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An oceanic heat budget for the Pacific Decadal Oscillation derived from satellite observations

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On the time scale of decades, climate variations over the North Pacific Ocean are related to the Pacific decadal oscillation (PDO). Distinguishing this internal, quasi-periodic climate variability from long term trends requires an understanding of the relationship among the observable quantities. A number of oceanic properties, such as upper ocean heat content and sea surface temperature, vary strongly with the phase of the PDO. Satellite observations make it possible to analyze these relationships over a period of fifteen years, including a notable change in the sign of the PDO index in 1999. The leading empirical orthogonal functions (EOF) of both sea surface temperature (SST) and sea surface height (SSH) in this region are highly correlated with each other. Sea surface velocities (SSV) constructed from satellite-observed SSH, SST, and vector winds show that Ekman and geostrophic components of velocity changed by similar magnitudes but with different spatial structures. Combining SSV with the SST field, in situ sub-surface temperature data, and surface heat fluxes from an atmospheric model makes it possible to construct an approximate SST budget based on an integral model damped to climatological means. Anomalous Ekman advection of the mean temperature gradient dominated smaller contributions from the other terms in the budget, a result which agrees generally with analysis of a simulation using an ocean general circulation model. Previous studies have demonstrated the dominance of Ekman pumping to pycnocline depth and SSH variability. The dominant role of Ekman transport and its divergence accounts for the co-variability of SSH and SST.