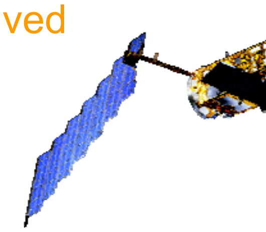
Cross-comparisons of Sea Surface Height derived from In-Situ and Altimeter measurements



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Overview

To date, the global assessment of altimeter data is performed through 3 main approaches, **see AVISO website (1)**: the internal assessment of altimeter data (comparison of instrumental corrections with global models, calculation of SSH at crossovers), the cross-calibration between altimeter missions (Jason-1 and Envisat for instance) and the comparison with in-situ measurements which are used as independent sources of comparison to better assess the multiple system performances **(2)**. This study focuses on the latter considering two kinds of in-situ measurements, which are the tide gauge measurements and the Temperature and Salinity vertical profiles (T/S). Regarding the SSH, both data are complementary since tide gauges provide a very good temporal sampling with measurements mainly widespread along the coastal areas, whereas T/S data are very well spread out over the open ocean but with only a 10-day temporal sampling.

The study presents the main results obtained from comparisons between these in-situ measurements and altimeter data from 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 the 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...). Finally, this study focuses on the quality control performed 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.

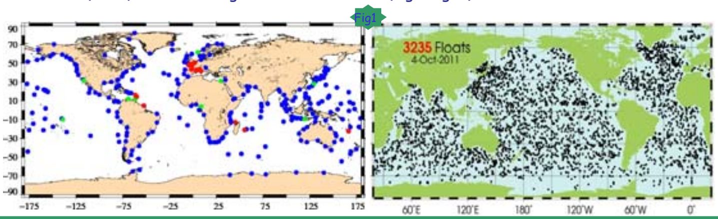
References :
- (1) CLS Aviso website: www.aviso.oceanobs.com
- (2) Valladeau et al., 2012: "Altimeter and in-situ sea level comparisons with tide gauges and temperature / salinity profiles" (in progress, Marine Geodesy 2012, Special Issue)

Maps of in-situ datasets

<u>Altimeter drift is estimated:</u>

➢ using the GLOSS/CLIVAR "fast" sea level database (279 tide gauges uniformly widespread, blue and green dots) and the REFMAR network (38 tide gauges, red dots) (see fig.1 left)

➢ using the Temperature/Salinity profiles of the Argo network which measure Dynamic Height Anomalies (DHA) or steric heights of the sea level (fig.1 right)

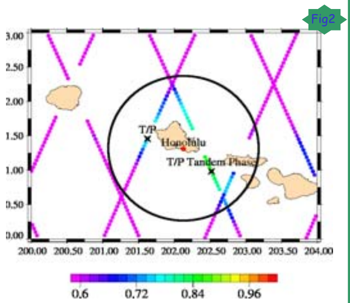


Altimeter/Tide Gauges method to assess MSL drift

➢ <u>Colocation Method:</u> maximal correlation criteria derived from theoretical altimeter along track products within a 100 km distance circle (fig. 2). The main advantage is to reduce the effect of the oceanic variability and the error on the MSS considering the same altimeter point on the theoretical track.

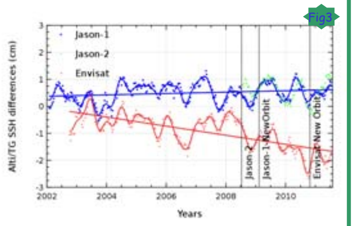
➢ <u>Spatial weighting:</u> taking into account the rocking sampling of tide gauges in the whole ocean.

➢ <u>Editing:</u> time series which are not well correlated are edited. Finally, a dataset of about 150 tide gauge is selected.



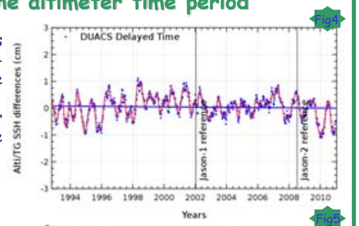
Assessment of Jason-1&2, Envisat and TOPEX/Poseidon MSL drifts

Fig. 3 provides a good reliability in the Jason-1 global MSL trend estimate with a slope of **0.3 mm/yr**. Moreover, the monitoring of the Jason-2/tide gauges differences has been overlaid on (green dots) but its short time period doesn't allow enough confidence in the altimeter drift assessment.
On the 2002-2011 time period, Envisat displays a negative drift close to **-1.9 mm/yr**. Note that the method developed allows to take the Envisat drifting orbit into account (since October 2010).
Finally, the monitoring of TOPEX/Poseidon/tide gauges differences leads to a slope of **0.5 mm/yr** on the 1992-2004 time period (not shown here).



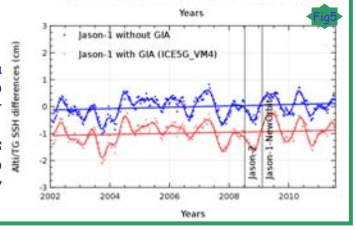
Estimation of the MSL drift over all the altimeter time period

The DUACS Delayed Time multi-missions products have been compared with tide gauges. On the 1993-2011 time period the MSL drift is very close to **0.0 mm/yr ±0.5 mm/yr** (Fig. 4).
However, periodic signals seem to be displayed over all the altimeter time period, which are to be thoroughly investigated.



Particular investigation: impact of the Glacial Isostatic Adjustment (ICE5G_VM4)

In order to make the comparison with altimeter data more relevant, the effect of GIA on tide gauges has to be taken into account. While Jason-1 altimeter drift estimate is low without GIA on Fig. 5 (**0.3 mm/yr**, blue curve), the global trend of the time series considering the ICE5G_VM4 GIA model is reduced to **0.2 mm/yr** (red curve), which seems to slightly improve the consistency between both datasets.

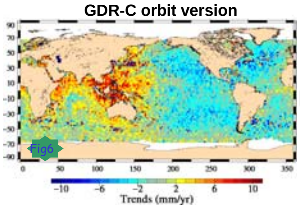


Detection of anomalies in the altimetric MSL:

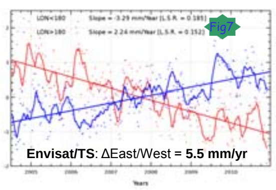
Envisat/Jason-1 regional MSL discrepancies

Regional MSL trend differences between Jason-1 and Envisat underline large longitudinal structures using GDR-C products (fig6): **± 3 mm/yr**. These differences are due to errors on orbit solutions.

GDR-C orbit version

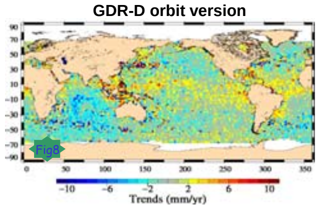


Separating the East/West SSH differences between altimetry and T/S profiles, we clearly detect a strong trend difference for Envisat (**ΔEast/West = 5.5 mm/yr** see fig. 7) instead of **1.1 mm/yr** for Jason-1.
This result highlights that the anomaly is mainly observed on Envisat.

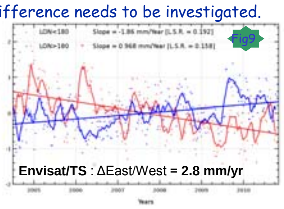


We have tested the impact of using new preliminary CNES GDR-D orbit solutions where the long-term evolution of gravity fields has been improved (cf L. Cerri presentation). The previous longitudinal structures using GDR-C orbits solutions are removed (fig 8).

GDR-D orbit version



Comparing with in-situ T/S profiles, the use of the new CNES preliminary orbit has a strong impact on the East/West trend difference observed on Envisat: initially 5.5 mm/yr, the difference is now reduced to **2.8 mm/yr** (fig 9).
The residual observed trend difference needs to be investigated.

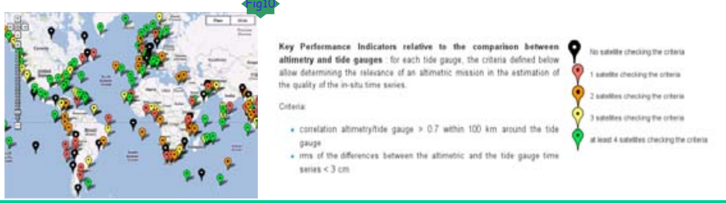


Quality assessment of in-situ tide gauge time series

The cross-comparison of altimeter and tide gauges comparisons obtained from all the missions (Jason, Envisat and T/P) allows us to detect the potential drifts or jumps which remain in in-situ time series and have no physical signification (drift of the beacon, anthropogenic sources ...). These measures are then corrected or removed to further improve the SSH comparison with altimeters.

➢ For instance, the tide gauge quality control can be performed:
- by comparing atimeter/tide gauges SLA differences using the four main missions
- by correlating altimeter and in-situ SSH time series

➢ From now on, the quality control is displayed as a Key Performance Indicator on the AVISO in-situ googlemap (Fig. 10). This quality control is a way of selecting relevant tide gauges for the altimeter/in-situ comparisons. Clicking on a tide gauge makes the quality control data sheet appear.



Conclusions

Thanks to the cross-comparisons between results provided by the different approaches, the assessment of the MSL drift is more and more reliable and accurate, globally as well as regionally:

➢ The use of tide gauges as independent data provide a relevant information in the long-term evolution of altimeter SSH, especially concerning TOPEX/Poseidon, Jason-1&2 and Envisat space missions. The reliability of the method is strengthened thanks to the use of GIA models.

➢ In-situ measurements as external data enable us to assess and precisely measure the contribution of a new altimeter standard in the computation of the SSH too. In this way, the SSH consistency analysis between altimeter and in-situ data gives independent information to measure the quality of these new altimeter standards (see the impact of the new gravity field in the orbit correction).

➢ The method presented here can provide a quality assessment on both altimeter and in-situ datasets through SSH comparisons. Concerning tide gauges, information cards for available networks are now routinely performed each week and distributed on the AVISO website (1).

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