On the Sea Level Rising Rate Since 1993

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Introduction

The rate of global mean sea level rise over the last two decade (1993-2010) determined from TOPEX/Poseidon altimeter measurements is 2.89 mm/yr, which is significantly larger than estimates (1-2 mm/yr) of the 20th century linear trend for sea level rise [Church et al.,2001], and have raised the discussion on whether sea level rise is accelerating. Sea level change is one of the direct socioeconomic consequences for global warming. Thus it is necessary to describe the low-frequency change of sea level at long-term scale, and to identify the causes of these changes.

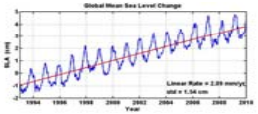
Measurements of present-day sea level change rely on two different techniques:

- tide gauge measurements
- satellite altimeter measurements

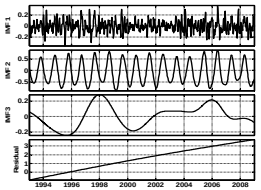
Other measurements provide constraints on different aspects of sea level change.

Owing to the advantages of processing non linear and non station data, EMD method help us to analysis the global sea level change. Using the intrinsic trend we describe the sea level change and determine to identify the contribution from thermal expansion to sea level rise.

1. Global mean sea level variability



(Top) Sea level curve from TOPEX/Poseidon and Jason-1 satellite altimetry over 1993 – 2010 (data averaged over 60°N and 60°S).



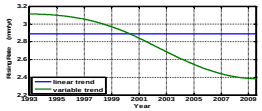
(Middle) Ensemble empirical mode decomposition of global mean sea level based on satellite altimeter.

The first component is high frequency signal, which is related to high frequency variable process.

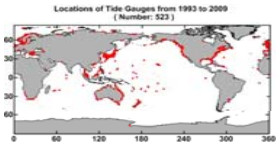
The second component means significant annual cycle signal.

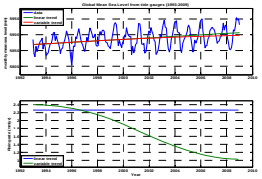
The third component means inter-annual oscillation.

The last component is monotonic function within the given data span, which is intrinsic trend.



(Bottom) Although the global mean sea level kept rising, the rising speed has decreased from 3.13 mm/yr in 1993 to 2.37 mm/yr in 2010, which is lower than the expected minimum mean linear rate 2.89 mm/yr.

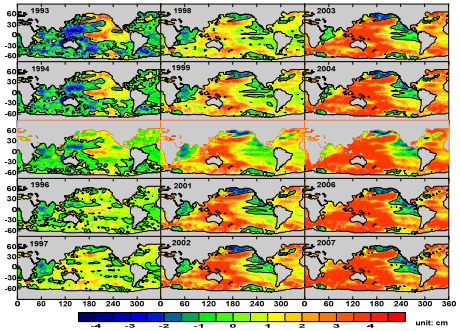




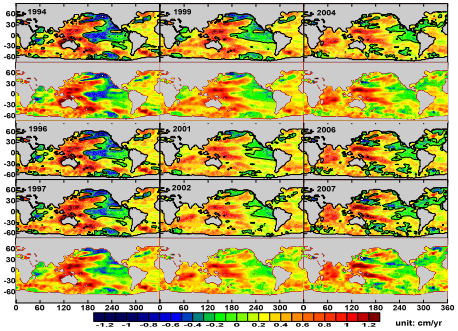
Compared to the tide gauge measurements during the same period the result shows that the global averaged sea level kept rising, but the rising rate has declined since 1993.

The data sources is PSMSL.

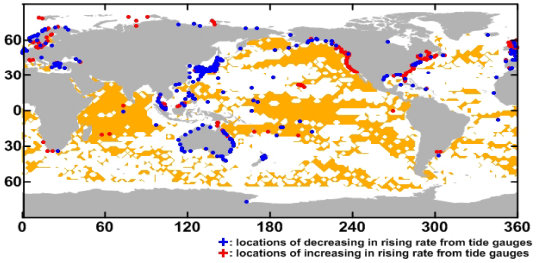
2. Regional distribution of Sea level variability



Map of the geographical distribution of sea level intrinsic trend over 1993 – 2008 computed from TOPEX/Poseidon altimetry.



Map of the geographical distribution of sea level rising rate over 1993–2008 computed from TOPEX/Poseidon altimetry.



Map of geographical distribution of sea level acceleration over 1993 – 2010. Contours in light yellow represents acceleration whereas light blue denotes deceleration, which is coincide with tide gauges results.

Statistically, 60% of the 472 tide gauges show that the rising rate is decreasing.

3. Influence factors of sea level rise

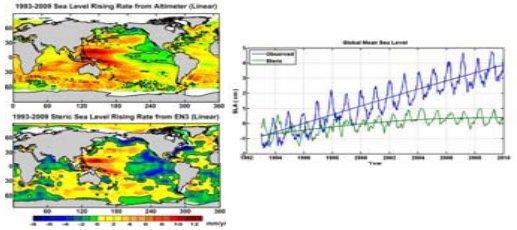
Global mean sea level change results from two major processes:

- the volume of water in global ocean: thermal expansion --- *steric sea level*
- the exchange of water between ocean and other reservoirs (glaciers and polar ice caps/sheets) --- *eustatic sea level*

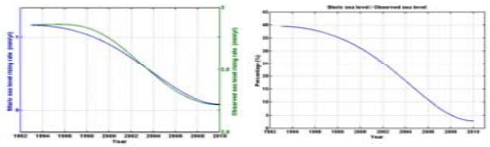
The thermosteric sea level is further obtained by vertically integrating density anomalies at each grid point and each time step according to:

$$h_{steric}(x,y,t) = \int_{-H}^{0} \frac{\rho_0(x,y,z) - \rho(x,y,z,t)}{\rho_0(x,y,z)} dz$$

(Gill, 1982)



Comparison of sea level linear trend maps of (top) total sea level derived from altimetry and (bottom) thermosteric sea level based on the EN3 data for the time span 1993-2009.



The upper 700 m steric sea level rising rate is reduced significantly, which is quite coincided with the sea level rising rate from satellite results.
Averaged contribution from thermal expansion to sea level rise has dropped from 40% before 1994 to 3% at the end of 2009.

Conclusions

- Although the global mean sea level kept rising over the period 1993-2009, the nonlinear sea level rising speed has decreased, which is consistent with the nonlinear warming rate of the global upper 700 m ocean heat content during the same period.
- If global mean sea level keeps rising with current rate, the projected sea level would rise no more than 4.08cm±0.86cm in the next two decades, which is considered the annual oscillation and seasonal oscillations.
- Regional distribution of sea level rising rate from satellite altimeter coincided with tide gauge's results.
- Averaged contribution from thermal expansion to sea level rise has dropped from 40% before 1994 to 3% at the end of 2009.
- Since the beginning of the 21st century, glaciers melting accelerate with global temperature rising. The mass of cold water has increased, which restrain the effect of thermal expansion.

Reference

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