CAL/VAL at Kerguelen Island

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Summary: In collaboration with the CNES and NASA oceanographic projects (T/P and Jason-1), the OCA developed a verification site in Corsica since 1996 and LEGOS installed sites in Kerguelen in 1993 and at Vanuatu in 1999. In-situ calibration of altimetric height (SSH for ocean surfaces) is usually done at the vertical of a dedicated CAL/VAL site, by direct comparison of the altimetric data with in-situ data [*Bonnefond et al.*, 2011]. This configuration leads to handle the differences compare to the altimetric measurement system at the global scale: the Geographically Correlated Errors at regional (orbit, sea state bias, atmospheric corrections…) and local scales (geodetic systematic errors, land contamination for the instruments, land contamination for the radar echoes). In the frame of the OST/ST **FOAM** project (2007-2011) we have conducted cal/val activities at various sites (Corsica, Vanuatu, Kerguelen, lakes and rivers…) where the local conditions are different from each others but where permanent instruments and infrastructures already exist and have to be reinforced. The present poster will shows the main results of the Kerguelen site.

Leveling of the instruments

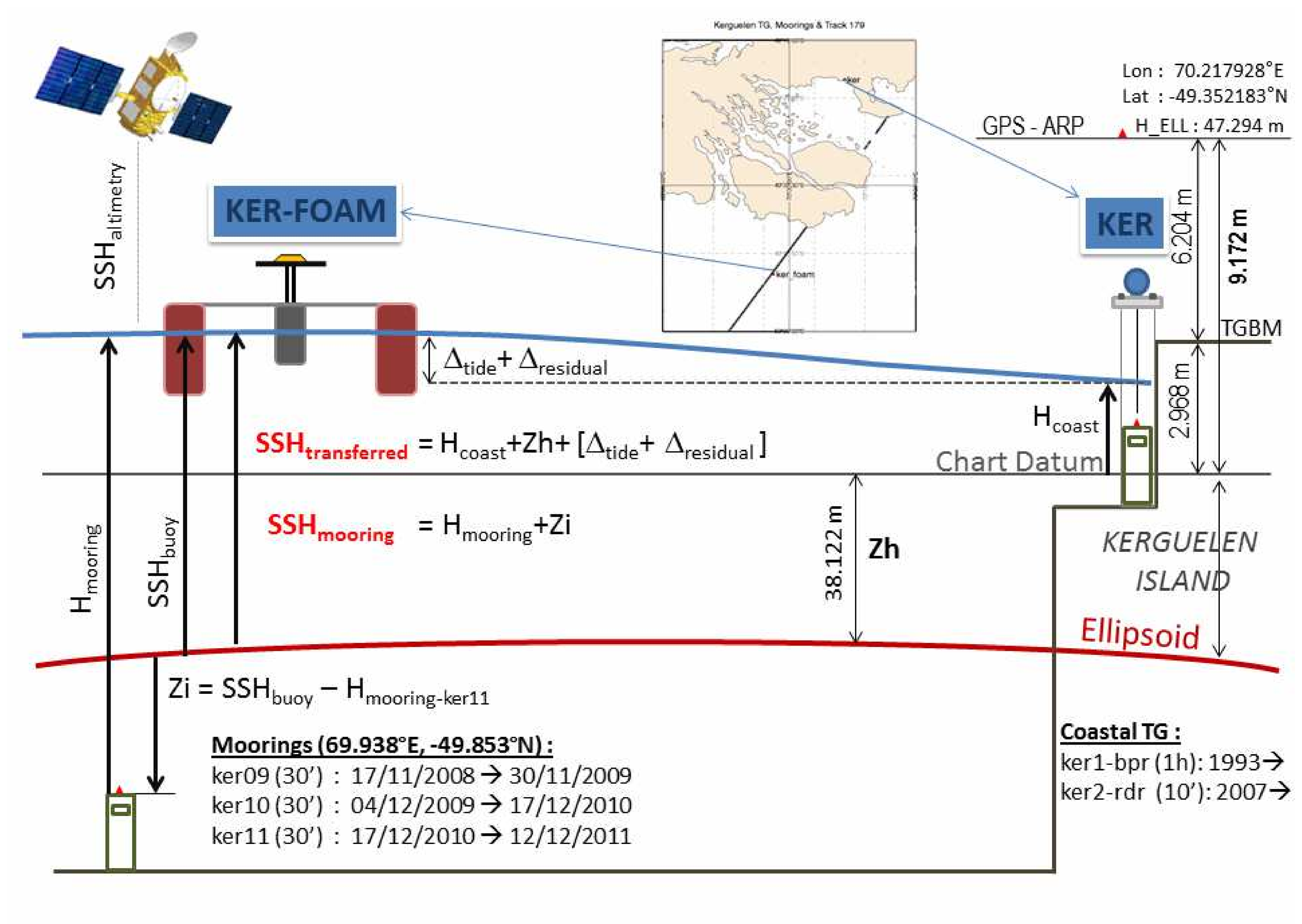


Figure 2: Location of the instruments and leveling information. The coastal KER and cal/val site KER-FAOM are 25 Km apart. Since 2008, 3 moorings (ker09,ker10,ker11) were deployed under the TP/J1/J2 track n° 179. The coastal station KER (ker1-bpr) monitor the sea level almost since the launch of TOPEX/POSEIDON in 1993 [*Testut et al. 2005*]. It was complemented by a high frequency sampling radar station in 2007 (ker2-rdr).

Processing of the GPS buoy session

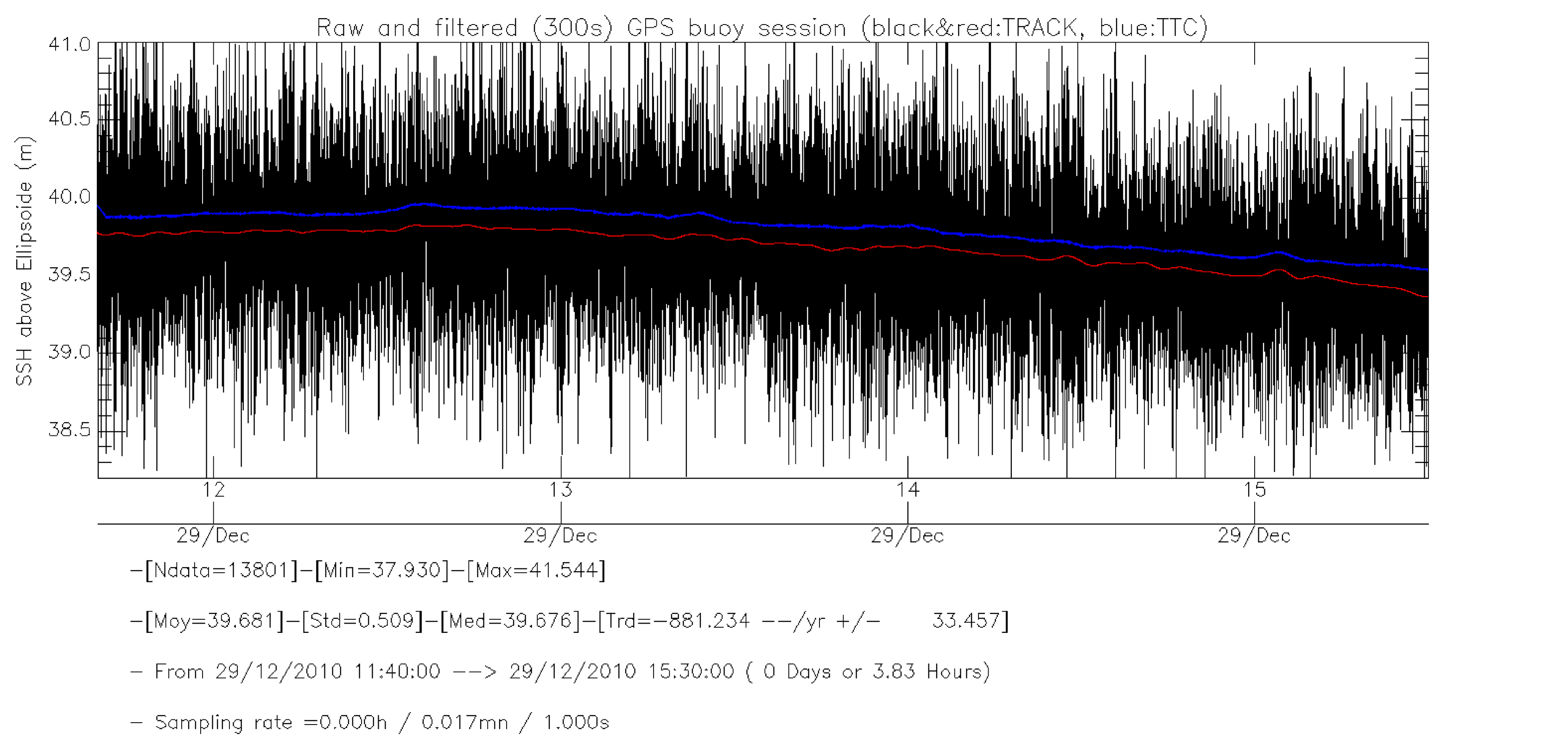


Figure 1: SSH_buoy GPS session at the location of the foam mooring in 29 of December 2010. The red and blue curves are the 300s running mean filtered version of the raw 1Hz data (shown in black). The TTC solution is biais of about 12cm compared to the TRACK solution.

The GPS buoy and base station were processed in differential mode respectively with TTC Trimble software and TRACK GAMIT. The precise coordinates of the base station were computed in ITRF05 using the Precise Point Positioning online software provided by the NRCAN CSRS (http://www.geod.nrcan.gc.ca/). The coordinates of the base station are (70.217928E,-49.352183N, Zh_Ell=38.122 +/- 0.008 m). During a period of almost 5 hours in 29 of December 2010, the buoy recorded the Sea Surface Height (SSH_buoy) at the location of the mooring (-49.853N, 69.938E). Only the 4 hours (from 12h to 15h) obtained from the 300s running mean filtered SSH_buoy session were kept for comparison with moorings and coastal tide gauge (cf. Figure 2 red curve). The TTC solution is +12cm biased in comparaison of the TRACK solution.

Methodology

The sea level from the moorings ($H_{mooring}$) is compute from the bottom (P_b) and atmospheric pressure (P_a) according the formula : $H_{mooring} = P_b - P_a/(g*rho)$. Where *rho* has been taken as a constant of value 1027.61 kg/m3. The raw $H_{mooring}$ is referenced to the instrumental reference Zi. Differencing the buoy SSH and $H_{mooring}$ during the GPS_buoy session provides the ellipsoidal height of Zi. $\mathbf{Zi = \langle SSH_{buoy} - H_{mooring} \rangle_{[session]} = -71.300\ (std=0.015)\ m}$. We then call $\mathbf{SSH_{mooring} = H_{mooring} + Zi}$ the ellipsoidal height of the mooring. In the same way if Zh is the ellipsoidal height of the hydrographic zero given by levelling and GPS processing of the base station. We call $\mathbf{SSH_{coast} = H_{coast} + zh}$ the ellipsoidal height of the coastal sea level (Zh= 31.122 m). The total sea level difference $SSH_{coast} - SSH_{mooring}$ between the coastal and calibration site, can be decomposed as a constant μ and a zero-mean variable part $\Delta(t)$ or expressed as the sum of a tidal $\mu_{tides} + \Delta_{tides}(t)$ and a residual $\mu_{residual} + \Delta_{residual}(t)$ signal. The tidal signal can be isolated by harmonical analysis (HA) of the total signal [*Watson et al. 2011*]. The constant part of difference $\mu = \mu_{tides} + \mu_{residual}$ includes the geoid, "permanent" dynamic SSH slope and the mean tidal level differences between the two locations. In the present case the variable part $\Delta(t)$ is largely dominated by the differential tidal signal (rms=18.3 cm) compared to 4.2 cm for the residual part $\Delta_{residual}(t)$ which contains the remaining non-tidal differential sea level signal (as for example the differential high frequency response of the sea level in response of the atmospheric forcing).

$$SSH_{coast} - SSH_{mooring} = \mu + \Delta(t) = \mu_{tides} + \Delta_{tides}(t) + \mu_{residual} + \Delta_{residual}(t)$$

Using the coefficient of the HA and the computed values of μ we build a correction function $\Delta_{corr}(t)$ for any time t.

$$\Delta_{corr}(t) = \mu_{tides} + \Sigma A_i \cos(\omega t + \phi) + \mu_{residual} \approx \mu + \Delta(t) \pm \sigma_{\Delta residual(t)}$$

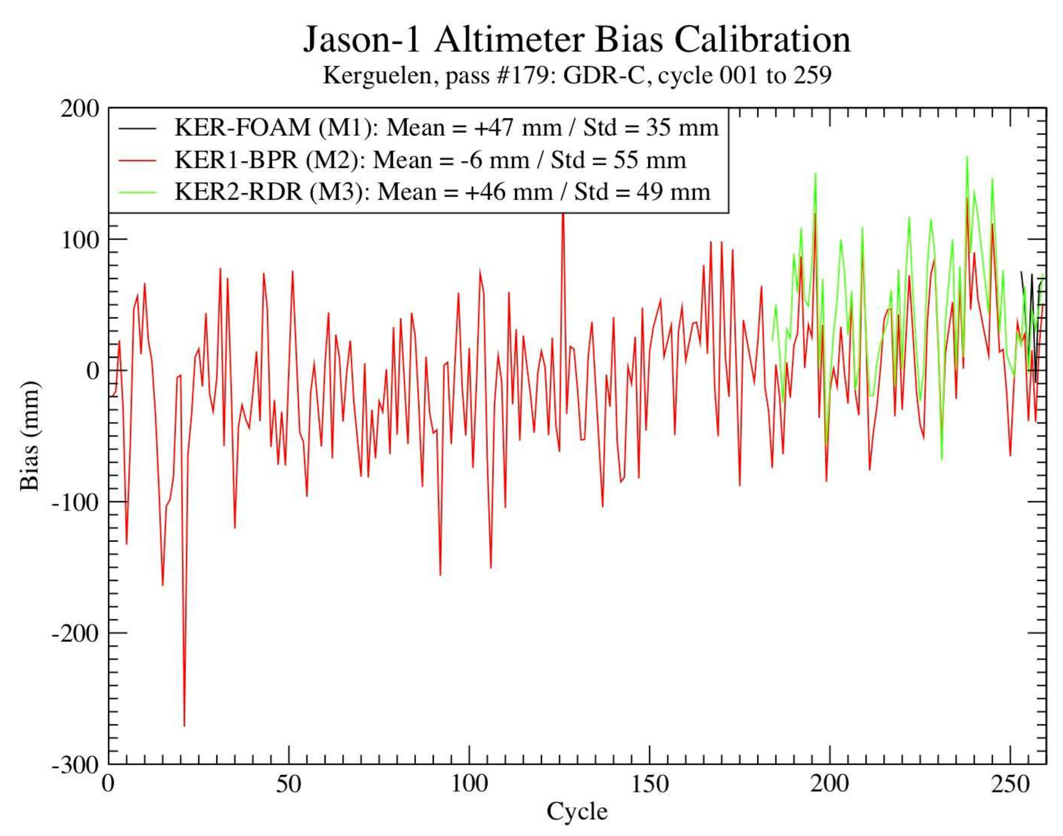
$$SSH_{transferred}(t) = SSH_{coast}(t) - \Delta_{corr}(t)$$

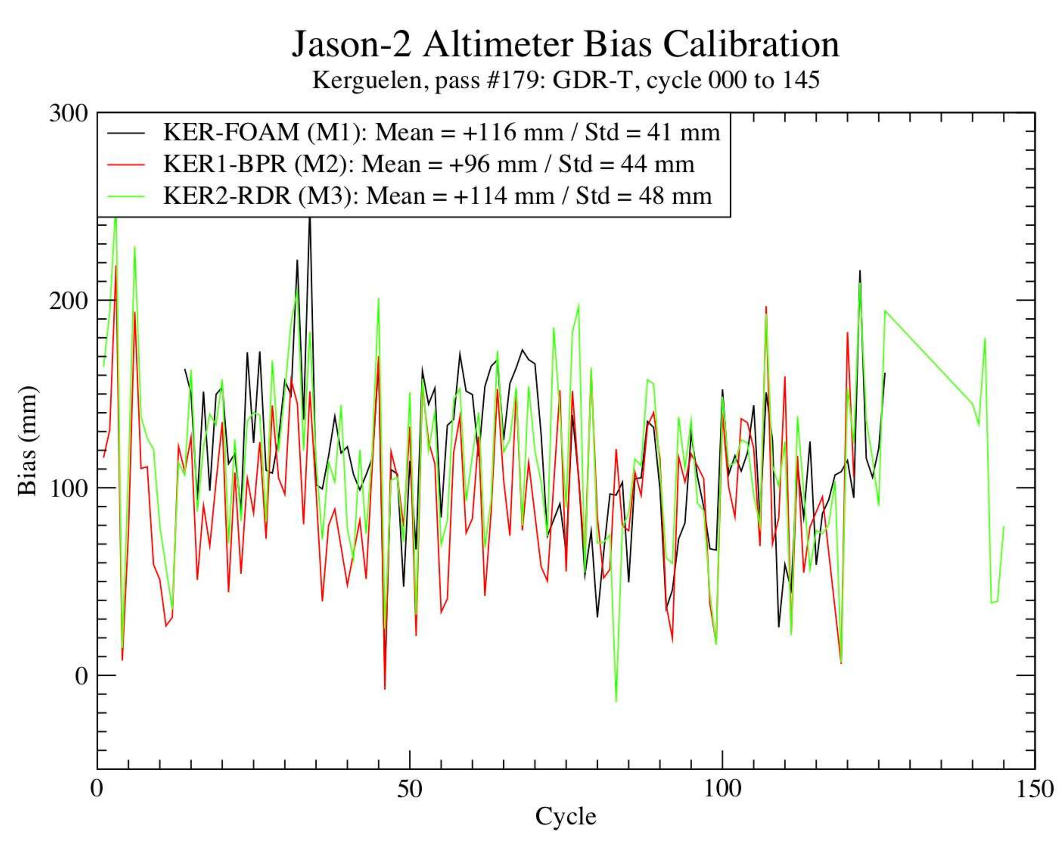
Results

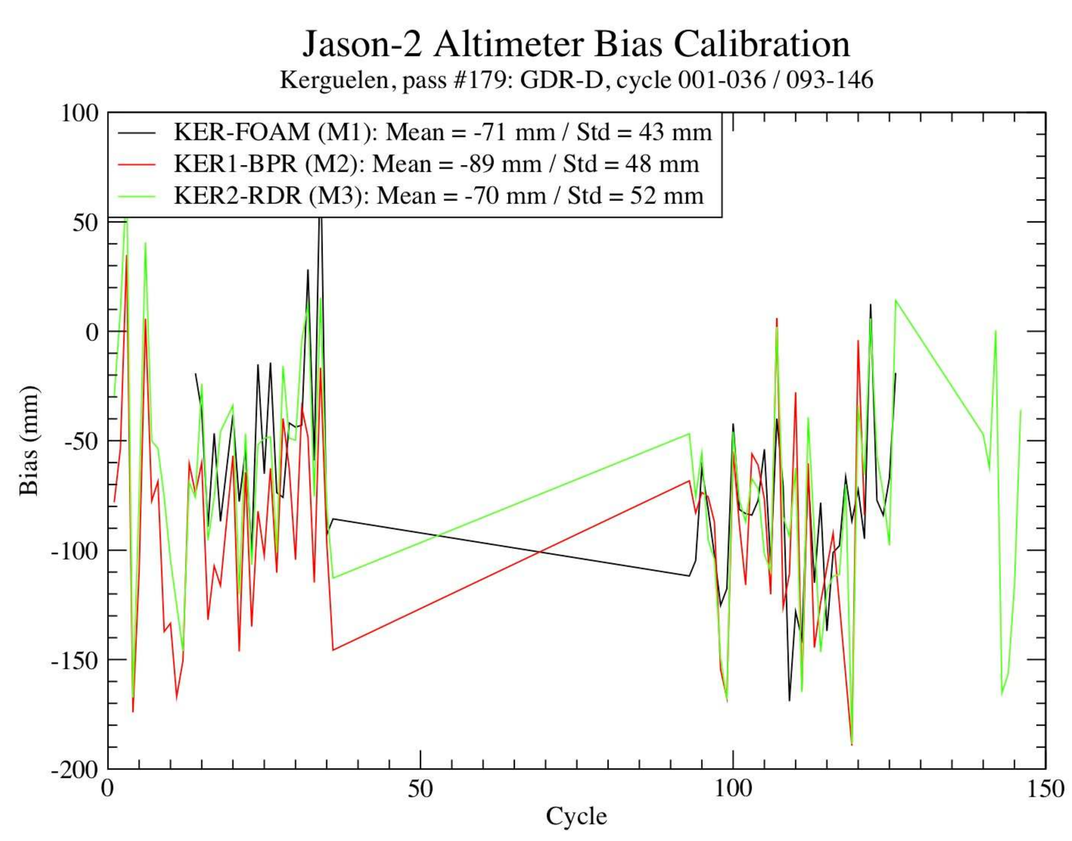
	Jason-1 GDR-C	Jason-2 GDR-T	Jason-2 GDR-D
KER-FOAM (M1)	**+47 mm (std=35)**	**+116 mm (std=41)**	**-71 mm (std=43)**
KER1-BPR (M2)	**-6 mm (std=55)**	**+96 mm (std=44)**	**-89 mm (std=48)**
KER2-RDR (M3)	**+46 mm (std=49)**	**+114 mm (std=48)**	**-70 mm (std=52)**
Mean	**+29 mm (std=46)**	**+109 mm (std=44)**	**-77 mm (std=48)**
CORSICA	***+77 mm (std=35)***	***+155 mm (std=35)***	***-1 mm (std=37)***

Table 1: Computed bias between the 3 tide gauges of Kerguelen (ker-foam,ker1-bpr,ker2-rdr) and J1 & j2

Then for each of the two coastal tide gauge ker1-bpr and ker2-rdr a correction was removed in order to transfer the sea level to the cal/val site. The ker11 mooring was directly tied to the ellipsoid by the mean of the GPS buoy session. The mooring ker09 and ker10 were tied to the ellispoid using the transferred ker2-rdr time serie. Then the 3 moorings were then concatenate into a single 3 years long time serie called ker-foam. These 3 series ker1-bpr, ker2-rdr and ker-foam were then compared to the Jason1 and Jason2 SSH in order to estimate the bias (see Table 1). The bias find at Kerguelent are lower than the mean bias found in historic cal/val site (Harvest, Bass Straits and Corsica). This is due most probably due to the small number of GPS buoy session (only 1 !) used to tied our series. Once the constant part of the difference between the cal/val site and the coastal region will be accurately estimate Kerguelen will provide a valuable cal/val in for the southern ocean.







Reference:
Bonnefond, P., B. Haines and C. Watson. In Situ Calibration and Validation: A Link from Coastal to Open -ocean altimetry, chapter in *Coastal Altimetry*, edited by S. Vignudelli, A. Kostianoy, P. Cipollini, J. Benveniste, Springer, ISBN: 978-3-642-12795-3, 2011.
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