Global calibration of SARAL/AltiKa using multi-mission sea surface height crossovers

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Introduction

In September 2014 SARAL/AltiKa completes its 1.5 year in orbit. We perform a comprehensive quality assessment based on the first 15 cycles of GDR-T 1 Hz data set by means of a global multi-mission crossover analysis. Within this approach, SARAL sea surface heights (SSH) are compared with data from other current missions, mainly Jason-2 and Cryosat-2, to reveal its accuracy and consistency with the other altimeter systems. Alongside with global mean range bias and instrumental drifts, investigations on geographically correlated errors as well as on the realization of the systems origin are performed. The study proves the high quality and reliability of SARAL.

Method: Multi-Mission Crossover Analysis

The multi-mission crossover analysis (MMXO) aims to estimate relative radial errors for all altimeter systems operating simultaneously. The used approach does not use an analytic function (such as piecewise polynomials or splines) for modeling the radial errors but rely on a discrete modeling to estimate the radial errors in a least squares adjustment.

All computations are done **with respect to one reference mission (i.e. Jason-2)** in order to overcome a rank defect of the system to be solved. As a consequence, only relative calibrations with respect to Jason-2 are performed.

Input:

- sea surface height (SSH) crossover differences (single-satellite and dual-satellite)

Main outputs of MMXO:

- time series of radial errors for every mission involved in the analysis
- stochastic properties, especially empirical auto-covariance functions
- Geographically correlated mean errors
- Range biases (global mission means and with ten days resolution)
- Information on center-of-origin realization and low-order harmonics

More details: Bosch et al., 2014

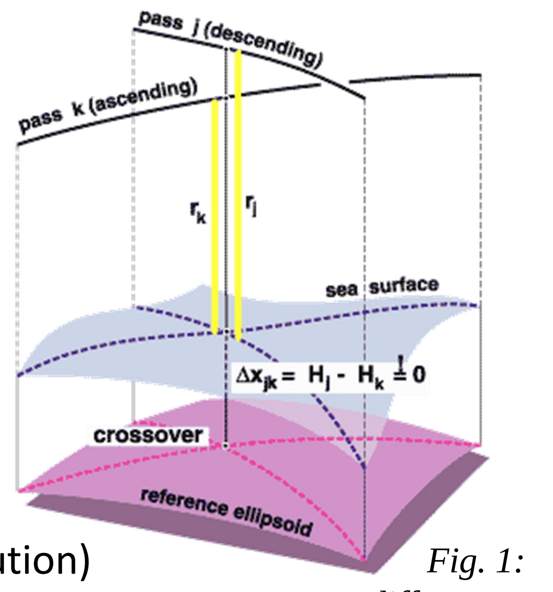


Fig. 1: crossover differences

Input Data / Missions

In our modeling approach we use 1 Hz data of **SARAL patch 2 GDR** data from about 1.5 years (cycles 1-15). In addition, data from **Jason-1** (geodetic orbit, GDR-C with GDR-D orbit), **Jason-2** (GDR-D), and **Cryosat-2** (Baseline B) are used.

The geophysical corrections are harmonized as far as possible (e.g., EOT11a for ocean tides and AVISO DAC for atmospheric correction). The dual-frequency altimeter correction is used whenever available (Jason-1/2). For SARAL and Cryosat-2 global ionospheric maps (GIM) based on GPS data are used.

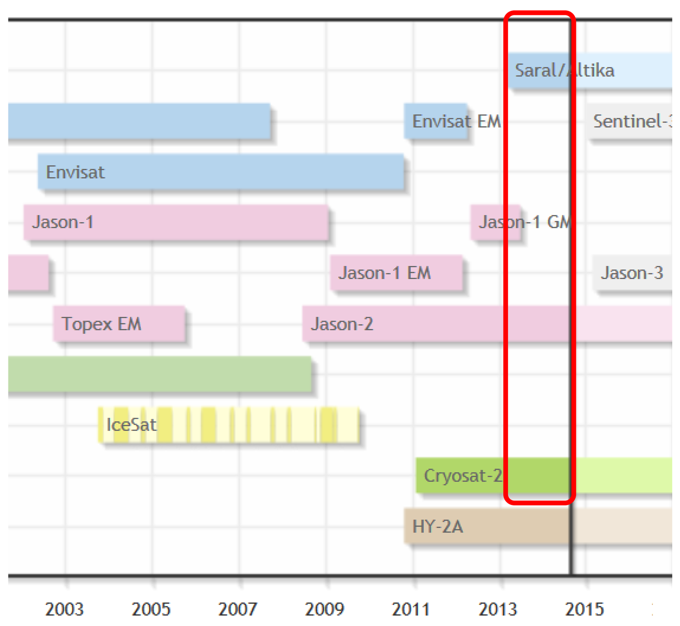


Fig. 2: Altimeter missions used in MMXO (March, 2013-Aug. 2014)

SARAL Microwave Radiometer (MWR)

SARAL is equipped with a dual-frequency microwave radiometer (MWR) for extracting the wet troposphere range correction based on the measured brightness temperatures and a neural network approach – similar to Envisat the altimeter-derived backscatter coefficient is used to represent the surface roughness and to replace the third frequency channel which is available for the Jason-2 radiometer (JMR).

Radial errors

An 2-day subset of radial errors of SARAL can be seen in Fig. 3a). For SARAL the complete time series of radial errors shows a mean offset with respect to TOPEX of **-5.1 cm** and a standard deviation of **1.3 cm** which is in the same order of magnitude as for Cryosat, but larger than for Jason-2.

In order to interpret the radial errors an analysis of some of their stochastic properties (covariance functions and power spectrum) is meaningful (Fig 3b) and c)). Clear periods of about 0.07 days and 0.5 days are visible caused by the precise orbit determination POD (orbital period, 1/rev effect) and model effects. The half-daily signals become more prominent when using a model for correcting wet tropospheric effects.

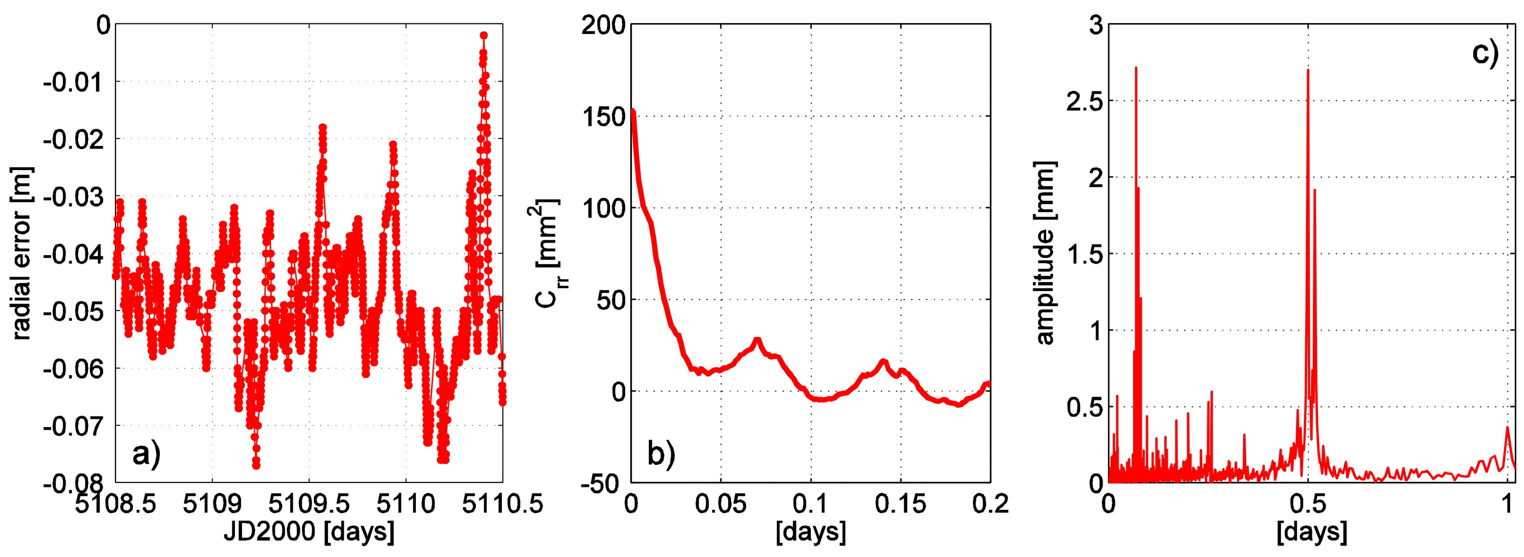


Fig.3: Radial errors of SARAL (plot a), 2-day subset for Dec 2013, 27-29), derived empirical auto-covariance function (plot b), from whole time series), and related power spectrum (plot c)) based on data corrected by radiometer wet troposphere. [from Dettmering et al, submitted]

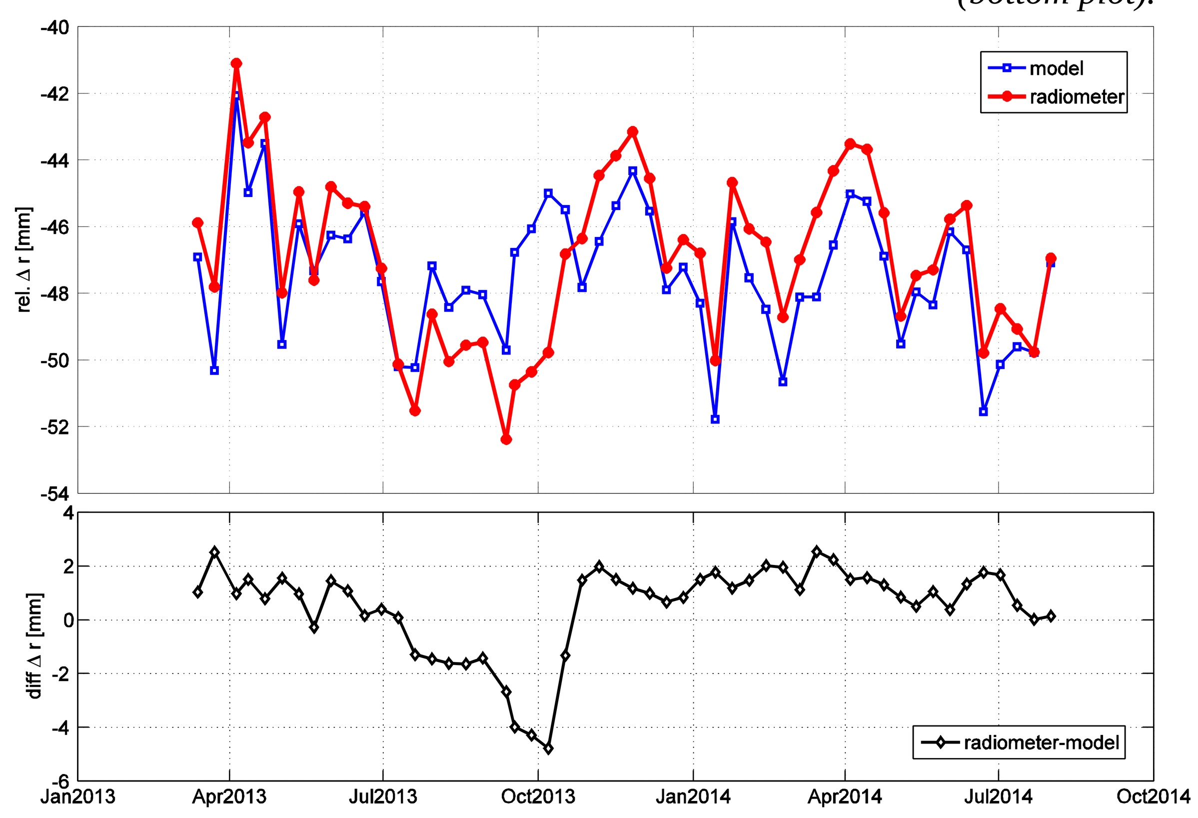
Range bias

Most of the radial errors are caused by the range bias of the altimeter mission, mainly by instrumental delays. In order to separate this effect from other effects (e.g., from POD), a fragmentation of the radial errors is performed.

This is done by approximating the time series by a spherical harmonic series up to degree 2.

The mean range bias equals to the coefficient C_{00}. For SARAL a mean range bias of **-4.7 cm** wrt. Jason-2 can be estimated (Fig. 5). The bottom plot shows the influence of the radiometer. The drift in the first part of the time series is due to a problem of on-board parameterization solved in Oct. 2013.

Fig.5: SARAL relative range bias wrt jason-2 (top plot) based on two different wet tropospheric corrections and their difference (bottom plot).



Center-of-origin

By estimating spherical harmonic coefficients from the radial errors of each mission valuable information on systematic effects in the realization of the origin (mainly due to POD) can be extracted. We calculate 7 low-order coefficients. One of them, C_{10}, corresponds to an origin shift in z-direction. It shows a clear annual systematic, especially when relying on the radiometer correction (Fig. 6). Annual oscillations are also visible in the z-component of the wet troposphere corrections differences (Fig. 7); not only for SARAL but –with smaller amplitudes– also for Envisat and Jason-2. This behavior is still under investigation and not yet fully understood. Probably it is related to the algorithms and data used to calibrate the radiometer.

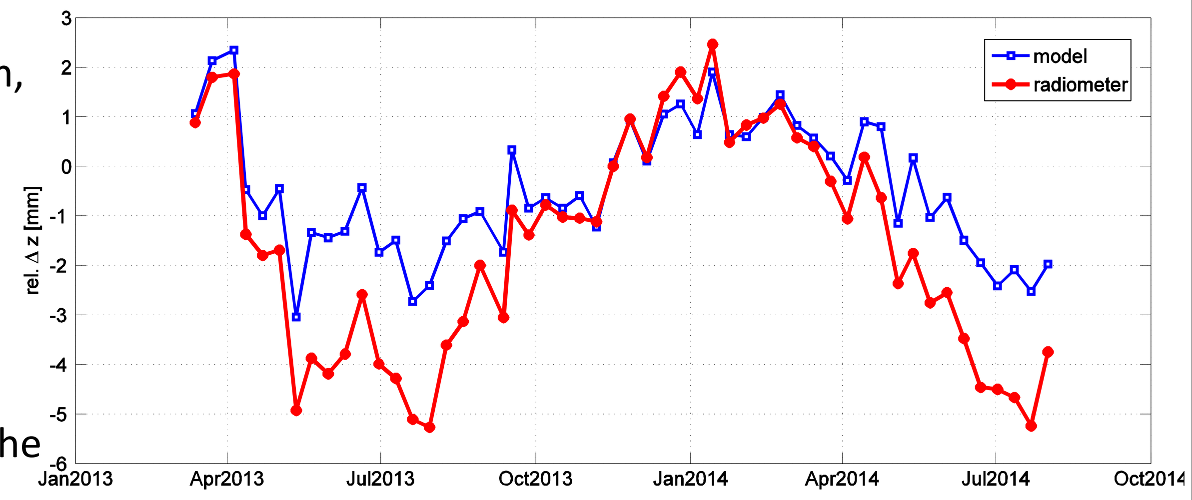


Fig.6: Differences of the origin (z-component) between SARAL and Jason-2 using different wet troposphere corrections.

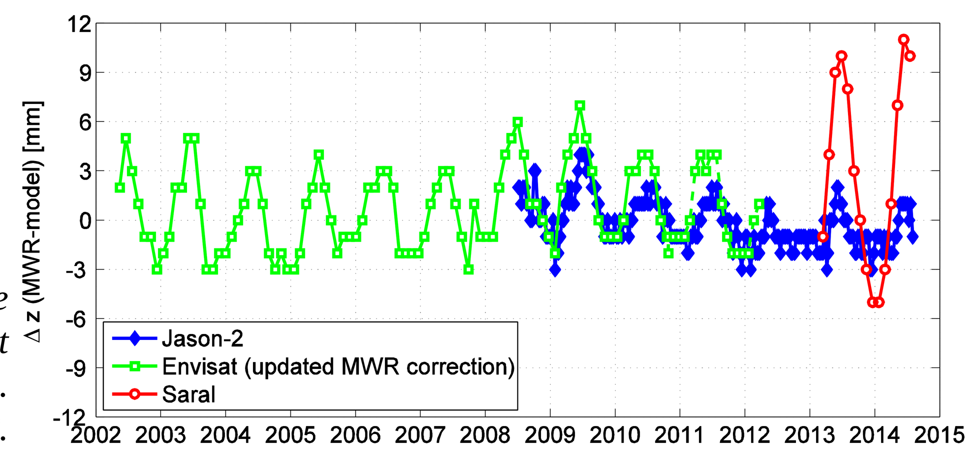


Fig.7: Differences between wet troposphere corrections from radiometer and model (z-component of the origin) for three different altimeter missions. Without high-latitude observations north/south of 50°.

Geographically correlated mean errors (GCE)

GCE are estimated based on the radial errors of SARAL by gridding the ascending and descending radial errors separately after subtracting a cycle-average and building the mean values for 2.5° grid cells. Fig. 4 shows errors smaller than 1 cm. However, systematic patterns are visible, especially in the right plot which is based on radiometer corrections.

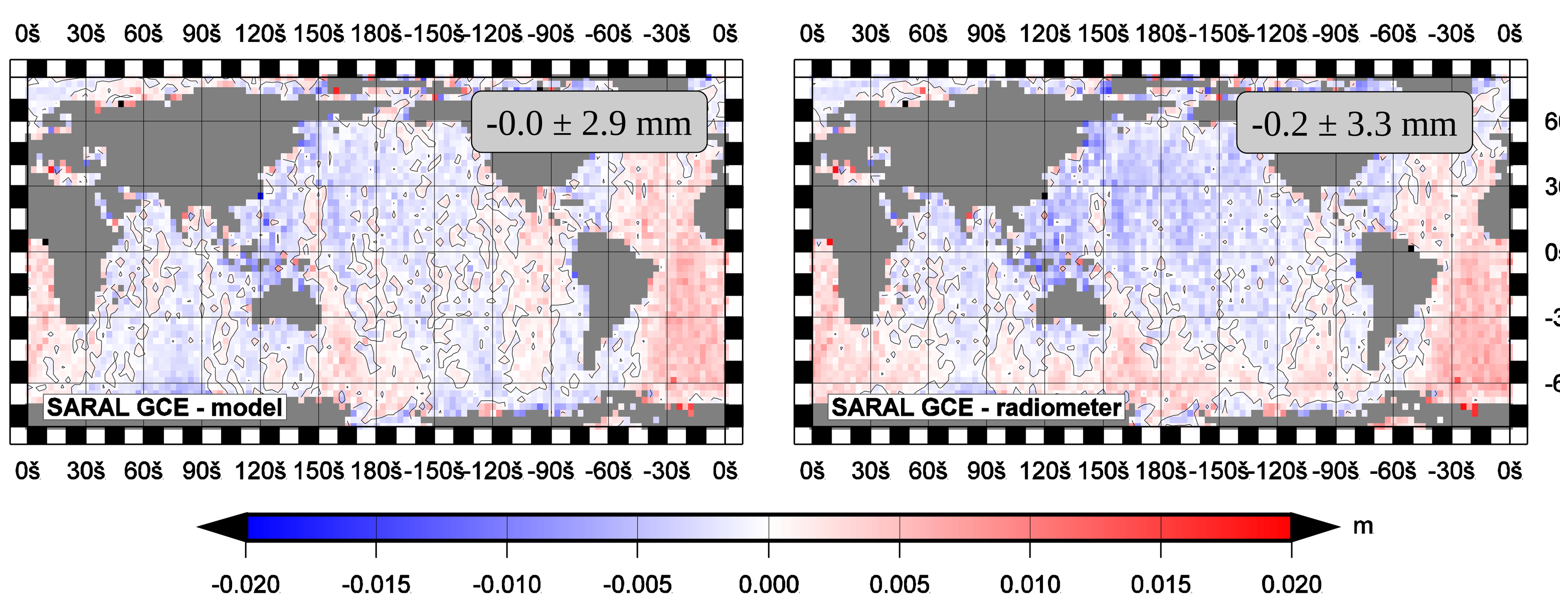


Fig. 4: Geographically correlated mean errors for SARAL (left-hand side: based on model troposphere corrections; right-hand side: based on radiometer data (mixed solution)).

References:

Bosch W., Dettmering D., Schwatke C.: Multi-Mission Cross-Calibration of Satellite Altimeters: Constructing a Long-Term Data Record for Global and Regional Sea Level Change Studies. Remote Sensing, 6(3), 2255-2281, DOI:10.3390/rs6032255, 2014

Dettmering D., Bosch W.: Global Calibration of Jason-2 by Multi-Mission Crossover Analysis. Marine Geodesy, 33:S1, 150-161, DOI:10.1080/01490419.2010.487779, 2010

Dettmering D., Schwatke C., Bosch W.: Global calibration of SARAL/AltiKa using multi-mission sea surface height crossovers. Submitted to Marine Geodesy

Conclusions

The SARAL GDR-T data show high quality and good consistency to Jason-2 and Cryosat-2. MMXO reveals neither a significant time tag bias nor any instrumental drifts. The range bias yields -4.7 cm with respect to Jason-2 and shows no systematics. However, the current version of radiometer-derived wet troposphere correction evokes systematic effects in SARAL's radial errors, GCE, and realization of the origin. In the z-component significant annual oscillations with amplitudes of about half a centimeter are visible.

SARAL/AltiKa Workshop, 27 October 2014, Konstanz, Germany