Evaluation of the Ocean Observing System for Ocean Heat Storage Studies

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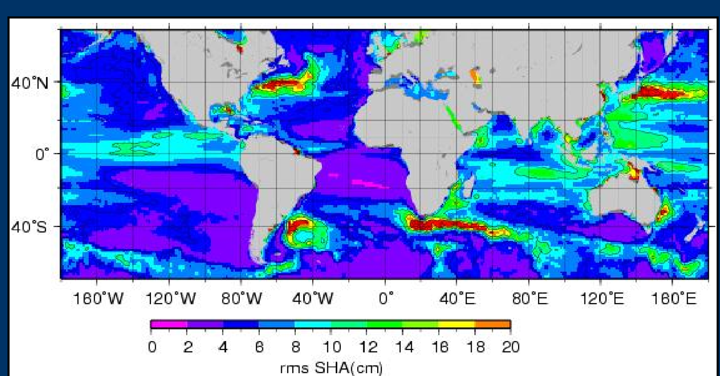
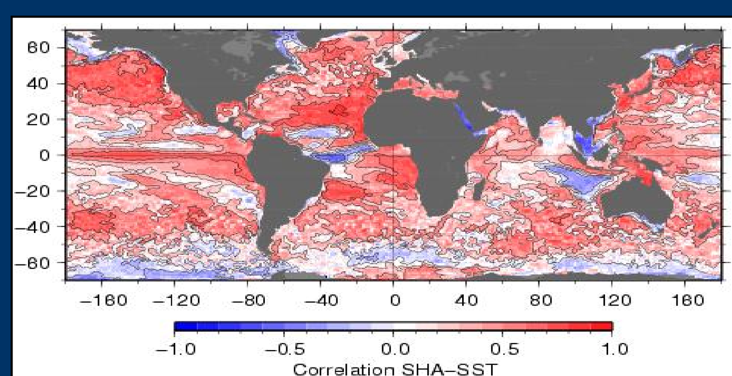
Sea height fields are regarded as being representative of the thermal structure of the whole ocean column. In principle this is true, although for practical purposes there are depths beyond which changes in the thermal structure are reflected very little or not at all in the sea surface height. We present here results on the correlation between sea height anomaly fields and the upper ocean thermal structure, which would allow to identify areas where sea height anomalies can be used as a proxy to estimate the depth of isotherms and of the upper ocean heat storage from the surface to selected depths.

The temperature profile data are from XBTs, profiling floats and moorings, and sea height anomaly data are from altimetry. Results obtained from this study are key to evaluate the global ocean observing system and how altimetry can improve the spatial and temporal coverage of the global estimates of heat storage. Additionally, this work will help to achieve a better understanding of the heat balance in the world oceans to improve climate forecast capabilities of coupled general circulation models.

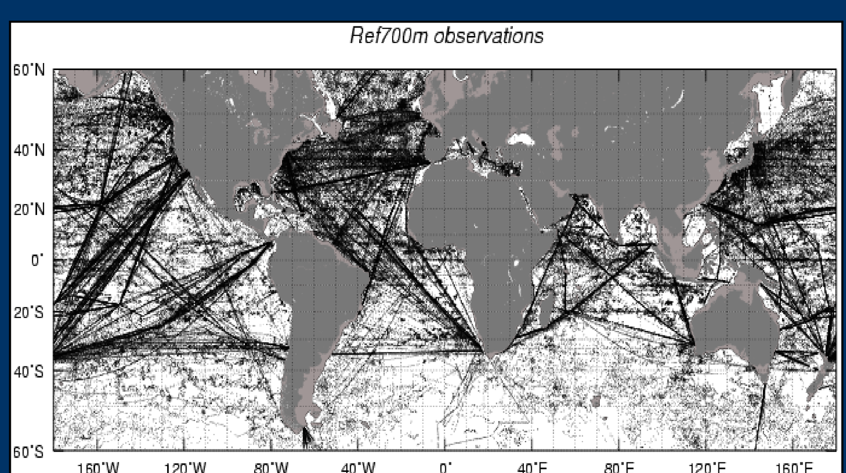




(top left) Rms of sea height computed from altimetry derived sea height anomaly. (top right) Correlation between SHA and sea surface temperature.

SEA HEIGHT AND SEA SURFACE TEMPERATURE

The variability of the sea height anomaly is linked to the ocean dynamics and heat storage of the upper ocean. The rms of sea height anomaly (left) shows regions with very high variability, such as those influenced by the Gulf Stream, Agulhas Current, and Brazil-Malvinas Confluence. The sea height anomaly is, in general, linked to the variability of the main thermocline. There is a positive correlation between the sea height anomaly and sea surface temperature fields over most regions (right), with some exceptions, such as of the tropical North Atlantic and ACC regions. This may be due to wind effects causing the sea height anomaly to peak with a lag of months with respect to the peak of surface heat fluxes. This figure clearly indicates that the sea surface temperature cannot be always used as a proxy to infer the heat content in the upper layer.



(top) Locations of temperature profiles obtained from XBTs, profiling floats and moorings used in this study.

DATA

The temperature profile data we use cover the years 1992 through 2005. Temperature profiles, approximately 150,000, are obtained from XBTs, profiling floats and moorings (left) These data are obtained from GTSPP and GDAC Argo.

The altimeter data consist of the gridded AVISO sea height anomaly fields.

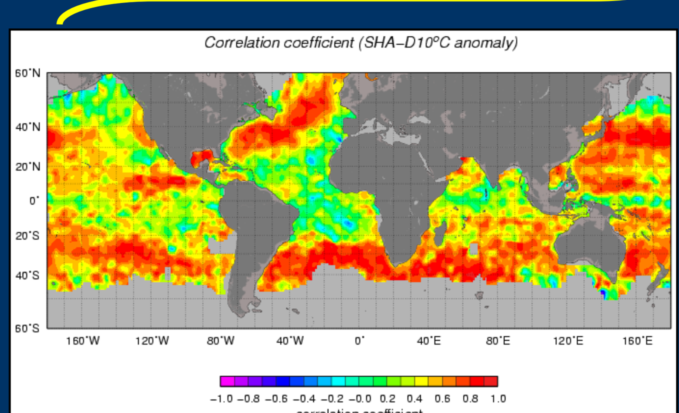
SEA HEIGHT ANOMALIES VS HEAT STORAGE

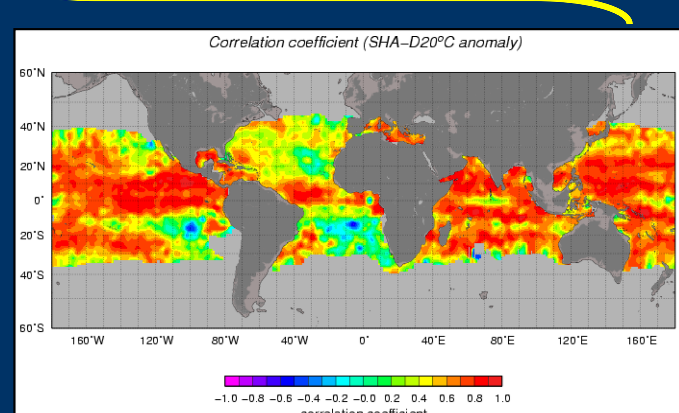
The correlation coefficient between the sea height anomaly and the mixed layer depth (MLD, defined as where the vertical temperature gradient is larger than 0.05ºC/m) and selected depths to 800m (50m to 800m, with 50m intervals) and of the sea height anomaly and the heat storage (HS) between the sea surface and the MLD and selected depths are computed here (below).

In areas where there is a good correlation, the altimeter-derived sea height anomalies can be used as a proxy to estimate the depth of an isotherm and the upper ocean heat storage.

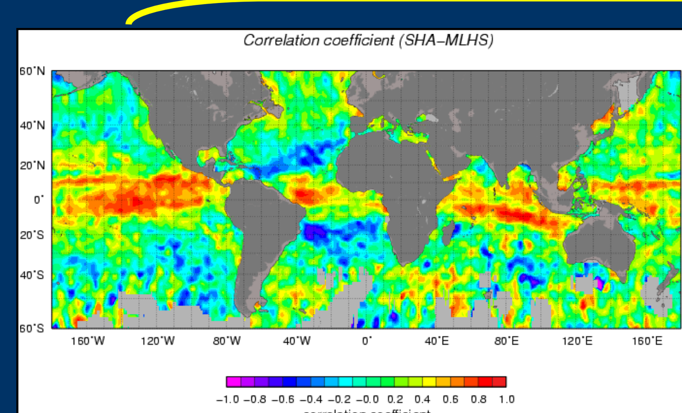
Our results indicate that the global correlation coefficients are low (0.3) for the mixed layer but that they increase to almost 0.7 at larger depths, such as 700m. In some regions correlations of 0.8 and more are also observed.

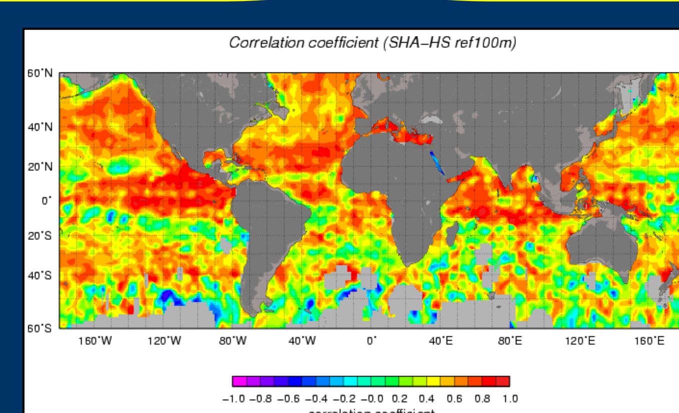
Sea height anomaly vs D20C and D10C

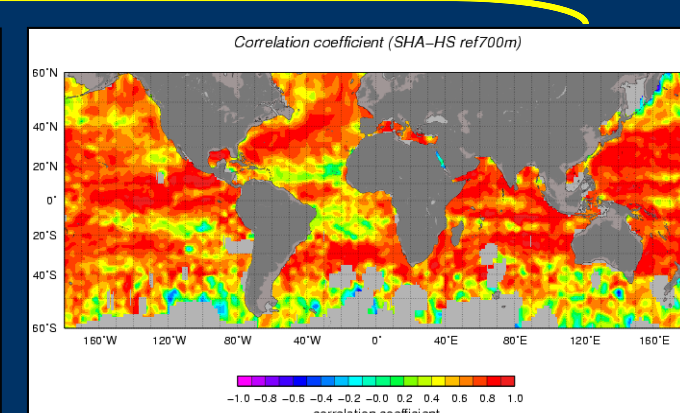




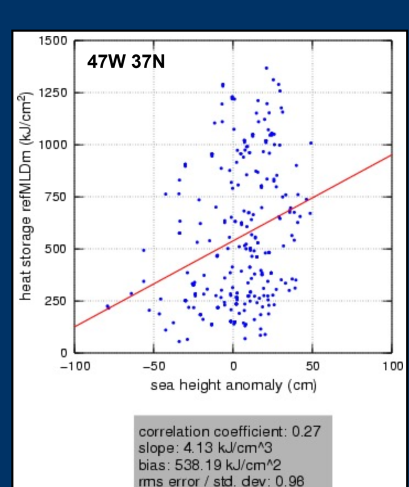
Sea height anomaly vs HS_MLD, HS_100m and HS_700m

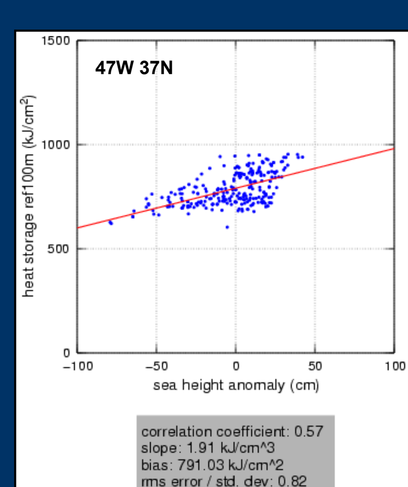


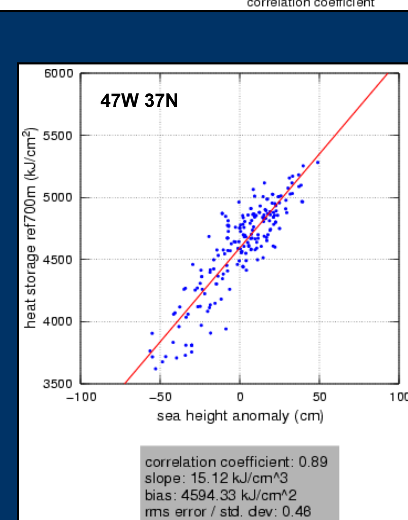




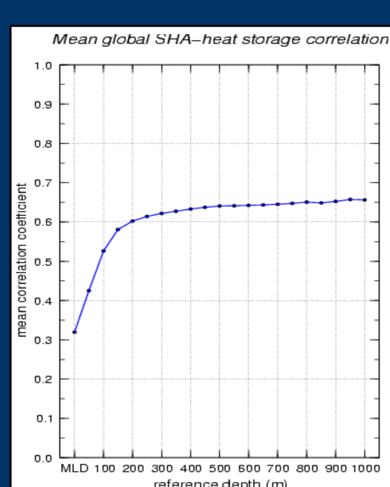
(right) Dispersion plots and linear fits (red lines) for one 3 degree by 3 degree box in the North Atlantic showing the relationship between the sea height anomaly and the heat storage to the MLD, 100m and 700m.

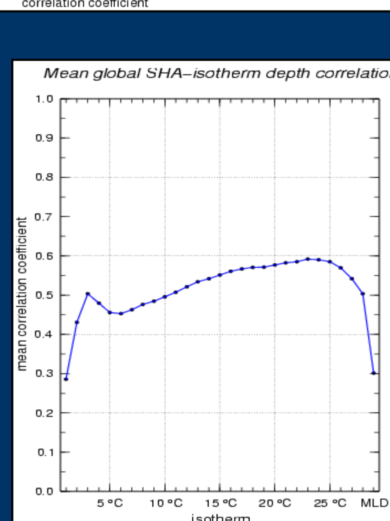






(right) Mean global correlation coefficient between the sea height anomaly and the depth of selected isotherms and heat storage to selected depths.



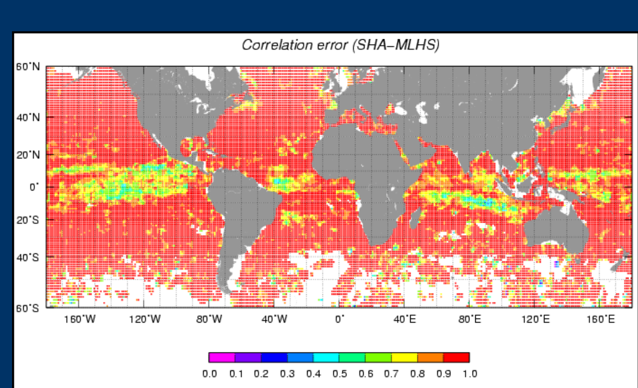


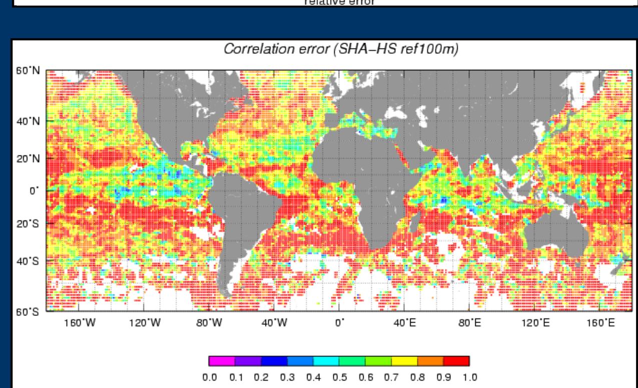
ERRORS OF ESTIMATES

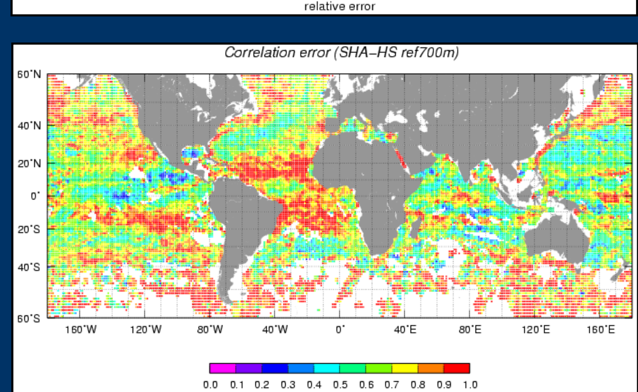
One of the goals of this work is to use altimetry to complement the ocean observing system for upper ocean heat content by completing the spatial gaps created where profiling float coverage is not adequate with altimetry estimates. In these cases altimetry-derived estimates of heat storage may be used in regions where the correlation coefficient between the sea height and heat storage is high.

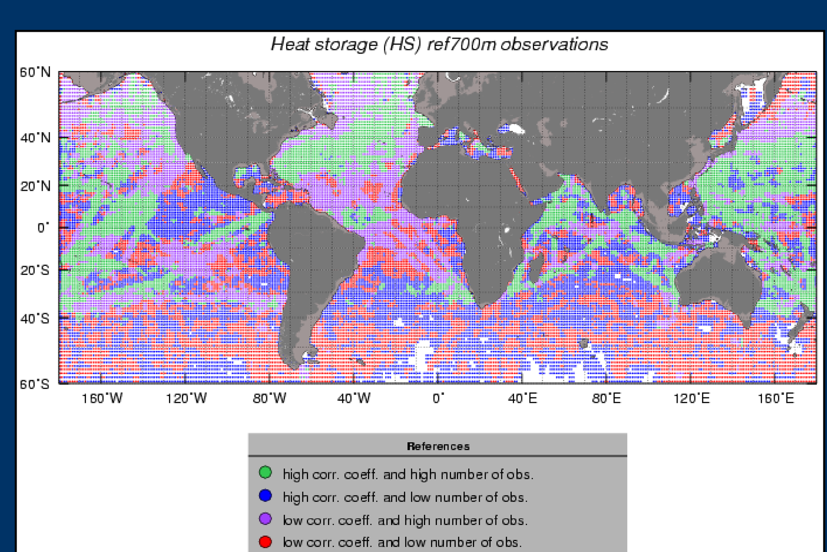
The mean error in the estimates of the heat storage is estimated by comparing the altimeter estimates against the observed values of heat storage. The relative error, ranging from 0 to 1, computed here is the ratio between the correlation error and the standard deviation of the independent variable (either heat storage or isotherm depth). The correlation error is the rms difference between observation and the predicted values by the regression line.

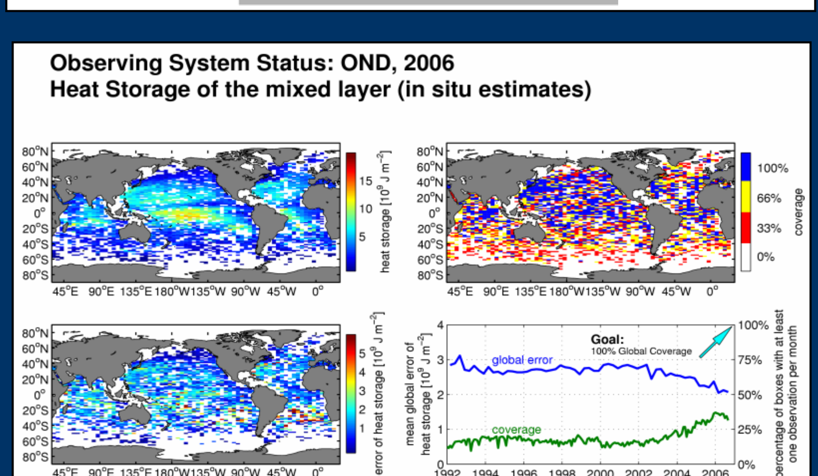
(right) Average relative error of the altimeter estimates of HS for the mixed layer depth, 100m and 700m.











EVALUATING AND IMPROVING THE OBSERVING SYSTEM

The main goal of this work is to also evaluate the ocean observing system by providing information on where in-situ observations are needed because altimetry cannot be used as a proxy to estimate the heat storage in the upper ocean.

(right top) Evaluation of the observing system for heat storage referenced to 700m depth. Green and blue indicate 3x3 degree squares where satellite altimetry may be used as a proxy for heat storage. A large number of observation is defined as where there are more than 4 years with 6 months with at least one in-situ observation. 0.6 is defined here as a high correlation coefficient.

(right bottom) Quarterly report on the state of the Global Ocean Observing System (GOOS) for heat storage of the mixed layer. For each quarter starting in JFM 2005, NOAA Office of Climate Observations evaluates the performance of the GOOS heat storage estimates with respect to the GOOS/GCOS (1999) requirement for hydrographic measurements. (**www.aoml.noaa.gov/phod/soto/ghs/reports/**). We plan to use the results of this study to complement the in-situ observations with altimetry estimates in regions where correlation coefficients are high.

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