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

Wind/Wave Product with Height Information (RA2_WWV_2P)

By: *Saleh Abdalla*

Date: *5 May 2006*

Overview:

Based on the data received during this month, on average, 16092 observations arrived at ECMWF every 6-hour window of which an average of 7626 observations were rejected initially because of one of the following reasons: being over land, being outside model domain, being a double observation or flagged for rain contamination. On average 72.75% of the remaining part passed the quality control. As can be seen in Figure 1, there was no data during the periods (in terms of 6-hour time-windows; all times are in UTC):

- from 00:00 on the 6th. to 12:00 on the 8th. of the month (both inclusive), and
- time window centred at 00:00 on the 21st. of the month.

Furthermore, there was significant reduction in data volume during the following periods:

- time windows centred at 00:00 on the 1st., the 2nd., the 3rd., the 4th., the 5th. and the 16th. of the month,
- time windows centred at 06:00 and 12:00 on the 4th. of the month,
- time window centred at 06:00 on the 21st. of the month.

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 excellent 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 good. 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 rain flag was rather active during the whole month as was the case during last few months.**

Backscatter:

- ENVISAT Ku-band $<\sigma_0>$ = 11.07 dB (with a main peak at 11.1 dB and a secondary peak at 10.6 dB).
- ENVISAT S-band $<\sigma_0>$ = 11.30 dB (with a main peak at 10.6 dB and two secondary peaks at 10.1 and 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	15.5	- 0.21	18.5
Northern Hemisphere	+ 0.17	16.2	- 0.19	19.3
Tropics	+ 0.06	15.2	- 0.30	12.8
Southern Hemisphere	+ 0.48	14.7	----	----

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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	10.1	0.13	15.9
Northern Hemisphere	0.13	11.5	0.14	16.4
Tropics	0.08	8.8	0.08	10.4
Southern Hemisphere	0.12	9.6	----	----

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

	RA2 (S) - WAM		RA2 (S) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	- 0.01	13.7	+ 0.07	21.0
Northern Hemisphere	+ 0.07	16.1	+ 0.08	21.7
Tropics	+ 0.09	17.5	+ 0.00	12.9
Southern Hemisphere	- 0.11	10.4	----	----

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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	- 0.013	8.4	- 0.60	8.2
Northern Hemisphere	- 0.015	10.3	- 1.41	9.9
Tropics	- 0.015	5.9	+ 0.12	5.7
Southern Hemisphere	- 0.011	10.6	- 0.64	10.2

Remarks:

- **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.**
- There was no related ECMWF model changes this month (current operational cycle is CY30R1 since 1 February 2006).
- 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.

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- **The rain flag is responsible for the rejection of 11% of the data this month. This value, which is similar to the last few months, is more than double the usual value few months ago. The rain flag was rather active 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 wave model with a scatter index reduced by more than 5% compared to months before the implementation of the IPF version 5.02. ENVISAT wind speed product is now about 30 cm/s higher than the model. This value is supported by the comparison between the model and the in-situ observations. The upper limit of the algorithm is now shifted from 20.0 to 21.3 m/s.
- There is a trend for Ku-band wave heights to be overestimated by about 4.5% when compared to WAM results (5.7% in the NH, 4.4% in Tropics and 4.2% in SH). This is visually clear in the scatter plots in Figures 22-25 (Ku-band - WAM comparisons) and can be inferred from the symmetric slope values in same scatter plots. On the other hand, the RA-2 Ku-band wave heights are about 3.8% 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 in the Tropics (with low sea state dominance).

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- The ratio between Ku-band and S-band wave heights this month was slightly above 1.0 as can be seen in Figure 48. The new processing chain (IPF ver. 5.02) caused this ratio to increase. It is important to notice the seasonal variation for this ratio with low values (~0.92-0.94) reached during the period from late April to late September and high values (slightly less than 1.0) during the remaining part of the year.
- 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/m^2 as can be seen in Figures 42-45. It occurs almost anywhere. Although this type of outliers is always there, it was noticed only when it became clear in the rather long-period scatter plots. This will be investigated further at a later stage. The additional quality control criteria mentioned above did not help much to eliminate this kind of outliers.**
- 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.
- 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.

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List of Figures:

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Figure 45: Comparison between ENVISAT MWR and ECMWF total column water vapour for April 2006 (Southern Hemisphere).

Figure 46: ENVISAT MWR wet tropospheric correction: Timeseries of daily bias (MWR-model) and scatter index for April 2006.

Figure 47: ENVISAT MWR total column water vapour: Timeseries of daily bias (MWR-model) and scatter index for April 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.

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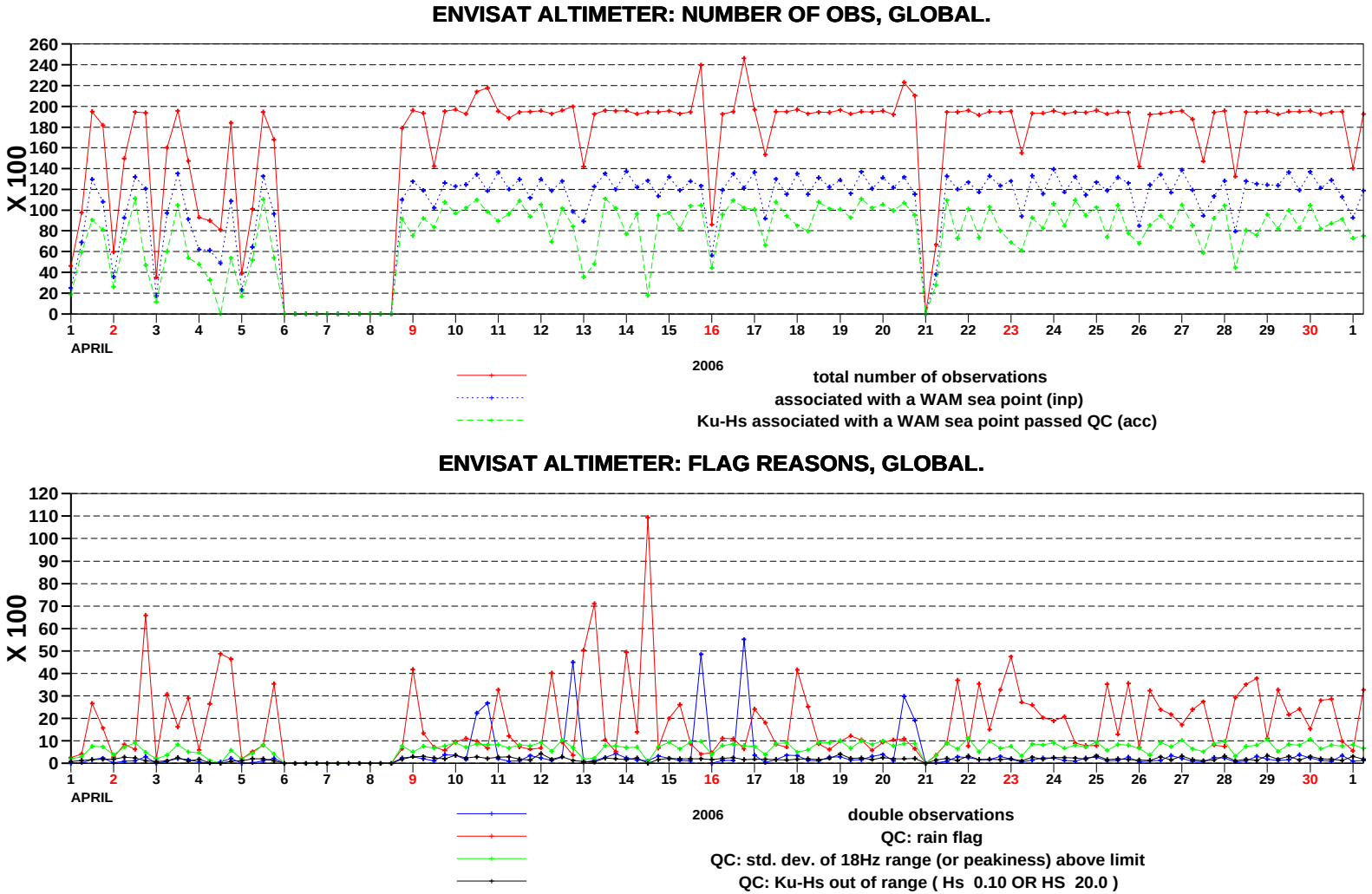

Figure 1: Time series of data reception for ENVISAT Altimeter data for April 2006

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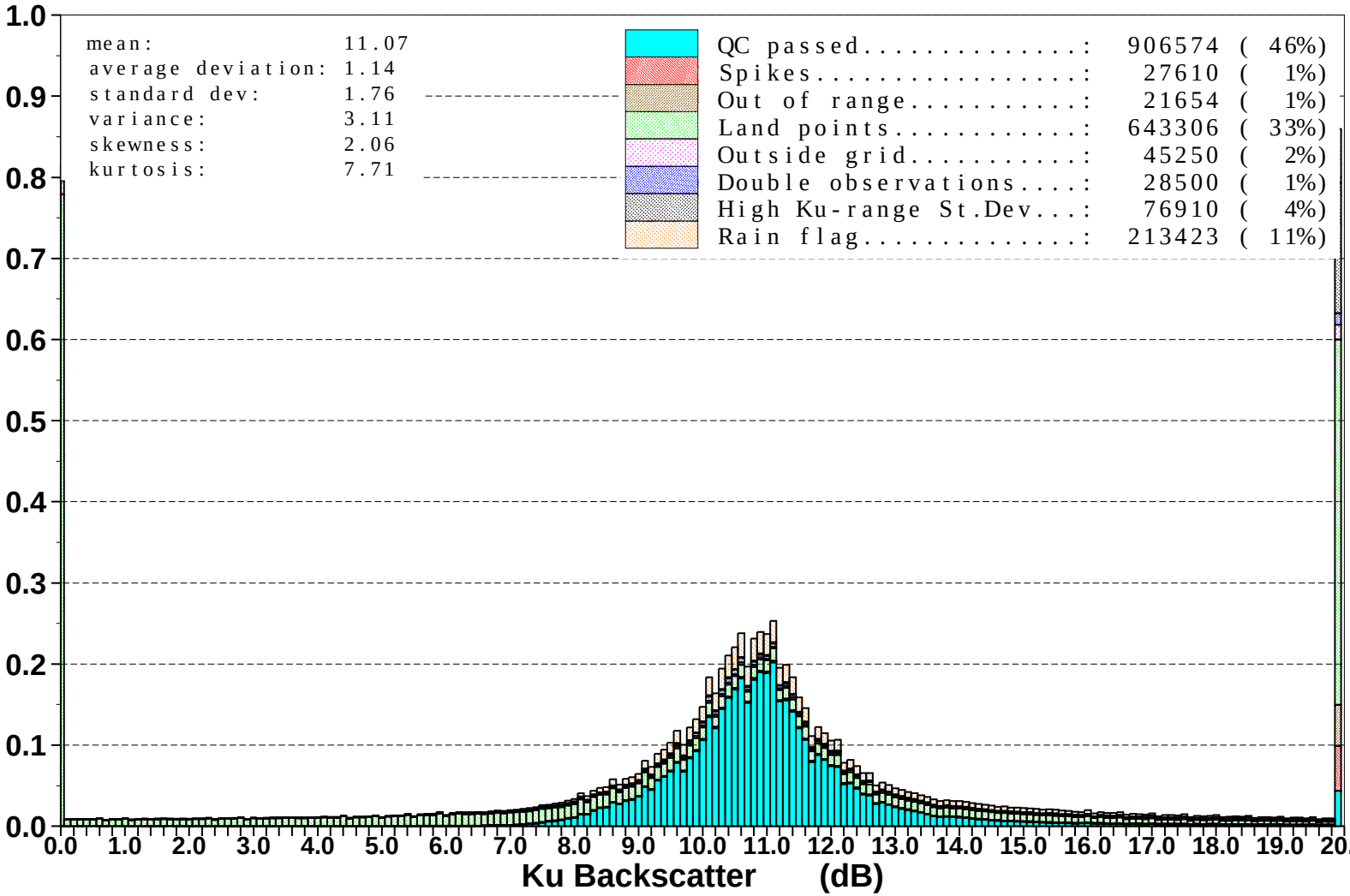

Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for April 2006

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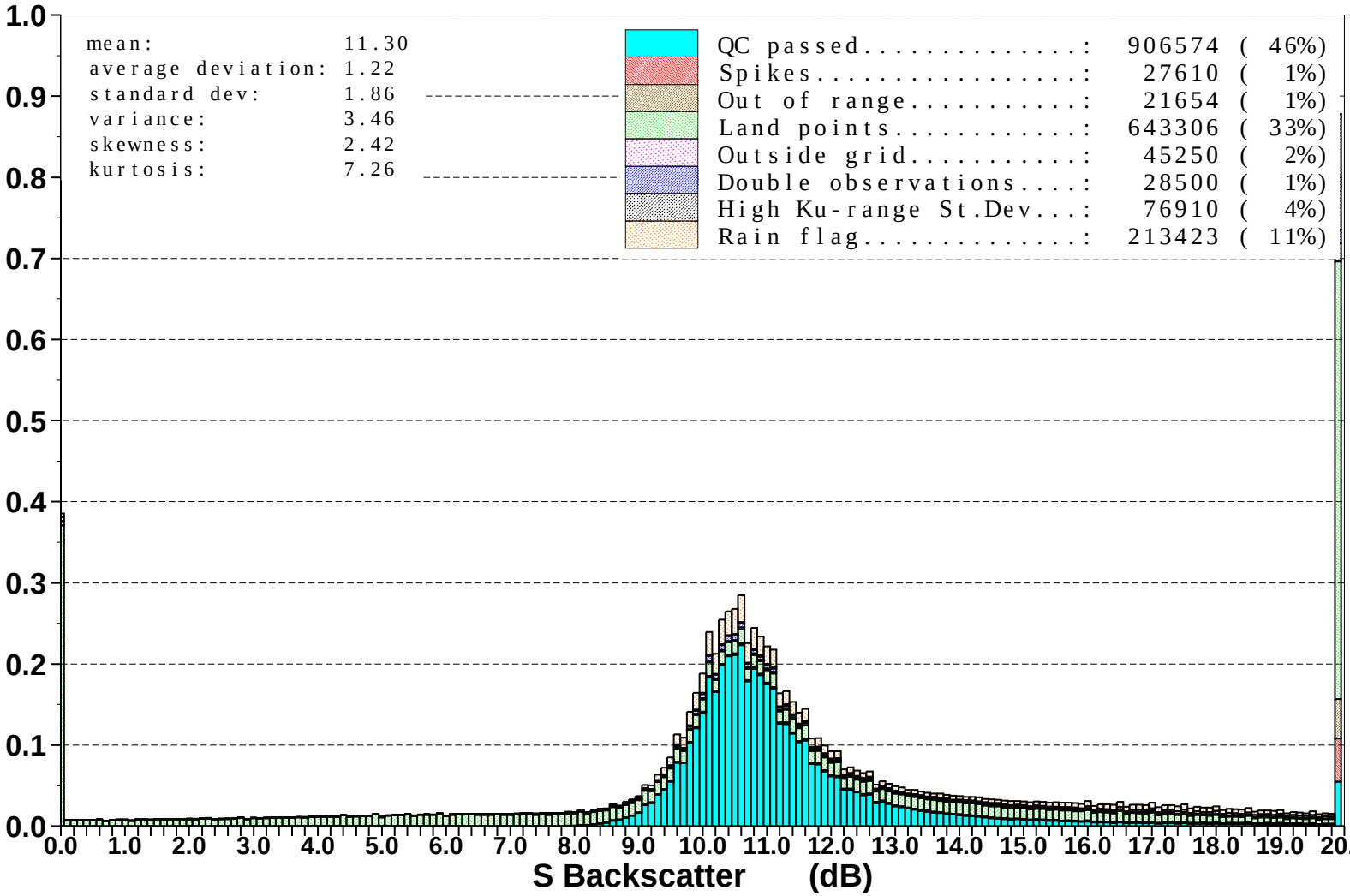

Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for April 2006

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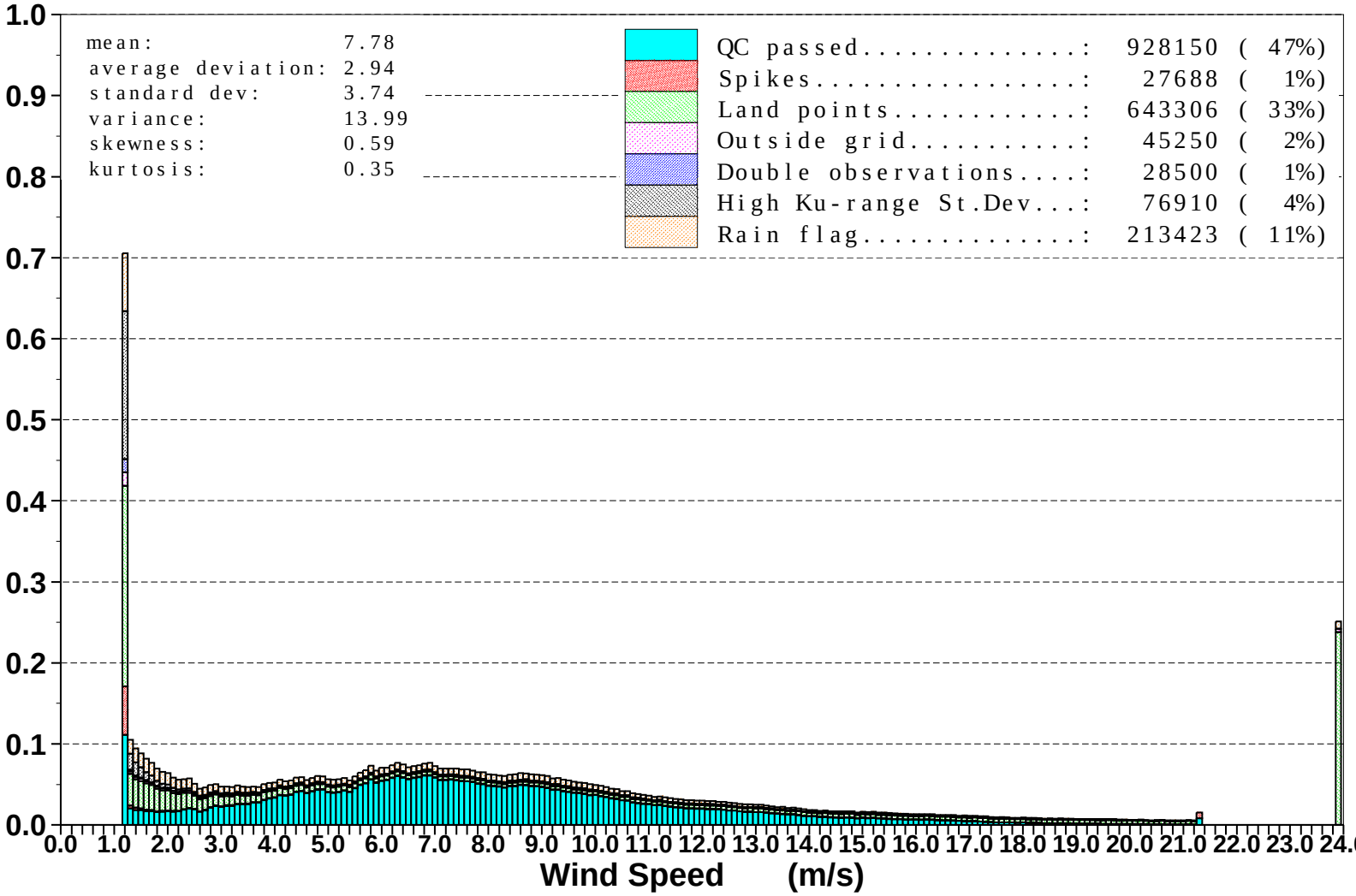

Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for April 2006

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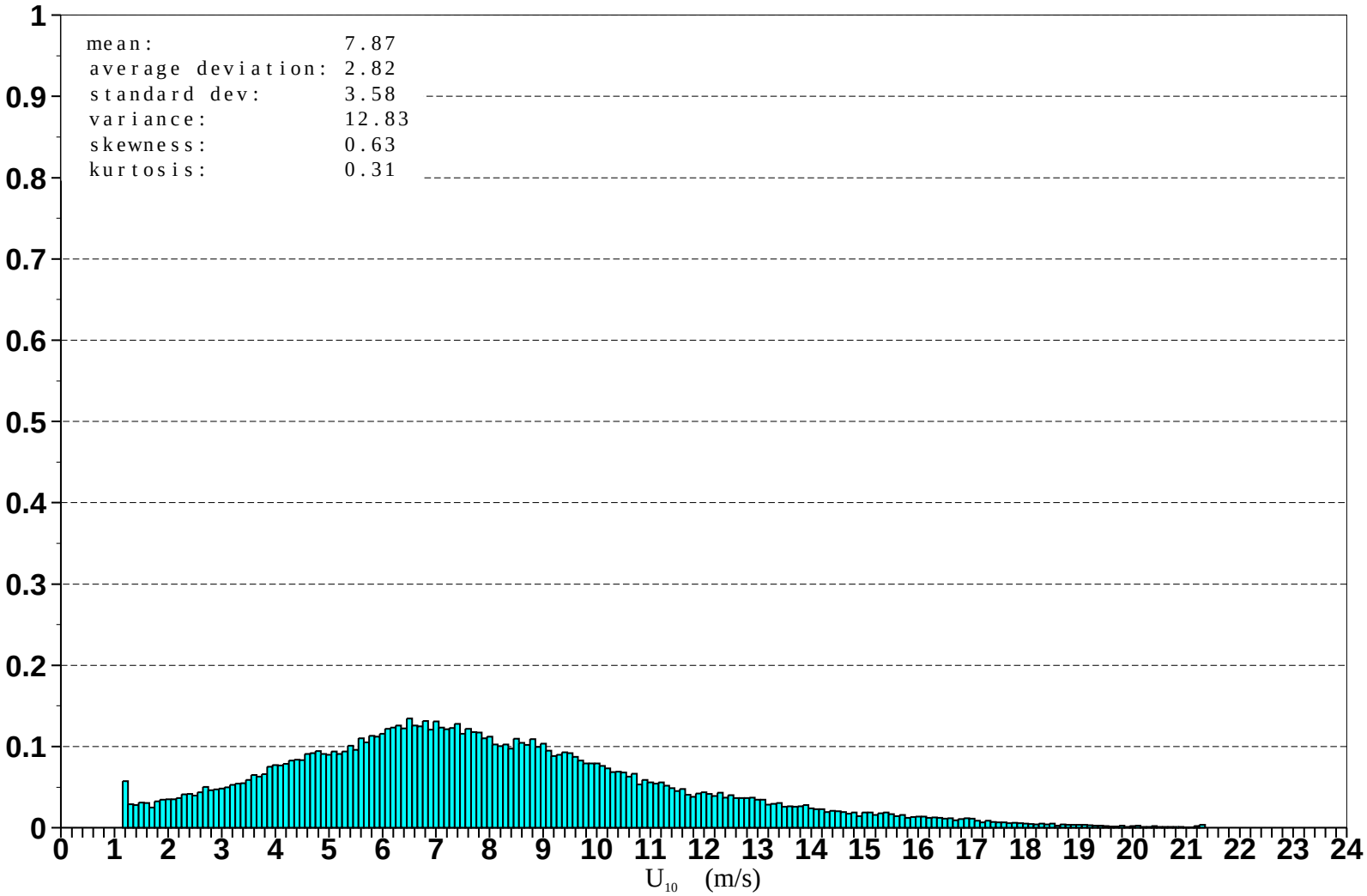

Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for April 2006

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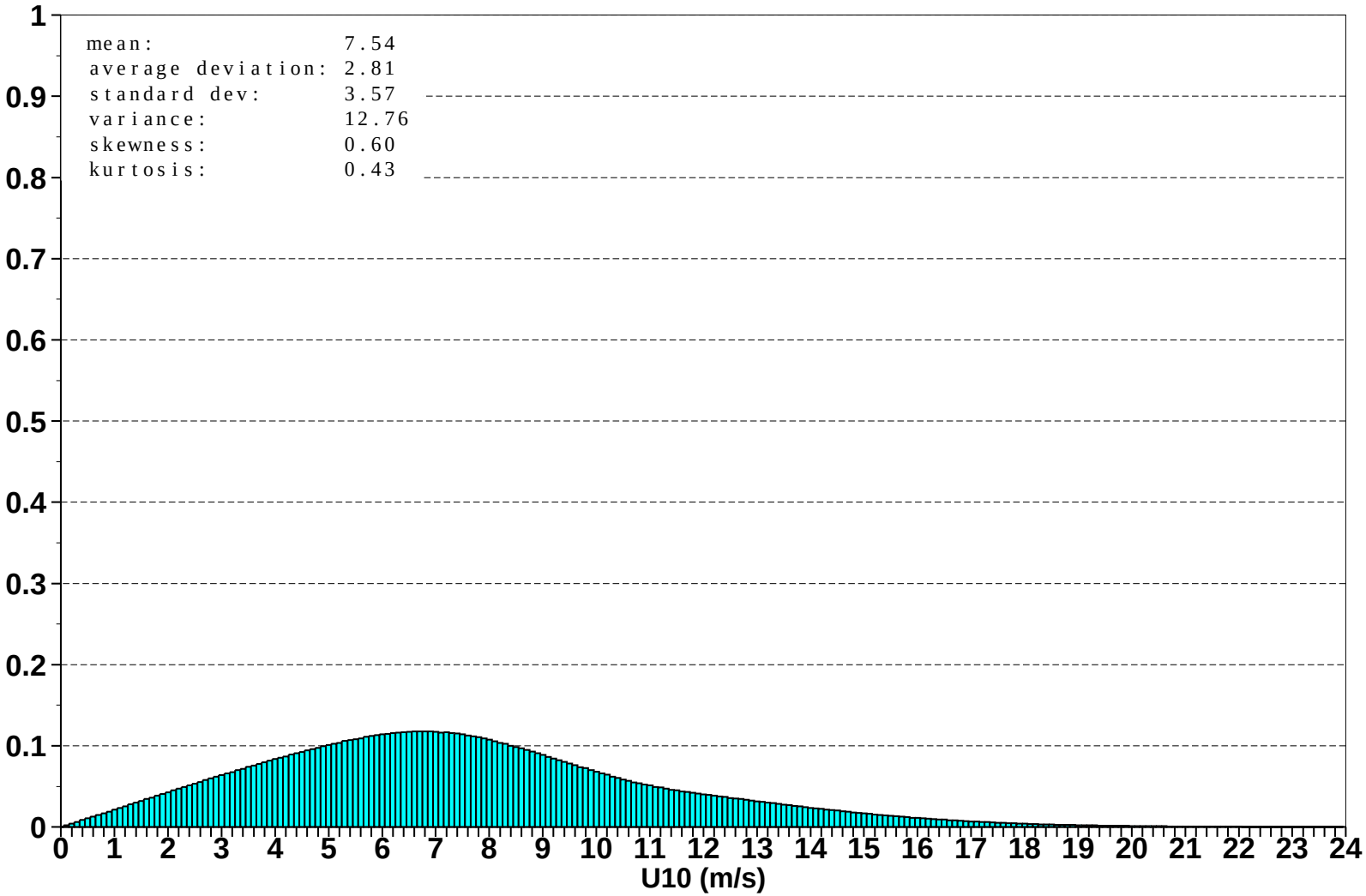

Figure 6: Global distribution of ECMWF Analysis ocean surface wind speeds for April 2006

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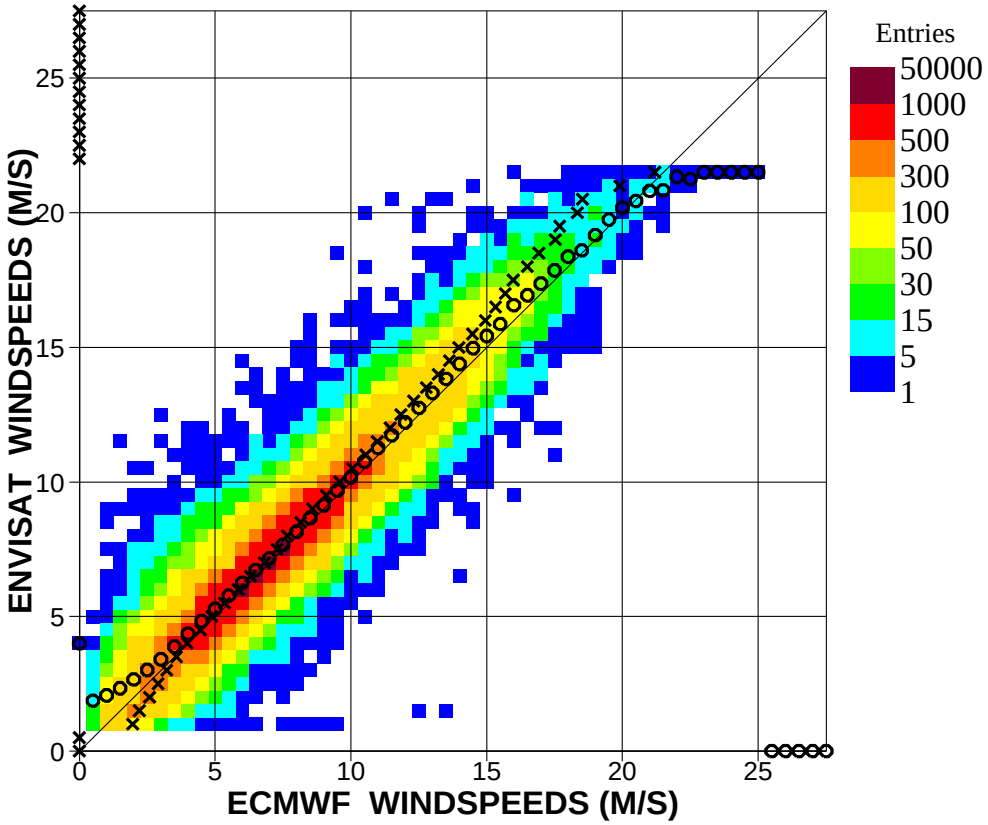

STATISTICS

ENTRIES	82462
MEAN ECMWF	7.5949
MEAN ENVISAT	7.8681
BIAS (ENVISAT - ECMWF)	.2732
STANDARD DEVIATION	1.1800
SCATTER INDEX	.1554
CORRELATION	.9443
SYMMETRIC SLOPE	1.0372 (.0012)
REGR. COEFFICIENT	.9852 (.0012)
REGR. CONSTANT	.3858 (.0100)

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

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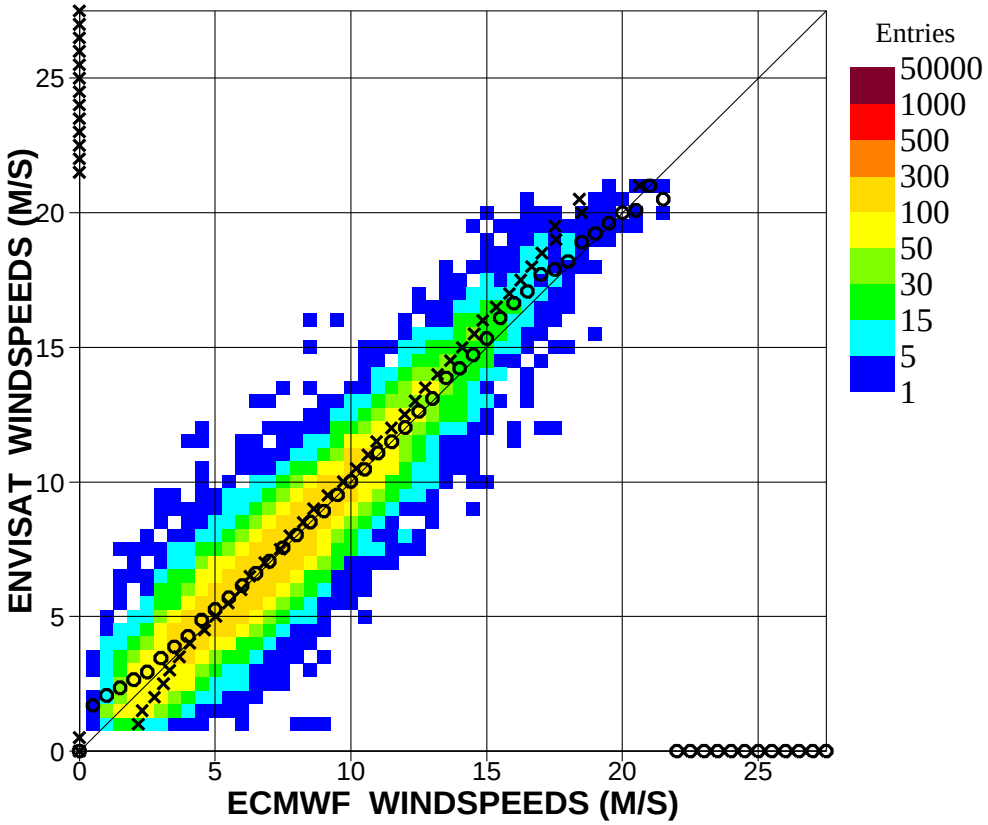

STATISTICS

ENTRIES	20075
MEAN ECMWF	7.4519
MEAN ENVISAT	7.6170
BIAS (ENVISAT - ECMWF)	.1651
STANDARD DEVIATION	1.2042
SCATTER INDEX	.1616
CORRELATION	.9356
SYMMETRIC SLOPE	1.0250 (.0026)
REGR. COEFFICIENT	.9728 (.0026)
REGR. CONSTANT	.3675 (.0211)

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

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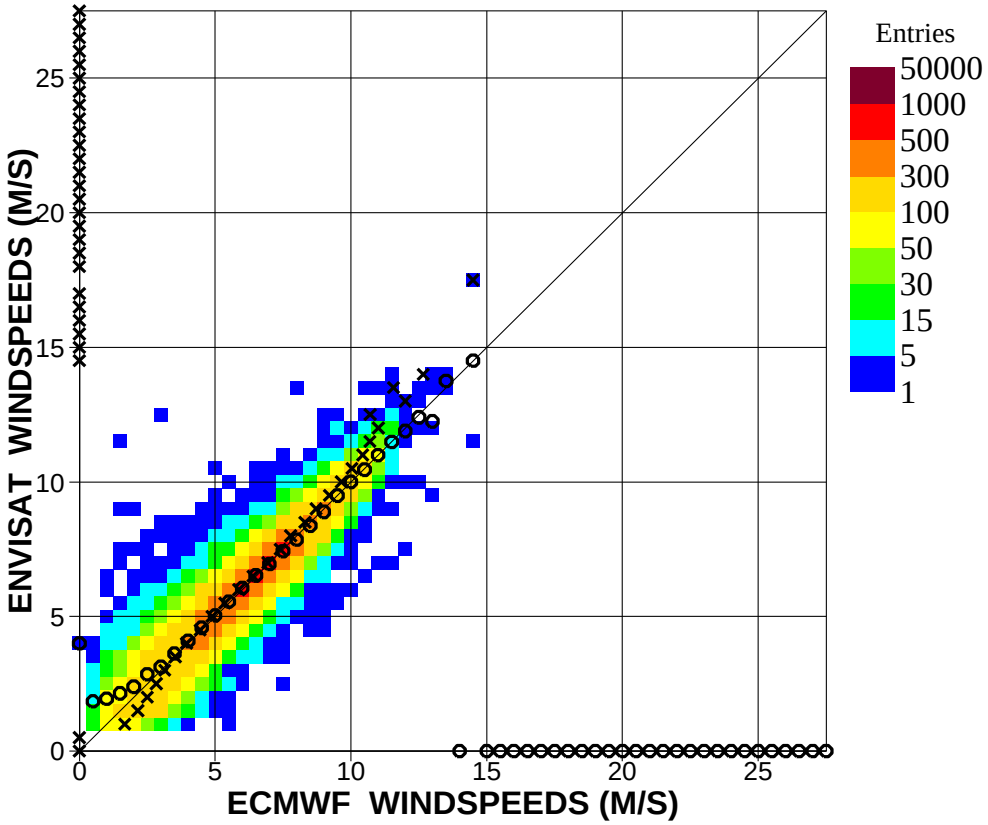

STATISTICS

ENTRIES	25727
MEAN ECMWF	5.8566
MEAN ENVISAT	5.9172
BIAS (ENVISAT - ECMWF)	.0606
STANDARD DEVIATION	.8928
SCATTER INDEX	.1524
CORRELATION	.9270
SYMMETRIC SLOPE	1.0107 (.0024)
REGR. COEFFICIENT	.9387 (.0024)
REGR. CONSTANT	.4196 (.0149)

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

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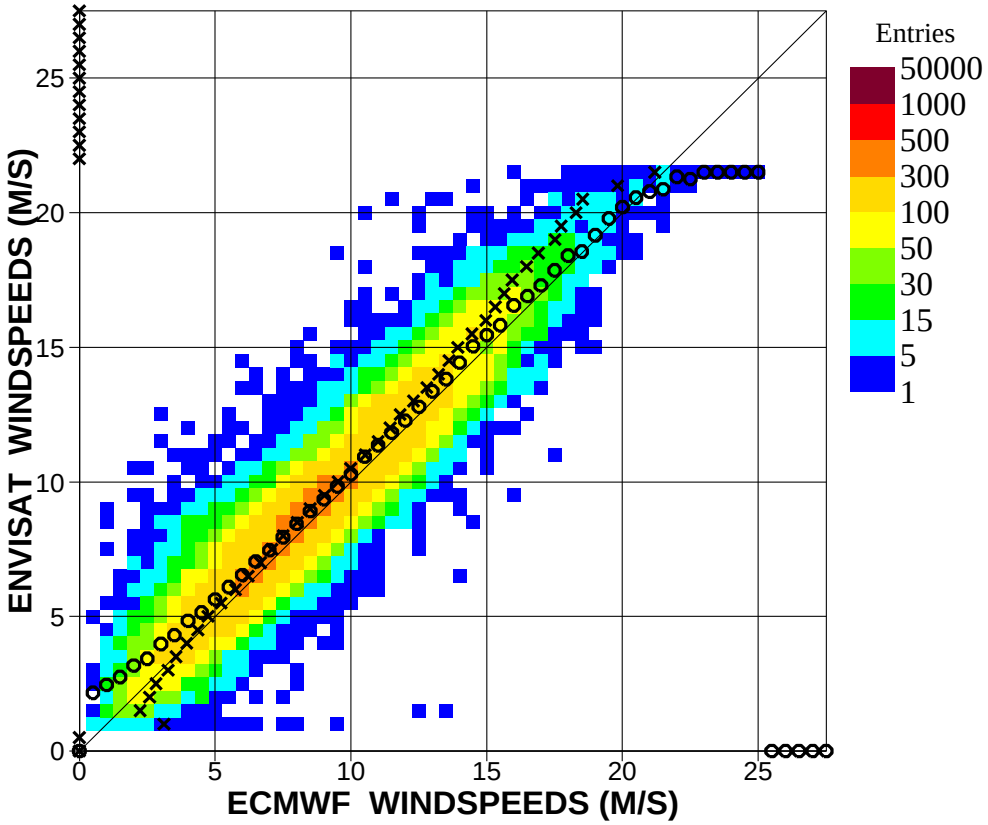

STATISTICS

ENTRIES	37278
MEAN ECMWF	8.8530
MEAN ENVISAT	9.3284
BIAS (ENVISAT - ECMWF)	.4754
STANDARD DEVIATION	1.2982
SCATTER INDEX	.1466
CORRELATION	.9371
SYMMETRIC SLOPE	1.0496 (.0019)
REGR. COEFFICIENT	.9598 (.0019)
REGR. CONSTANT	.8309 (.0177)

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

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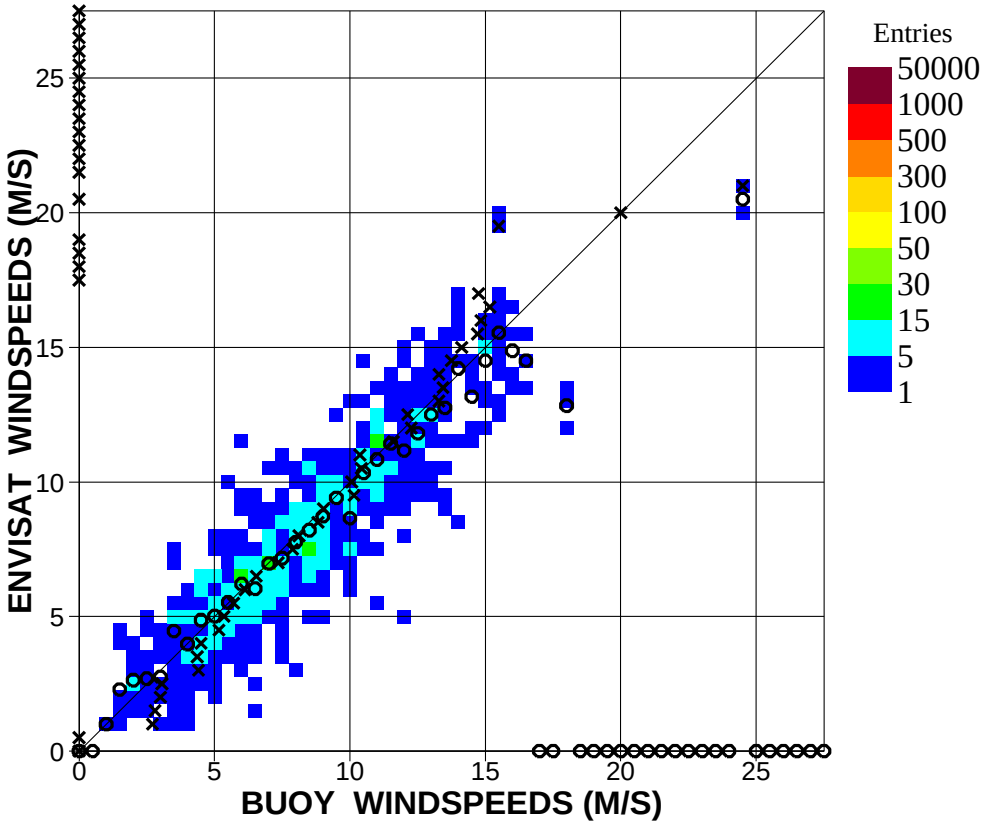

STATISTICS

ENTRIES	985	
MEAN BUOY	8.2471	
MEAN ENVISAT	8.0386	
BIAS (ENVISAT - BUOY)	-.2085	
STANDARD DEVIATION	1.5283	
SCATTER INDEX	.1853	
CORRELATION	.8949	
SYMMETRIC SLOPE	.9787	(.0145)
REGR. COEFFICIENT	.8972	(.0143)
REGR. CONSTANT	.6391	(.1269)

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

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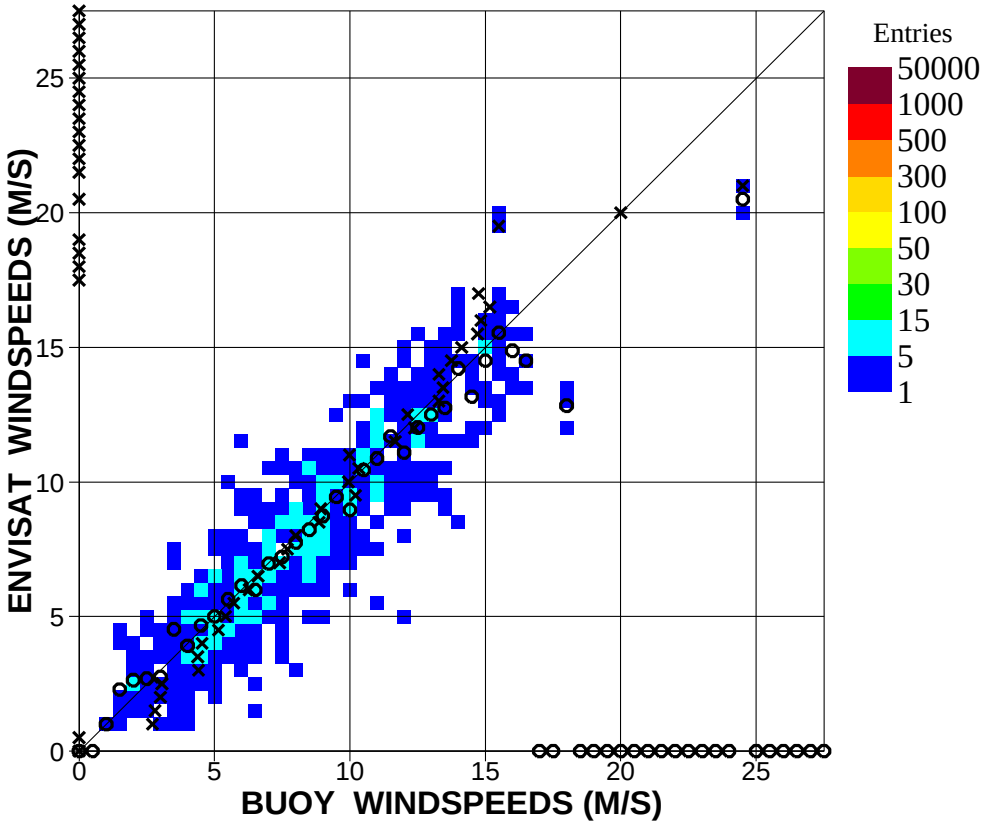

STATISTICS

ENTRIES	837	
MEAN BUOY	8.2849	
MEAN ENVISAT	8.0916	
BIAS (ENVISAT - BUOY)	-.1933	
STANDARD DEVIATION	1.5990	
SCATTER INDEX	.1930	
CORRELATION	.8955	
SYMMETRIC SLOPE	.9822	(.0158)
REGR. COEFFICIENT	.9072	(.0156)
REGR. CONSTANT	.5758	(.1402)

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

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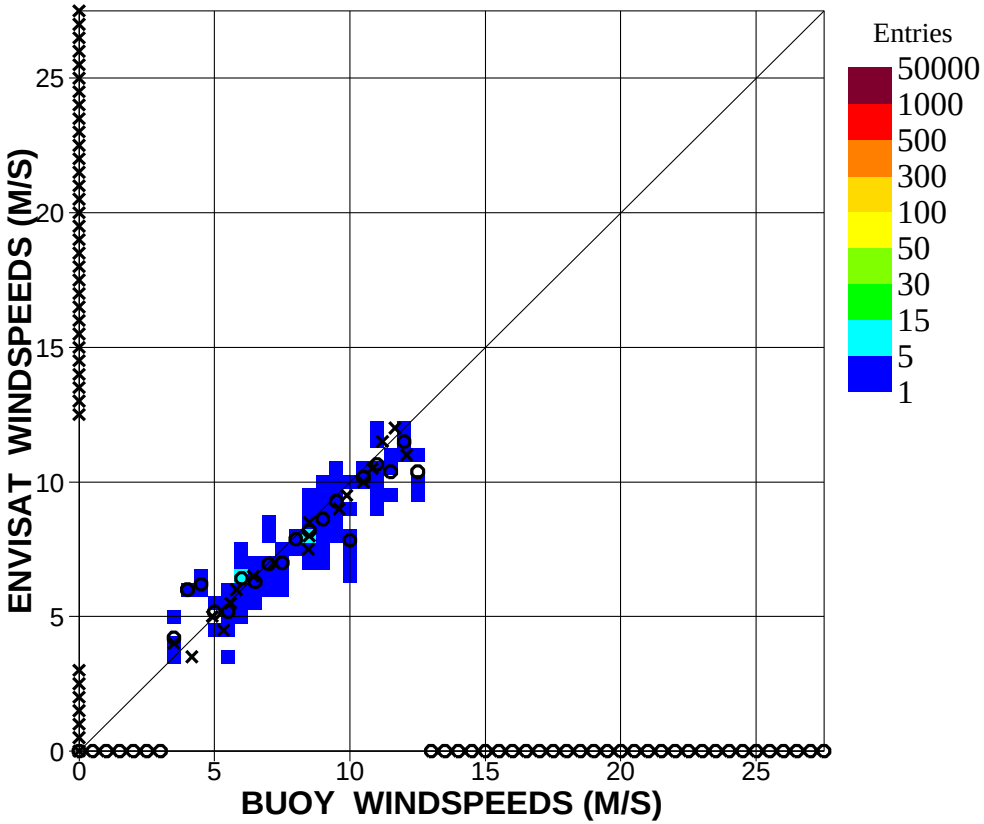

STATISTICS

ENTRIES	145	
MEAN BUOY	8.0381	
MEAN ENVISAT	7.7411	
BIAS (ENVISAT - BUOY)	-.2970	
STANDARD DEVIATION	1.0296	
SCATTER INDEX	.1281	
CORRELATION	.8998	
SYMMETRIC SLOPE	.9557	(.0349)
REGR. COEFFICIENT	.7777	(.0315)
REGR. CONSTANT	1.4896	(.2640)

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

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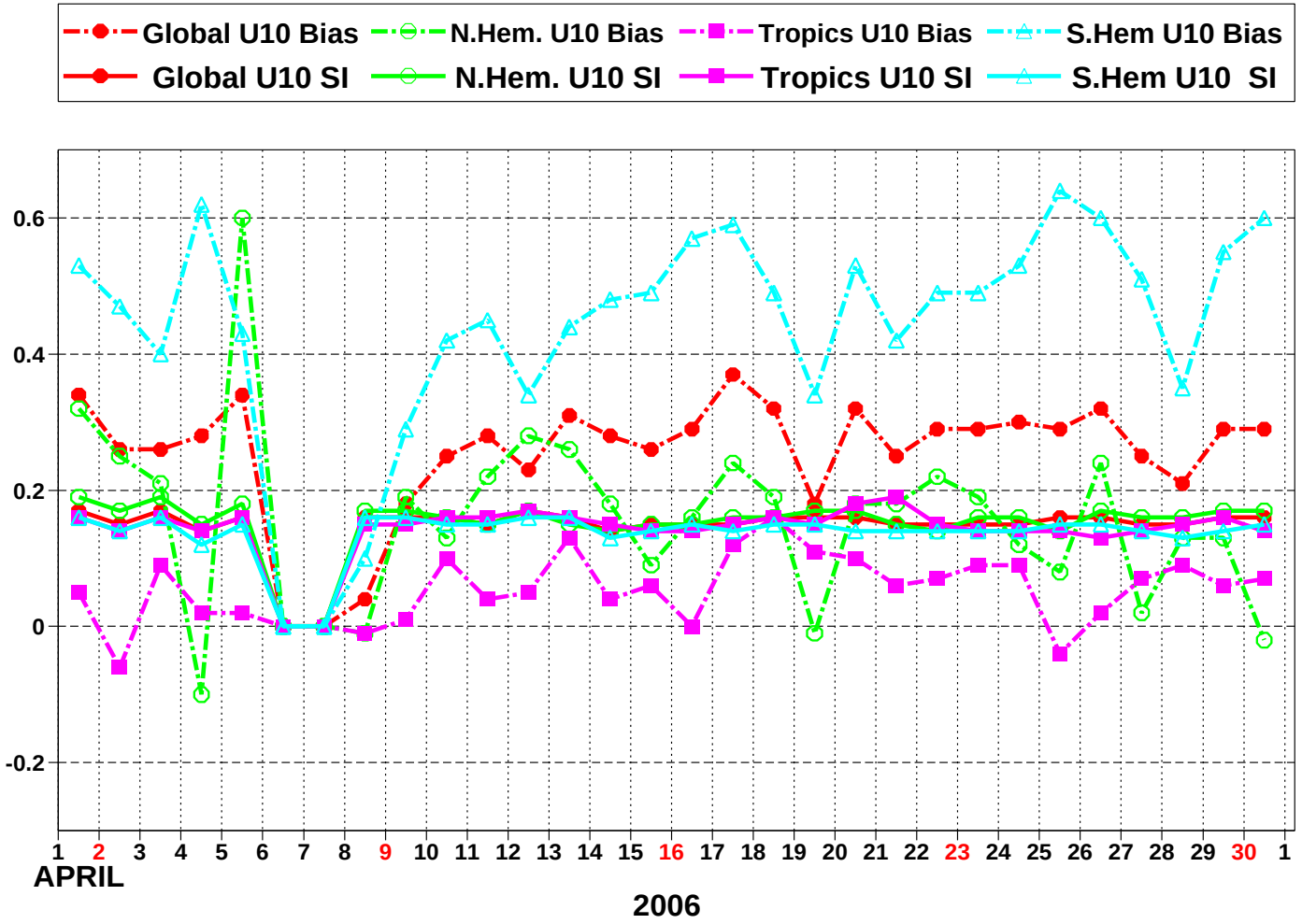

Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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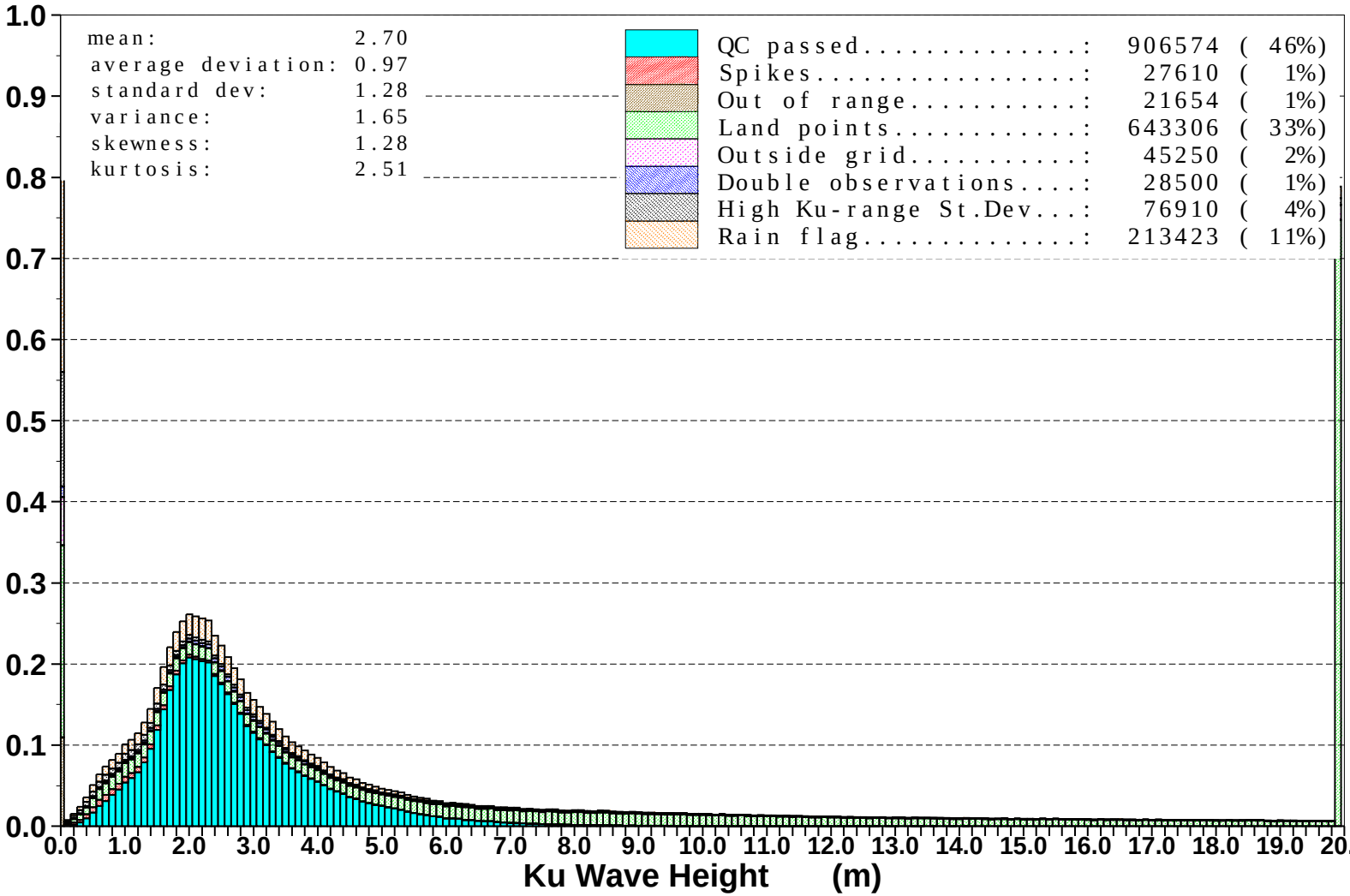

Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for April 2006

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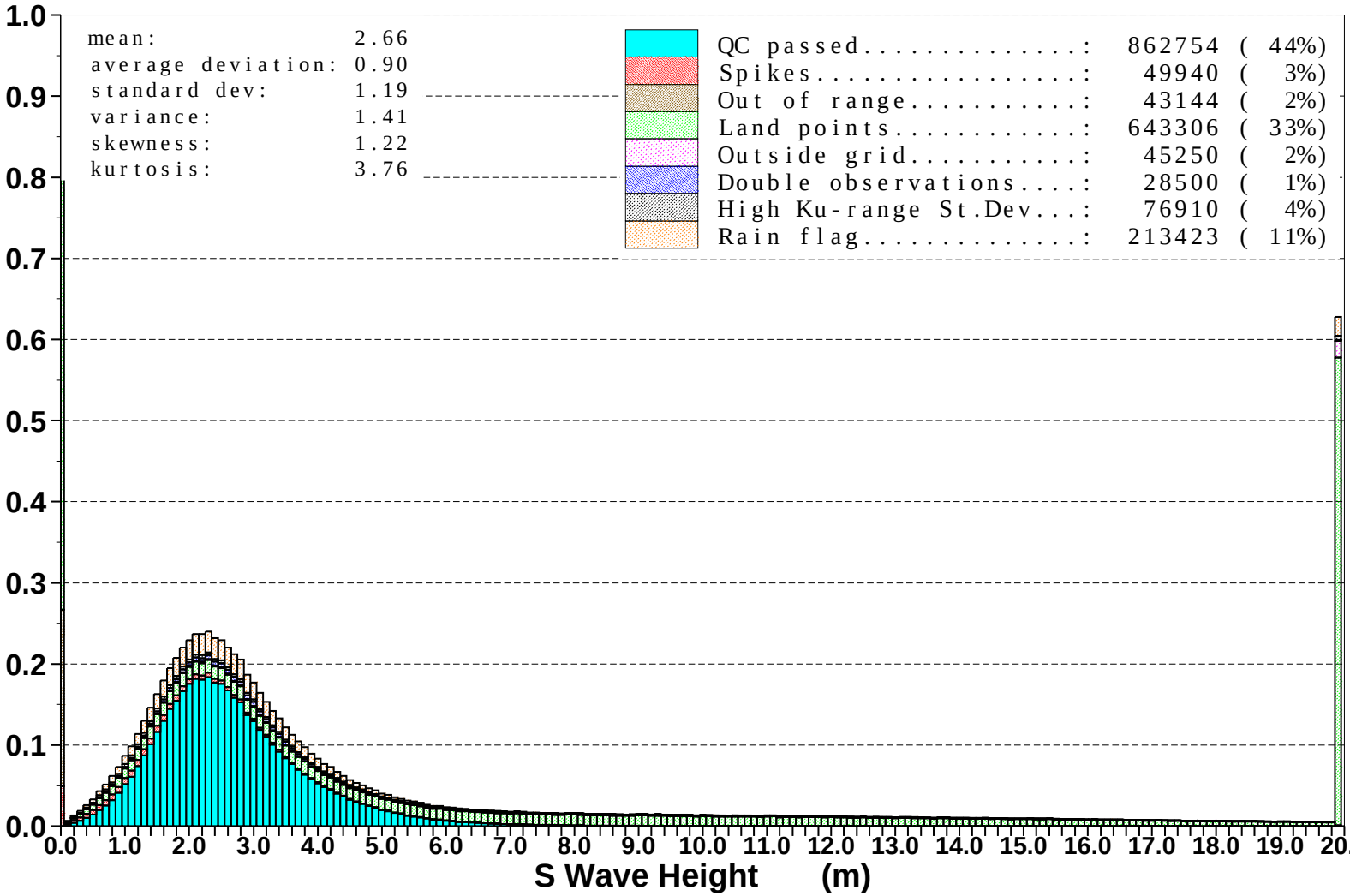

Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for April 2006

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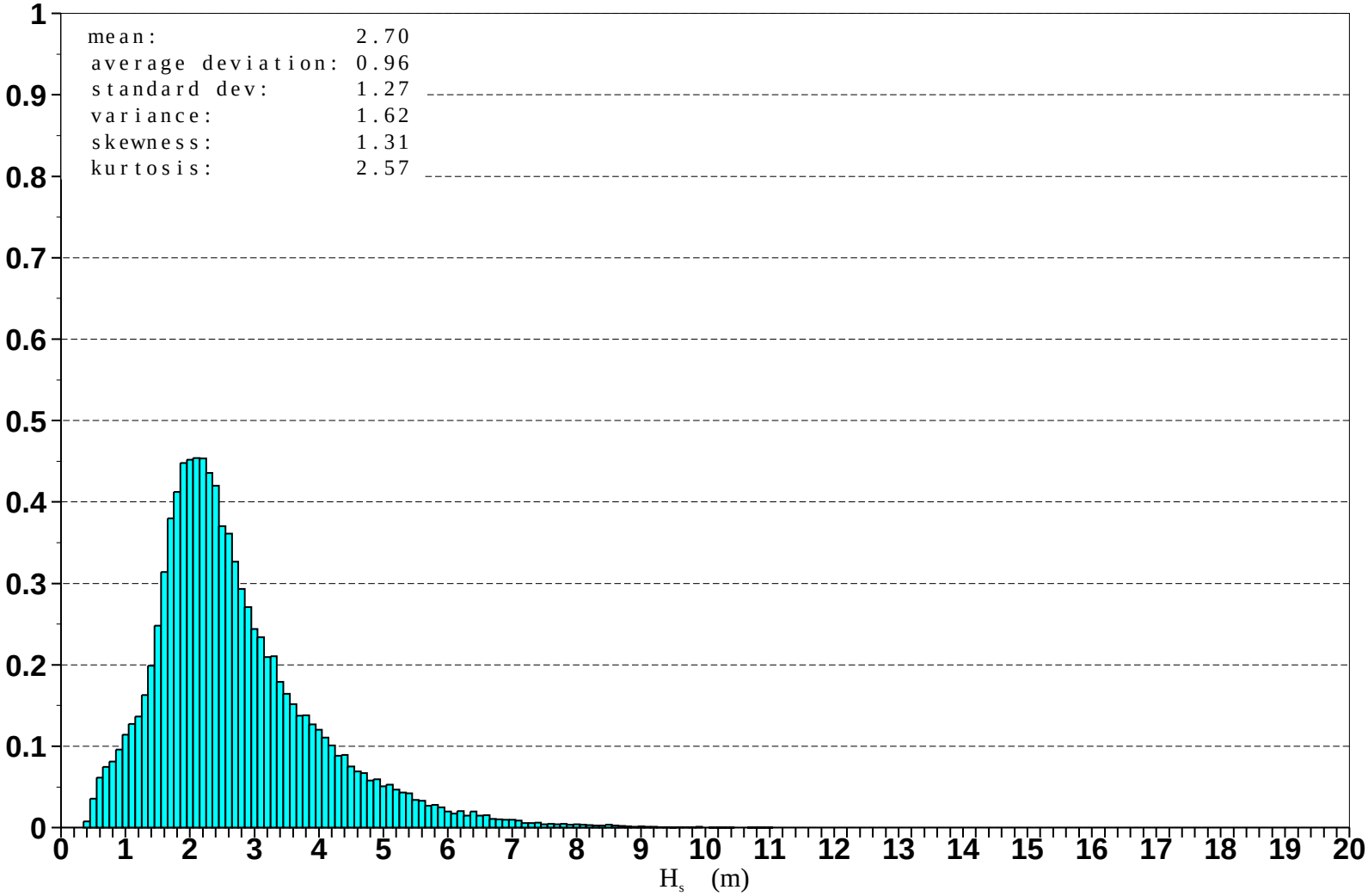

Figure 17: Distribution of ENVISAT Altimeter Ku-Band Wave Heights after Along-Track Averaging for April 2006

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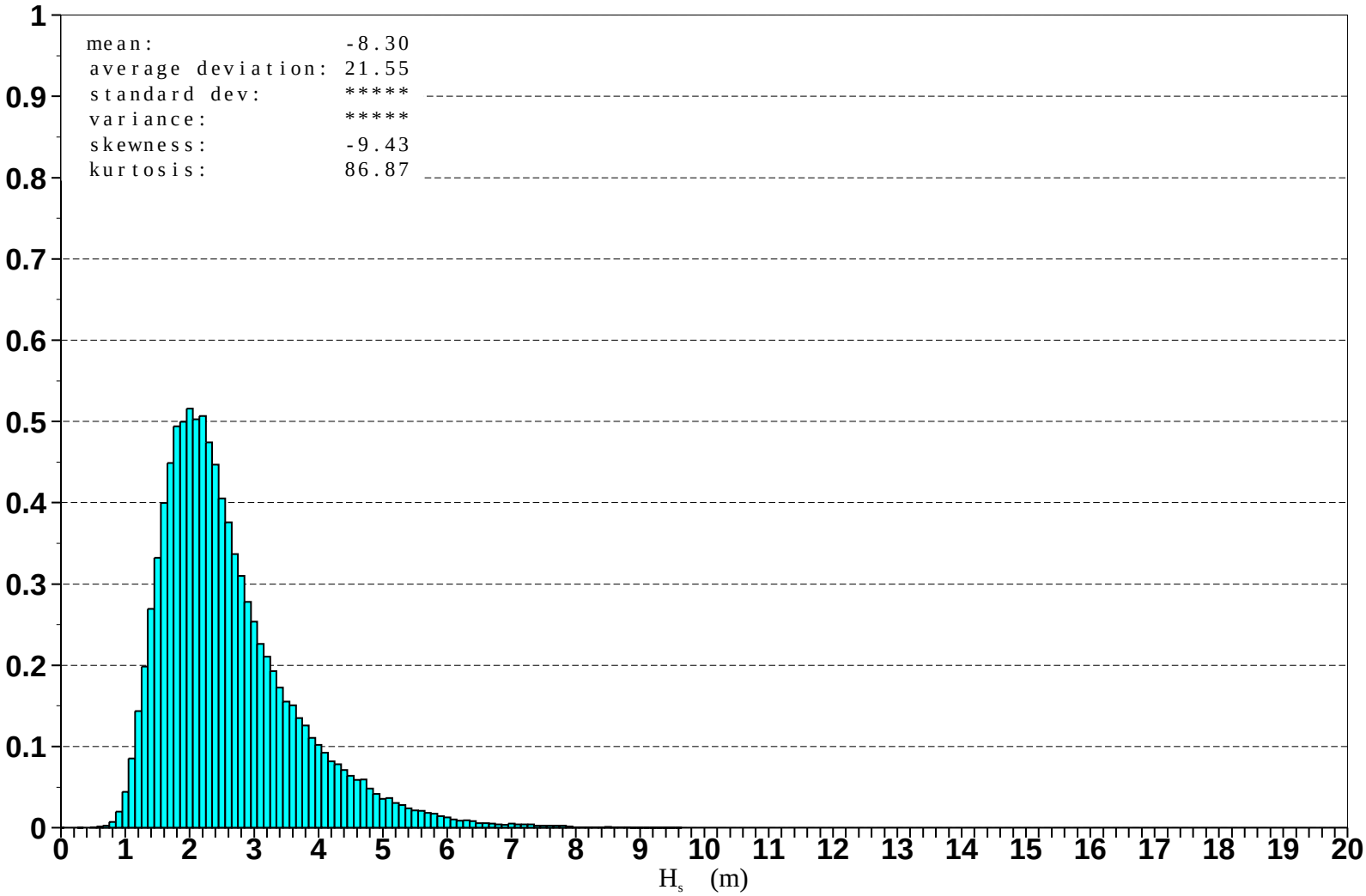

Figure 18: Distribution of ENVISAT Altimeter S-Band Wave Heights after Along-Track Averaging for April 2006

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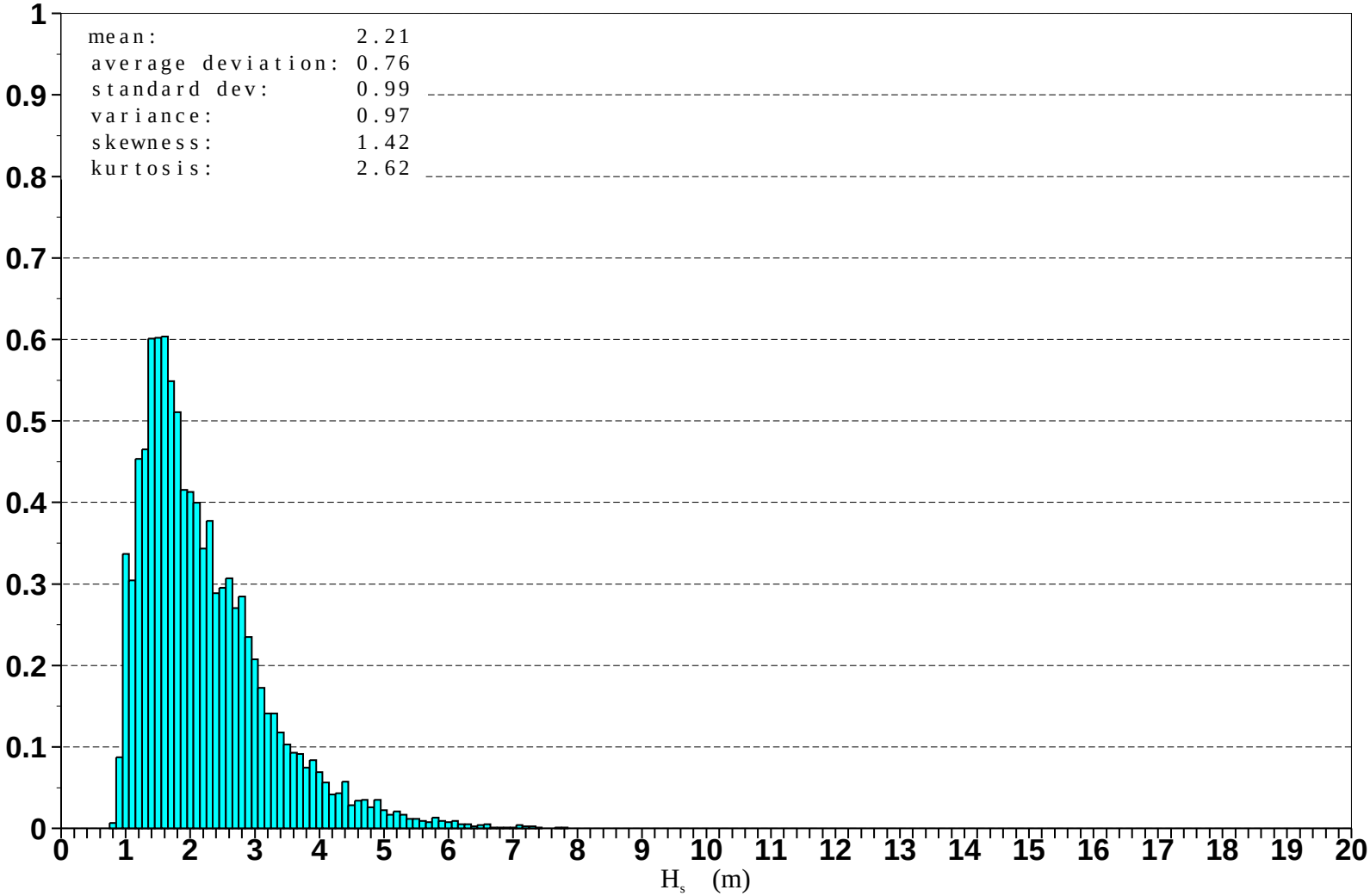

Figure 19: Distribution of ERS-2 Altimeter Wave Heights after Along-Track Averaging for April 2006

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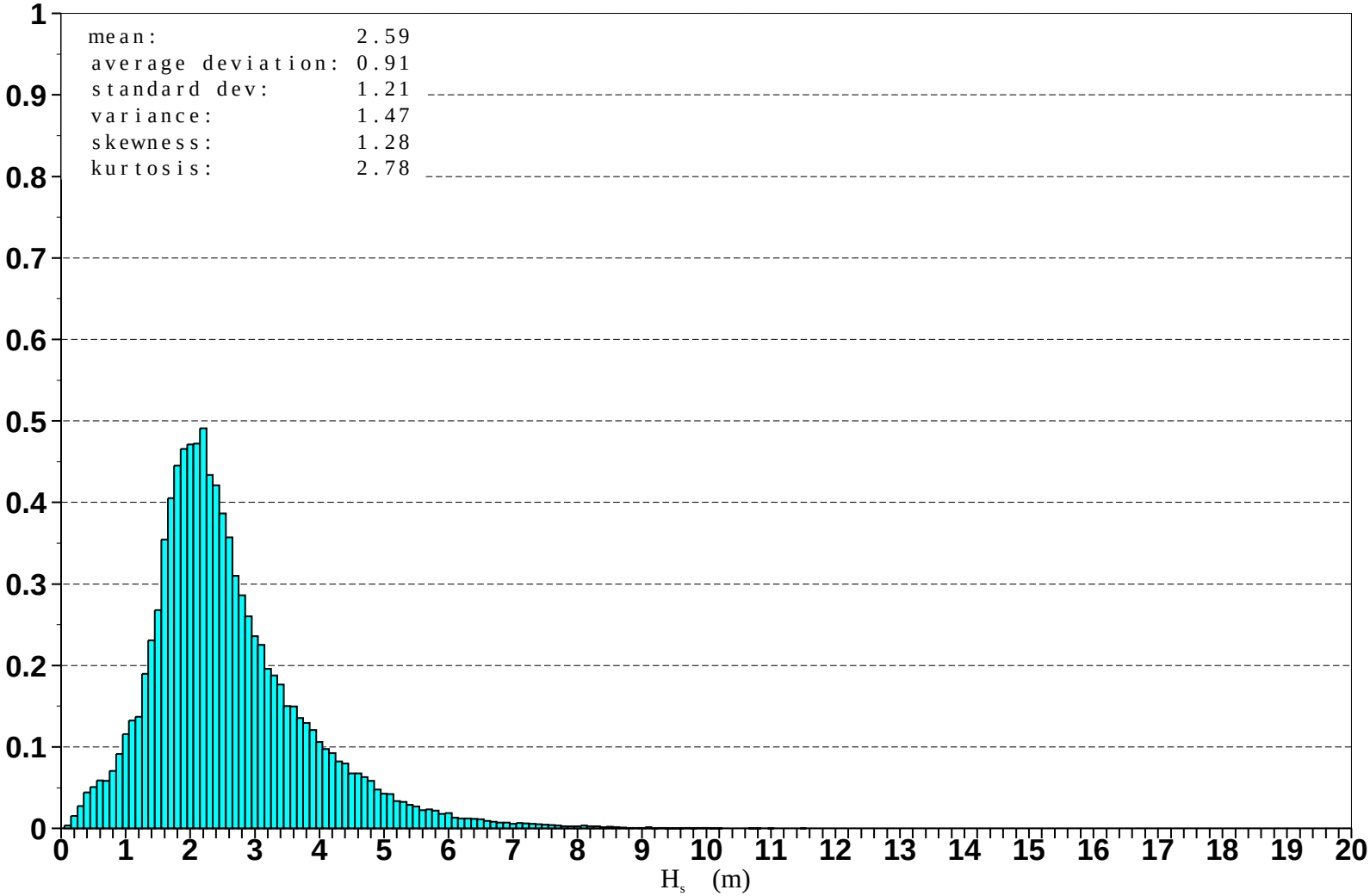

Figure 19b: Distribution of WAM 4V Wave Height (Collocated with ENVISAT) for April 2006

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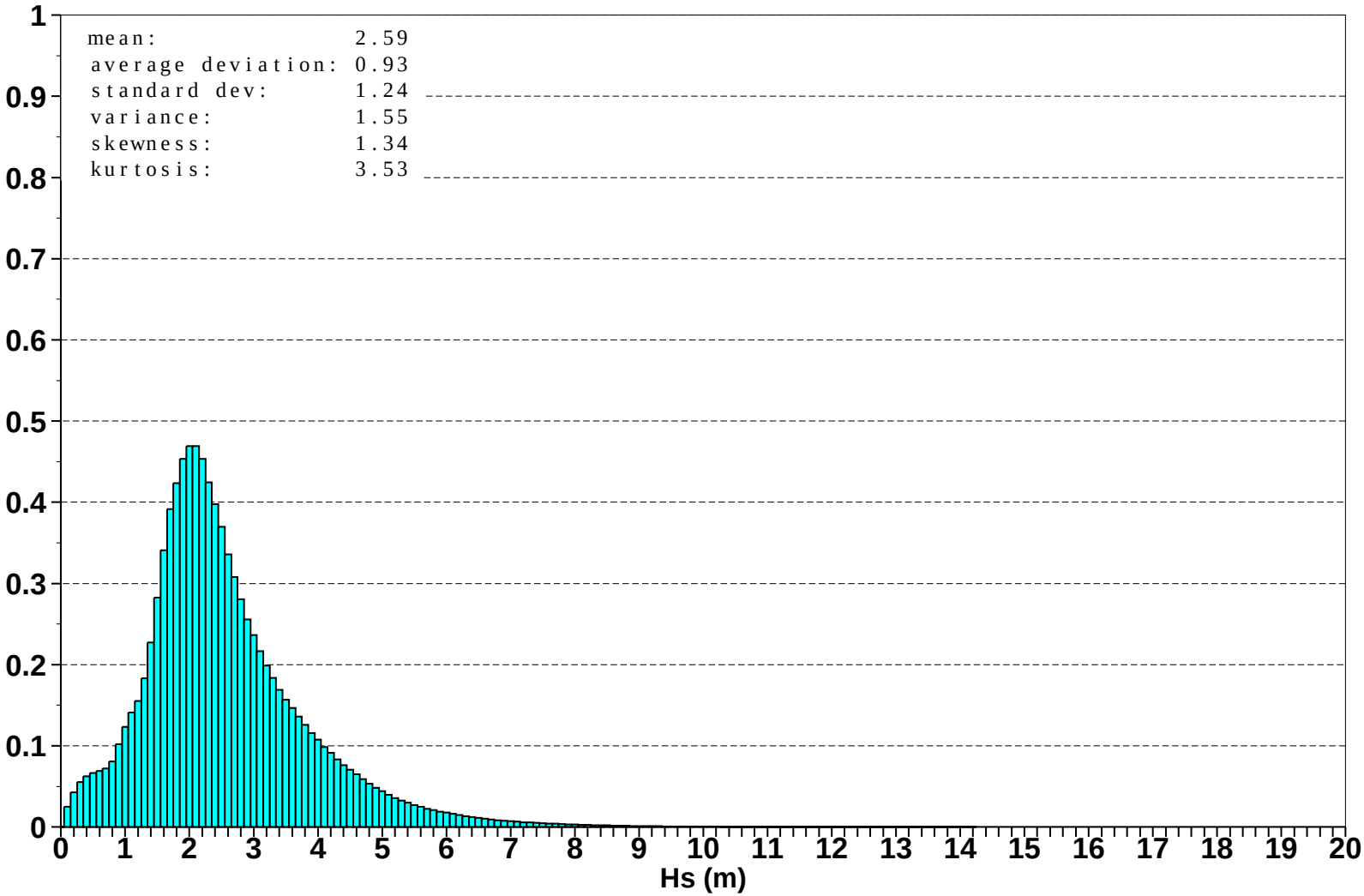

Figure 20: Global distribution of ECMWF First-Guess wave heights for April 2006

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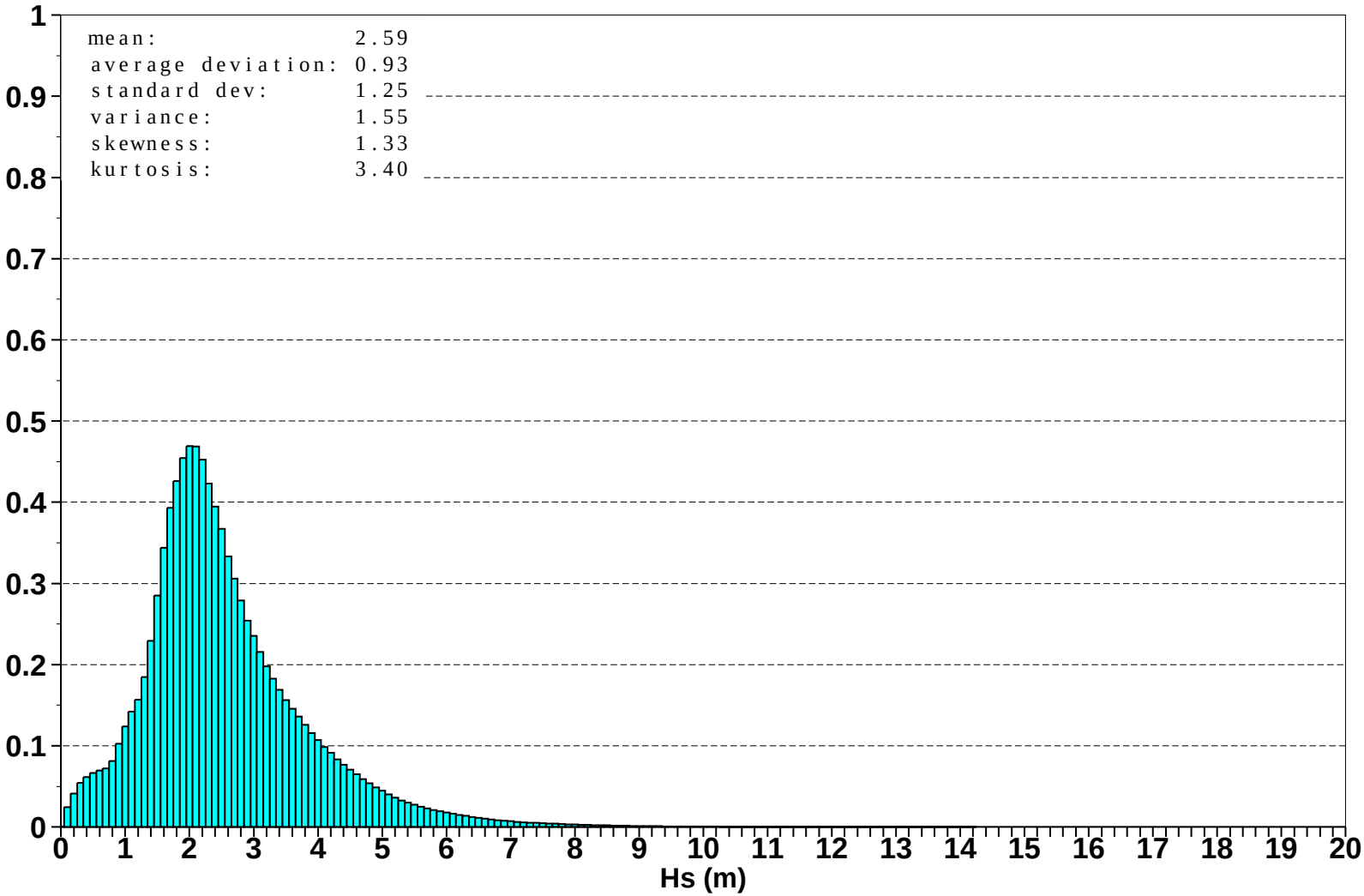

Figure 21: Global distribution of ECMWF Analysis wave heights for April 2006

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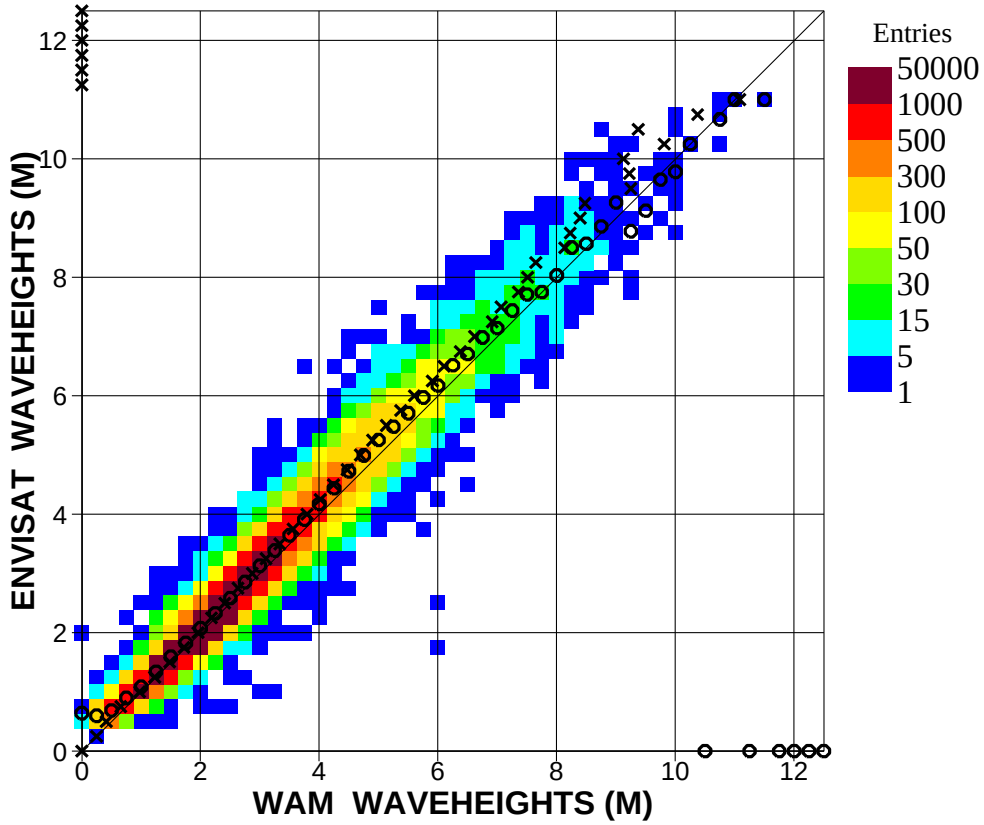

STATISTICS

ENTRIES	82462
MEAN WAM	2.5894
MEAN ENVISAT	2.7029
BIAS (ENVISAT - WAM)	.1135
STANDARD DEVIATION	.2625
SCATTER INDEX	.1014
CORRELATION	.9789
SYMMETRIC SLOPE	1.0450 (.0007)
REGR. COEFFICIENT	1.0283 (.0007)
REGR. CONSTANT	.0402 (.0021)

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

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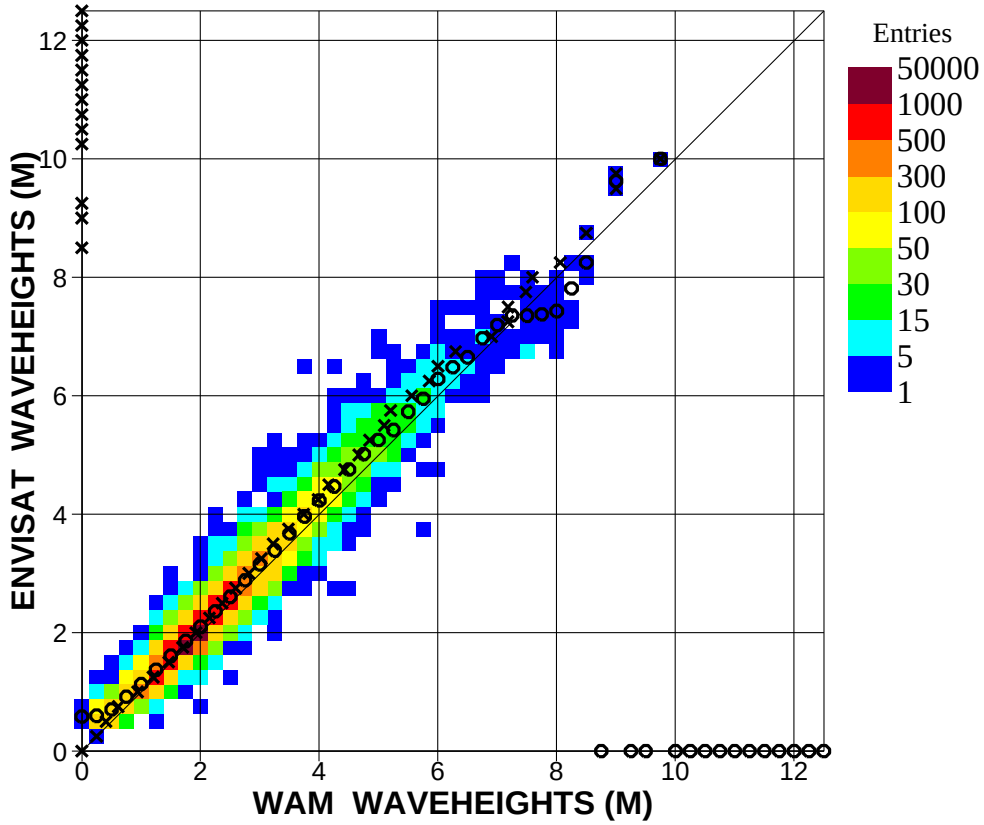

STATISTICS

ENTRIES	20075
MEAN WAM	2.2655
MEAN ENVISAT	2.3991
BIAS (ENVISAT - WAM)	.1336
STANDARD DEVIATION	.2595
SCATTER INDEX	.1146
CORRELATION	.9717
SYMMETRIC SLOPE	1.0567 (.0018)
REGR. COEFFICIENT	1.0162 (.0017)
REGR. CONSTANT	.0968 (.0044)

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

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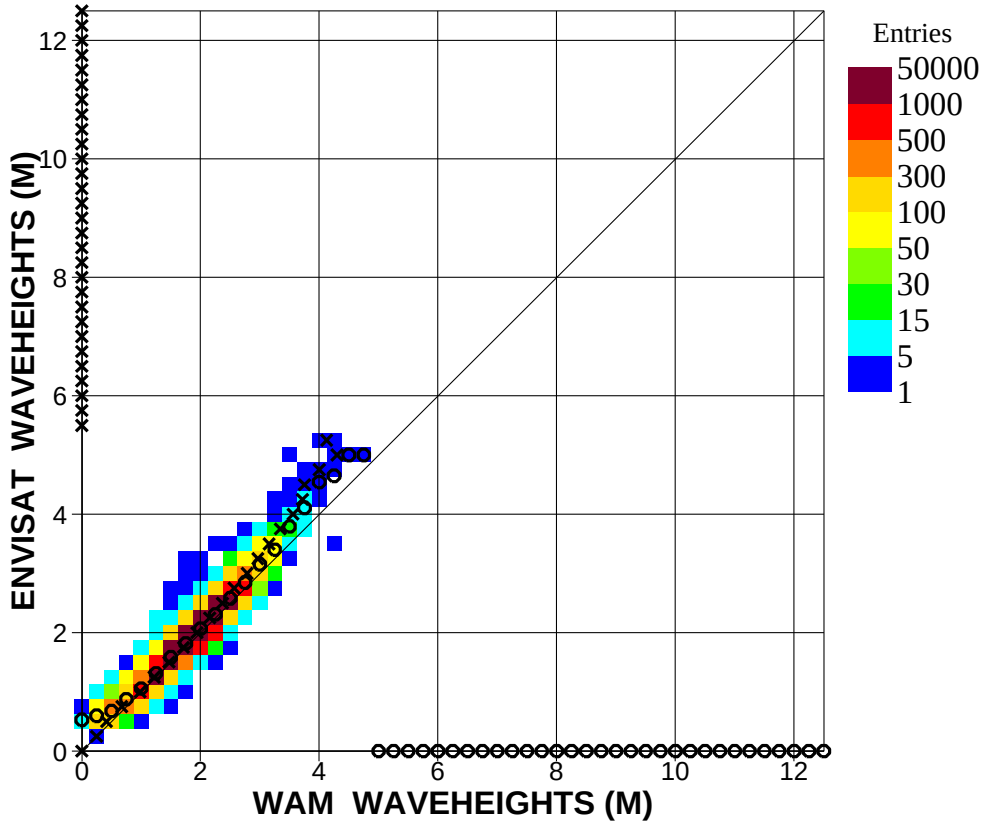

STATISTICS

ENTRIES	25727
MEAN WAM	1.8432
MEAN ENVISAT	1.9238
BIAS (ENVISAT - WAM)	.0806
STANDARD DEVIATION	.1623
SCATTER INDEX	.0880
CORRELATION	.9643
SYMMETRIC SLOPE	1.0435 (.0017)
REGR. COEFFICIENT	1.0044 (.0017)
REGR. CONSTANT	.0725 (.0033)

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

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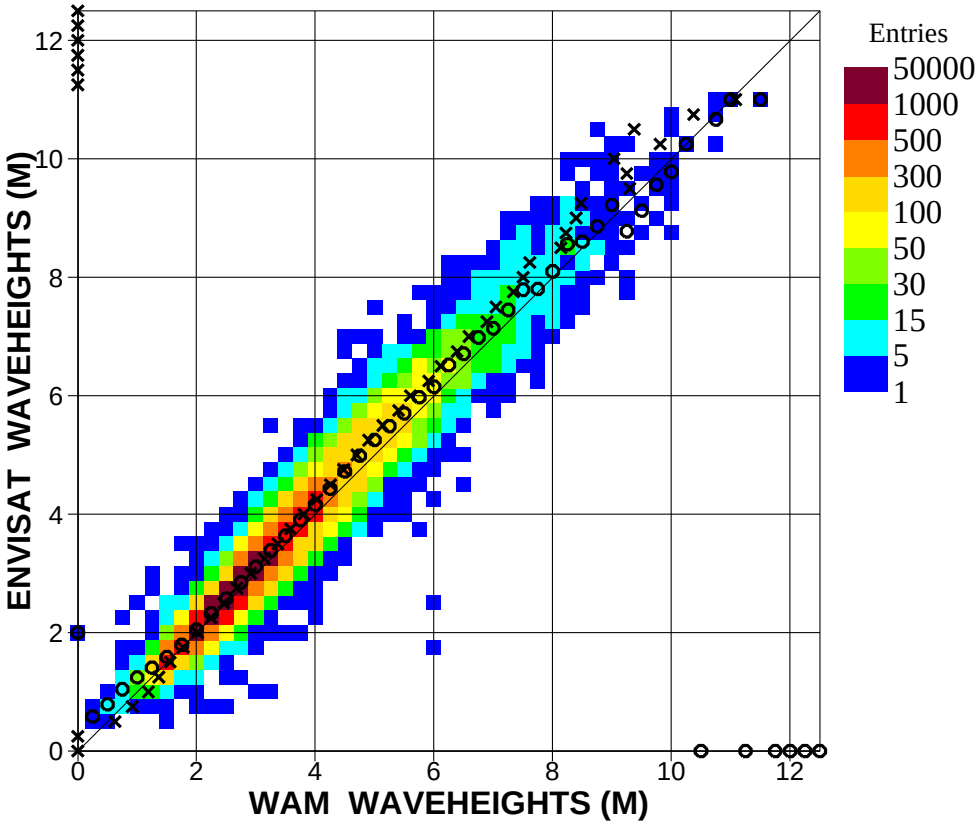

STATISTICS

ENTRIES	37278
MEAN WAM	3.2698
MEAN ENVISAT	3.3946
BIAS (ENVISAT - WAM)	.1248
STANDARD DEVIATION	.3123
SCATTER INDEX	.0955
CORRELATION	.9724
SYMMETRIC SLOPE	1.0421 (.0013)
REGR. COEFFICIENT	1.0398 (.0013)
REGR. CONSTANT	-.0055 (.0045)

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

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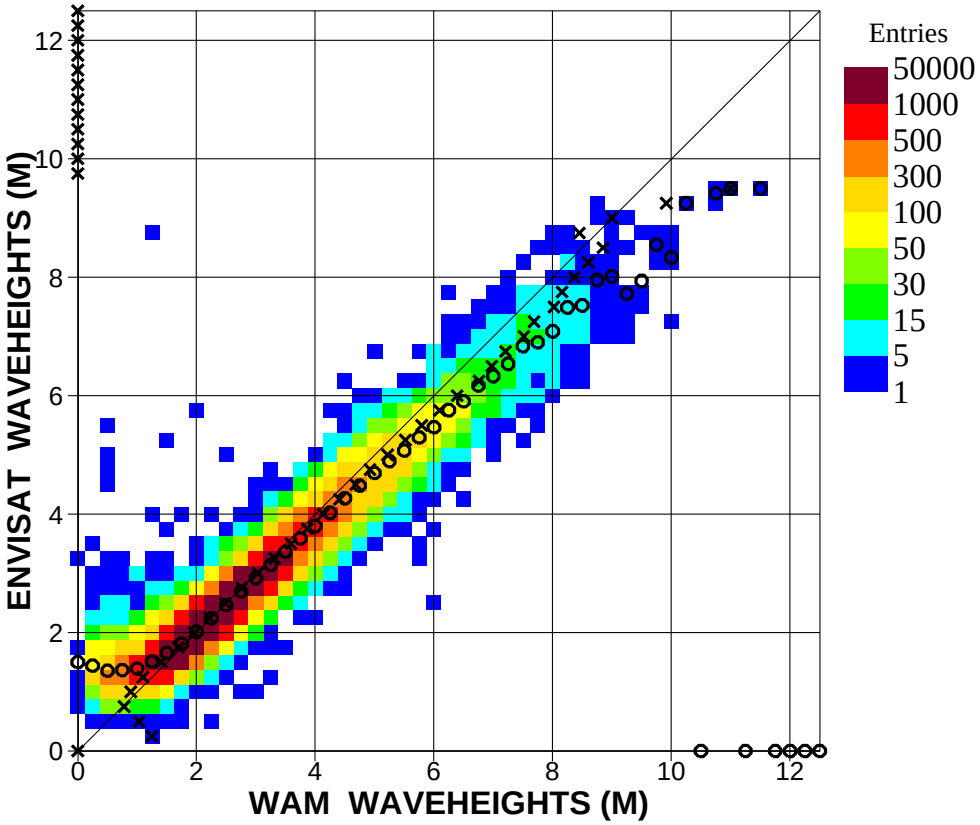

STATISTICS

ENTRIES	81564
MEAN WAM	2.5996
MEAN ENVISAT	2.5931
BIAS (ENVISAT - WAM)	-.0065
STANDARD DEVIATION	.3557
SCATTER INDEX	.1368
CORRELATION	.9594
SYMMETRIC SLOPE	.9767 (.0010)
REGR. COEFFICIENT	.8383 (.0009)
REGR. CONSTANT	.4139 (.0025)

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

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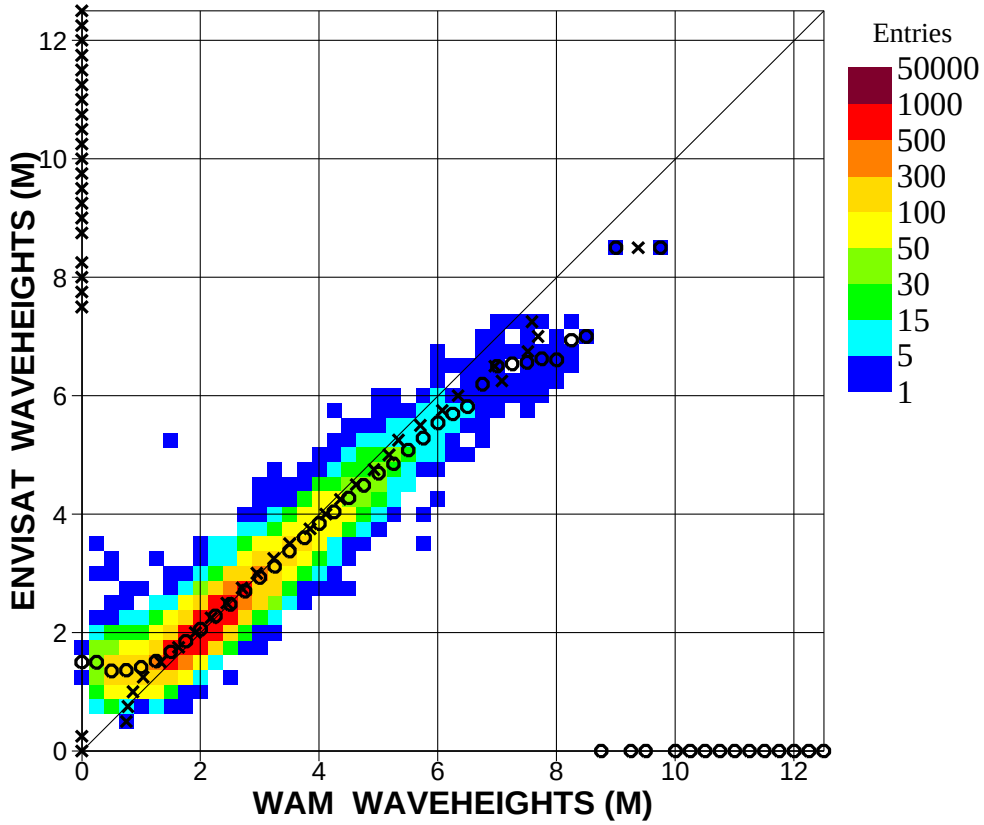

STATISTICS

ENTRIES	19813
MEAN WAM	2.2767
MEAN ENVISAT	2.3499
BIAS (ENVISAT - WAM)	.0733
STANDARD DEVIATION	.3675
SCATTER INDEX	.1614
CORRELATION	.9398
SYMMETRIC SLOPE	1.0032 (.0026)
REGR. COEFFICIENT	.8000 (.0021)
REGR. CONSTANT	.5287 (.0052)

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

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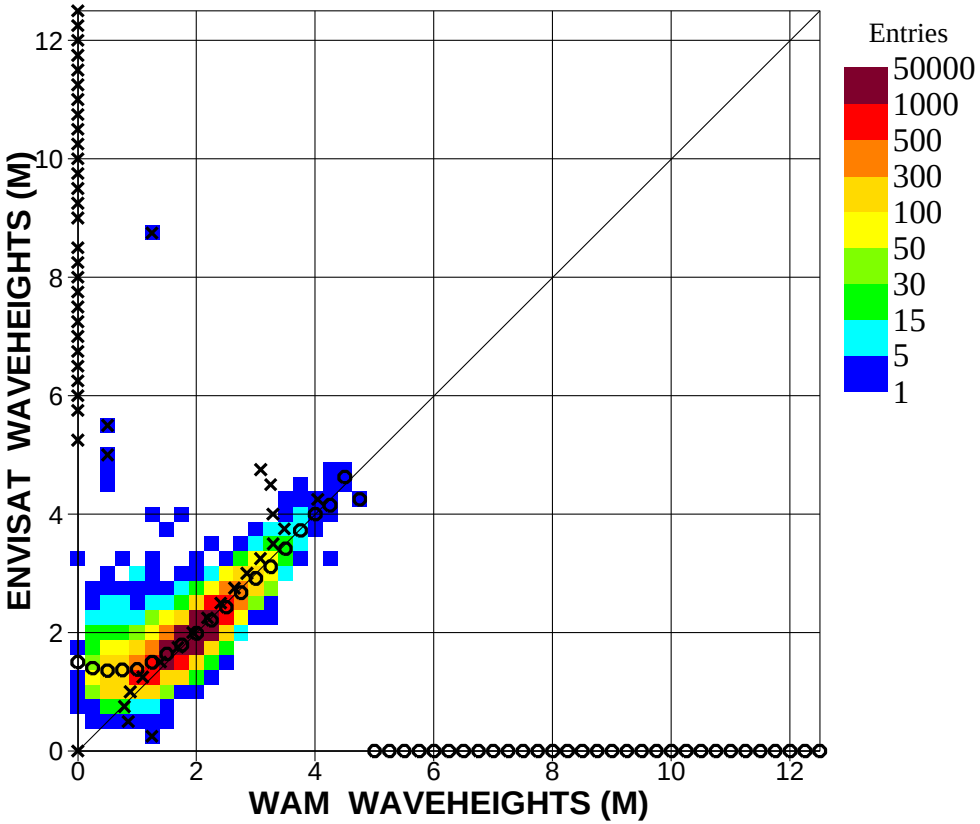

STATISTICS

ENTRIES	25309
MEAN WAM	1.8542
MEAN ENVISAT	1.9420
BIAS (ENVISAT - WAM)	.0878
STANDARD DEVIATION	.3238
SCATTER INDEX	.1747
CORRELATION	.8307
SYMMETRIC SLOPE	1.0294 (.0036)
REGR. COEFFICIENT	.6857 (.0029)
REGR. CONSTANT	.6705 (.0056)

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

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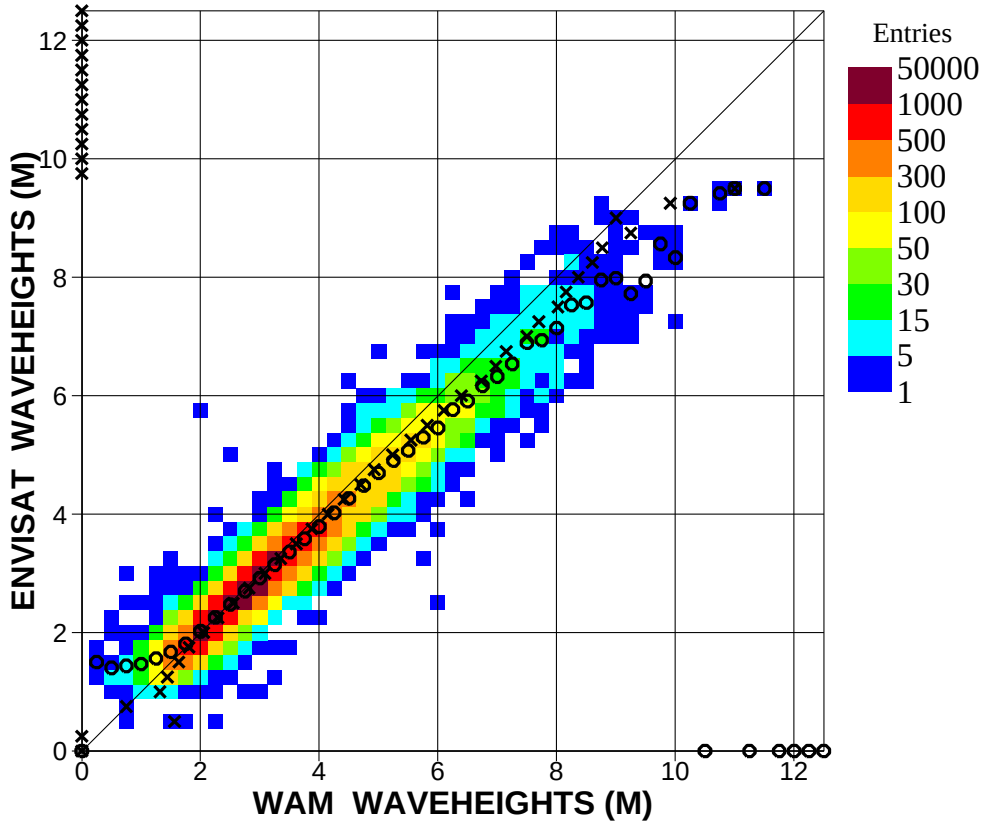

STATISTICS

ENTRIES	37052
MEAN WAM	3.2723
MEAN ENVISAT	3.1598
BIAS (ENVISAT - WAM)	-.1126
STANDARD DEVIATION	.3398
SCATTER INDEX	.1039
CORRELATION	.9631
SYMMETRIC SLOPE	.9580 (.0014)
REGR. COEFFICIENT	.8690 (.0013)
REGR. CONSTANT	.3161 (.0044)

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

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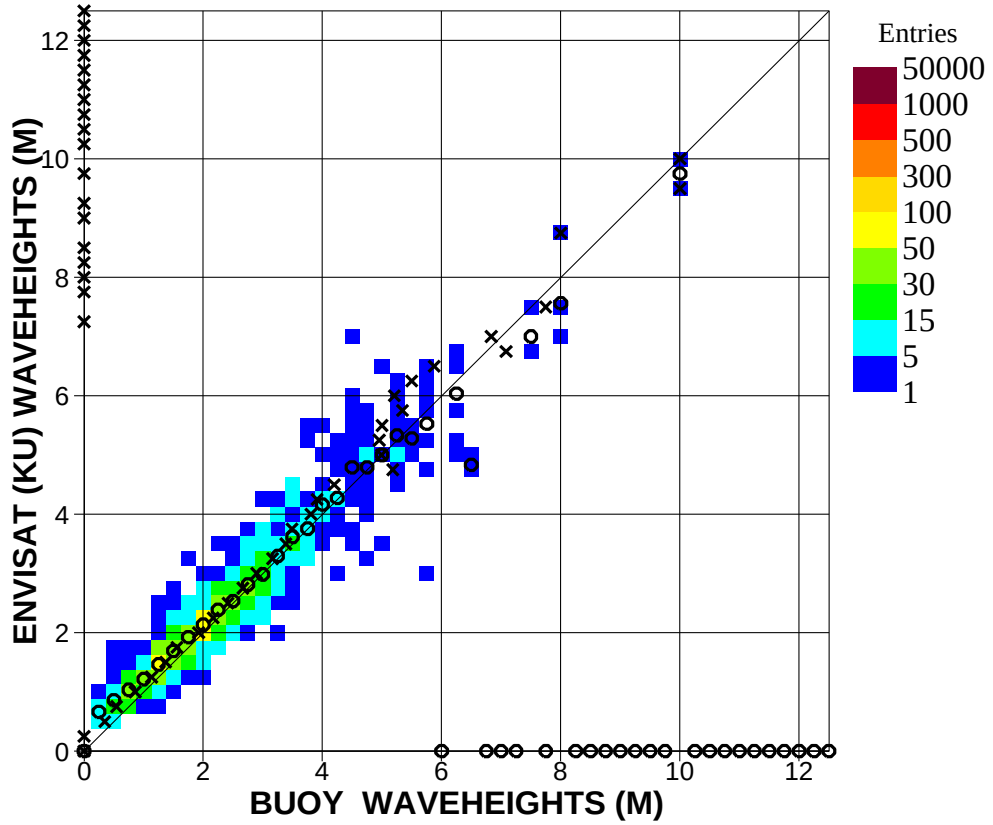

STATISTICS

ENTRIES	1517	
MEAN BUOY	2.3026	
MEAN ENVISAT	2.4301	
BIAS (ENVISAT - BUOY)	.1275	
STANDARD DEVIATION	.3664	
SCATTER INDEX	.1591	
CORRELATION	.9560	
SYMMETRIC SLOPE	1.0375	(.0079)
REGR. COEFFICIENT	.9310	(.0073)
REGR. CONSTANT	.2863	(.0192)

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

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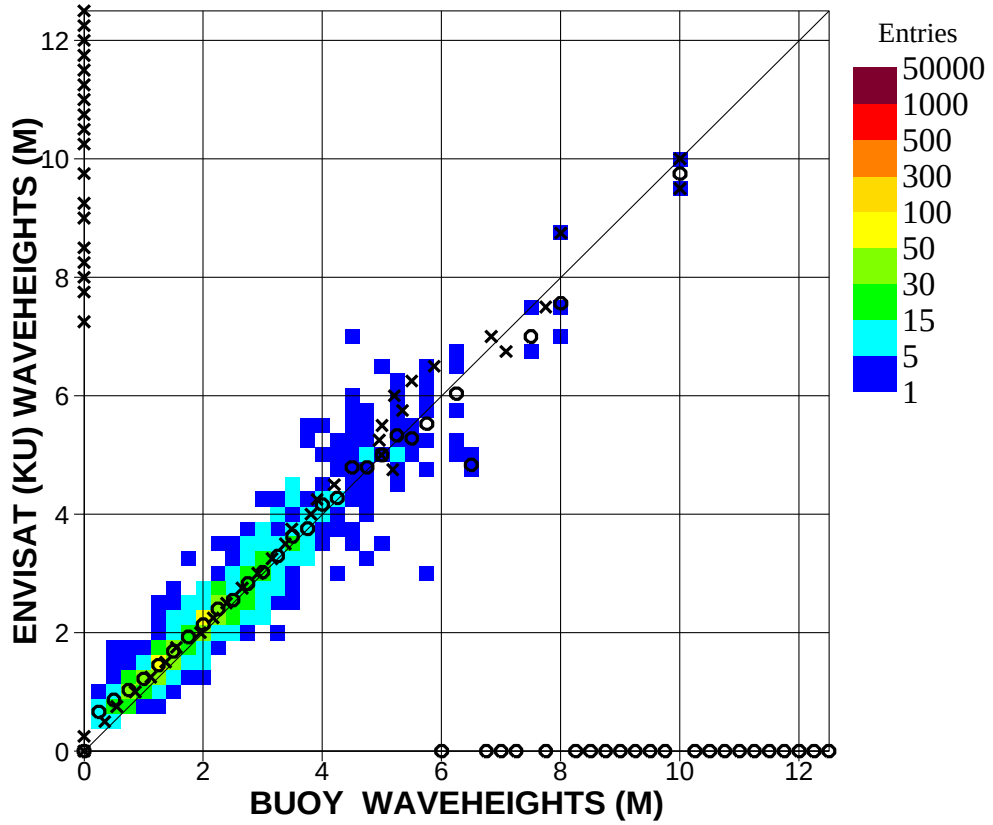

STATISTICS

ENTRIES	1307	
MEAN BUOY	2.3378	
MEAN ENVISAT	2.4734	
BIAS (ENVISAT - BUOY)	.1356	
STANDARD DEVIATION	.3843	
SCATTER INDEX	.1644	
CORRELATION	.9568	
SYMMETRIC SLOPE	1.0386	(.0084)
REGR. COEFFICIENT	.9329	(.0078)
REGR. CONSTANT	.2925	(.0211)

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

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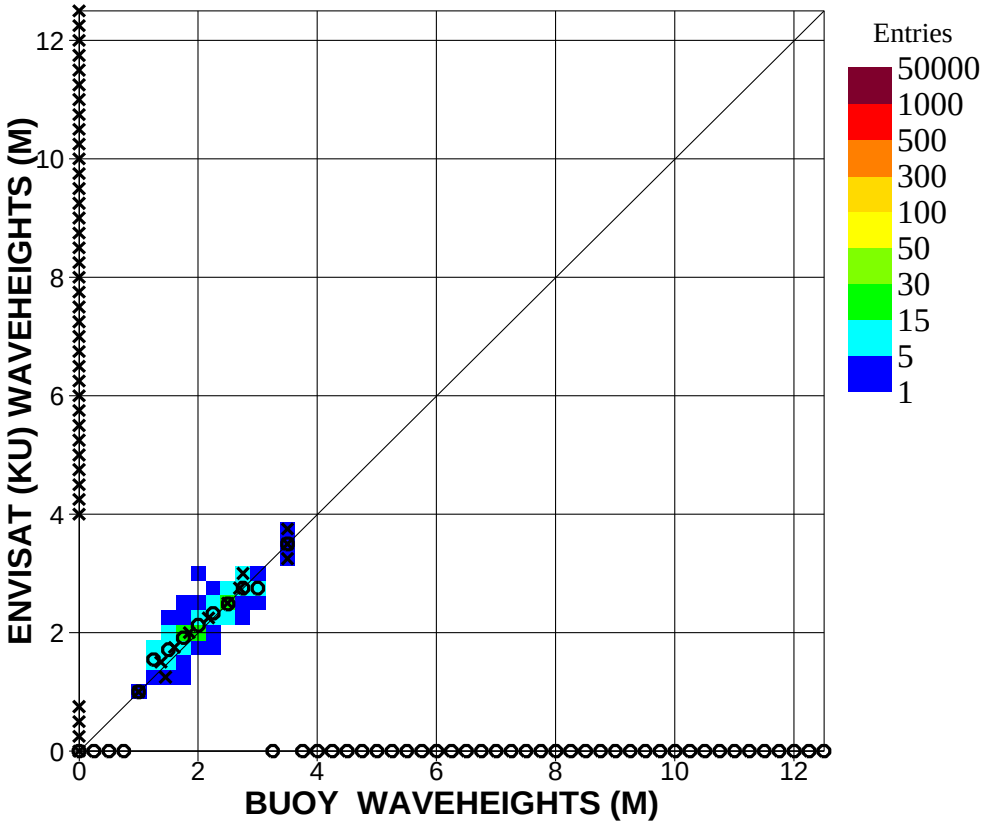

STATISTICS

ENTRIES	204	
MEAN BUOY	2.1055	
MEAN ENVISAT	2.1814	
BIAS (ENVISAT - BUOY)	.0759	
STANDARD DEVIATION	.2179	
SCATTER INDEX	.1035	
CORRELATION	.9214	
SYMMETRIC SLOPE	1.0274	(.0284)
REGR. COEFFICIENT	.8244	(.0245)
REGR. CONSTANT	.4455	(.0533)

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

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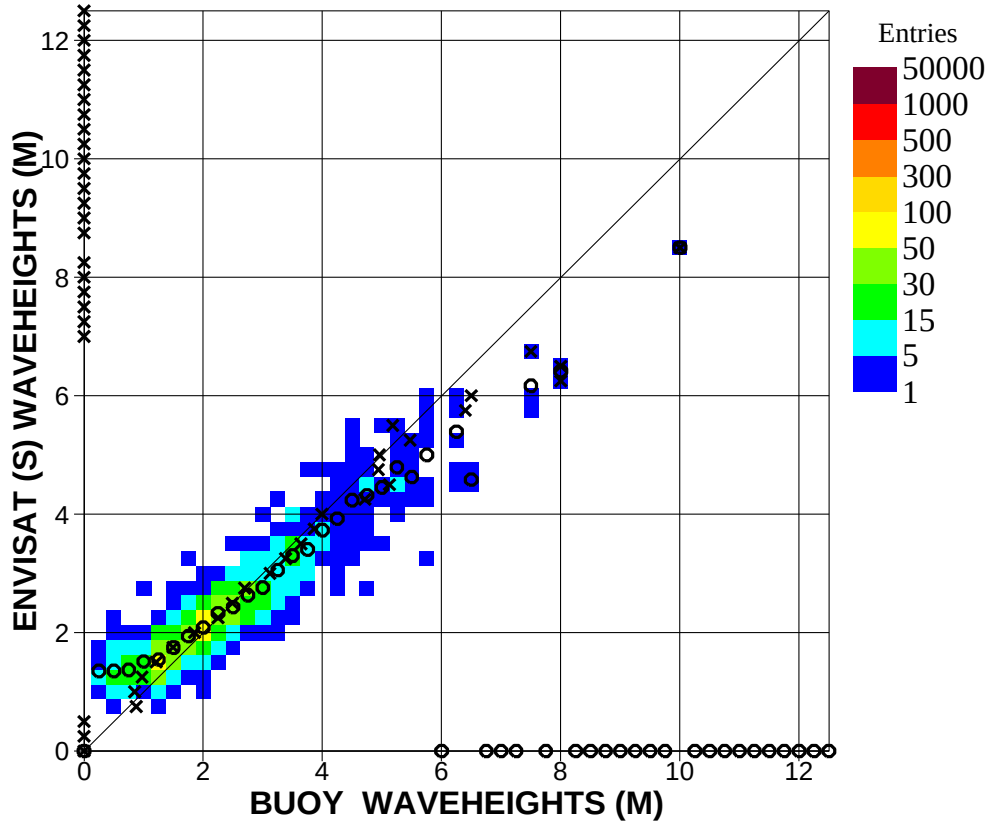

STATISTICS

ENTRIES	1501	
MEAN BUOY	2.3070	
MEAN ENVISAT	2.3741	
BIAS (ENVISAT - BUOY)	.0671	
STANDARD DEVIATION	.4844	
SCATTER INDEX	.2100	
CORRELATION	.9312	
SYMMETRIC SLOPE	.9804	(.0101)
REGR. COEFFICIENT	.7331	(.0074)
REGR. CONSTANT	.6828	(.0194)

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

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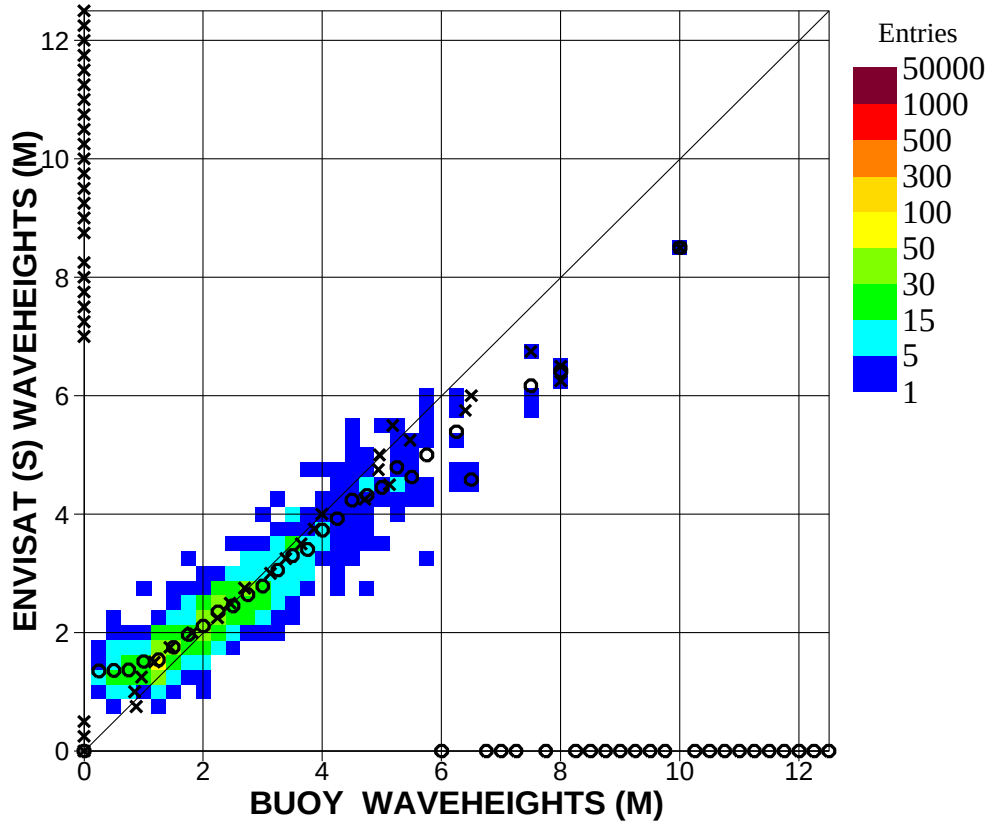

STATISTICS

ENTRIES	1291	
MEAN BUOY	2.3434	
MEAN ENVISAT	2.4202	
BIAS (ENVISAT - BUOY)	.0767	
STANDARD DEVIATION	.5095	
SCATTER INDEX	.2174	
CORRELATION	.9331	
SYMMETRIC SLOPE	.9793	(.0108)
REGR. COEFFICIENT	.7312	(.0078)
REGR. CONSTANT	.7067	(.0211)

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

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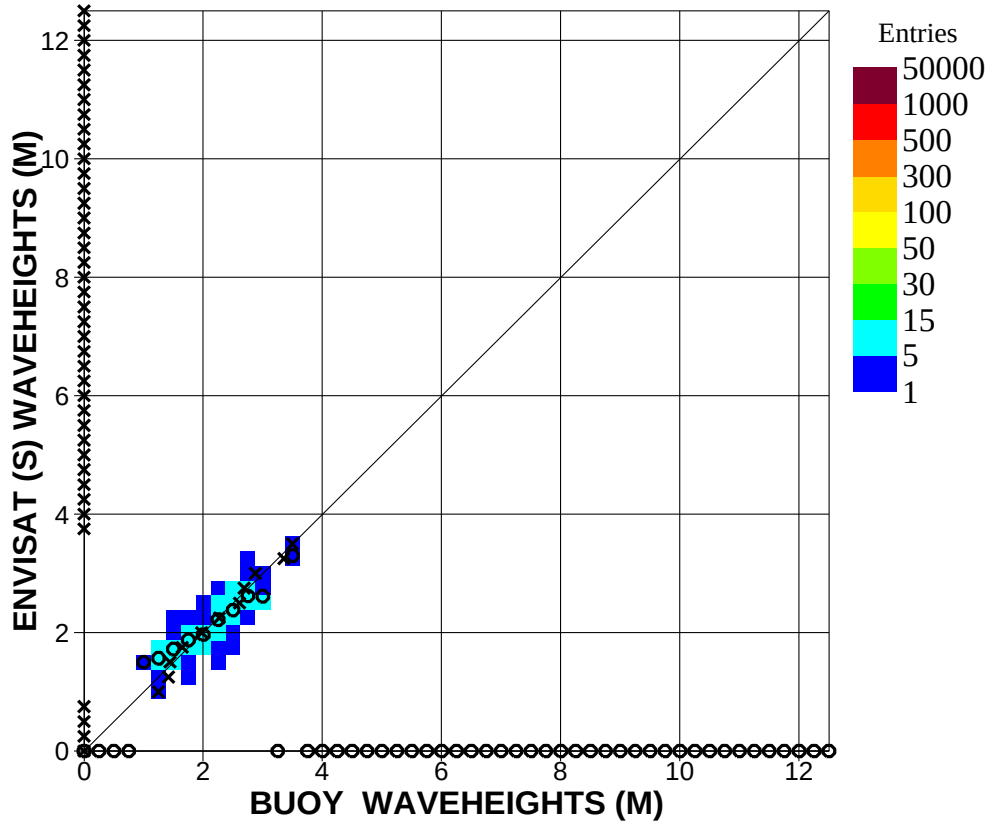

STATISTICS

ENTRIES	204	
MEAN BUOY	2.1055	
MEAN ENVISAT	2.1059	
BIAS (ENVISAT - BUOY)	.0004	
STANDARD DEVIATION	.2720	
SCATTER INDEX	.1292	
CORRELATION	.8759	
SYMMETRIC SLOPE	.9891	(.0339)
REGR. COEFFICIENT	.7128	(.0276)
REGR. CONSTANT	.6051	(.0602)

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

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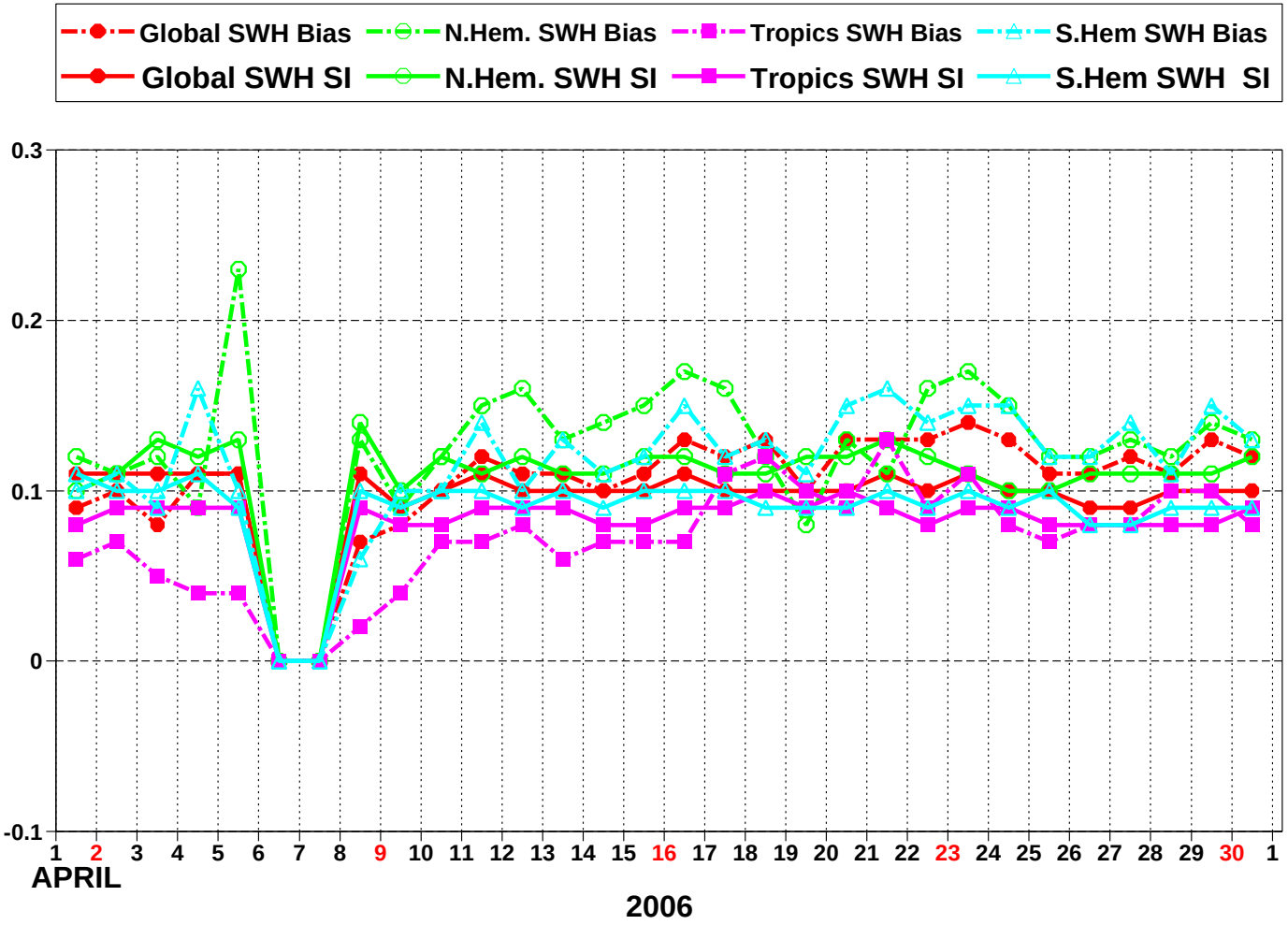

Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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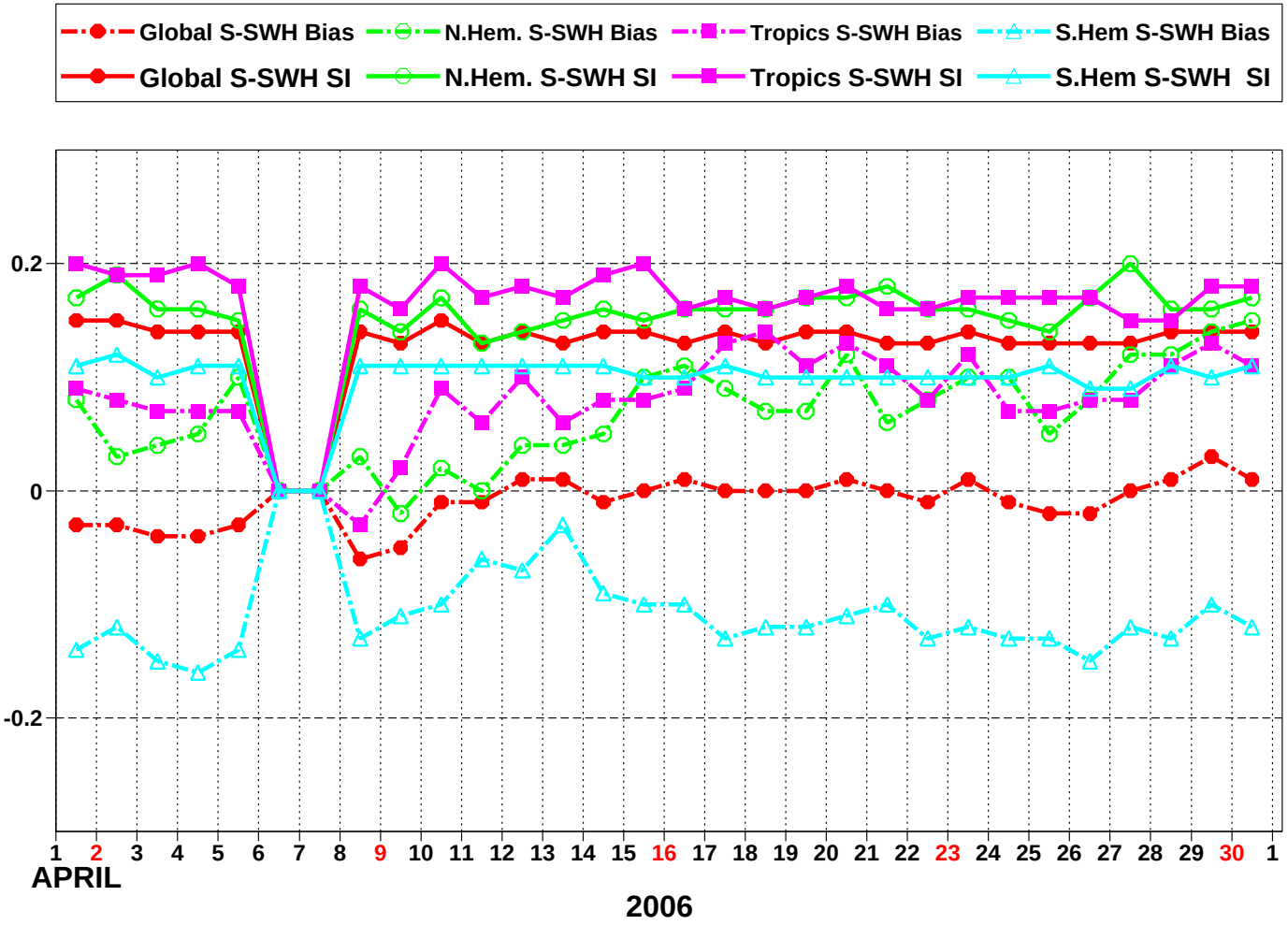

Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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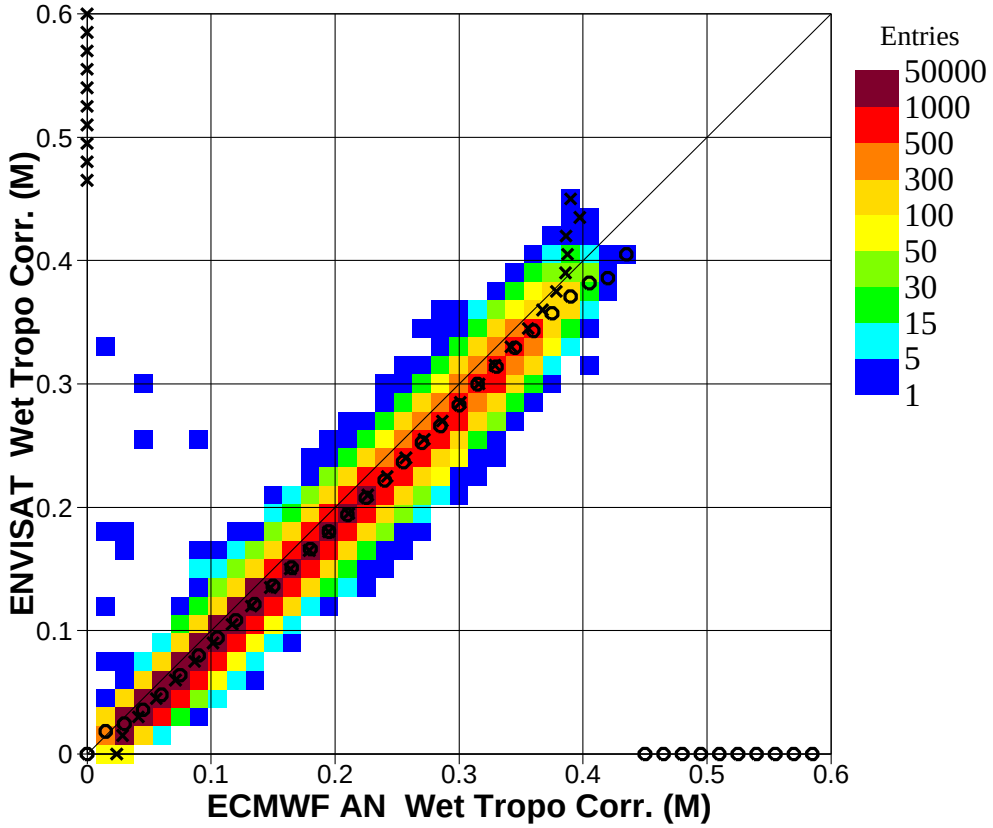

STATISTICS

ENTRIES	80118
MEAN ECMWF	.1591
MEAN ENVISAT	.1460
BIAS (ENVISAT - ECMWF)	-.0132
STANDARD DEVIATION	.0133
SCATTER INDEX	.0835
CORRELATION	.9908
SYMMETRIC SLOPE	.9343 (.0005)
REGR. COEFFICIENT	.9695 (.0005)
REGR. CONSTANT	-.0083 (.0001)

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

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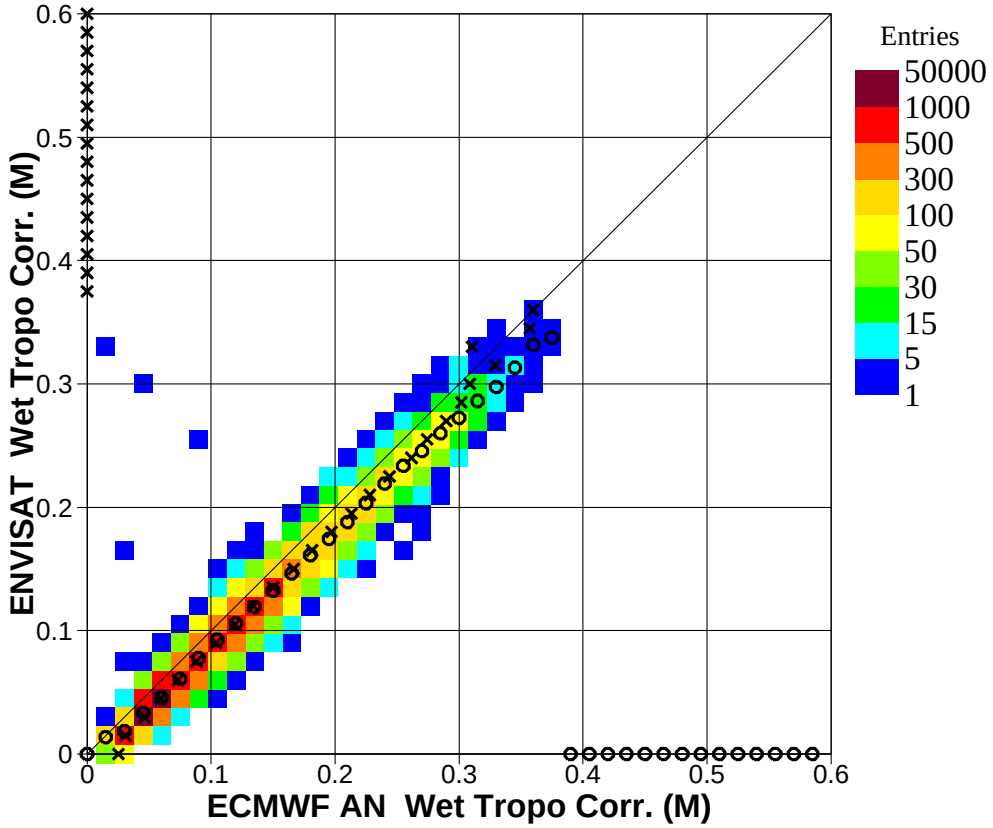

STATISTICS

ENTRIES	19628
MEAN ECMWF	.1135
MEAN ENVISAT	.0983
BIAS (ENVISAT - ECMWF)	-.0152
STANDARD DEVIATION	.0117
SCATTER INDEX	.1028
CORRELATION	.9832
SYMMETRIC SLOPE	.8909 (.0014)
REGR. COEFFICIENT	.9498 (.0013)
REGR. CONSTANT	-.0095 (.0002)

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

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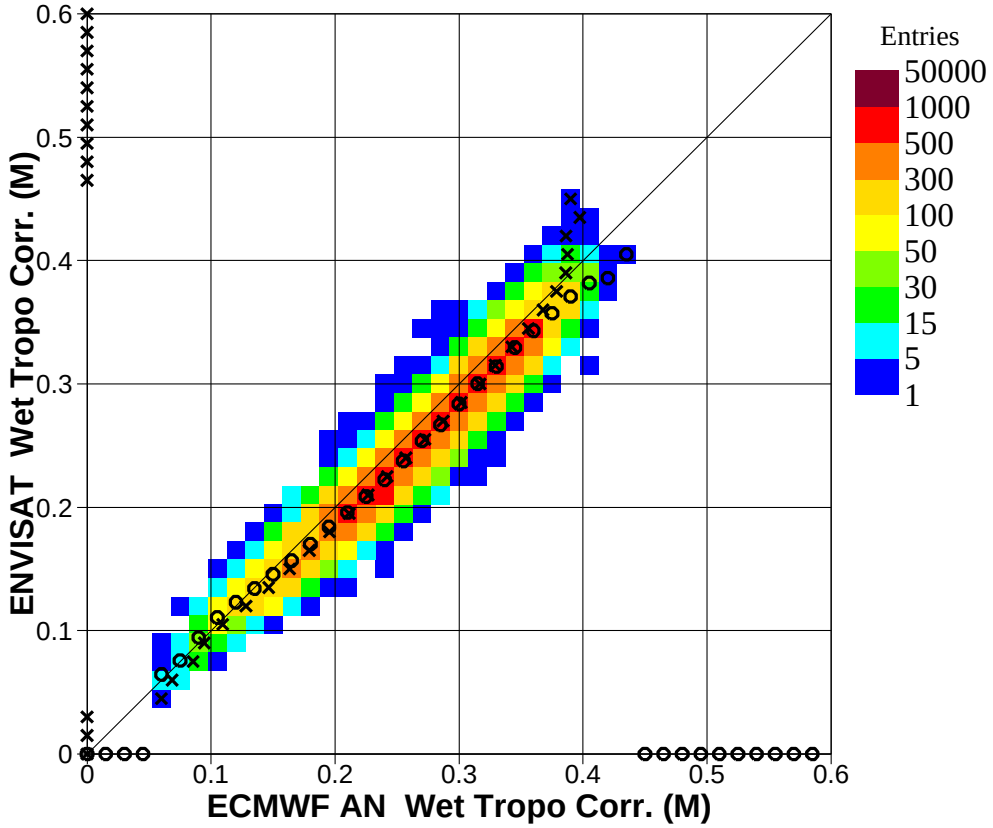

STATISTICS

ENTRIES	24426
MEAN ECMWF	.2683
MEAN ENVISAT	.2536
BIAS (ENVISAT - ECMWF)	-.0148
STANDARD DEVIATION	.0158
SCATTER INDEX	.0590
CORRELATION	.9725
SYMMETRIC SLOPE	.9473 (.0015)
REGR. COEFFICIENT	.9573 (.0015)
REGR. CONSTANT	-.0033 (.0004)

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

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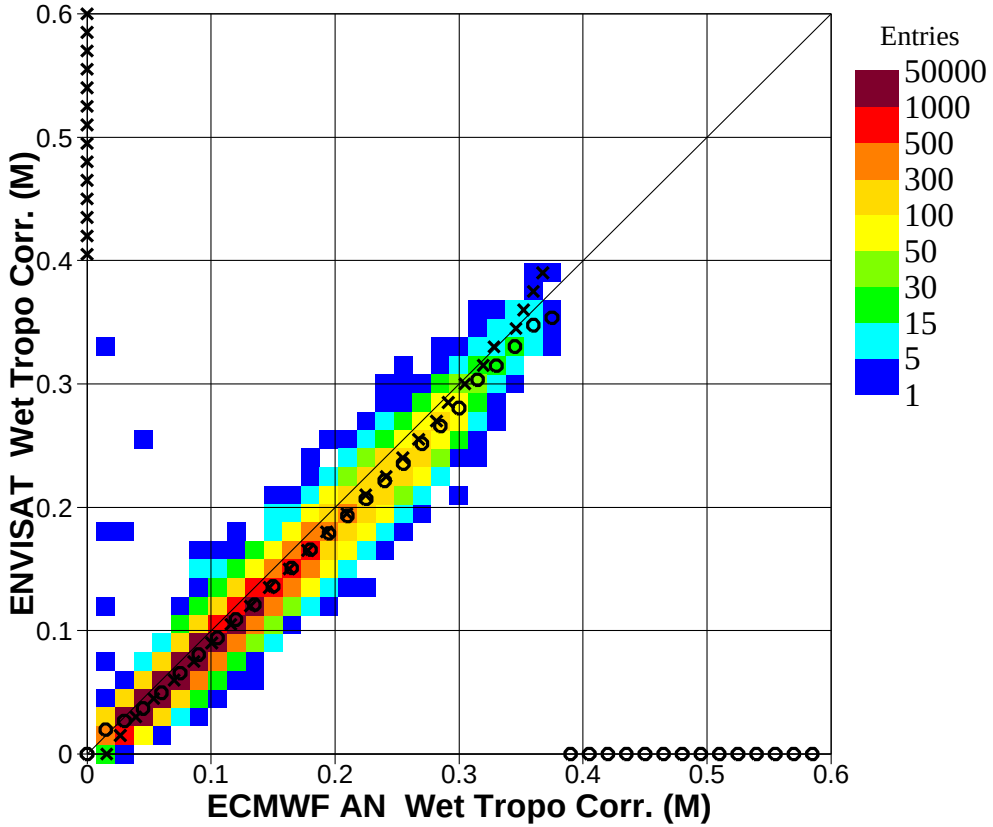

STATISTICS

ENTRIES	36664
MEAN ECMWF	.1116
MEAN ENVISAT	.1006
BIAS (ENVISAT - ECMWF)	-.0110
STANDARD DEVIATION	.0119
SCATTER INDEX	.1062
CORRELATION	.9839
SYMMETRIC SLOPE	.9174 (.0009)
REGR. COEFFICIENT	.9469 (.0009)
REGR. CONSTANT	-.0051 (.0001)

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

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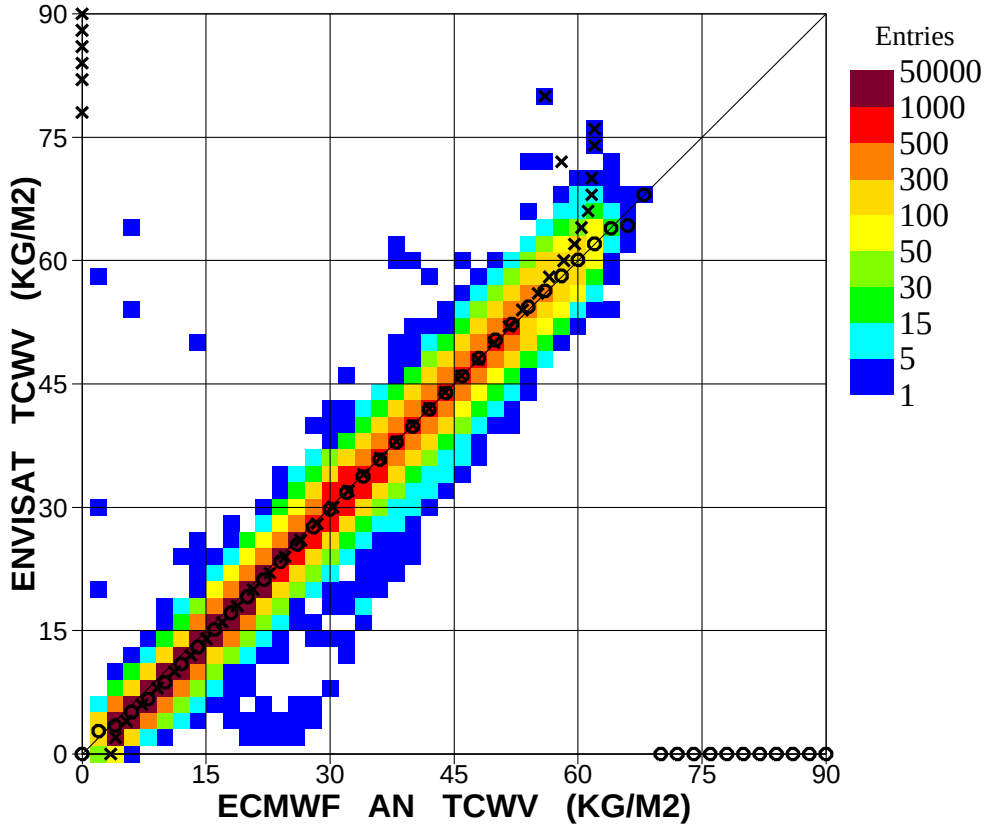

STATISTICS

ENTRIES	80117
MEAN ECMWF	24.3711
MEAN ENVISAT	23.7722
BIAS (ENVISAT - ECMWF)	-.5989
STANDARD DEVIATION	2.0063
SCATTER INDEX	.0823
CORRELATION	.9926
SYMMETRIC SLOPE	.9935 (.0005)
REGR. COEFFICIENT	1.0291 (.0004)
REGR. CONSTANT	-1.3075 (.0129)

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

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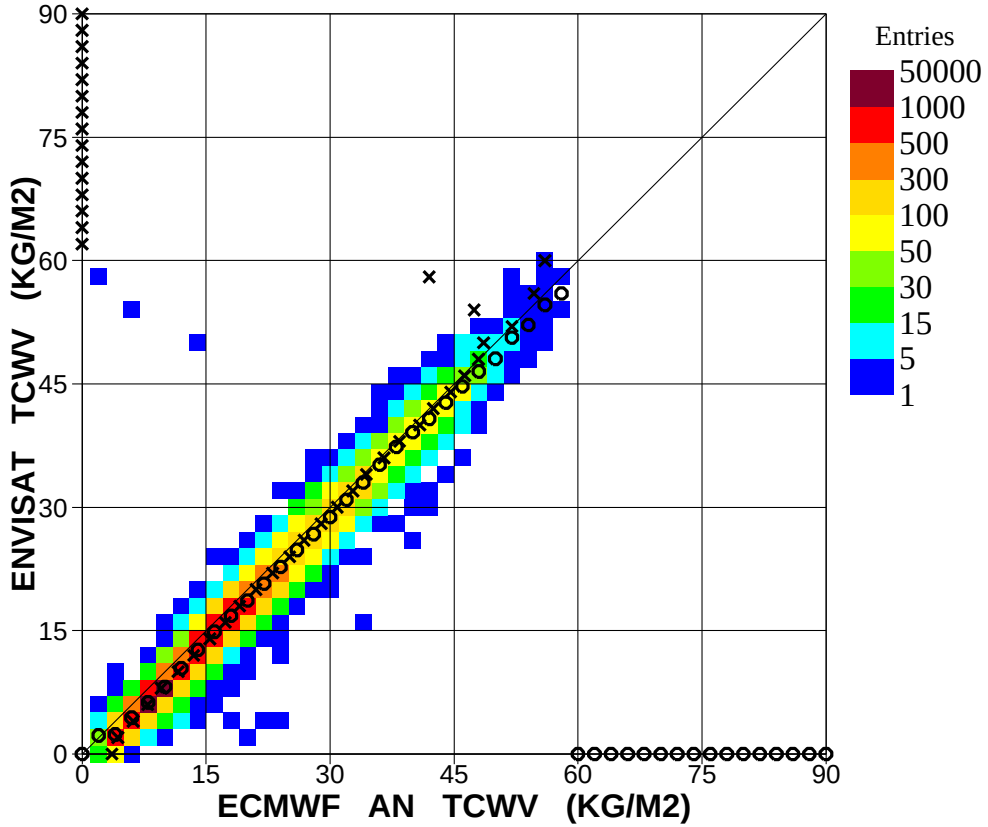

STATISTICS

ENTRIES	19628
MEAN ECMWF	17.1363
MEAN ENVISAT	15.7308
BIAS (ENVISAT - ECMWF)	-1.4055
STANDARD DEVIATION	1.7024
SCATTER INDEX	.0993
CORRELATION	.9865
SYMMETRIC SLOPE	.9488 (.0014)
REGR. COEFFICIENT	1.0204 (.0012)
REGR. CONSTANT	-1.7558 (.0240)

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

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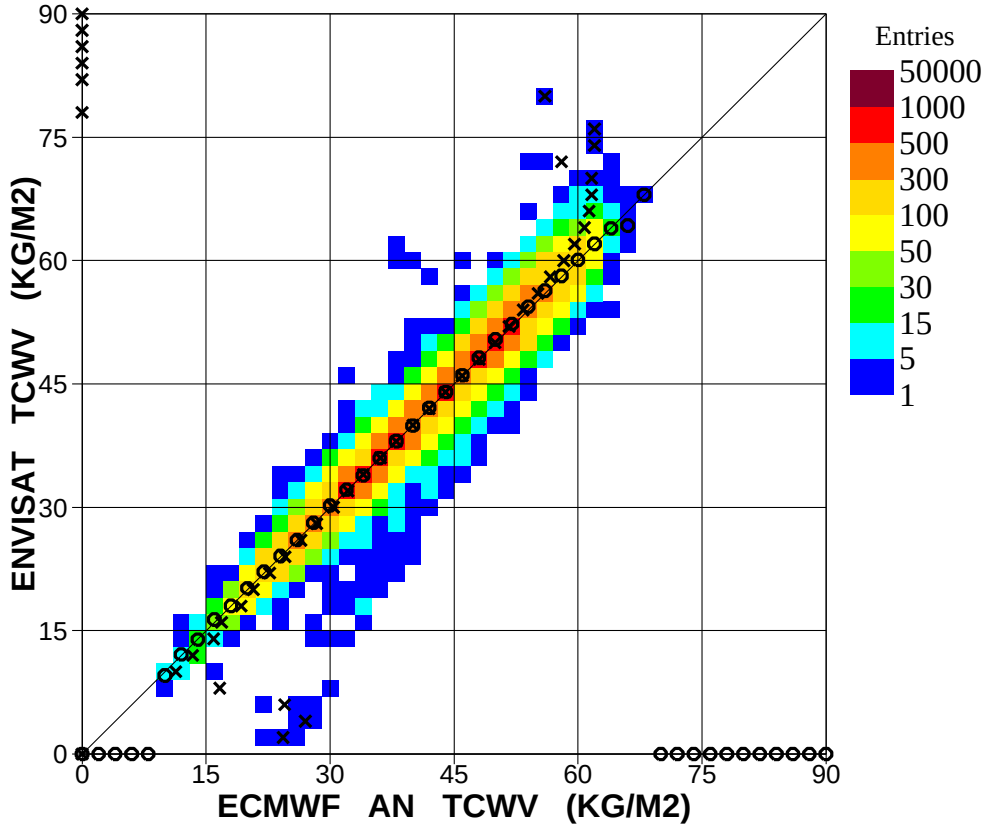

STATISTICS

ENTRIES	24426
MEAN ECMWF	41.8056
MEAN ENVISAT	41.9271
BIAS (ENVISAT - ECMWF)	.1215
STANDARD DEVIATION	2.3614
SCATTER INDEX	.0565
CORRELATION	.9779
SYMMETRIC SLOPE	1.0049 (.0014)
REGR. COEFFICIENT	1.0104 (.0014)
REGR. CONSTANT	-.3113 (.0598)

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

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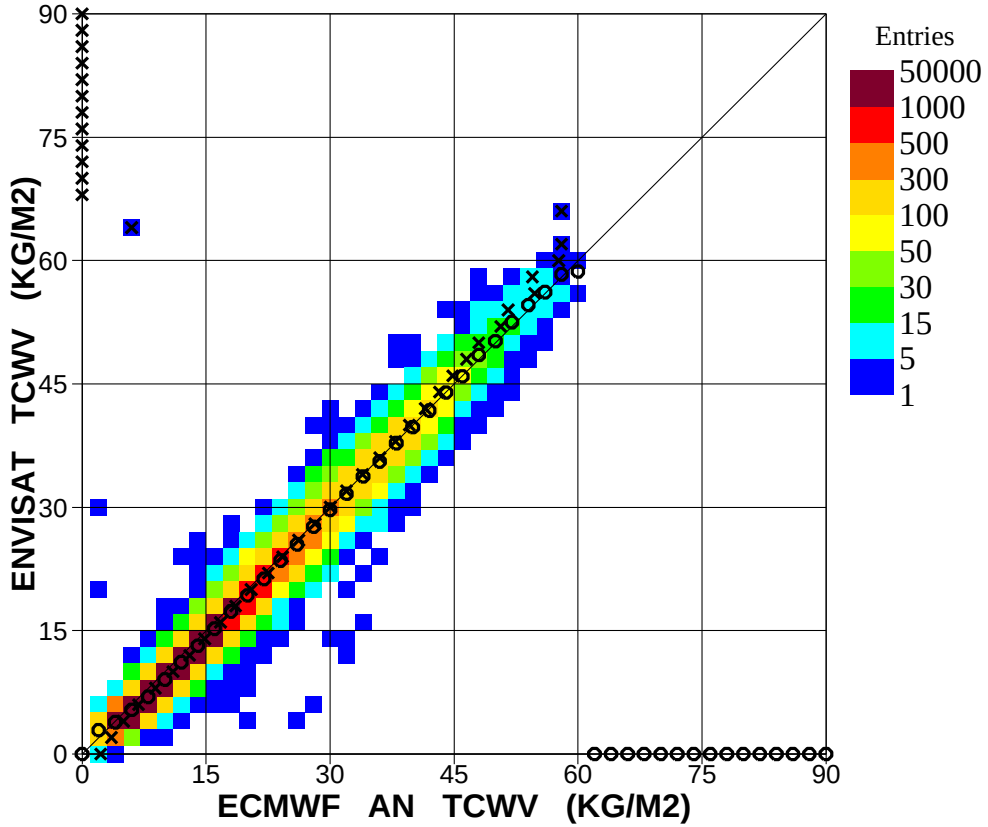

STATISTICS

ENTRIES	36663
MEAN ECMWF	16.7532
MEAN ENVISAT	16.1144
BIAS (ENVISAT - ECMWF)	-.6388
STANDARD DEVIATION	1.7062
SCATTER INDEX	.1018
CORRELATION	.9871
SYMMETRIC SLOPE	.9806 (.0009)
REGR. COEFFICIENT	1.0154 (.0009)
REGR. CONSTANT	-.8960 (.0169)

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

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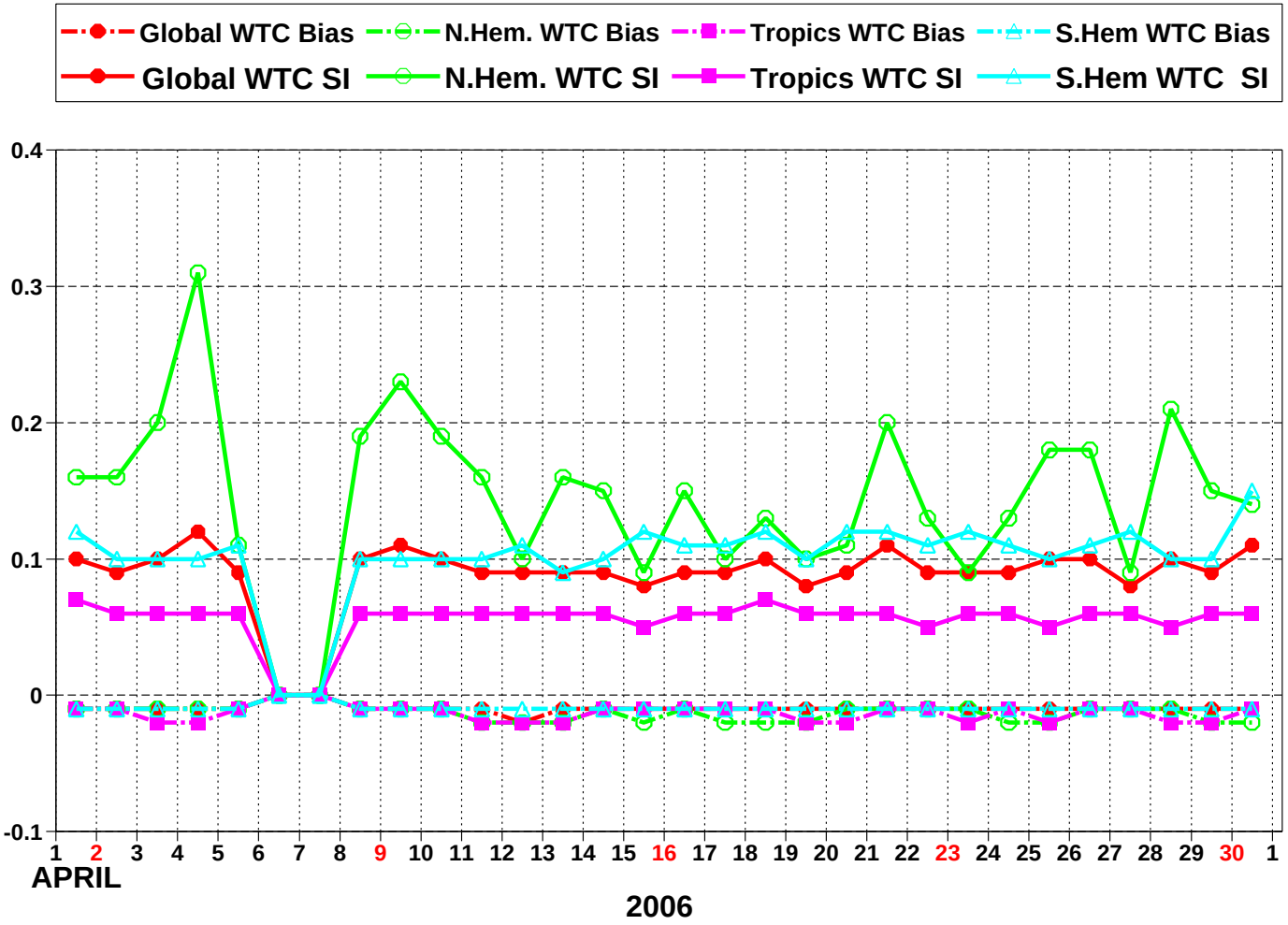

Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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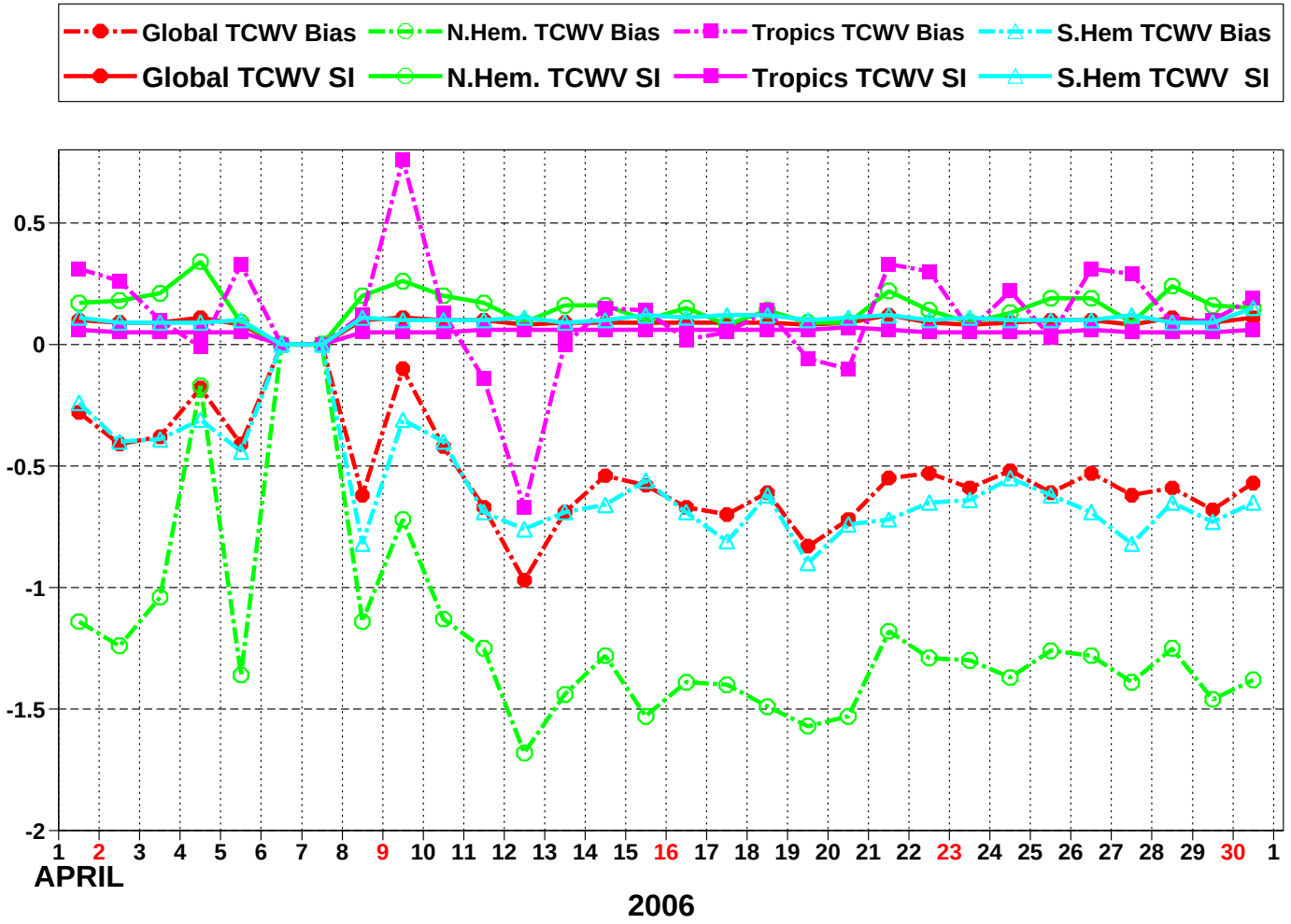

Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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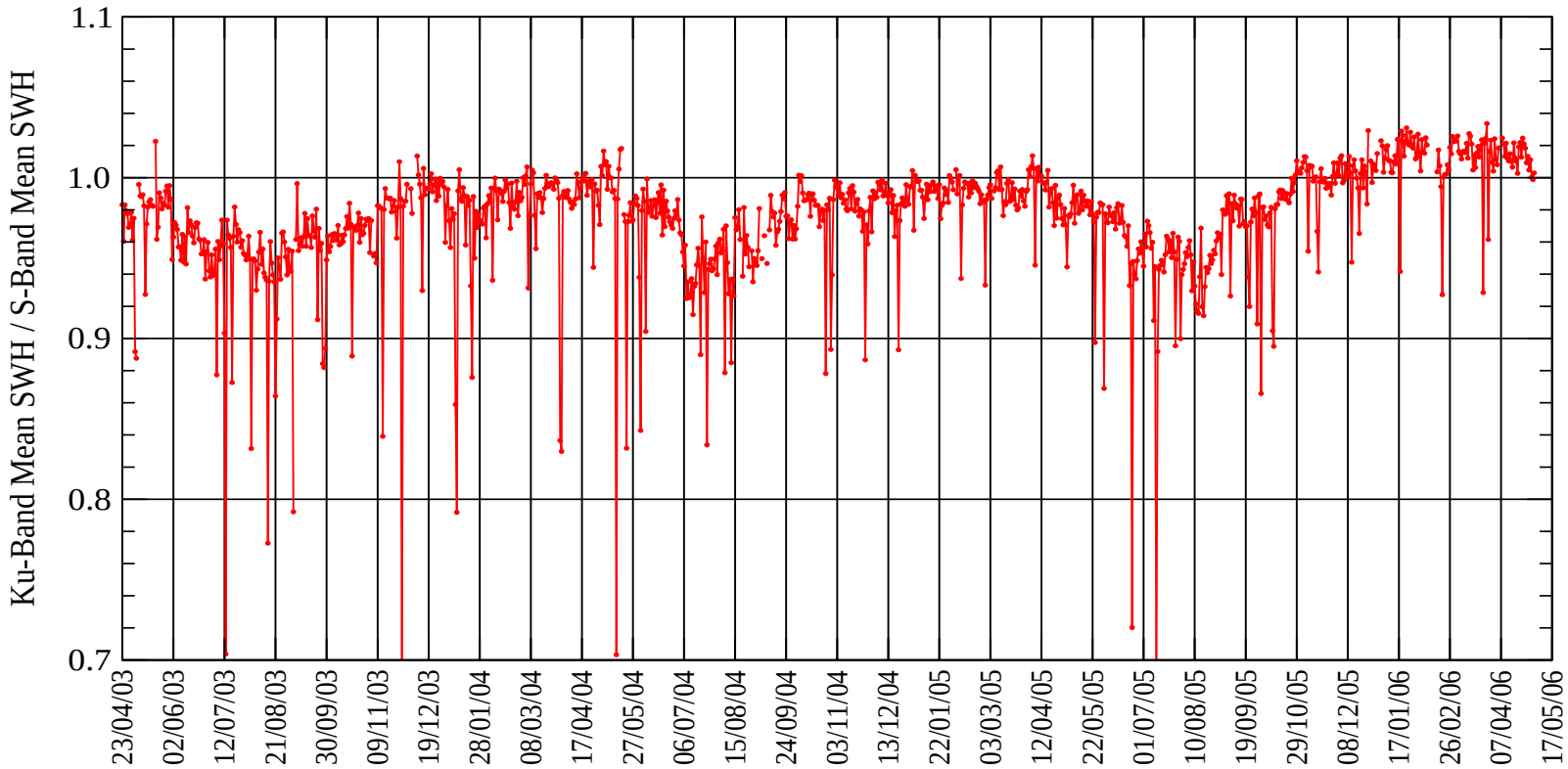

Figure 48: Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 23rd. of April 2003.

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