Altimetry in a regional tropical sea: benefits from the SARAL/AltiKA mission

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1. Motivation

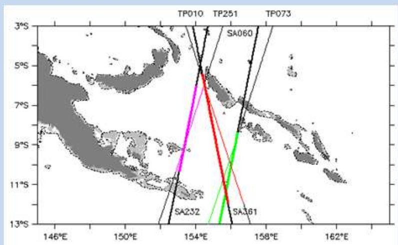
The SARAL/AltiKa satellite is the first ocean altimeter mission to operate in Ka-band frequency. The objective of this paper is to investigate the extent to which SARAL/AltiKa sea level measurements provide valuable information in a complex bathymetric region, the semi enclosed Solomon Sea in the South West Tropical Pacific. Results are illustrated for a few tracks (**Fig. 1**).

The data editing procedure is revisited and we propose two new data editing criteria. The first one is based on the detection of erroneous sea level values after computation and the second one analyzes directly the radar measurement and geophysical corrections.

Sea level variations (SSHA) derived from altimeter data is very sensitive to the choice of the Mean Sea Surface Height (MSSH) used in the processing. Different available MSSH are tested.

The performance of SARAL/AltiKA mission is finally evaluated in comparison with the classical Ku-band Jason-2 altimeter.

Figure 1: The different SARAL/AltiKa and Jason tracks crossing the Solomon Sea, and used to illustrate this study. Land is in dark grey. Light grey is for the bathymetry above 100m depth.



2. Data Editing

The standard global editing procedure (**STGL-EP**), based on threshold values applied to the geophysical corrections, altimetric parameters or the SSHA estimation, is not always robust in coastal areas where some erroneous data are still present after the editing procedure. We propose two other data editing procedures :

- the SSHA Editing Procedure (**SSHA-EP**) simply focuses on the detection of erroneous SSHA values from a Median Absolute Deviation filter (MAD).

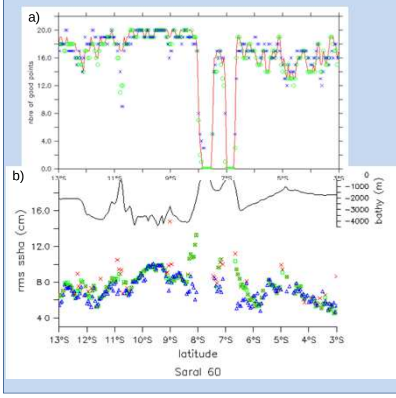
$MAD = medf\,51\,(|SSHA - medf\,11\,(SSHA)|)$

$SSHA = SSHA$ if $|SSHA - medf\,11\,(SSHA)| < 7 * MAD$; flagged if not

Medf 51 and medf 11 are median filters on 51 and 11 points respectively.

- The Clustering Editing Procedure (**CLUS-EP**) analyzes directly the radar measurement and geophysical corrections to identify the more relevant parameters to use. It is based on a principal component analysis (PCA) to reduce the dimension of the initial space, and clustering methods to differentiate good coastal data from outliers. All data in a cluster are edited if:

$max(|data_{cluster} - data_{loess\_smoothed}|) > K * MAD(data_{loess\_smoothed})$; *K is a tuning parameter*



Whatever the editing procedures used the number of data edited is around 20-25% of the raw data (**Fig. 2a**). Using STGL-EP the signature of bad points is still visible in the standard deviation of SSHA. SSHA-EP is well suited to filter out such erroneous data, and CLUS-EP seems more efficient when approaching the coast (**Fig. 2b**).

Figure 2): Example of editing procedures for the SARAL track 60. In red, STGL-EP; in green, SSHA-EP, and in blue, CLUS-EP. Top) number of points retained as valid. Bottom) standard deviation of SSHA

3. Impact of MSSH

In practice, SSHA are computed relative to an along-track mean sea surface height Profile (MP) in the case of a satellite mission flying on an historical repeat orbit. But, SARAL/AltiKA's ground track has been drifting from its nominal track, and the SARAL/AltiKa measurements are now processed as those of a geodetic mission, and the use of a gridded MSS is required. Three MSS are tested relative to MP referenced to the 1993-2012 period:

- MSS_CNES_CLS01 referenced to a 7 year period (1993-1999)
- MSS_CNES_CLS11 referenced to a 20 year period (1993-2012)
- MSS_DTU13 referenced to a 20 year period (1993-2012)

Relative to MP (**Fig. 3a**), MSS_CNES_CLS01 is different from the others MSSHs with a larger positive bias attributable to low frequency signals observed in the western tropical Pacific as the long term sea level trends, and interannual variability associated with ENSO (**Fig. 3b**). Now considering the same 20 year reference period, the MSS_CNES_CLS11 provides better SSHA estimates than the MSS_ DTU13 in our region of interest when compared with MP, with a ~1 cm SSHA rms difference against ~3.2 cm rms difference.

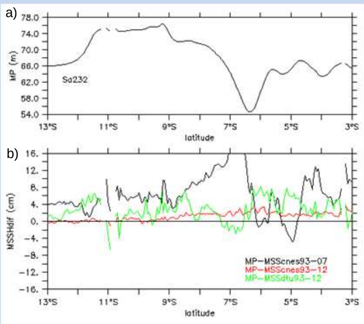


Figure 3: Top) Mean Profile (in m) along the 232 SARAL/AltiKA track. Bottom) Rms difference (in cm) of the different global MSS with MP (black: MSS_CNES_CLS01, red: MSS_CNES_CLS11, green: MSS_ DTU13).

4. SARAL AltiKa/Jason-2

The performance of the Ka-band altimeter from SARAL/AltiKa is evaluated in comparison with the Ku-band altimeter from Jason-2.

Data availability: Jason-2 provides less valid data than SARAL/AltiKA because of coastal effects (**Fig. 4**). For example, tracks Sa-060/J2-073 cross two Islands. SARAL/AltiKA SSHA data are available very close to the coast, whereas Jason-2 data are flagged when approaching the islands and remain unavailable between the islands. Tracks Sa-232/J2-251 intersect at about 9°S when the tracks fly near a small island. If Saral/AltiKA is able to get data near the island, Jason-2 cannot because of its larger footprint. More to the south, around 11°S, the tracks fly over a reef and a lagoon. Only the Jason2 data are flagged out over these shallow waters.

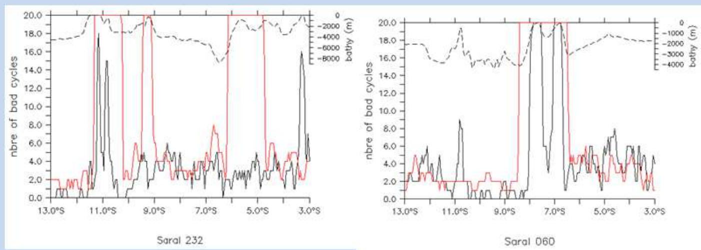


Figure 4: unavailability of SSHA data along the tracks Sa-232/J2-251 (left), and Sa-60/J2-073 (right). The red curve is for Jason and the black curve is for Saral. The dash line is the bathymetry along the tracks.

Wavenumber spectrum: The spectra for the different tracks share the same features, so we present only those of tracks (Sa-361/Ja-010) in **Fig. 5**.

SARAL/AltiKA has a steeper slope than Jason-2. It is a consequence of the higher quality of the SARAL/Altika altimetric measurements, and altimetric noise in Jason-2 flattens the spectrum (Xu and Fu, 2012). Down to 50 km, SARAL/AltiKa shows a k^{-3} slope instead of a k^{-2} slope for Jason-2. For wavelengths below 30 km, the energy decreases, in agreement with the resolution capability of SARAL AltiKa (Dufau et al., 2016).

The SARAL AltiKa spectrum approaches the SSH wavenumber spectrum for Surface Quasi Geostrophic (SQG) dynamics ($k^{-11/3}$ slope) that has been discussed from a regional model of the Solomon Sea (Djath et al., 2014).

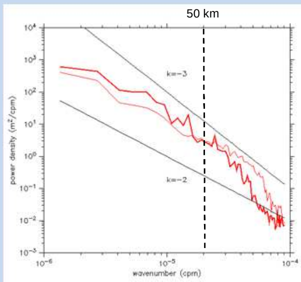


Figure 5: Averaged wavenumber SSH spectra for tracks (Sa-361/Ja-010). Thick line is for SARAL/AltiKA, thin line is for Jason-2. Black lines are for the k^{-2}, and k^{-3} slopes.

5. Conclusions

- Data editing:

SSHA-EP is very easy to implement and provides robust results compared to the classical STDGL-EP. CLUS-EP has the advantage to be independent of any a priori knowledge of threshold values for the different corrections and SSHA data .

- MSSH:

It has been shown how in the south west tropical Pacific SSHA must be referenced to mean reference period long enough to be not polluted by low frequency signals. Results give confidence on the use of the global MSS_CNES_CLS11 instead of the along track mean profile.

- Saral AltiKa/Jason-2:

In a semi enclosed sea like the Solomon Sea, the contribution of Saral Altika is essential to gain the maximum of information. The higher data accuracy of Saral/altiKa SSHA data has a direct impact on the spectral estimation of the dynamics with a k^{-3} slope instead of a k^{-2} slope for Jason-2.

These results are detailed in Gourdeau et al. (2016)

References

Dufau et al. (2016). Mesoscale Resolution Capability of altimetry: present & future. *J. Geophys. Res.*
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