ALTIMETER WAVE HEIGHT MEASUREMENTS - VALIDATION OF LONG TIME SERIES

Pierre Queffeulou IFREMER, Laboratoire d'océanographie spatiale, Plouzané, France

From ERS-1 to Jason-2, eighteen years of altimeter wave height measurements are available (GEOSAT should be added to extend this time period). For an easier access to these multi-altimeter data a simplified homogeneous data base was developed.
ftp://ftp.ifremer.fr/ifremer/cersat/products/swath/altimeters/waves

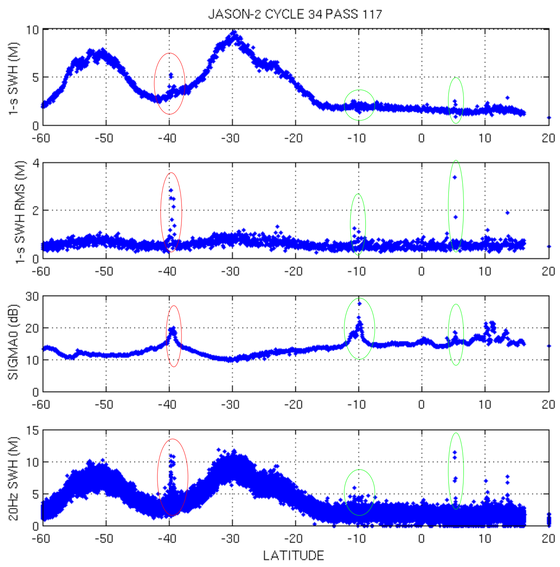
The goal is to gather, in the same format, significant wave height measurements from the various altimeters and space agencies in order to construct an homogeneously validated and calibrated data set.

Two main aspects:

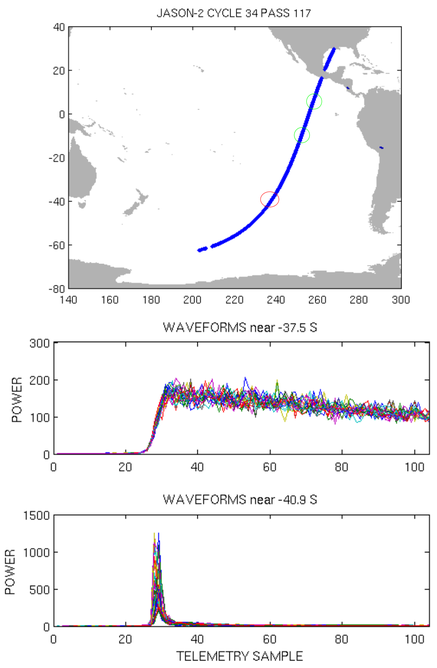
1-Detection and correction or elimination of any anomaly in the measurements: this is achieved using the quality flags and dedicated parameters within each altimeter product, and also performing specific tests.

2-Calibration of the wave height measurements, using buoy measurement and cross altimeter comparisons.

EXAMPLE OF SWH MEASUREMENT ANOMALIES

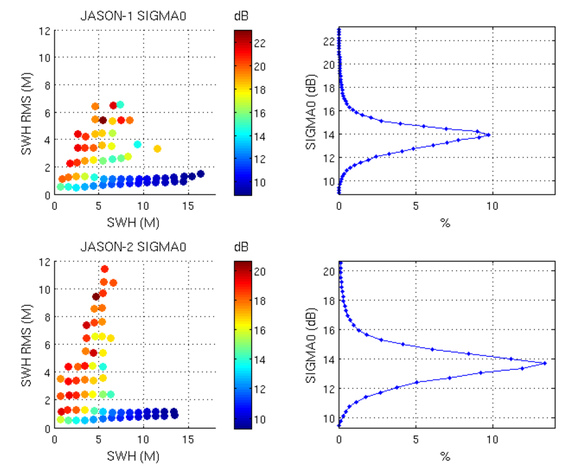


In high sigma0 areas, SWH estimates can be erroneous, with large values of the 1s SWH rms, induced by large fluctuations of individual 20 Hz SWH values, due to specific waveform characteristics in such conditions.



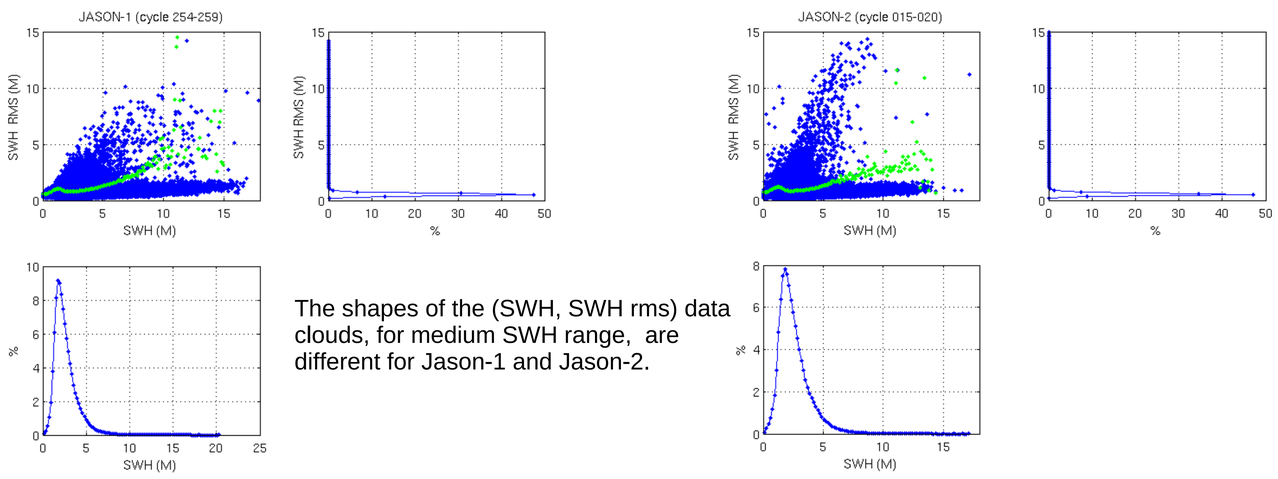
Above 20 Hz telemetry waveforms (courtesy J. Tournadre) in the sigma0 bloom area (lower graph) are typical of quasi-specular reflection, and are very different from the waveforms in normal conditions (upper graph).

HIGH SWH RMS IN SIGMA0 BLOOMS



Analysis of the distributions of 1s SWH, SWH rms and sigma0, for both Jason-1 (cycles 254 - 259) and Jason-2 (cycles 15 - 20), from November 27, 2008 to January 26, 2009, shows that the highest values of 1s SWH rms correspond mainly to the highest sigma0 values, over 16 dB, for medium wave heights, in sigma0 bloom areas.

SWH RMS THRESHOLD AS A FUNCTION OF SWH



The shapes of the (SWH, SWH rms) data clouds, for medium SWH range, are different for Jason-1 and Jason-2.

To eliminate spurious SWH data, a threshold was estimated for the 1s SWH rms as a function of SWH. This is based on previous observation (Cotton et al. 2003) that the distribution of the SWH rms is not Gaussian, but that the distribution of the logarithm of the SWH rms is « more » Gaussian.

Thus, for each SWH bin, 0.1 m wide, a threshold value of log(swh_rms) was estimated in adding 3 times the standard deviation of the log(SWH_rms) to the mean value of log(SWH_rms). Then the SWH_rms thresholds are obtained. These threshold values are reported in green on the left figures. About 0.7 % of the data are above the threshold, for both Jason 1&2.

On a practical aspect, for testing the data, this swh_rms threshold is applied for SWH lower than 5 m. Between 5 m and 8 m, the threshold is estimated by a polynomial fit. Above 8 m SWH, the threshold is fixed to 2.5 m and 2.4 m, for Jason-1 and Jason-2, respectively.

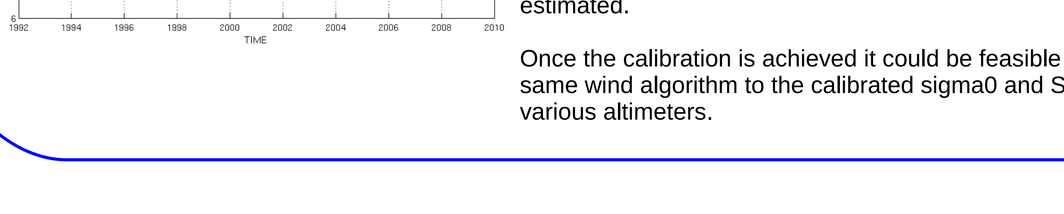
SWH UPDATED VALIDATIONS

The data base has been completed by ERS-1 measurements from phases A, B and D (3-day repeat cycle) and phases E and F (168-day repeat cycle) which were recently re-processed using the same OPR software as for ERS-2. A new calibration relation was obtained from buoy comparisons (Queffeulou and Croizé-Fillon 2009).

The Jason-1 version *c* was also calibrated. The corrections are slightly different from the previous version *b*.

Jason-2 GDR SWH was compared to Jason-1 over cycles 15 to 20. The differences are low: mean bias of 1.5 cm with a standard deviation of differences about 4.5 cm. Jason-2 SWH is slightly under-estimated at high SWH. The same correction as for Jason-1 is presently applied to Jason-2 GDR. A new one will be estimated using buoy data.

Altimeter SWH accuracy : comparison with buoy data



Altimeter GDR SWH updated linear corrections

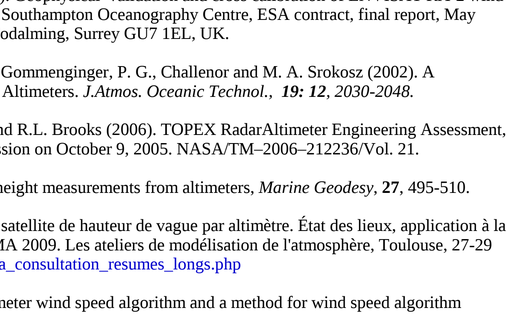
Altimeter	Slope	Intercept
ERS-1	1.1259	0.1854
ERS-2	1.0642	0.0006
ENVISAT	1.0585	- 0.1935
GFO	1.0625	0.0754
TOPEX side A *	1.0539	- 0.0766
TOPEX side B	1.0237	- 0.0476
JASON-1 version *b* **	1.0250	0.0588
JASON-2 ***	1.0250	0.0588

* Topex side-A has also to be corrected for the 1996-1999 drift (Queffeulou 2004).

** this correction is presently applied to version *c*, a new version *c* calibration will be estimated when the re-processing is completed.

*** presently Jason-2 correction is the same as for Jason-1; it will be updated with buoy comparisons when more GDR data is available.

Long term SWH corrected monthly mean values



PERSPECTIVE: CALIBRATION OF ALTIMETER WIND SPEED MEASUREMENTS

Altimeter wind speed is estimated either from sigma0 values (Witter and Chelton 1991) or from sigma0 and SWH values (Gourion et al 2002).

Large biases and trends are observed on the GDR sigma0 from the various altimeters (upper graph). Though some biases are known and are taken into account to compute wind speed, large discrepancies still remain in the altimeter wind speed values (lower graph).

There is a clear need for calibration of the various long term sigma0. Some calibrations already exist, as for TOPEX (Lockwood et al 2006) and for GFO (R. Scharroo, personal communication). The case of ERS-2 has to be examined: sigma0 jumps at the beginning of years 2000 and 2001 are associated with gyro failures. A slight trend in Jason-1 sigma0 can also be estimated.

Once the calibration is achieved it could be feasible to apply the same wind algorithm to the calibrated sigma0 and SWH, for the various altimeters.

REFERENCES

Cotton, P.D., D.J.T. Carter and P.G. Challenor (2003). Geophysical validation and cross calibration of ENVISAT RA-2 wind and wave products at Satellite Observing System and Southampton Oceanography Centre, ESA contract, final report, May 2003. Satellite Observing System, 15 church street, Godalming, Surrey GU7 1EL, UK.

Gourion, J., D. Vandemark, S. Bailey, B.Chapron, C. Gommenginger, P. G., Challenor and M. A. Srokosz (2002). A Two-Parameter Wind Speed Algorithm for Ku-Band Altimeters. *J.Atmos. Oceanic Technol.*, ***19: 12****, 2030-2048.*

Lockwood, D. W., D.W. Hancock, III, G.S. Hayne and R.L. Brooks (2006). TOPEX RadarAltimeter Engineering Assessment, Report Final Update—Side B Turn-On to End-of-Mission on October 9, 2005. NASA/TM–2006–212236/Vol. 21.

Queffeulou P. (2004). Long term validation of wave height measurements from altimeters, *Marine Geodesy*, **27**, 495-510.

Queffeulou, P. et D. Croizé-Fillon (2009). La mesure satellite de hauteur de vague par altimètre. État des lieux, application à la climatologie et à la modélisation des états de mer. AMA 2009. Les ateliers de modélisation de l'atmosphère, Toulouse, 27-29 janvier 2009. http://www.cnrm.meteo.fr/ama2009/ama_consultation_resumes_longs.php

Witter, D. L. and D. B. Chelton(1991). A Geosat altimeter wind speed algorithm and a method for wind speed algorithm development. *J. Geophys. Res.*, **96**, 18853-18860.