THERMAL EXPANSION OVER THE PAST 50 YEARS :
INFERENCE ON OCEAN MASS CHANGE AND SEA LEVEL RISE

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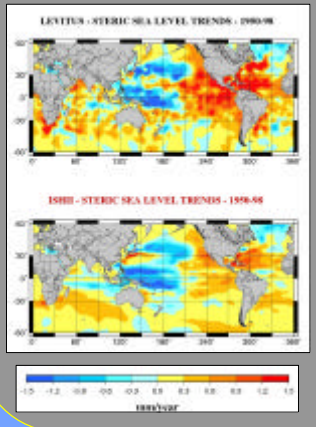
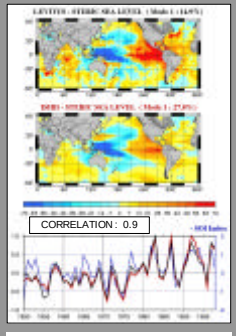
SUMMARY. We investigate the thermosteric (i.e., due to temperature only) sea level change over the last 50 years using two global ocean temperature data sets recently published (Levitus et al., 2000 and Ishii et al., 2003). These data sets which pro vide gridded temperatures, down to 3000 m and 500 m respectively, are based on objective analyses of raw historical profiles over 1950-1998. We find that the two data sets compare well, both in terms of thermosteric sea level trends and global mean, altho ugh some difference is noticed beyond 1990 for the latter. Analyses based on 'Emprical Orthogonal Functions' show that the interannual variability of the thermosteric sea level is dominated by the signatures of El Nino Southern Oscillation and Pacific Dec adal Oscillation. Some correlation is also noticed with the North Atlantic Oscillation. As a result, regional thermosteric sea level trends are not stationary on a multi-decadal time-scale and have a typical life-time on the order of a few years.

We also compare sea level series and trends observed at a few selected tide gauges of good quality record with thermosteric sea level series and trends over 1950-1998 using the two gridded ocean temperature data sets. We note high thermosteric rates at si tes located along the northeast coast of the USA, north of 37°N, when using the Levitus et al. data. Much smaller rates are obtained with the Ishii et al. data. Elsewhere, thermosteric rates agree reasonably well whatever the data used. Excluding the nort heast US coastline sites north of 37°N, we note that, in spite of a significant correlation, the thermosteric trends are much too small to explain observed trends After correcting for thermosteric sea level trends, residual (observed minus thermosteric) trends have an average value of 1.4 ± 0.5 mm/yr, which should be of eustatic (i.e., due to ocean mass change) origin. This result confirms recent investigations (Miller and Douglas, 2004) suggesting a dominant eustatic contribution to last decades mean se a level rise.

THERMOSTERIC SEA LEVEL TRENDS FOR 1950-98 BASED ON LEVITUS (up) AND ISHII DATA (down)



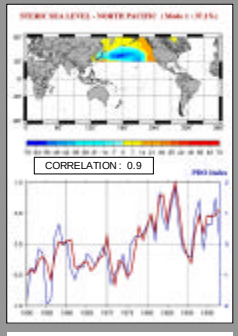
EOF MODE 1 OF THERMOSTERIC SEA LEVEL for 1950-98



ENSO

Maps show the geographical patterns for **Levitus** and **Ishii** thermosteric sea level data. Curves show the temporal evolution on which is superimposed the SOI index.

EOF MODE 1 OF THERMOSTERIC SEA LEVEL (NORTH PACIFIC ONLY) for 1950-98

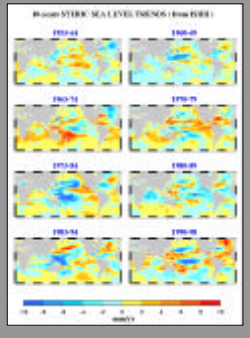


PDO

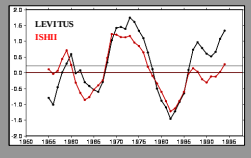
On the temporal curve is superimposed the Pacific Decadal Oscillation (PDO Index). Note the high correlation (0.9) between the two curves.

NON STATIONARY PATTERNS

Geographical distribution of thermal expansion for successive and overlapping 10-year periods, from Ishii data set.



10-YEAR PERIOD GLOBAL MEAN SEA LEVEL TRENDS (MM/YR)



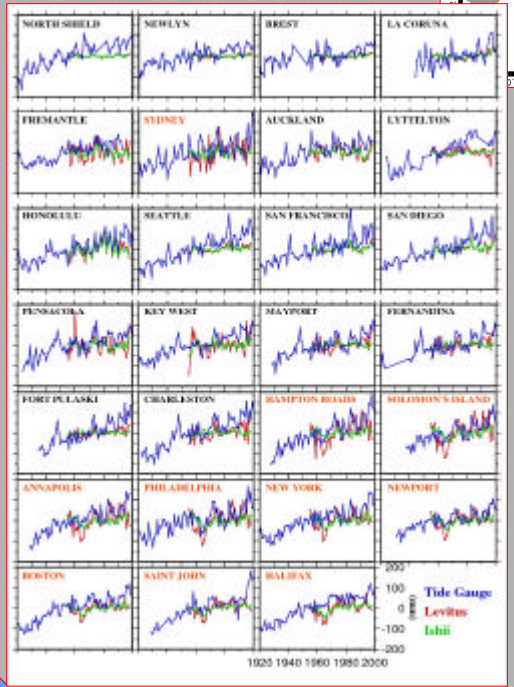
CONCLUSIONS

Thermosteric sea level variations are dominated by the decadal oscillations of the main coupled ocean-atmosphere climatic perturbations (ENSO, PDO and NAO).

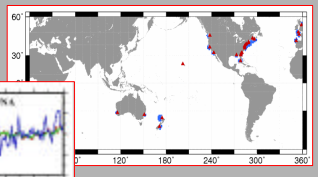
Thus thermal expansion patterns are not stationnary in time. Their life time seems to be on the order of 10 years.

SEA LEVEL COMPARISONS

Sea level records at 27 historical **tide gauges** having long, good quality records (blue curves). The red and green curves show the thermosteric sea level computed with the **Levitus** and **Ishii** data respectively, interpolated in the vicinity of the tide gauge sites.

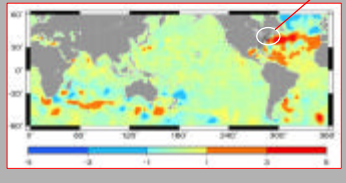


LOCATION OF THE 27 TIDE GAUGES USED IN THIS STUDY



DEEP CONTRIBUTION (500m-3000m) FROM LEVITUS DATA

Map of the difference between thermosteric sea level trends based on Levitus data down to 3000m and Levitus data down to 500m. Note the high positive anomaly in the Gulf Stream region.

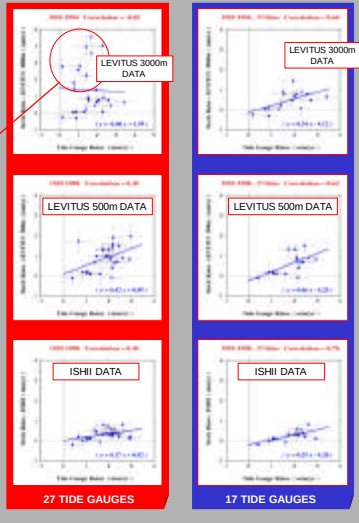


REGRESSION BETWEEN OBSERVED AND THERMOSTERIC TRENDS

First case : 27 tide gauge sites.
Note the very poor correlation between 27 tide gauge trends and Levitus 3000m-derived thermosteric trends, and the huge dispersion of trends.

Second case : 17 tide gauge sites.
Plots are the same as for the case before, but without the 10 sites located in the region of abnormaly high thermosteric trends (Northeast US coastline, north of 37°N). Note the much higher correlation between observed and thermosteric trends.

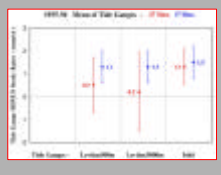
REGRESSION PLOTS BETWEEN TIDE GAUGE TRENDS AND THERMOSTERIC TRENDS OVER 1955-98



RESIDUAL TRENDS

Observed by tide gauges minus thermosteric trends for 3 cases : Levitus data down to 500m, Levitus data down to 3000m, and Ishii data (down to 500m). Red and blue dots correspond respectively to the **27 stations** and the **17 stations**.

RESIDUAL TRENDS



CONCLUSIONS

Despite a good correlation after excluding sites in the problematic region of the northeast US coast, we note that – whatever the data set used – thermal expansion appears too small to account for the rate of sea level rise observed by tide gauges : residual rates have an average value of 1.4 ± 0.5 mm/yr, which should have an eustatic origin.

This new analysis confirms the result of Miller an Douglas (2004), that a dominant water mass contribution is needed to explain the rate of last decades sea level rise observed by tide gauges.

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