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## Intense Subsurface Upwelling Associated with Major Western Boundary Currents

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Western boundary currents (WBC), fast flowing currents on the western side of ocean basins, transport a huge amount of warm water poleward, affect the atmospheric conditions along their paths, take up a large amount of carbon dioxide, and regulate the global climate (Minobe et al. 2008; Takahashi et al. 2009; Wu et al. 2012). In contrast to their widely examined horizontal motions, much less attention has been paid to the vertical motions associated with the WBC systems. Here, we examined the spatial and temporal characteristics of vertical motions associated with the major WBC systems by analyzing vertical velocity estimates from five ocean synthesis products and one eddy-permitting ocean simulation over an overlapping period from Jan 1992 to Dec 2009. Robust and intense subsurface upwelling occurs in the five major subtropical WBC systems. These upwelling systems together with the vast downwelling inside subtropical ocean basins form basin-scale zonal overturning circulations and play a crucial role in the vertical transport of ocean properties and tracers inside the global ocean. Also, the vertical motions in the Kuroshio Current and the Eastern Australian Current regions display robust interannual and decadal oscillations, which are well correlated with El Niño–Southern Oscillation and Pacific Decadal Oscillation, respectively. This study unveils an overlooked role of the WBCs in the subsurface oceanic vertical transport and is expected to be a starting point for more in-depth investigations on their dynamics and roles in the climate system.