A comparison of SARAL/Altika coastal altimetry and in-situ observations across Australasia and Maritime Continent


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Outline

• Introduction.
• Comparison between SARAL and Jason-2 satellite altimetry data.
• Comparison with tide gauges.
• Comparison with high frequency (HF) radar.
Radar altimetry missions

- Nowadays, only Jason-2, SARAL and Cryosat-2 are operating in orbits.
- April 2012: loss of Envisat.
- June 2013: loss of Jason-1
SARAL-New generation of satellite altimeter

• Launched on 25th February 2013.
• SARAL/AltiKa fly on the same orbit than ENVISAT, to ensure a continuity of altimetry observations in the long term.
• Operate at a high frequency (35.75 GHz, Ka-band) which supplies more accurate measurements (improvement of the spatial and vertical resolution).
• Reduces the size of altimetry footprint, thus enabling a better observation of ocean mesoscale, coastal areas, continental water bodies as well as the waves height.
• The drawback of this Ka-band frequency is its sensitivity to rain/cloud that can lead to signal attenuation.
• Currently on the calibration phase.
• Our goal:
  To identify the consistency of sea level anomaly derived from SARAL/AltiKa Geophysical Data Product (GDR) with in-situ measurement.
Comparison between SARAL and Jason-2 altimetry data: waveforms and SLAs
From near parallel tracks

Jason-2: Impact of land is shown by the high peak in the waveform trailing edge. Non-brown like waveform even at 7 km from the coastline.

SARAL: Ideal waveform shapes over the ocean surface following the Brown (1977) model.
- The impact of land is clearly seen on both Jason-2 and SARAL.
- But it seems that the impact of land is much obvious on Jason-2 than SARAL, which is indicated by the high peak of amplitude.
At a cross-over point 2: ~3 km from the coast

- The impact of land is clearly seen on both Jason-2 and SARAL.
At a cross-over point 3: ~6 km from the coast

Exmouth, Western Australia

- Both Jason-2 and SARAL show an ideal ocean-like waveform pattern.
Summary of the coastal waveforms

- Jason-2 waveforms are much noisier than those of SARAL waveforms especially in the trailing edge partly because Jason-2 footprint is twice (~10 km) that of SARAL (~6 km). → impact of land is much larger in Jason-2 than in SARAL waveforms.

- Waveforms from both satellite missions still show a clear leading edge, thus enabling the estimation of range parameter (and SLA) from the Ocean retracker: optimization of the parameters based on a specific algorithm (e.g. Brown (1977) model).
SLA profiles of SARAL and Jason-2 near the coast

Based on MLE4 retracked data
Jason-2 date 24/4/2014
SARAL date 20/4/2014

SARAL provides more data than Jason-2 near the coast < 5 km
*Notes; Retracked SLAs from combined retrackers are derived from a retracking system (Idris 2014: PhD thesis)

(Adapted from Idris and Deng 2012, Marine geodesy)
Comparison with tide gauge stations
Near Brisbane

Temporal correlation

RMS Error (cm)

1) SLA (cm)

2) SLA (cm)

3) SLA (cm)

- MLE-4 retracted SLAs
- Tide gauge SLAs
Near Langkawi Island

Temporal correlation

Low correlation and high RMS error near the coast may be due to
1) tidal aliasing,
2) inaccurate tidal model and
3) erroneous estimation of SLAs from satellite altimetry.
Comparison with high frequency (HF) radar from IMOS
First initiative

• Applied on the Jason-1 data over the southern Great Barrier Reef region. Two HF radar stations located at Tannum Sand and Lady Elliot Island.

• Jason-1 pass 149 crosses the area of HF radar coverage.

For further details see: Idris (2014), Development of new retracking method for mapping sea levels over the shelf areas from satellite altimetry data, PhD thesis, The University of Newcastle Australia.
Before comparison can be made, physical contents of both datasets should be made consistent.
Deriving geostrophic currents from HF radar

HF radar

Geostrophic + Ageostrophic current components.

Remove tidal signals
- Loess low pass filter with 40 hours cut-off wavelength (cf. Saraceno et al. 2008).

Remove wind-driven currents
- Derive wind-driven currents (Lenn and Chereskin 2009) based on wind data from ASCAT satellite.
The monthly HF and Jason-1 altimeter geostrophic $u$ (east) velocity components from 2009-2011. The altimeter geostrophic velocities are filtered with a cut-off wavelength of 56 km. Latitude $-24^\circ$ is the closest point to the coastline (Idris, 2014, PhD Thesis).
• In general, both velocity data show a similar pattern along the satellite track over the periods. The trends are well represented and the small spatial structures are almost in phase.
• An offset of \( \sim 5 \text{ cm s}^{-1} \) between the altimeter and HF velocities may be due to a difference in the measurements (e.g., accuracy and spatiotemporal scales).
• The HF velocity also shows little variations when compared to those from altimetry.
• Although a comparison has been performed based on the filtered data, it shows the altimeter captures more signals than the HF radar.
• The HF radar data does not seem to be able to resolve some coastal processes operating at spatial scales smaller than the radar resolution. Also accuracy of altimetry data may be inaccurate in the coastal regions.
• Although both velocity data agree relatively well, in some cases, the altimeter shows the velocity signals in the opposite direction to those in the HF radar.

• It is also observed that in some cases, peaks or “wiggles” in the altimeter velocity are shifted from the position observed on the HF velocity.
Overall, low correlation between both datasets.

The validation method has successfully applied to the Great Barrier Reef (GBR), but a different story in the Coff Harbour.

The characteristics of ocean dynamics in both regions are different. Geostrophic current in Coff Harbour is much stronger than GBR. Therefore, the approach of validation needs to be improvised.
Summary

• SARAL altimetry data may be available much closer to the coast (2-3 km from the coastline) than that of Jason-2 (>5 km from the coastline).

• The derived-SLAs from SARAL have a good agreement with the tide gauge stations near Brisbane and Langkawi Island.
Further improvement

• The approach of validation with HF radar needs to be improvised based on the local ocean dynamics.
• Regional tidal model is required for deriving accurate coastal SLAs.
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- Retracked SLAs around the Great Barrier Reef region.
- The retracked data from Pistach and SGDR products unavailable near the coastline.
- Further improved by a retracking system (Idris 2014: PhD thesis), which applies several retracking algorithms to retrack various shapes of waveforms.

(Adapted from Idris 2014)
1) Issue on the accuracy of tidal model when deriving coastal SLAs:
- A global model e.g. FES2004 or GOT4.8 is used.
- It still introduces considerable residual ocean tide signals in the coastal SLAs.
- Regional tidal model is required.
Low correlation and high RMS error near the coast may be due to 1) tidal aliasing, 2) inaccurate tidal model and 3) erroneous estimation of SLAs from satellite altimetry.
• Obvious tidal signals can be seen in the $u$ velocity component.

• The $v$ velocity component is likely to be influenced by the wind.

• These have been confirmed with ADCP and HF radar observations by Mantovanelli et al. (2010) in the very similar location, in which the tidal forces are found to be strong in the $u$ velocity component, while the south-easterly and northerly winds are strong in the $v$ velocity component.