Sea Level, Subsurface Gradients, and the Temporal Variability of Mesoscale Eddies

Andrew Delman[1], Tong Lee[1], Bo Qiu[2]

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[2] University of Hawai‘i at Mānoa, Honolulu, HI, USA

Oceanic mesoscale eddies exchange heat and momentum directly with the atmospheric boundary layer, and play an important role in meridional transports of heat, freshwater, and nutrients. Therefore, the interannual and decadal (ID) modulation of eddy activity influences water mass characteristics, marine ecosystem behavior, and air-sea interactions that drive coupled modes of climate variability. In an analysis of remote sensing data, we have found robust relationships between the ID variability of sea level, sea level gradients, and eddy kinetic energy (EKE). In contrast with other parts of the ocean, higher EKE levels near energetic currents are associated with a reduction in the magnitude of the cross-current sea level gradient, and therefore with higher (lower) sea levels on the side of the current where mean sea level is lower (higher). This result is inconsistent with the hypothesis that a simple intensification of ambient gradients drives more instability and mesoscale eddy activity. Instead, a preference for anticyclonic (cyclonic) eddies on the side of the current with lower (higher) mean sea level contributes to the observed sea level-EKE relationship. An analysis of subsurface density and potential vorticity gradients using the Estimating the Circulation and Climate of the Oceans, Phase II (ECCO2) state estimate implies that potential vorticity (PV) gradients in the thermocline contribute to variations in mesoscale eddy activity. PV gradient reversals along isopycnals can support increases in mesoscale eddy activity even when lateral density gradients and current shear are stagnant or reduced, highlighting the role of PV structure in the conversion of available potential energy to EKE. These results have implications for transports and air-sea interaction that are modulated by mesoscale eddies, as well as for model representations of the temporal variability of eddy activity.