Upper-ocean Heat Budget Inferred From ECCO-2 Ocean Data Assimilation

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Sea level anomaly measured by the TOPEX/Poseidon altimeter, reanalyzed momentum, heat, and freshwater fluxes from the National Center for Environmental Prediction (NCEP), and climatological temperature and salinity are assimilated by a near-global version of the MIT ocean general circulation model. The model has a resolution of 1x0.3 degree in the tropics and 1x1 degree in the extratropics. There are 46 vertical levels with a 10-meter thickness above 150 m. The enhanced resolution in the tropics and in the upper ocean is to ensure a reasonable representation of the tropical current system. The adjoint method is used to adjust the initial state and surface boundary conditions so as to reduce model-data misfit, subject to model dynamical constraints. The assimilation results in overall better agreement with independent observations (TOGA-TAO mooring measurements, scatterometer wind, etc.). This is part of the ECCO Consortium effort to estimate the state of the ocean (http://www.ecco-group.org) [7]. The assimilation product used in this analysis, ECCO-2 , is described in [1], and is available through a Live Access Server (http://eyre.jpl.nasa.gov/las/). See also [2]-[6] for other analyses and applications.

The assimilation product is used to investigate the processes that control the anomaly (relative to averaged seasonal cycle) of mixed-layer temperature for the period of 1997-2000. In particular, we focus on the following areas: (a) the eastern equatorial Pacific (150-90W, 5S-5N), (b) the western equatorial Indian Ocean (45-66E, 5S-5N), and (c) the northern subtropical Pacific (170E-150W, 25-40N). During the period of the study, these areas display anomalous changes in sea level and surface temperature relative to the averaged seasonal cycle. They are associated with different climate variations. The anomalous warming in 1997-1998 and subsequent cooling in 1999-2000 in areas (a) and (b) are associated with El Nino/La Nina and the Indian-Ocean Dipole. In area (c), the upper ocean begins to warm up in the second half of 1998 and persists through 2000. It appears to signal a phase change of the Pacific Decadal Oscillation.

The tendencies of mixed-layer temperature averaged over each of the three areas are computed. We focus on analysis of the anomaly by removing the averaged seasonal cycle from the tendencies. The tendencies are then integrated in time starting from January 1997 (referred to as cumulative anomalous tendency). Figure 1 shows the relative contributions of advection, diffusion, and surface heating to the total cumulative anomalous tendency for each of the three areas.

The role of advection is similar for all three areas because it (red curve) is well correlated with the change of mixed-layer temperature (black curve), especially during the warming phase in 1997 for area (a) and (b) and in 1999 for area (c). While the role of advection is similar, that of surface heat flux is not. In area (a), surface heat flux tends to oppose advection and thus total temperature change, a negative feedback mechanism. In areas (b) and (c), however, surface heating tends to assist the warming like the advection does. The results highlight some differences in how the ocean interacts with the atmosphere for different climate phenomena. The relative role of zonal, meridional, and vertical components of advection is examined. Interannual heat balance for the mixed layer in the equatorial Pacific is compared to that for the warm water volume above the thermocline.

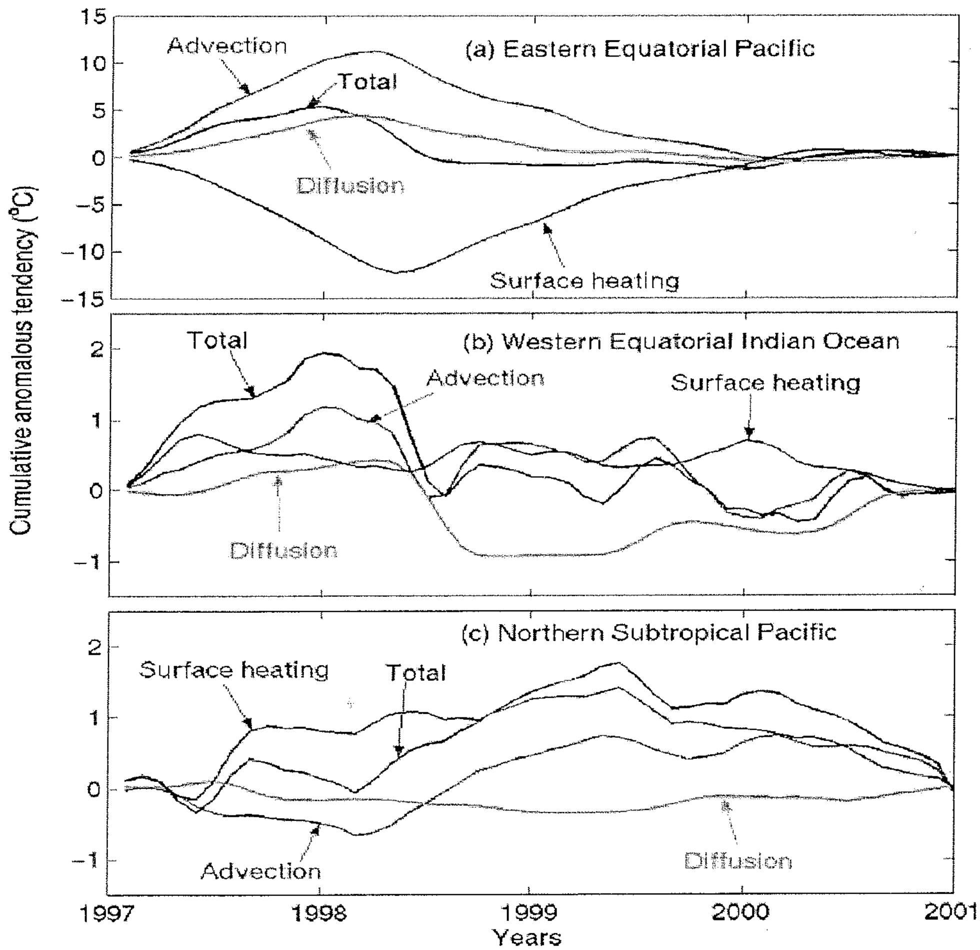

FIG.1 Anomalous mixed-layer heat balance in the (a) eastern equatorial Pacific, (b) western equatorial Indian Ocean, and (c) northern subtropical Pacific. The role of advection is similar, that of surface heating is not.

References

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