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Estimating upper ocean heat content

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The majority of the Earth's total energy uptake since the 1970s has occurred in the upper ocean, but underlying uncertainties are difficult to quantify, limiting our ability to assess closure of sea-level budgets, the global radiation imbalance, and climate models. We examine two sources of uncertainty that contribute to differences among global average annual upper ocean heat content anomaly (OHCA) curves over recent decades. Firstly, prior to the achievement of global coverage of Argo Program profiling Conductivity-Temperature-Depth (CTD) instrumented floats around 2005, ocean temperature sampling is inhomogeneous and often sparse. This sparseness, with large undersampled regions in many years, increases the errors in estimating global average annual OHCA and in constructing a climatology from which to estimate local OHCA. For instance, assuming zero OHCA in unsampled regions when constructing a global average generally yields smaller OHCA trends than assuming that the averages of OHCA in sampled regions is representative of the global average. This mapping error generally gets larger further back in time, especially prior to 1970 when the sampling is quite sparse. Secondly, the instrumental composition of the observing system has changed over time, and biases in temperature measurements by some instrument types require correction to increase the accuracy of global annual mean OHCA values. For instance, less accurate expendable bathythermograph (XBT) data appear in the archives from 1966, with numbers peaking in 1990, whereas more accurate Argo float CTD data begin around 2000, and build to near full strength around late 2007. The XBT data require a time and instrument-dependent bias correction for depth errors. There are several proposed corrections in the literature, and optimizing the corrections is still an area of active research. During the time the XBT data are predominant in the temperature record, after 1970 but before Argo, sampling errors are smaller than for earlier periods, but the remaining uncertainty in the bias corrections is then one of the larger sources of error in global annual average OHCA estimates.