Calibration and Extreme Wave Heights in the Southern Ocean from Altimeter Data

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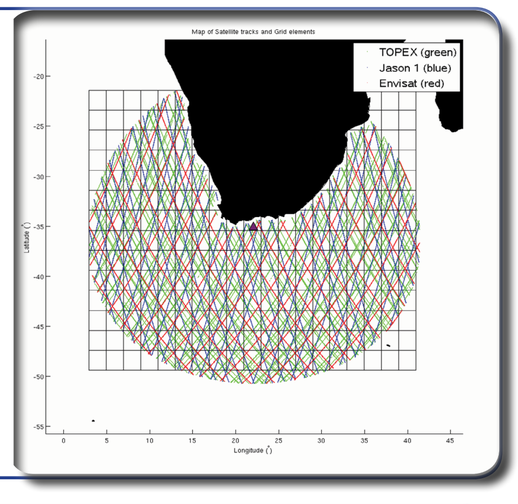
Overview

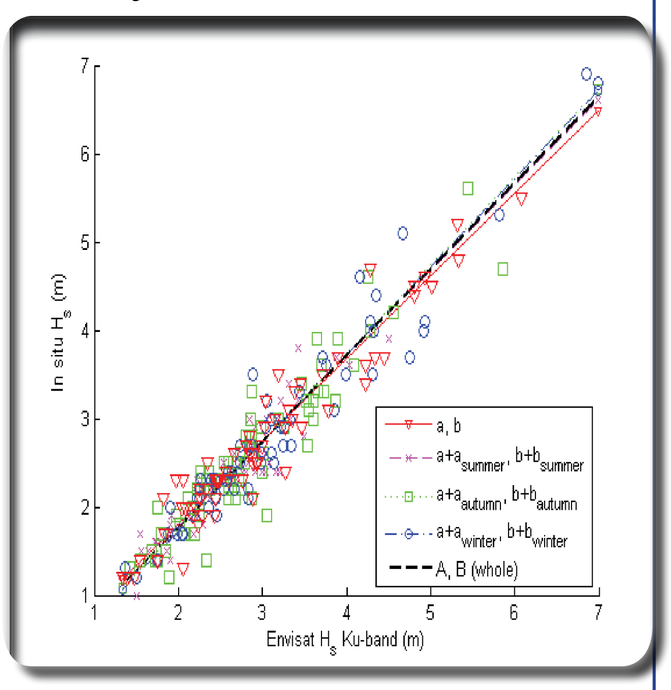
The Southern Ocean is consistently the roughest ocean in the world. Reliable description and prediction of extreme wave conditions is urgently required. Satellite observations are crucial in such isolated, hostile areas. The availability of buoy measurements from the Agulhas Bank off South Africa offers for the first time the potential for the calibration of altimeter-derived significant wave height (Hs) and period (Tz) in the Southern Ocean from TOPEX, Jason-1 and Envisat missions.



Calibration/Validation

This figure shows linear best fit using Orthogonal Distance Regression on all available Envisat data within 30 min and 100 km of the buoy. The lines also include seasonal regressions.

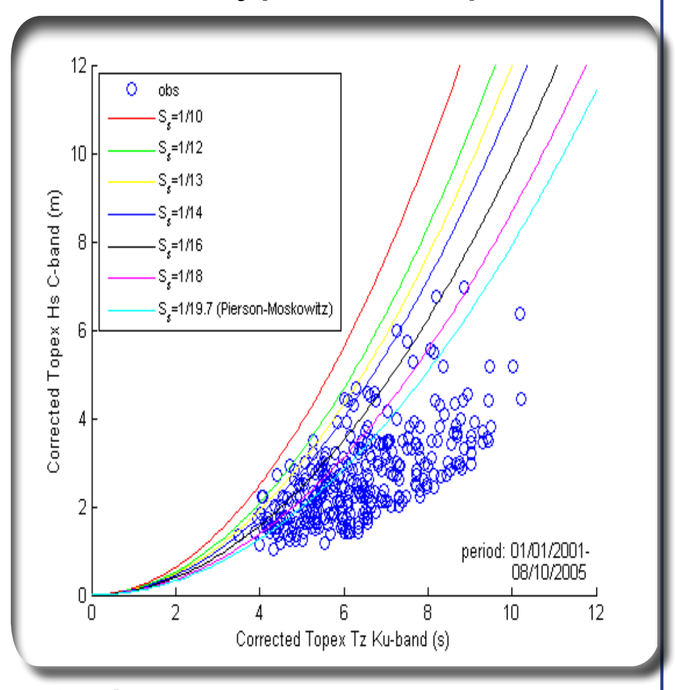
In general, altimeter Hs (Ku, C and S-band) is in agreement with the in situ data, needing only a few percent correction. Moreover, altimeter Tz, using *Mackay et al*. [2008], appears to be overestimated, with Envisat showing the greatest overestimation of about 20%.



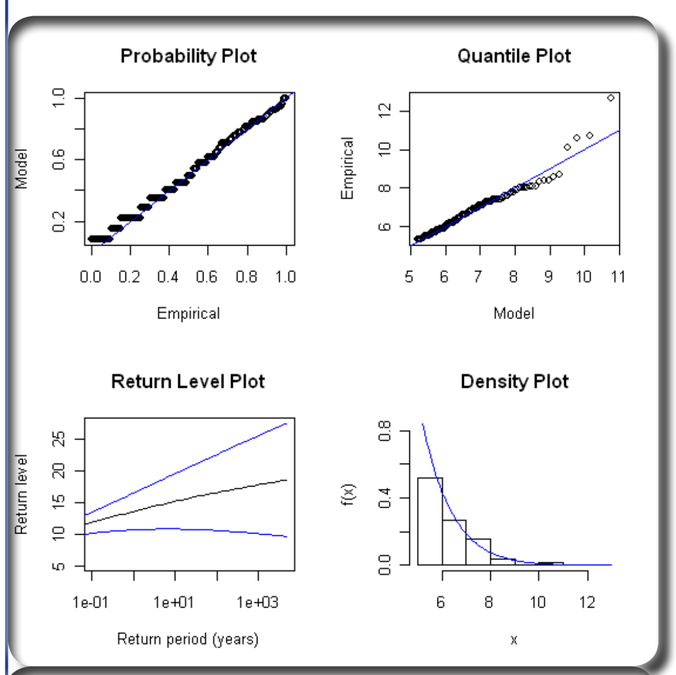
Significant wave steepness

Scatter diagrams of Hs vs Tz with lines of constant steepness, show that both in situ and calibrated altimeter observations agree with the typical steepness of 1/13 for exposed sites.

In contrast, for higher waves, in situ data are upper-bounded by 1/14 to 1/16, while the altimeter data by 1/20, indicating sea-states probably not “fully-developed” due the presence of swell, characteristic of the Southern Ocean. Such plots are also useful for quality control.



Extreme Wave Height Analysis in the Southern Ocean



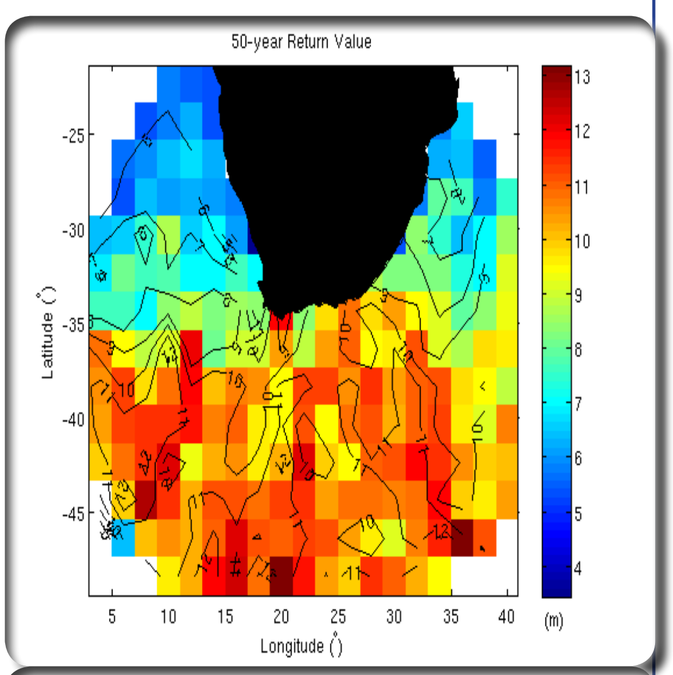
Using the Peaks Over Threshold method [*Boggs and Rogers*, 1990], the 50-year return value (RV) is estimated for both the in situ and calibrated altimeter datasets, and on a seasonal basis with different selected thresholds.

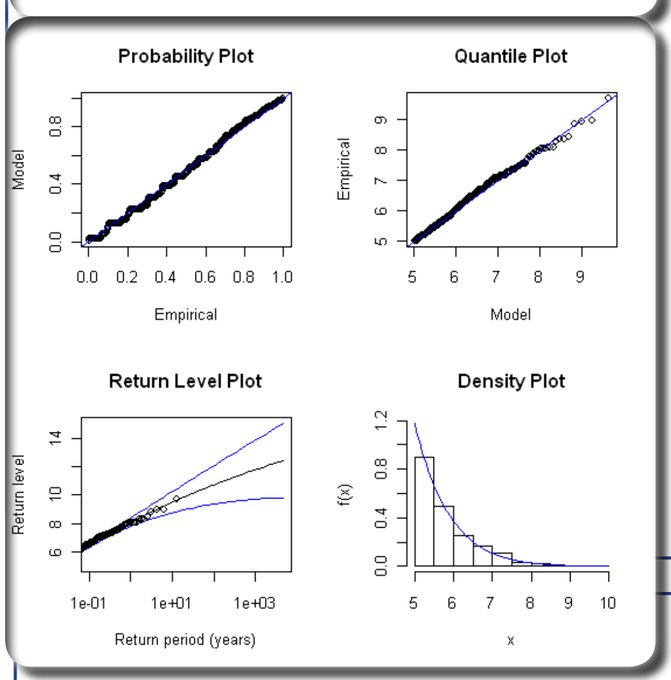
(left top) The fit of the GPD over a threshold 5.2m for the declustered in situ measurements. The 50-year RV is 12.5m.

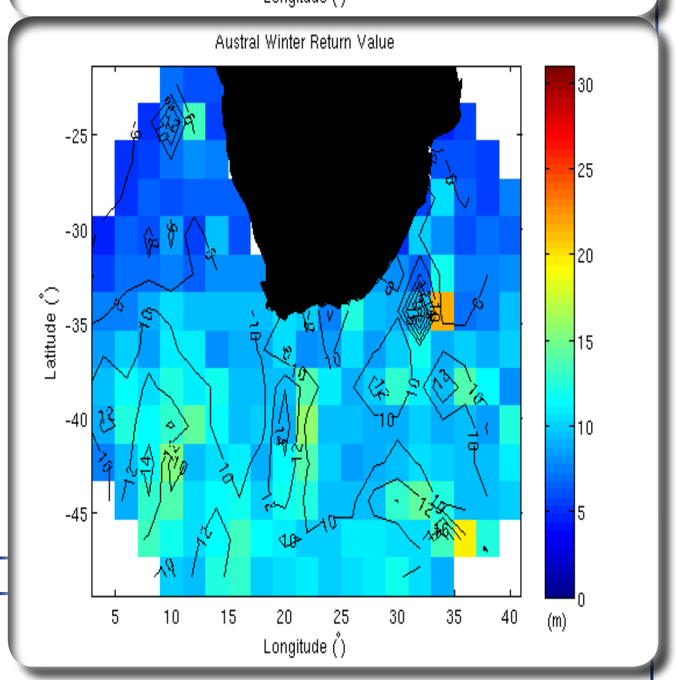
(left bottom) Similar plots for calibrated TOPEX data, indicating a 50-year RV of 10.4m for a threshold 5m (Jason-1 and Envisat give 11.5m and 10.6m, respectively).

(right) Maps of the 50-RV in the Southern Ocean from the combined calibrated TOPEX, Jason-1 and Envisat data for the whole dataset (top) and austral winter (bottom).

In austral winter, the 50-year RV mainly varies around 10-14m, but also reaches up to 21 m away from S. Africa. Suprisingly, the highest RV of about 30m Hs is found during the austral spring.







Conclusions

A first comparison of altimeter-derived wave data against in situ observations in the swell dominated Southern Ocean reveals that Hs calibration holds, apart from some Tz calculations. This, in turn, ensures a more accurate estimation of extreme wave conditions off S. Africa using altimeter Hs data. This work is currently being written up. Please ask if you would like a copy.

References: Boggs, P. T., and Rogers, J. E., 1990, Orthogonal distance regression: in Contemporary Mathematics: Am. Math. Soc.: edited by P. J. Brown, and W. A. Fuller, v. 112, p. 183-194.
Mackay, E. B. L., Retzler, C. H., Challenor, P. G., and Gommenginger, C. P., 2008, A parametric model for ocean wave period from Ku band altimeter data: J. Geophys.Res., v. 113, C03029, doi:10.1029/2007JC004438.