Regional in situ Cal/Val of Sentinel-3A&B altimeter range at non-dedicated sites

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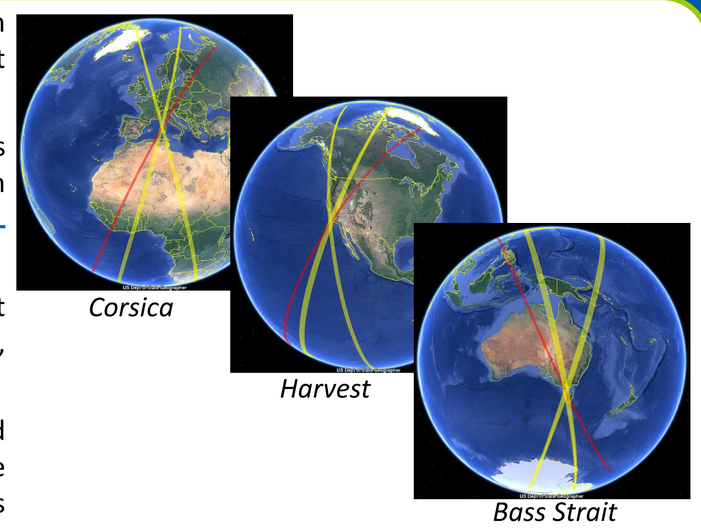
Introduction

In situ calibration ensures **regular and long-term control of the altimeter sea surface height** (SSH) time series through comparisons with independent records. Usually, in situ calibration of altimeter SSH is undertaken at specific CALVAL sites through the direct comparison of the altimeter data with in situ data.

However, Noveltis has developed a **regional CALVAL technique**, which aims at increasing the number and the repeatability of the altimeter bias assessments by determining the altimeter bias both on overflying passes and on satellite passes located far away from the calibration site. In principle this extends the single site approach to a wider regional scale, thus **reinforcing the link between the local and the global CALVAL analyses**. It also provides a means to maintain a calibration time series through periods of data-outage at a specific dedicated calibration site.

The regional method was initially developed at the Corsican calibration sites of Senetosa and Ajaccio. It was then successfully implemented at the Californian site of Harvest and at the Australian site of Bass Strait, in close collaboration with JPL and the University of Tasmania, respectively. The method was used to compute the altimeter biases of Jason-1, Jason-2, Envisat and SARAL/AltiKa at all these sites.

These studies gave the **first Envisat and SARAL/AltiKa absolute bias estimates at non-dedicated sites using the same method**, and showed high consistency with the analyses of the global CalVal teams and the work of the in situ CalVal teams. The method has been used in the frame of the ESA Mission Performance Center (MPC-S3) project to **monitor Sentinel-3A&B at the three calibration sites** (Corsica, Harvest and Bass Strait), and shows high potential for the monitoring of any altimetry mission.



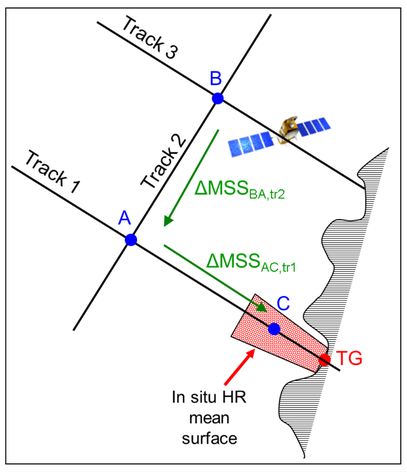
The regional CALVAL method

LOCAL CALVAL: Direct comparison between the altimeter SSH and the tide gauge measurements (point C on *Figure 1*).

- Only for satellite flying over the calibration sites.
- Directly comparable to the bias estimates computed by the local in situ calval teams (Corsica, Harvest, Bass Strait, Gavdos…).

OFFSHORE CALVAL: Computation of the bias on offshore passes

- Following a succession of accurate mean sea surface profiles, combining several missions.
- Using a high resolution mean sea surface to link the in situ and altimetry SSH, when available (MSS otherwise).



Generic method highly depending on:

- Good-quality SSH data (altimetry & tide gauge);
- Accurate mean sea surface profiles;
- High resolution local mean sea surface (GPS survey) or accurate global MSS;
- Accurate ocean tides and atmospheric effects corrections.

Figure 1: *Generic diagram of the regional in situ calibration method*

$$bias_{alti,tr3}(t) = (SSH^{alti}_{B,tr3}(t) - dyn_{B,tr3}(t)) - (SSH^{gauge}_{TG,tr1}(t) - dyn_{TG,tr1}(t)) + (\overline{SSH}^{insitu}_{TG,tr1} - \overline{SSH}^{insitu}_{C,tr1}) + (\overline{SSH}^{alti}_{C,tr1} - \overline{SSH}^{alti}_{A,tr1}) + (\overline{SSH}^{alti}_{A,tr2} - \overline{SSH}^{alti}_{B,tr2})$$

Altimetry and in situ data

SENTINEL-3 ALTIMETRY DATA:

- EUMETSAT BC004 Non-Time-Critical (NTC) Marine products.
- Range: SAR and PLRM
- Wet troposphere: ECMWF model in Corsica (land contamination), radiometer in Harvest & Bass Strait
- Ionosphere: GIM
- Ocean tides (regional Cal/Val): In-house regional tidal model (Corsica) or FES2014b global model (Harvest & Bass Strait)
- DAC (regional Cal/Val): TUGOm simulation provided by LEGOS

IN SITU DATA

- **Corsica:** The Ajaccio tide gauge dataset was provided by REFMAR. The Senetosa site is maintained by CNES and OCA.
- **Harvest:** Tide gauge data provided by JPL.
- **Bass Strait:** Mooring SSH data provided by Univ. of Tasmania.

Sentinel-3A&B bias estimates

CORSICA (SENETOSA AND AJACCIO)

The Sentinel-3A orbit provides a unique opportunity to estimate the absolute SSH bias at two sites in Corsica a few seconds apart. Sentinel-3A&B can also be monitored at offshore crossover points with Envisat and Jason-2 tracks using the NOVELTIS regional approach (Fig. 2).

→ Sentinel-3A: SSH bias estimates at 8 crossover points in Senetosa and 10 crossover points in Ajaccio.

→ Sentinel-3B: SSH bias estimates at 6 crossover points in Senetosa and 4 crossover points in Ajaccio.

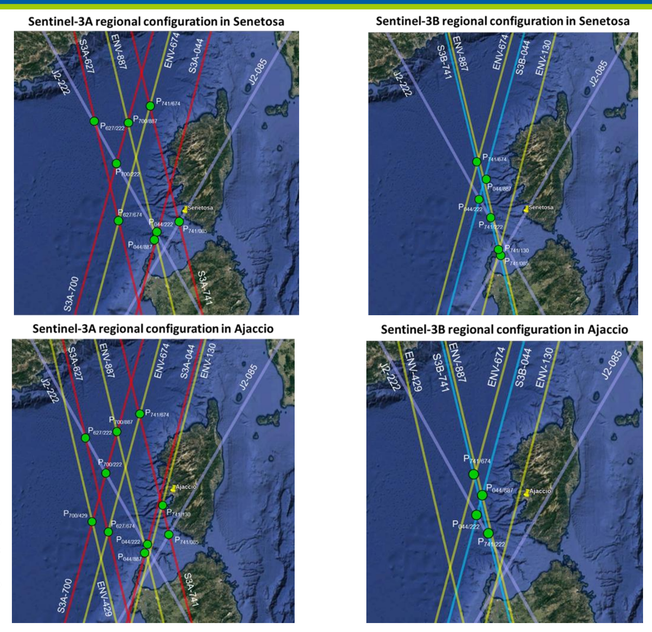


Figure 2: *Regional Calval configuration in Senetosa and Ajaccio for the Sentinel-3A&B missions. Ground-tracks: S3A (red), S3B (blue), Jason-2 (purple) and Envisat (yellow). Green dots show the crossover points where the offshore S3A and S3B SSH bias estimates were computed.*

→ In Senetosa: S3A absolute bias of about 2 cm, S3B about 3 cm.

→ In Ajccio: Larger regional bias estimates (already observed with other missions), probably due to the tide correction: need for further local investigations with high-frequency in situ measurements

→ PLRM data in general slightly more noisy than SAR data, as expected (not shown here).

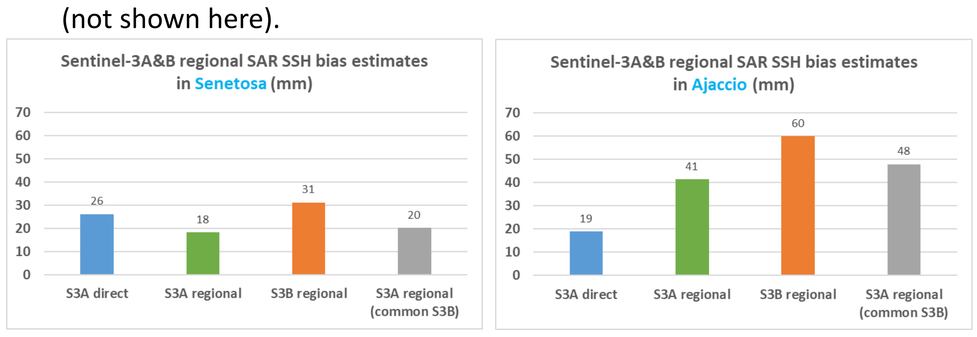


Figure 3: *Sentinel-3A&B mean regional SAR SSH bias estimates in Senetosa (left) and Ajaccio (right). Sentinel-3A regional SSH bias computed over the Sentinel-3B period in grey.*

HARVEST

The Harvest calibration site is located beneath the Jason-2 track 043. Two Sentinel-3A tracks (067 and 710) cross nearby, at about 18 km from the Harvest platform. Sentinel-3B tracks are located a bit further but can be monitored thanks to the regional approach (Fig. 4).

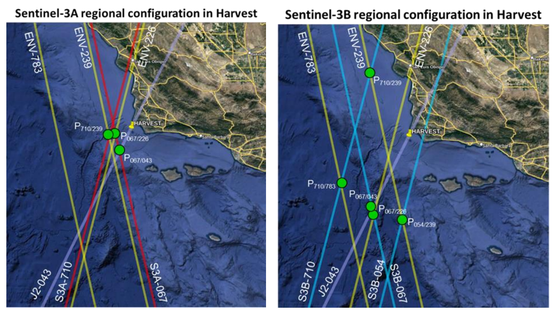


Figure 4: *Regional Calval configuration in Harvest for the Sentinel-3A&B missions. Ground-tracks: S3A (red), S3B (blue), Jason-2 (purple) and Envisat (yellow). Green dots show the crossover points where the offshore S3A and S3B SSH bias estimates were computed.*

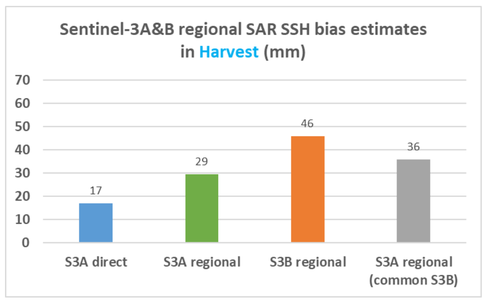


Figure 5: *Sentinel-3A&B mean regional SAR SSH bias estimates in Harvest. Sentinel-3A regional SSH bias computed over the Sentinel-3B period in grey.*

→ Like in Corsica, S3B absolute bias about 1.5 cm larger than S3A estimates.

→ More variability in the offshore bias estimates in Harvest, probably due to more ocean dynamics variability and wave regime is quite rough: need for a SAR-dedicated SSB correction.

BASS STRAIT

Mooring data are available at the crossover point between Sentinel-3A tracks 060 and 247. This enables to estimate the range bias for these two tracks (ascending and descending) 6 days apart.

The regional approach provides additional estimates for both missions at crossover points (Fig. 6).

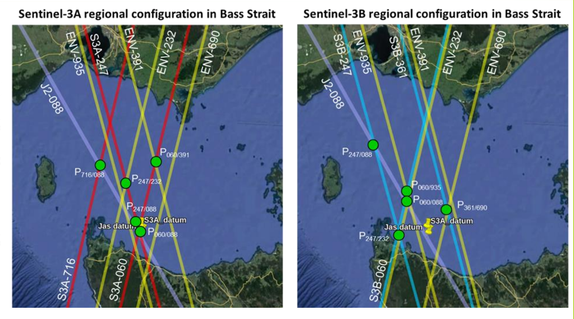


Figure 6: *Regional Calval configuration in Bass Strait for the Sentinel-3A&B missions. Ground-tracks: S3A (red), S3B (blue), Jason-2 (purple) and Envisat (yellow). Green dots show the crossover points where the offshore S3A and S3B SSH bias estimates were computed.*

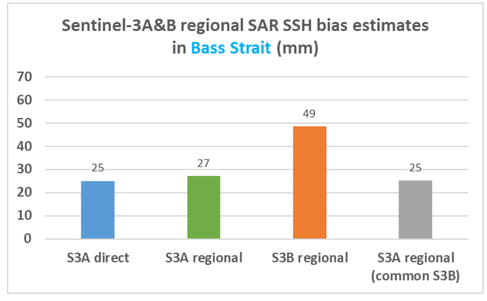


Figure 7: *Sentinel-3A&B mean regional SAR SSH bias estimates in Bass Strait. Sentinel-3A regional SSH bias computed over the Sentinel-3B period in grey..*

→ Bass Strait bias estimates very consistent with the two other sites.

→ Generally less variability in the bias estimates in Bass Strait, for both missions. Largest bias variability observed at the furthest crossover points from the calibration site (not shown here).

CONCLUSIONS

- The regional Cal/Val approach provides SSH bias estimates at calibration sites that are not directly over-flown by either Sentinel-3A or Sentinel-3B.
- Offshore bias estimates can highlight larger variability than the local direct estimates, due to the ocean dynamics conditions, but the mean regional bias estimates are quite consistent from one site to the other, for the two Sentinel-3 satellites. Ajaccio shows larger bias estimates than the other sites, and further local investigations are needed to better understand the dynamics.
- When available, the SAR-dedicated SSB correction is expected to reduce the uncertainties on the SSH bias estimates. Regional bias estimates could be used to assess the SSB correction.