Toward Closing the Sea Level Budget on Regional to Global Scales

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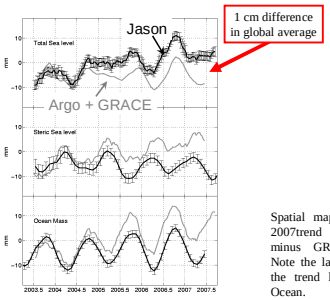
Background

Understanding the causes of sea level rise in a warming climate remains one of the major challenges for predicting climate change in the 21st century. Three global observing systems currently provide independent observations of sea level rise and its two major components, changes in ocean mass and steric variability. Recent work suggests that Jason, GRACE and Argo have the required precision to close the sea level budget on seasonal to interannual time scales, attributing globally averaged sea level rise to either upper ocean thermal expansion or increases in ocean mass. Despite this, significant discrepancies remain between sea level rise and its components, with the total sea level rise observed by Jason outpacing the components by almost 1 cm over 4 years. Regional analyses show a seasonal discrepancy of approximately 1 cm amplitude in the Tropical Pacific and a very secular discrepancy over most of the Indian Ocean

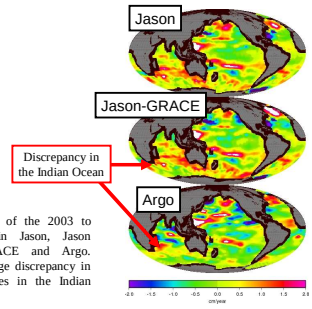
Discrepancies in the Sea Level Budget

Globally averaged Sea Level Observations



The thick black curves show observed sea level rise from the altimeter (top) steric sea level from Argo (middle) and ocean mass from GRACE (bottom). Gray curves show inferred estimates made by adding or subtracting the other two.

2003-2007 Trend

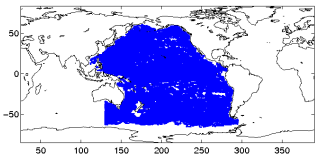


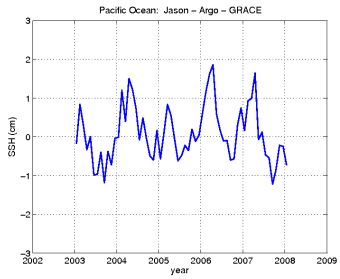
Spatial map of the 2003 to 2007trend in Jason, Jason minus GRACE and Argo. Note the large discrepancy in the trend lies in the Indian Ocean.

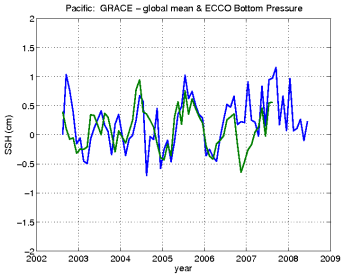
Discrepancies in the Sea Level Budget by Basin

Discrepancies in the three observing systems (Jason, GRACE and Argo) were tested using AVISO maps interpolated to the time and location of each Argo profile. Steric height was computed using both temperature and salinity. Subtracting steric height from interpolated AVISO prior to averaging over the basins dramatically reduces sampling error. The basin averages were then compared with basin averages from GRACE. GRACE basin averages (with the global ocean average removed) were also compared with basin average bottom pressure in an ECCO forward model run.

Pacific

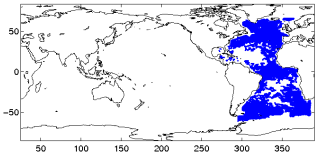




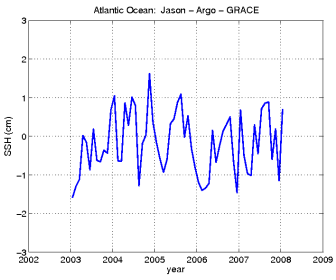


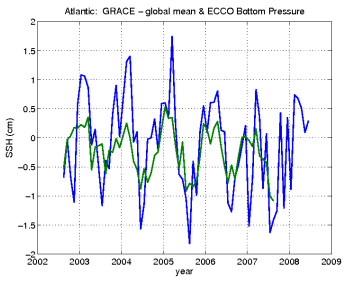
The discrepancy in the Pacific has a clear seasonal signature. Furthermore, GRACE agrees very well with bottom pressure as simulated by the ECCO model. This suggests a problem in either Jason or Argo. Because of the uniform sampling of the Argo array, it seems more likely to be an issue with Jason. Averages over the tropics suggest that most of the seasonal discrepancy originates at low latitudes.

Atlantic

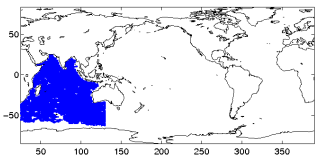


The sea level budget in the Atlantic closes fairly well. Month-to-month discrepancies can be as large as 1 cm. GRACE bottom pressure also agrees well with ECCO.





Indian



The discrepancy in the Indian Ocean is very linear, with Jason – Argo increasing slightly and GRACE decreasing slightly over this period. GRACE suggests that the Indian Ocean should be losing mass, however, the ECCO model does not simulate this mass loss.