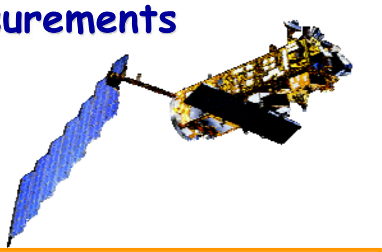
Quality assessment of in-situ and altimeter measurements through SSH comparison



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Overview

Altimetry missions provide accurate measurements of sea surface height (SSH) from 1992 onwards with TOPEX/Poseidon (T/P), and until now thanks to Jason-1, Envisat and more recently Jason-2. A global assessment of these data is systematically performed in order to detect potential anomalies and estimate system performances. In addition, cross-calibration between each altimeter mission is carried out to thoroughly analyze SSH bias, and potential drifts or jumps in the global Mean Sea Level (MSL), see MSL AVISO website **(1)**. In order to complete this assessment, in-situ measurements are also used as independent sources of comparison. In this way, tide gauge networks have been compared to altimeter data **(2)**.

In this study, we present the main results obtained from these comparisons (for T/P, Jason-1, Jason-2 and Envisat) through the 3 following objectives linked together. The first one consists in detecting drifts or jumps in altimeter SSH by comparison with in-situ measurements. The second goal is the analysis of the SSH consistency improvement between altimeter and in-situ data using new altimeter standards (orbit, geophysical corrections, ground processing...). The last objective is the detection of anomalies on in-situ time series thanks to the cross-comparison with all available altimeter data. In-situ measurements can thus be corrected or even removed in order to further improve the SSH comparison with altimeters.

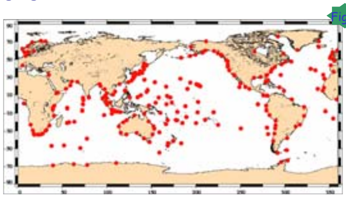
References :
-(1) MSL Aviso website: www.aviso.oceanobs.com/msl/
-- (2)Ablain et al., 2009: "A new assessment of global mean sea level from altimeters highlights a reduction of global trend from 2005 to 2008" (in press)

Estimation of altimeter MSL drift

Data & Method

Altimeter drift is estimated using the GLOSS/CLIVAR "fast" sea level database: about 255 tide gauges uniformly widespread (see fig.1).
After colocating the nearest altimeter measurements with each tide gauge, time data series which are not well correlated are edited. Finally, a dataset of about 120 tide gauge is selected.

Fig1



In addition, a drift correction is applied (**+0.2 mm/yr**) in order take into account the vertical movements observed only by tide gauges. This correction has been estimated using GPS data, but at the moment its accuracy is on the order of the correction value.

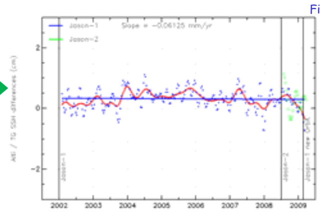
Accuracy of the method

The accuracy of the drift estimation is impacted by the formal error adjustment (on the order of 0.2 mm/yr), the uncertainty to take into account the vertical movements (using GPS station network), and also the sensitivity to the tide gauges number impacting the drift around ± 0.2 mm/yr.
Finally the accuracy of the method to estimate the MSL drift is close to **±0.5 mm/yr** over Jason-1, Envisat or T/P periods. This uncertainty increases considering shorter periods.

Main results

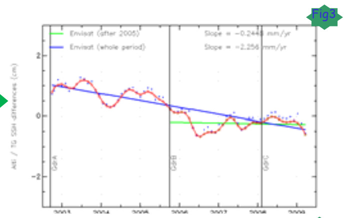
Considering Jason-1 (from GDR-C and GDR-B products linked correctly together), the altimeter drift estimate is almost null : **-0.1 mm/yr.**
The first 24 cycles of Jason-2 have been overlayed (green dots) but for instance its very short time period doesn't allow an altimeter drift assessment.
This result highlights the Jason-1 reliability to calculate the global MSL trend.

Fig2



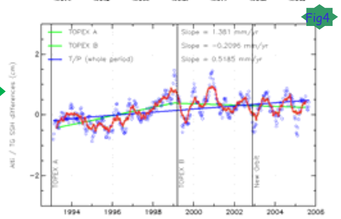
For Envisat, a negative drift close to **-2.2 mm/yr** is detected from 2002 to 2009 after homogenizing as well as possible the Envisat GDR products.
However, focusing only on the end of the period (GDR-A products are excluded), this drift is now weaker close to **-0.2 mm/yr**.
These results are in well agreement with global Cal/Val studies, showing the reliability of the method.

Fig3



The T/P MSL drift have been calculated from updated M-GDR products (GSFC orbit , corrected TMR, ...) : it is slightly positive close to **+0.5 mm/yr.**
The slope estimate is almost null on the TOPEX-B period (**-0.2 mm/yr**) whereas a drift is detected on the TOPEX-A period around **1.3 mm/yr.** This drift seems correlated with TOPEX-A anomaly : SWH and SIGMA-0 drift are observed on this period.

Fig4



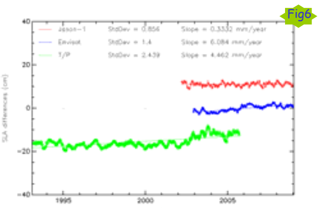
Quality assessment of in-situ tide gauge time series

The cross-comparison of altimeter and tide gauges SSH comparisons obtained from all the missions allows us to detect anomalies on tide gauge time data series. This is mainly possible comparing SLA differences (fig.6-7). This diagnostic allows us to detect jumps as displayed in fig. 7 (a jump is observed simultaneously at the end of the Jason-1 and Envisat periods). Unlike fig.7, fig. 6 doesn't highlight any anomaly on tide gauge.

On the other hand, maps of temporal correlation between altimeter and in-situ SSH time data series (fig.8-9) are systematically produced for each tide gauge and altimeter. Generally the correlation is good close to the coasts close to 0.9 (fig. 8). But for some tide gauges, it is bad (> 0.5 in fig. 9). It could be due to geophysical processes but also to jump or drift in in-situ data

Finally the comparison of altimeter and in-situ SSH allows us to assess the tide gauge SSH as well as the altimeter SSH.

Fig6



SLA differences for J1, Envisat and T/P missions for the Pohnpei (fig.6) and the Valparaiso (fig.7) tide gauges

Fig7

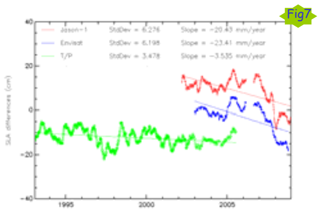
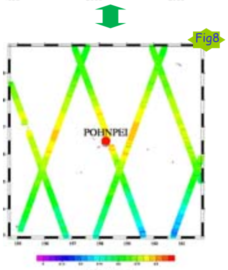
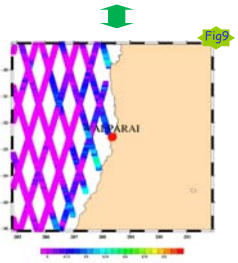


Fig8



SSH correlation with Jason-1 for the Pohnpei tide gauge (fig.8) and with Envisat for the Valparaiso tide gauge (fig.9)

Fig9



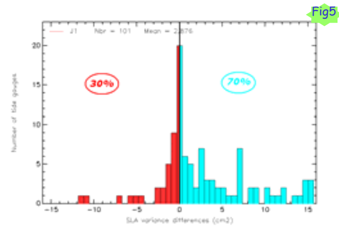
Impact of new standards in the SSH consistency

This part aims at presenting the capability of the altimeter/tide gauges comparison procedure to measure the impact of new altimeter standards on the SSH consistency. The basic principle of the method is to compare the SLA consistency between altimeter and tide gauges data using successively the old and new standards in the altimeter SSH calculation. The main criteria used is the analyze of SLA variance differences.

In figure 5 is plotted the histogram of the variance SLA differences as function of the tide gauge number in order to estimate the impact of new editing criteria allowing to compute the SSH closer from the coasts.

Results provided explain how can be improved the consistency between altimeter data and in-situ measurements at the different tide gauge locations. Here the impact of the coastal editing flag are relevant, with a mean variance of 2.8 cm² for Jason-1, which demonstrates the improvement of altimeter/in-situ SLAs consistency using this criteria.

Fig5



Histogram of SLA variance differences as function of the tide gauge number for Jason-1, using successively the basic and the coastal editing flags

Conclusion

Thanks to the comparison of altimeter data with in-situ measurements, the MSL drift can be more precisely estimate. Moreover, the method presented here can provide a quality assessment on both altimeter and in-situ datasets through SSH comparisons.
To date, 3 limited points have to be investigated to give even better results:

- the way of computing vertical movements , by using more GPS at tide gauge location
- the correction of jumps in tide gauge time data series
- the errors on the method itself (especially the colocation with the nearest points on altimeter tracks)