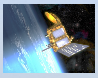

SPRAY glider for altimetric cal/val activities in the South-Western Pacific: the case example of The East Caledonian Current

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ABSTRACT:

We present an assessment of SARAL/AltiKa Ka-band satellite altimeter for the monitoring of a tropical western boundary current in the south-western Pacific Ocean: the East Caledonian Current. The experiment relies on repeated BLUEFIN/SPRAY glider transects along SARAL ground tracks, supplemented by deep-ocean current-meters moorings deployed in the core of the coastal current. The current has a width of about 200 km, and flows along the north-eastern flank of New Caledonia archipelago. It is one of the major currents of the south-western tropical Pacific, with 10 to 15Sv transported over the upper 1000 m. We compare surface geostrophic current estimates obtained from AltiKa along-track sea level height with co-located in situ estimates. The glider provides two independent estimates of the surface current. First one is the classical absolute geostrophic current (obtained by combining the glider CTD profiles and its dead-reckoned underwater trajectory). Second one is simply deduced from the glider drift inferred from its GPS fixes during the few-minutes long period spent at sea surface between two consecutive dives. It is concluded that AltiKa-derived current successfully captures the velocity of the boundary current, with a standard error of 11 cm/s with respect to the in situ data (SPRAY glider estimates or current-meter moorings). This level of accuracy is commensurate with previous estimates of SARAL/AltiKa accuracy obtained in the Med Sea. The present study illustrates the benefit of the reliable, low-cost monitoring operated by the SPRAY glider. However we emphasize the need to complement the glider operations with synergetic in situ systems because of the lack of synopticity of the glider sampling in occasions of adverse current conditions.

1. Context and objectives

The South-West Pacific basin is a key region for the ocean circulation and the climate system of the tropical Pacific, where a broad westward-flowing current - the South Equatorial Current (SEC) - encounters a large number of islands and subdivides into multiple intense zonal jets. (Fig. 1). However, this remote region suffers from a dearth of in situ observations.
SARAL/AltiKa is a novel altimetric mission launched in 2013, dedicated to the observation of sea surface height in the coastal ocean. Our objective is to assess the capability of SARAL/AltiKa altimeter to capture the surface flow velocity of a major western boundary oceanic current of the region: the East Caledonia Current (ECC) that flows along the east coast of New Caledonia (Fig. 2).
We rely on direct comparison of spaceborne measurements with a dedicated in situ observing system that has been designed and implemented since 2010. This observing system includes a long-term subsurface current mooring and repeated hydrographic surveys with underwater gliders.

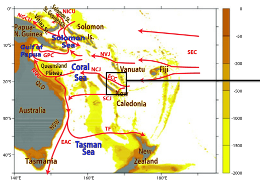


Fig 1: Schematic of the mean circulation in the South-West Pacific Ocean (Ganachaud et al., 2013). Bathymetry is shaded. The red labels feature the main current branches. The East Caledonian Current (black box) forms the focus of the present study

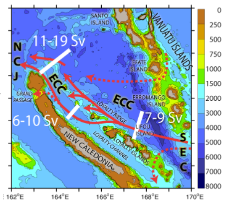


Fig 2: Mean transports associated with the ECC path along the east coast of New Caledonia (Gasparin et al., 2011)

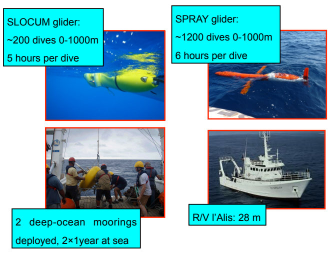
Question addressed in the present poster: What is the performance of SARAL/AltiKa in monitoring a tropical western boundary current ?

2. Our in situ observing system of ECC

Our system is dedicated to the observation of two specific SARAL ground tracks (#746 and #202, cf Fig. 3), cutting through the pathway of ECC.

We first deployed successively two current-meter moorings on track #746 in the core of ECC, at the bottom of the continental slope (167°15'E, 20°26'S):
- 0 to 1000 m measurements: nov. 2010 – oct. 2011 (prior to SARAL launch)
- 0 to 500 m measurements: oct. 2012 – nov. 2013 (at sea during the SARAL cycles #1 to #7)

We then deployed several gliders that sailed along tracks #746 and #202, both prior to SARAL launch and after launch. In this poster we will present in details the results of 5 of our glider transects that we performed in the course of the first 7 SARAL cycles (April-November 2013)



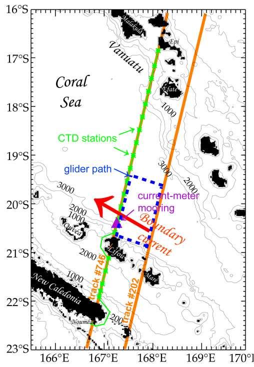


Fig 3: Layout of our si situ observing system. Orange: SARAL ground tracks. Purple: current meter mooring. Blue: gliders path. Green: shipborne cruise.

3. Observed characteristics of the East Caledonian Current

The two deep-ocean moorings show that the current is prominently north-westward throughout the upper 1000 m, but it is highly variable at intra-seasonal timescales. The variability is stronger in the upper ocean and the vertical shear is generally weak over the thermocline (upper 200 m). The long-term mean current from the 2 years of moored records at 10 m depth amounts to 9 cm/s (North-westward), its standard deviation amounts to 15 cm/s. The mooring records indicate a decorrelation timescale of the surface current of about 15 days.
This variability is not restricted to the slope region but extends far offshore, as illustrated by two successive glider transects operated within a couple of weeks in late 2010 (Fig. 5).

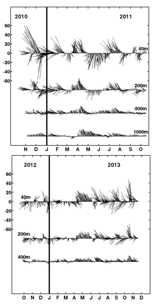


Fig. 4. 40h-low passed stickplots of the current observed with the moorings in 2010-2011(left) and 2012-2013 (right), from surface to depth. See Fig. 3 (diamond) for mooring location.

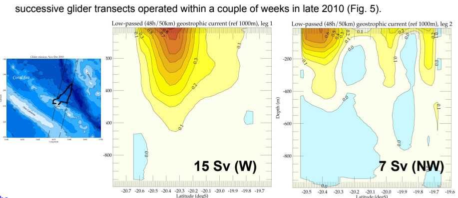
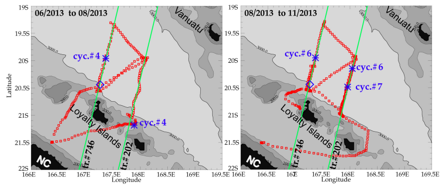


Fig 5.Cross-track sections of geostrophic current (referenced to 1000 m) from two glider transects through the ECC in November 2010 (middle) and December 2010 (right), along the trajectory shown on left panel. Red is for north-westward current (in m/s).

4. SPRAY glider and mooring measurements simultaneous with SARAL/AltiKa passes

Our study relies on co-located in situ observations and SARAL passes. Figure 6 presents the meeting points we could achieve during the first cycles of SARAL in 2013, with our glider (sailing accurately along SARAL tracks#746 and #202) and with our second current-meter mooring (deployed right on pass #746). Overall, we could manage 5 glider-SARAL encounters (during cycles #4, 6 and 7), while the mooring was at sea during SARAL cycles #1 to #7.

Fig 6. Positions of in situ measurements simultaneous with SARAL passes. Red squares show the glider trajectory in (left) June-August 2013 and (right) August-November 2013. Blue diamond shows the current-meter mooring location. SARAL ground tracks #746 and #202 in green. Blue stars show the glider position during SARAL passes (with corresponding SARAL cycle number).



5. SARAL vs glider: SLA and DHA

We first compared two SARAL sea level anomaly products: CNES/AVISO (1 Hz data) as well as the version produced by the PEACHI project (40 Hz data). We compared them with the dynamic height anomaly retrieved from the glider CTD profiles.
It is seen that there is a global agreement between SARAL SLA and glider DHA in the large-scale slope of the sea level (scales larger than about 80 km) (Fig. 8). The glider sections reveal ubiquitous signature of the (aliased) internal tide, with dominant semi-diurnal frequency. The relatively bad agreement between glider and SARAL seen in cycle 7 is explained by non-synopticity of the glider sampling. Indeed, the glider speed is rather slow (~20 km/day) compared to the decorrelation timescale of the current, hereby inducing a mismatch with the SARAL sampling as we go far from the encounter point.

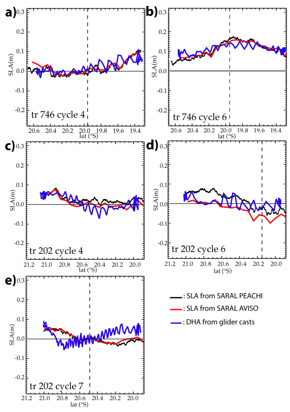


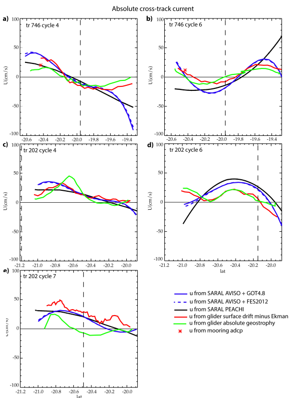
Fig 8. Along-track sections of SLA from SARAL CNES (1Hz) (red), from SARAL PEACHI 40Hz (dots), and glider dynamic height anomaly (blue) along tracks #202 and #746, cycles #4, #6 and #7. The glider position at the time of SARAL pass is shown with dashes.

6. SARAL vs glider vs mooring: surface current

From the raw SARAL SLA profiles, we computed cross-track current, following the method of Durand et al (2009). It basically amounts to geostrophy applied selectively at scales larger than 1 Rossby radius (60 km).
The glider geostrophic velocities were derived from DHA sections in a comparable manner. The glider-derived geostrophic shear was referenced through the dead-reckoned trajectory. In parallel, we considered the drift of the glider recorded through its successive GPS fixes during the surfacing phases (assuming it behaves as a purely lagrangian drifter during these phases).
We finally considered the uppermost ADCP record from the mooring (58 m depth). Fig 9 shows the comparisons of these various estimates. It is seen that the overall agreement with these various estimates is quite good. Besides, the two different glider estimates indicate that ageostrophic effects are probably minor in our region (except during SARAL cycle #7).

The overall consistency between SARAL-derived absolute surface current and in situ observations is illustrated on Figure 11. It is seen that, consistently with the sections of Figs 8 and 9, the benefit of higher resolution of 40 Hz data is not balanced by the loss of accuracy compared to 1 Hz data. For the SARAL-vs-mooring comparison, the 7 co-located couples of estimates yield a root-mean square error of 11 cm/s. This is smaller than the current variability of 15 cm/s but commensurate with it. Interestingly, this level of accuracy is basically in line with the performances reported by Troupin et al. (2014) in a completely different region (the western Mediterranean Sea)

Fig 9. Along-track sections of cross-track current from SARAL, from glider surface drift, from glider absolute geostrophy and from current-meter mooring records. SARAL tracks and passes numbers areindicated. The glider position at the time of SARAL passes is shown with dashes.



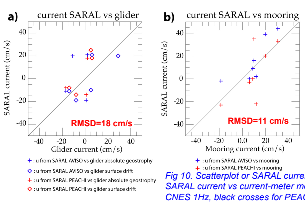


Fig 10. Scatterplot or SARAL current vs glider (left) and scatterplot of SARAL current vs current-meter mooring (right). Blue diamonds for CNES 1Hz, black crosses for PEACHI 40Hz.

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6. Conclusions

We performed an assessment of the surface current derived from SARAL SLAs, in a western boundary current sitting in the South-Western tropical Pacific Ocean. To do so, we implemented an in situ observing system based on repeated glider transects and moorings located on SARAL ground tracks. It is concluded that the accuracy of SARAL altimetry in the coastal domain is good enough to retrieve the magnitude of the surface current, on condition that a proper MDT is used. The accuracy of 11 cm/s is comparable to that obtained for SARAL in the mid-latitudes. The adverse current conditions on some occasions illustrates a fundamental limitation of a glider-based sampling: with one vehicle only, it is hard to ensure synopticity of the monitoring over our region. This legitimates the synergetic system we implemented with glider transects and current-meter moorings. This further pleads for the deployment of other synoptic observational systems such as HF radars for the near-shore ocean (as was done by Pascual et al 2015) complemented by glider transects and deep-ocean current meter moorings for the offshore domain, for an efficient calibration/validation of spaceborne sensors.