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Evaluation of sub-monthly oceanographic signal in GRACE "daily" swath series using altimetry

Jennifer A. Bonin and Himanshu Save

Correspondence to: Jennifer A. Bonin (jbonin@usf.edu)

Supplemental Material: MSS Bias Jump in Altimetric GDR Files

While computing the sea level anomaly values, we stumbled across one surprise difficulty which we would like to make particular note of, for the benefit of other Jason GDR data users. When we went to reference the Jason-2 data to the Jason-1 data, we determined that there is a large, geographically-correlated bias between the most modern data releases of the two missions (Fig. S1a). To provide a historical backdrop, Jason-1 produced solo data from January 2002 through July 2008, at which point it was joined by Jason-2. The two satellites flew in the same orbit, one shortly behind the other, until the start of 2009, at which point Jason-1 was moved into an interleaved complementary orbit. The last of the Jason-1 data was captured in March 2012, after which Jason-2 flew alone for four years. In February of 2016 (near the end of GRACE) Jason-3 was added in an identical orbit for eight months, until Jason-2 was moved to the complimentary orbit through its demise in May 2017. The common way of aligning the two missions is to take the data during the overlap periods and compute a bias from that. Historically these mission biases have pointed out several complex error types, but those are now understood, so that the Jason-1 GDR-D to Jason-2 GDR-D biases were constant across the ocean. When we compute the Jason-2 GDR-D to Jason-3 GDR-D biases (Fig. S1b), that is still what we see.

However, the transition from Jason-1 GDR-E to Jason-2 GDR-D creates a large, non-uniform bias (Fig. S1a). We have determined that this bias pattern comes from a change in the mean sea surface (MSS) model used between the D and E versions of the GDR output. In version D, a 16-year MSS correction (MSS_CNES-CLS-2011) was created by averaging satellite altimetry data over the years 1993-2008. In version E, a different dynamic topography model (MSS_CNES-CLS-2015) was created over the longer 1993-2012 timespan instead. For details on the Jason-1 GDR-E MSS, see the AVISO website (CNES, 2020). For details on the Jason-2 GDR-D MSS, see the Jason-2 Handbook (CNES et al., 2011).

The change of MSS model results in two types of differences during the Jason-1 to Jason-2 leveling process. First, the newer GDR-E MSS model has a finer resolution and is averaged over differing years, which will result in slightly different values in some areas. We are currently assuming that any such differences will be small and will tend to cancel out when looking at data over the entire globe. The second, much more concerning issue is that of the mean bias. The MSS model used in GDR-E is referenced to a center date of 2003, while the GDR-D is referenced to a center date of 2001 – and no bias correction has been applied (or provided) to align the two averages to an identical epoch. In areas where the sea surface height is experiencing a trend, this will introduce an artificial jump between the two averages. Averages made from even identical input data would be offset from each other by a time-constant, but spatially-variable, bias of approximately the size shown in Figure 1a.

To correct for this properly, one would ideally need to reprocess both (or all three) sets of Jason data with a consistent MSS model. This being a lengthy process, however, we used the following approximate technique instead. We computed the average overlap bias (Fig. 1a) along the ground-tracks, then smoothed it with a 100km Gaussian smoother to remove very short-wavelength features, and used the value of that at each point as the Jason-2 bias correction. We note that it is very important to compute the value at each point, as there would be a ±4 cm spread in water heights otherwise, depending on where in the ocean you are looking. Using the mean bias over this map would result in a constant -0.785 cm correction, which would not be accurate in most places. (As a comparison, we found the Jason-2D to Jason-3D bias to be a larger but very stable -2.871 cm.)

Our ultimate results are double-differenced, comparing the statistics of Altimetry minus GRACE to Altimety minus a model. Because of this, the treatment of the MSS model is non-critical. There could be an effect in the percent of altimetry's variance explained by each other series (Fig. 3) but that effect would cancel itself out in the difference in P.V.E. between two comparison series (Fig. 4). For this reason, the rough treatment we have used here is effective. However, any GDR user interested in looking at non-differenced results should be aware of this bias and correct for it by the consistent replacement of the MSS model.

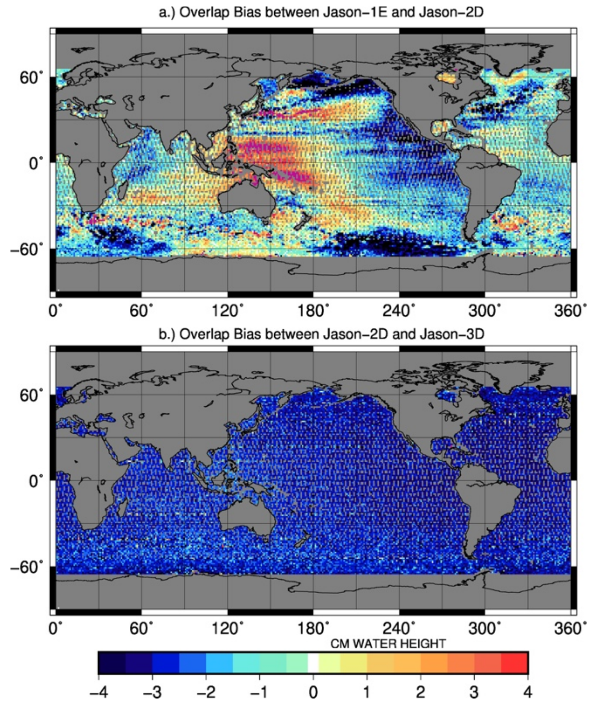

Figure S1: Bias offsets between (a) Jason-1 GDR-E and Jason-2 GDR-D, and (b) Jason-2 GDR-D and Jason-3 GDR-D.

Reference:

CNES: AVISO Satellite Altimetry Data, https://www.aviso.altimetry.fr/en/data/products/auxiliary-products/mss/mss-description.html. Last access: 4/8/2020.

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