Calibration and Validation of JASON Wind Wave Data Based on in situ Data.

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Calibration / validation of JASON & TOPEX IGDR wind /wave data against buoys.

Procedures used which allow for errors in satellite and in-situ data.

186 triple co-locations of JASON, TOPEX, and buoy data from 38 buoy sites.

Orthogonal Distance Regressions between JASON – Buoy, TOPEX-Buoy, and JASON-TOPEX to derive calibration correction functions

Analysis of triple co-locations to derive estimates of error in each of JASON, TOPEX and Buoy

Data, and Data Processing

Altimeter Data

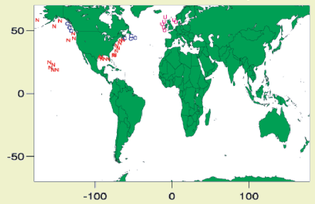
Jason IGDR data, cycles 3,4,6-13
TOPEX IGDR, cycles 346, 347,349-356
1 Hz Data (Hs, σ0 +0.63 dB)

Parameter	JASON IGDR Check	TOPEX IGDR Check
IGDR flags	Qual_1hz_alt_data, Qual_1hz_alt_instr_corr (not c8) Rad_surf_type, Ice_flag	geo_bad_1: 1 altbad_2:4,6
σ0 range	0-20	0-20
H range	-130.0m < H < 100.0m	
H s range	0-25	0-25
U10 range		0-20
sdHs range		
sdH range	<0.2m	
sdAGC range		0.000001 < sdAGC<0.1
Attitude		
Dry trop corr.	-25.0m < mdtc < -19.0m	
Wet trop corr.	-5.0m < rwtc < -0.001m	
iono corr.	-4.0m < ic < 0.4m	
ssb corr.	-5.0m < ssb < 0.0m	
Ocean Tide	-50.0m < ot < 50.0m	
Solid Earth Tide	-10.0m < set < 10.0m	
Pole Tide	-1.5m < pt 1.5m	

Table 1 TOPEX and JASON IGDR Quality Checks

Buoy Data

34 N. Hemisphere Buoys:
20 US NDBC buoys
9 UK Met Office Offshore Buoys
5 Environment Canada Buoys



Buoy U10, Ta, Tp, Hs, Tair, Tsea, Wdir, ...) retrieved from standard met. records within 30 minutes of satellite overpass.

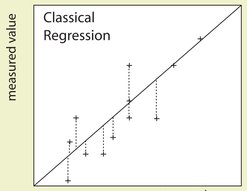
Satellite data taken from valid 1 Hz record closest to buoy (< 50 km)
186 triple co-locations found in 100 days data

Calibration Procedure

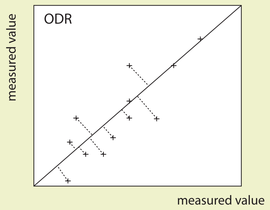
"Orthogonal Distance Regressions (ODR)" -
Errors to be found in both satellite and reference data set, neither data set represents the "absolute" truth.
ODR mininises residual variance by fitting a line orthogonal to direction of maximum variance.
Calibration equations are presented which give the correction needed for satellite data (outliers more than 5σ from initial fit are first removed)

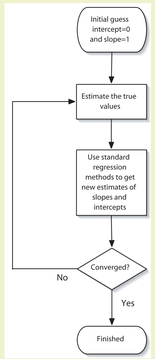
A new method for calibrating satellites

Normally calibrations are performed using a 'standard' which can be assumed to be error free. In this case we can use traditional regression. Our *in situ* data is anything but error free



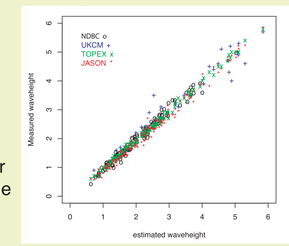
An alternative is to use orthogonal distance regression (ODR). Here rather than minimising the distance in the y direction we minimise the orthogonal distance to the line. However we have to assume that the error variances of both datasets are the same





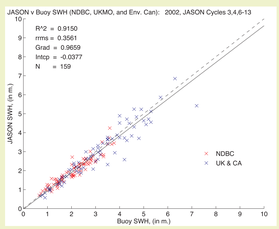
As an alternative we propose to estimate the 'true value of waveheight at the same time as the intercepts and slopes. The procedure is shown on the left. If our regression equation is $y_i=\alpha_i+\beta_i x$ we estimate the α_i, β_i and x's (i denotes the instrument). Because of a linear indeterminacy we need to set $\alpha_1=0$ and $\beta_1=1$, i.e. the calibration is relative to the NBDC buoys.

The measured wave heights plotted against our estimate of the true values



Results (1) - JASON v Buoy

JASON v Buoy Wave Height

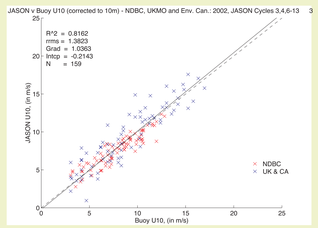


Calibration correction:
Hs(cor) = 1.0353 Hs(J) + 0.0390
95% conf limits 0.9867-1.0839 -0.0917 - 0.1698

No significant difference between Jason and Buoy Hs
(confidence limits ± 5% on gradient, ±13 cm on intercept)

Lefevre regression JASON (cycle 8) against WAM:
Jason v WAM slope = 0.96 (these data 0.97)
Jason - WAM bias , -6cm (these data -11 cm at Hs=2.1m)

JASON v Buoy Wind Speed



Calibration correction:
U10(cor) = 0.9650 U10(J) + 0.2069
95% conf limits 0.8964-1.0335 -0.4149 - 0.8288

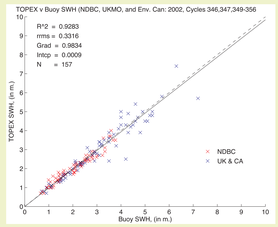
No significant difference between Jason and Buoy U10
(confidence limits ± 7% on gradient, ±0.6 m/s on intercept)

Lefevre regression JASON (cycle 8) against ECMWF:
Jason v ECMWF slope = 1.04 (these data 1.04)
Jason - ECMWF bias , -0.39 m/s (these data 0.03m/s at U10=7 m/s)

NOTE: Previous comparisons of altimeter (GFO, TOPEX, ERS-2, ERS-1, GEOSAT) and buoy data show altimeters underestimate low winds (< 5 m/s) and over estimate higher winds (to 15 m/s).
These results do not follow this pattern, suggesting σ0 adjustment does not match other altimeter data sets

Results (2) - TOPEX IGDR v Buoy

TOPEX v Buoy Wave Height



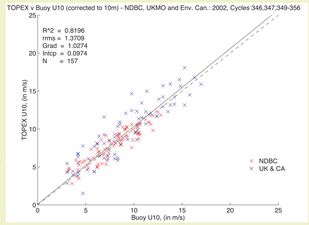
Calibration correction:
Hs(cor) = 1.0169 Hs(T) - 0.0009
95% conf limits 0.9729-1.0609 -0.1234 - 0.1215

No significant difference between Topex IGDR and Buoy Hs
(confidence limits ± 4.5% on gradient, ±12 cm on intercept)

Lefevre regression TOPEX (cycle 351) against WAM:
Topex v WAM slope = 0.94 (these data 0.98)
Topex - WAM bias , -13cm (these data -3 cm at Hs=2.1m)

No significant difference between Topex IGDR and Buoy Hs
(confidence limits ± 4.5% on gradient, ±12 cm on intercept)

TOPEX v Buoy Wind Speed



Calibration correction:
U10(cor) = 0.9733 U10(T) - 0.0947
95% conf limits 0.9045-1.0422 -0.7358 - 0.5465

No significant difference between Jason and Buoy U10
(confidence limits ± 7% on gradient, ±0.6 m/s on intercept)

Lefevre regression Topex (cycle 351) against ECMWF:
Topex v ECMWF slope = 1.04 (these data 1.03)
Topex - ECMWF bias , +0.43 m/s (these data 0.28m/s at U10=7 m/s)

NOTE: These results do not follow the expected pattern (see Jason results panel), suggesting σ0 adjustment applied toTopex IGDR does not produce a good match with other altimeter data sets

Results of New Method

H_s	NDBC	UKCM	TOPEX	JASON
Intercept	0.0000	0.6228	-0.0786	-0.2076
sd intercept	NA	0.0324	0.0076	0.0153
Slope	1.0000	0.8025	1.0081	1.0348
sd slope	NA	0.0116	0.0027	0.0055
Residual sd	0.1299	0.3915	0.0919	0.1850

ln H_s	NDBC	UKCM	TOPEX	JASON
Intercept	0.0000	0.2025	0.0018	-0.0639
sd intercept	NA	0.0071	0.0035	0.0056
Slope	1.0000	0.8576	1.0040	1.0401
sd slope	NA	0.0079	0.0039	0.0062
Residual sd	0.0835	0.0861	0.0422	0.0681

U_{10}	NDBC	UKCM	TOPEX	JASON
Intercept	0.0000	-0.3903	-3.4231	-2.4877
sd intercept	NA	0.1507	0.0506	0.0491
Slope	1.0000	0.7157	1.0890	0.9763
sd slope	NA	0.0128	0.0043	0.0042
Residual sd	1.8660	1.8212	0.6114	0.5931

ln U_{10}	NDBC	UKCM	TOPEX	JASON
Intercept	0.0000	-0.1930	-0.9803	-1.1204
sd intercept	NA	0.0223	0.0028	0.0051
Slope	1.0000	0.7137	1.0075	1.0401
sd slope	NA	0.0073	0.0009	0.0017
Residual sd	0.3401	0.2701	0.0337	0.0618