Geophysical Research Abstracts
Vol. 17, EGU2015-549, 2015
EGU General Assembly 2015

Informing a strategy for Deep Argo temperature observations

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The ocean has the largest available capacity for heat uptake in the Earth's climate system. However, sparse and infrequent measurements of ocean temperatures below 2000 m limit our ability to observe deep ocean heat content changes and therefore close the global heat budget. Recent analyses of surface temperatures and ocean heat content variability have suggested that variations in ocean heat uptake may have played a role in the recent 'hiatus' in surface temperature trends. Such results highlight the importance of improved estimates of top-to-bottom ocean heat content changes to progress our understanding of internal climate variability and advance projection capability for future climate change and sea level rise.

We present results from state of the art climate model experiments that inform the optimal design of a deep ocean observing system of automated floats that repeatedly sample to either 4000 or 6000 m and transmit data via satellite (a deep water extension of the current core Argo array). Using long control simulations and forced experiments, we consider to what depths and in which regions we need observations to effectively capture internal variability of temperature in the oceans and emergent signals of climate change.

Our results highlight the continuing importance of the core Argo array (to 2000 m) for measuring total ocean heat content variability accurately (with associated implications for climate prediction and sea level rise estimates). In forced scenarios we find additional deep ocean sampling below 2000 m is essential in most ocean basins to accurately estimate total ocean heat content changes, but monitoring in the Atlantic and Southern Ocean is most critical. In a likely future forced scenario, regions for additional sub-2000 m sampling are the Indian Ocean and southern/westerly Pacific Ocean. Model estimates suggest that over the next century, global sampling to 4000 m would offer a $\sim$10% improvement on the percentage of total ocean heat content variability captured compared to global sampling to 2000 m.

Analysis of model output indicate that deep ocean sampling below 2000 m is much more important in some areas than others. For example, we highlight the particular importance of monitoring temperature changes in the Southern Ocean to at least 4000 m to gain accurate estimates of global ocean heat content change and the thermosteric component of sea level rise. Our work indicates that more than half of the total ocean heat content variability in the Southern Ocean is deeper than 700m.