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

Wind/Wave Product with Height Information (RA2_WWV_2P)

By: *Saleh Abdalla*

Date: *7 March 2006*

Overview:

Based on the data received during this month, on average, 16372 observations arrived at ECMWF every 6-hour window of which an average of 7802 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 72.43% of the remaining part passed the quality control. As can be seen in Figure 1, there was no data during the following periods (in terms of 6-hour time-windows; all times are in UTC):

- time windows from 12:00 on the 9th. to 18:00 on the 12th. of the month (both windows inclusive). The data loss during this period is due to the change in the BUFR format which caused data retrieval software to fail.

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

- time windows centred at 06:00 and 12:00 on the 1st. of the month,
- time window centred at 06:00 on the 9th. 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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ECMWF Report on ENVISAT RA-2 for February 2006

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 $<\sigma_0>$ = 11.03 dB (with a main peak at 11.1 dB and a secondary peak at 10.6 dB).
- ENVISAT S-band $<\sigma_0>$ = 11.29 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	15.3	+ 0.09	16.4
Northern Hemisphere	+ 0.48	15.5	+ 0.19	16.5
Tropics	+ 0.13	15.8	- 0.62	11.3
Southern Hemisphere	+ 0.25	14.4	----	----

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

	RA2 (Ku) - WAM		RA2 (Ku) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	0.10	10.9	0.12	14.1
Northern Hemisphere	0.14	11.1	0.12	14.1
Tropics	0.08	10.0	0.12	13.5
Southern Hemisphere	0.10	10.7	----	----

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

	RA2 (S) - WAM		RA2 (S) - Buoy	
	Bias (m)	SI (%)	Bias (m)	SI (%)
Global	+ 0.01	13.8	- 0.05	18.2
Northern Hemisphere	- 0.04	13.7	- 0.06	18.2
Tropics	+ 0.10	16.9	+ 0.05	17.0
Southern Hemisphere	- 0.03	12.0	----	----

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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	8.2	- 0.53	7.8
Northern Hemisphere	- 0.012	11.1	- 0.97	10.4
Tropics	- 0.014	6.1	+ 0.17	5.5
Southern Hemisphere	- 0.012	9.5	- 0.73	9.1

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.**
- **On 1 February 2006, the ECMWF operational model was changed (current operational cycle is CY30R1) and the related changes are as follows. The horizontal and vertical resolutions of atmospheric model were enhanced to T799 and 91 levels, respectively. The horizontal resolutions of the wave model was enhanced to 0.36^o.**

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ENVISAT ASAR Wave Mode Level 1b is assimilated instead of ERS-2 SAR Wave Mode. Jason altimeter significant wave heights are also assimilated.
For further information and the other changes see:
http://www.ecmwf.int/products/data/operational_system/evolution/evolution_2006.html#1February2006

- 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.
- **The rain flag is responsible for the rejection of 12% of the data this month. As in the case of the last two months, it is more than two times higher than usual. There was one major event of over-active rain flagging on the 20th. of the month (lower panel of Figure 1). Furthermore, in addition to several minor events, the flag was rather active during the whole month similar to the previous 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 25 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 4.4% when compared to WAM results (4.7% in the NH, 4.8% in Tropics and 4.0% 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 2.5% higher than buoy wave heights as can be seen in Figures 30-32 (Ku-band - buoy comparison).

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- 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 S-band - wave model significant wave height scatter plots (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 slightly lower than the model except in the Tropics (with low sea state dominance).
- There was an abnormal hike in the bias and scatter index of S-band wave heights with respect to wave model on the 9th. of the month as can be seen in Figure 37.
- The ratio between Ku-band and S-band wave heights this month was around 1.02 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.**

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- 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.

List of Figures:

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ECMWF Report on ENVISAT RA-2 for February 2006

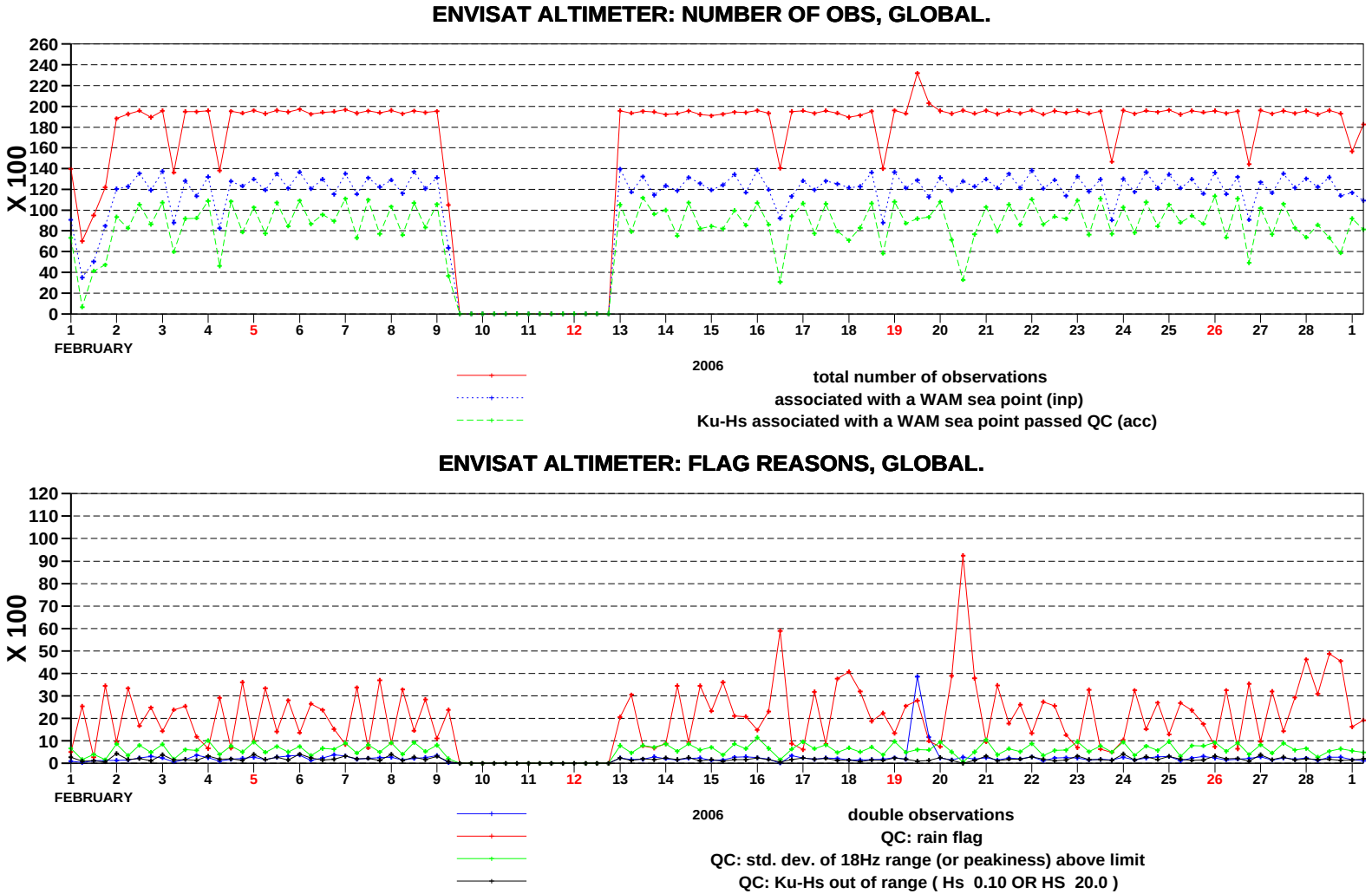

Figure 1: Time series of data reception for ENVISAT Altimeter data for February 2006

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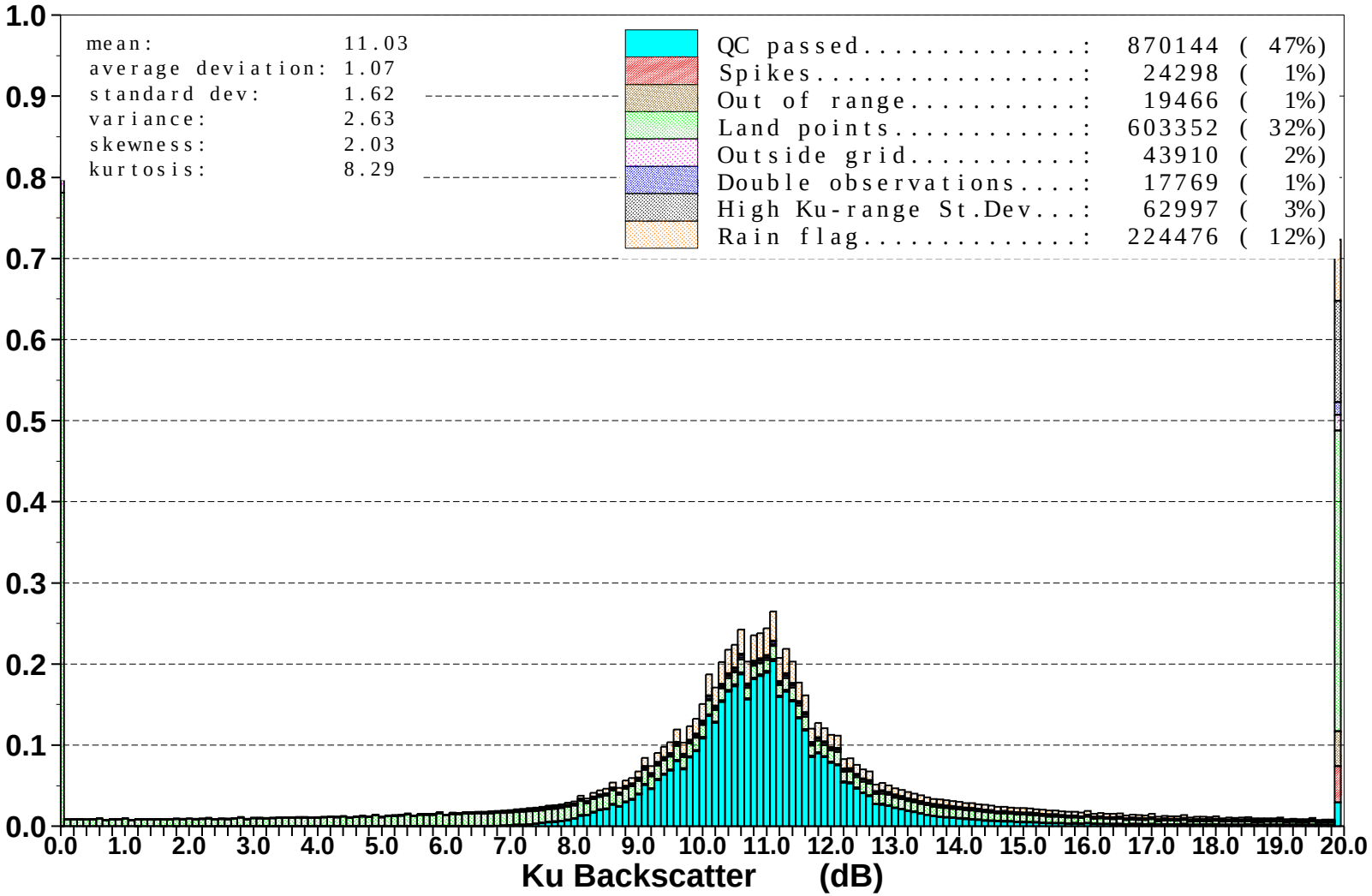

Figure 2: Distribution of the ENVISAT Altimeter Ku Backscatter after QC for February 2006

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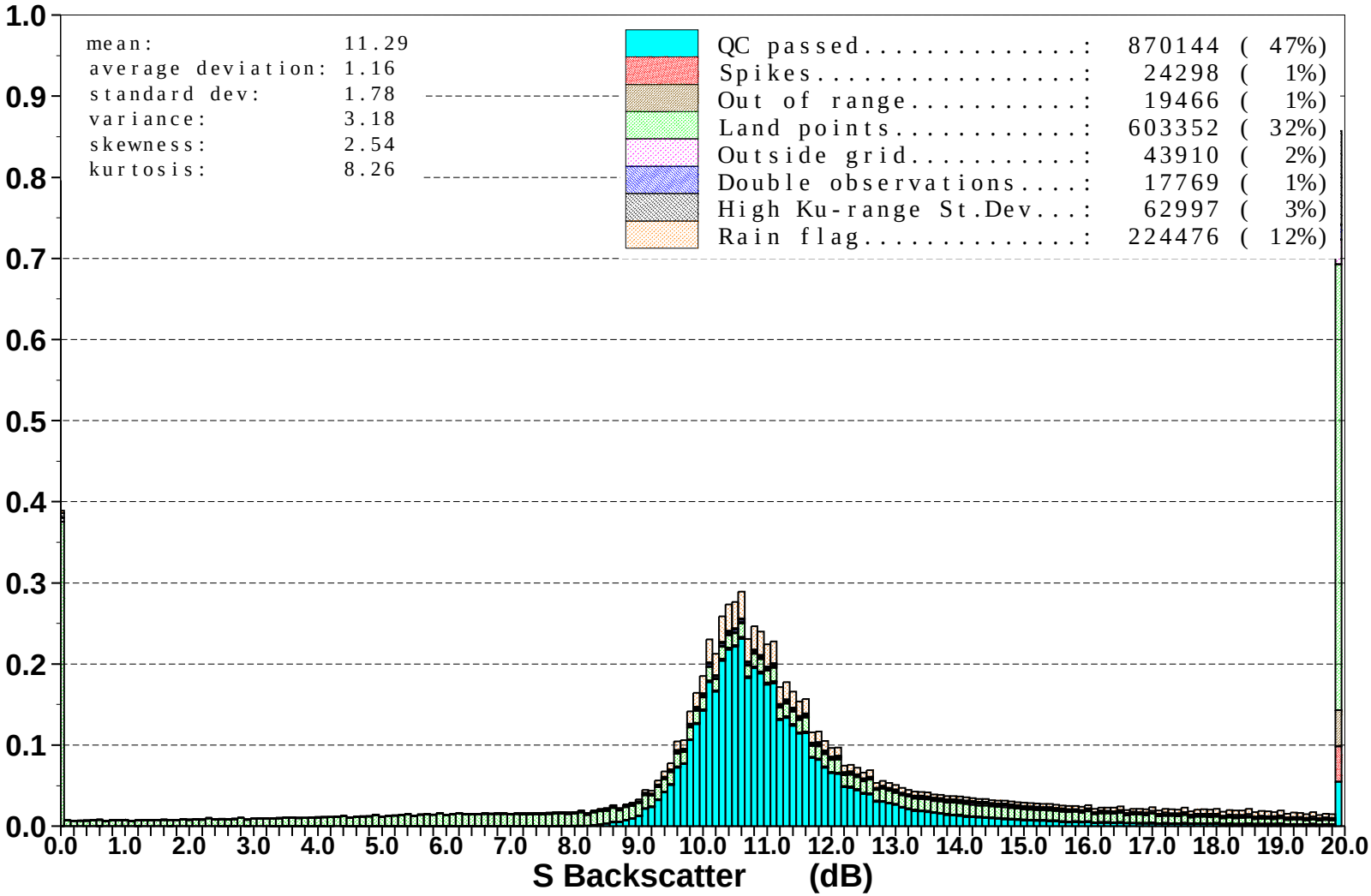

Figure 3: Distribution of the ENVISAT Altimeter S Backscatter after QC for February 2006

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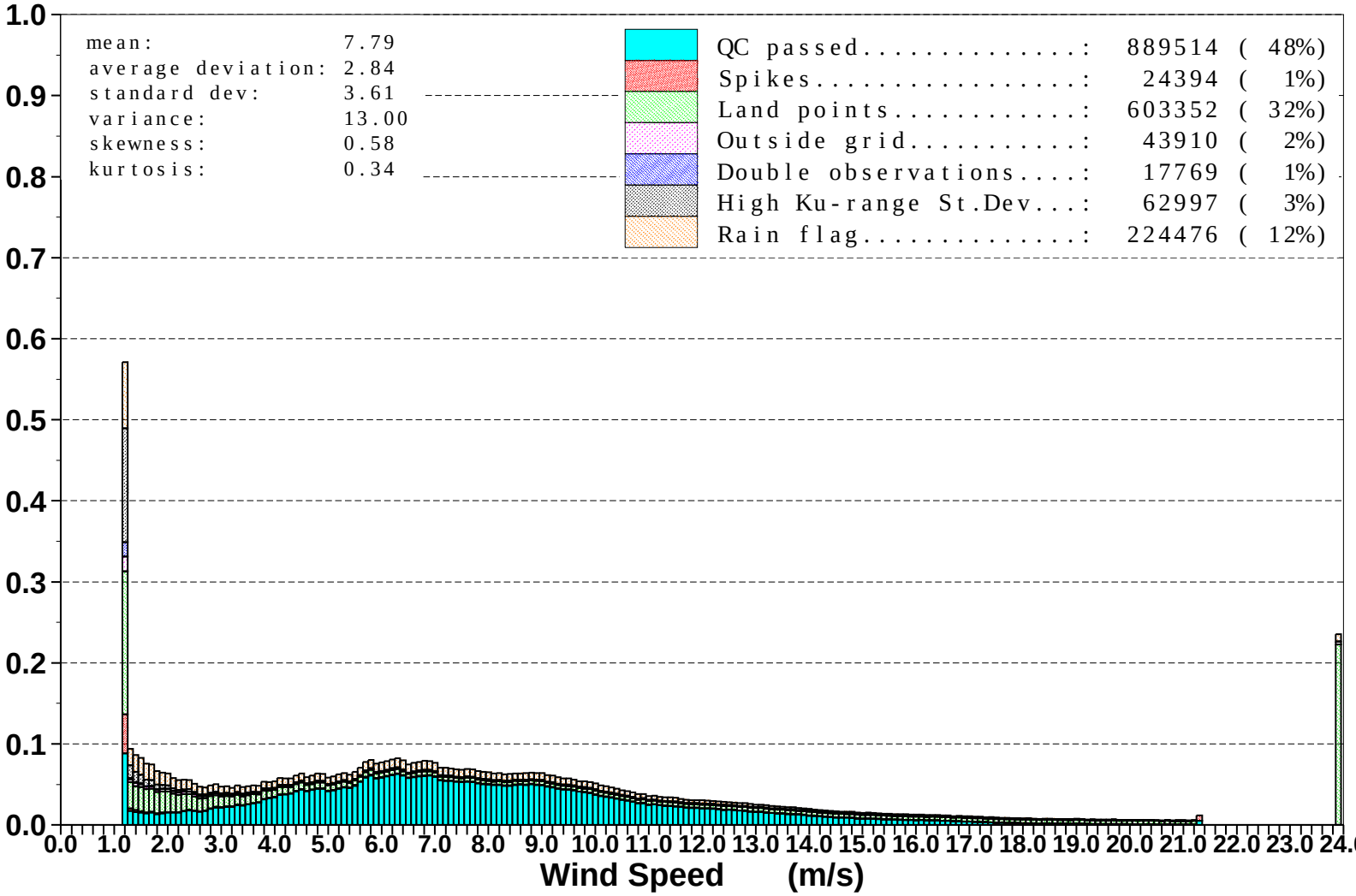

Figure 4: Distribution of the ENVISAT Altimeter Wind Speed after QC for February 2006

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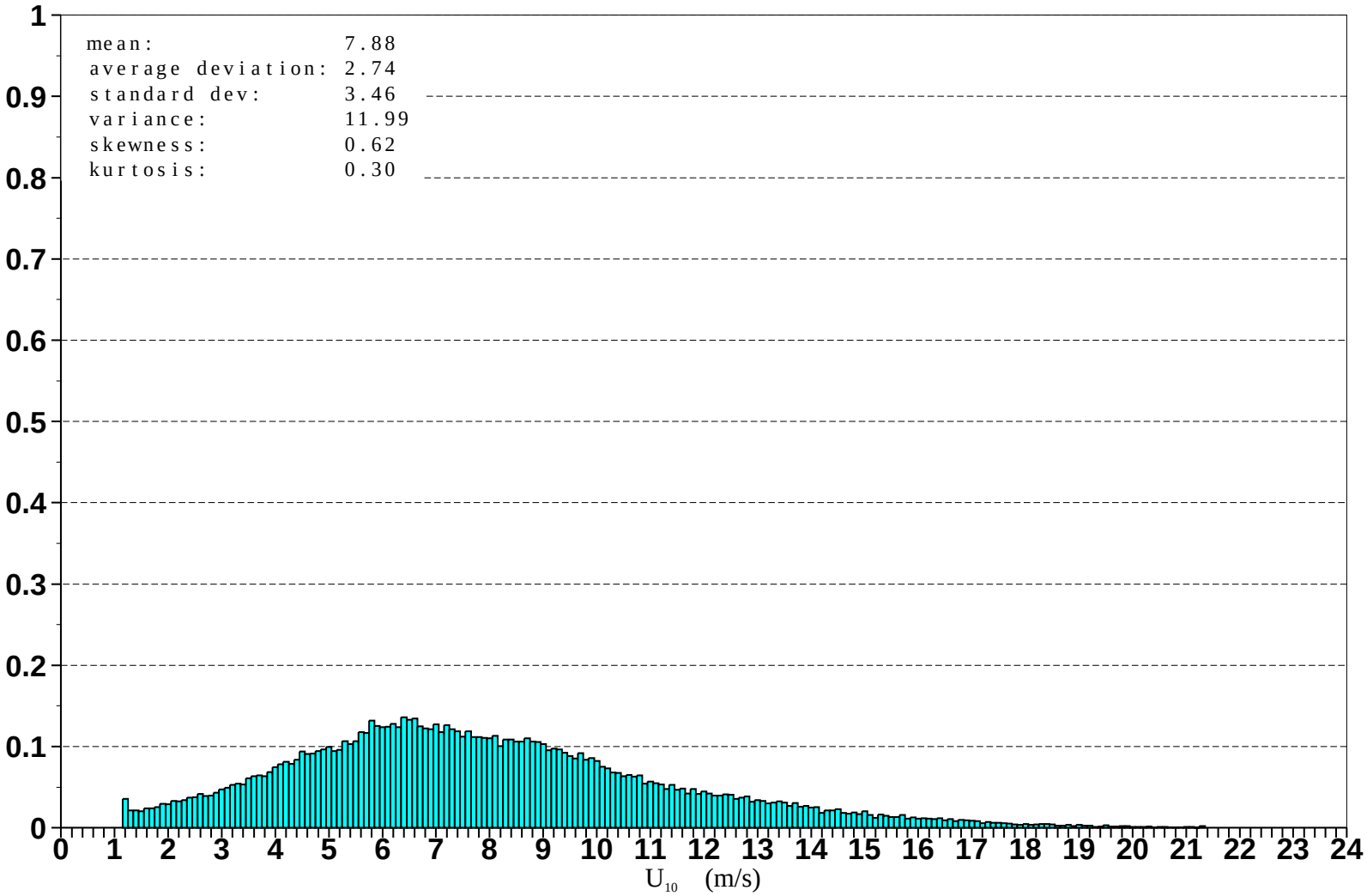

Figure 5: Distribution of ENVISAT Altimeter Wind Speeds after Along-Track Averaging for February 2006

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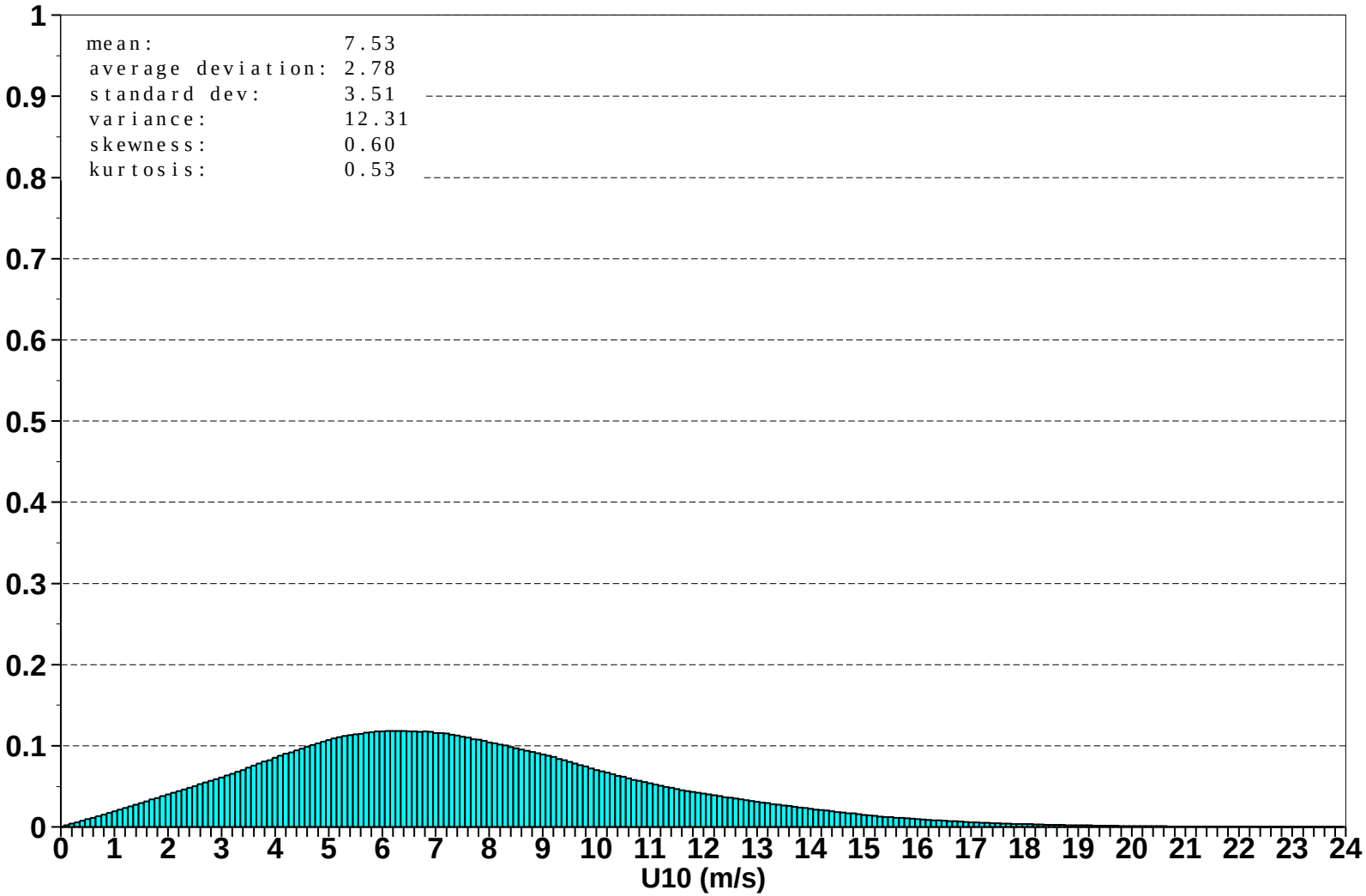

Figure 6: Global distribution of ECMWF Analysis ocean surface wind speeds for February 2006

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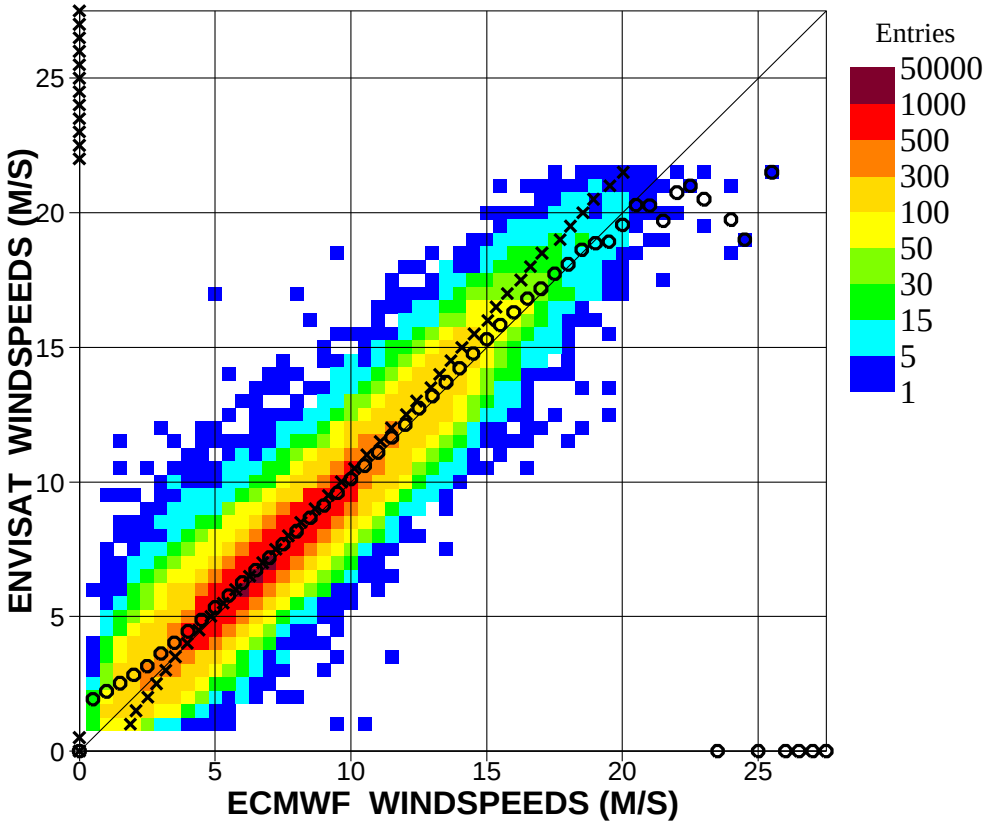

STATISTICS

ENTRIES	79207
MEAN ECMWF	7.6066
MEAN ENVISAT	7.8784
BIAS (ENVISAT - ECMWF)	.2718
STANDARD DEVIATION	1.1618
SCATTER INDEX	.1527
CORRELATION	.9428
SYMMETRIC SLOPE	1.0330 (.0012)
REGR. COEFFICIENT	.9611 (.0012)
REGR. CONSTANT	.5674 (.0101)

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

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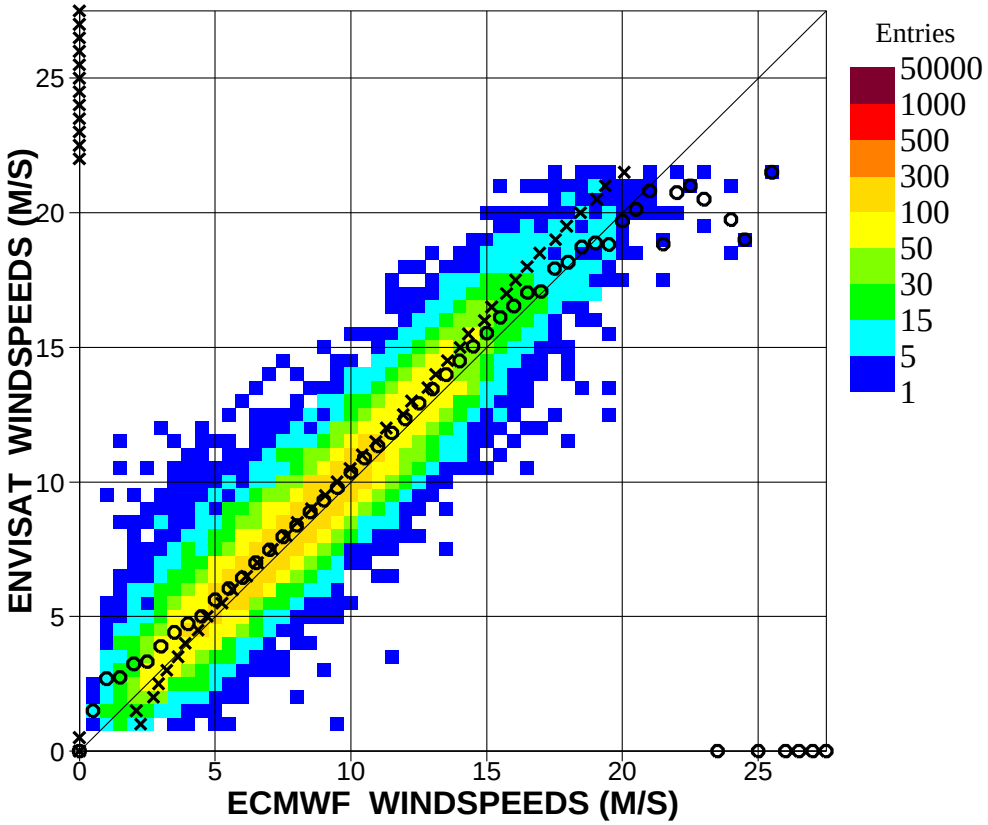

STATISTICS

ENTRIES	19488
MEAN ECMWF	8.6789
MEAN ENVISAT	9.1547
BIAS (ENVISAT - ECMWF)	.4757
STANDARD DEVIATION	1.3452
SCATTER INDEX	.1550
CORRELATION	.9379
SYMMETRIC SLOPE	1.0507 (.0026)
REGR. COEFFICIENT	.9646 (.0026)
REGR. CONSTANT	.7830 (.0242)

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

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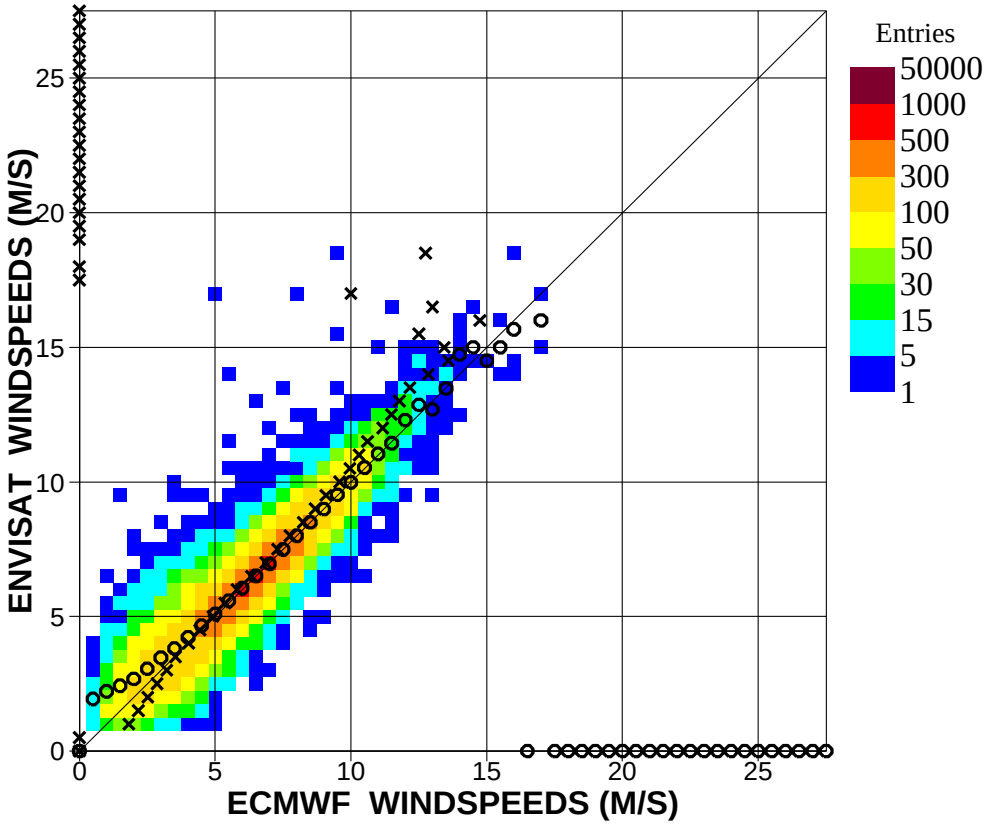

STATISTICS

ENTRIES	24233
MEAN ECMWF	6.1007
MEAN ENVISAT	6.2315
BIAS (ENVISAT - ECMWF)	.1308
STANDARD DEVIATION	.9661
SCATTER INDEX	.1584
CORRELATION	.9143
SYMMETRIC SLOPE	1.0208 (.0027)
REGR. COEFFICIENT	.9295 (.0026)
REGR. CONSTANT	.5611 (.0173)

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

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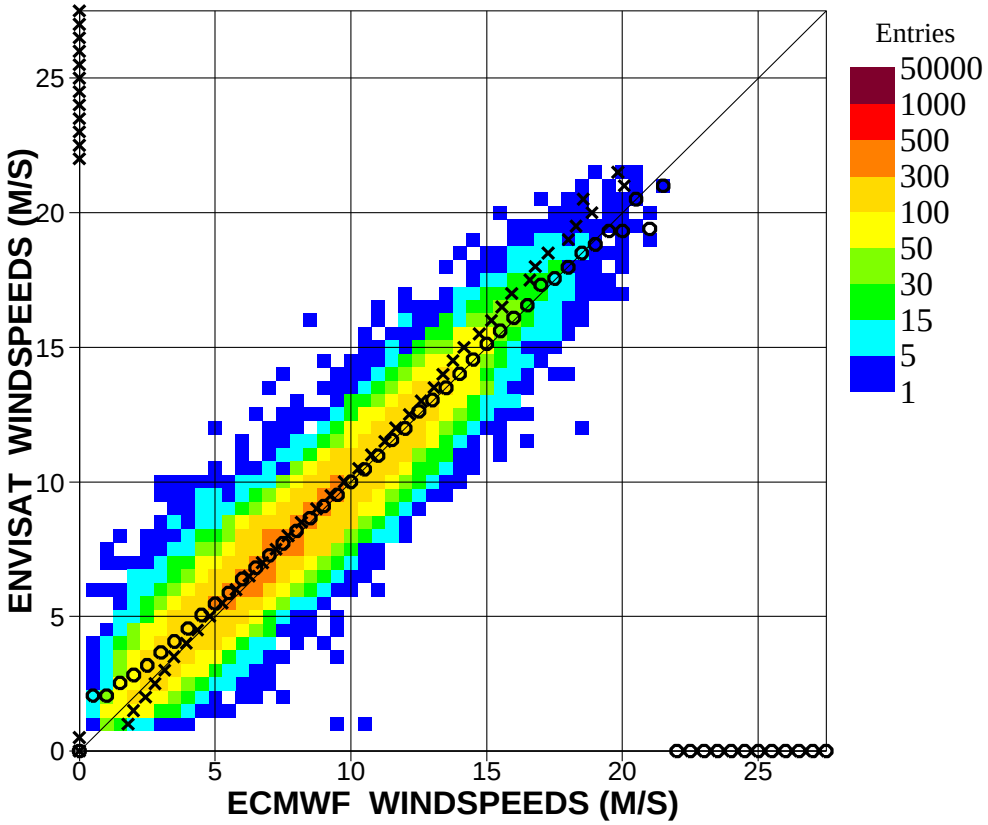

STATISTICS

ENTRIES	36071
MEAN ECMWF	8.0211
MEAN ENVISAT	8.2759
BIAS (ENVISAT - ECMWF)	.2549
STANDARD DEVIATION	1.1581
SCATTER INDEX	.1444
CORRELATION	.9436
SYMMETRIC SLOPE	1.0262 (.0018)
REGR. COEFFICIENT	.9396 (.0017)
REGR. CONSTANT	.7392 (.0152)

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

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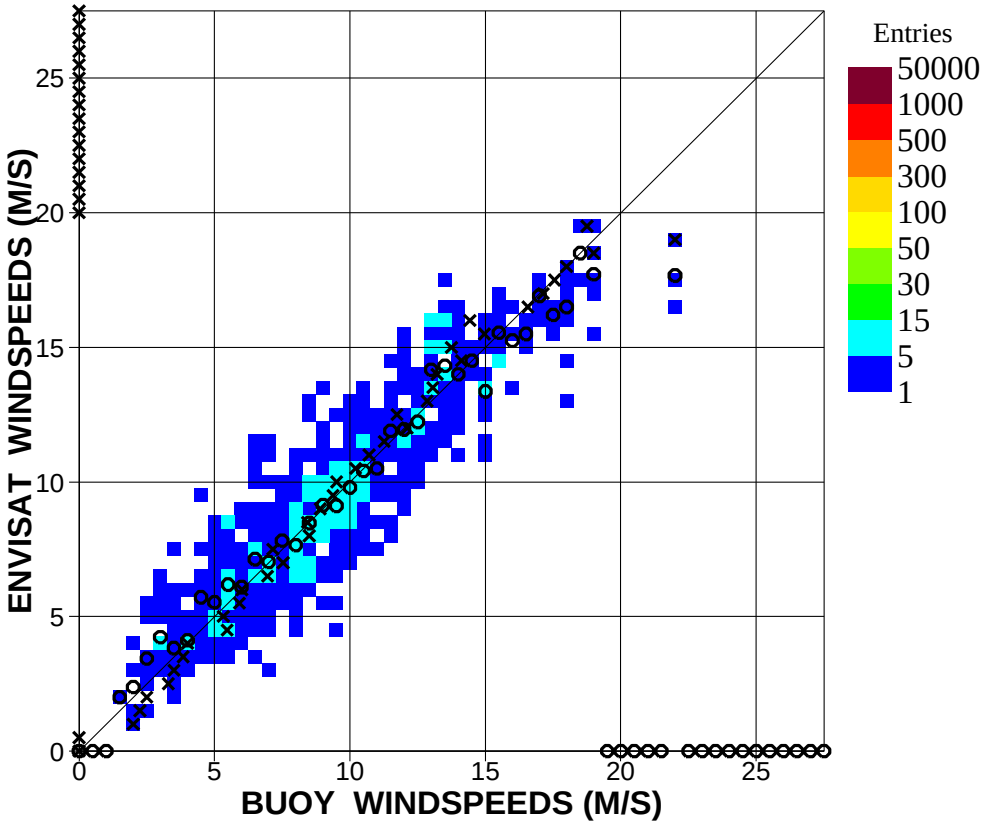

STATISTICS

ENTRIES	880	
MEAN BUOY	9.4316	
MEAN ENVISAT	9.5231	
BIAS (ENVISAT - BUOY)	.0915	
STANDARD DEVIATION	1.5497	
SCATTER INDEX	.1643	
CORRELATION	.9101	
SYMMETRIC SLOPE	1.0086	(.0144)
REGR. COEFFICIENT	.9114	(.0140)
REGR. CONSTANT	.9272	(.1416)

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

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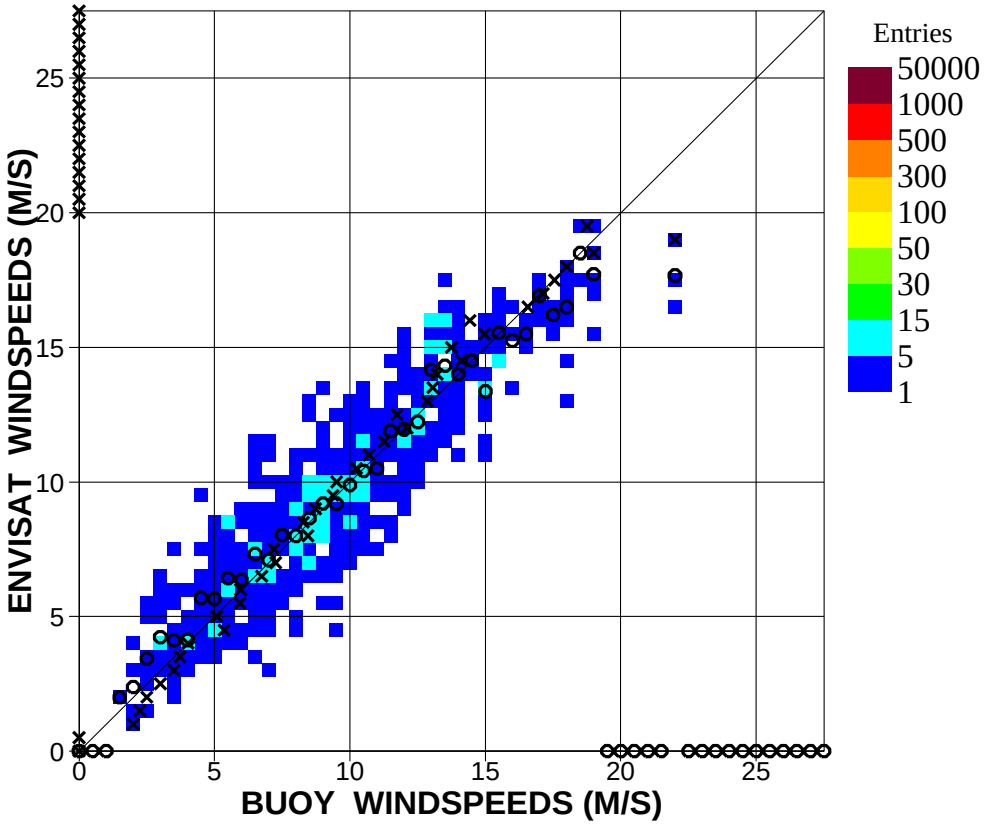

STATISTICS

ENTRIES	769	
MEAN BUOY	9.7005	
MEAN ENVISAT	9.8861	
BIAS (ENVISAT - BUOY)	.1856	
STANDARD DEVIATION	1.5963	
SCATTER INDEX	.1646	
CORRELATION	.9087	
SYMMETRIC SLOPE	1.0146	(.0155)
REGR. COEFFICIENT	.8943	(.0148)
REGR. CONSTANT	1.2107	(.1543)

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

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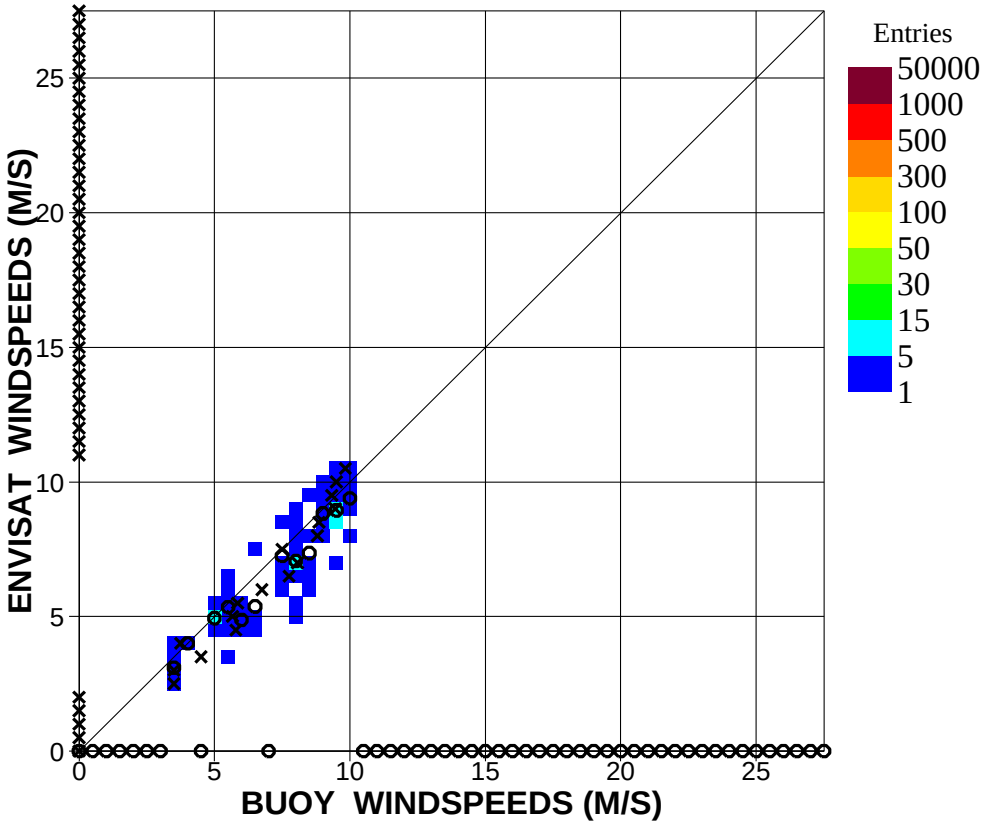

STATISTICS

ENTRIES	105	
MEAN BUOY	7.6898	
MEAN ENVISAT	7.0668	
BIAS (ENVISAT - BUOY)	-.6230	
STANDARD DEVIATION	.8664	
SCATTER INDEX	.1127	
CORRELATION	.8947	
SYMMETRIC SLOPE	.9265	(.0464)
REGR. COEFFICIENT	.9409	(.0463)
REGR. CONSTANT	-.1683	(.3657)

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

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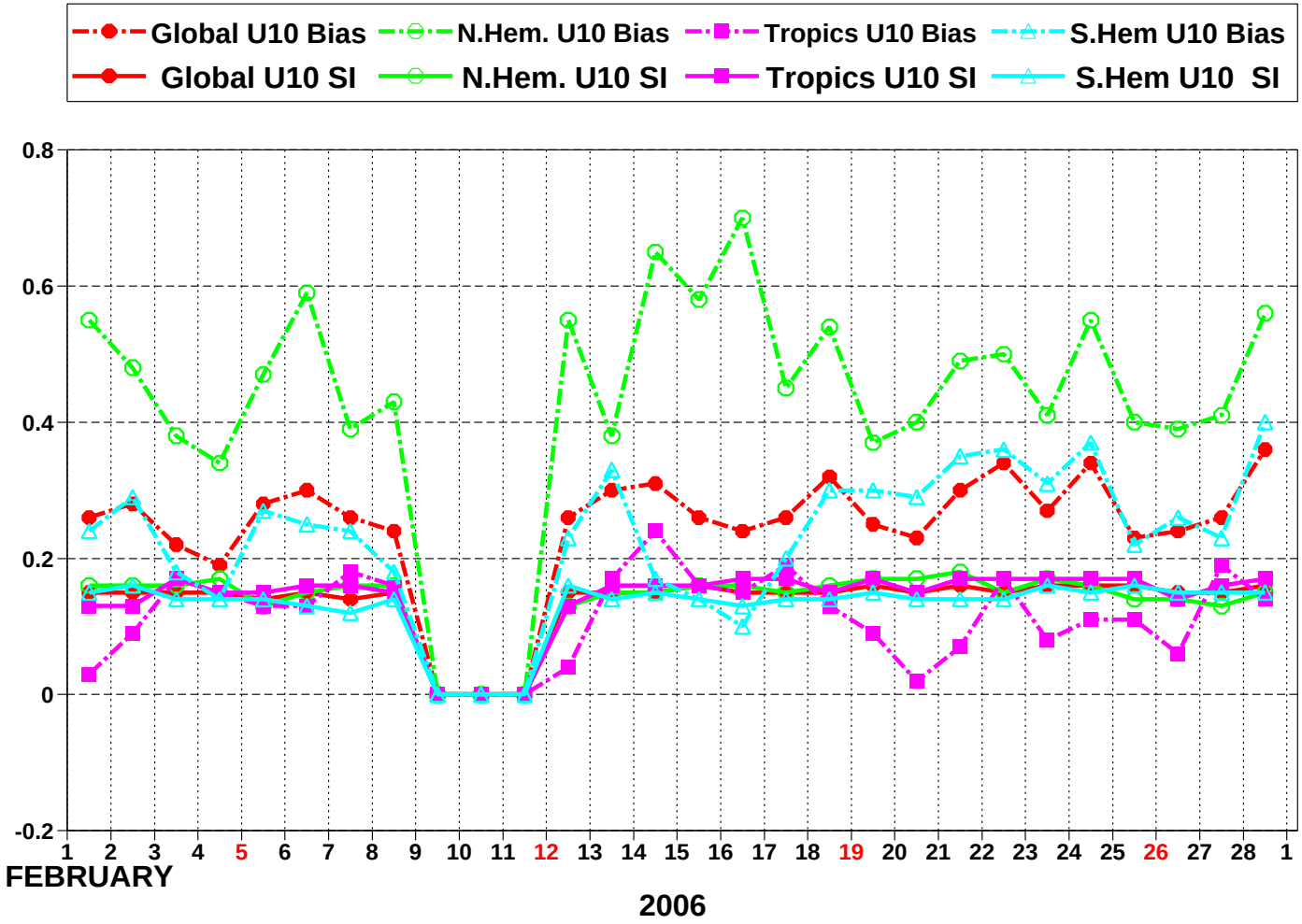

Figure 14: ENVISAT Altimeter wind speeds: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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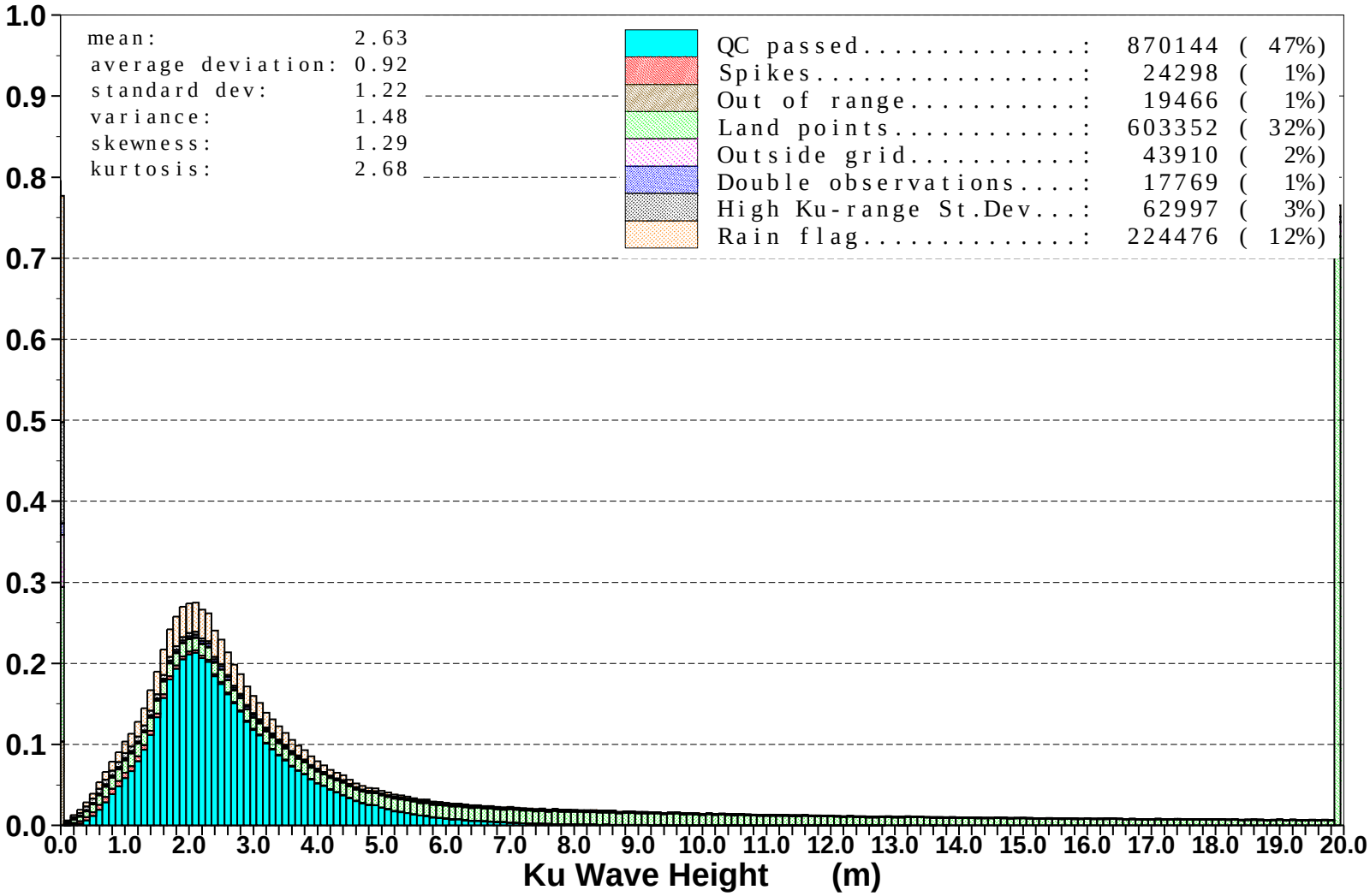

Figure 15: Distribution of the ENVISAT Altimeter Ku Wave Height after QC for February 2006

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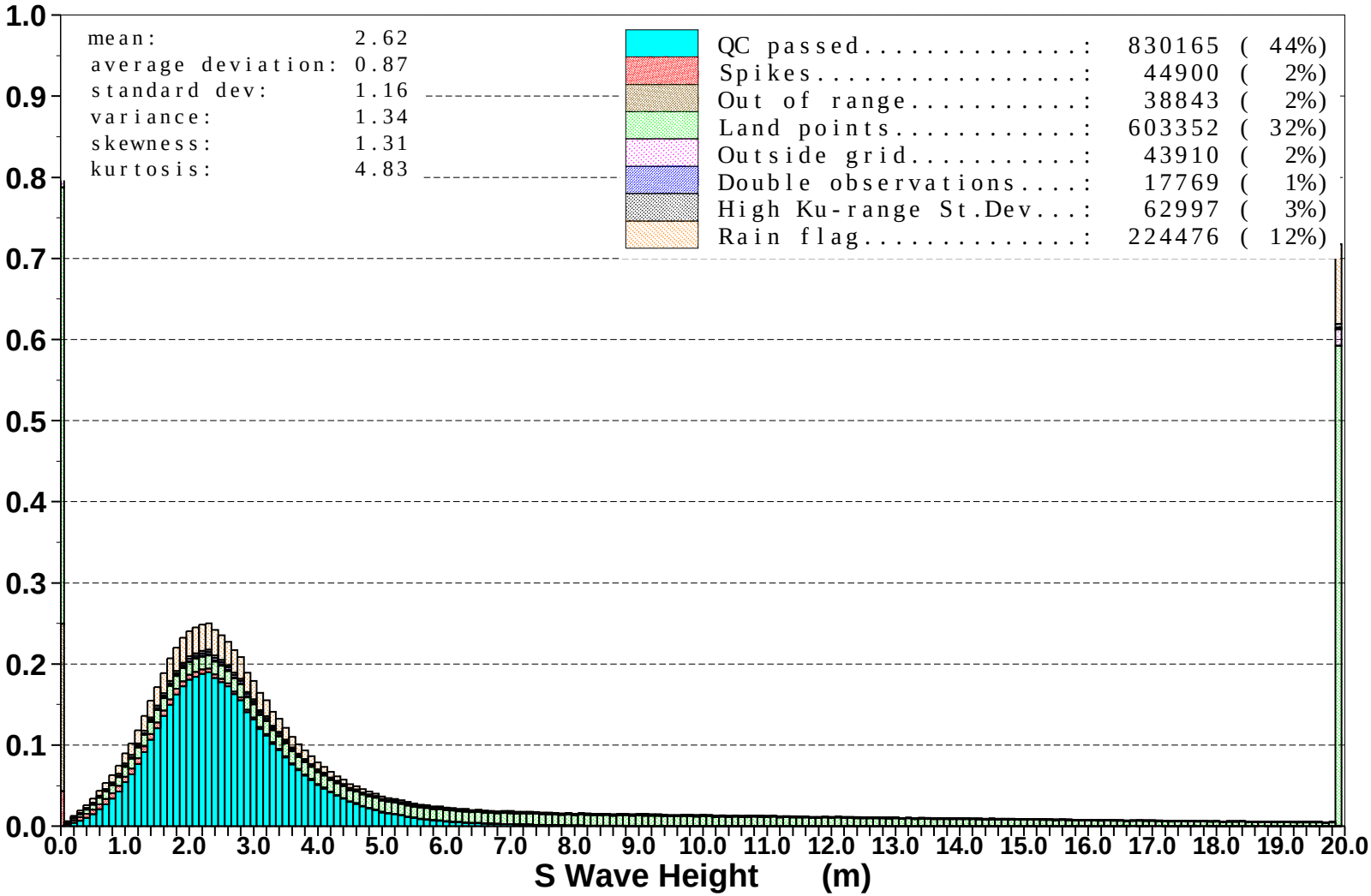

Figure 16: Distribution of the ENVISAT Altimeter S Wave Height after QC for February 2006

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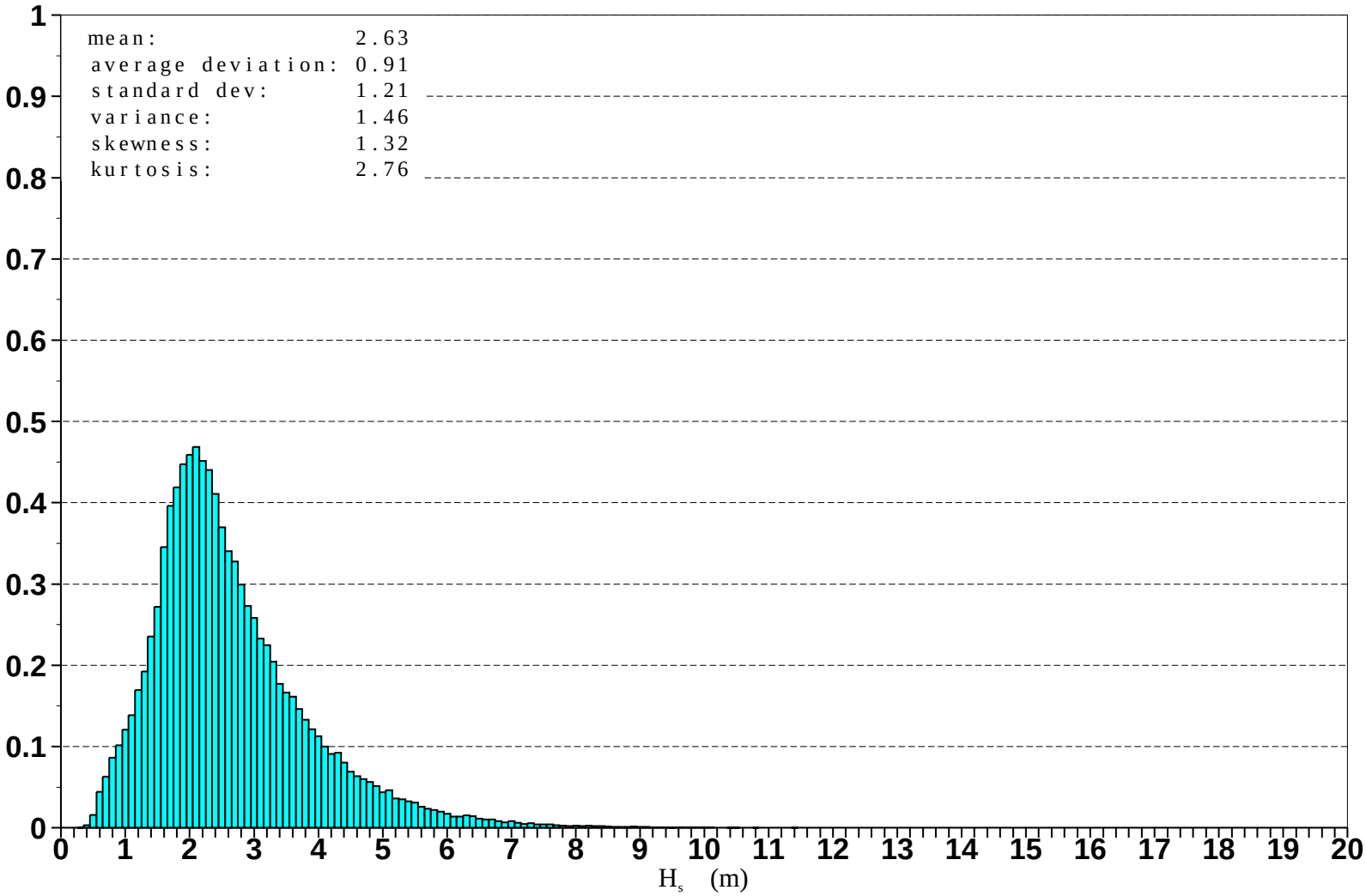

Figure 17: Distribution of ENVISAT Altimeter Ku-Band Wave Heights after Along-Track Averaging for February 2006

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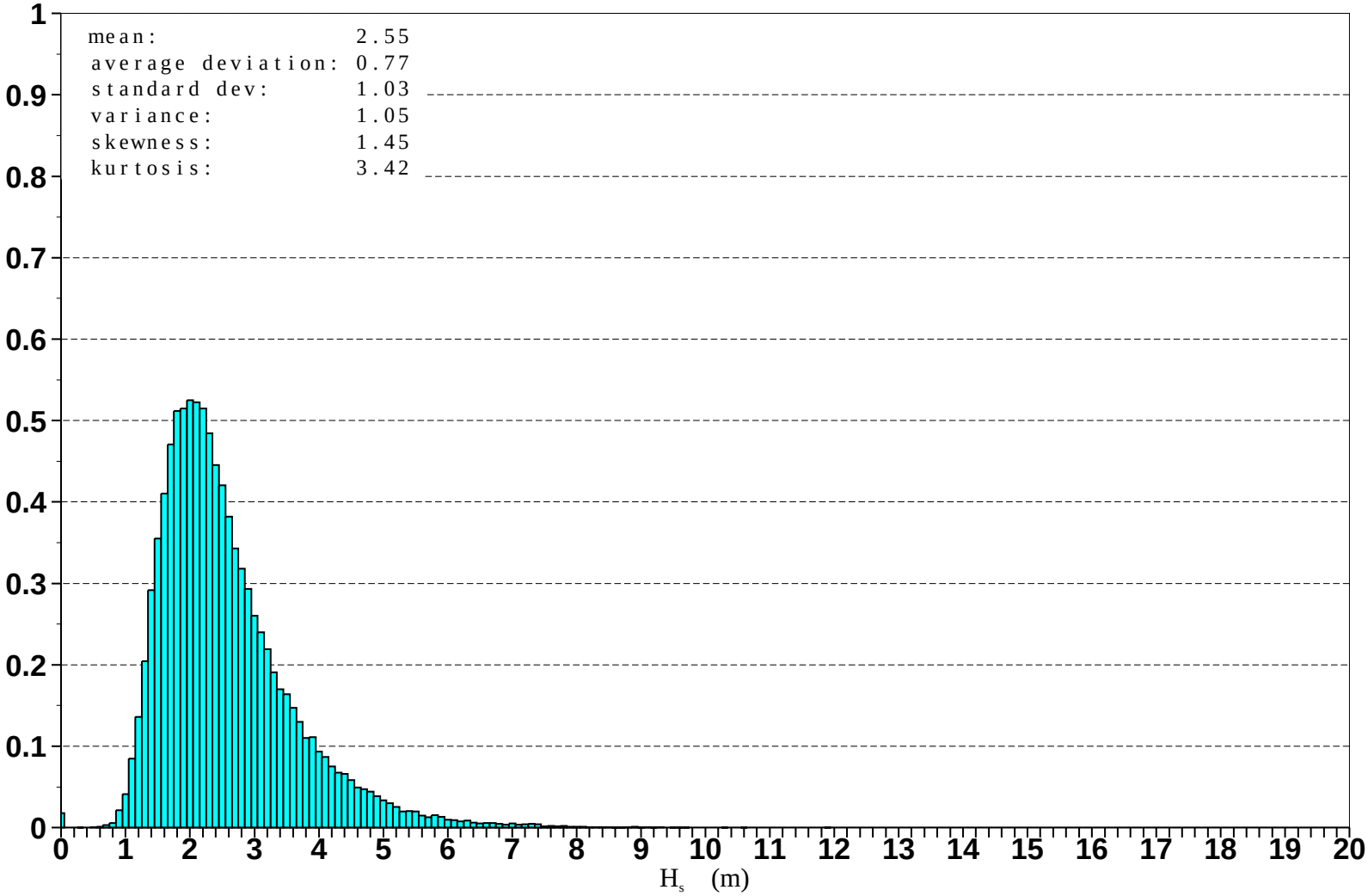

Figure 18: Distribution of ENVISAT Altimeter S-Band Wave Heights after Along-Track Averaging for February 2006

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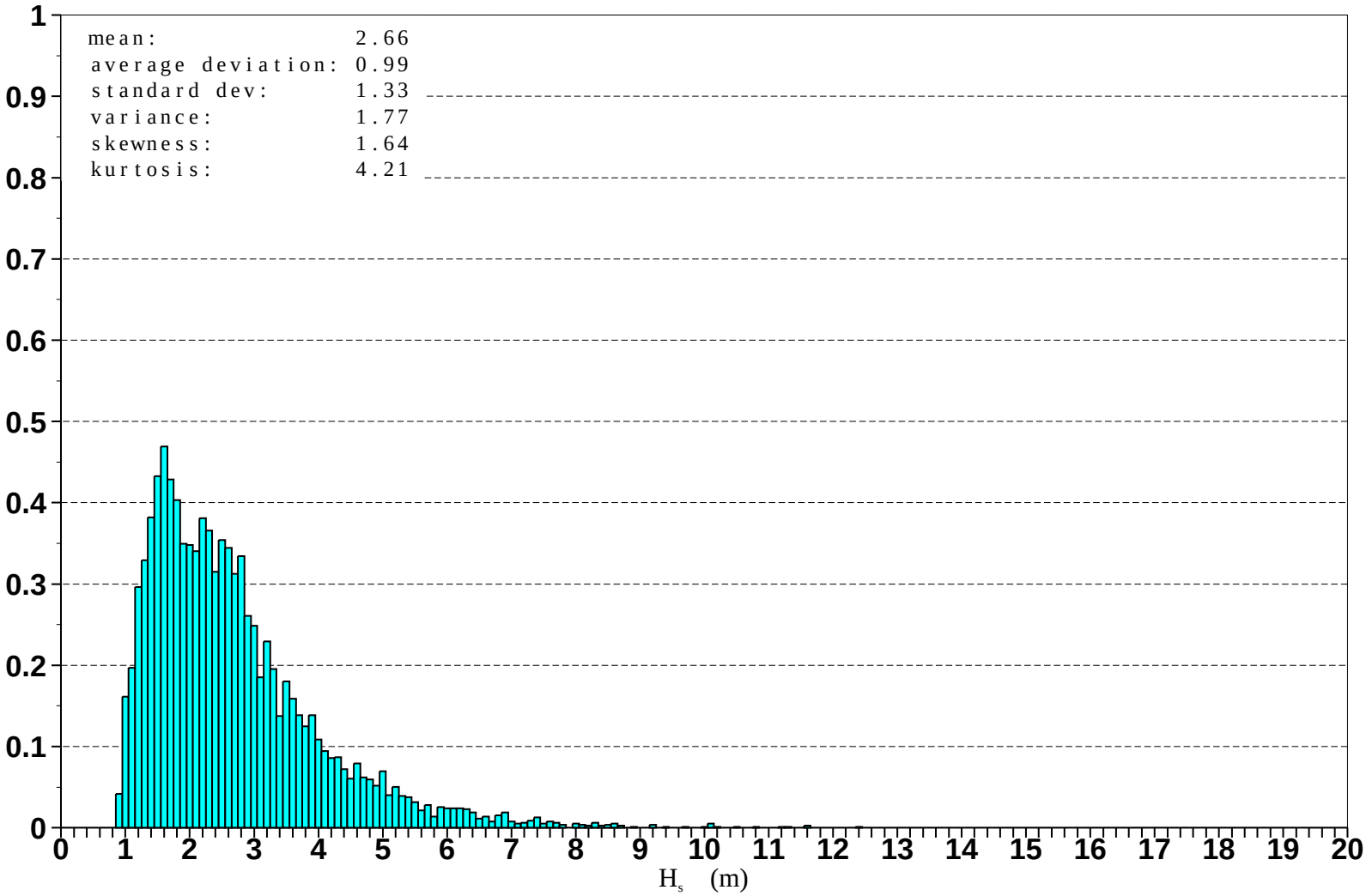

Figure 19: Distribution of ERS-2 Altimeter Wave Heights after Along-Track Averaging for February 2006

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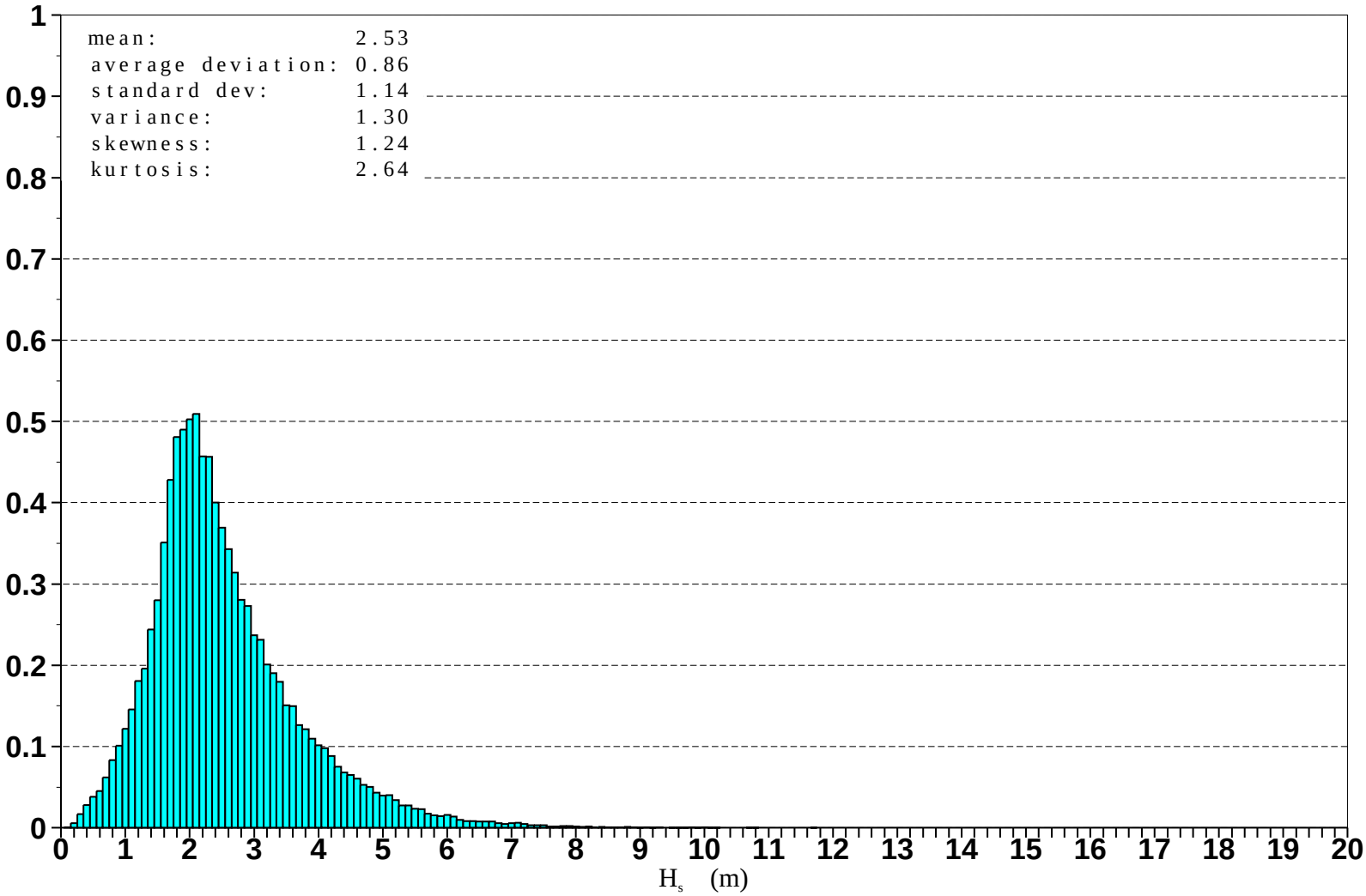

Figure 19b: Distribution of WAM 4V Wave Height (Collocated with ENVISAT) for February 2006

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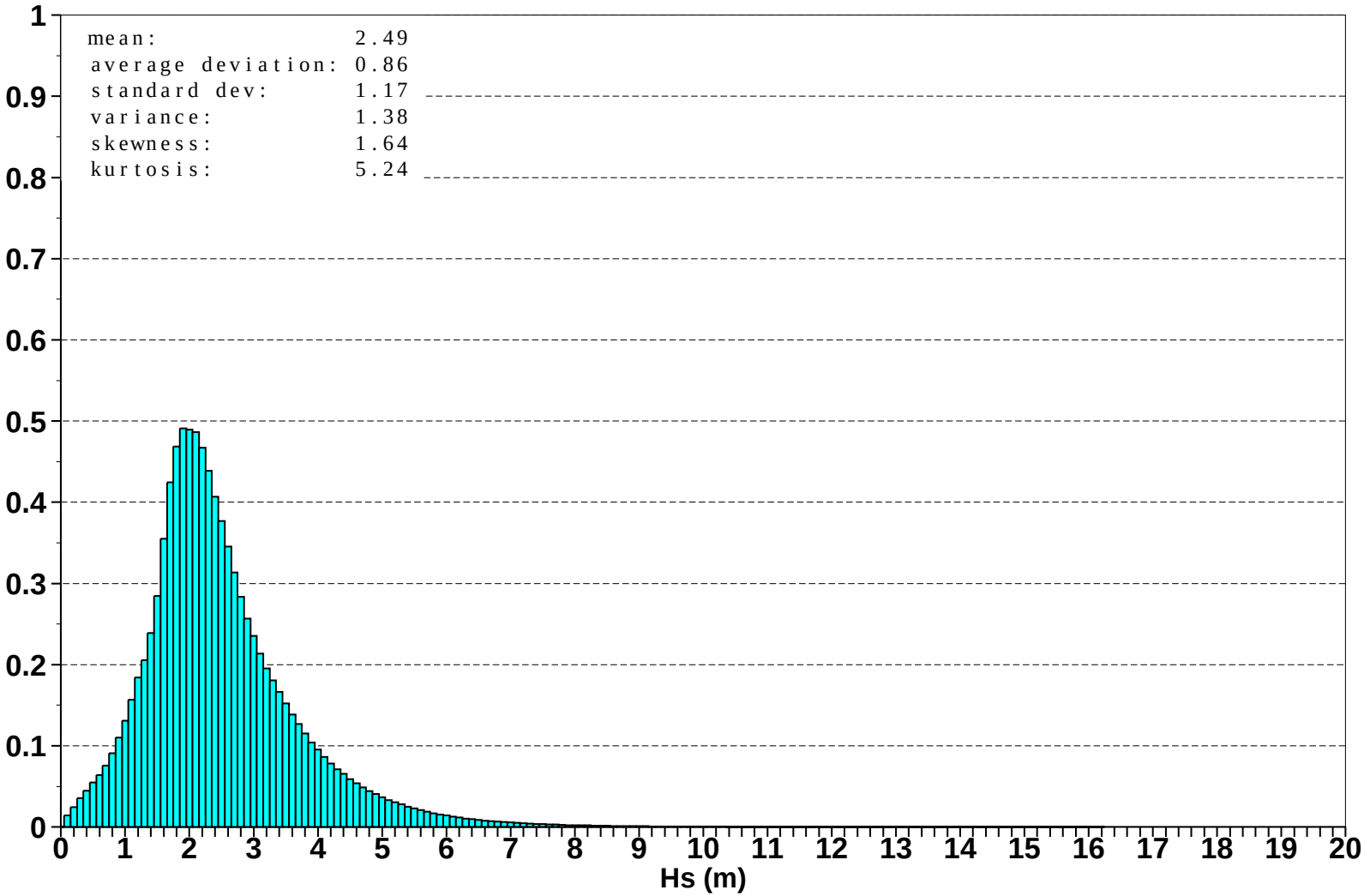

Figure 20: Global distribution of ECMWF First-Guess wave heights for February 2006

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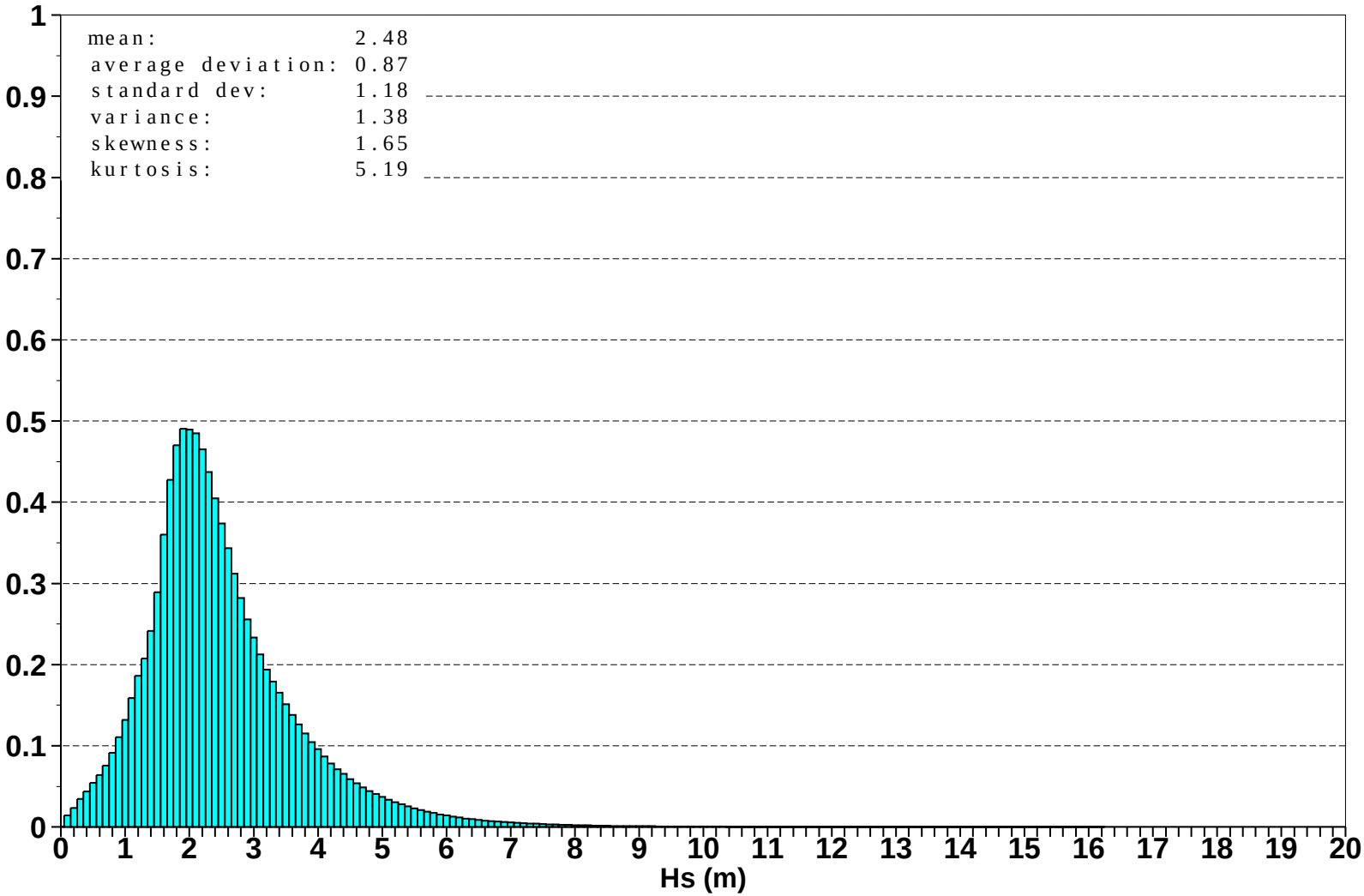

Figure 21: Global distribution of ECMWF Analysis wave heights for February 2006

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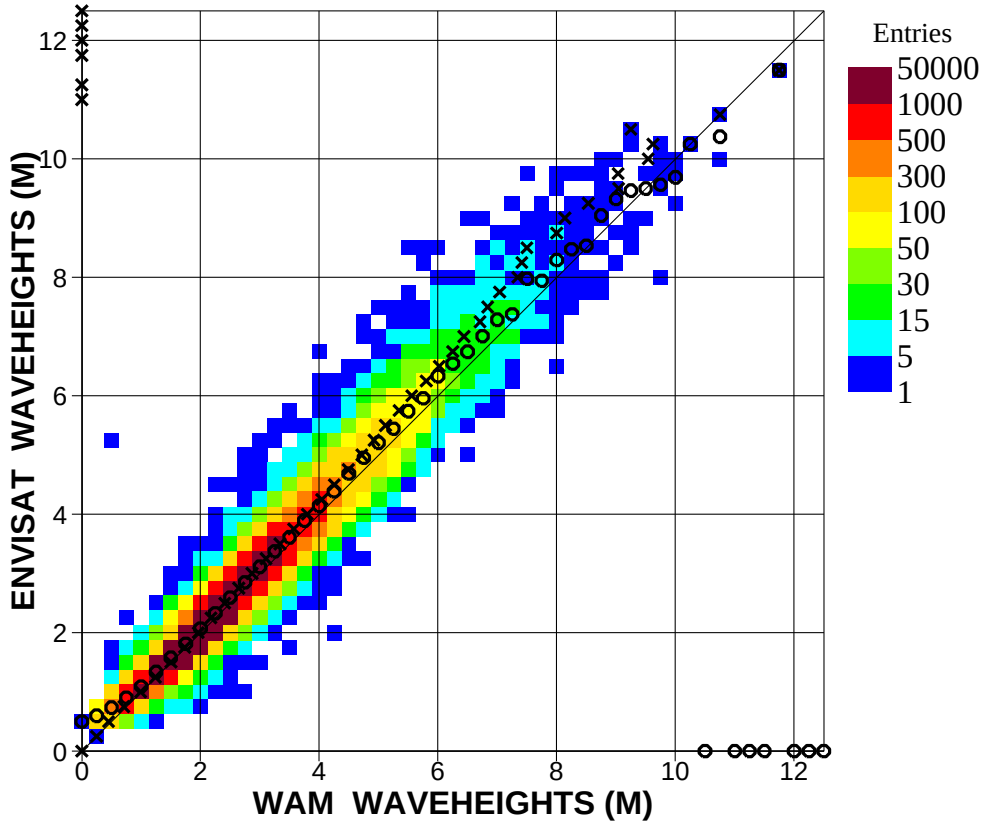

STATISTICS

ENTRIES	79207
MEAN WAM	2.5322
MEAN ENVISAT	2.6350
BIAS (ENVISAT - WAM)	.1028
STANDARD DEVIATION	.2767
SCATTER INDEX	.1093
CORRELATION	.9738
SYMMETRIC SLOPE	1.0435 (.0009)
REGR. COEFFICIENT	1.0297 (.0009)
REGR. CONSTANT	.0276 (.0024)

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

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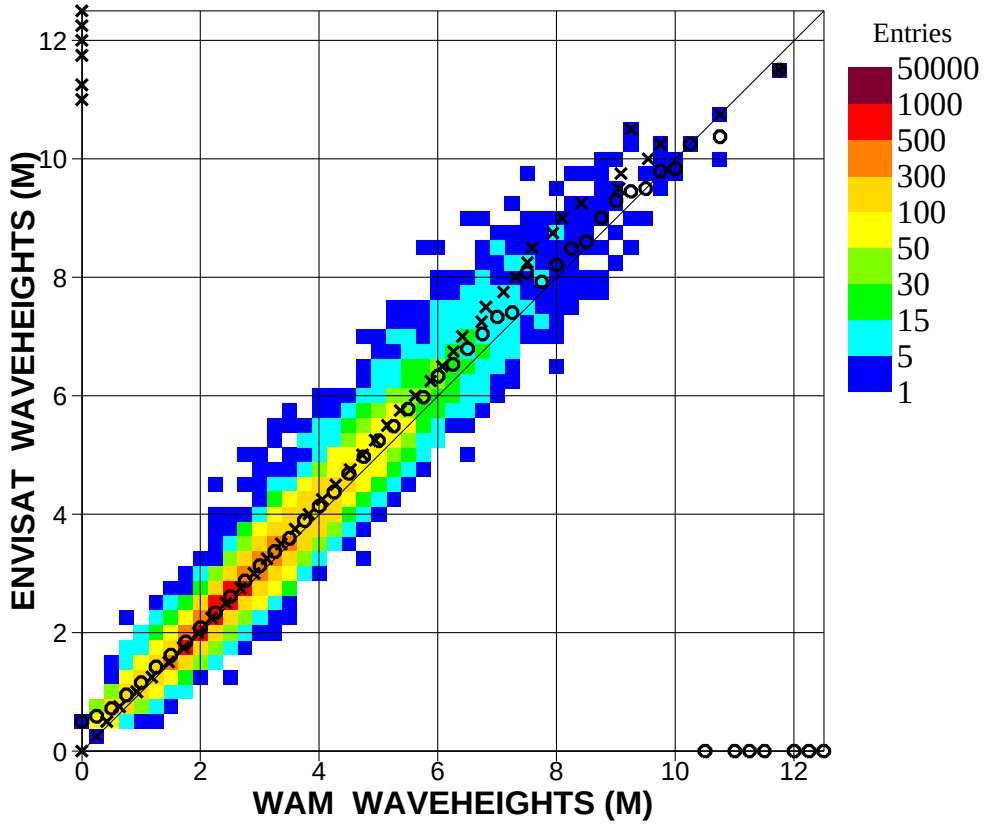

STATISTICS

ENTRIES	19488
MEAN WAM	2.9922
MEAN ENVISAT	3.1300
BIAS (ENVISAT - WAM)	.1379
STANDARD DEVIATION	.3332
SCATTER INDEX	.1114
CORRELATION	.9741
SYMMETRIC SLOPE	1.0468 (.0017)
REGR. COEFFICIENT	1.0229 (.0017)
REGR. CONSTANT	.0694 (.0056)

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

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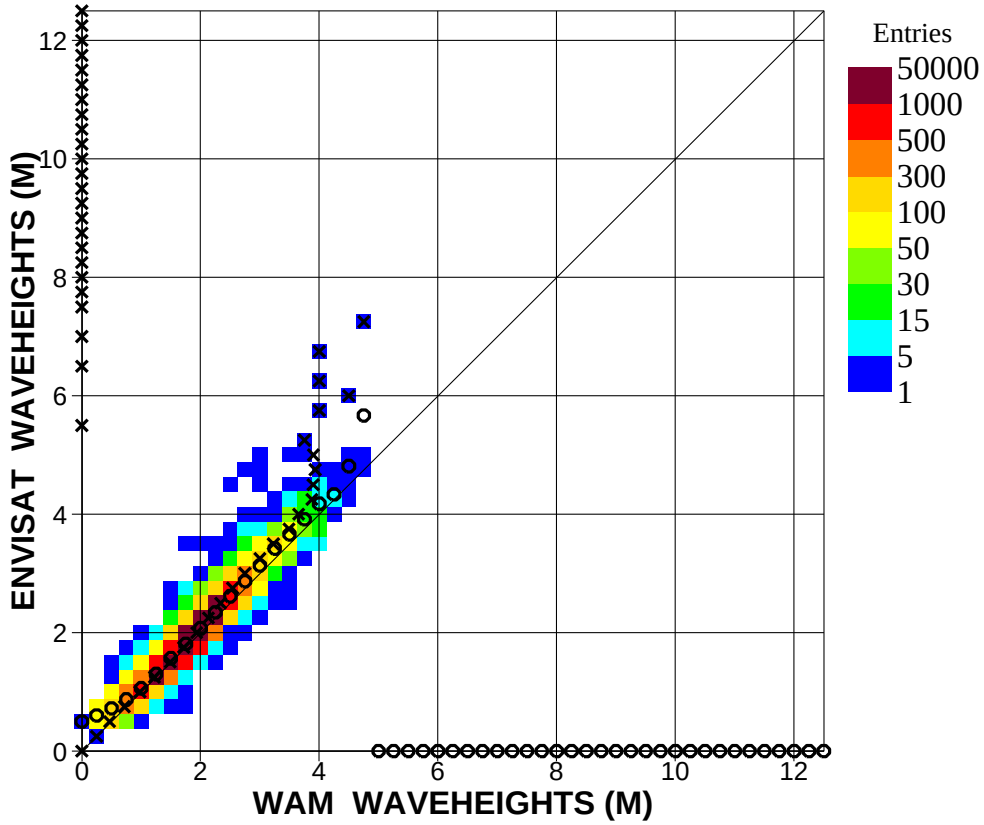

STATISTICS

ENTRIES	24233
MEAN WAM	1.8378
MEAN ENVISAT	1.9215
BIAS (ENVISAT - WAM)	.0837
STANDARD DEVIATION	.1837
SCATTER INDEX	.1000
CORRELATION	.9611
SYMMETRIC SLOPE	1.0481 (.0019)
REGR. COEFFICIENT	1.0284 (.0019)
REGR. CONSTANT	.0315 (.0037)

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

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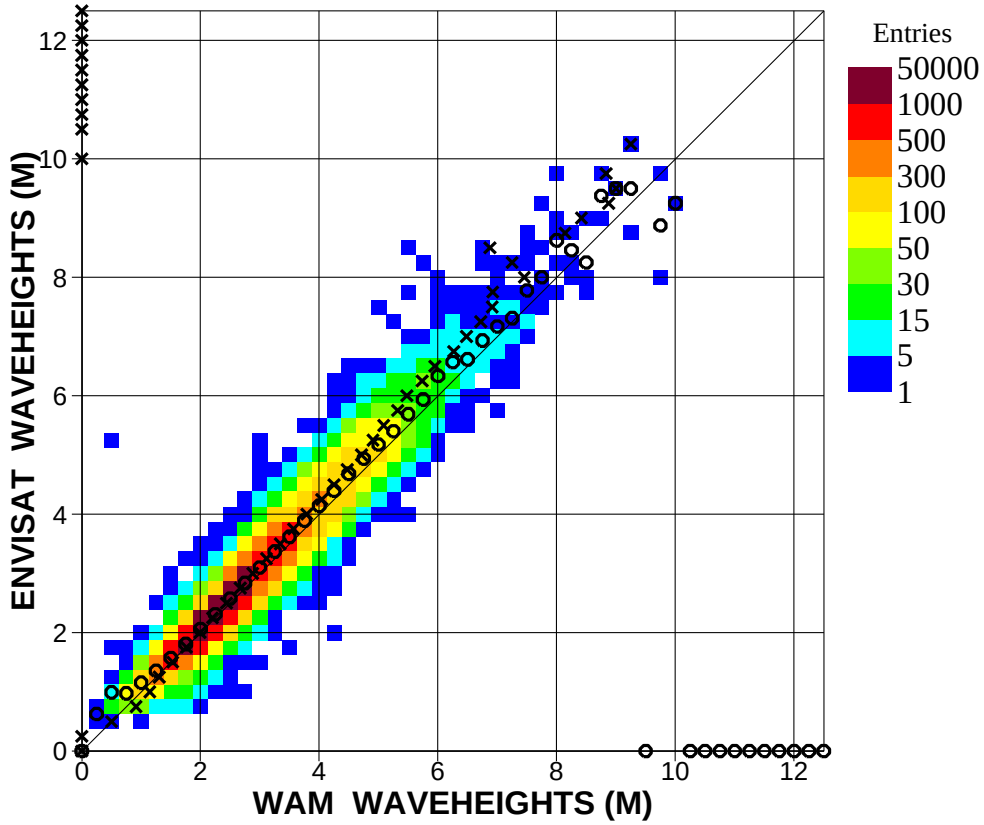

STATISTICS

ENTRIES	36071
MEAN WAM	2.7428
MEAN ENVISAT	2.8395
BIAS (ENVISAT - WAM)	.0967
STANDARD DEVIATION	.2920
SCATTER INDEX	.1065
CORRELATION	.9653
SYMMETRIC SLOPE	1.0399 (.0015)
REGR. COEFFICIENT	1.0346 (.0015)
REGR. CONSTANT	.0018 (.0043)

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

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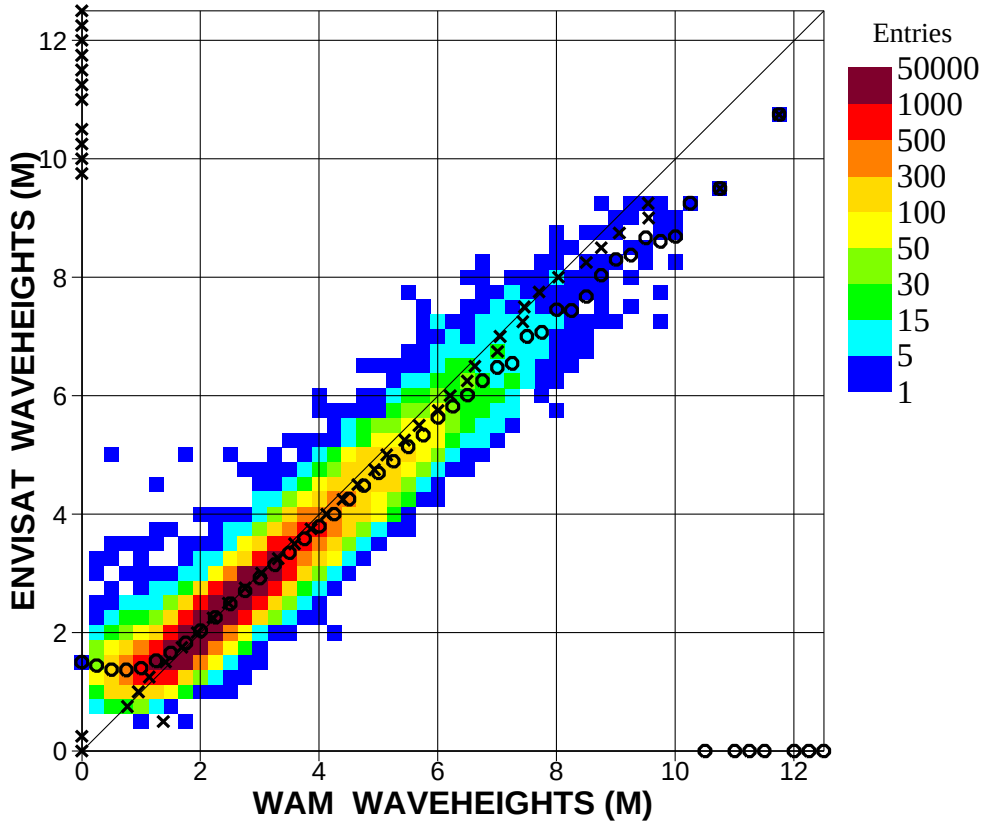

STATISTICS

ENTRIES	78133
MEAN WAM	2.5398
MEAN ENVISAT	2.5484
BIAS (ENVISAT - WAM)	.0086
STANDARD DEVIATION	.3513
SCATTER INDEX	.1383
CORRELATION	.9536
SYMMETRIC SLOPE	.9845 (.0011)
REGR. COEFFICIENT	.8433 (.0010)
REGR. CONSTANT	.4067 (.0027)

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

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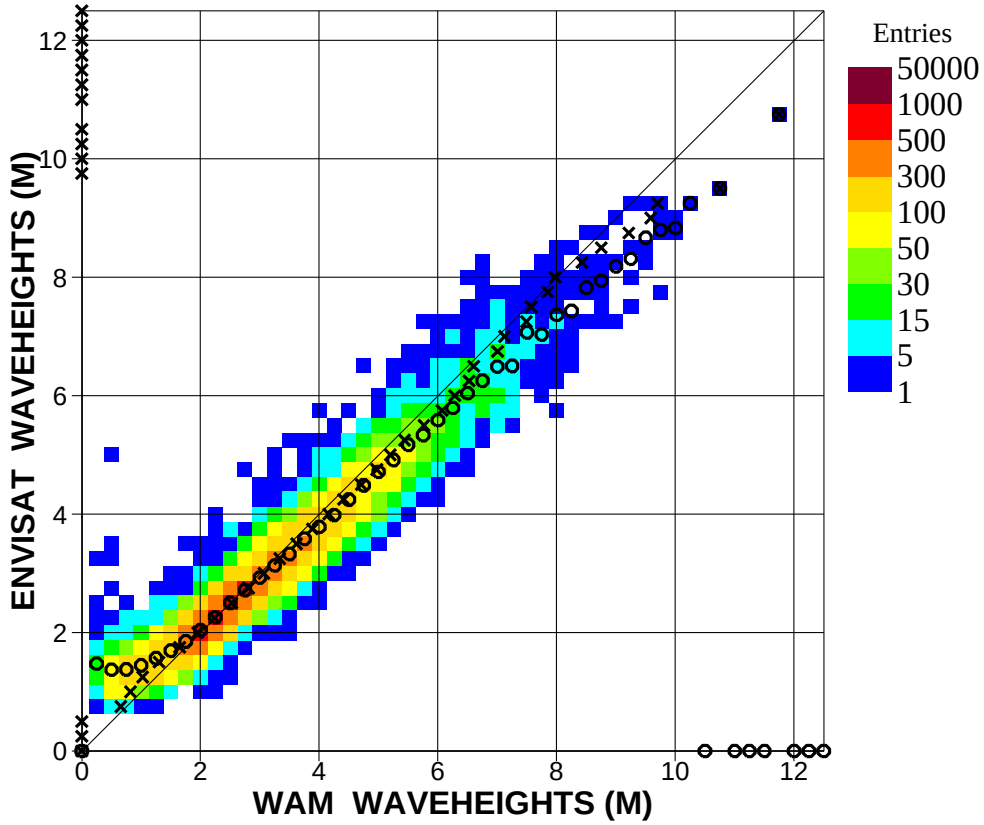

STATISTICS

ENTRIES	19177
MEAN WAM	3.0004
MEAN ENVISAT	2.9637
BIAS (ENVISAT - WAM)	-.0367
STANDARD DEVIATION	.4096
SCATTER INDEX	.1365
CORRELATION	.9591
SYMMETRIC SLOPE	.9689 (.0021)
REGR. COEFFICIENT	.8393 (.0018)
REGR. CONSTANT	.4456 (.0060)

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

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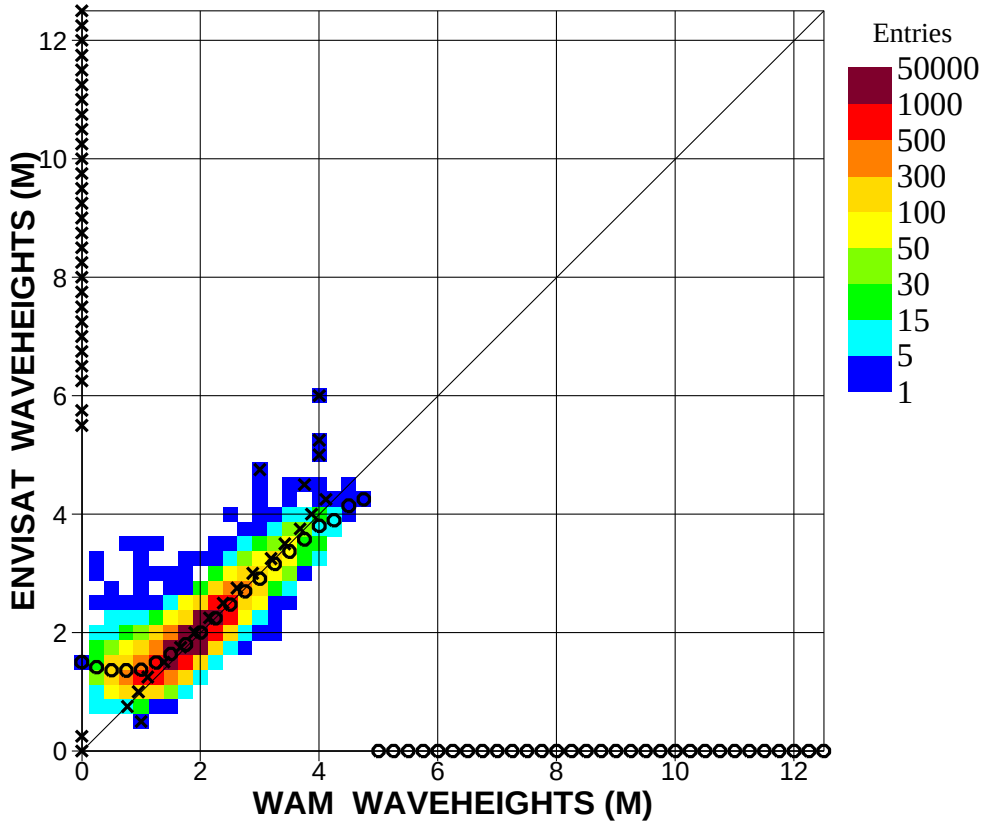

STATISTICS

ENTRIES	23824
MEAN WAM	1.8444
MEAN ENVISAT	1.9475
BIAS (ENVISAT - WAM)	.1031
STANDARD DEVIATION	.3120
SCATTER INDEX	.1692
CORRELATION	.8620
SYMMETRIC SLOPE	1.0372 (.0034)
REGR. COEFFICIENT	.7343 (.0028)
REGR. CONSTANT	.5932 (.0054)

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

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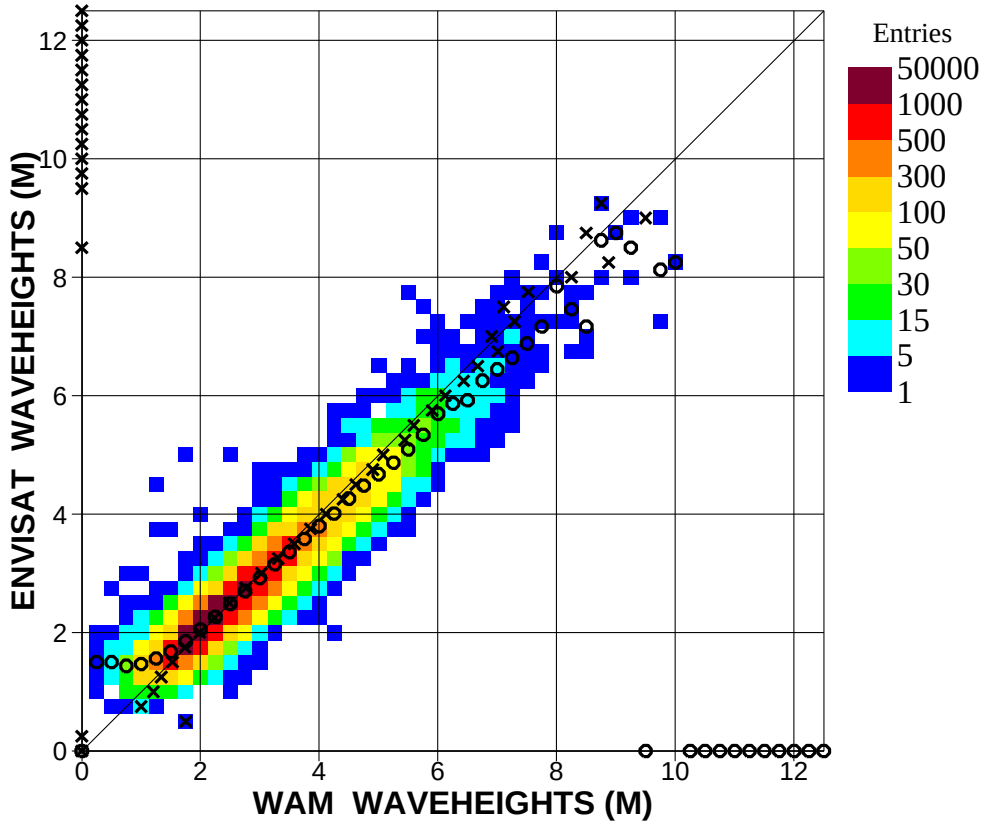

STATISTICS

ENTRIES	35710
MEAN WAM	2.7488
MEAN ENVISAT	2.7199
BIAS (ENVISAT - WAM)	-.0289
STANDARD DEVIATION	.3289
SCATTER INDEX	.1196
CORRELATION	.9491
SYMMETRIC SLOPE	.9796 (.0016)
REGR. COEFFICIENT	.8608 (.0015)
REGR. CONSTANT	.3538 (.0045)

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

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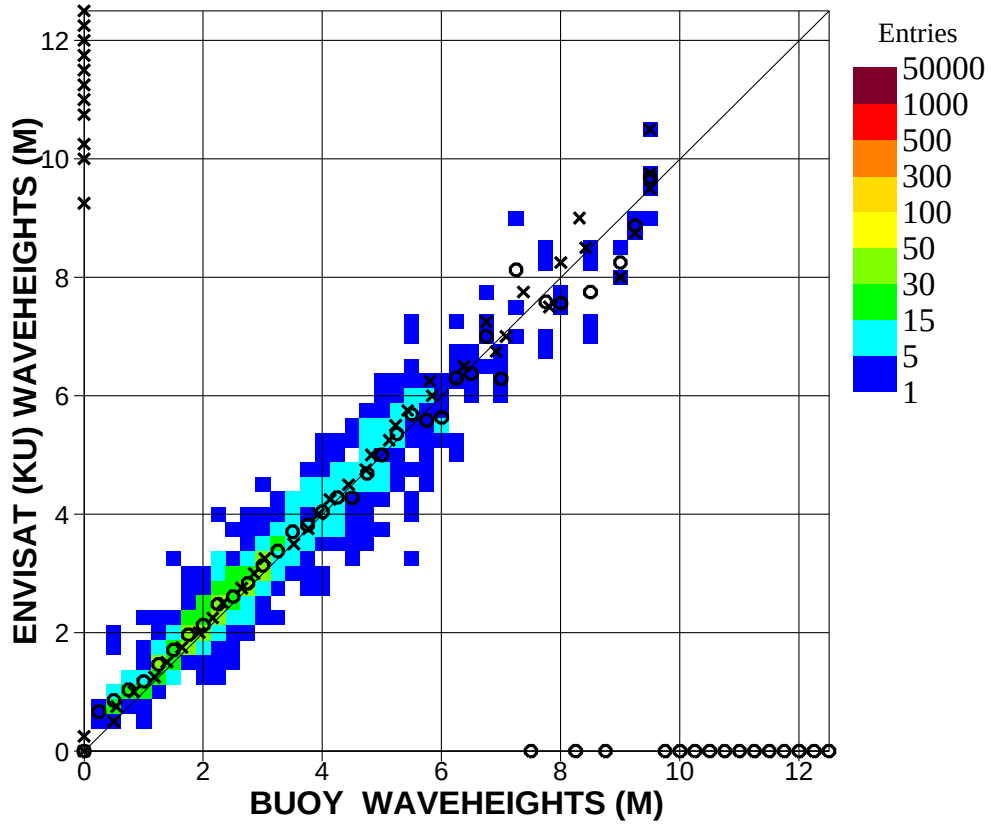

STATISTICS

ENTRIES	1365	
MEAN BUOY	3.0214	
MEAN ENVISAT	3.1377	
BIAS (ENVISAT - BUOY)	.1163	
STANDARD DEVIATION	.4261	
SCATTER INDEX	.1410	
CORRELATION	.9642	
SYMMETRIC SLOPE	1.0248	(.0074)
REGR. COEFFICIENT	.9396	(.0070)
REGR. CONSTANT	.2989	(.0240)

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

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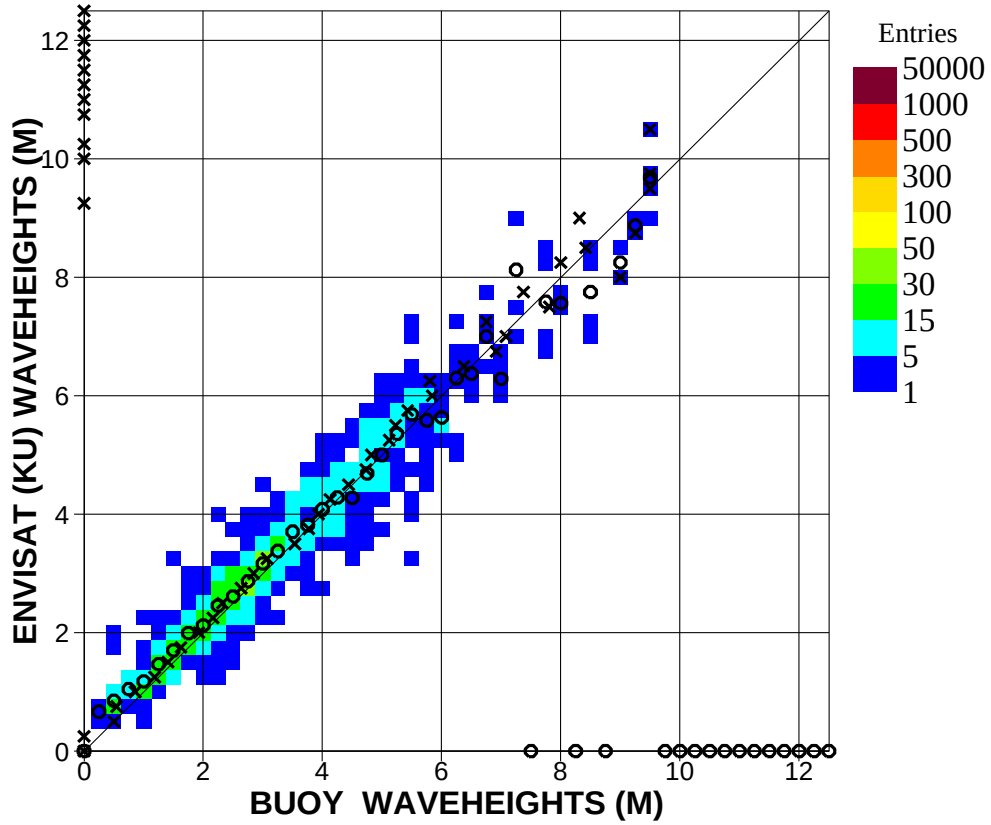

STATISTICS

ENTRIES	1207	
MEAN BUOY	3.1416	
MEAN ENVISAT	3.2574	
BIAS (ENVISAT - BUOY)	.1158	
STANDARD DEVIATION	.4416	
SCATTER INDEX	.1406	
CORRELATION	.9638	
SYMMETRIC SLOPE	1.0236	(.0079)
REGR. COEFFICIENT	.9389	(.0075)
REGR. CONSTANT	.3077	(.0266)

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

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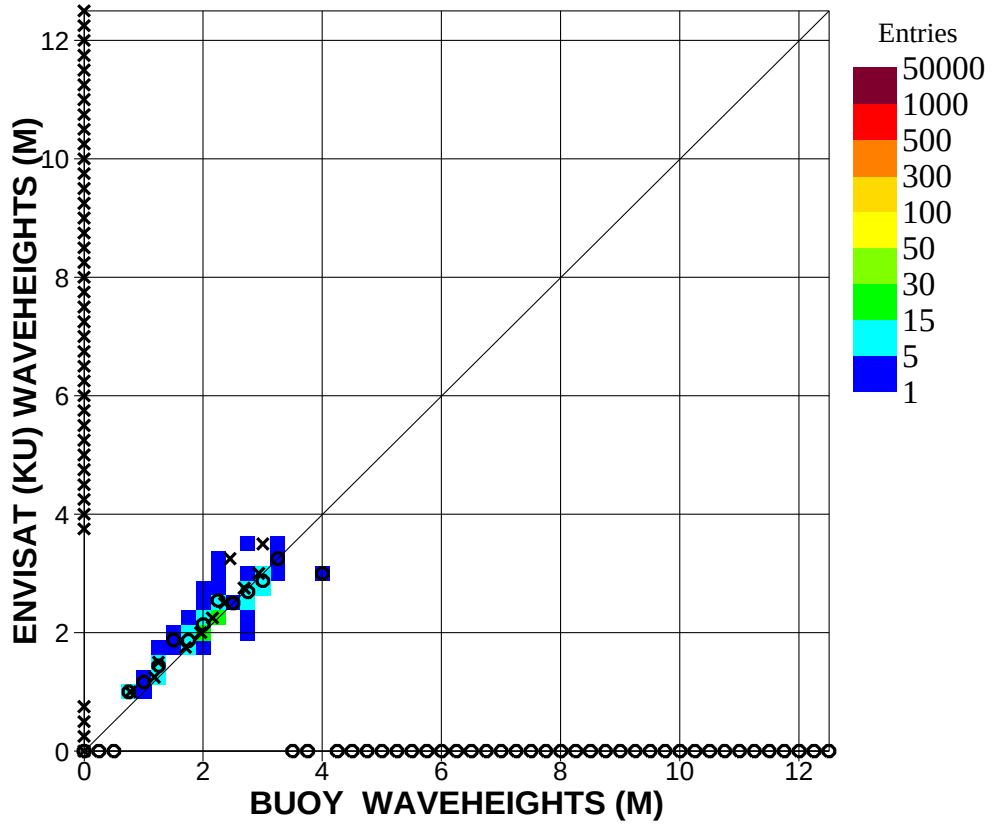

STATISTICS

ENTRIES	152	
MEAN BUOY	2.1083	
MEAN ENVISAT	2.2233	
BIAS (ENVISAT - BUOY)	.1150	
STANDARD DEVIATION	.2848	
SCATTER INDEX	.1351	
CORRELATION	.8884	
SYMMETRIC SLOPE	1.0451	(.0393)
REGR. COEFFICIENT	.8237	(.0348)
REGR. CONSTANT	.4866	(.0763)

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

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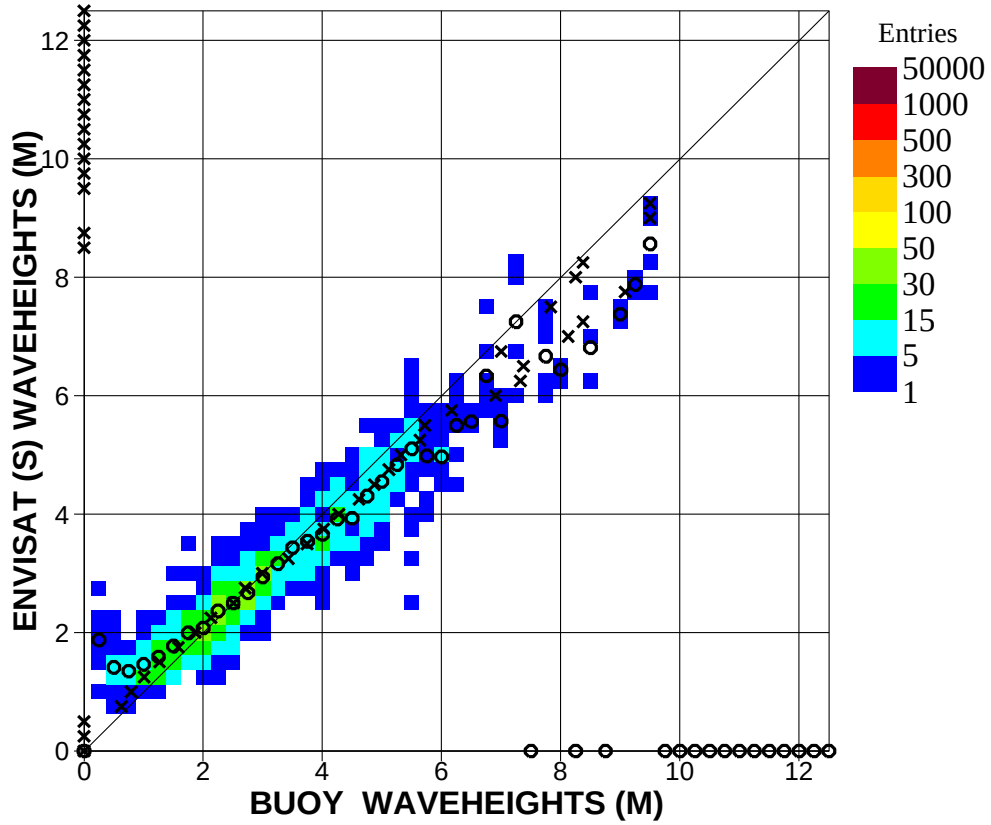

STATISTICS

ENTRIES	1363	
MEAN BUOY	3.0209	
MEAN ENVISAT	2.9740	
BIAS (ENVISAT - BUOY)	-.0469	
STANDARD DEVIATION	.5508	
SCATTER INDEX	.1823	
CORRELATION	.9494	
SYMMETRIC SLOPE	.9491	(.0086)
REGR. COEFFICIENT	.7705	(.0069)
REGR. CONSTANT	.6464	(.0236)

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

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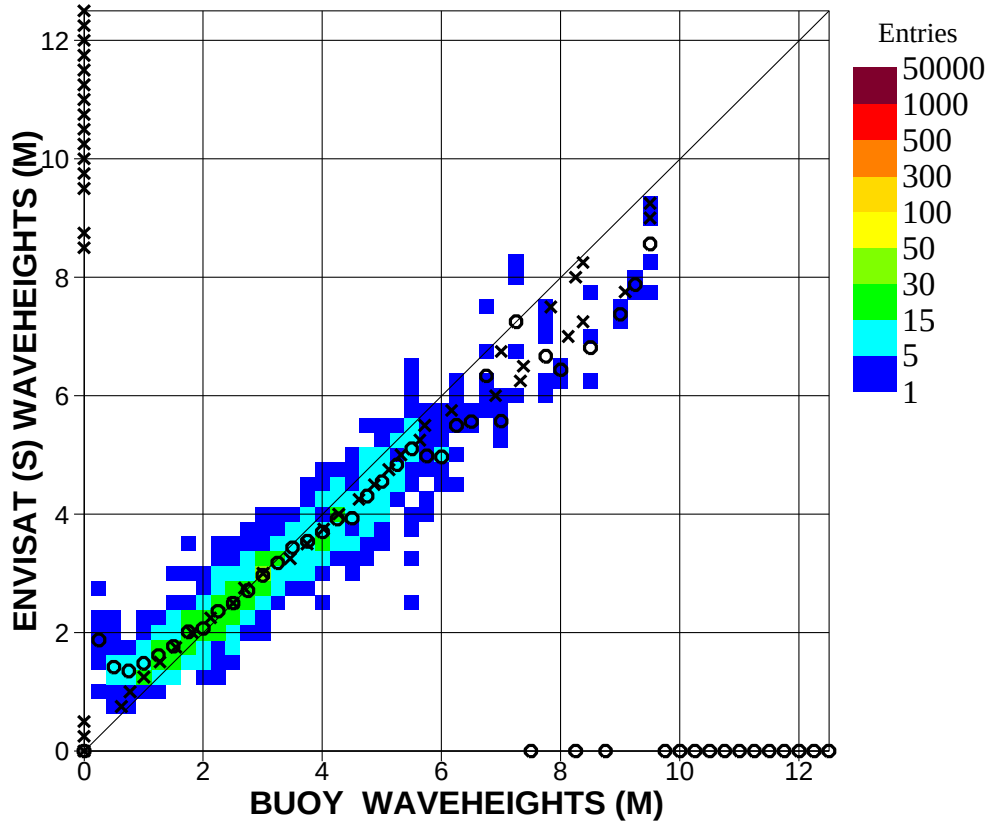

STATISTICS

ENTRIES	1205	
MEAN BUOY	3.1412	
MEAN ENVISAT	3.0809	
BIAS (ENVISAT - BUOY)	-.0603	
STANDARD DEVIATION	.5701	
SCATTER INDEX	.1815	
CORRELATION	.9494	
SYMMETRIC SLOPE	.9460	(.0091)
REGR. COEFFICIENT	.7675	(.0073)
REGR. CONSTANT	.6700	(.0260)

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

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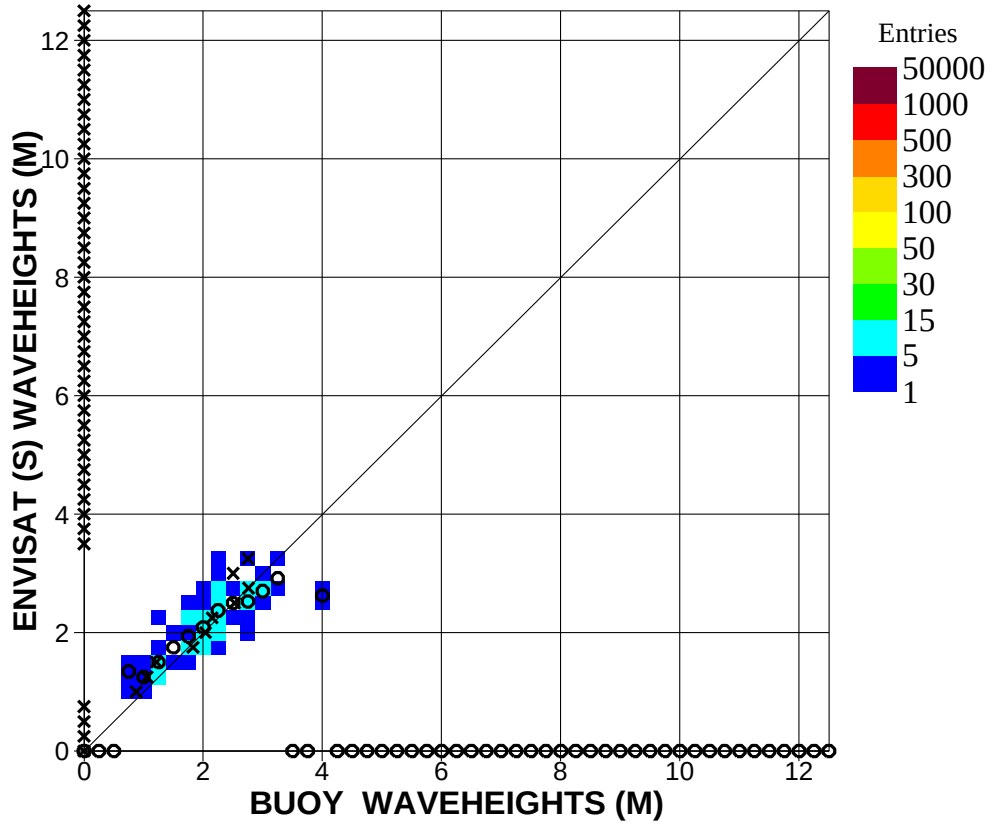

STATISTICS

ENTRIES	152	
MEAN BUOY	2.1083	
MEAN ENVISAT	2.1628	
BIAS (ENVISAT - BUOY)	.0545	
STANDARD DEVIATION	.3589	
SCATTER INDEX	.1702	
CORRELATION	.8149	
SYMMETRIC SLOPE	1.0088	(.0481)
REGR. COEFFICIENT	.6369	(.0370)
REGR. CONSTANT	.8200	(.0812)

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

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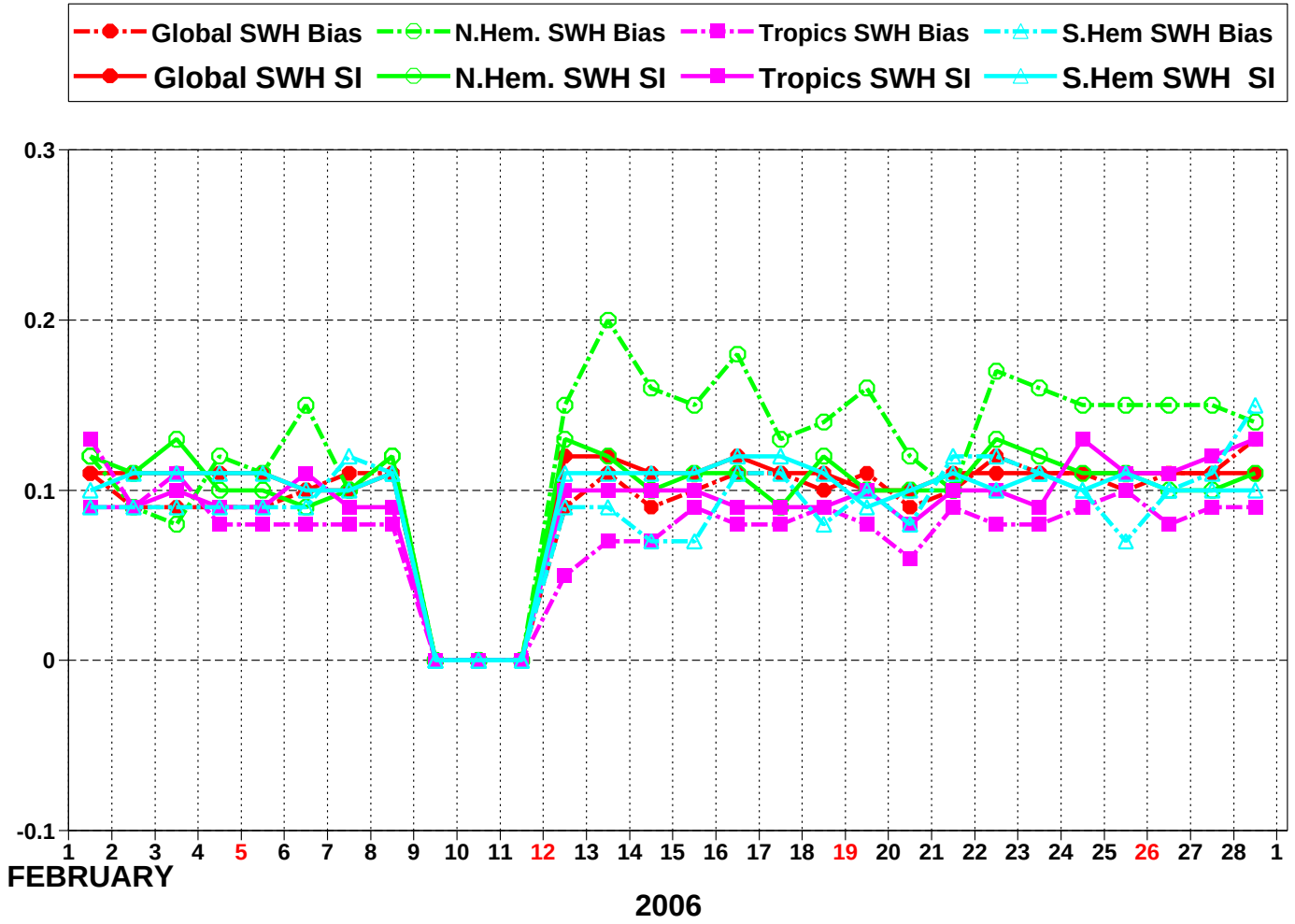

Figure 36: ENVISAT Altimeter Ku-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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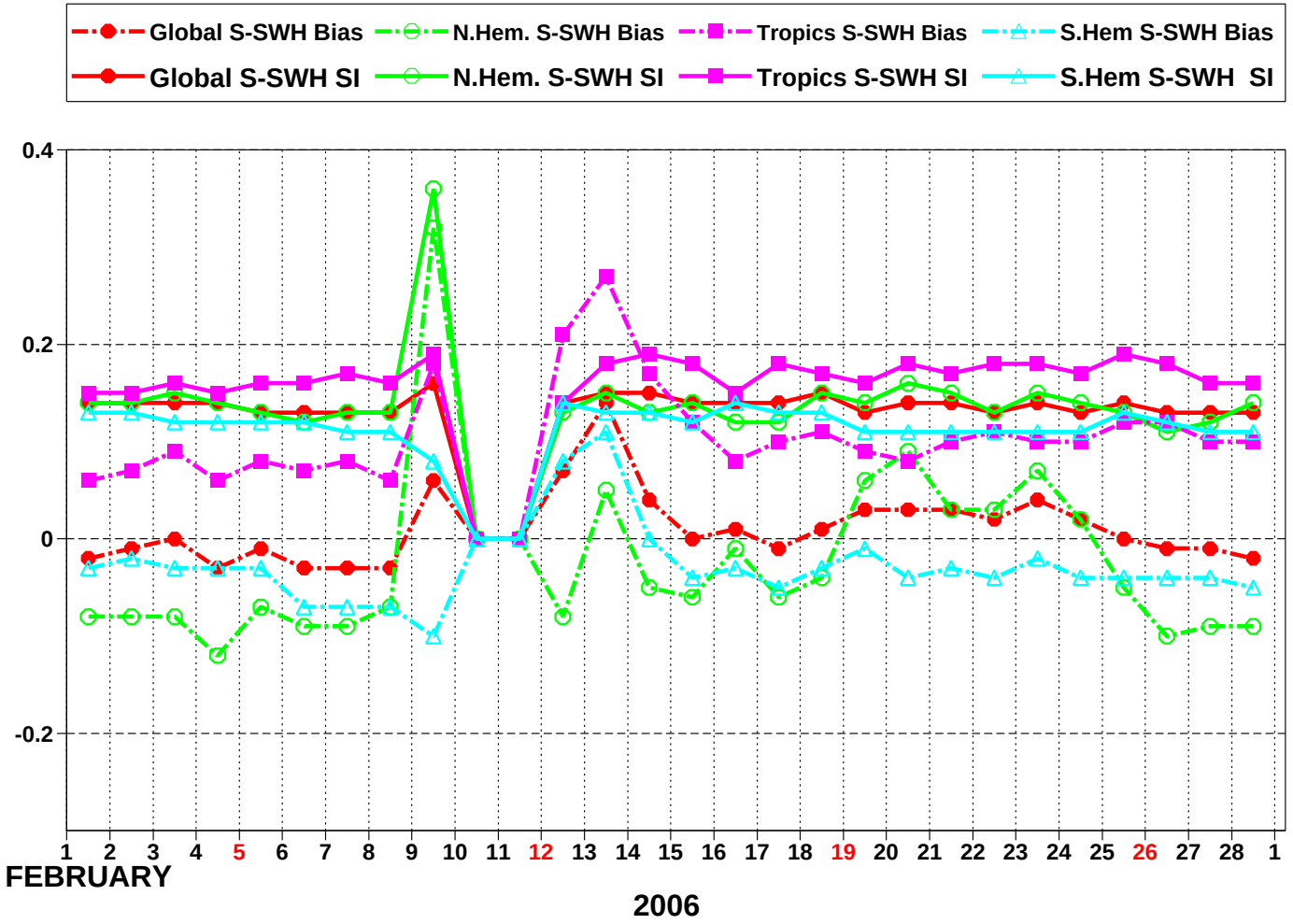

Figure 37: ENVISAT Altimeter S-band wave heights: Timeseries of bias (ENVISAT - WAM_FG) and scatter index (SI)

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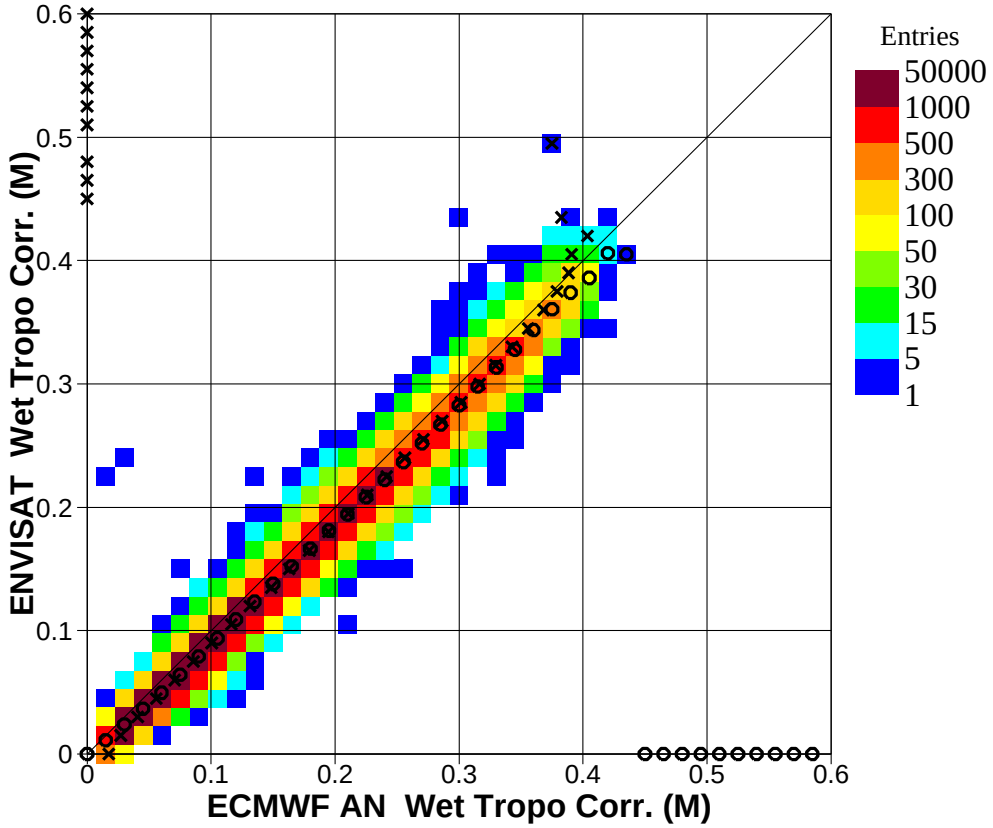
ECMWF Report on ENVISAT RA-2 for February 2006



STATISTICS

ENTRIES	77028
MEAN ECMWF	.1572
MEAN ENVISAT	.1444
BIAS (ENVISAT - ECMWF)	-.0128
STANDARD DEVIATION	.0129
SCATTER INDEX	.0820
CORRELATION	.9914
SYMMETRIC SLOPE	.9355 (.0005)
REGR. COEFFICIENT	.9689 (.0005)
REGR. CONSTANT	-.0079 (.0001)

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

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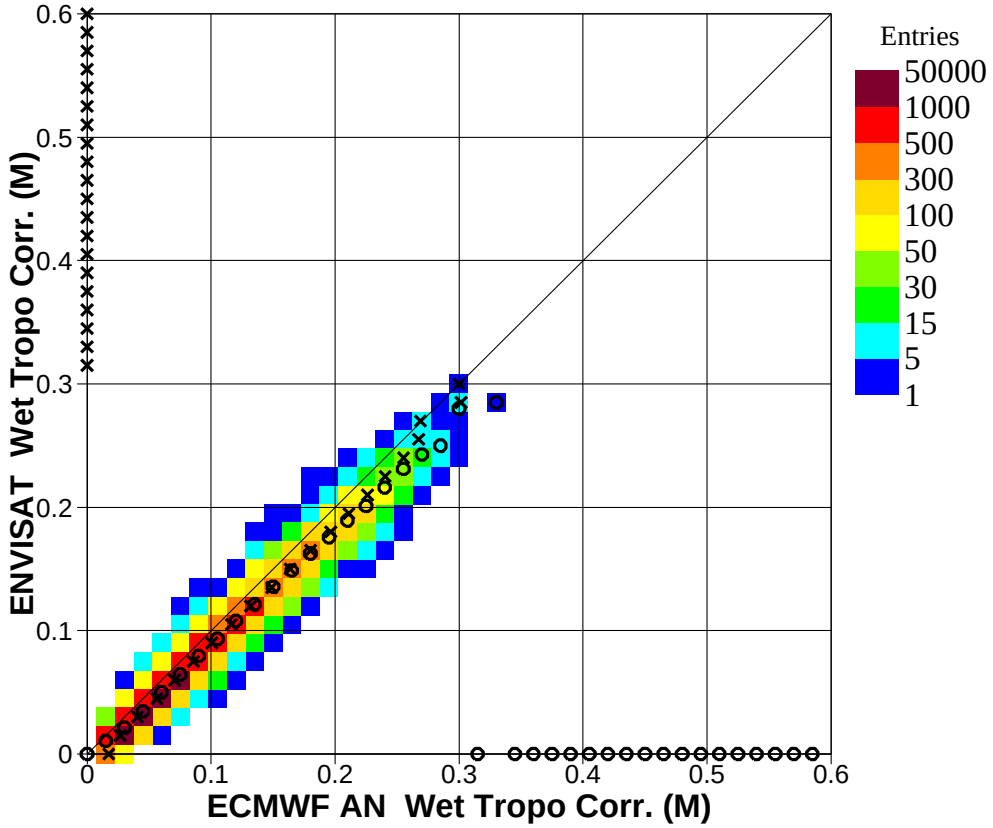

STATISTICS

ENTRIES	19133
MEAN ECMWF	.0964
MEAN ENVISAT	.0844
BIAS (ENVISAT - ECMWF)	-.0120
STANDARD DEVIATION	.0107
SCATTER INDEX	.1108
CORRELATION	.9826
SYMMETRIC SLOPE	.8972 (.0013)
REGR. COEFFICIENT	.9402 (.0013)
REGR. CONSTANT	-.0062 (.0001)

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

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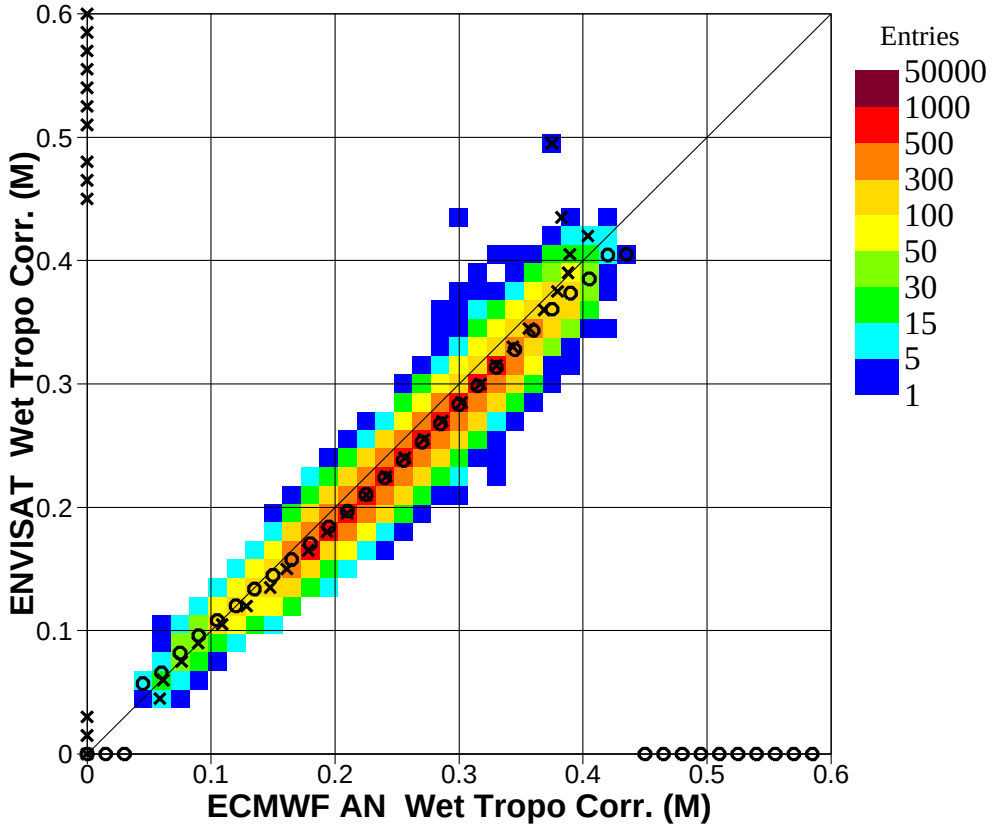

STATISTICS

ENTRIES	23219
MEAN ECMWF	.2593
MEAN ENVISAT	.2453
BIAS (ENVISAT - ECMWF)	-.0140
STANDARD DEVIATION	.0159
SCATTER INDEX	.0611
CORRELATION	.9749
SYMMETRIC SLOPE	.9480 (.0014)
REGR. COEFFICIENT	.9493 (.0014)
REGR. CONSTANT	-.0009 (.0004)

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

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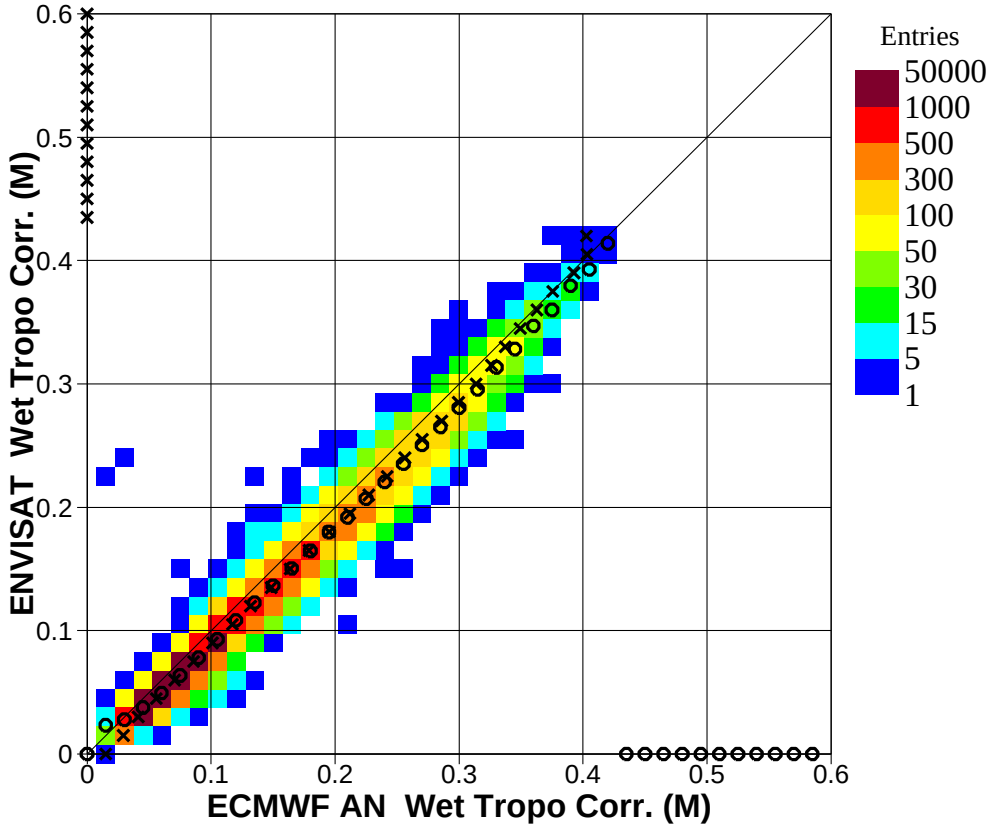

STATISTICS

ENTRIES	35241
MEAN ECMWF	.1238
MEAN ENVISAT	.1114
BIAS (ENVISAT - ECMWF)	-.0124
STANDARD DEVIATION	.0117
SCATTER INDEX	.0948
CORRELATION	.9886
SYMMETRIC SLOPE	.9196 (.0008)
REGR. COEFFICIENT	.9567 (.0008)
REGR. CONSTANT	-.0070 (.0001)

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

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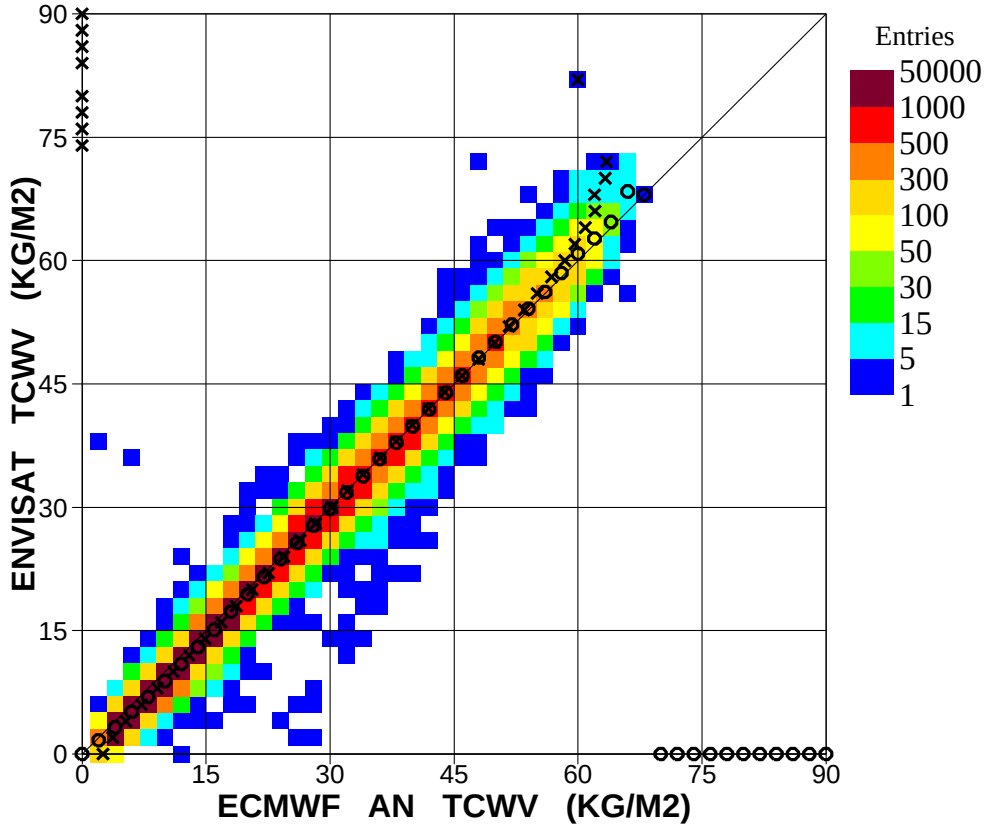

STATISTICS

ENTRIES	77028
MEAN ECMWF	24.0539
MEAN ENVISAT	23.5286
BIAS (ENVISAT - ECMWF)	-.5254
STANDARD DEVIATION	1.8781
SCATTER INDEX	.0781
CORRELATION	.9936
SYMMETRIC SLOPE	.9955 (.0004)
REGR. COEFFICIENT	1.0292 (.0004)
REGR. CONSTANT	-1.2289 (.0121)

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

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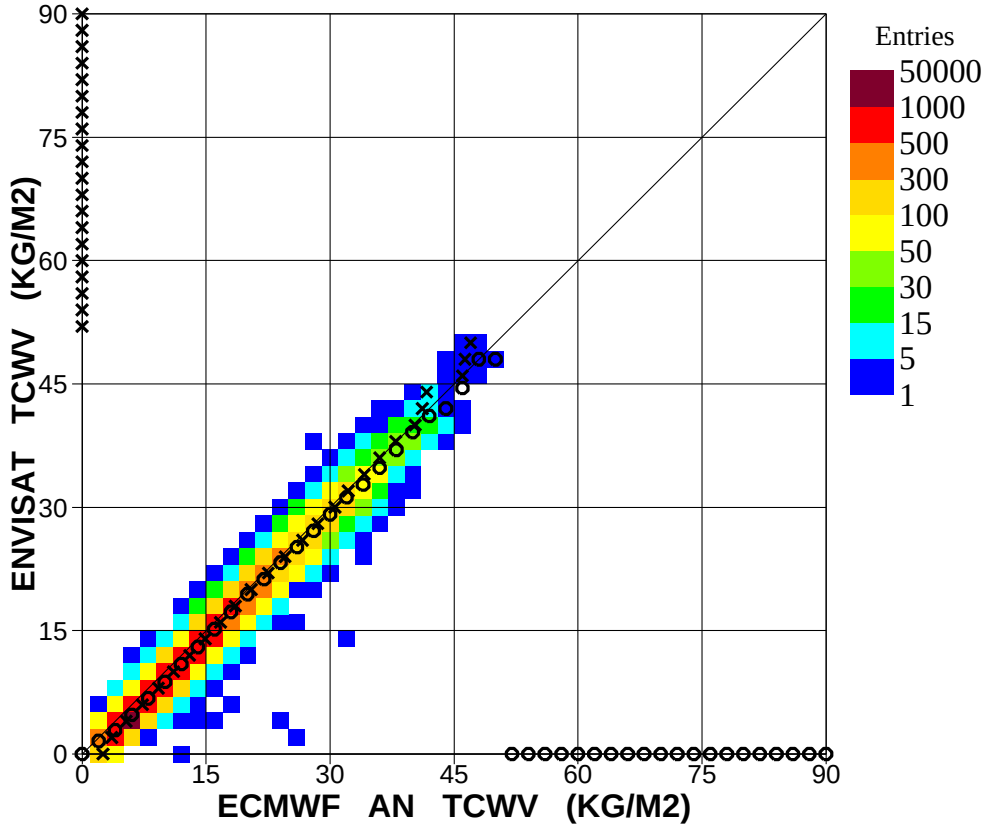

STATISTICS

ENTRIES	19133
MEAN ECMWF	14.3938
MEAN ENVISAT	13.4245
BIAS (ENVISAT - ECMWF)	-.9693
STANDARD DEVIATION	1.4942
SCATTER INDEX	.1038
CORRELATION	.9862
SYMMETRIC SLOPE	.9596 (.0013)
REGR. COEFFICIENT	1.0148 (.0012)
REGR. CONSTANT	-1.1829 (.0207)

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

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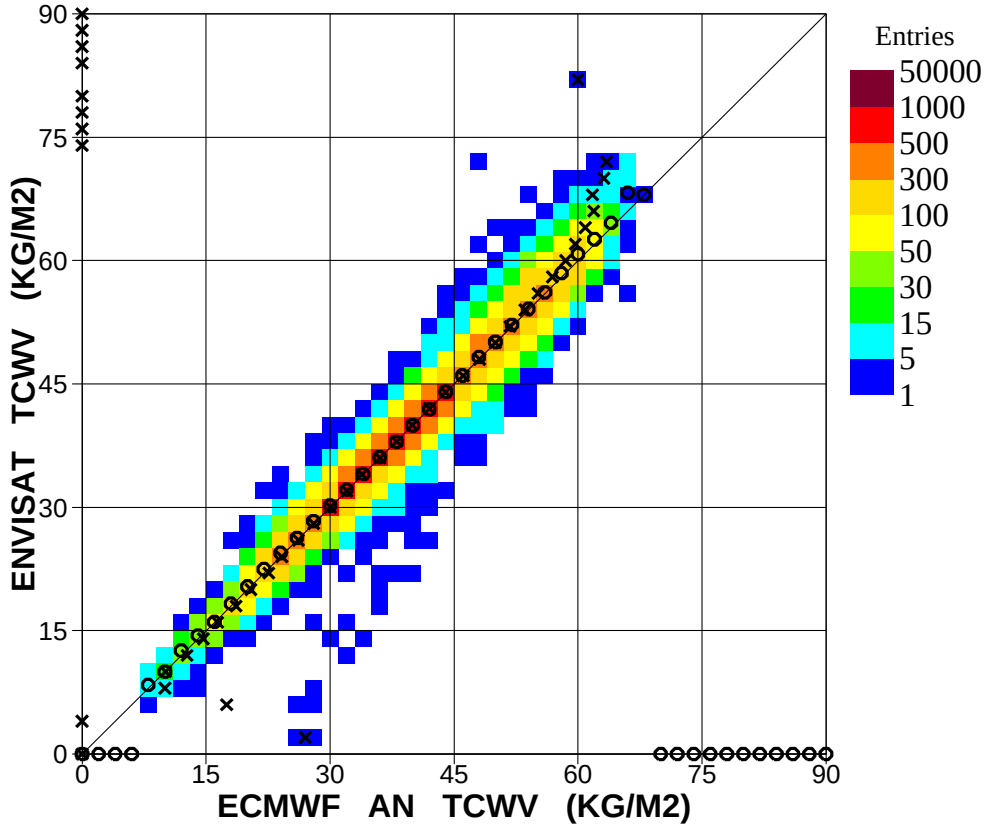

STATISTICS

ENTRIES	23219
MEAN ECMWF	40.4050
MEAN ENVISAT	40.5734
BIAS (ENVISAT - ECMWF)	.1685
STANDARD DEVIATION	2.2139
SCATTER INDEX	.0548
CORRELATION	.9818
SYMMETRIC SLOPE	1.0055 (.0013)
REGR. COEFFICIENT	1.0034 (.0013)
REGR. CONSTANT	.0294 (.0535)

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

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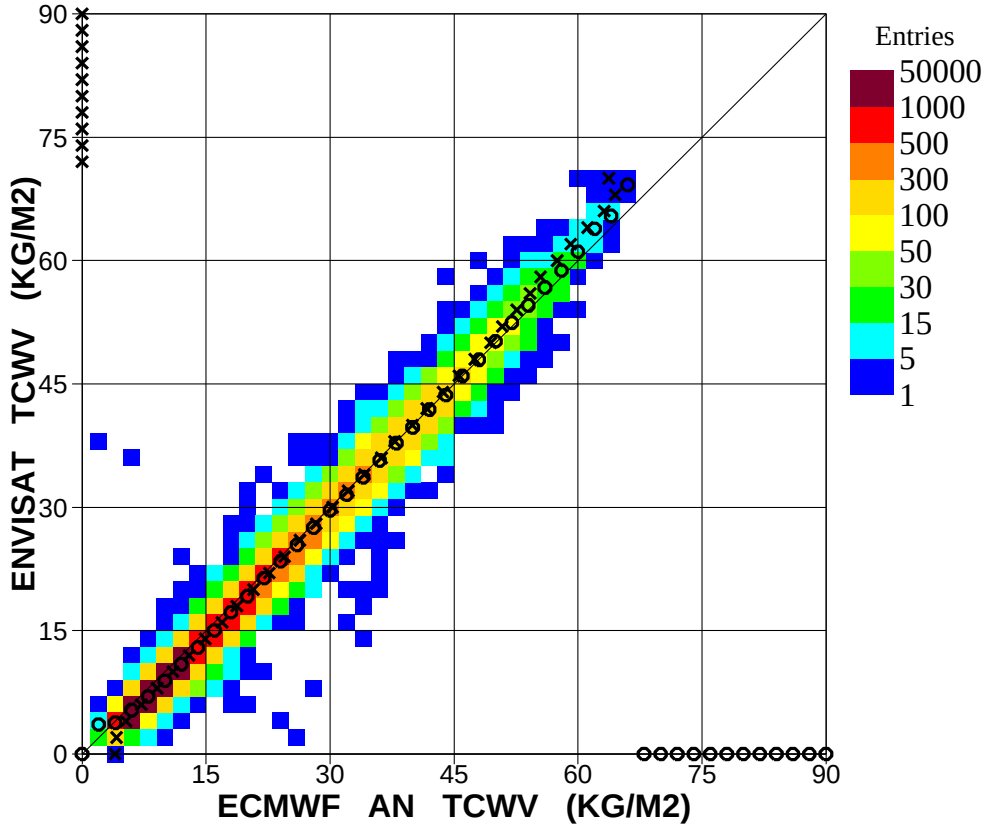

STATISTICS

ENTRIES	35241
MEAN ECMWF	18.6633
MEAN ENVISAT	17.9334
BIAS (ENVISAT - ECMWF)	-.7299
STANDARD DEVIATION	1.6954
SCATTER INDEX	.0908
CORRELATION	.9913
SYMMETRIC SLOPE	.9835 (.0008)
REGR. COEFFICIENT	1.0254 (.0007)
REGR. CONSTANT	-1.2038 (.0162)

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

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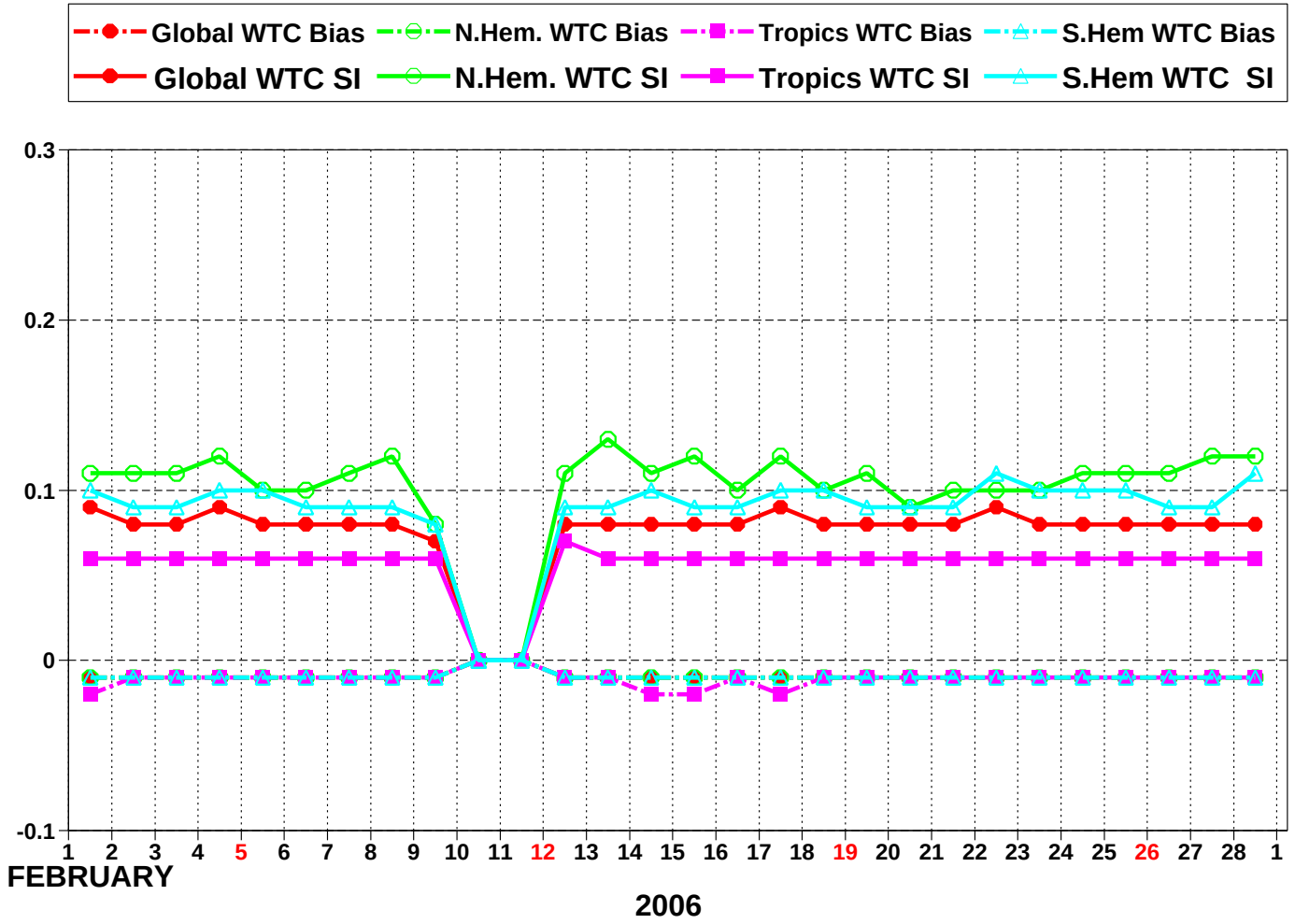

Figure 46: ENVISAT Altimeter wet tropo correction: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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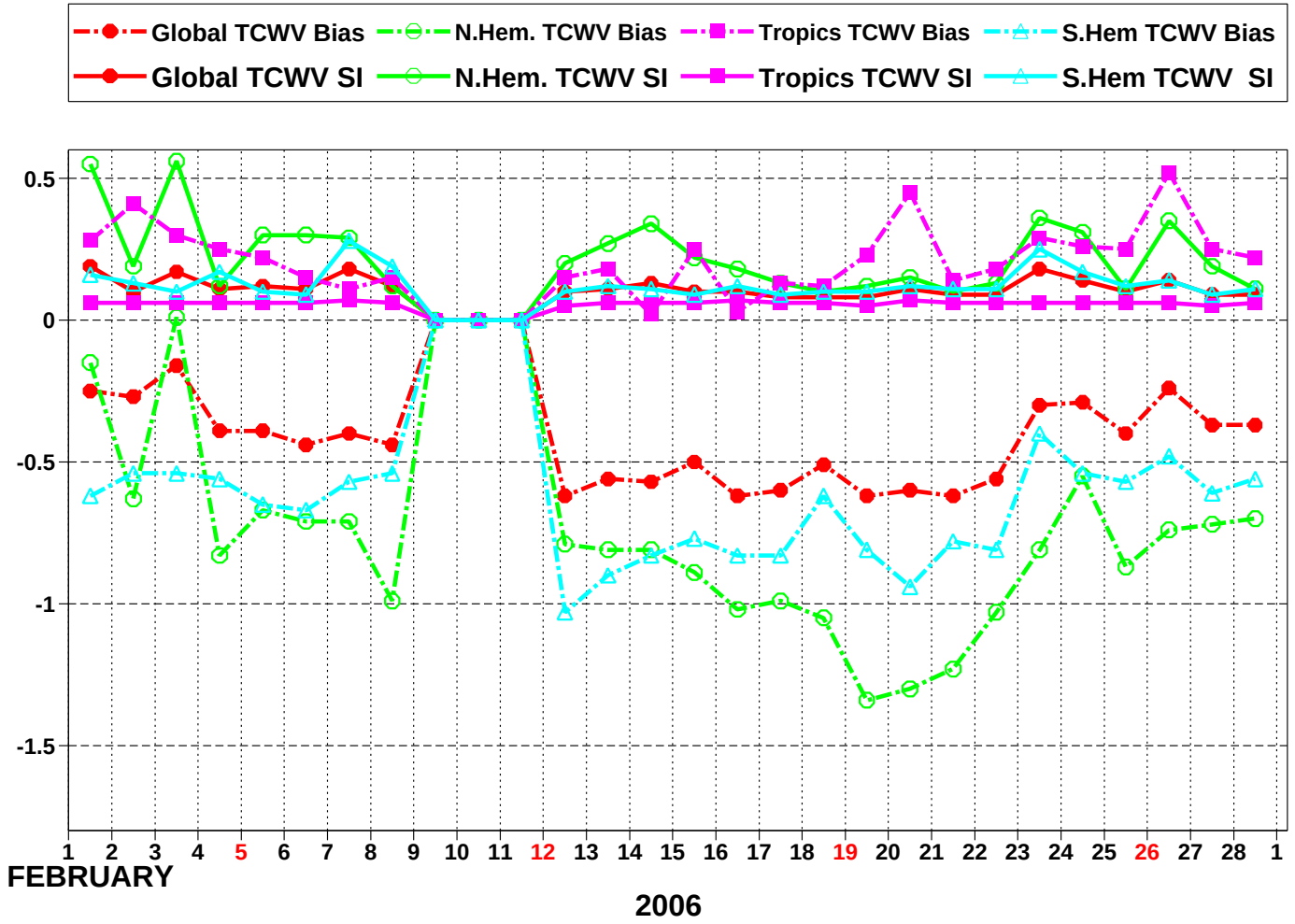

Figure 47: ENVISAT Altimeter total column water vapour: Timeseries of bias (ENVISAT - ECMWF) and scatter index (SI)

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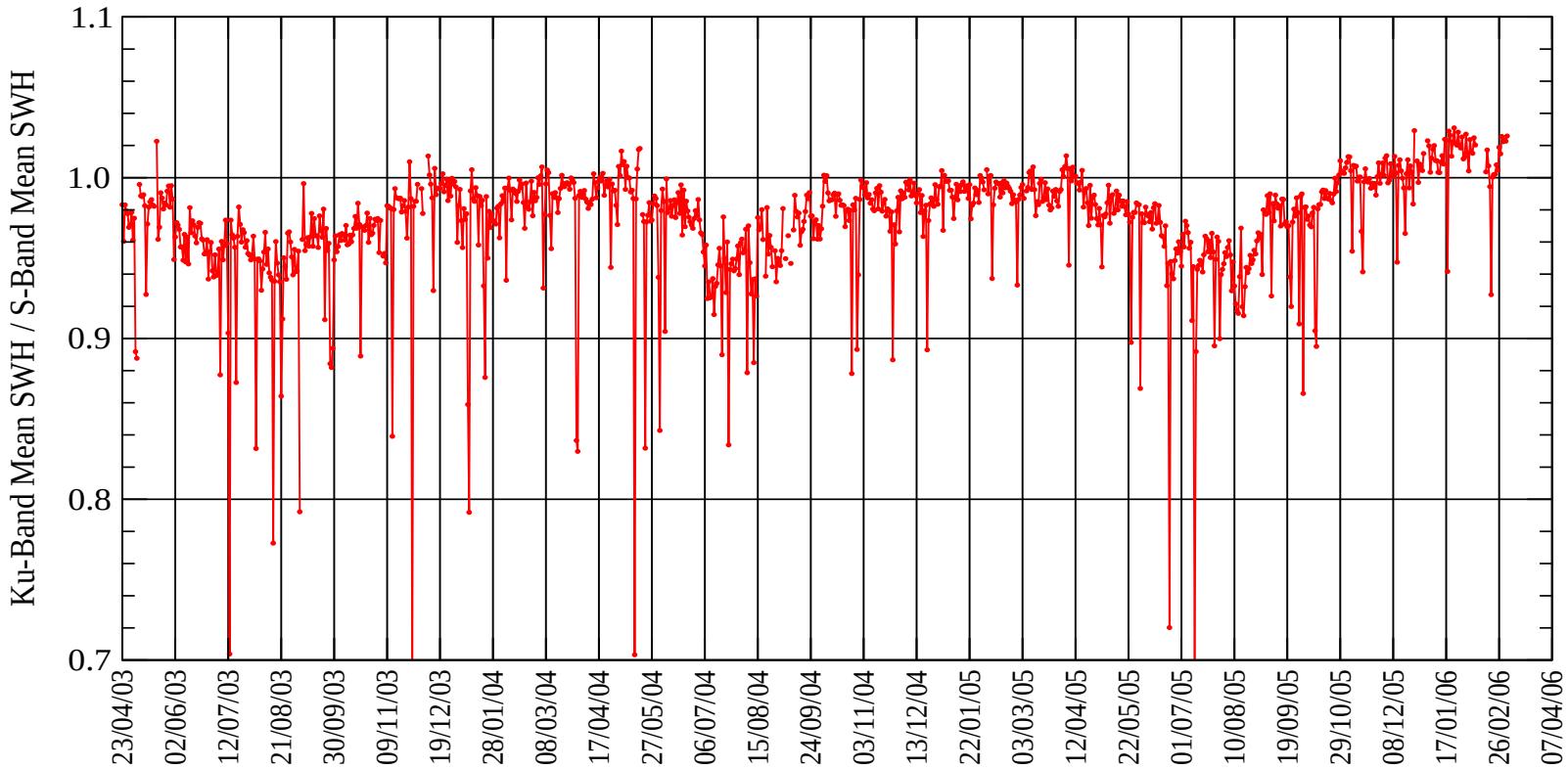

Figure 48: Timeseries of daily global ratio between mean Ku-Band to mean S-Band significant wave heights since the 23rd. of April 2003.

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