Accurcay of the mean sea level continuous record with future altimetric missions: Jason-3 versus Sentinel-3a
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Overview

Thanks to satellite altimetry, the Mean Sea Level (MSL) continuous record is maintained since January 1993 using TOPEX/Poseidon data followed on the same orbit by Jason-1 and Jason-2 data.

- Apart from their identical orbit, the second advantage comes from the 9-month “calibration phases” between TOPEX/Jason-1 in 2002 and Jason-1/Jason-2 in 2008; they are essential for an accurate estimation of the sea level relative biases between two missions in order to link their MSL time-series (Leuillette et al., 2004; Dorandeu et al., 2003).

- Even though the uncertainties on the relative biases are low (Ablain et al., 2009) estimated they induced about 0.2 mm.yr⁻¹ of the global MSL trend uncertainty which is significant with regard to climate users requirements: 0.3 mm.yr⁻¹ over 10-year (GCOS, 2011).

Estimated uncertainty on the Global MSL continuous record trend over 15-20 years:

- (Ablain et al., 2009): 0.6 mm.yr⁻¹
- (Leuillette et al., 2012): 0.8 mm.yr⁻¹

- Climate users requirements (UR) on Global MSL trend uncertainty: 0.3 mm.yr⁻¹ over 10 years
  - In order to extend the current MSL continuous record, Jason-3 altimetric mission will be the natural successor of Jason-2: on the same orbit with a calibration phase (~9 months).
  - Shortly after Jason-3, another altimetric climate-oriented mission, Sentinel-3a, will be launched on a different orbit from Jason-2.

Question:

Would it be possible to extend the continuous MSL record with Sentinel-3a instead of Jason-3, conserving the same accuracy level?

Impact of Sea Level Bias Uncertainties on the Global MSL Trend

Methodology

- The methodology to estimate relative biases accuracies is based on synthetic Jason-2, Jason-3 and Sentinel-3a MSL time series based on Mercator-Océan’s reanalysis GLORYS, enhanced with high-frequency correlated noises.
- These series allow to simulate a significant number of independent and realistic calibration phases between Jason-2/Jason-3 or Jason-2/Sentinel-3a and estimate the corresponding relative bias.

Results

- The relative bias uncertainty for each pair of mission is then estimated via the standard deviation of the samples with a 95% confidence level, see table below:

<table>
<thead>
<tr>
<th>Relative Bias Uncertainty</th>
<th>Jason-2 / Jason-3</th>
<th>Jason-2 / Sentinel-3a</th>
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<tbody>
<tr>
<td></td>
<td>0.9 mm</td>
<td>2.5 mm</td>
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</table>

- These uncertainties in the biases impact the MSL trend estimation differently depending on the length of the linear regression period, see Fig. 2.
- Over 10 years, the impact due to Jason-2/Sentinel-3a relative bias uncertainty on the MSL trend is very significant: about 0.4 mm.yr⁻¹.

Impact of orbit change on Global and Regional MSL Trends

Methodology

- Since Jason-2 and Jason-3 have the same orbits, studying the long-term uncertainty induced by the difference between Jason-2 and Sentinel-3a ground tracks is equivalent to studying the differences between Jason-3 and Sentinel-3a space-time samplings.
- Therefore, Mercator-Océan’s reanalysis GLORYS has been bi-linearly interpolated in time and space over Jason-3 and Sentinel-3a ground-tracks over a period of 10 years.

Results

- At regional scale, the errors are mainly below 1 mm.yr⁻¹ over 10 years, even though they may reach 3 mm.yr⁻¹ in regions of high oceanic variability, see Fig. 3. This is significant considering climate UR: 1 mm.yr⁻¹ over 10 years in 2°x2° boxes.
- At global scale, the long-term error reaches 0.05 mm.yr⁻¹ over 10 years, which is low but significant considering UR: 0.3 mm.yr⁻¹ over 10 years.

Fig 2: Global MSL trend uncertainties induced by relative bias uncertainties versus period length

Conclusions

- To the extent possible, the use of Sentinel-3 in the reference Mean Sea Level records should therefore be avoided. It is necessary to conserve the historical TOPEX/Jason ground track to compute MSL time series and MSL trend maps.

- The different sampling of oceanic variability –induced by the difference of ground tracks– prevents from meeting UR concerning regional Mean Sea Level trends uncertainty (<1mm/yr).

- Linking Sentinel-3 to the reference Mean Sea Level time series makes it impossible to respect the UR concerning Global Mean Sea Level trend uncertainty (<0.3mm/yr). The main reason is that it is important to remain consistent in the errors we commit to minimize sources of uncertainty.