Quantifying the respective contribution of wind stress and diabatic forcing to decadal temperature changes and regional sea level trends over 1993-2010 based on ECCO solutions

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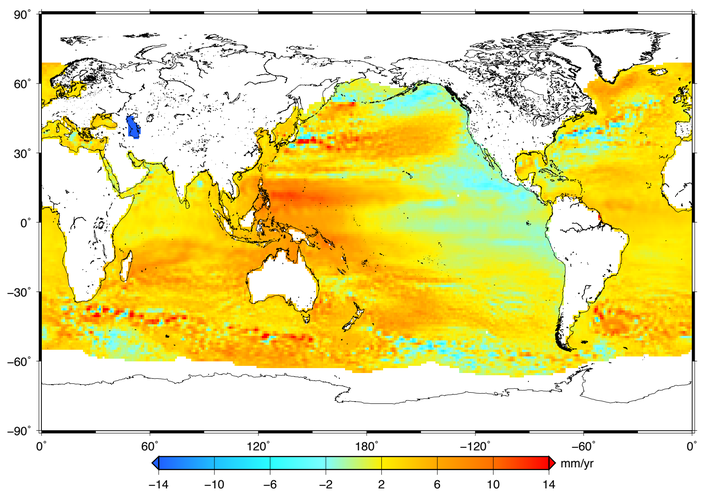
Introduction

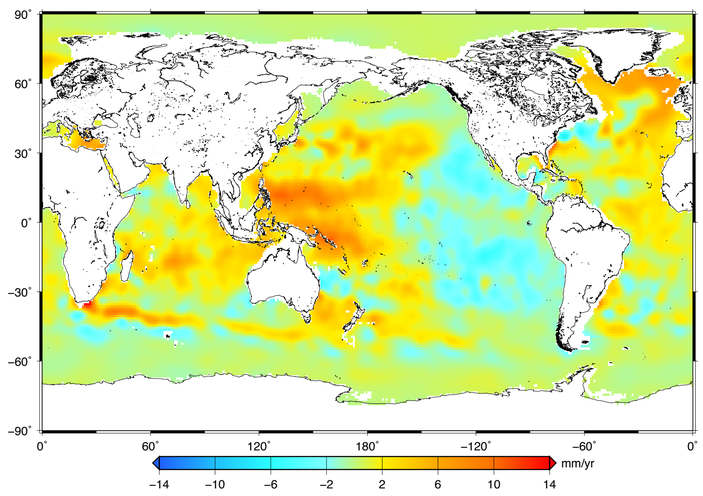
Sea level rise is one of the most important consequence of actual global warming. This rise has been recorded with satellite altimetry measurements and accounts for ~3.3 +/- 0.4 mm/yr since 1993 and, sea level trends display a large regional variability. Some regions experience a sea level rise (e.g., the west tropical Pacific ocean, the subpolar north Atlantic ocean …) whereas other regions experience a sea level drop (e.g., the east tropical Pacific ocean, golf of Alaska …) over 1993-2010 (Ablain et al., 2009). Those sea level trends appear to be steric in nature. Moreover, steric changes appear to be mainly thermosteric, although halosteric effects can reduce or enhance thermosteric changes in some specific regions (Stammer et al., 2013). In this study, we analyze the ocean heat content change and its origin by analyzing Estimating the Circulation and Climate of the Ocean (ECCO, Wunsch et al., 2009). We run different experiments to estimate and quantify the respective contribution of atmospheric forcing (e.g., wind stress and diabatic forcing) to heat content change and regional thermosteric sea level trends.

Observed sea level trend maps

Observed sea level trend map over 1993-2010



Thermosteric sea level trend map over 1993-2010



Data

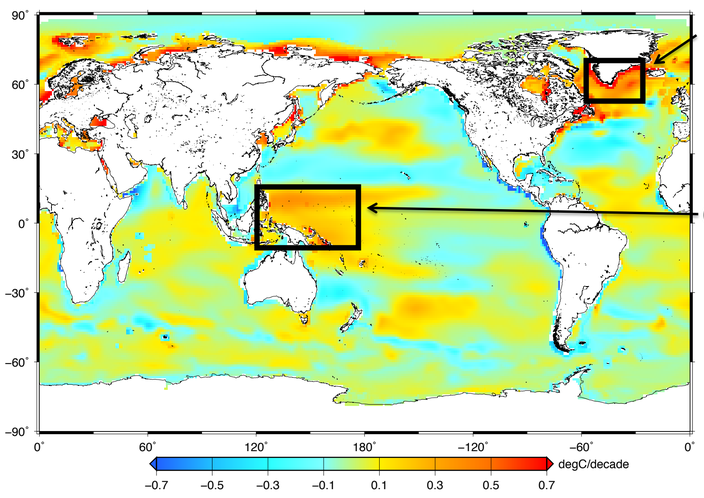
✓ Satellie altimetry data from AVISO (Ablain et al., 2009)

✓Temperature estimate from Levitus et al. (2009; 2012)

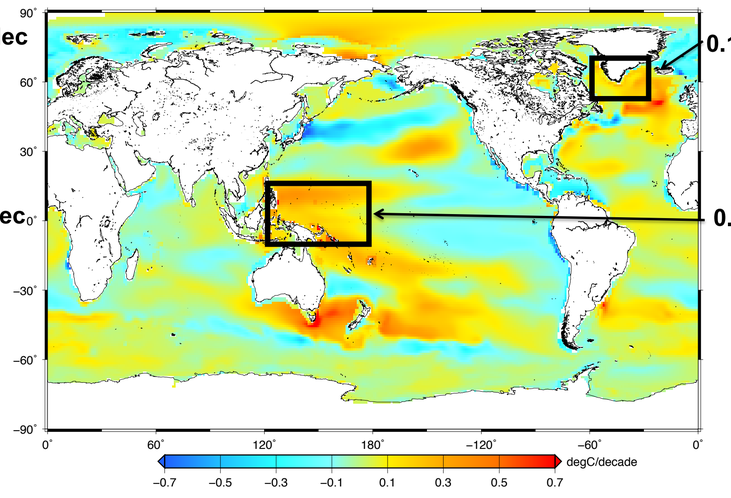
✓Estimating the Circulation and Climate of the Ocean solution (ECCO, Wunsch et al., 2007) Version4, Iteration 9.

Mean temperature trend maps over 1993-2010 (0-700m contribution)

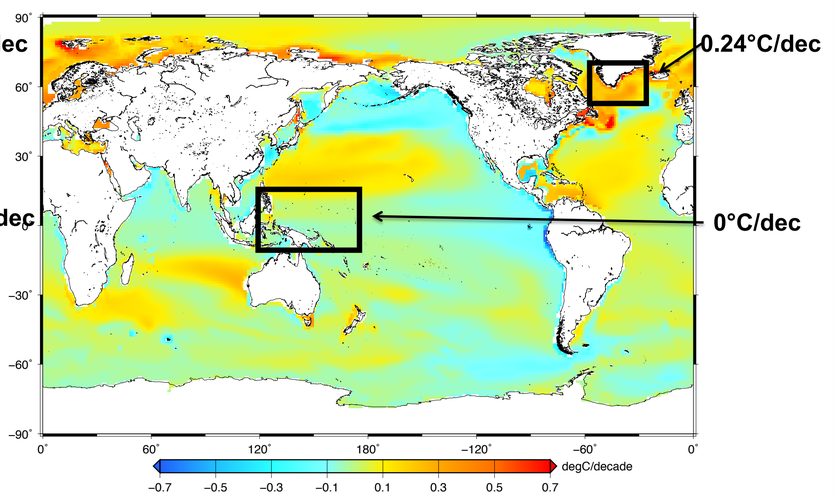
Net atmospheric forcing trend contribution



Wind stress trend contribution

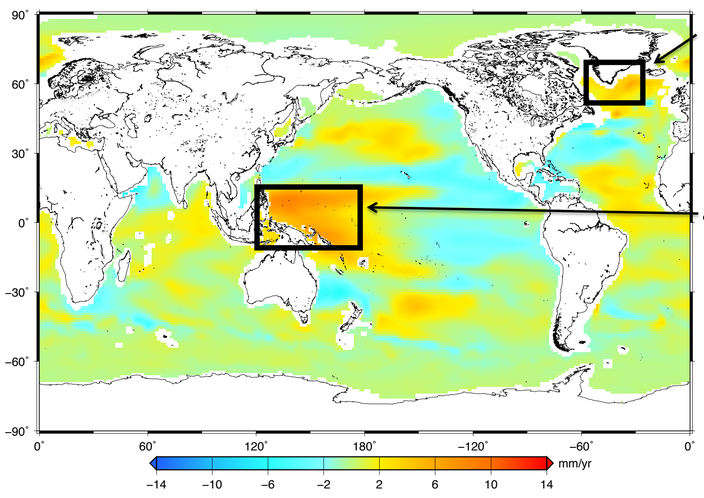


Diabatic forcing trend contribution

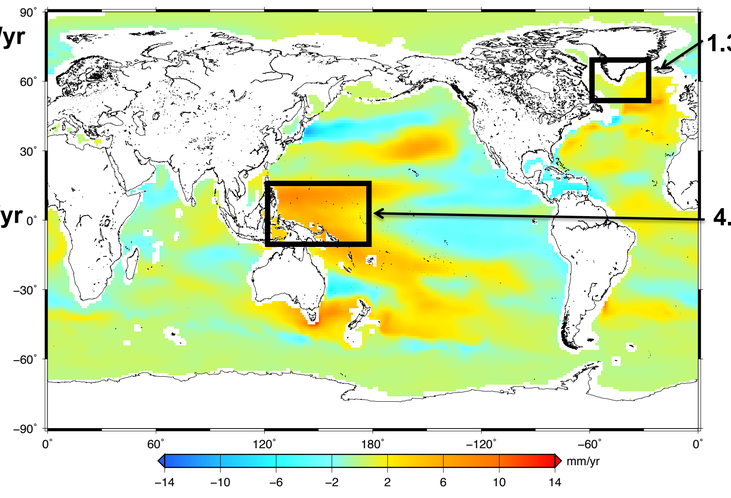


Thermosteric sea level trend maps over 1993-2010 (0-700m contribution)

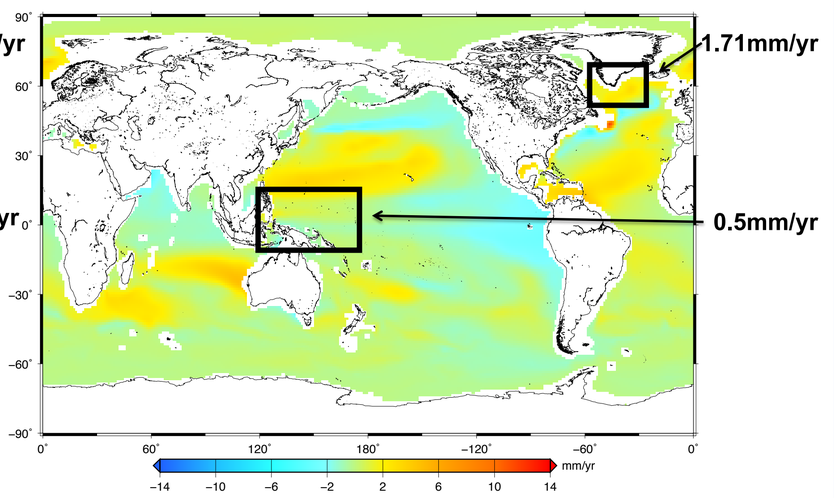
Net atmospheric forcing trend contribution



Wind stress trend contribution



Diabatic forcing trend contribution



Conclusion

In the present study, we investigate the respective contribution of atmospheric forcing (i.e., wind stress and diabatic forcing trends) using ECCO estimate to ocean heat content and thermosteric sea level trends over 1993-2010. We confirm the linear response of wind stress trend contribution to the west tropical Pacific ocean warming and regional sea level rise which has been previously reported by recent studies (Timmermann et al., 2010; Merriefield et al., 2012 …). However, in some regions, it appears to be more complex. For instance, the subpolar north Atlantic ocean experiences a warming over 1993-2010 with a rate of 0.37 °C/decade with 35% due to wind stress trend contribution and 65% due to diabatic forcing trend contribution. Further investigations using ECCO solutions are needed to better understand and ascertain the physical processes involved in the regional variability of ocean warming and its impact on sea level variability.

References

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- Timmermann et al., Journal of Climate, 2010.
- Wunsch et al., Oceaography, 2009.