NOAA Operational Oceanic Heat Content Product Suite

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In September 2012, the National Oceanic and Atmospheric Administration (NOAA) and the National Environmental Satellite Data and Information Service (NESDIS) began providing operational ocean heat content (OHC) measurements. OHC is a measure of the integrated vertical temperature from the sea surface to the depth of the 26°C isotherm. It is computed from the altimeter-derived isotherm depths in the upper ocean relative to 20°C based on a hurricane season climatology and a two layer ocean model. In the present model, the OHC estimates are calculated from the sea surface temperatures (SST) obtained from NESDIS GEO-POLAR SST Analysis combined with altimeter-estimates of the 20°C and 26°C isotherm depths derived from a reduced gravity scheme using a daily ocean climatology of mean isotherm depths and reduced gravities. Based on a mean ratio between the 20 and 26°C isotherm depths, and the depth of the 26°C isotherm depth and the ocean mixed layer depth are inferred. By integrating the 26°C isotherm depth to the surface (where SST is the surface boundary condition) an ocean heat content is calculated (i.e., area under the curve) as shown in Figure 1. The algorithm that generates the OHC product ran in development mode for more than 10 years at the NHC and University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS). The algorithm uses a reduced gravity model to estimate the 20°C isotherm depth based on objectively analyzed sea surface height anomaly fields (SSHA) from available altimeter missions, currently Jason-2 and Saral, and the NESDIS GEO-POLAR Blended SST Analysis. The approach is evaluated with in situ ocean sensors such as ARGO floats, XBT transects, mooring data etc.(Figure 2). The software allows for additional satellite data such as another altimeter-derived SSHA field to be ingested into the calculation (Figure 3). Currently, NOAA's Office of Satellite Data Processing and Distribution (OSPO) generates operational daily fields that include input Sea Surface Height Anomaly, Geo-Polar Blended SST, 20° isotherm depth (H_{20}), 26° isotherm depth (H_{26}), mixed layer depth (MLD), ocean heat content (OHC) (Figure 3), and mapping error (not shown) from the objective mapping technique for the North Atlantic and North Pacific Basins (#s1, 2, and 3 in Figure 4). The Southern Pacific Basin (#7 in Figure 4) is scheduled to go operational in the spring of 2015. Figure 5 shows the influence OHC had on the development and intensification of Super Typhoon (ST) Haiyan in 2013.

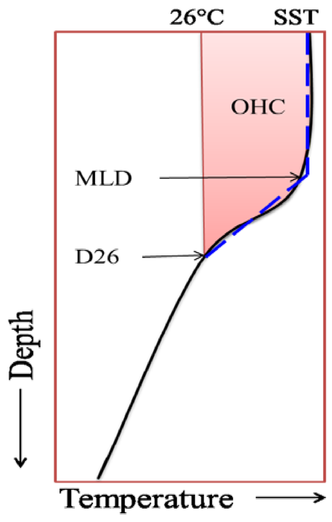


Figure 1: Schematic of OHC calculation. The red shading in the blow-up shows the true OHC by integrating the black temperature profile. The dashed blue line shows the approximated temperature profile of the upper ocean.

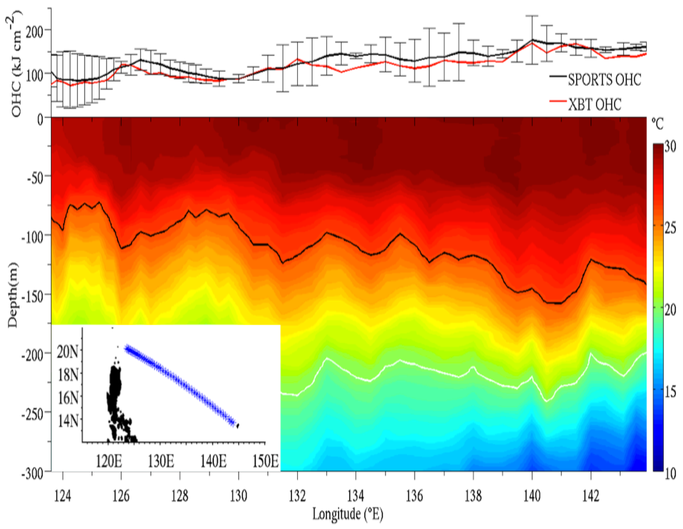


Figure 2: Three-year averaged XBT transect and SPORTS data averaged (08-10) for the month of Sept. Upper panel shows average OHC calculated from SPORTS (black line) with ±2σ and from the XBTs (red). Lower panel shows averaged temperature profiles from the XBT transect with the 26°(20°) C isotherms in black (white). The XBT transect path is shown in the inset in the lower left corner.

Figure 4: The seven tropical cyclone "basins" where storms occur on a regular basis.

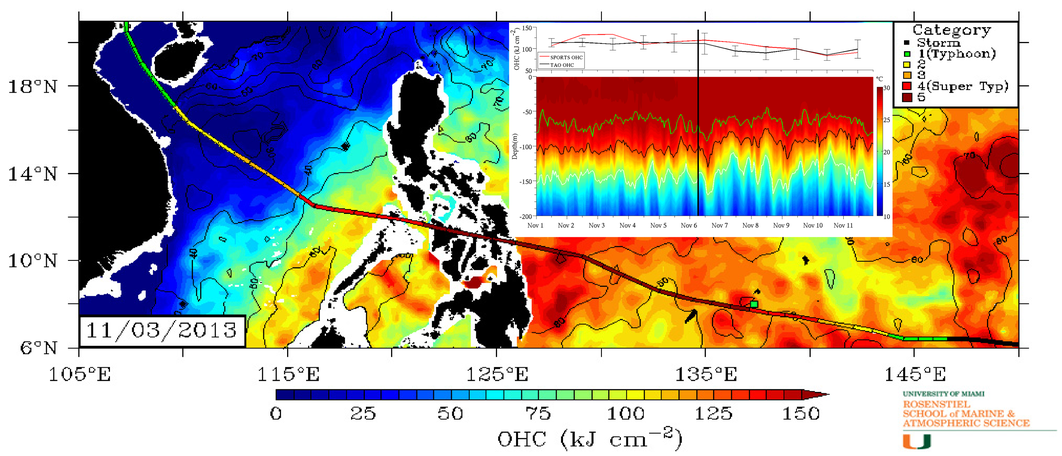
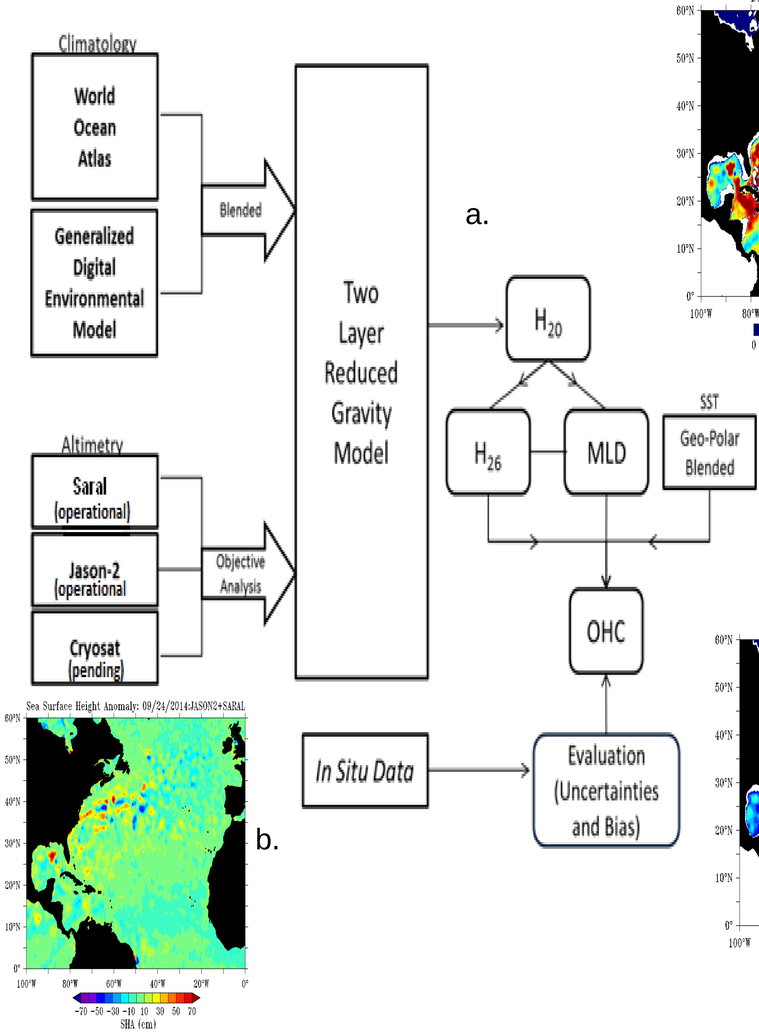


Figure 5: OHC prior to development of Super Typhoon (ST) Haiyan utilizing both Jason-2 and SARAL data. The green dot represents a TAO mooring that was directly hit by Haiyan. The inset shows the temperature time series (lower panel) and the estimated OHC from SORTS and the TAO mooring data (upper panel) and the black line is the time of the closet approach of the ST.



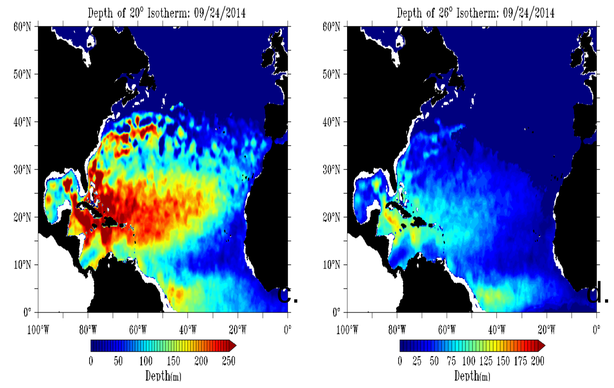
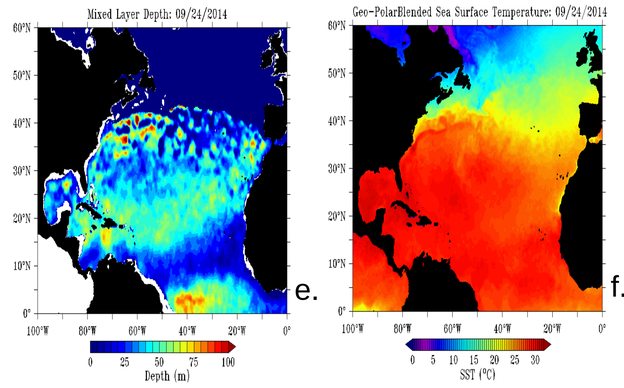
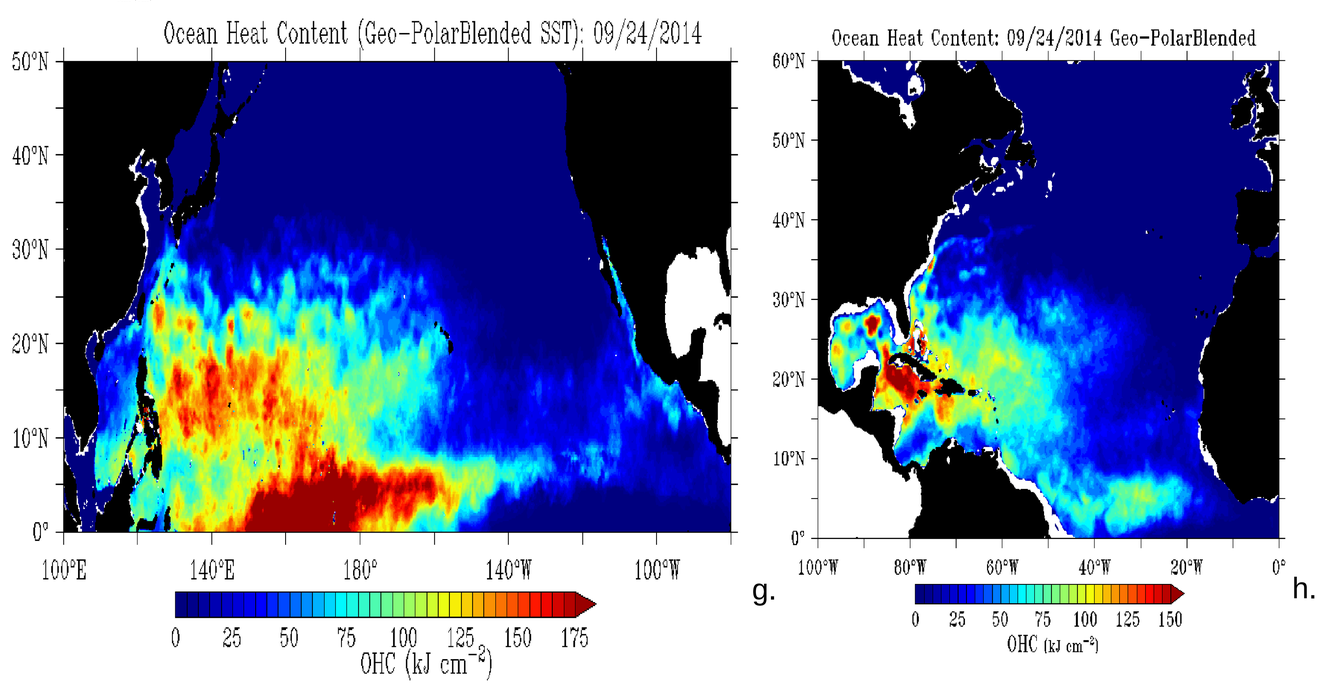


Figure 3: Flow diagram of the inputs to the reduced gravity model (3a) including the objectively analyzed SSHA from radar altimetry (3b) to estimate the depth of the 20ºC isotherm (3c) which is then used to determine the depth of the 26ºC isotherm (3d) and MLD (3e) and the GEO-POLAR SST (3f) to calculate OHC (3g and 3h). *In situ* data includes profile data from ARGO Floats, XBT transects, AXBTs deployed from research aircraft and PIRATA moorings in the North Atlantic Ocean Basin.





REFERENCES:
Maturi, E., et al 2014: GHRSST Sea Surface Temperature Products. 2014 GHRSST Science Team Meeting, 2-6 June, Capetown, South Africa
Jaimes, B., L. K. Shay and E. W. Uhlhorn, 2014: Observed enthalpy fluxes during the rapid intensity change of hurricane Earl. Mon. Wea. Rev (In Press)
McCaskill, E. C., and L. K. Shay 2014: The systematically merged Pacific Ocean regional temperature and salinity (SPORTS) climatology for typhoon intensity forecasts. 31th AMS Hurricane and Tropical Meteorology Conference, 31 Mar-4 April, San Diego, CA, https://ams.confex.com/ams/31Hurr/webprogram/Paper244756.html (6pp. Extended Abstract).
Meyers, P. C., L. K. Shay, and J. K. Brewster, 2014: The development of the systematically merged Atlantic regional temperature and salinity climatology for hurricane intensity forecasting. J. Atmos. Oceanogr. Tech., 31, 131-149.
Shay, L. K., and J. Brewster. 2010: Oceanic heat content variability in the eastern Pacific Ocean for hurricane intensity forecasting. Mon. Wea. Rev., 138, 2110-2131.
Shay, L. K., J. Brewster and E. Maturi, 2013: Algorithm Theoretical Basis Document: Satellite-derived Oceanic Heat Content Product, V2.5, Satellite Products and Review Board, NOAA National Environmental Satellite Data Information Service, World Weather Research Center, College Park, MD (42pp).