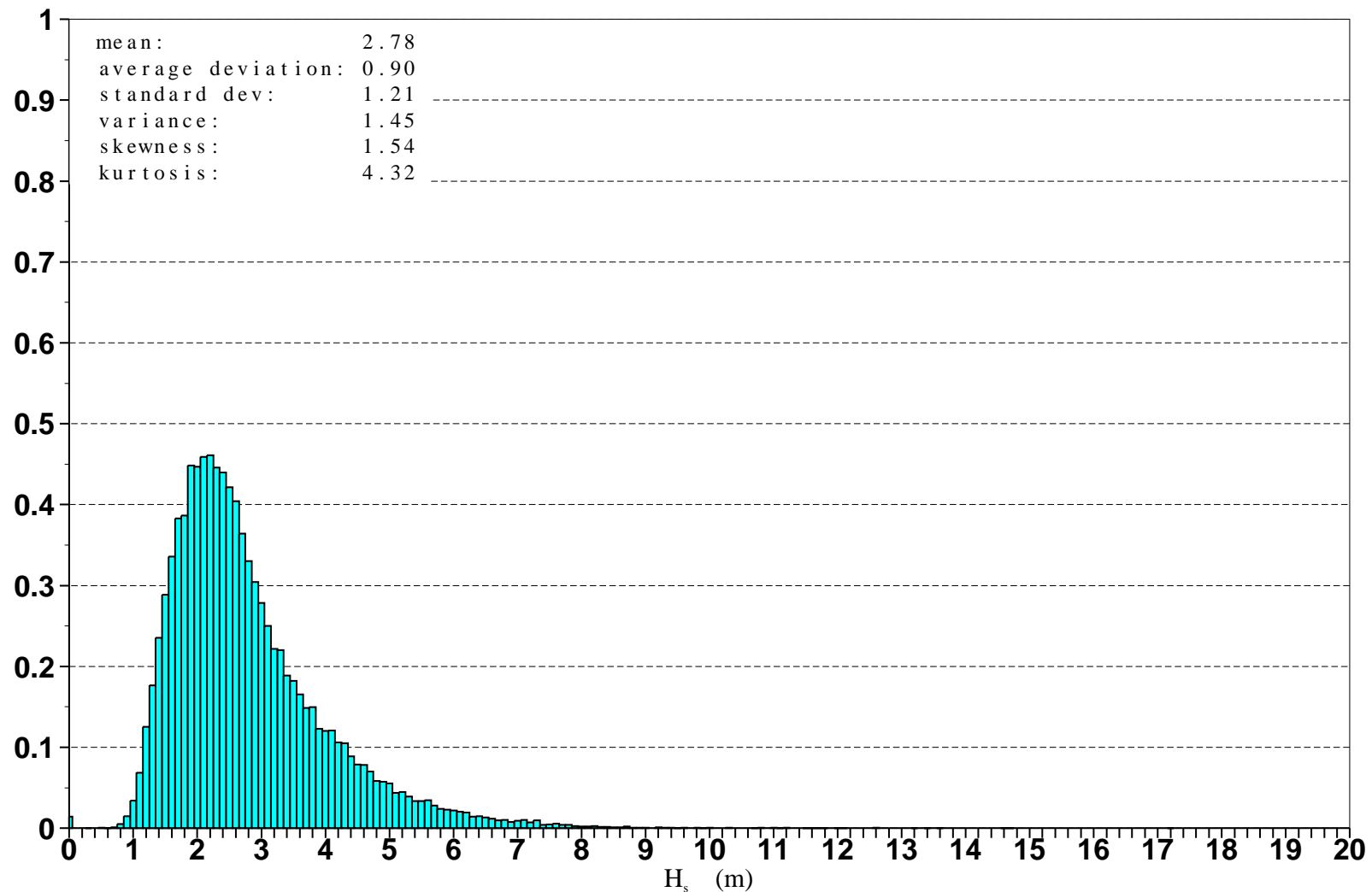
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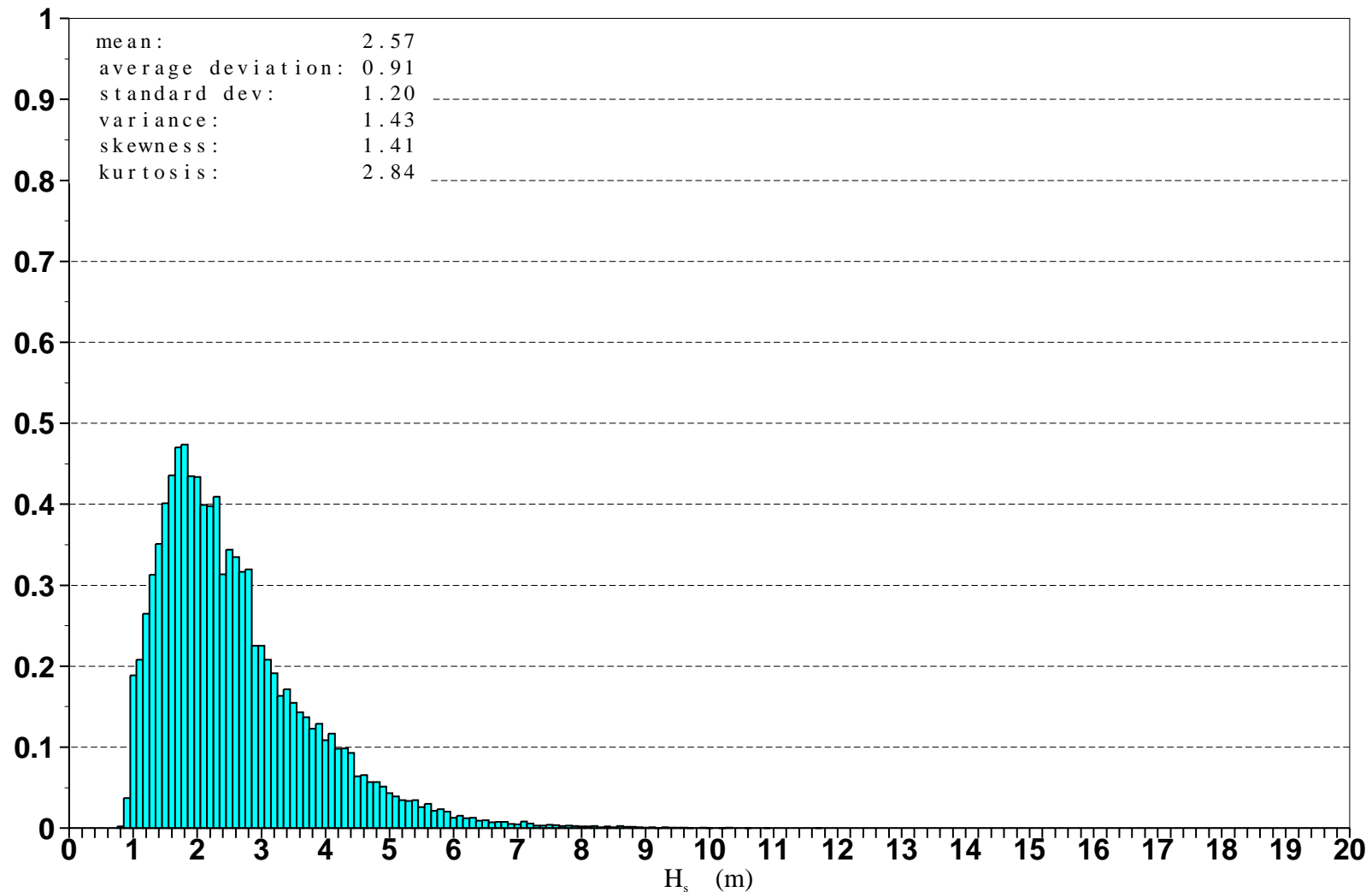
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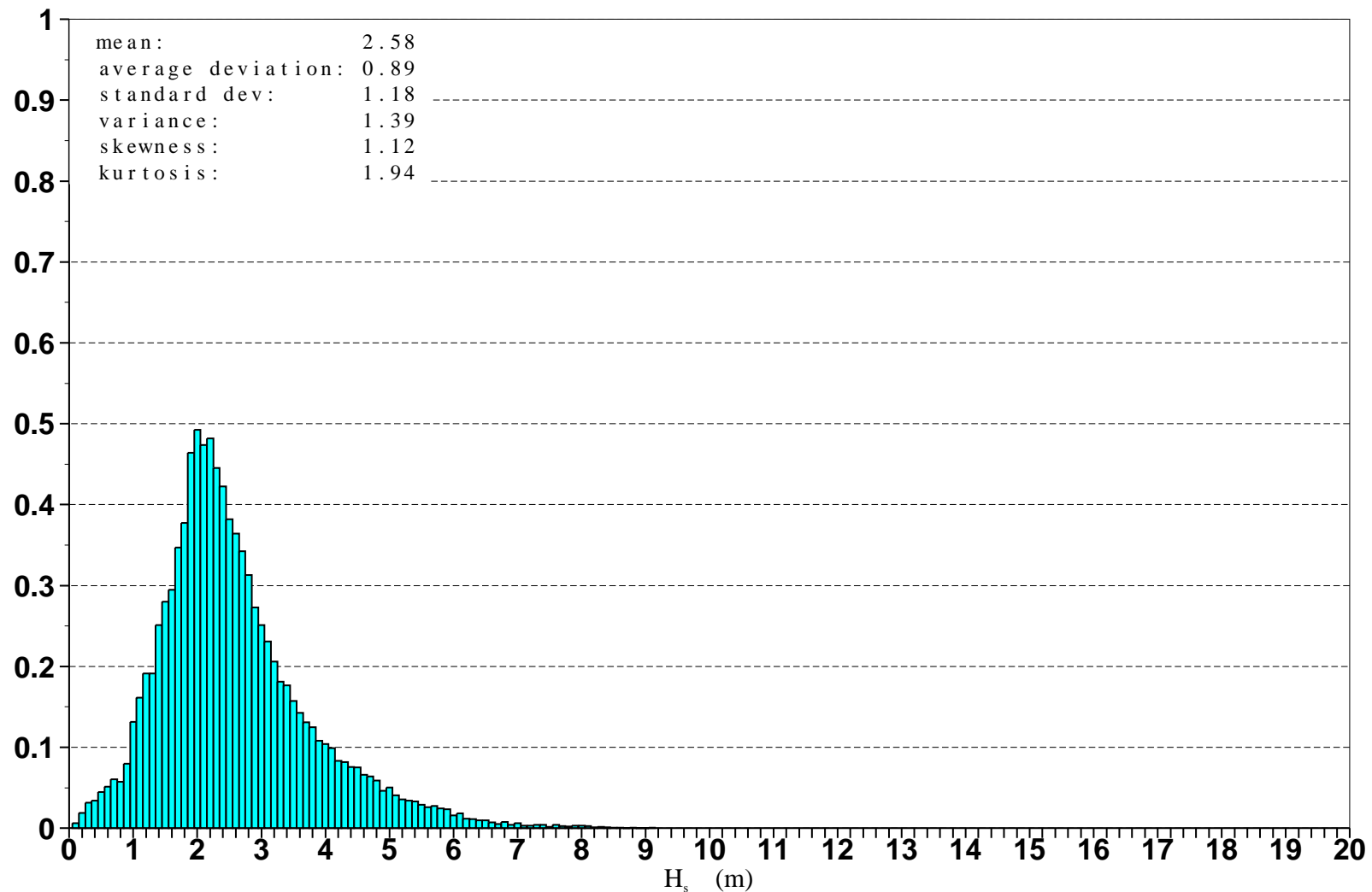
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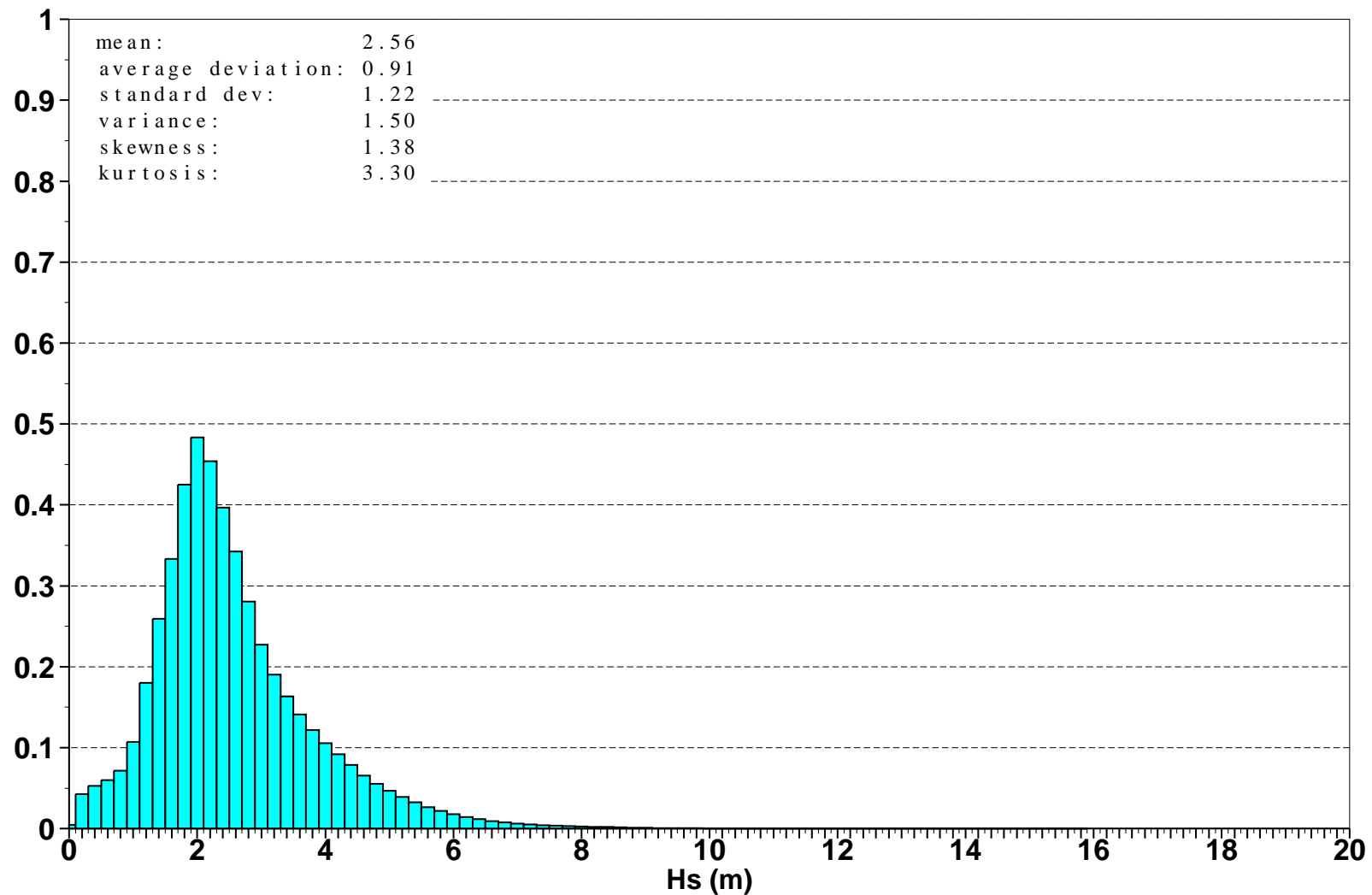


Figure 20: Global distribution of ECMWF First-Guess wave heights for April 2003



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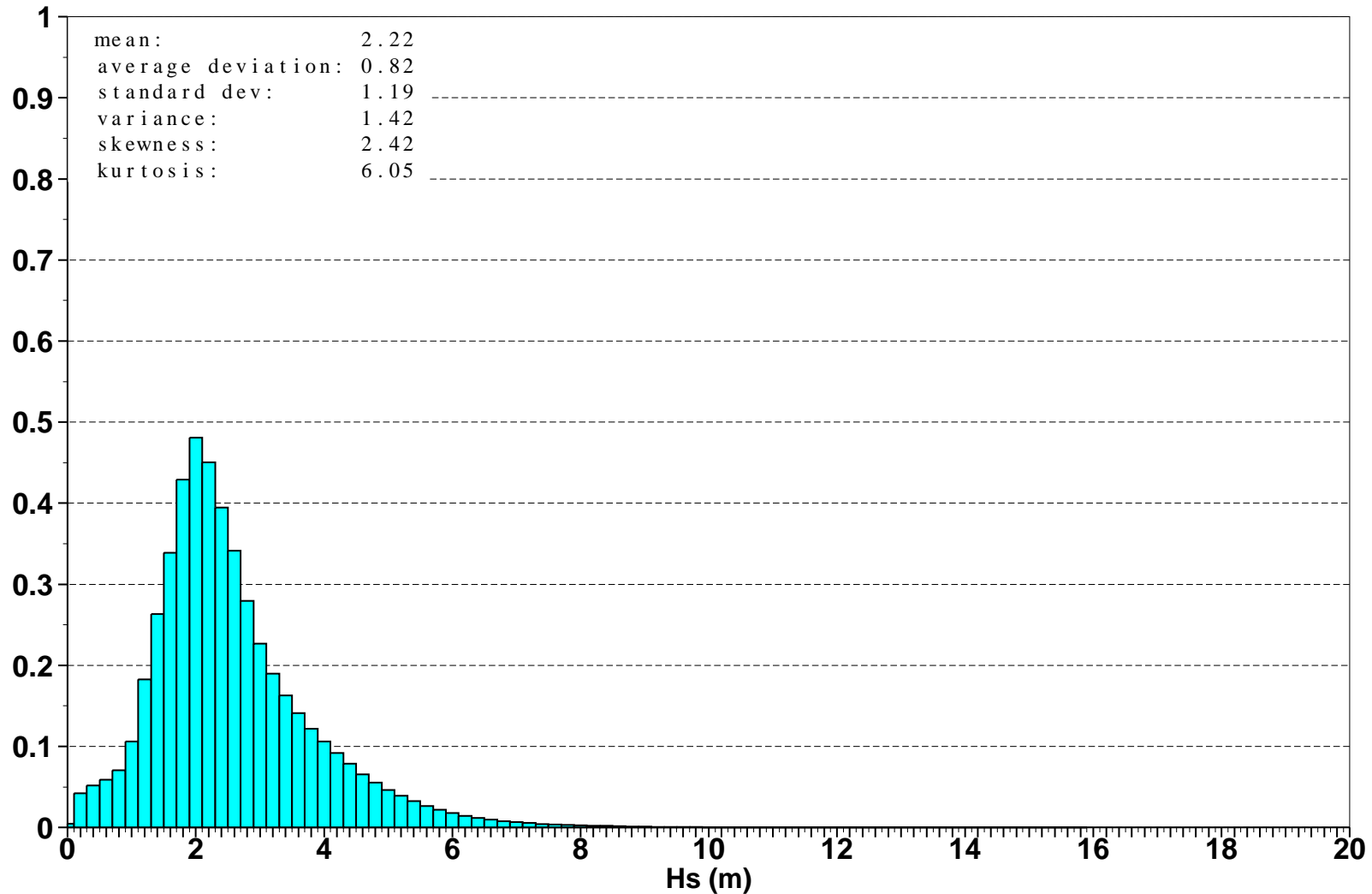


Figure 21: Global distribution of ECMWF Analysis (using ERS-2 data) wave heights for April 2003



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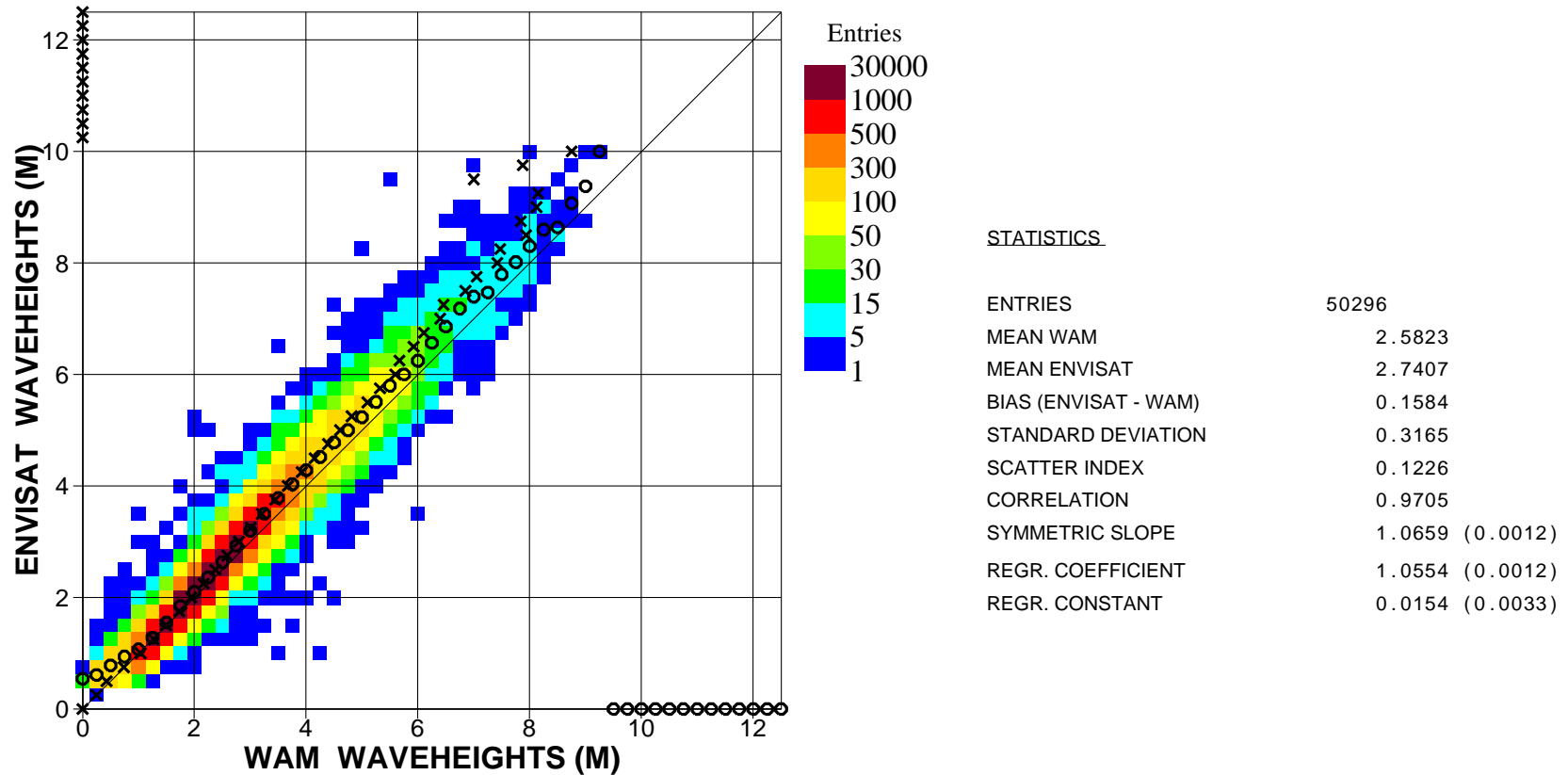


Figure 22. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for April 2003 (Global)

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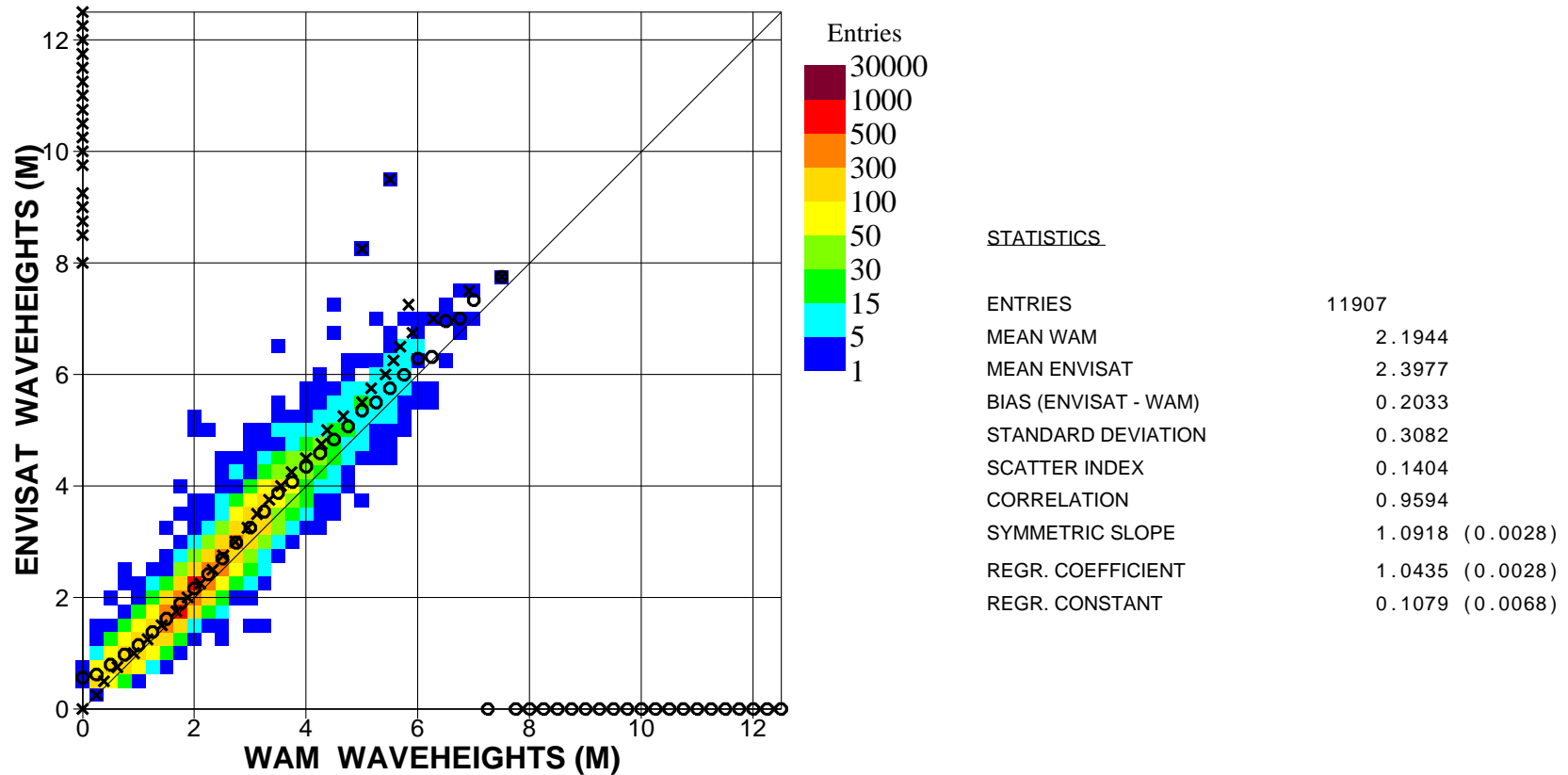


Figure 23. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for April 2003 (N.Hem.)

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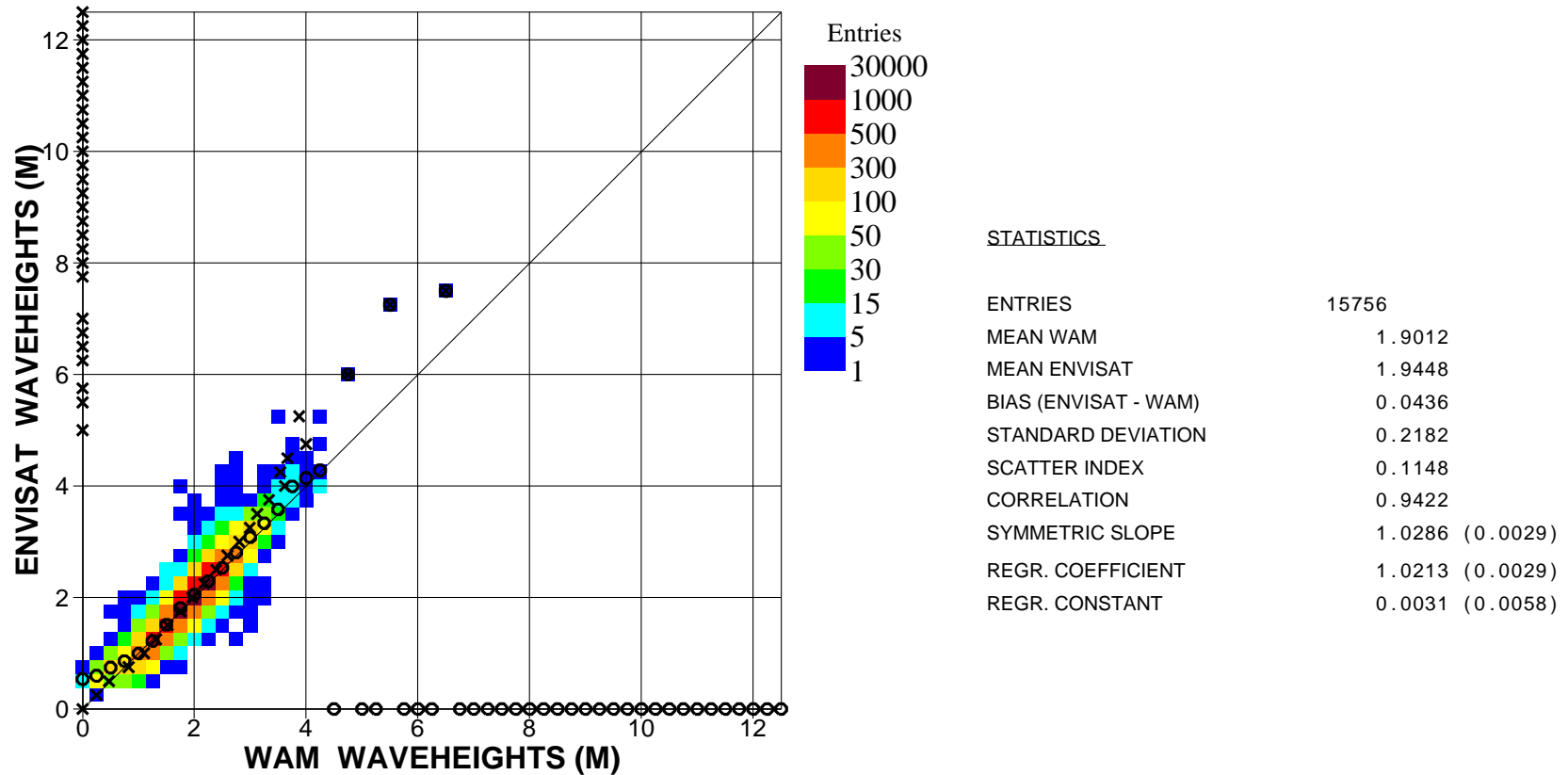


Figure 24. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for April 2003 (Tropics)

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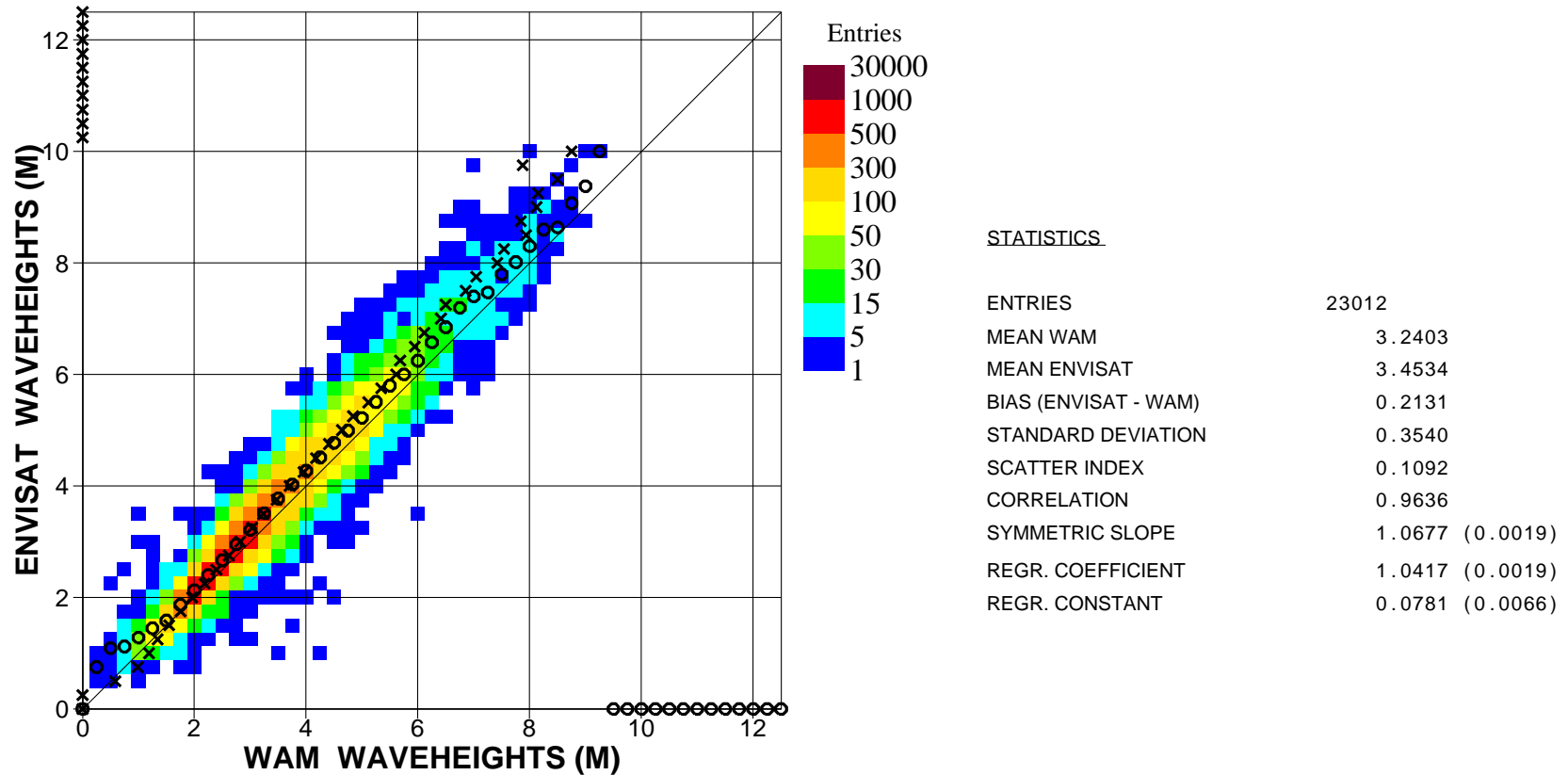


Figure 25. Comparison between ENVISAT Altimeter Ku-Band and WAM (first guess) significant wave heights for April 2003 (S.Hem.)

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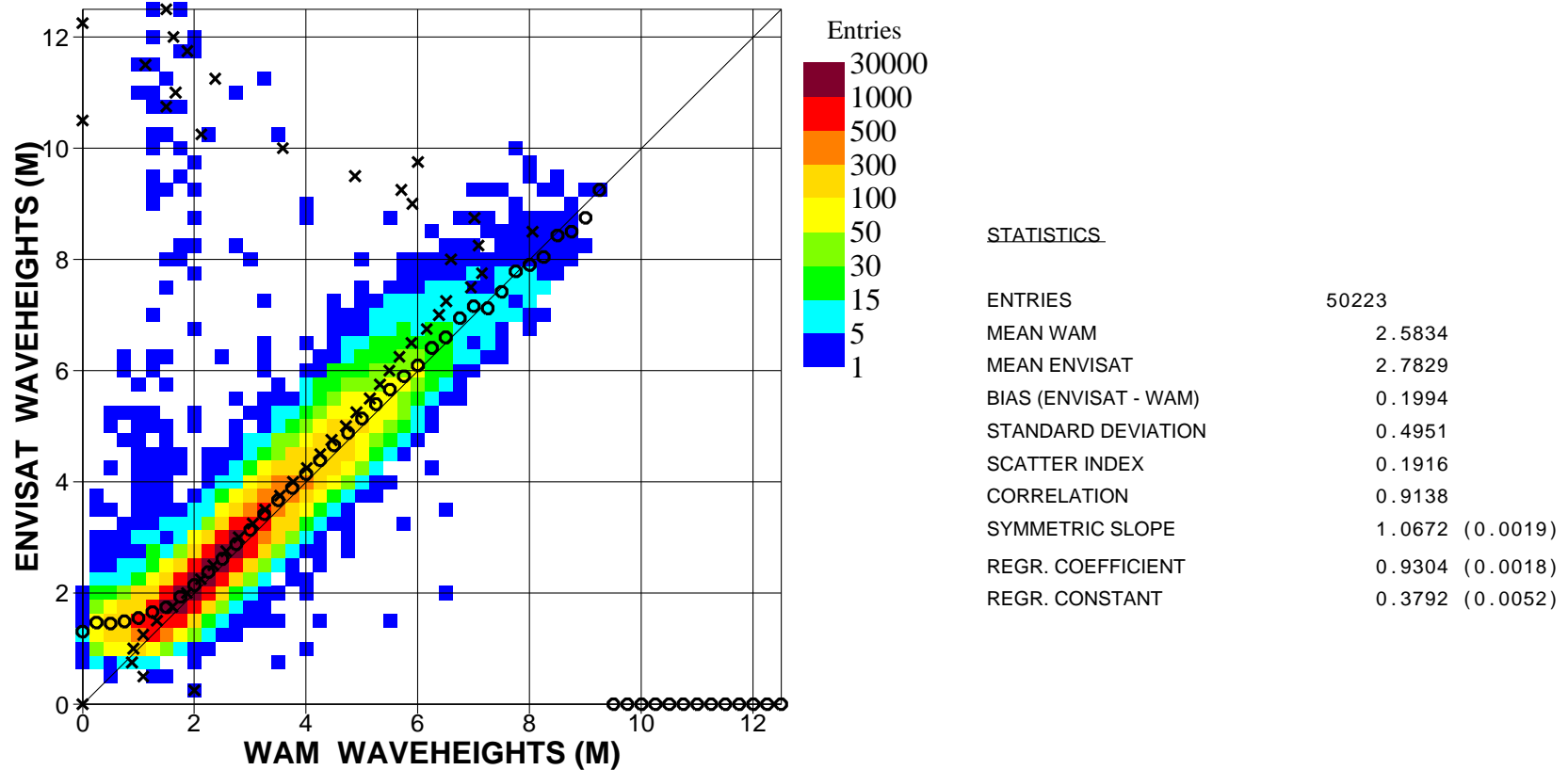


Figure 26. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for April 2003 (Global)

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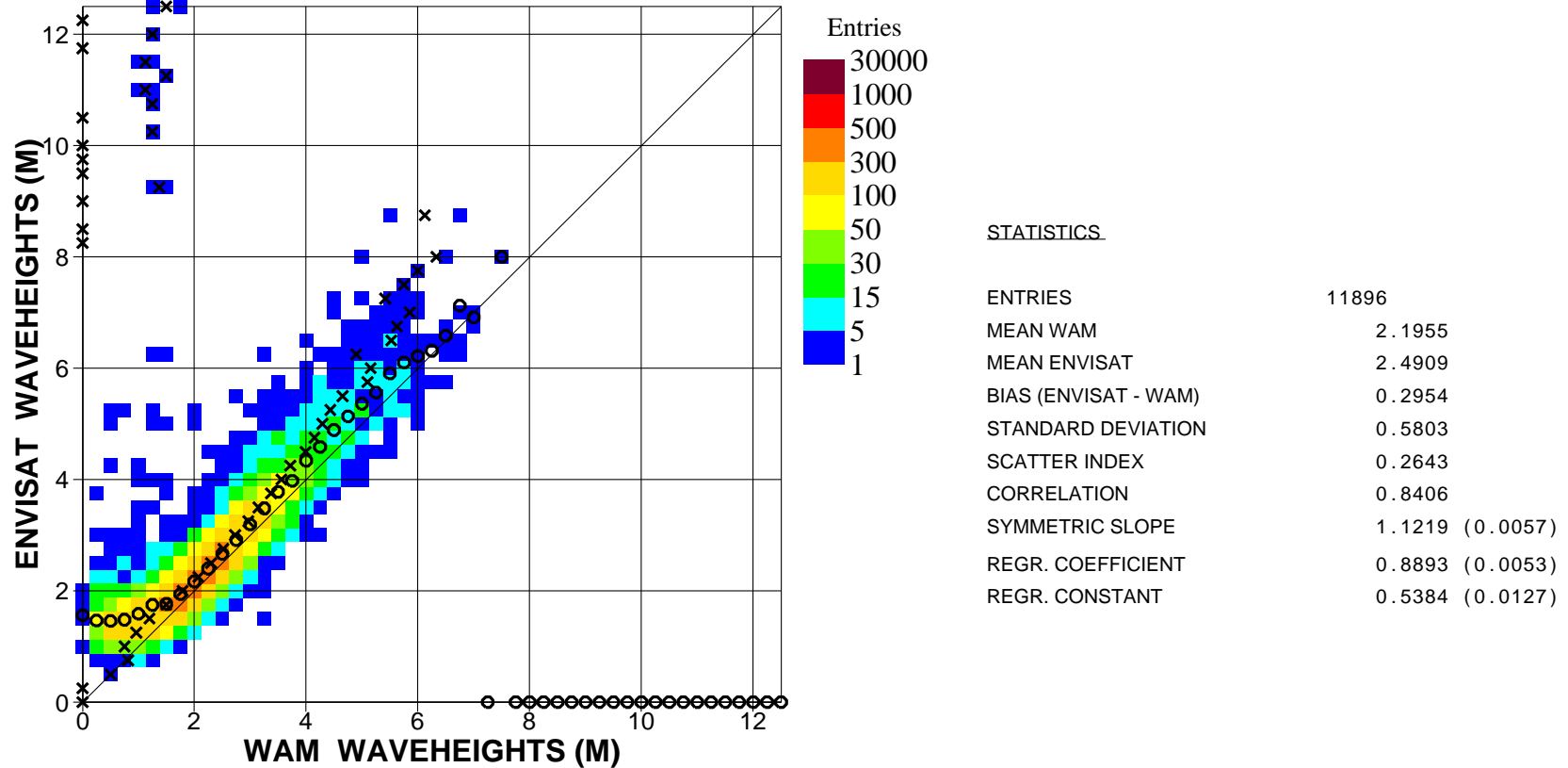


Figure 27. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for April 2003 (N.Hem.)

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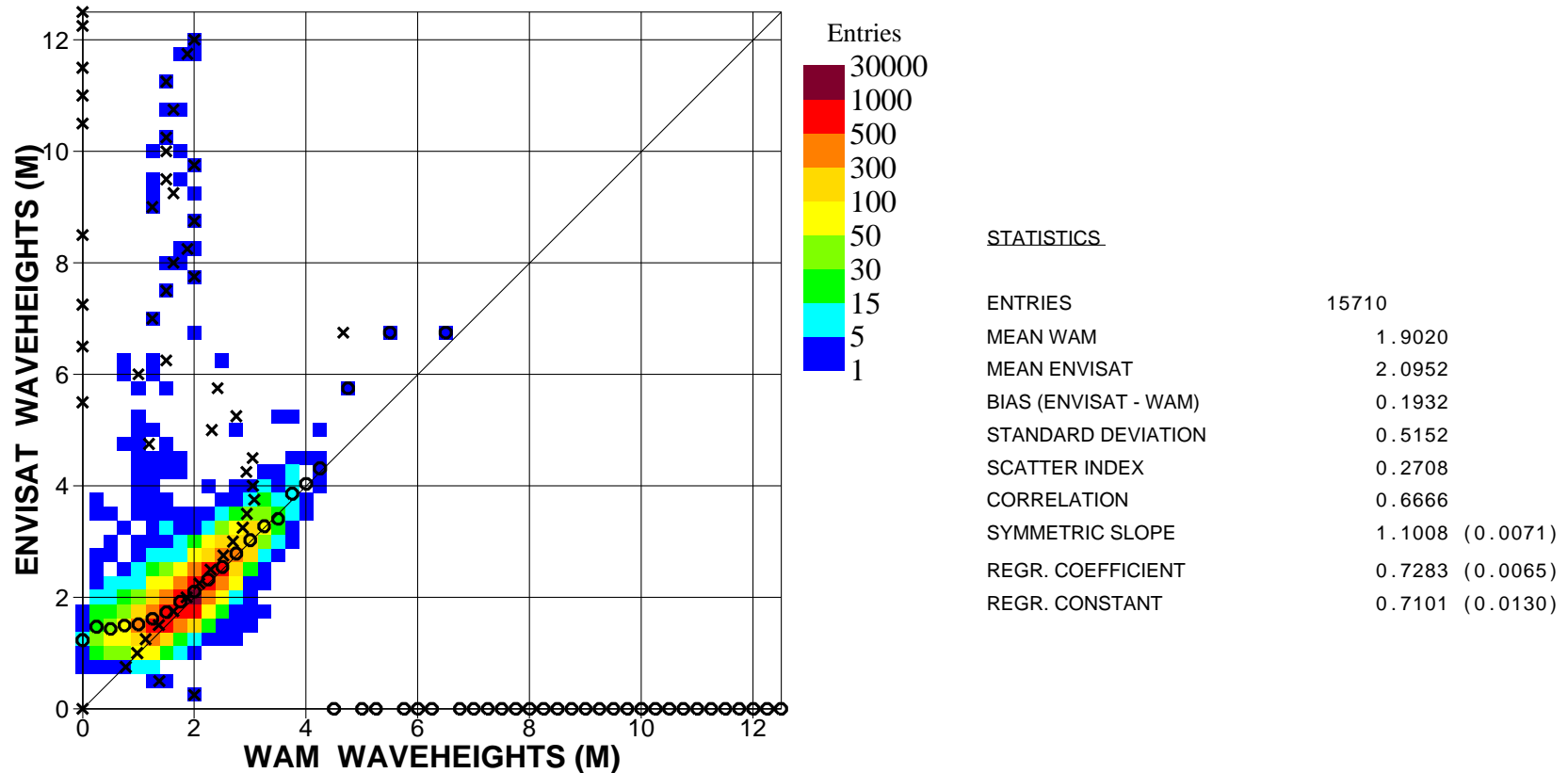


Figure 28. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for April 2003 (Tropics)

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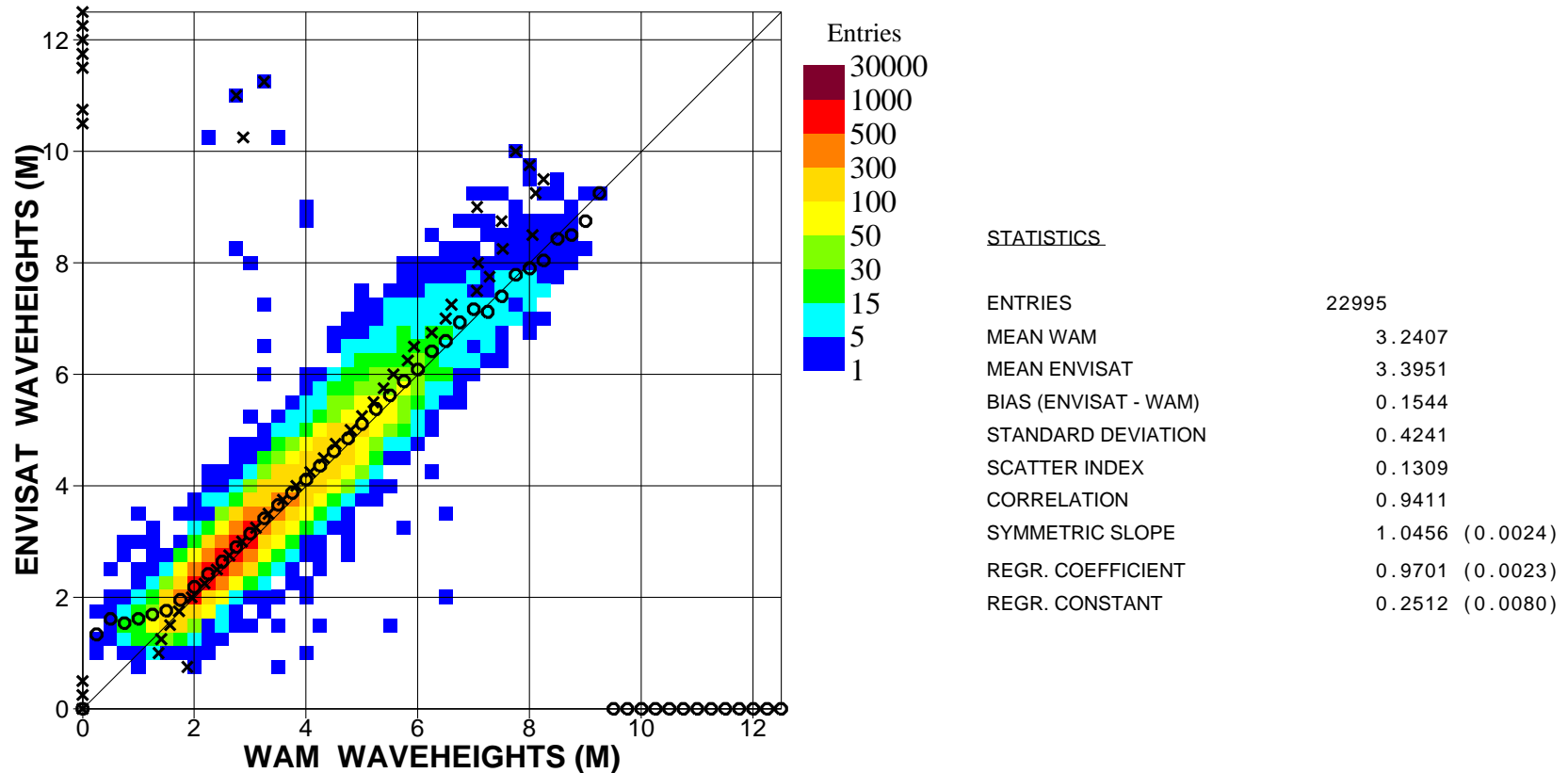


Figure 29. Comparison between ENVISAT Altimeter S-Band and WAM (first guess) significant wave heights for April 2003 (S.Hem.)

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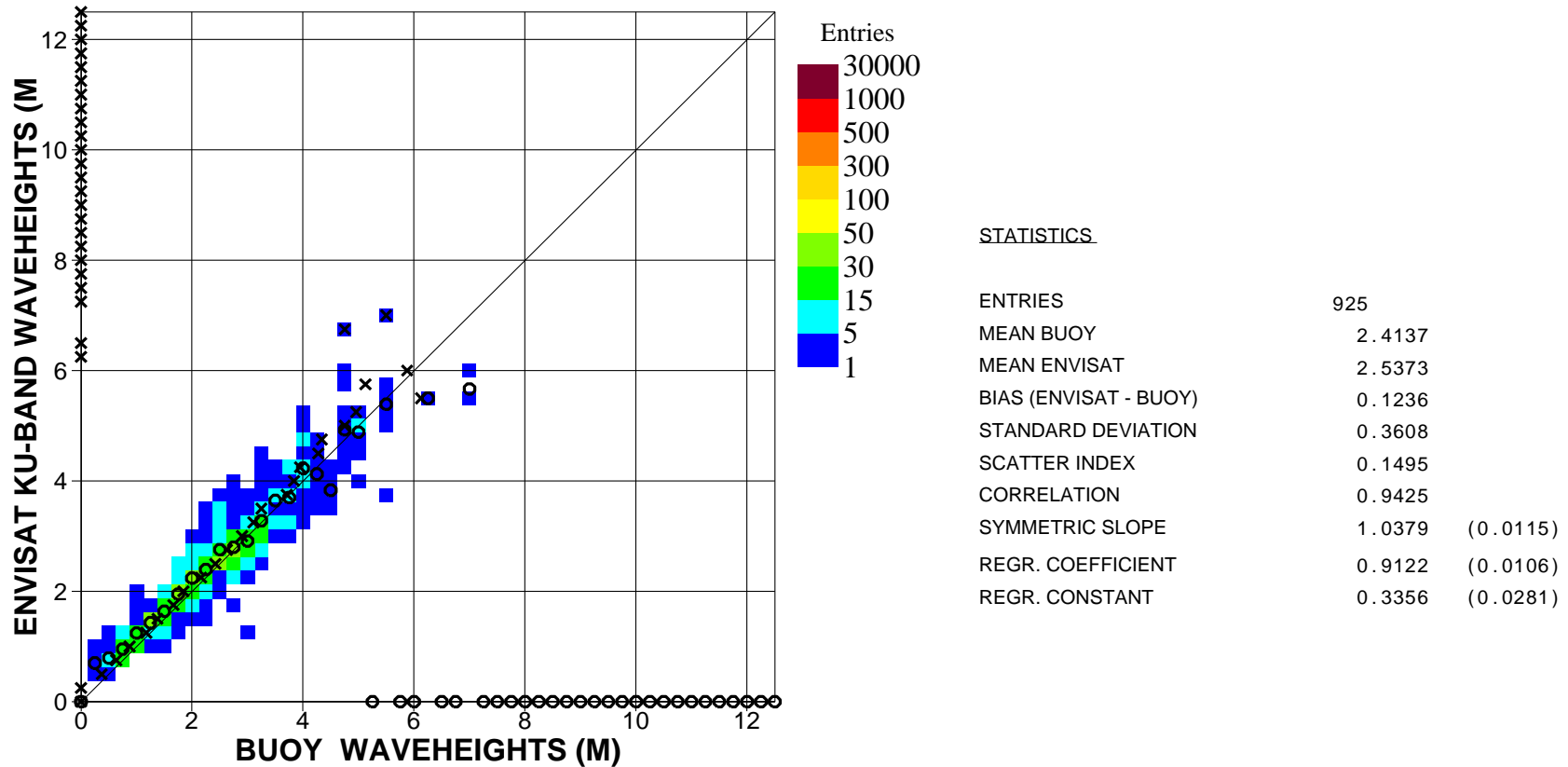


Figure 30. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for April 2003 (Global)

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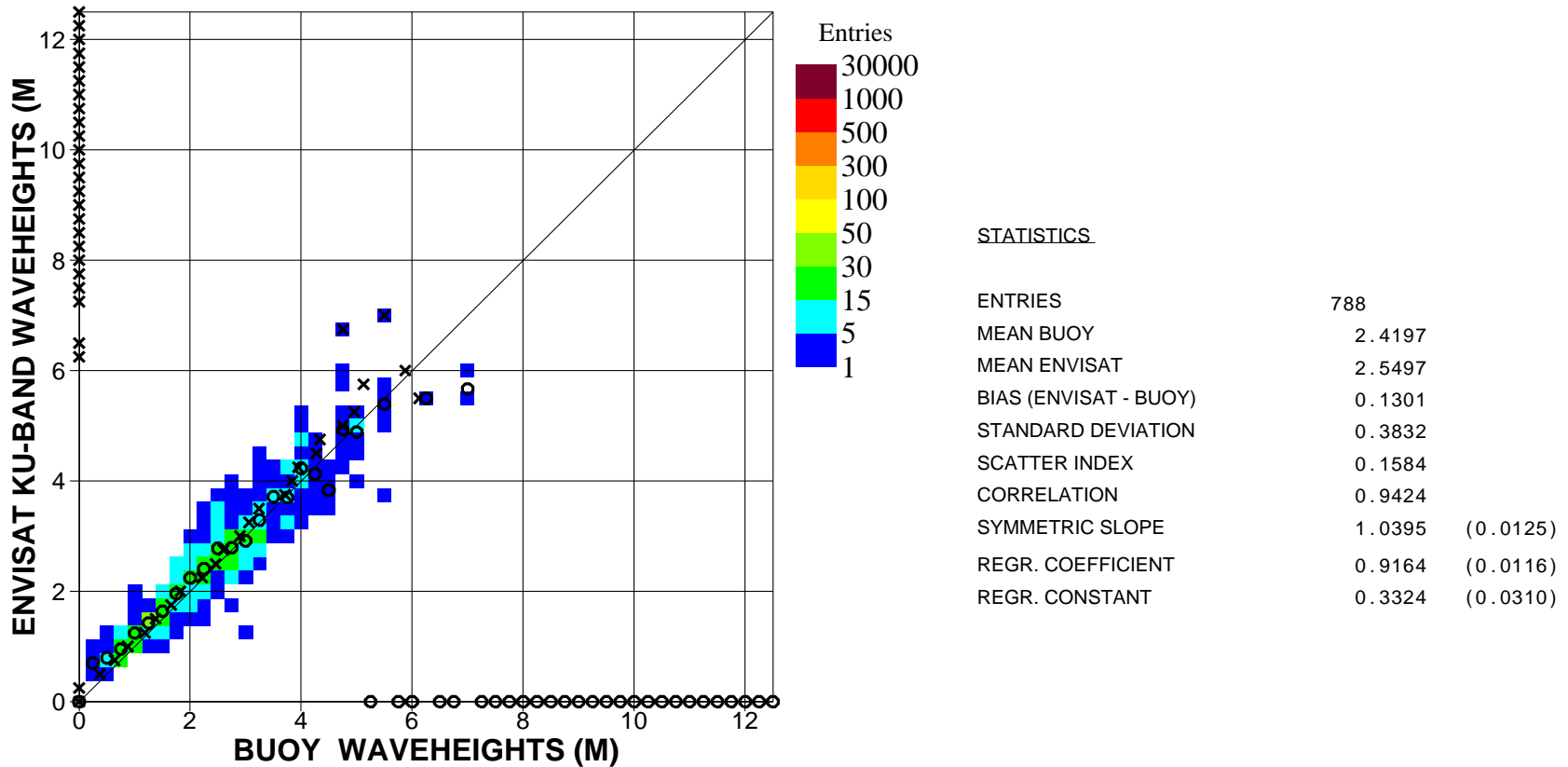


Figure 31. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for April 2003 (N.Hem.)

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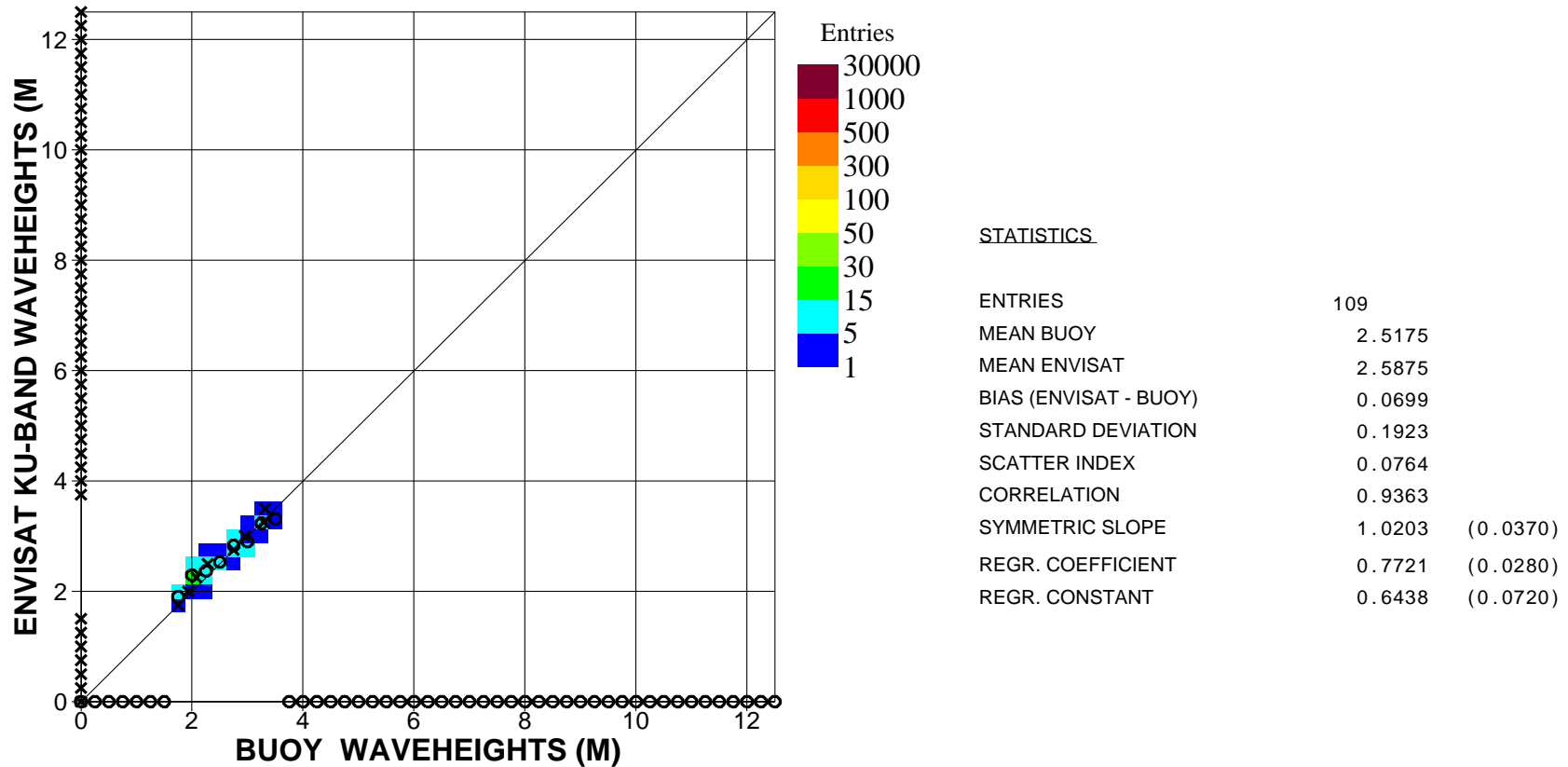


Figure 32. Comparison between ENVISAT Altimeter Ku-Band and buoy significant wave heights for April 2003 (Tropics)

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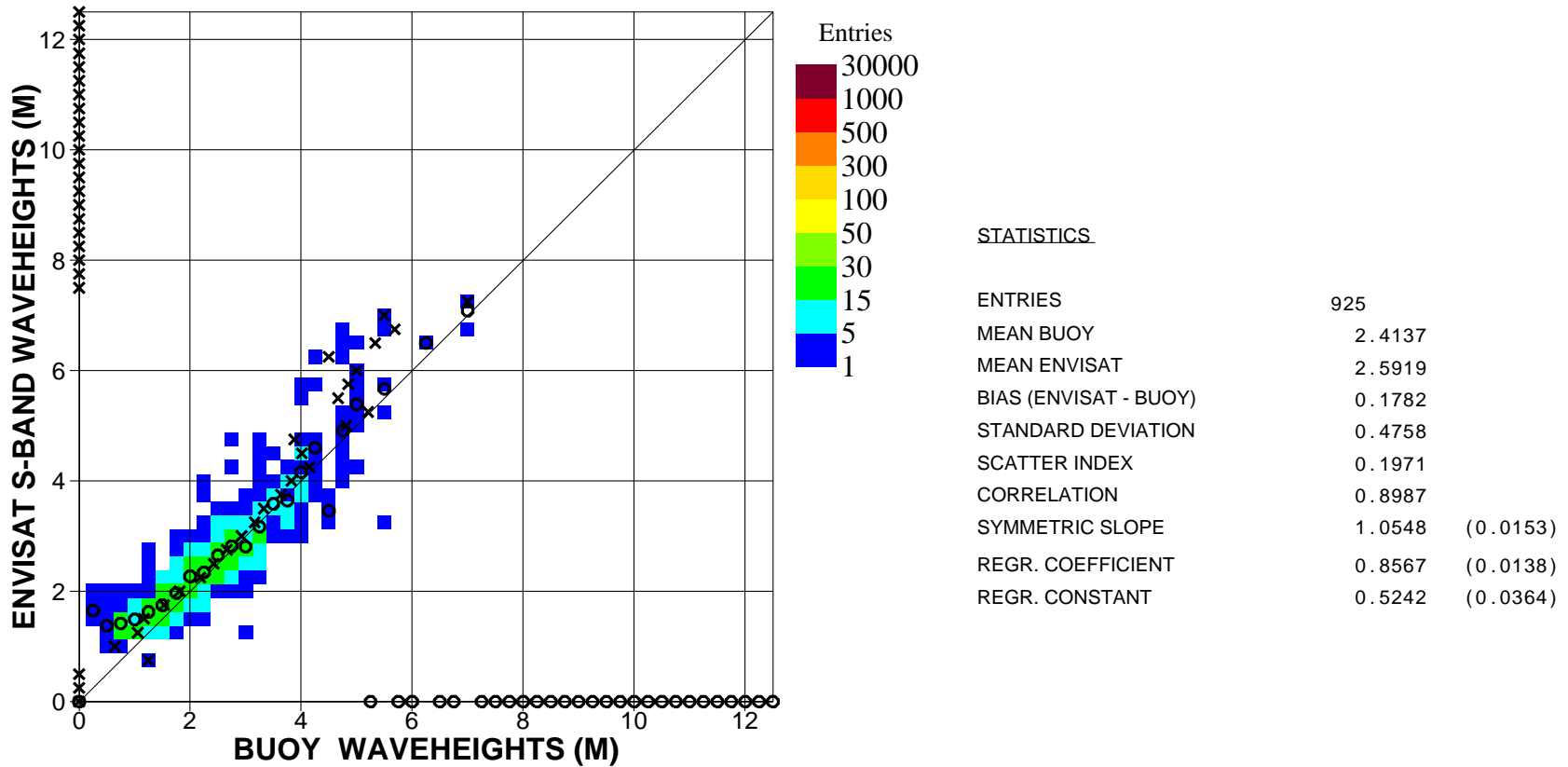


Figure 33. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for April 2003 (Global)

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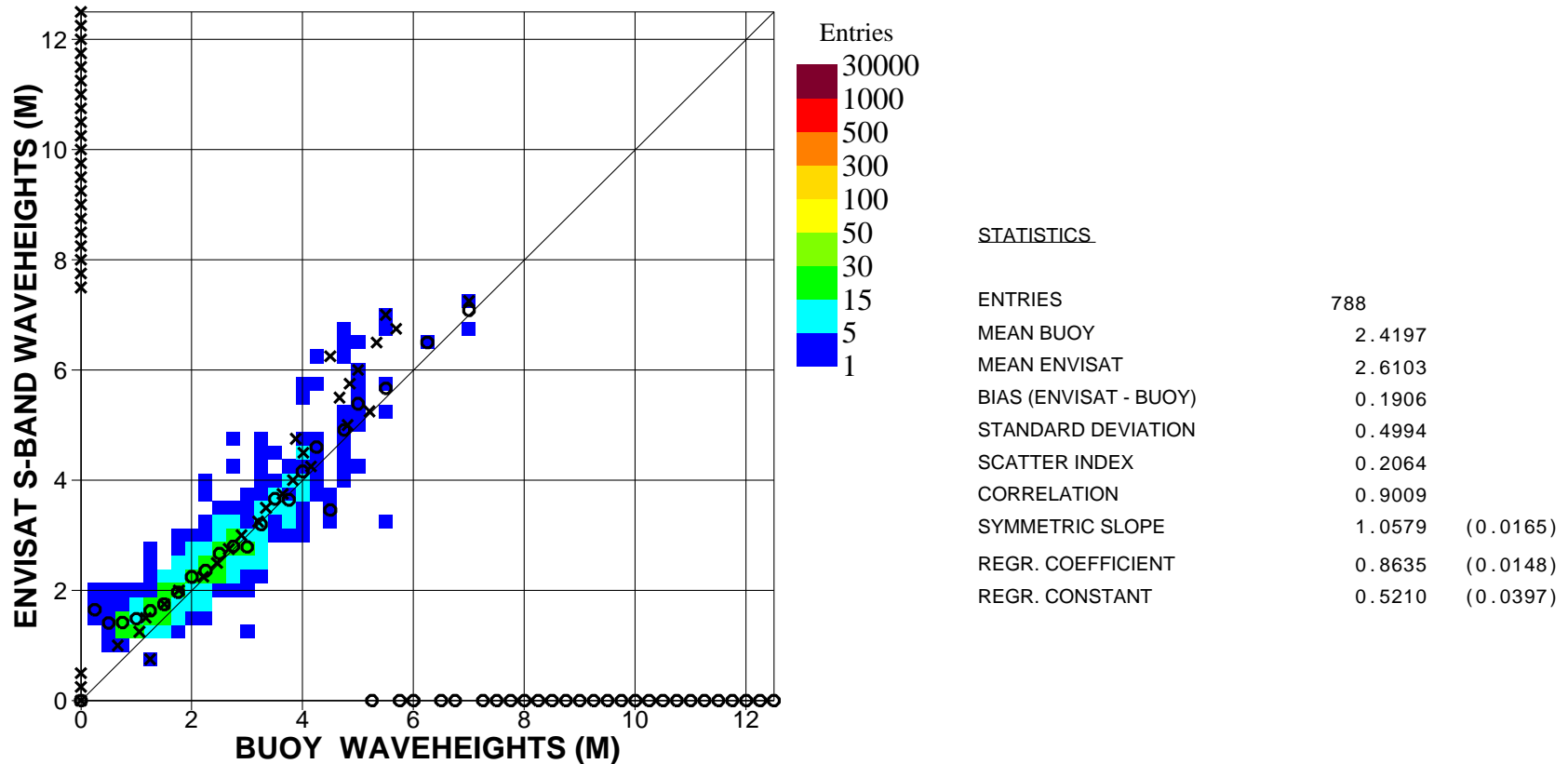


Figure 34. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for April 2003 (N.Hem.)

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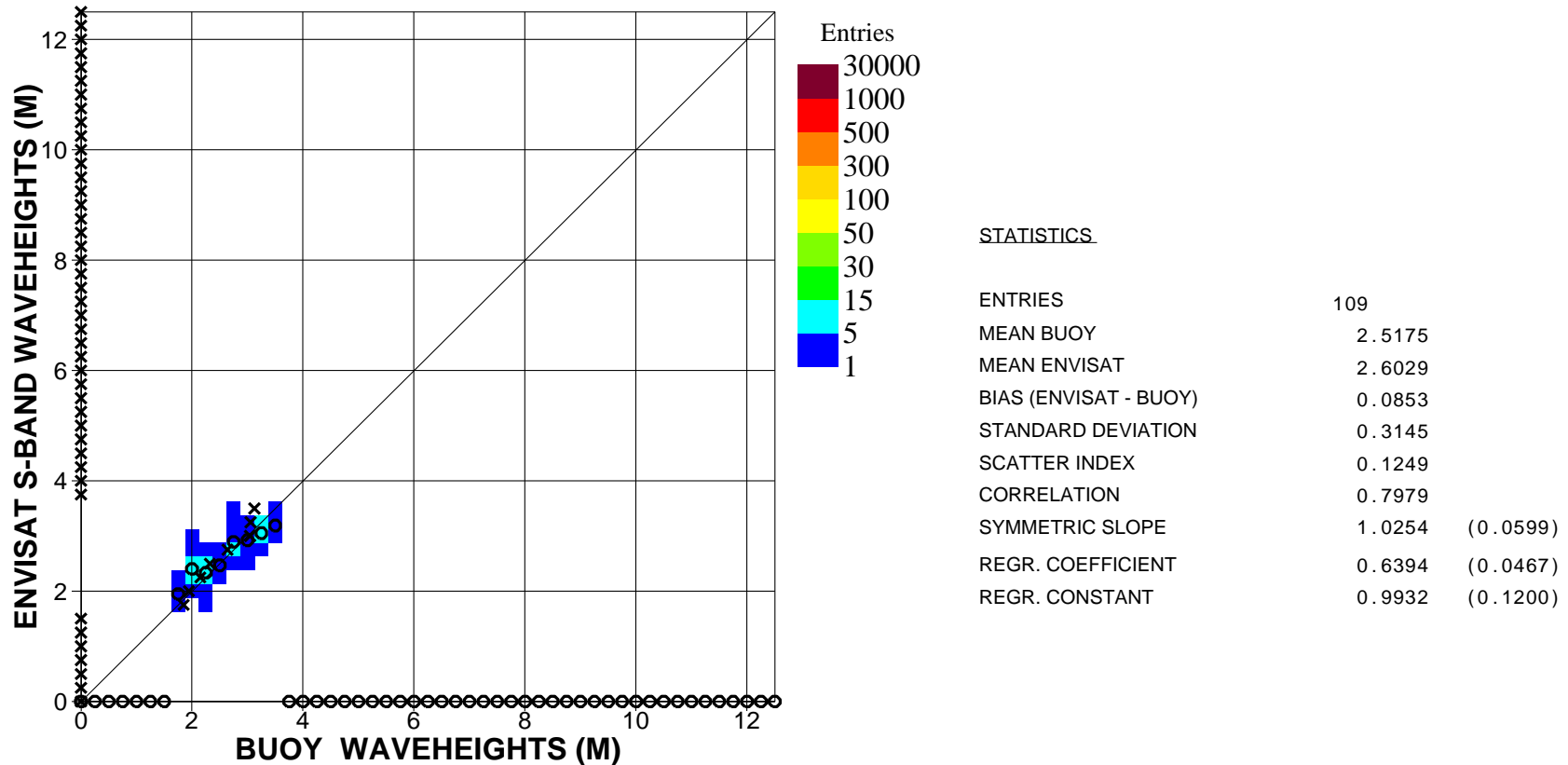


Figure 35. Comparison between ENVISAT Altimeter S-Band and buoy significant wave heights for April 2003 (Tropics)

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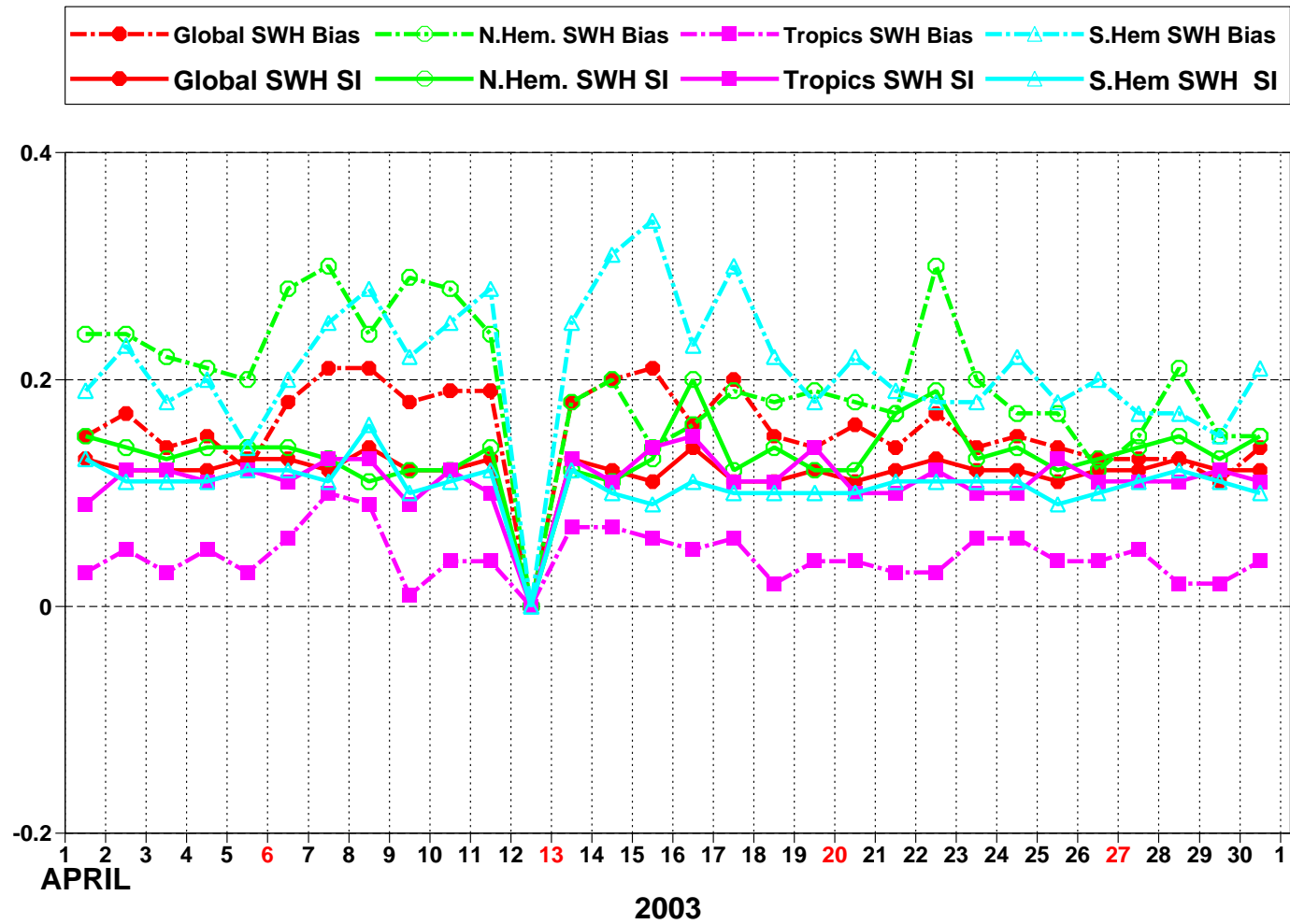


Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM\_FG) and scatter index (SI)

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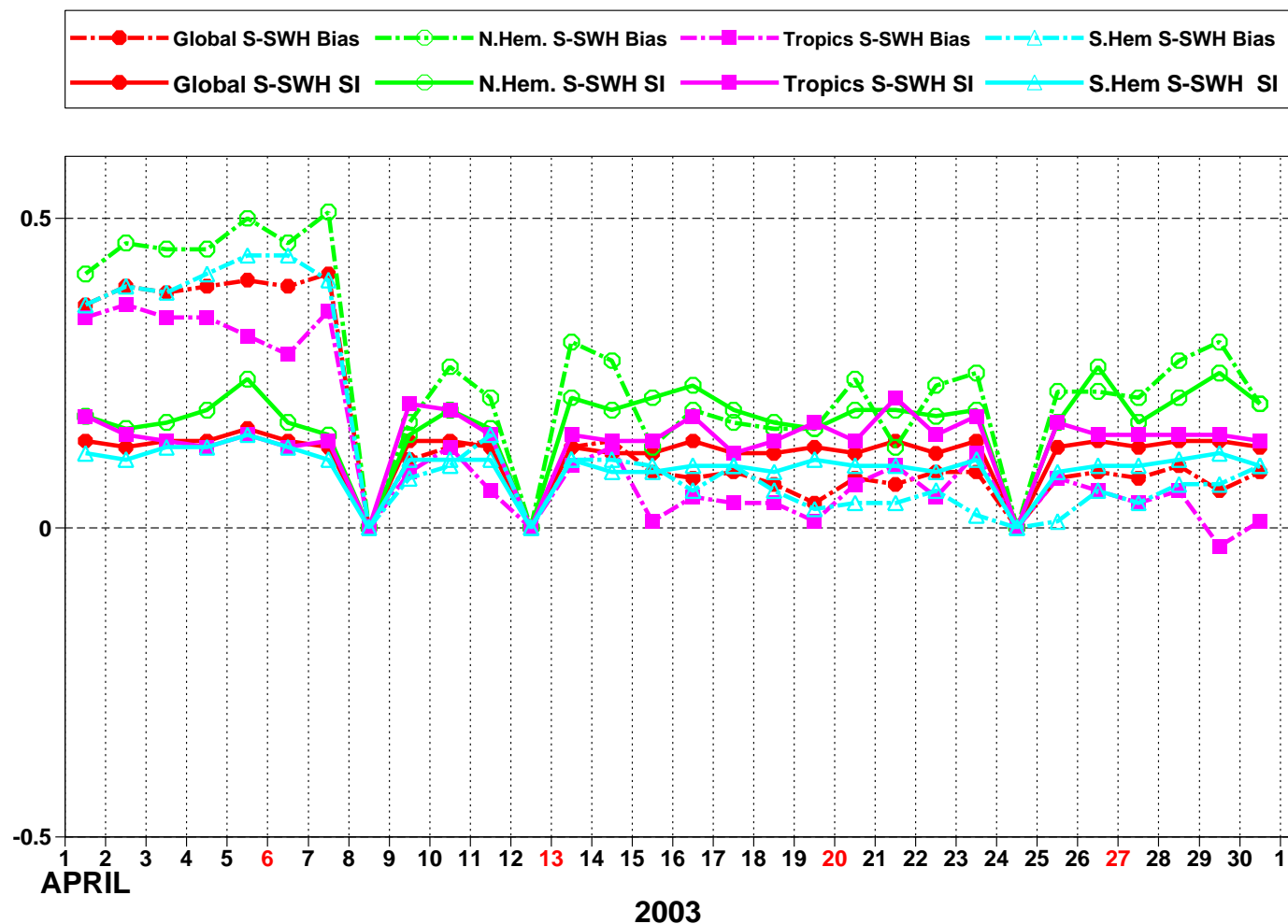


Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM\_FG) and scatter index (SI)



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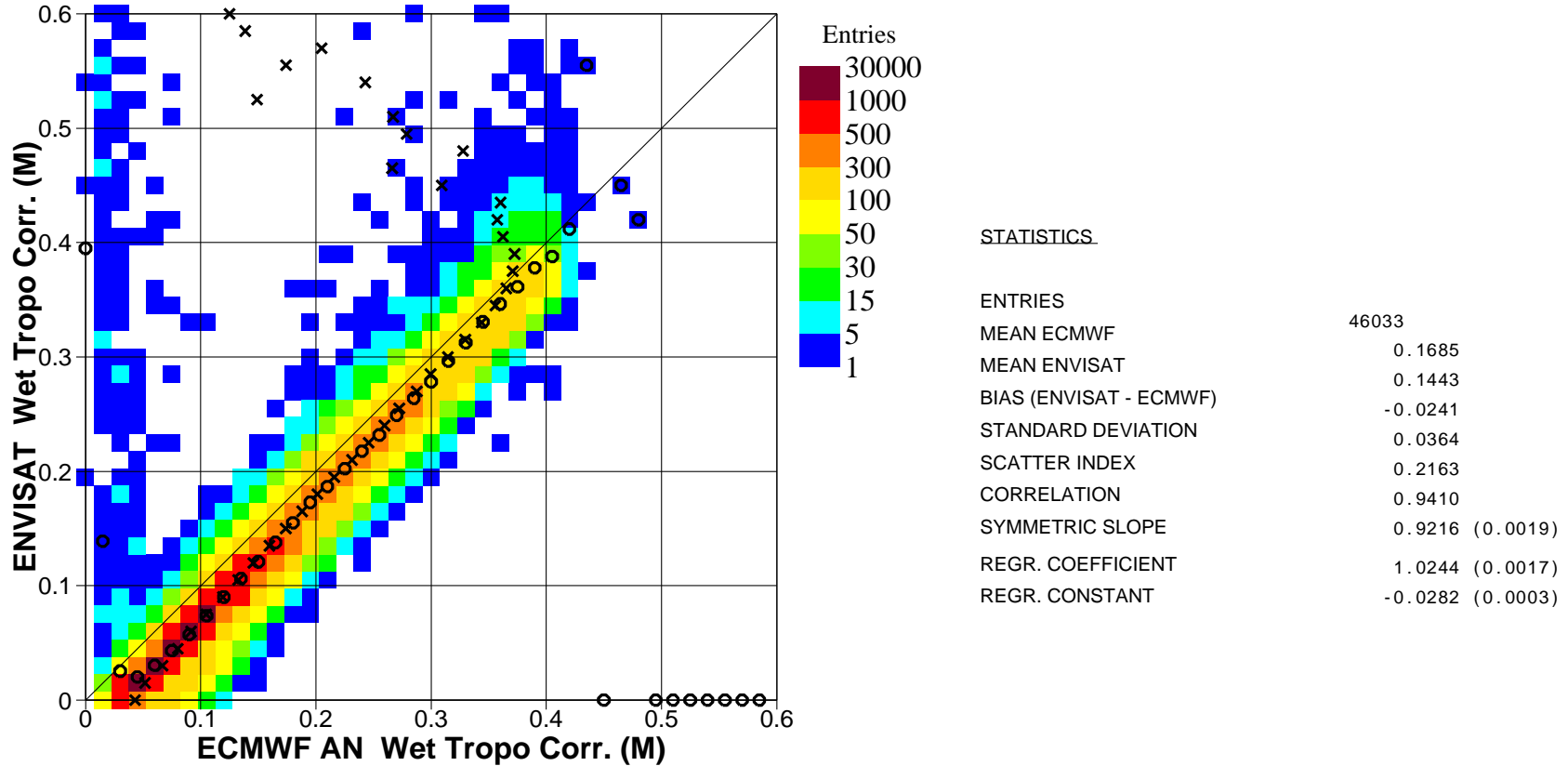


Figure 38. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for April 2003 (Global)

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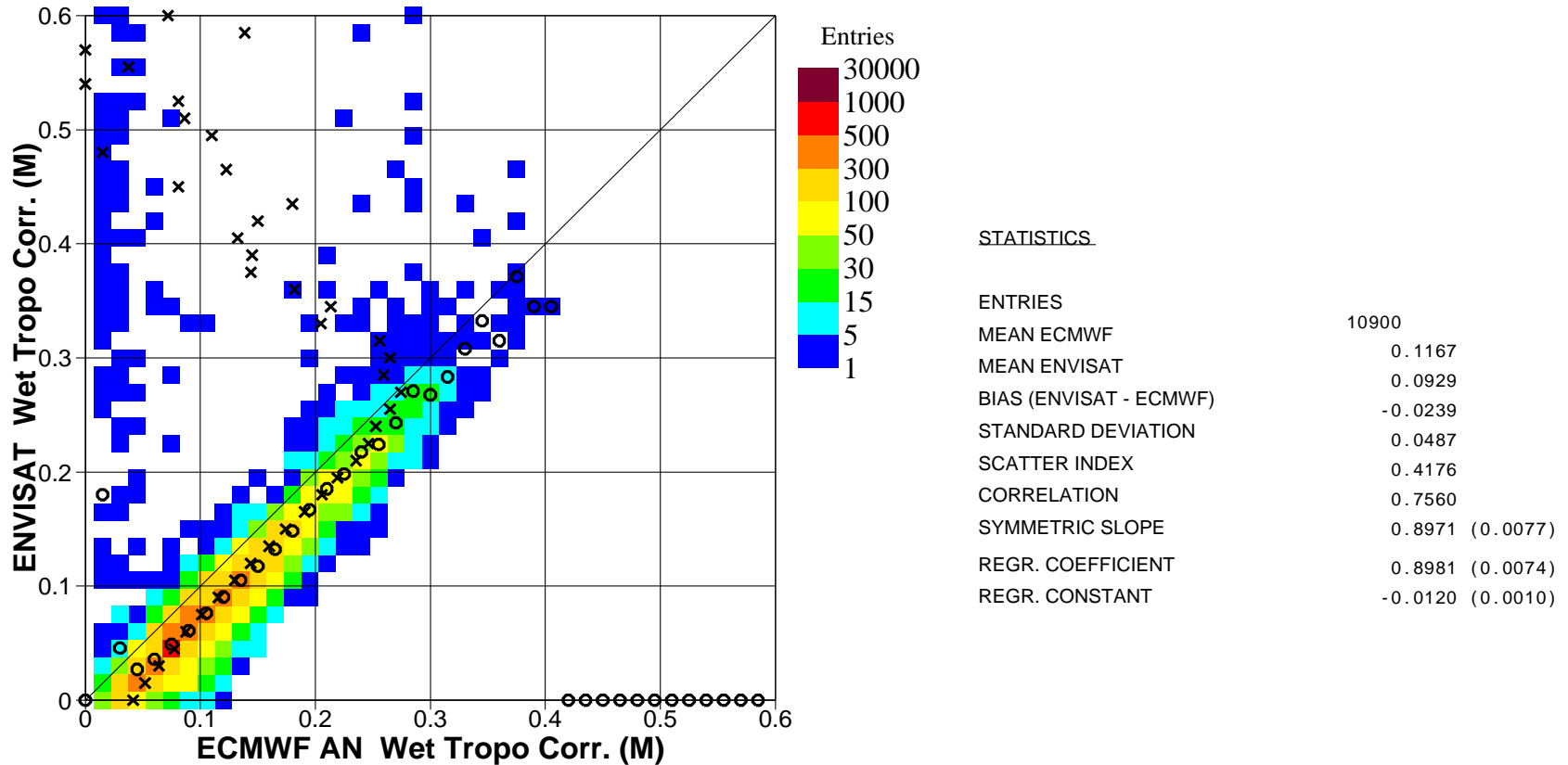


Figure 39. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for April 2003 (N.Hem.)

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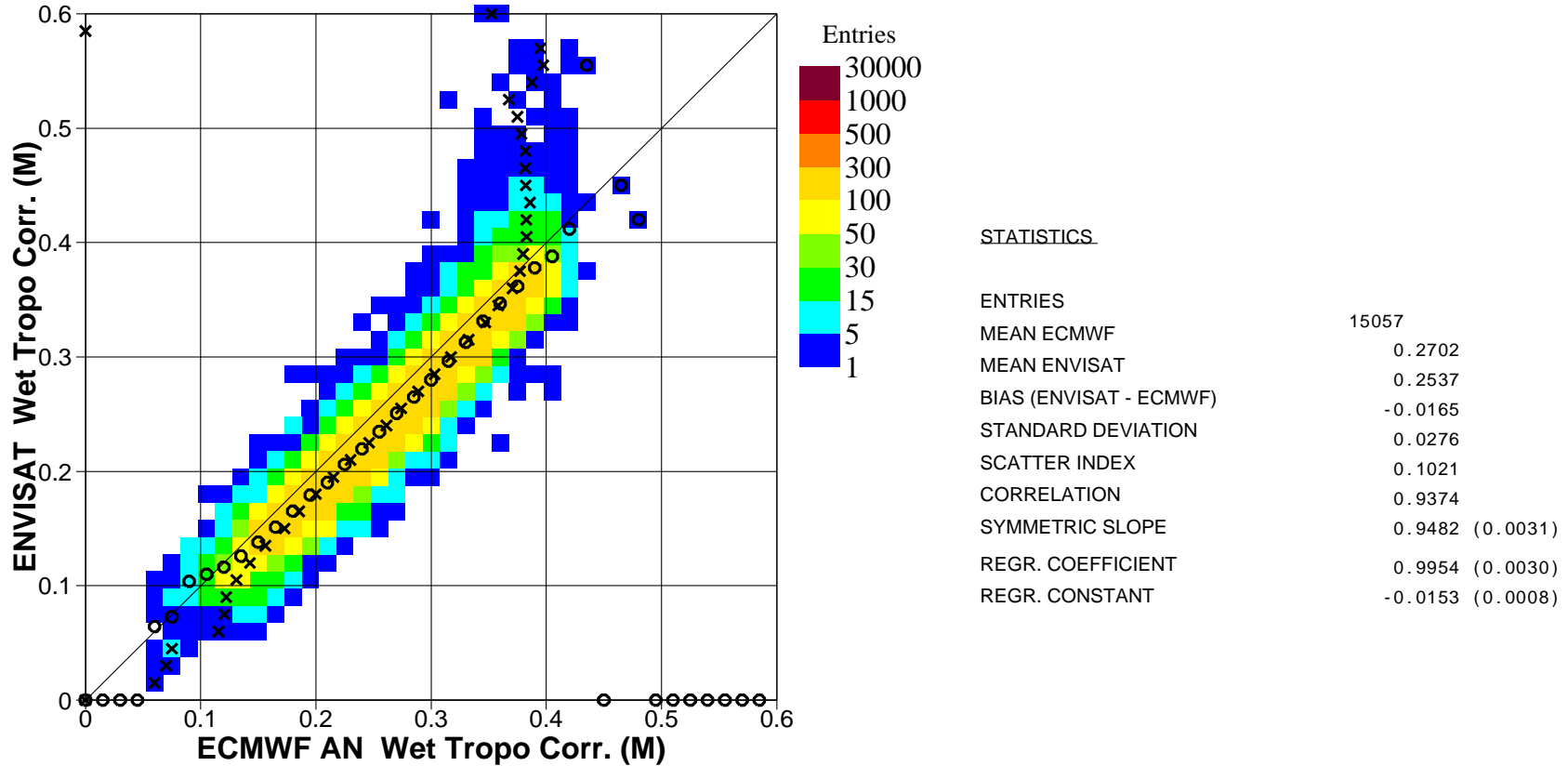


Figure 40. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for April 2003 (Tropics)

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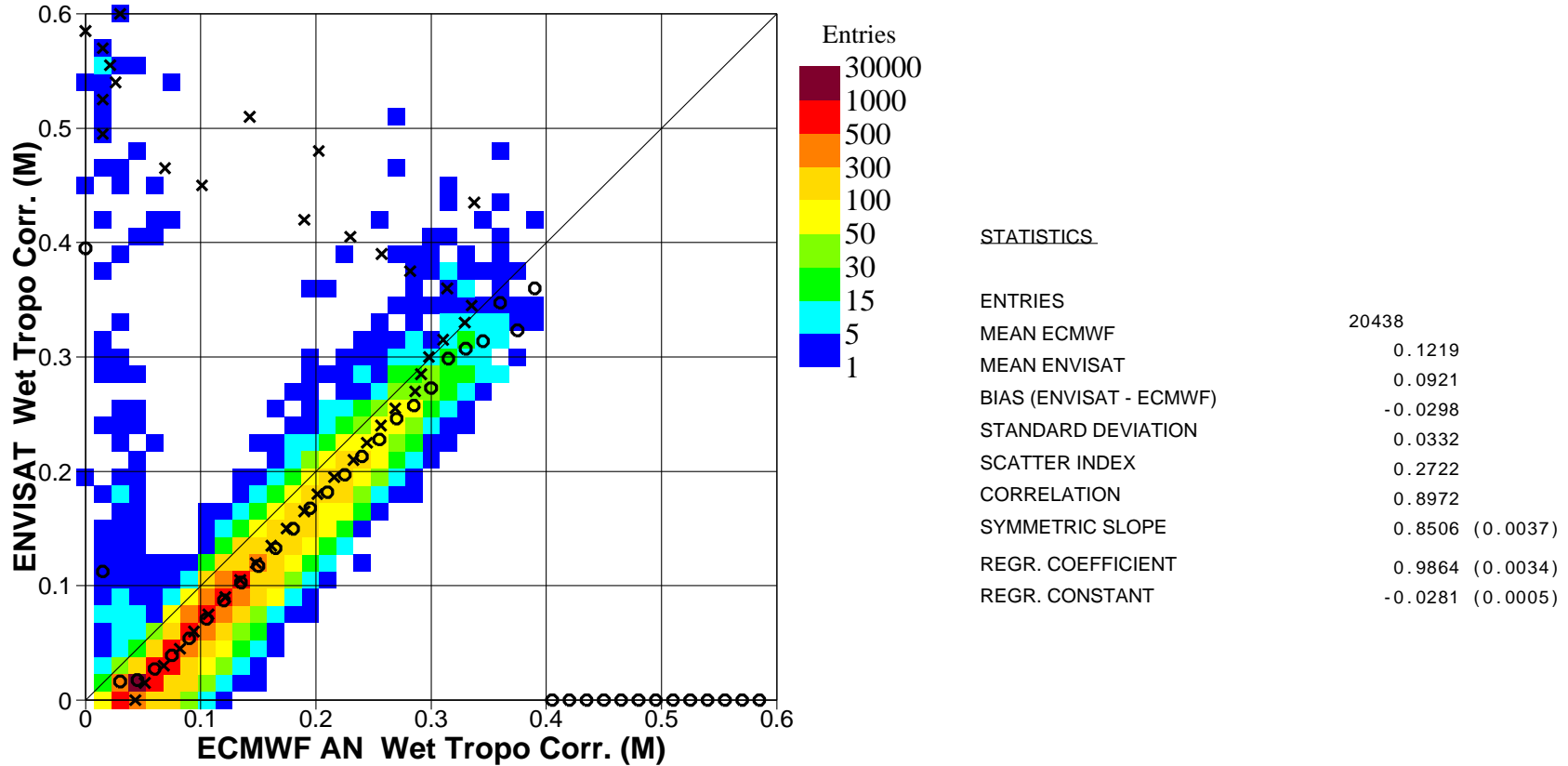


Figure 41. Comparison between ENVISAT MWR and ECMWF (analysis) wet tropo correction for April 2003 (S.Hem.)

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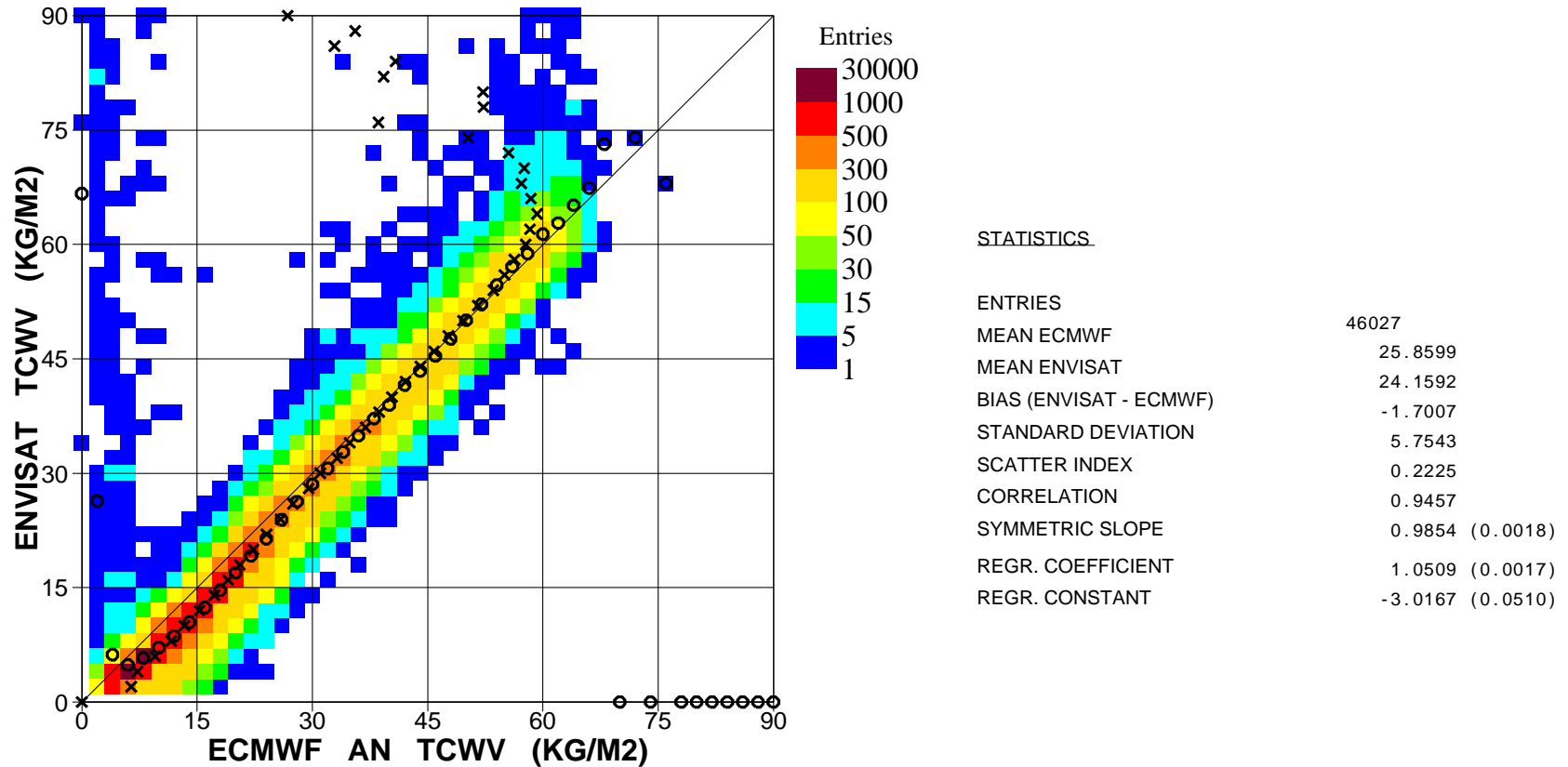


Figure 42. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for April 2003 (Global)

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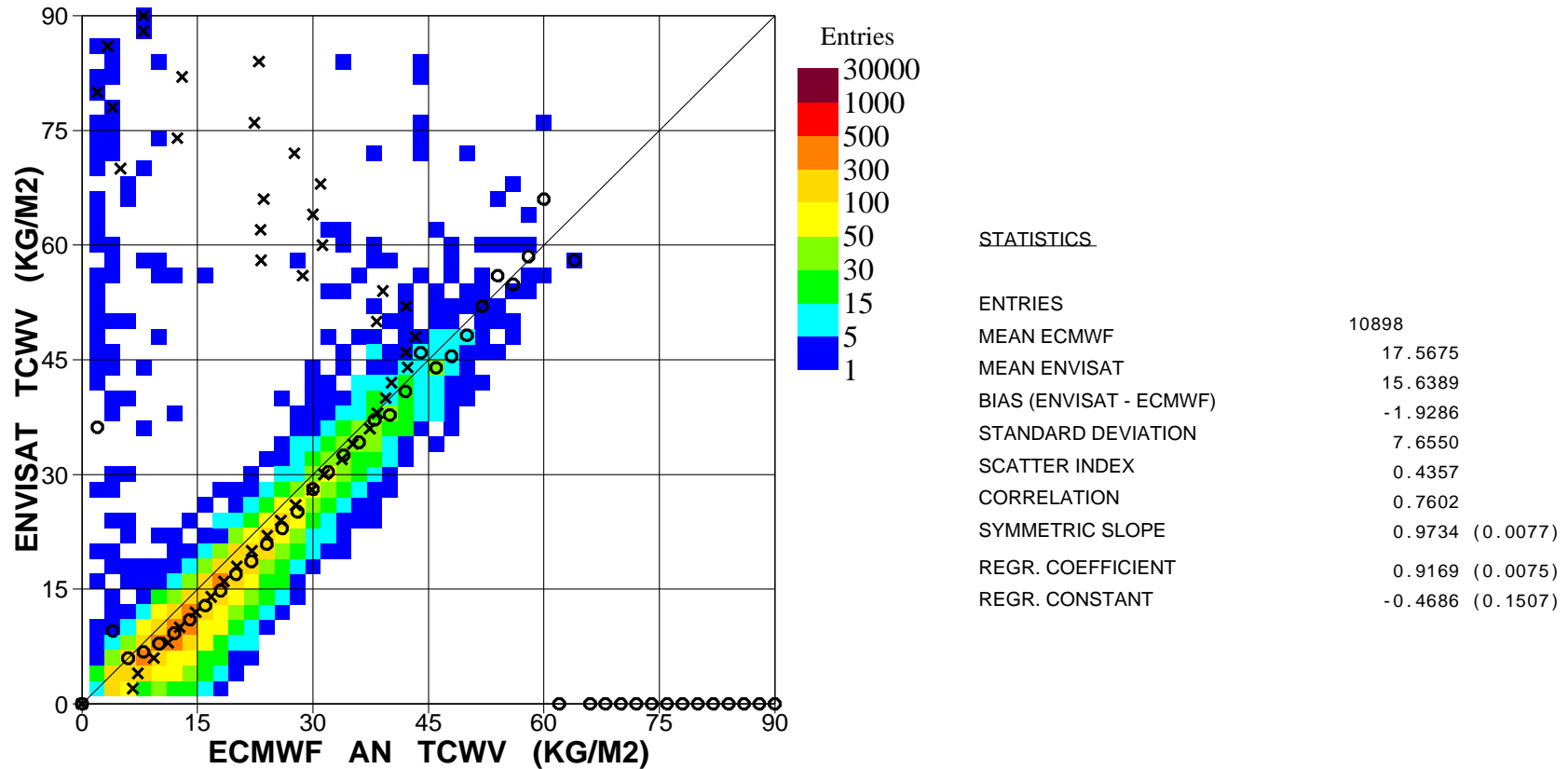


Figure 43. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for April 2003 (N.Hem.)

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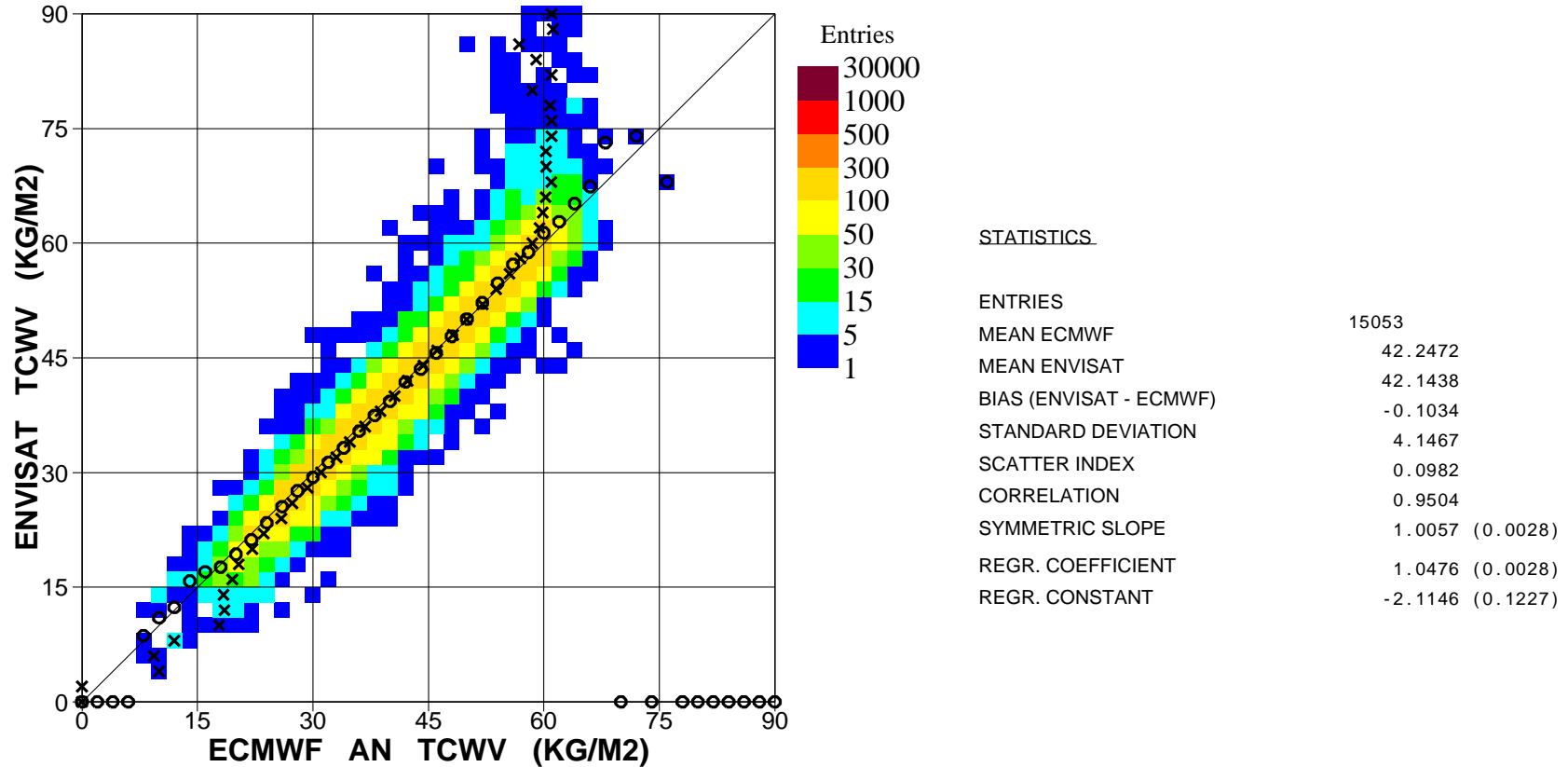


Figure 44. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for April 2003 (Tropics)

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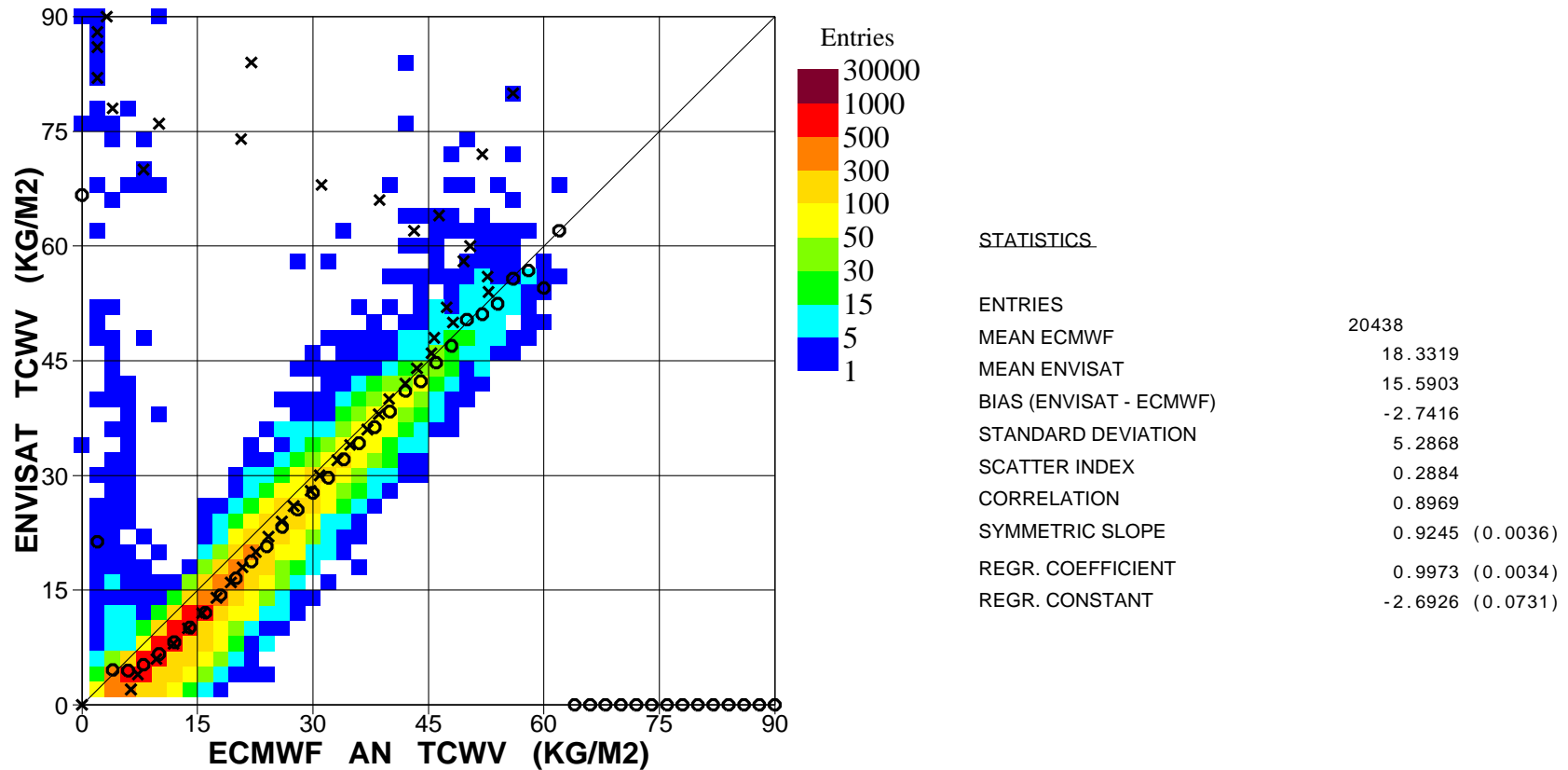


Figure 45. Comparison between ENVISAT MWR and ECMWF (analysis) total column water vapour for April 2003 (S.Hem.)

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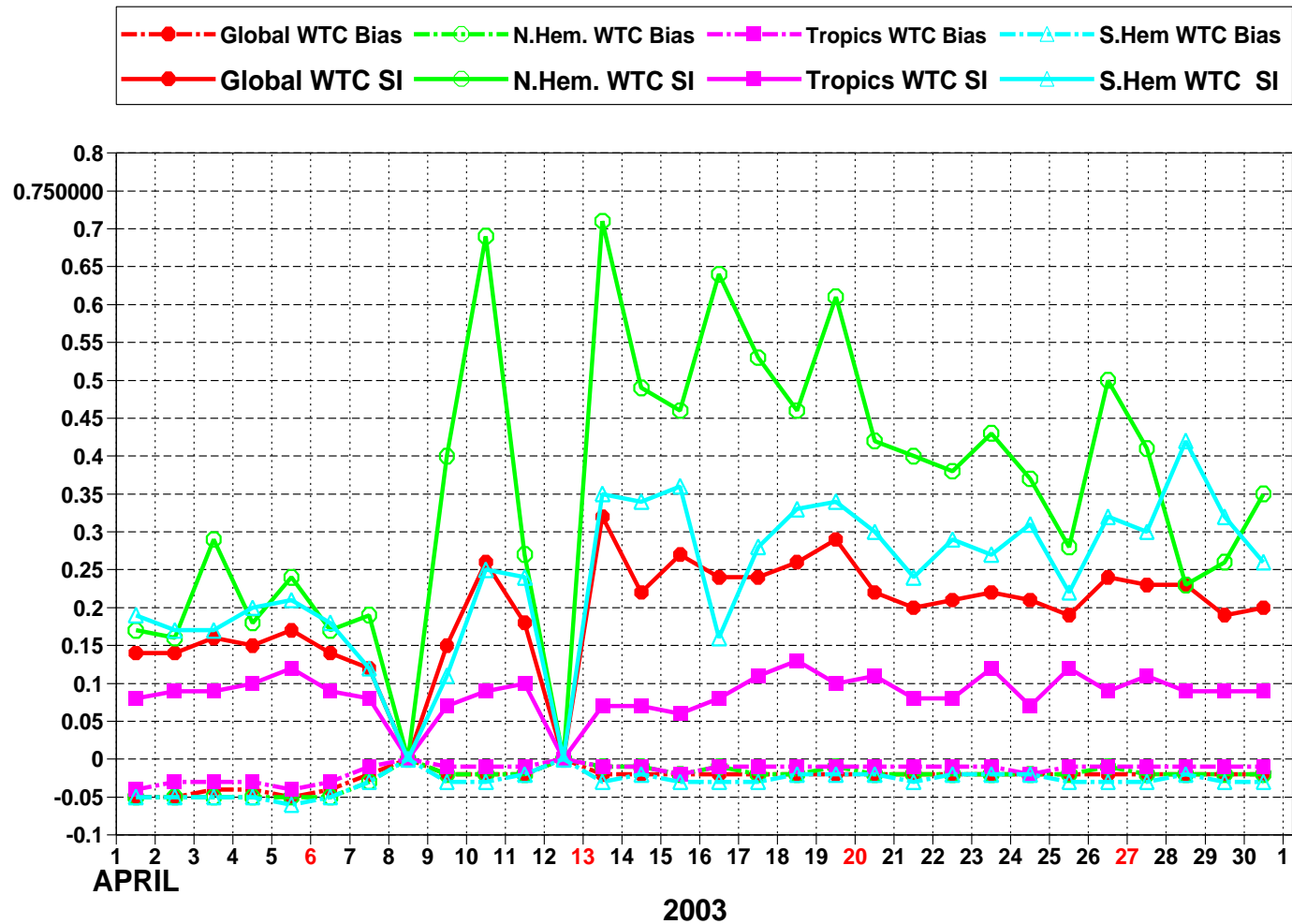


Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)





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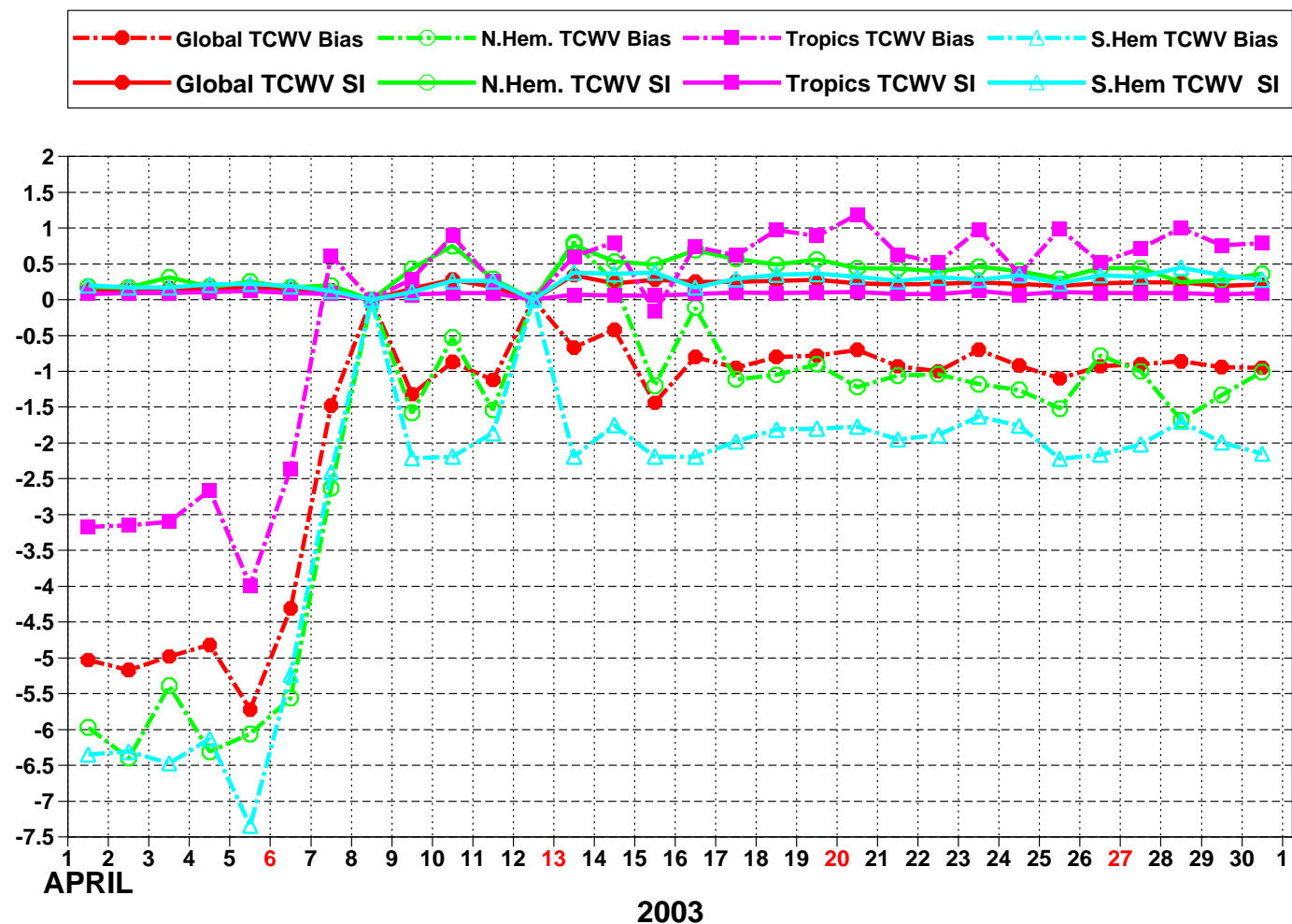


Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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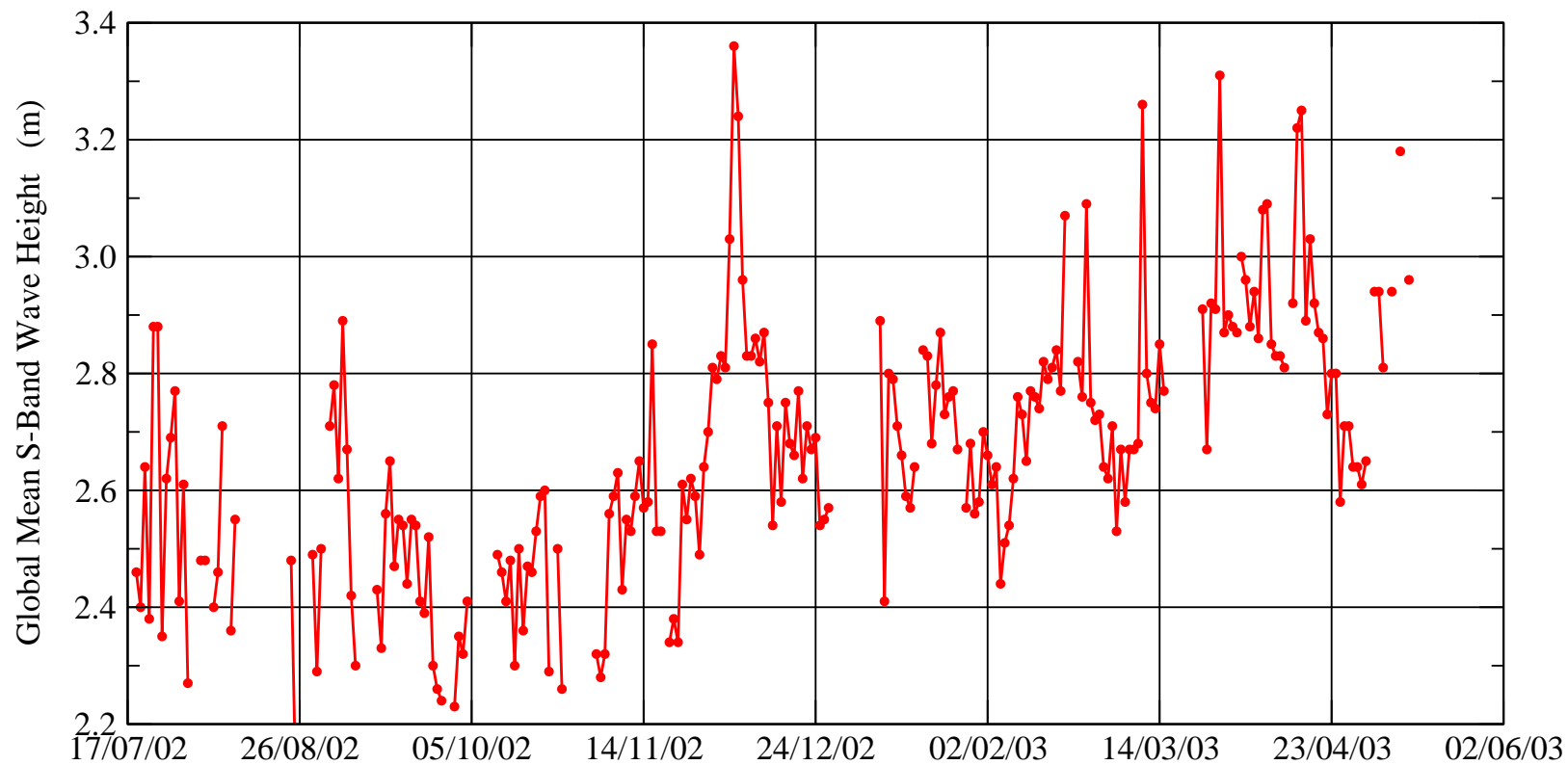


Figure 48. Timeseries of daily global mean of S-Band significant wave height since the 18th. of July 2002.



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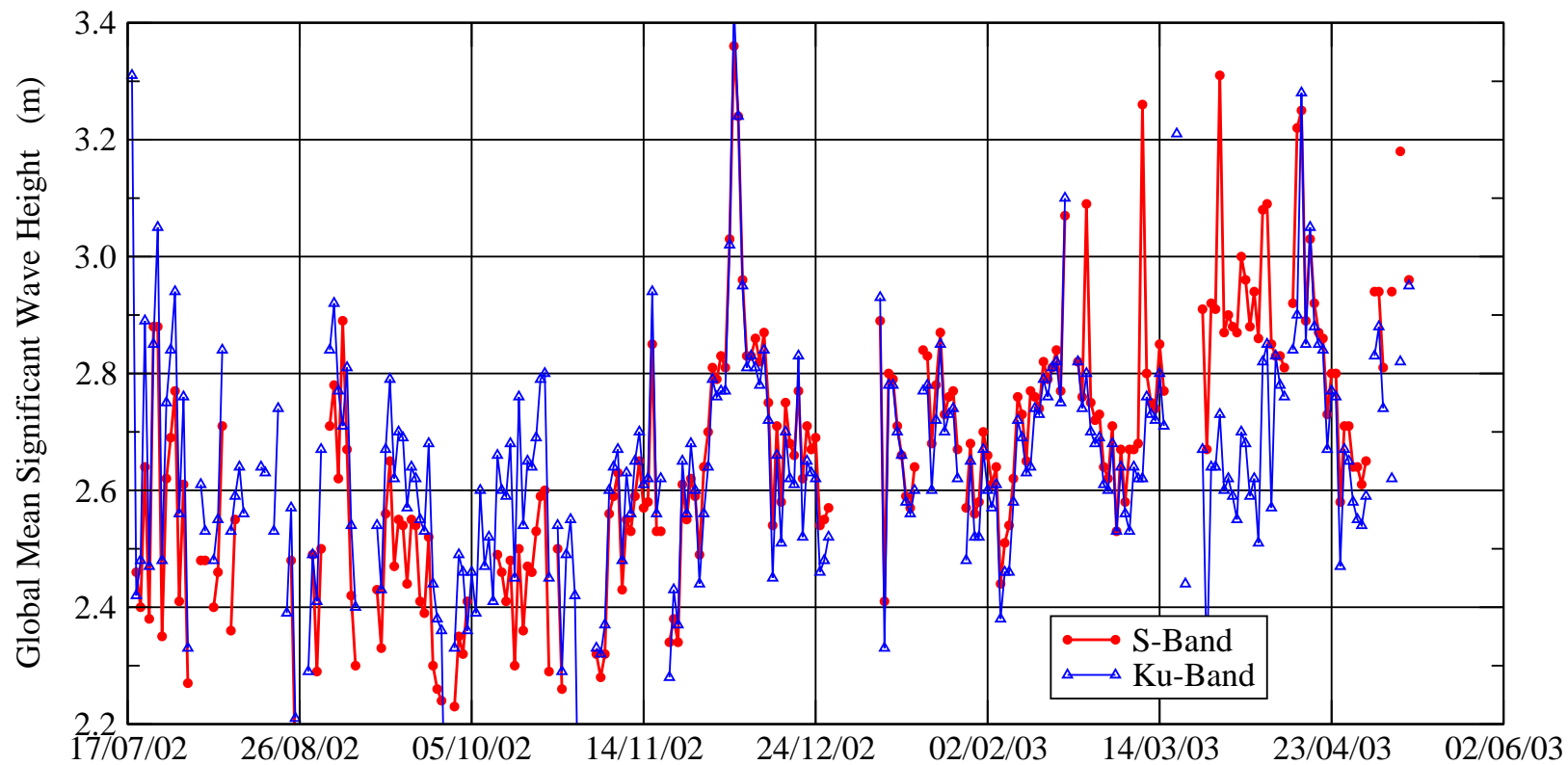


Figure 49. Timeseries of daily global mean of Ku-Band and S-Band significant wave heights since the 18th. of July 2002.

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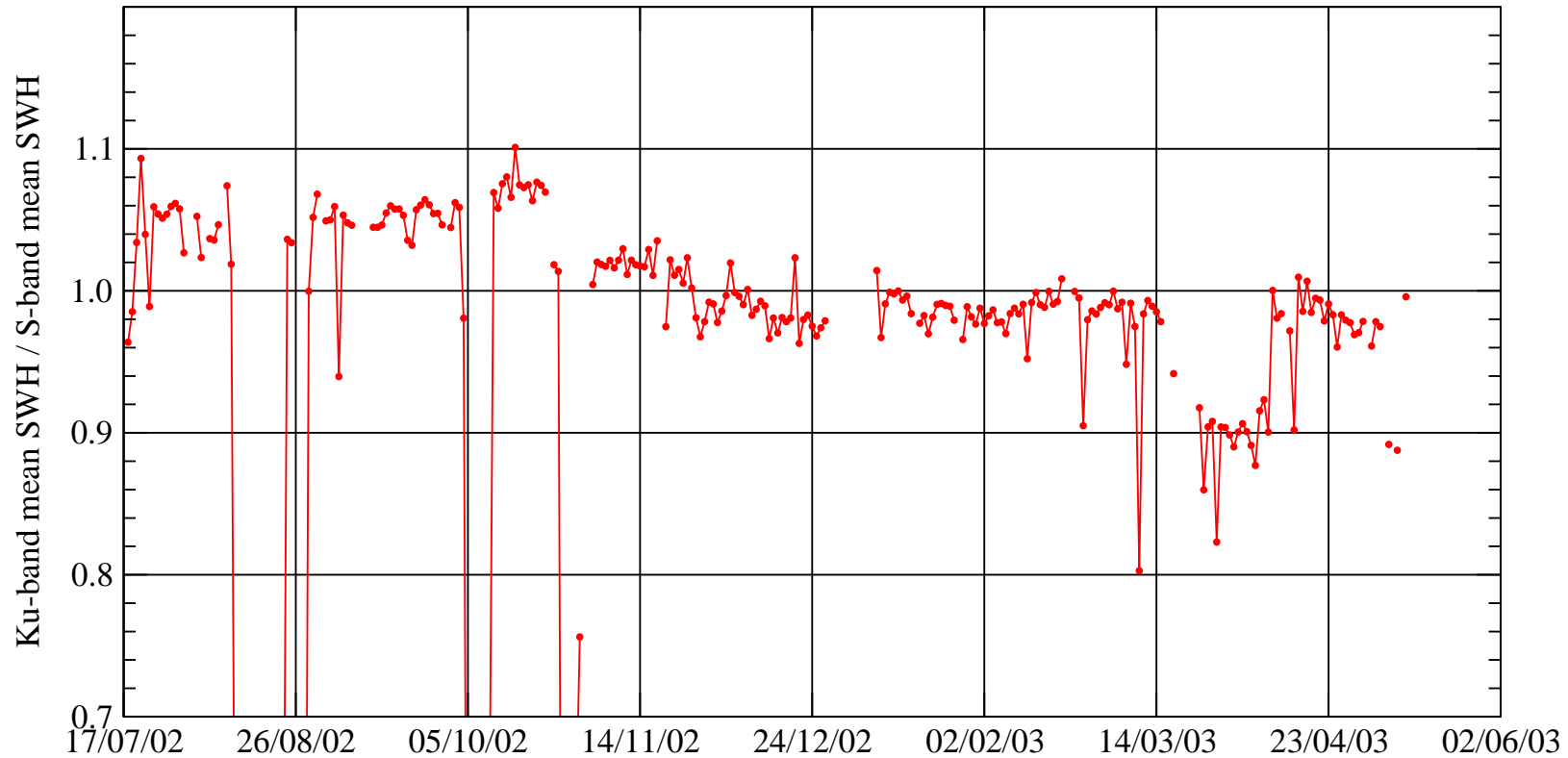


Figure 50. Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 18th. of July 2002.

