STATE OF THE CLIMATE IN 2005

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Contributing Editors
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whether or not the reduction in oceanic heat loss for 2005 is a trend change, or merely a short-term anomaly. Additionally, the globally averaged LHF plus SHF has increased by about 10 W m^{-2} in the past 20 yr, and the magnitude of the variability is dominated by that of the LHF. The mean SHF value is about one order smaller than that of LHF, and the change in SHF is also small (< 2 W m^{-2}) over the entire analysis period.

Areal averages of LHF plus SHF variability in the Kuroshio and Gulf Stream regions clearly show a large upward trend in both (Fig. 3.6, bottom). However, unlike the global averages, the regional averages show strong interannual fluctuations. Whereas the upward trend in global averages begins in 1981 (start of the analysis record) and has flattened in recent years, the boundary current regional averages show a trend toward larger values only starting in the early 1990s but remaining positive to the present. Furthermore, the slope of the trend in these two regions is twice as great as that of the global averages. Overall, the regional oceanic heat loss has been enhanced by about 20 W m^{-2} over the past two decades.

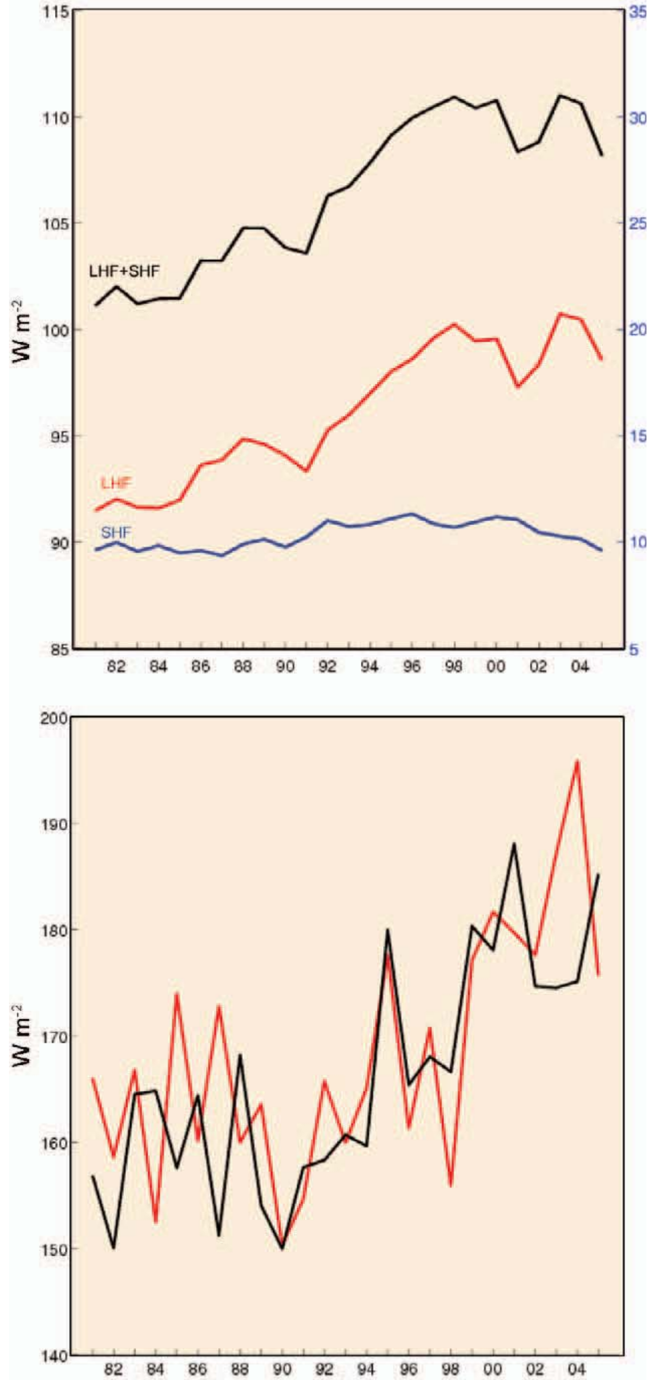

Fig. 3.6. (top) Year-to-year variations of globally averaged annual mean latent heat flux (red), sensible heat flux (blue), and latent plus sensible heat flux (black). (bottom) Year-to-year variations of the annual mean latent heat plus sensible heat fluxes averaged over the regions of the Gulf Stream [(25°–45°N, 85°–50°W), red] and Kuroshio [(20°–40°N, 120°–150°E), black].

c. Circulation

1) Surface currents—R. Lumpkin[48] and G. Goni[30]

Near-surface currents are measured in situ by satellite-tracked drifting buoys and by acoustic point-measuring meters on the Autonomous Temperature Line Acquisition System (ATLAS) moorings. In 2005, the drifter array reached its target goal of 1250 drifters worldwide, becoming the first fully realized component of the Global Ocean Observing System. During 2005, surface currents were well sampled globally, except in the far northern Pacific, the southwest Pacific between 20° and 40°S, 150°E to the date line, the Arabian Basin of the Indian Ocean, and the extreme Southern Ocean south of 55°S.

A climatology of monthly mean currents was computed from all available drifter observations from 1994 to 2004, using the methodology of Lumpkin and Garraffo (2005). Anomalous currents were calculated with respect to this climatology (Fig. 3.7).

(i) Indo-Pacific basins

Annual mean anomalies were most prominent in the tropical Pacific Ocean (Fig. 3.7). Westward anomalies of nearly 20 cm s^{-1} were observed on the equator between 120°W and the date line. Weaker anomalies of 5–10 cm s^{-1} were seen in the North Equatorial Current (NEC) region (10°–20°N). Drifter observations did not indicate anomalously strong eastward currents in the Kuroshio Extension or North Pacific Current, conflicting with the simple hypothesis of a more-intense-than-average wind-driven gyre.

The strongest intraseasonal anomalies were observed in early 2005 in the western and central tropical Pacific, associated with Kelvin wave activity driven by

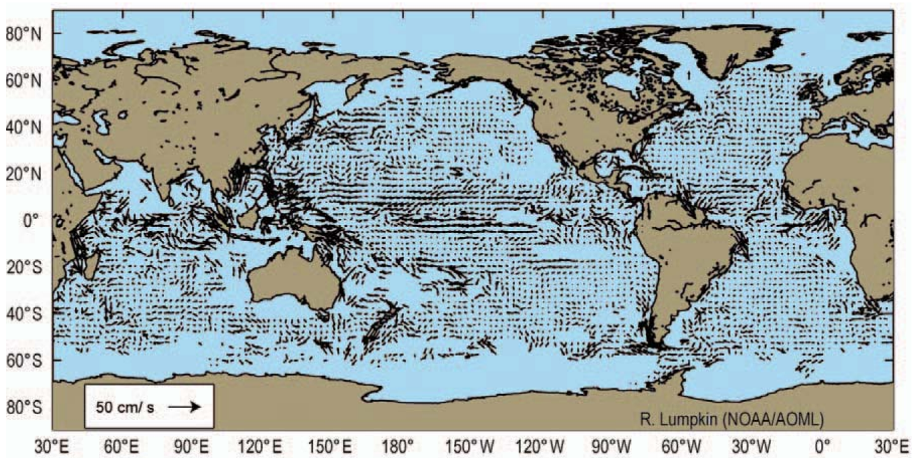

Fig. 3.7. 2005 mean anomalies (cm s^{-1}) from 1994–2004 surface current climatology.

intraseasonal (MJO) wind fluctuations (cf. Eisenman et al. 2005). In January (Fig. 3.8), very strong westward anomalies were measured in the northern branch of the South Equatorial Current (nSEC). The nSEC at 0°–5°S, 160°W–170°E was 80–100 cm s^{-1} westward, compared to a mean January speed of 40–60 cm s^{-1}. During February, a dramatic reversal was seen at 6°–12°S, 155°W–180° where several drifters moved eastward at 50–100 cm s^{-1}. Drifters suggested the passage of a second Kelvin wave in March and April, when strong westward, then eastward, anomalies were seen west of the date line (Fig. 3.8). This was corroborated by observations at the TAO mooring at 0°, 170°W. The previously noted NEC anomalies were first observed in February. Westward anomalies in the South Equatorial Current (SEC) at 0°–6°S appeared in April. Both the NEC and SEC continued to flow anomalously quickly through the remainder of the year.

(ii) Atlantic Basin

The North Atlantic subtropical gyre, benchmarked by transport through the the Florida Straits and Yucatan Channel, was close to its decadal mean strength during 2005. The Western Boundary Current transport through the Florida Straits, measured by cable voltage, averaged 31.4 ±1.2 Sv (1 Sv is 10^6 m^3 s^{-1}) during 2005 (C. Meinen 2006, personal communication), not significantly different from the 1982–2005 mean of 32.1 Sv. Transport through the Yucatan Channel, estimated from altimetric sea level anomaly variations calibrated by in situ transects, indicated a transport within 1 Sv of the long-term mean. In the North Equatorial Current region (5°–15°N, 30°–50°W), westward anomalies of 10 cm s^{-1} were observed. Drifter deployments during recent French research cruises seeded the Gulf of Guinea region heavily for the first time, and anomalies here were large, but may reflect a poorly defined climatology for the period of 1994–2004. Thus, it is difficult to tell from these data what role anomalous advection may have played in the development of the unusually large cold tongue during 2005.

(iii) Southern Ocean

Drifters did not reveal large-scale anomalies in the strength of the Antarctic Circumpolar Current (Fig. 3.7). From August to December, 18 drifters passed south of Cape Horn. These drifters indicated that the flow entering the Drake Passage was 8 ±9 cm s^{-1}, much weaker than the mean speed of 23 ±11 cm s^{-1} here. This anomaly was most prominent during August–September. Four drifters passed through the region during February–May, measuring speeds of 27 ±14 cm s^{-1}

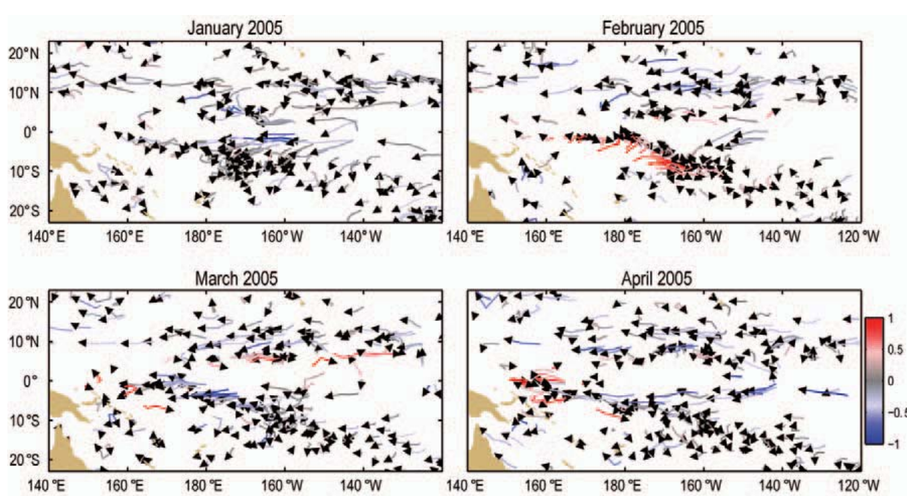

Fig. 3.8. January–April 2005 drifter trajectories in the tropical Pacific. Arrowheads indicate direction; color indicates zonal speed anomaly (m s^{-1}, positive eastward).

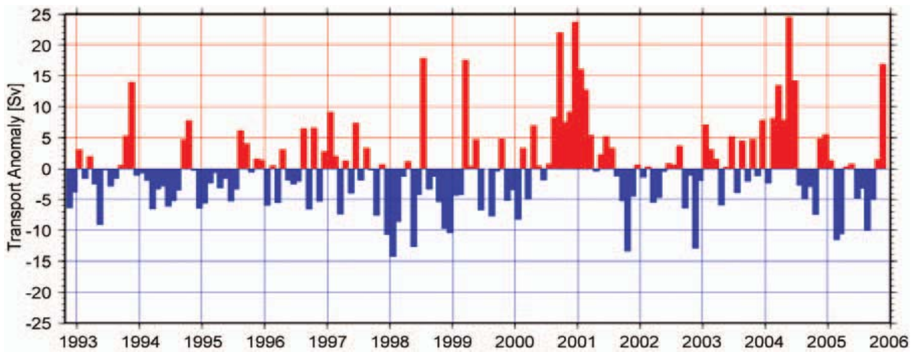

Fig. 3.9. Monthly geostrophic transport anomalies (Sv) of the Agulhas Current at 28°W derived from satellite altimetry observations.

(very close to normal). Altimetric estimates of geostrophic transports suggest that the 2005 annual mean of the geostrophic transport remained slightly lower than its historical value, and significantly lower (5–10 Sv) than during 2004 (Fig. 3.9).

ii) Thermohaline Circulation—M. O. Baringer[4] and C. S. Meinen[54]

The component of the ocean circulation associated most with variability in heat redistribution is the meridional overturning circulation (MOC), also called the thermohaline circulation. The MOC is a global circulation cell wherein high-latitude surface waters are cooled and become denser, and in certain locations this dense water sinks and flows toward the Tropics. In tropical and subtropical regions around the world these waters warm, become less dense, and return to the surface to flow back toward higher latitudes, while transporting a significant amount of heat. The primary locations where deep convection occurs are in the northern North Atlantic and in the subpolar ocean around Antarctica, while the upwelling of new surface waters is spread broadly around the globe.

Variations in the strength of the overturning circulations are directly related to variations in net poleward heat transport. Current best estimates for the steady-state global mass and heat transport can be found in the analyses of Ganachaud and Wunsch (2003; see also Talley 2003). For example, the North Pacific overturning cell carries about 0.5 PW northward, but most of this heat transport is associated with water mass transformations in the upper layers of the ocean, while the North Atlantic carries a much larger transport of 1.2 PW northward, most of which is carried in the top-to-bottom MOC system. Typically, it is this deep circulation cell that is described as the MOC, although other oceans and water masses are important for the redistribution of heat.

The Florida Current contains most of the upper limb of the MOC as it flows through the Florida Straits in the North Atlantic, with a smaller contribution being carried by the Antilles Current east of the Bahamas. Fluctuations in the Florida Current have shown a clear negative correlation with the atmospheric phenomenon known as the NAO, however while the NAO has been trending toward its negative extreme over the past 20 yr, the Florida Current transport shows no such long-term trend through 2005 (Fig. 3.10). The annual mean transport observed in 2005 (31.4 Sv) falls just within the lowest quartile of historical annual mean transports from the cable. However, this transport is well within 1 std dev of the long-term mean of 32.1 Sv, and given the statistical standard error (1 Sv) of the mean for the year, 2005 cannot be considered anomalous in terms of the Florida Current transport.

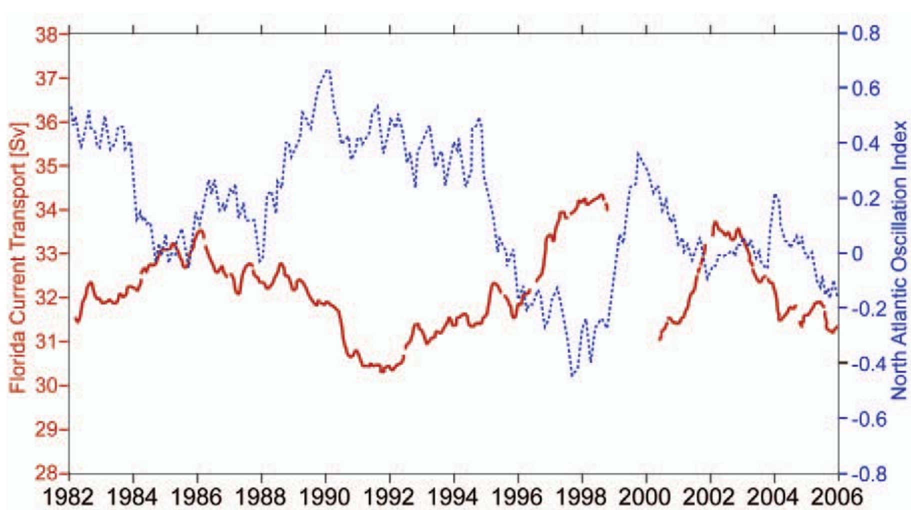

Fig. 3.10. Florida Current transport (Sv; red solid) as measured by the NOAA-funded submarine cable across the Florida Straits, along with the NAO index (blue dashed) produced by NOAA/NCEP.