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Upper Ocean Response to Convective and Stratiform Rains in the ITCZ

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In this work, we are interested in the upper ocean response to the freshwater and wind forcing in the ITCZ. In this work, we have conducted a series of three-dimensional numerical experiments using computational fluid dynamics tools to reveal the relationship between vertical mixing and horizontal advection of salinity under various environmental conditions including convective and stratiform rains. The numeric results are discussed in the context of the available field data for interpretation of the Aquarius and SMOS satellite data. Convective rains produce freshwater lenses localized in space. As a result, large horizontal density and pressure gradients develop in the near-surface layer of the ocean, which result in lateral spreading of these freshwater lenses in the form of gravity currents. Interaction of the gravity current with wind stress results in lens asymmetry, which can be described by Stommel's Overturning Gate theory. Under certain conditions, the upwind edge of the lens can be destabilized by the wind-driven flow of higher salinity/density water over the lens's edge, which results in the convection triggering Kelvin-Helmholtz instability in the form of billows. The Kelvin-Helmholtz billows produce large entrainment fluxes at the upwind edge of the lens; in contrast, the downwind edge of the lens is stabilized by horizontal advection of the lower salinity (less dense) water. The vertical mixing in the core of the lens is mainly driven by the vertical shear due to horizontal propagation of the lens. The impact of the wind stress appears to be less important in the core of the freshwater lens than at its edges. A freshwater inflow to the upper ocean due to a stratiform rain produces salinity anomalies, which are relatively homogeneous in space. One-dimensional simulations and parameterizations can be applicable to the case of the freshwater anomalies produced by stratiform rains; while, the response of the upper ocean to convective rains inherently involves three-dimensional dynamics.