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3D Dynamics of Freshwater Lenses in the Near-Surface Layer of the Tropical Ocean

Alexander Soloviev and Cayla Dean
Nova Southeastern University, Oceanographic Center, Dania Beach, United States (soloviev@nova.edu)

Convective rains in the Intertropical Convergence Zone (ITCZ) produce lenses of freshened water on the ocean surface. These lenses are localized in space and typically involve both salinity and temperature anomalies. Due to significant density anomalies, strong pressure gradients develop, which result in lateral spreading of freshwater lenses in a form resembling gravity currents. Gravity currents inherently involve three-dimensional dynamics. As a type of organized structure, gravity currents in the upper layer of the ocean may also interact with, and be shaped by, the ambient oceanic environment and atmospheric conditions. Among the important factors are the background stratification, wind stress, wind/wave mixing and spatially coherent organized motions in the near-surface layer of the ocean. Under certain conditions, a resonant interaction between a propagating freshwater lens and internal waves in the underlying pycnocline (e.g., barrier layer) may develop, whereas interaction with wind stress may produce an asymmetry in the freshwater lens and associated mixing. These two types of interactions working in concert may explain the series of sharp frontal interfaces, which have been observed in association with freshwater lenses during TOGA COARE. In this work, we have conducted a series of numerical experiments using computational fluid dynamics tools. These numerical simulations were designed to elucidate the relationship between vertical mixing and horizontal advection of salinity under various environmental conditions and potential impact on the Aquarius and SMOS satellite image formation. Available near-surface data from field experiments served as a guidance for numerical simulations. The results of this study indicate that 3D dynamics of freshwater lenses are essential within a certain range of wind/wave conditions and the freshwater influx in the surface layer of the ocean.