Self-calibration of Sigma0 for Dual-Frequency Altimeters

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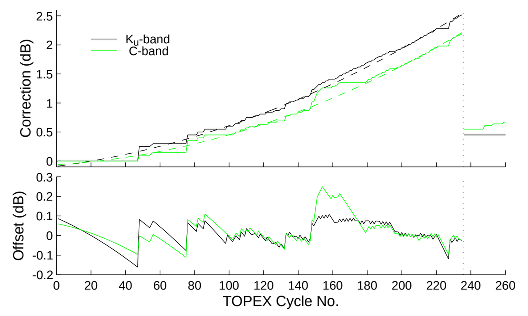
INTRODUCTION

1. Reported Drift in Sigma0 Values

Over the many years of TOPEX's mission, estimates have been made of the changes in σ^0 calibration at both K_u- and C-band. Initially assessment was via internal calibration loops and monitoring of cycle averages of σ^0. However when these started to diverge, the latter was the prefered method. The corrections already applied to the GDR are as shown below.

The top panel shows the applied corrections, and also the quadratic trend (dashed lines); the lower panel shows the deviation of the applied corrections from the trends.



However if the calibration is adjusted so that the mean σ^0 remains constant, how can we detect global environmental changes in the wind field?

Here, rather than assuming the constancy of the mean of the individual σ^0 distributions, I assume that the mean relationship between them (illustrated in the central panel) is constant, and adjust the σ^0 values for each cycle to have the same σ^0-σ^0 curves.

References

Chen, G., B. Chapron, J. Tournadre, K. Katsaros & D. Vandemark (1997), Global oceanic precipitation: A joint view by TOPEX and the TOPEX microwave radiometer, *J. Geophys Res.*, **102**, 10457-10471.

Elfouhaily, T., D. Vandemark, J. Gourrion & B. Chapron (1998), Estimation of wind stress using dual-frequency TOPEX data, *J. Geophys Res.*, **103**, 25101-25108.

Quartly, G.D., T.H. Guymer & M.A. Srokosz (1996), The effects of rain on Topex radar altimeter data, *J. Atmos Oceanic Tech.*, **13**, 1209-1229.

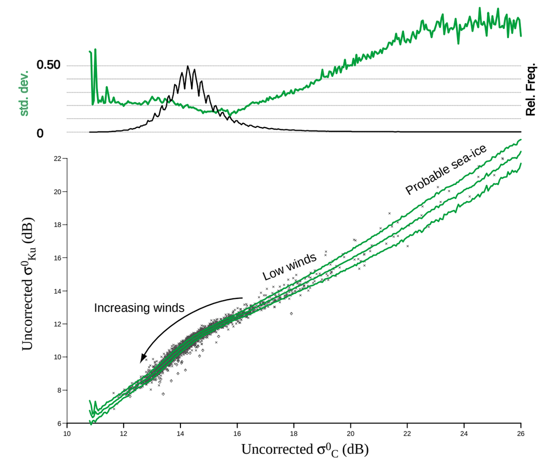
Quartly, G.D., M.A. Srokosz & T.H. Guymer (1999), Global precipitation statistics from dual-frequency TOPEX altimetry, *to appear in J. Geophys. Res.*

SYNOPSIS

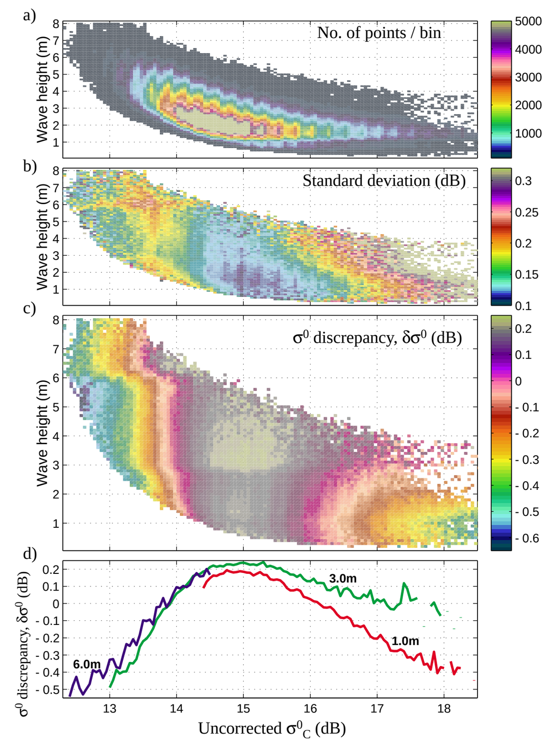
Many researchers have noted the close correlation between TOPEX's σ^0 values observed at K_u- and C-band, since increasing wind speed (the dominant factor) affects them both in a similar manner. Departures from this mean relationship have been used for global studies of rain (Quartly *et al.*, 1996, 1999; Chen *et al.*, 1997) and wind stress (Elfouhaily *et al.*, 1998).

However because of instrumental drift, no single mean relationship could be used for all time, but separate ones determined for each cycle. Thus the question arises: *May not these σ^0-σ^0 scatter plots provide a better basis for monitoring instrumenal drift?*

The key is the "bump" in the mean σ^0-σ^0 relationship near σ^0_C=15dB, σ^0_{Ku}=11.7dB (equivalent to a wind speed, u_{10}, of 7ms^{-1}). This bump (which can be emphasised by removing a linear term to give the sigma0 discrepancy, $\delta\sigma^0 = \sigma^0_{Ku} - (\sigma^0_C - 3.5)$) occurs at the same location whether data used are from the Arabian Sea or the Southern Ocean, because it represents those particular conditions under which the C-band (5.6 cm wavelength) radiation is scattered away proportionately more than the K_u-band (2.3 cm).



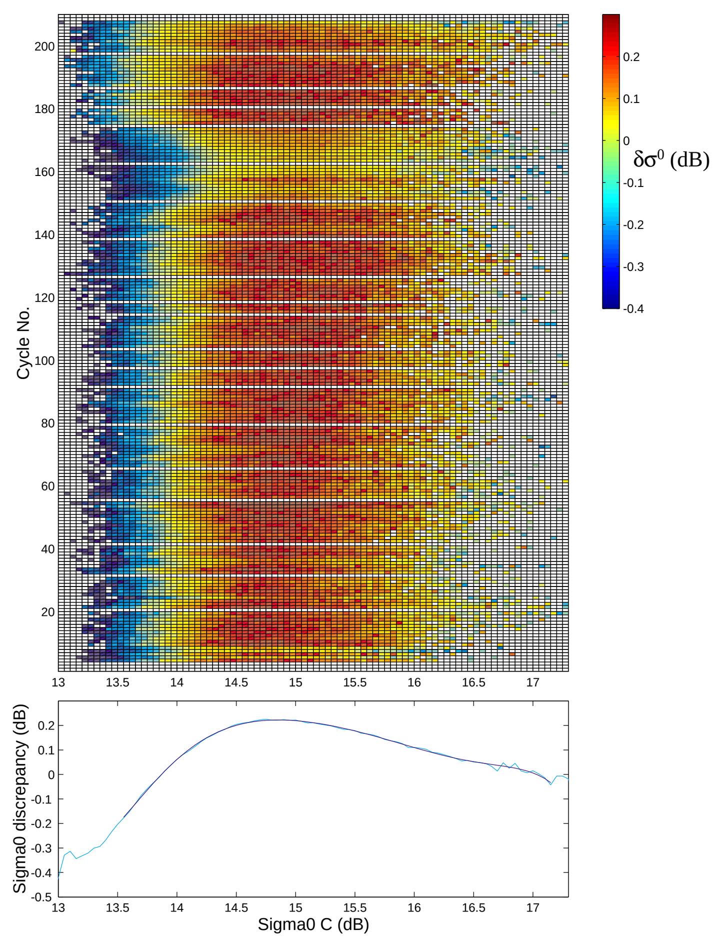
The plot below gives an expansion of that above, showing how no. of points, spread about mean and the mean curve itself all vary with gate index and wave height, H_s. For example there are strong changes in the $\delta\sigma^0$ values where the gate index changes from 2 to 3 (near H_s=2.9m) and from 3 to 4 (near H_s=6.2m). This illustrates why comparisons should be done using a narrow H_s range, but one that guarantees a robust representation of the bump.



METHOD

2. Calculation of a Reference Curve

I choose to do my monitoring of σ^0-σ^0 profiles using data for which H_s=2.9-3.0m (and both gate indices are equal to 3). The picture on the right shows the mean relationship (given by $\delta\sigma^0$ as a function of σ^0_C) for each of the first ~200 TOPEX cycles. A reference mean curve is then calculated from the curves for cycles 10 to 150 (i.e. avoiding the early cycles which suffered from mispointing, and the cycles after 150 where there has been a change in behaviour).

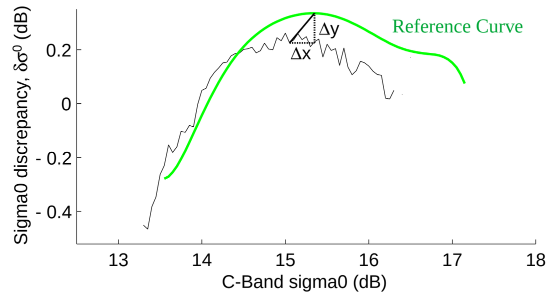


3. Determining offset for individual cycles

Then each cycle's individual $\delta\sigma^0$ curve is fitted (translated) so as to best overlay the reference curve. The amount of translation gives the necessary adjustments to the σ^0 values by:

$$\Delta\sigma^0_C = \Delta x$$

$$\Delta\sigma^0_{Ku} = \Delta y + \Delta x$$



Note:

i) Despite initial data quantization to 0.25dB, it is valid to look for much smaller shifts, as we are looking for changes in the average behaviour.

ii) No reliable fit can be done if the shapes of individual profiles differ markedly from the reference.

iii) This is only for sigma0 monitoring (i.e. internal consistency within dataset) — there is no absolute calibration.

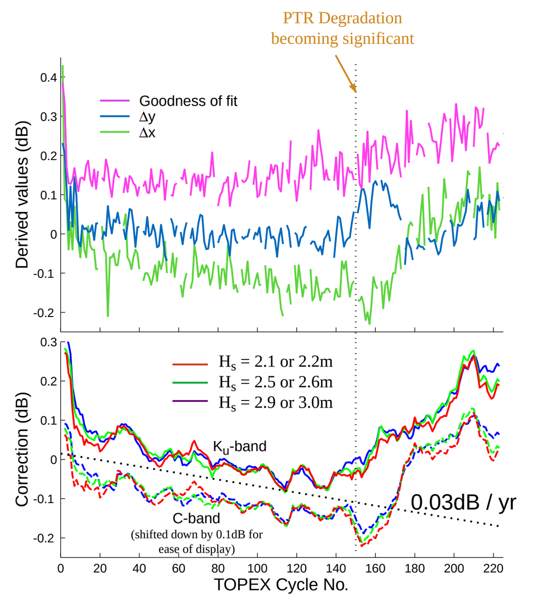
RESULTS

4. Observed Drift in the GDR

The top plot shows the values for Δx, Δy and a "goodness of fit" parameter for each indivdual TOPEX cycle. The shape of the $\delta\sigma^0$ curves changes significantly after cycle 150, and this affects the quality of the fits determined.

The second plot shows the derived values for $\Delta\sigma^0_C$, $\Delta\sigma^0_{Ku}$ (corrections to be added to the GDR to give consistency) after a 9-point (3-month) running mean filter has been applied. As well as data for H_s=2.9-3.0m, curves are also shown for H_s=2.1-2.2m and H_s=2.5-2.6m (both of which have slightly different shaped reference curves). A close agreement is found between these independent datasets, all suggesting an overcompensation of σ^0 drift by ~0.03dB/yr.

Derived corrections beyond cycle 150 are meaningless.



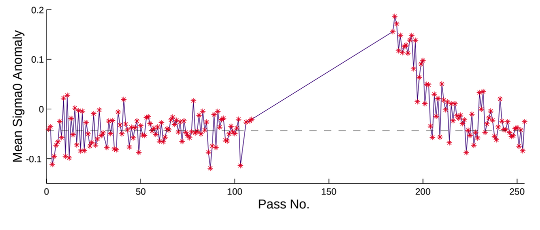
EXTENSIONS

5. Conclusions

According to the dual-frequency σ^0 analysis presented here, the σ^0 values on the standard GDRs have been overcompensated for instrumental drift. For the first 150 cycles, a trend of ~0.03dB/yr should be removed.

SINGLE PASSES

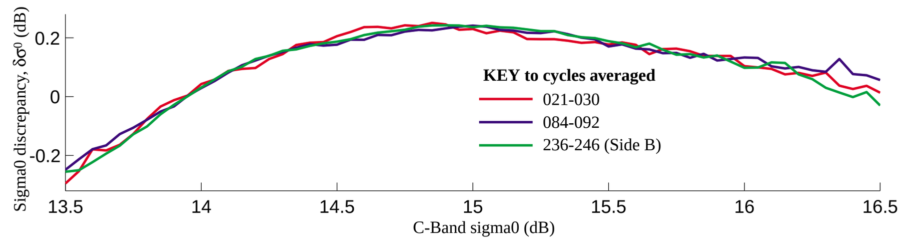
For individual passes there are too few data for an analysis as above. However for each pass one may note the mean sigma0 anomaly (i.e. mean deviation above or below the σ^0-σ^0 curve). On average these should be close to zero. An exceptional situation is shown below.



This plot is for cycle 123, during which there was a computer malfunction leading to loss of data for passes 110 to 183. Over the subsequent 30 passes (1 day) there is a gradual return to the mean sigma0 anomaly before the upset. This lengthy return to thermal stability and hence σ^0 performance is a rare event, not associated with most instrumental upsets.

ALT-A / ALT-B

As the PTR degradation of the TOPEX altimeter was starting to become significant, during cycle 236 it was switched to side B. Since that side uses different components, which have not deteriorated through use, care is needed to make its data consistent with those from side A. The plot below shows the *shapes* of the mean $\delta\sigma^0$ curves for 3 periods in the TOPEX mission. Each curve has been adjusted (translated) for co-alignment. The similarity of the shapes shows the validity of the technique for cross-calibration between two non-simultaneous sensors.



INTER-SATELLITE CALIBRATION

Obviously the shape of the σ^0-σ^0 relationship for K_u- and C-band should be independent of the instrumental design. Thus it is *expected* that the $\delta\sigma^0$ curves for Jason-1 (with solid state amplifiers) will be the same as for TOPEX (with travelling wave tube amplifiers). Thus an accurate cross-calibration of the two could be achieved even if their missions didn't overlap!