

FIG. 3.3. Tropical monthly SST anomalies ($^{\circ}\text{C}$) for July, August, and September (left) 2004 and (right) 2005. Contours show the corresponding monthly total (anomaly + climatology) SST isotherms for 26° , 27° , and 28°C .

hurricanes. A closer examination of the 2004 and 2005 tropical Atlantic anomalies shows that areas exceeding 26.5°C are similar in the corresponding months for 2004 and 2005 (Fig. 3.3). However, the areal extent of SST greater than 28°C is larger in July and August 2005 than in July and August 2004.

ii) HEAT CONTENT—G. C. Johnson,³⁵ J. M. Lyman,⁴⁹ and J. K. Willis⁹³

Ocean storage and transport of heat and freshwater, and their variations, are intrinsic to many aspects of climate, including El Niño, the North Atlantic Oscillation (NAO), the global water cycle, hurricane seasons, and global change (e.g., Levitus et al. 2005; Hansen et al. 2005). Regional studies of decadal freshwater variability are possible in well-sampled regions like the North Atlantic (e.g., Curry and Mauritzen 2005), but in situ ocean salinity data are too sparse and their reporting is too delayed for a global 2005 perspective of ocean freshwater storage. However, the rapidly maturing Argo Project array of profiling floats measuring temperature and salinity (Roemmich et al. 2004) is remedying this situation.

Here we discuss an estimate of the upper-ocean (0–750 m) heat content anomaly (OHCA) for 2005

produced by combining in situ ocean temperature data and real-time satellite altimetry data collected from 1 January to 31 October 2005 following the techniques of Willis et al. (2004). The 2005 combined OHCA map when compared to a 1993–2002 baseline (Fig. 3.4, top) shows eddy and meander variability down to 100-km mapping scales. There is a great deal of small-scale spatial variability associated with the western boundary currents in every gyre, as well as the Antarctic Circumpolar Current.

Large-scale patterns are also evident in the OHCA. The combined OHCA map for 2005 is high in the subpolar North Atlantic and low in the subtropical North Atlantic, consistent with a decreased strength of the North Atlantic Current. This pattern is probably related to decadal changes in the NAO index (e.g., Curry and McCartney 2001). The NAO index was lower in 2005 than during the baseline period, and has generally trended lower from 1993 through 2005. For the most part, the Tropics in 2005 have

only slightly higher OHCA than average, reflecting the lack of a pronounced El Niño or La Niña in 2005. In 2005, OHCA is high throughout the South Pacific and South Atlantic Oceans in a belt located north of the Antarctic Circumpolar Current. This change may be related to changes in the wind-stress field associated with an increase in the Antarctic Oscillation.

The difference in combined OHCA maps between 2005 and 2004 (Fig. 3.4, bottom) illustrates the large year-to-year variability in ocean heat storage, with changes reaching or exceeding the equivalent of an 80 W m^{-2} surface flux. Ocean advection likely plays a large role in many of these changes. Such differences between the two years clearly show the influence of eddies and meanders, but there are also contributions from some of the aforementioned larger-scale patterns in the subtropics and subpolar regions. The decrease of OHCA in the central equatorial Pacific between 2005 and 2004 probably reflects the transition from weak El Niño to more normal conditions. Finally, given the strong 2005 hurricane season and the potential link between hurricane intensity and warm ocean waters (e.g., Emanuel 2005), the large increases in OHCA around Florida and the Gulf of Mexico are also of interest.

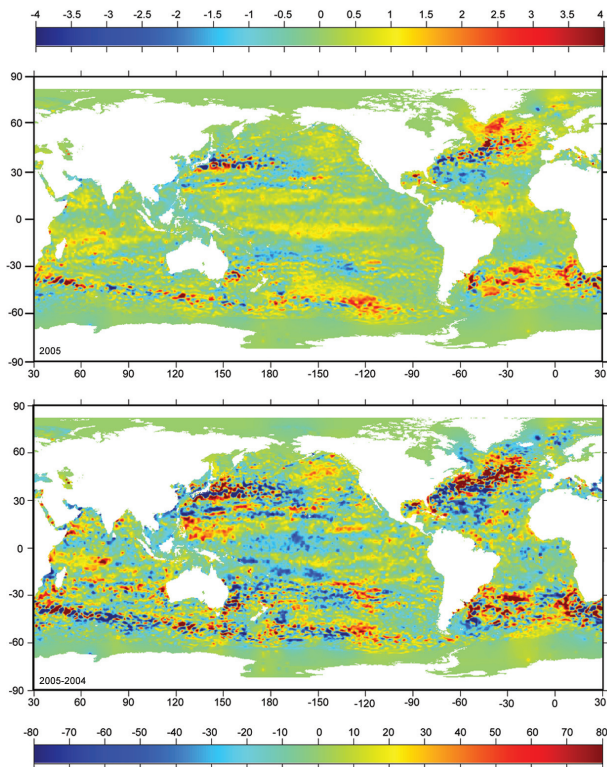


FIG. 3.4. Combined satellite altimeter and in situ ocean temperature data upper-ocean (0–750 m) heat content anomaly (OHCA) (J m^{-2}) map for (top) 2005 relative to a 1993–2002 base period, following Willis et al. (2004), and (bottom) the difference between 2005 and 2004 OHCA maps expressed as a surface heat flux equivalent (W m^{-2}).

III) HEAT FLUXES—L. Yu⁹⁶ and R. A. Weller⁹¹

The oceanic latent heat flux (LHF) is heat energy extracted from the ocean by the evaporation of surface water, and sensible heat flux (SHF) is heat energy transferred by conduction and convection at the air–sea interface. These two fluxes vary with near-sea surface circulation, humidity, and temperature, and influence weather and climate processes. The global change of the two fluxes in 2005 is examined here using daily analyzed fields produced by the Objectively Analyzed Air–Sea Fluxes (OASFlux) project. The resulting flux fields were validated against more than 100 flux buoy measurements acquired by the Woods Hole Oceanographic Institution (WHOI) Upper Ocean Processes group (Moyer and Weller 1997) and by the Pilot Research Moored Array in the Tropical Atlantic (PIRATA) and Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) moored buoy arrays in the tropical Atlantic and the equatorial Pacific Oceans (Yu et al. 2004).

The 2005 annual mean field of LHF plus SHF over the global oceans (Fig. 3.5, top) shows that large

oceanic latent and sensible heat losses occurred over the regions associated with three major Western Boundary Currents (WBCs): the Kuroshio, Gulf Stream, and African Agulhas Currents. In these regions near-surface vertical gradients of humidity and temperature are largest and the wind speeds are greatest in the respective hemisphere’s fall and winter seasons, and the cold season variability of LHF plus SHF dominates the annual mean pattern. On a year-to-year basis, variability of the oceanic heat losses in the three WBC regions is also largest, with magnitudes reaching or exceeding 40 W m^{-2} . This is clearly shown from the difference map of the 2004 and 2005 annual mean LHF plus SHF (Fig. 3.5, bottom). Interestingly, the signs of the anomalies associated with different WBC systems are different. For example, the total oceanic heat loss was enhanced (large positive anomalies) from 2004 to 2005 over the Kuroshio region, but reduced (large negative anomalies) over the Gulf Stream region.

Influence of eddy-scale structures is evident in the 2-yr difference map (Fig. 3.4, bottom). Nevertheless, the change in the LHF plus SHF field from 2004 to 2005 is large scale—the anomalies are primarily negative over the global basins, suggesting that the oceanic heat loss was overall reduced in 2005 (Fig. 3.6, top). A persistent, long-term increase in the globally averaged annual mean LHF plus SHF is particularly notable, although that trend appears to have decreased in recent years. It is not clear yet

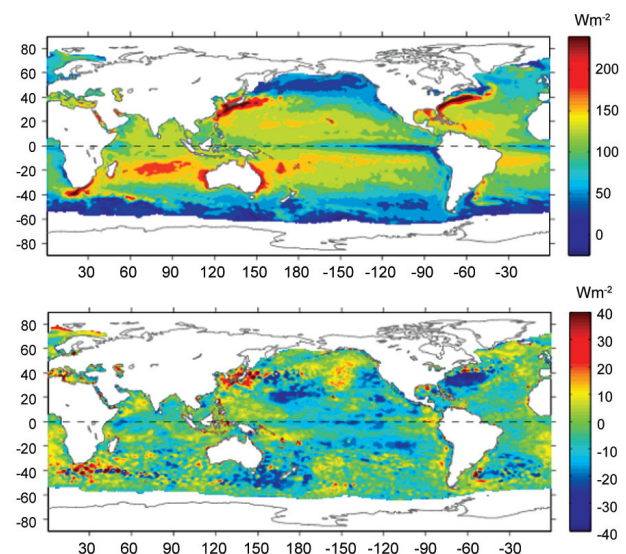


FIG. 3.5. (top) Annual mean latent plus sensible heat fluxes (W m^{-2}) in 2005. Sign is defined as upward (downward) positive (negative). (bottom) Differences between 2004 and 2005 annual mean latent plus sensible heat fluxes.