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Global and Regional ocean thermosteric sea level change from in-situ data: Influence of sampling, complementarities with satellite data, role of salinity

-I- Objectives

Global and regional mean sea level anomalies from altimeter measurements and thermosteric and steric sea level from in-situ T and S profiles for the layer (0-700) m are studied in order to quantify :

- the influence of sampling of the in-situ data set
- the complementarities between the in-situ and altimeter measurements
- the role of salinity

-II- Data sets

Data sets involved in this study include :

- Delayed mode maps of SLA from the SSALTO/DUACS center (1/3° horizontal grid, weekly) (Ssalto/Duacs User Handbook , 2006)
- T and S in-situ profiles from the ENACT/ENSEMBLE-EN2 data base for the years 1993-2004 (Ingleby and Huddleston, 2006)
- T and S in-situ profiles from the CORIOLIS data base for the years 2005-2006 (http://www.coriolis.eu.org/)

-III- Mapping method

Before all analysis, global maps of thermosteric sea level are constructed at a monthly period from the individual T profiles. The mapping method is very similar to the one developed by Larnicol et al. (2006). It is based on an optimal interpolation method with :

- temporal correlation scale of 45 days,

- spatial correlation scale – 5 times the one used to produce the SSALTO/DUACS SLA maps (from 1500 km at the equator to 700 km at 50°N),

- error associated to each in-situ measurement equal to 20 % of the variance of the SSALTO/DUACS SLA maps, in order to take into account error associated to aliasing of the mesoscale variability.

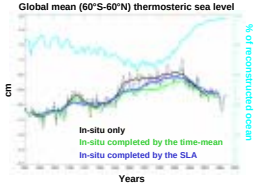
The time-mean and seasonal cycle were removed from the altimeter and in-situ data prior to mapping.

-V- Global ocean thermosteric sea level

Three tests have been performed in order to calculate the Global mean thermosteric sea level variability :

- Test 1 (black curve) : from non global in-situ mapped fields
- Test 2 (green curve) : from global in-situ mapped fields completed by the time-mean field (static field during the whole period)
- Test 3 (blue curve) : from global in-situ mapping fields completed by "steric" SLA fields (time-variable fields)

The "steric" SLA fields are deduced from regression coefficients computed from a global altimeter/in-situ comparison study (Guinehut et al., 2006)



➔ Global tendency are very similar but trends can be quite different

➔ Results are sensitive to the method used to complete or not the fields – particularly when the % of the reconstructed ocean is lower

➔ Which one tells the truth ??

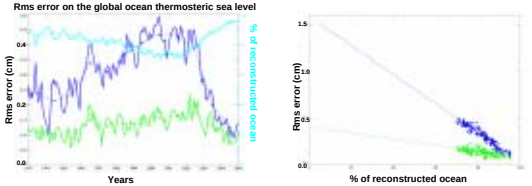
-IV- Error on the global ocean thermosteric sea level

Error on the global ocean thermosteric sea level have been estimated in a very similar way as in Lyman et al. (2006) :

- 13 Reference fields : 1993 to 2005 annual means of SLA maps
- 13 sets of simulated observations : each reference fields sub sampled by the 1993-2004 in-situ T profiles (date and position)
- 13 sets of reconstructed fields : monthly SLA maps calculated from the simulated observations from 1993 to 2004

➔ Error : rms of the differences between the reconstructed fields and the reference fields as global averaged for the 13 realizations

- Test 1 (green curve) : reconstructed fields not complete = global averaged value calculated only on the reconstructed areas
- Test 2 (blue curve) : reconstructed fields complete = maps have been completed by zero values when missing



➔ Test 1 minimizes the error since it assumes that the missing field is centered around zero

➔ Test 2 maximizes the error since it assumes that the missing field is everywhere equal to zero

✓ We assume that the true error might be somewhere between the blue and the green curve

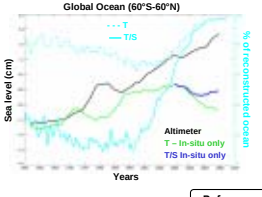
✓ A strong correlation is found between the error and the % of reconstructed ocean

➔ A good tool to infer the error, to anticipate the in-situ observations needed in term of array design experiment

➔ Error values can be very high (from **0.5 to 1.5** cm) in very low sampled regions

➔➔ important impact on the results interpretation

-VII- Global ocean steric sea level



At a global scale, it is also only possible to calculate steric sea level since the year 2003 :

- salinity reduces the observed cooling
- a slight steric sea level rise seems to be observed since 2005

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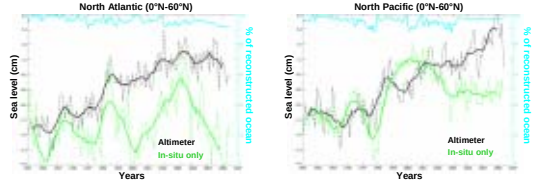
-VI- Regional ocean thermosteric/steric sea level

Interannual variability of thermosteric sea level is studied in North Atlantic and North Pacific regions which are very well sampled by T measurements during the past 14 years (90% of ocean reconstructed). Thus results for Test 1 to Test 3 are very similar and associated error assumed to be small.



North Atlantic and North Pacific thermosteric sea level show very strong interannual variations :

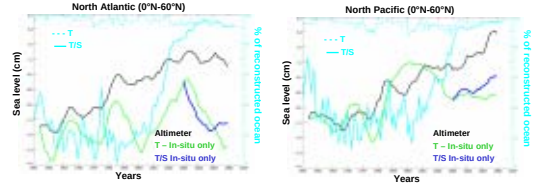
- Particularly, the 2.8 cm drop from 2003 to 2006 in the Atlantic seems to compensate the 2000-2003 2.8 cm rise. Two very similar structures but of lower amplitudes are found at the beginning of the period.

- In the Pacific, the 1997 drop is followed by a very important rise.

These signals have not always a very clear signature in the altimeter measurements but seem to be associated to internal variability of the system.

Greiner et al. (2006) have showed that in the North Atlantic Ocean, the S compensate partly the T effect by reducing the amplitude of the interannual variability. They also showed that the 700m-bottom signal implies a reduction in sea level trend for the 1993-2001 period.

Due to the lack of S measurements (see the turquoise lines), it is only possible to calculate steric sea level since the year 2003 :



➔ Comparisons between the green and the blue curves show the very strong influence of salinity

-VIII- Conclusions and Perspectives

- Errors on the ocean steric/thermosteric sea level variability can be estimated from the % of the reconstructed ocean by the given array
- Very strong interannual variability associated to basins dynamics are observed in the North Atlantic and Pacific basins
- Since the year 2003, it is possible to include the salinity effect in the steric sea level calculation ➔ the salinity reduces the global cooling and the steric sea level is rising since 2005
- Thanks to the Argo array, it should be possible to study the steric sea level variations for the (0-1000) m layer
- Steric sea level calculated from T and S in-situ profiles have to be compared to estimate from combined GRACE and Jason-1 data (Lombard et al., 2006)