Why altimetry errors at climate scales are larger in the first decade [1993-2002] ?

Michaël Ablain, Annabelle Ollivier, Sabine Philipps (CLS), Nicolas Picot (CNES)
CLS, Space Oceanography Division, Toulouse, France, (mablain@cls.fr)
CNES, Centre National d'Etudes Spatiales, Toulouse, France

Overview

Recently (Ablain et al, 2012), altimetry errors at climate scales have been described separating several spatial and temporal scales:
- Global and regional Mean Sea Level (GMSL and RMSL)
- long-term evolution, inter-annual signals (2-5 years), periodic signals

The errors described in table 1 have been averaged over all the altimetry period from 1993 to 2012 from TOPEX, Jason-1 and Jason-2. measurements.

Tab 1

Spatial Scales	Temporal Scales	Altimetry errors
Global Mean Sea Level (10-day averaging)	Long-term evolution (> 10 years)	< 0.5 mm/yr
	Inter annual signals (< 5 years)	< 2 mm over 2 year
	Periodic signals (Annual, 60-days,...)	Annual < 1 mm 60-day < 5 mm
Regional Mean Sea Level (2x2 deg boxes and 10-day averaging)	Long-term evolution (trend)	< 3 mm/yr
	Periodic signals (Annual, 60-days,...)	Annual < 1mm 60-day < 5 mm

But these errors at climate scales are in fact larger in the first altimetry decade [1993-2002] than in the second one due to :
- larger errors on TOPEX measurements
- larger errors in orbit solutions and atmospherical corrections
- a stronger uncertainty to estimate the errors on first decade

This study aims at describing in details the main errors impacting the MSL evolution during the first altimetry decade.

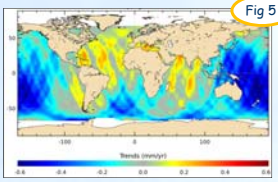
Orbit solutions & Atmospherical corrections

Errors on orbits solutions are larger on first altimetry decade mainly due to a poorer modelization of gravity fields models (GRACE data available from 2002 onwards).

The impact is mainly on RMSL trends:

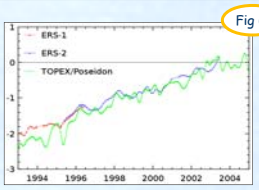
❑ 1-2 mm/yr for TOPEX and 3-4 mm/yr for ERS (due to the lower altitude)

Fig 5



Trend differences between 2 orbit solutions (CNES & GFZ) on TOPEX

Fig 6



Evolution of the SSH error reduction (cm) thanks to atmospherical corrections derived from ERA -interim

Atmospherical corrections derived from meteorological models (ECMWF,...) contain larger errors in the first altimetry decade. Recent analyses have shown that these errors were reduced at several scales by using ERA-interim analyses. But the remaining errors are quite difficult to evaluate: they could be reduced again with future meteorological reanalyses.

Uncertainty to estimate altimetry errors on first decade

The method to estimate altimetry errors based on multi-missions and external data comparisons are less accurate in the first altimetry decade than in the second one :

Tab 2

Multi-missions comparisons	ERS/TOPEX provide less relevant long-term analyses than Jason/Envisat due to stronger instabilities on ERS missions
In-Situ comparions	Data coverage of in-situ data are often lower in the first decade (ARGO profiles, Tide gauges for instance) reducing the reliability of the analyses.
Models comparisons	Most of the time, quality of models is poorer in the first altimetry decade (atmospheric models for instance) reducing the accuracy of the analyses.

Due to all these issues, errors are more difficult to measure on first decade than in the second one:
❑ the uncertainty to estimate altimetry errors is larger
❑ undetected errors are more likely

Errors on TOPEX measurements

Sigma-0 and SWH instabilities

Sigma-0 and SWH instabilities have been highlighted on TOPEX data thanks to comparisons with ERA-interim reanalyzes from ECMWF. The evolution of the global differences between altimeters and model wind speed (fig 1) and SWH (fig 2) displayed strong differences especially from 1997 to 1999 corresponding to TOPEX-A anomalies: until 20 cm/s-1 for wind speed and 30 cm for SWH (Ablain et al., 2012 (*)).

Fig 1

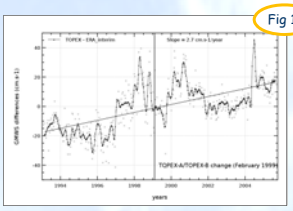
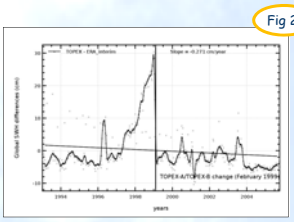


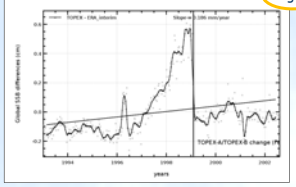
Fig 2



❑ The impact on the GMSL time series via the Sea Stare Bias correction (fig. 3) is close to 0.2 mm/yr on the trend.

❑ The strong differences between 1997 and 1999 (until 6 mm), considered as significant errors, prevent the good observation of global MSL variations at inter-annual scales

Fig 3



MSL bias between TOPEX-A and TOPEX-B

Due to the TOPEX altimeter change in February 1999, systematic SSH biases exist between both altimeters as well as at global as at regional scales. As there is no overlapping period between both altimeters, the uncertainty of the global bias is close to 2 mm and the regional bias cannot be determined. In addition, the regional bias depends on ascending and descending passes.

Due to this issue, the uncertainty on the first altimetry decade is:

❑ 0.15 mm/yr on the GMSL
❑ 0.5 mm/yr on the RMSL

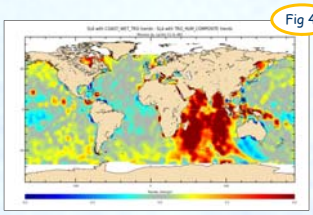
Wet troposphere radiometer errors

The TOPEX wet troposphere radiometer correction (TMR) is impacted by long-term errors as all the on-board radiometers (Jason, Envisat,...). But TMR is also deteriorated by interpolation anomalies close to data gaps impacting especially long-term scales in Indian Ocean.

Impact due to TMR error is

❑ 0.3 mm/yr on the GMSL
❑ 0.5 mm/yr on the RMSL

Fig 4



Trend differences between TMR (TOPEX° and a composite correction derived from GPS, model,and TMR (calculated by U.Porto)

Summary & Conclusions

The errors described here increase the sea level error budget at climate scales during the first altimetry decade :

The uncertainty of the MSL evolution between 1993 and 2002 is :
❑ 0.7-0.8 mm/yr on the GMSL trend
❑ until around 5 mm for inter-annual signal (2-5 years)
❑ 4 mm/yr on the regional MSL trends

Therefore, in order to reach GCOS requirements (e.g. 0.3 mm/yr for the GMSL trend), efforts should be made in priority on the first altimetry decade :
⇒To improve TOPEX data but also ERS-1/ERS-2 data
⇒To continue to analyze the quality of these data a posteriori

For climate studies, the altimetry error budget in the first altimetry decade must be carefully considered (e.g. : sea level budget closure studies).

(*) M. Ablain, S. Philipps, M. Urvoy, N. Tran, N. Picot , 2012. Detection of Long-Term Instabilities on Altimeter Backscatter Coefficient Thanks to Wind Speed Data Comparisons from Altimeters and Models. Marine Geodesy Vol. 35, Iss. sup1, 2012

Collecte Localisation Satellites
8-10 rue Hermes
31520 Ramonville Saint-Agne - France

OSTST
8-11 October 2013 | Boulders, US