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

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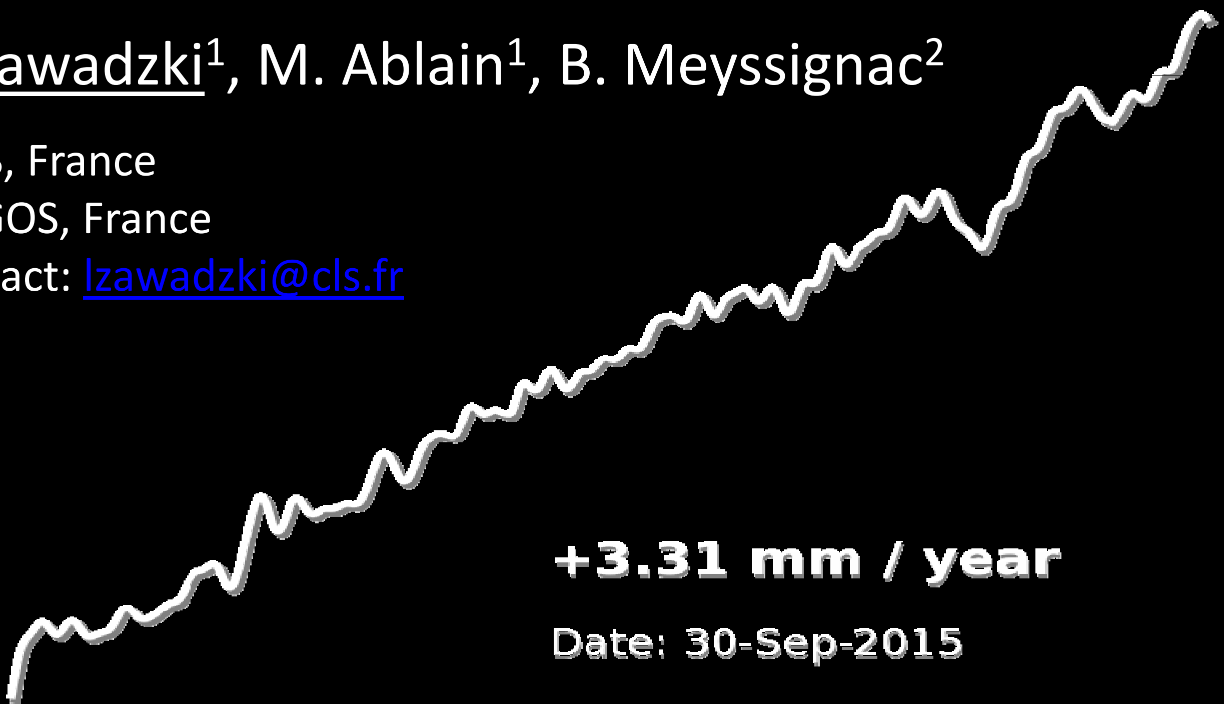

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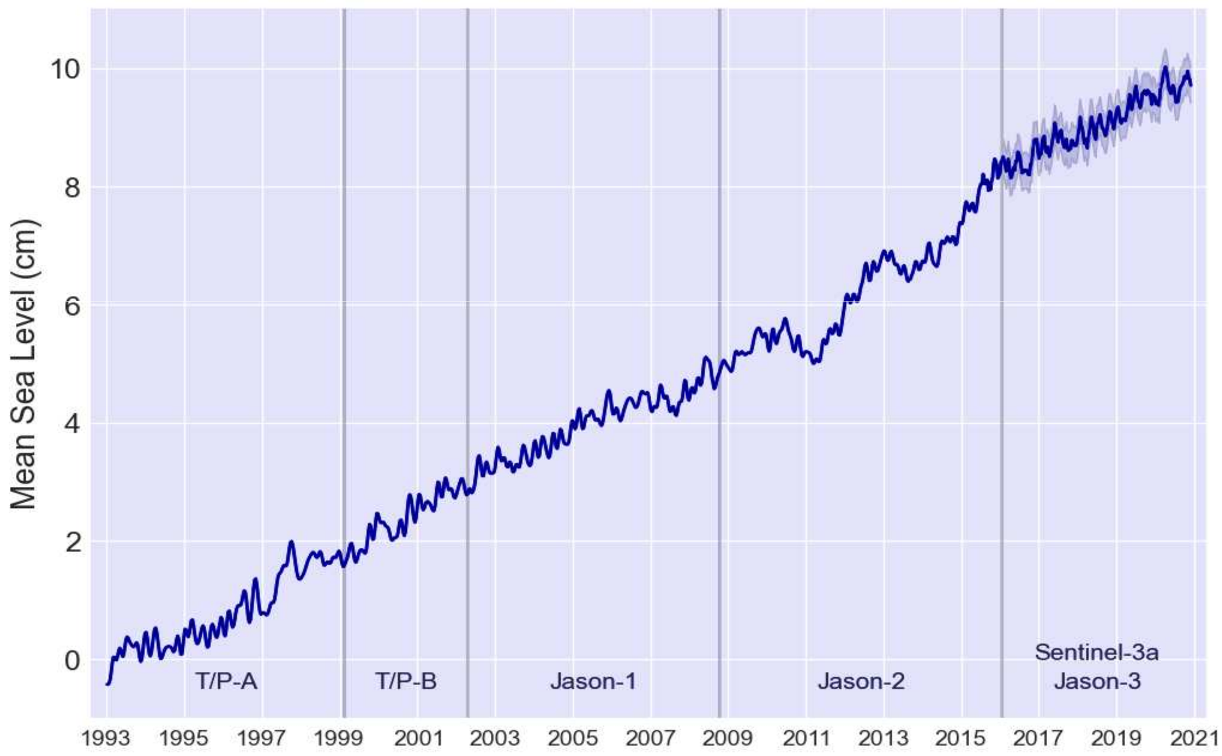
Introduction

- Current MSL continuous record:
  →Conservation of the "historical" TOPEX orbit
  →Calibration phases between the successive missions: rigorous estimation of their relative biases.

What would be the impact of changing the historical orbit ?

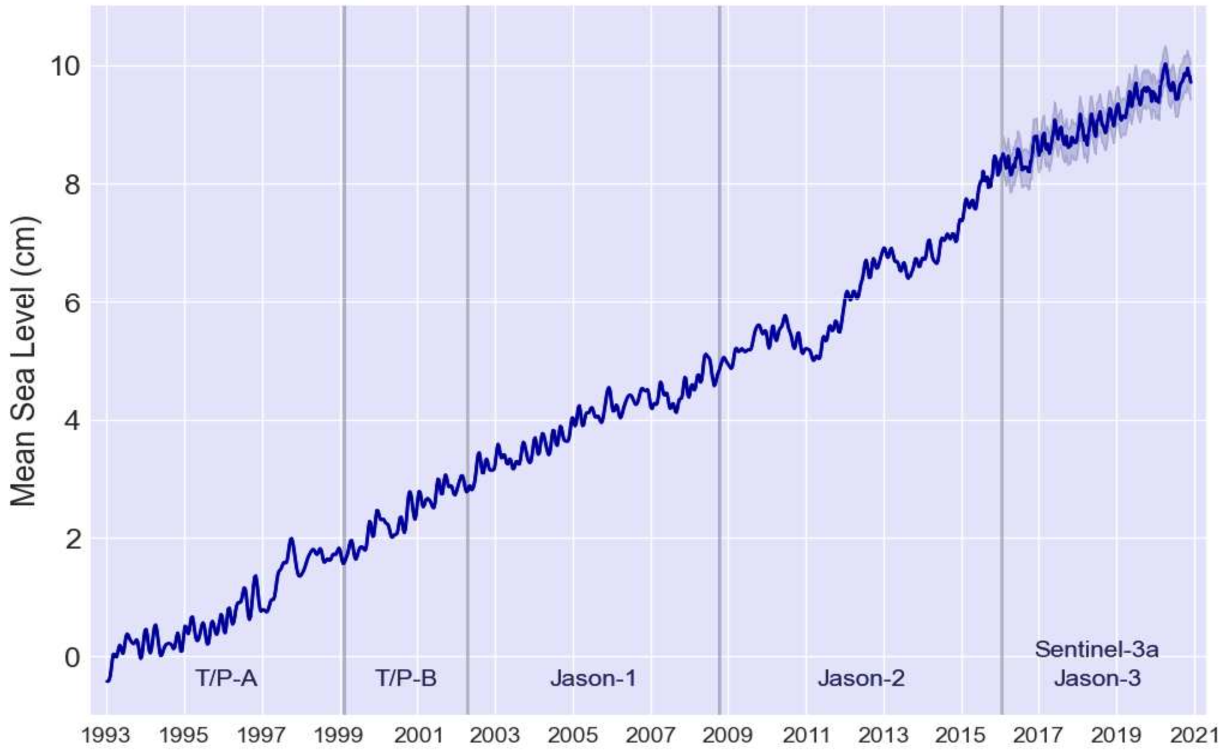


- Jason-3 will be the natural successor of Jason-2: on the same orbit with a calibration phase.
- Another altimetric climate-oriented mission, Sentinel-3a, will be launched on a different orbit.

Objectives

What would be the impact of changing the historical orbit ?

1. Estimate the impact of the absence of calibration phase on the MSL continuous record trend accuracy
2. Estimate the impact of the orbit change on the long-term continuity of this MSL record



Absence of calibration phase

1 2 3

Reference Scenario	Working Scenario
2 missions with: • Calibration phase • Same ground tracks E.g. Jason-1/Jason-2, Jason-2/Jason-3,…	2 missions with: • No calibration phase • Different ground tracks E.g. Jason-1/Envisat, Jason-2/Sentinel-3,…
Same space-time sampling ➔SSH errors positively correlated ➔Impact of oceanic variability sampling neglected ➔Minimum Relative Bias Uncertainty (Leuliette et al., 2004)	Differences in space-time sampling ➔Decorrelation of SSH errors ➔Impact of oceanic variability sampling

Absence of calibration phase

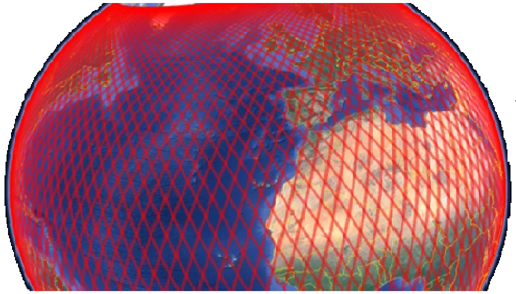
1 2 3

Case (Global)	Relative Bias Uncertainty (mm)		
	Impact of differences in oceanic variability sampling only	Impact of SSH errors decorrelation only	Total Uncertainty
Jason-2/Jason-3	0		
Jason-2/Sentinel-3a			

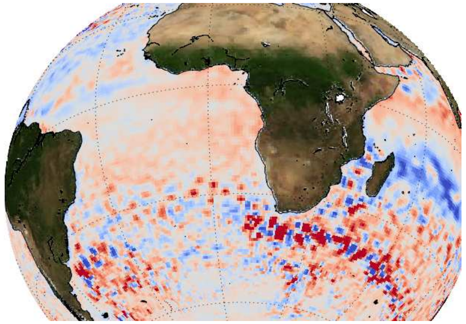
Tab. 1: Jason-2/Jason-3 and Jason-2/Sentinel-3a relative biases uncertainties on the global Mean Sea Level.

Absence of calibration phase

1 2 3

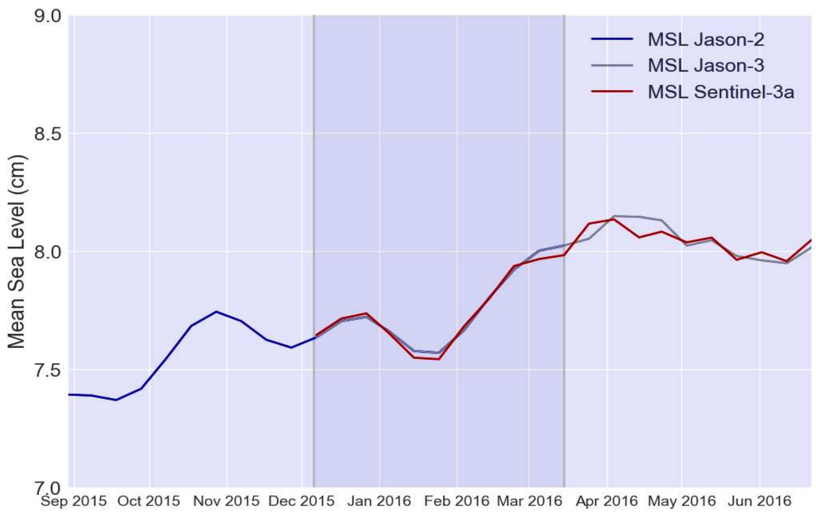


Model (GLORYS)



Bi-linear interpolation on theoretical ground-tracks: Jason-2, Jason-3, Sentinel-3a

Simulated GMSL computation



Absence of calibration phase

1 2 3

Simulated GMSL computation

Relative Bias Estimation (1.96σ)

Relative Bias Uncertainty due to differences in oceanic variability sampling

(case Jason-2/Sentinel-3a)

Absence of calibration phase

1 2 3

Case (Global)	Relative Bias Uncertainty (mm) Impact of differences in oceanic variability sampling only	Impact of SSH errors decorrelation only	Total Uncertainty
Jason-2/Jason-3	0		
Jason-2/Sentinel-3a	0.4		

Tab. 1: Jason-2/Jason-3 and Jason-2/Sentinel-3a relative biases uncertainties on the global Mean Sea Level.

Absence of calibration phase

1 2 3

Simulated GMSL computation (annual and semi-annual signals removed)

Relative Bias Estimation (1.96σ)

Total Uncertainty on Relative Bias

Correlated noise addition :
intermission correlation maintained to realistic levels (empirically estimated) between Ja2/Ja3 and Ja2/S3a

Absence of calibration phase

1 2 3

Case (Global)	Relative Bias Uncertainty (mm) Impact of differences in oceanic variability sampling only	Impact of SSH errors decorrelation only	Total Uncertainty
Jason-2/Jason-3	0		**0.9**
Jason-2/Sentinel-3a	0.4		**2.53**

Tab. 1: Jason-2/Jason-3 and Jason-2/Sentinel-3a relative biases uncertainties on the global Mean Sea Level.

Absence of calibration phase

1 2 3

Case (Global)	Relative Bias Uncertainty (mm) Impact of differences in oceanic variability sampling only	Impact of SSH errors decorrelation only	Total Uncertainty
Jason-2/Jason-3	0	0.9	**0.9**
Jason-2/Sentinel-3a	0.4	2.5	**2.53**

Tab. 1: Jason-2/Jason-3 and Jason-2/Sentinel-3a relative biases uncertainties on the global Mean Sea Level.

Absence of calibration phase

1 2 3

$$Uncertainty_{Trend\ (t)} = 6 * Uncertainty_{Bias} \frac{t_C(t - t_c)}{t(t^2 - P^2)}, \forall\, t \geq t_c$$

$$= 0, \forall\, t < t_c$$

where:

- t is the time
- t_c is the date of the mission switch
- P is the length of a cycle ($P^2 << t^2$)

Eq. 1: Impact of an intermission relative bias uncertainty on the MSL trend uncertainty with LSR approach. Derived from the application of LSR formula on a Heaviside function.

Absence of calibration phase

Fig. 1: Impact of global Mean Sea Level intermission relative bias uncertainties on the estimation of the MSL trend over 10 years (Upper panel), 15 years (middle panel), 25 years (lower panel), in the cases of Jason-3 and Sentinel-3a

Orbit Change

1 2 3

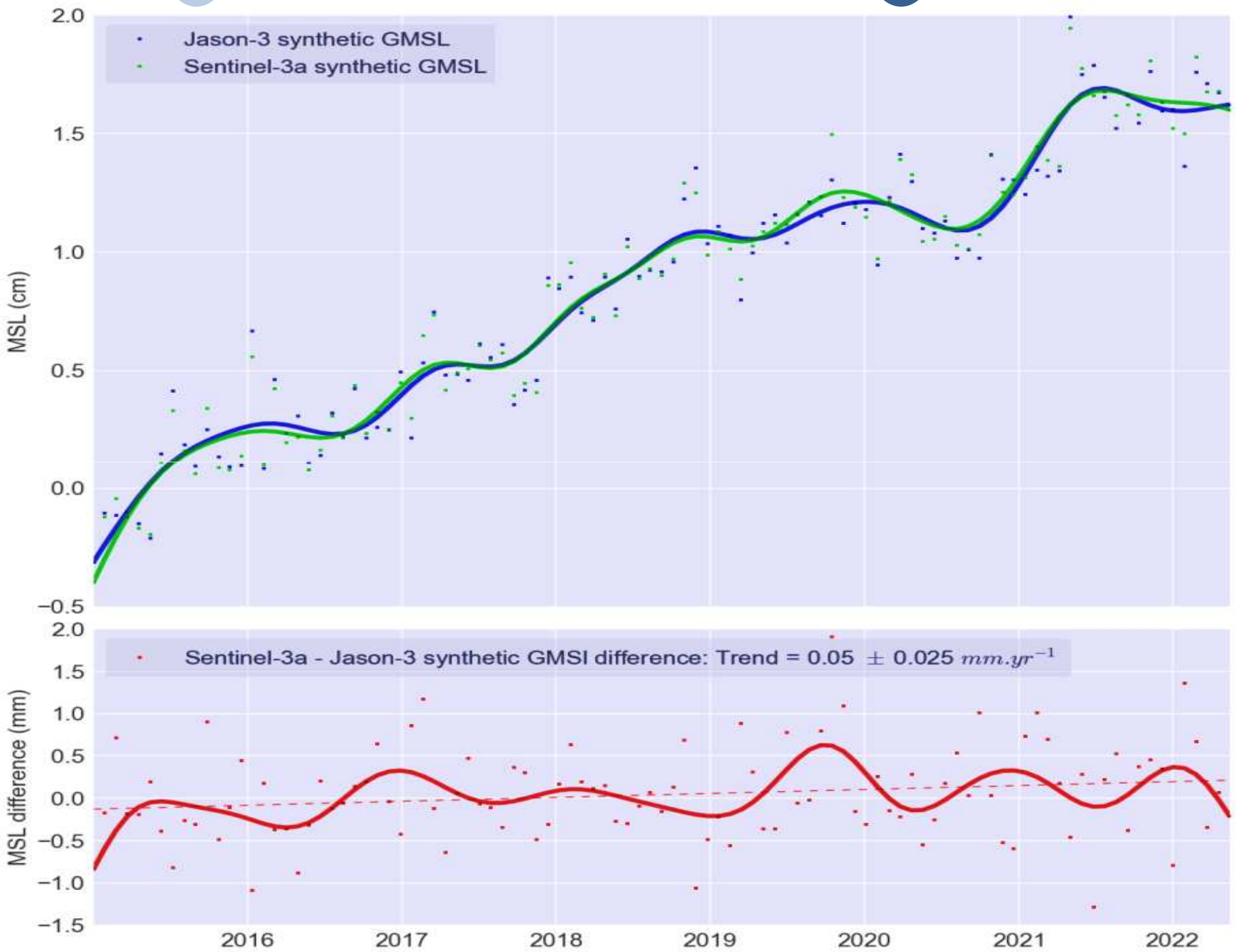
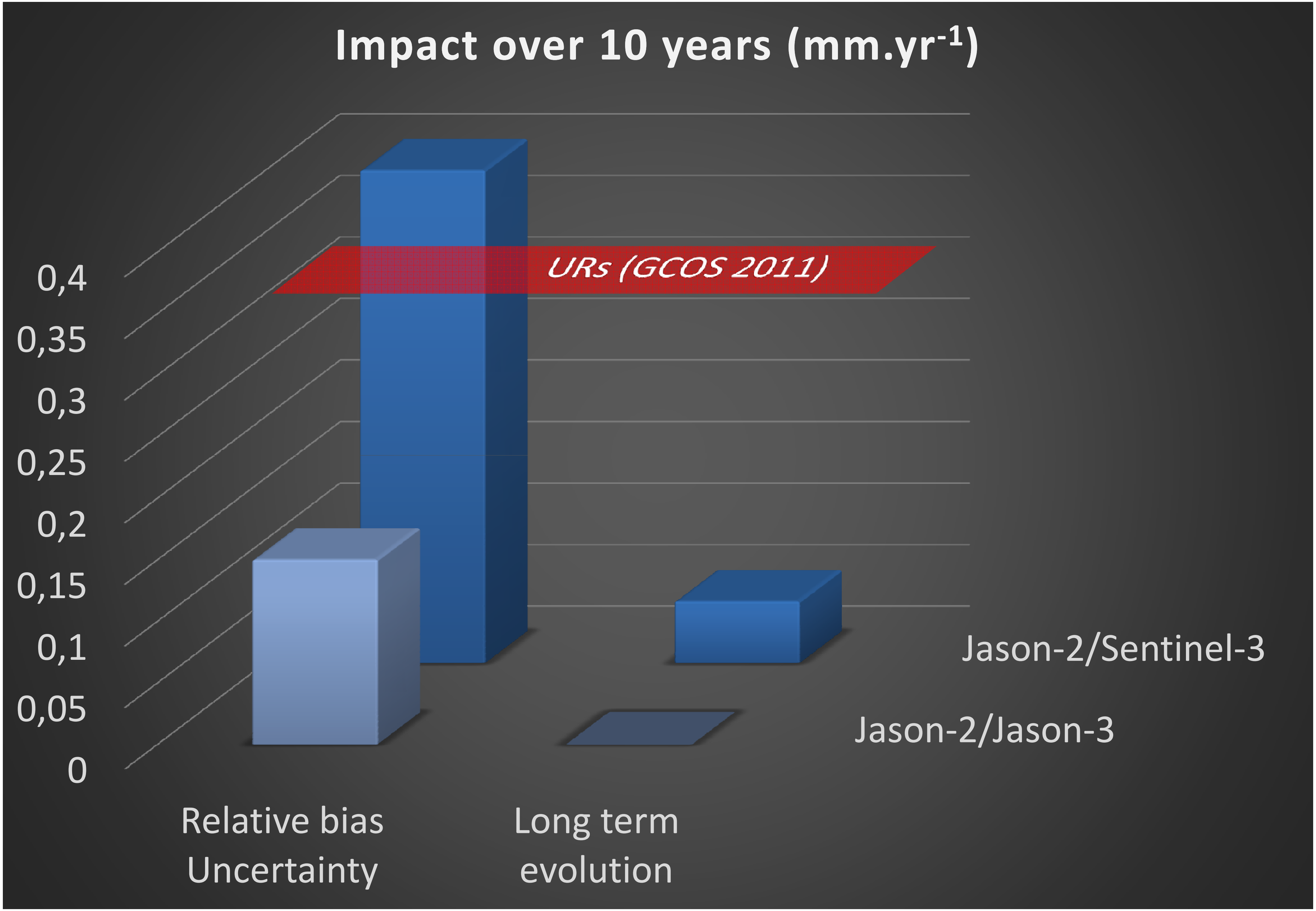


Fig. 2: Long-term impact of changing from TOPEX "historical" to Sentinel-3a ground-tracks on the global Mean Sea Level evolutions.

Long-term impact = 0.05 ± 0.025 mm.yr^{-1}


Impact over 10 years (mm.yr^{-1})
URs (GCOS 2011)
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
Jason-2/Sentinel-3
Jason-2/Jason-3
Relative bias Uncertainty
Long term evolution

Conclusions & Outlooks

1 2 3

- Linking Sentinel-3 MSL time series to Jason-2 has a strong impact on the global (and regional) MSL uncertainty, mainly due to the absence of a calibration phase.

- The climate user requirements (GCOS 2011) require an uncertainty below 0.3 $mm.yr^{-1}$ at global scale over 10 years on the MSL trend.

- Changing the historical TOPEX/Jason orbit for Sentinel-3a orbit would therefore exceed user requirements over 10 years even though it is only one component of MSL error budget (Ablain et al. 2015).

- The impact over the whole altimetry era is however small ($<0.1 mm.yr^{-1}$)