Sea level rise from satellite altimetery:Estimation of thermal expansion contribution using the ARGO float data and short-term disturbances by ENSO

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In recent years, global warming and sea level rise have been drawing a hot attention. The sea level rise has two major causes, i.e. (1) inflow of melt water to the sea from continental ice sheets and mountain glaciers, and (2) thermal expansion of seawater. The foci of the current discussion include the relative importance of these two contributions and the existence of the accelerating sea level rise. In addition to such secular components, the global mean sea level rise is modulated by interannual changes of the total land water storage by climate variations such as ENSO (El Nino Southern Oscillation), which alters rainfall patterns in a global scale. It is important to effectively remove this contribution to study, e.g. in identifying the acceleration in the current sea level rise (Yi et al., 2017 GRL). Here we study the two issues, i.e. ENSO contribution and thermosteric contribution in the global sea level rise, using the two data set, satellite altimetry and Argo floats.
The satellite altimetry data have globally uniform precision, and are available since the launch of the TOPEX/Poseidon satellite in August 1992. The ARGO is an international project to obtain temperature and salinity profiles of the ocean down to 2,000 m in depth. Many ARGO floats have been working In the worldwide ocean since 2005, and its number is about 3,900 right now.
First we analyzed the time series of the global mean sea level rise by satellite altimetry since December 1993 and found that the global mean sea level rise rate is about 3.0 mm/year. We also analyzed regional average sea levels, and compared the average rate and the characteristics of seasonal changes. We then analyzed the time series of the thermosteric sea level changes at grid points from the Argo float temperature profiles since 2005. We found that the changes are faster in tropical oceans including area around India, and that the sense of the change is different in the eastern and western parts of the equatorial Pacific Ocean. The northern Atlantic Ocean showed complicated behaviors. As the global average, the thermosteric sea level rise rate was about 1.4 mm/year, nearly one half of the total rate.
Second, we examined the influence of ENSO on the mean sea level in regional and global scales. We used sea surface temperature (SST) anomaly in the NINO.3 region as the ENSO index. The NINO.3 SST showed a significant positive correlation with the residual of global mean sea level from the best-fit quadratic polynomial model. This possibly reflect the change of total ground water storage by changing precipitation pattern by ENSO. We tried to correct sea level data using ENSO index using a simple model to obtain “ENSO-free” time series of the global mean sea level. This was successful to some extent, but the large global sea level drop associated with the 2010-2011 La Niña episode was not removed efficiently due possibly to the contribution from other climate changes like the Indian Ocean Dipole.

Keywords: Sea Level Rise, ARGO float, Satellite altimetry, ENSO, GMSL, Steric change

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