Development of Global Heat and Freshwater Anomaly Analyses

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Project Summary

We perform analyses of ocean heat content and salinity distribution and their variability to assess the role of ocean heat and freshwater storage in climate change. These assessments include quantification of year-to-year global upper (0-750 m) ocean heat content changes and global ocean surface salinity changes for the annual NOAA-led *State of the Climate* report, published as a supplement to the *Bulletin of the American Meteorological Society* (BAMS). We also work to quantify errors in estimates of upper ocean heat content, and to reduce those errors as feasible. We are also making global assessments of decadal abyssal ocean warming. These analyses are important for climate sensitivity, climate commitment, and sea level rise assessments and studies.

Understanding global climate variability requires knowledge of ocean temperature and salinity fields (or more precisely ocean heat and fresh water content). Accurate estimates of changes in distribution of ocean heat and fresh water content combined with analyses of how thermohaline (temperature-salinity) anomalies enter, circulate within, and leave the ocean are necessary to monitor and understand interannual to decadal changes in climate. Such fields and analyses help to verify climate models and improve their predictive skill. They also help to diagnose the components of sea level change (ocean temperature variations versus ocean mass variations) and radiative imbalance (net energy through the top of the atmosphere versus rate at which the oceans and rest of the earth warm).

This project is developing, updating, and analyzing global analyses of ocean temperature and salinity using quality-controlled compilations of in situ temperature and salinity data from CTD-equipped autonomous profiling floats (Argo), shipboard Conductivity-Temperature-Depth (CTD) instruments, eXpendable Bathy Thermographs (XBTs), moored buoys, and other sources. These data are used to estimate global ocean temperature and salinity fields, hence upper ocean heat and freshwater content variations, on annual time-scales. Historically, in situ data distributions are relatively sparse, especially before the advent of Argo. However, variations in upper ocean heat content are closely related to variations in sea-surface height, which has been very well measured since 1993 by satellite altimeters. By exploiting this close relationship, we are able to quantify sampling errors inherent in estimating a global average of upper ocean heat content from an incomplete data set. We also exploit the relationship to improve maps of upper ocean heat content from in situ data by using the altimeter data with local correlation coefficients applied as a first guess at upper ocean heat content in poorly measured regions. We exploit recent Argo data to map salinity fields in recent years, helping to assess the roles of ocean salinity in diagnosing and forcing climate variability. Furthermore, we analyze deep ocean temperature changes as data become available, and assess their contributions to global ocean heat content and sea level budgets.

By providing analyses of ocean data this project helps NOAA to use and assess the effectiveness of the sustained ocean observing system for climate, including developing a GPRA for ocean temperature measurements. We present some of our products in the NOAA-led annual BAMS *State of the Climate* report. Our customers include the climate modelers, the scientific climate community, and assessments such as those of the Intergovernmental Panel on Climate Change. The work is primarily carried out at NOAA's Pacific Marine Environmental Laboratory by the PMEL and JIMAR investigators, but in close consultation with the co-investigator at NASA's Jet Propulsion Laboratory.