Geosat Follow-On GDR calibrations

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Introduction

Earlier calibration of GFO significant wave height (*Hs*) and wind speed at 10 m (*U10*) have been carried out using IGDR's. In particular, David Cotton (pers. comm.) has put together a data set of co-located *Hs* and *U10* values from US NDBC buoys and from IGDR's when the altimeter track passed close to a buoy, taking the nearest 1 Hz record to the buoy providing it was within 50 km and within 30 minutes of the buoy measurements. Inspection indicates that the IGDR *Hs* values are the same as the GDR values. But the *U10* values are different, because of an adjustment of 0.63 dB, but the σ^0 values are the same, so I have derived the equivalent GDR *U10* values by applying the algorithm in the GFO Users Handbook - derived from Witter & Chelton (1991) but incorporating the adjustment - to get *U10* from the σ^0's.

These 'GDR' *U10* values include some less than 1.83 m/s; although using the quality_1 flag in the records removes all $\sigma^0 > 14$ dB, and hence all *U10* < 1.83 m/s.

Data

The data set contains values from January 2000 to August 2003. The numbers for each year and the co-located NDBC buoys are given in Table 1.

NDBC buoy	all years	2000	2001	2002	2003
41001	50	7	21	20	2
41002	109	20	25	37	27
41010	61	12	20	14	15
42001	49	9	0	24	16
42002	104	21	16	40	27
42003	47	9	18	18	2
42019	106	15	31	35	25
42020	106	13	28	40	25
44004	48	1	19	21	7
44008	94	18	9	40	27
44011	13	0	1	7	5
44014	60	18	42	0	0
46001	121	19	37	38	27
46002	86	16	35	35	0
46005	117	23	28	40	26
46006	46	7	15	16	8
46035	25	15	6	0	4
51001	103	14	37	43	9
51002	131	22	42	41	26
51003	1	0	1	0	0
51004	109	19	40	28	22

Table 1. Buoy/GFO comparisons by year and by US NDBC buoy.

Buoys 42001, 42002, 42003 and 46035 measure wind speed at 10 m. The others have anemometers at 5 m; the winds at 10 m were estimated from these using the air/sea temperature difference (Dobson, 1981: Appendix Table A-3); if either temperature was missing, the record was discarded.

Temporal variation

There seems to be some variation in the mean difference between buoy and altimeter *Hs* and *U10* from year to year, as shown in Tables 2 and 3.

Year	Number	mean	s.d.	s.e.(mean)
2000	291	0.2217	0.2192	0.01285
2001	472	0.2307	0.2549	0.01173
2002	552	0.2603	0.2515	0.01070
2003	304	0.2626	0.2139	0.01227

Table 2. Statistics of buoy *Hs* - GFO *Hs* by year

Year	Number	mean	s.d.	s.e.(mean)
2000	278	-1.0405	1.6114	0.0966
2001	471	-0.1638	1.5307	0.0705
2002	537	-0.03296	1.4778	0.0637
2003	300	0.07437	1.3429	0.0775

Table 3. Statistics of buoy *U10* - GFO *U10* by year

The Hs difference appears to increase slightly, but this might be due to the changes in the buoys used. The drift in the *U10* difference is more marked, and is significantly different in 2000 from the other years. There were some problems with GFO during 2000; it was not finally accepted by the US Navy until November 2000. So I have discarded the 2000 data from further analysis.

Wave height calibration

Regressing the 1328 pairs of US NDBC buoy *Hs* and the GFO *Hs* from 2001 to August 2003 gives the result shown in Figure 1.

The orthogonal distance regression is:

$$\begin{array}{lll} Hs_{\text{buoy}} = 1.088\,Hs_{\text{gfo}} & + & 0.093 \\ \qquad\quad (1.076 - 1.099) & & (0.069 - 0.118) \end{array} \qquad (1)$$

where the numbers in brackets are 95% confidence intervals on the estimated slope and intercept. The root mean square error, calculated from $Hs_{\text{buoy}} - \left(1.088\,Hs_{\text{gfo}} + 0.093\right)$, is 0.24 m, and the correlation coefficient is 0.98.

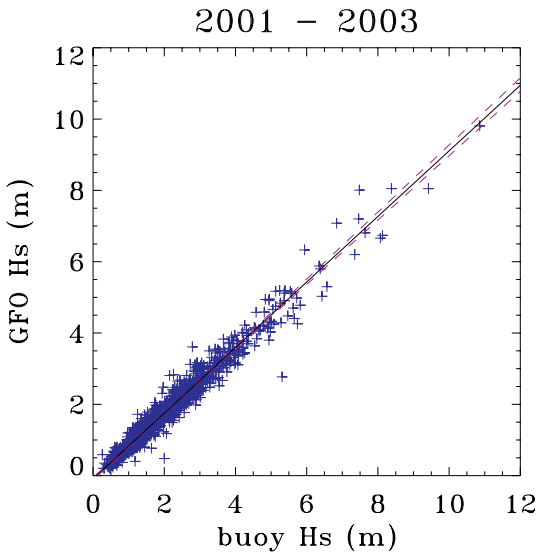

Figure 1. Comparison of significant wave heights from US NDBC buoys and the GFO altimeter. The solid line is the odr fit.

Queffeulou (2003, 2004) gives two calibrations for GFO IGDR *Hs* based on comparison against other altimeter values at ground-track crossings. Queffeulou(2003) gives :

$$Hs_{\text{cor}} = 1.0812\,Hs_{\text{gfo}} + 0.0392 \qquad (2)$$

in good agreement with (1).

Queffeulou (2004) uses a larger data set of Topex *Hs* (B transmitter) values at ground-track crossings from December 1999 to December 2003, and gets:

$$Hs_{\text{cor}} = 1.0625\,Hs_{\text{gfo}} + 0.0754 \qquad (3)$$

However, this is dependent on Queffeulou's calibration for Topex (B):

$$Hs_{\text{cor}} = 1.0237\,Hs_{\text{topex}} - 0.0476 \qquad (4)$$

Cotton (pers.comm, 2001) obtained, from a comparison against NDBC buoys:

$$Hs_{\text{cor}} = 1.0376\,Hs_{\text{topex}} - 0.0674 \qquad (5)$$

If (5) is used instead of (4) then (2) becomes:

$$Hs_{\text{cor}} = 1.0769\,Hs_{\text{gfo}} + 0.1921 \qquad (6)$$

in much closer agreement with (1). But the difference between (1) and (3) is quite small: less than 0.1 m for Hs < 3 m and less than 3% for Hs > 3 m.

Wind speed calibration

A comparison of the 1308 estimates of wind speed from GFO and the buoys, adjusted to 10 m, is shown in Figure 2 (left). Removing the 19 'outliers' with differences of more than 3 s.d., gives the right hand figure.

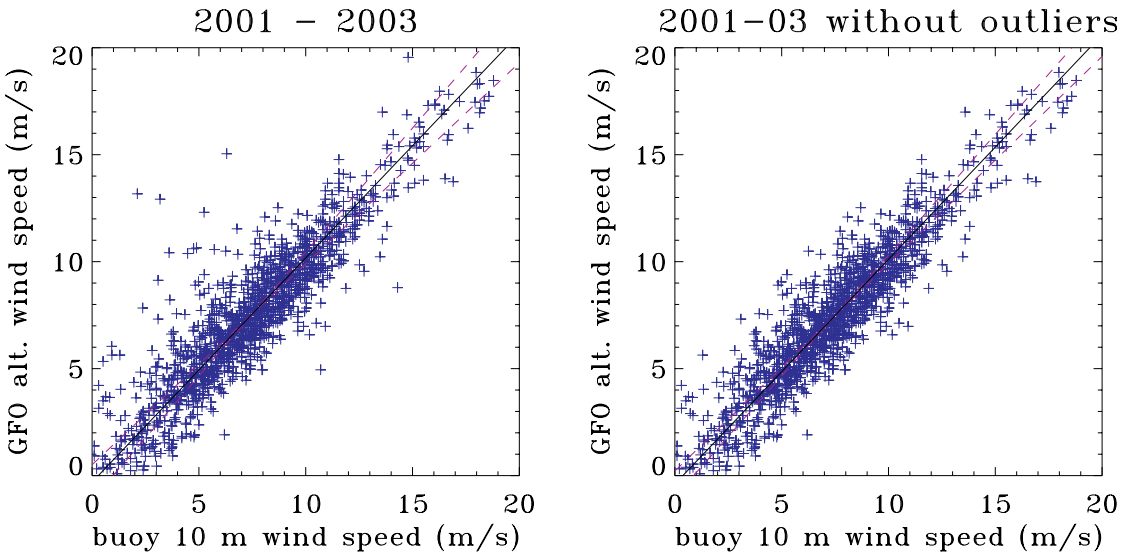

Figure 2. . Comparison of significant wave heights from US NDBC buoys and the GFO altimeter. The solid line is the odr fit.

The orthogonal distance regression (fitted assuming errors on the altimeter and buoy wind speeds are equal) from the right hand figure is:

$$U_{10(\text{buoy})} = 0.953 U_{\text{gfo}} + 0.374 \qquad (7)$$
$$(0.932 - 0.973) \quad (0.207 - 0.541)$$

with rrms of 1.22 m/s and correlation coefficient of 0.93.

The odr fit in the left hand figure of Figure 2 has slope and intercept of 0.954 and 0.292, within the 95% confidence intervals of (7), but the rrms is 1.43 m/s and the correlation coefficient is 0.90.

A similar analysis of the 827 data from 2002 and 2003 gives slope and intercept of 0.952 and 0.416, also within the 95% confidence intervals of (7).

Conclusions

GFO GDR significant wave heights appear to be about 9% low, when compared to US NDBC buoy values, while the GDR estimates of wind speed at 10 m are around 4% high. There is a need for further data to reduce the size of the confidence limits and to investigate possible changes in calibration over the years. In the meantime, equations 1 and 7 will give reasonably accurate corrections, i.e:

$$Hs_{(\mathrm{cor})} = 1.088\, Hs_{\mathrm{gfo}} \quad + \quad 0.093$$

and

$$U_{10(\mathrm{cor})} = 0.953 U_{\mathrm{gfo}} \quad + \quad 0.374$$

References

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