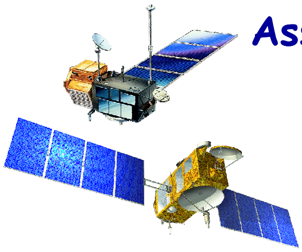

Assessment of global mean sea level from altimeters cross-calibration with in-situ measurements (TOPEX/Poseidon, Jason-1 and Envisat)

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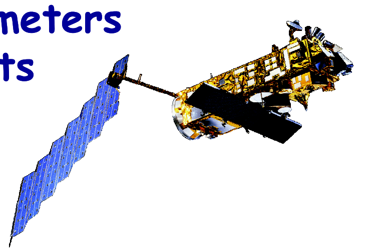


Overview

Measurements from space altimetric missions (TOPEX/Poseidon (T/P) and Jason-1) are believed to provide a reliable estimation of the Mean Sea Level (MSL) trend (to date 3.1 mm/year since 1993 without post glacial rebound). However, some potential drifts have been identified due to geophysical corrections, orbit solutions and the uncertainty to link the different MSL time series.

As in-situ datasets (tide gauges, Temperature/Salinity (T/S) profiles) provide independent measurements of sea surface height variations, methods have been developed to assess the global MSL trend from such data. The basic idea of the data processing is that differences between in-situ and altimetric measurements should not have any drift or bias over long time scales.

First, altimetric data are compared with tide gauge measurements using 4 different tide gauge networks (GLOSS/CLIVAR, SONEL, BODC database and OPPE). Second, an innovative method using the whole set of free-drifting profiling floats of the ARGO network is used. In this case, altimetric data are compared to sea level heights computed from T/S profiles for the 2004-2008 time period.

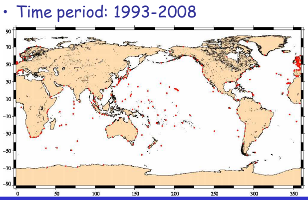
Both in-situ datasets complement each other since the first one (tide gauges) concerns coastal areas while the second one (T/S profiles) is widespread enough to detect potential drifts in the open ocean.

Inventory of data used in both methods

Tide gauge networks:

4 different tide gauge networks (GLOSS/CLIVAR "fast" sea level, SONEL, BODC, OPPE)

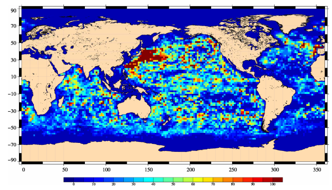
- ~320 tide gauges not uniformly widespread
- Only ~130 reliable time series
- Near real time data
- Time period: 1993-2008



T/S profiles network:

Argo profiling floats array

- Distributed by the Coriolis data center
- 3,000 free-drifting profiling floats
- Near real time data
- Time period: 2004-2008



Altimeter and Tide gauges SSH cross-calibration

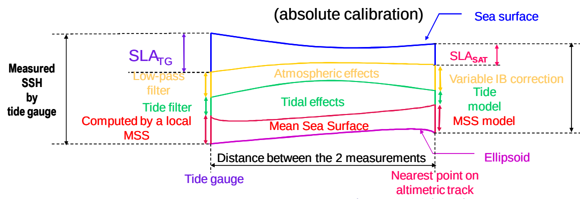
Methodology

1/ SSH calculation :

- The SSH reference is not the same: the Mean Sea Surface has to be removed from altimetric SSH
- Tidal effects (due to the distance between 2 measurements) have to be removed from both SSHs
- Atmospheric effects have to be removed for the same reason
- Vertical movements are corrected on tide gauge measurements using vertical velocities of the Earth's crust recorded by ground stations

Bias = SLA_{SAT} - SLA_{TG} (+/- errors on models and measurements)

(absolute calibration)

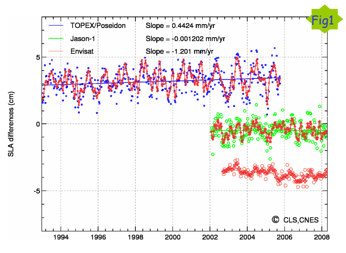


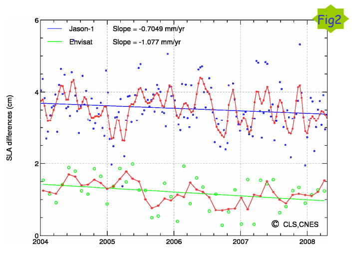
2/ Colocation of altimetric and in-situ data by interpolation on the altimeter time series of the 4 closest altimetric tracks

3/ Editing of tide-gauges time series using the cross-comparison from all the altimeters in order to remove tide gauges with an abnormal behavior (jump, very strong drift).

Estimation of MSL drift

Global MSL drift (derived from Jason-1 and T/P) estimated from tide gauges comparisons is **+0.3 mm/yr +/-0.5 mm/yr**





Trends of differences between altimetric and in-situ tide gauge SLA for TOPEX/Poseidon, Jason-1 and Envisat space missions over all the altimeter period (on left) and from 2004 only (on right).

The MSL altimeter drift estimate is very weak (almost null for Jason-1 and close to +0.4 mm/yr for T/P, see fig. 1). Merging both altimeter missions over the whole period, the global MSL drift becomes close to +0.3 mm/yr.

For Envisat, a negative MSL drift close to -1.2 mm/year is detected from 2002 to 2008 (fig. 1). But focusing only on the end of the period (from 2004), the Envisat MSL drift is now weaker close to -1 mm/yr (fig. 2). Over this period, Jason-1 and Envisat global MSL are in better agreement though a negative trend is displayed (-0.7 mm/yr for Jason-1 and -1.1 mm/yr for Envisat).

The precision of the MSL drift estimation is in the order of 0.5 mm/yr considering the longest altimeter period. It is depending on the accuracy of the colocation method between altimeter and in-situ measurements but also on the accuracy of the vertical movements correction.

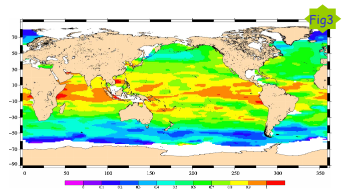
Altimeter and T/S profiles SSH cross-calibration

Methodology

1/ SSH calculation

The physical content of T/S profiles and altimeter SSH is not the same since the T/S profiles contain only the steric part of the altimeter SSH. Thus a method has been developed to compare equivalent physical content applying a regression coefficients grid in the altimeter SSH calculation (fig. 3) as described by Guinehut et al., 2006.

To date, this method does not allow us to know perfectly the altimeter steric part (for instance the regression coefficients grid does not depend on time). Thus, we performed our comparisons using total and steric altimeter SSH content in order to estimate the reliability of the method.

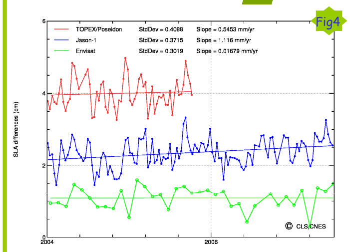


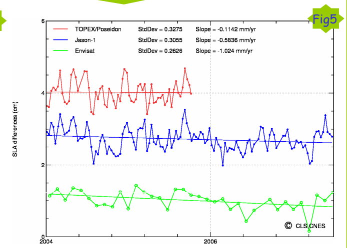
[0-900] m regression coefficicents

2/ Colocation of altimetric and in-situ data are performed by interpolation of altimeter data (from averaged SSH grid over a 10-day period) on in-situ measurements

3/ Validation of T/S profiles using the cross-comparison from all the altimeters in order to remove T/S profiles with an abnormal behavior (jump, very strong drift).

Estimation of MSL drift





Differences between total altimetric and in-situ SLA for TOPEX/Poseidon (red curve), Jason-1 (blue curve) and Envisat (green curve)

Considering all the ARGO data period from 2002 onwards, Jason-1 and T/P SLA comparisons with T/S profiles are very well correlated. A rise is observed from 2002 to 2004 (not shown here). It is completely due to the strong evolution of T/S sampling. The SLA comparison with Envisat from 2002 to 2004 does not show this evolution. This highlights the abnormal behavior of Envisat MSL at the beginning of the mission.

Thus, the MSL drift has to be estimate only from 2004. It is not very relevant for T/P since less than 2 years of T/P data are available. Concerning Jason-1, the +1.12 mm/yr drift obtained using total SLA content becomes -0.58 mm/yr using the altimeter steric content. In the meantime, Envisat MSL drift is respectively +0.02 mm/yr and -1.02 mm/yr, showing in both cases and MSL trend lower than for Jason-1.

The uncertainty associated to the absolute value of the MSL drift estimated here has to be thoroughly studied (it is preliminary results here). However, the most interesting result is the capability of this new method to detect the relative drift between different altimeter missions.

Conclusion

This study aims at demonstrating the capability of these both methods to detect drift or abnormal jump in the SSH provided by altimeters. The calculation of the trend and the comparison with in-situ results can lead to assess the error on the global MSL trend and thus estimate the absolute drift. The cross-comparison between altimeter missions is able to accurately detect the MSL relative bias. Here, we underline the drift of Envisat MSL, especially at the beginning of the time period (2002-2004). Finally, these both methods are complementary as the tide gauge one samples coastal areas with a good time resolution while the T/S has a better space sampling (open ocean) but a lower time resolution.

References :
- Guinehut, Le Traon and Larnicol, 2006: *What can we learn from Global Altimetry/Hydrography comparisons?*
- Poster, S. Guinehut, C. Coatanoan, A-L Dhomps, P-Y Le Traon and G. Larnicol: *On the use of Satellite Altimeter Data in ARGO Quality Control*

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