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# Interior fronts in a coastal plume formed by tidally-modulated estuarine outflow and upwelling-favorable wind

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This study is motivated by observations of a buoyant plume off Winyah Bay, SC, which was formed under conditions of high freshwater discharge and upwelling-favorable wind forcing. Analysis of observations demonstrated that the response of the anticyclonic bulge formed by tidally-modulated estuarine outflow to the light upwelling-favorable wind was more complex than the previously studied far field response. The latter can be described by a slab-like model with mixing concentrating at the offshore edge of a buoyant layer. The observed plume depth increased from ∼3 m near the mouth to 6 m at the offshore edge, with plume depth changing in a step-like fashion rather than continuously. CTD profiles near these steps revealed overturning indicative of vigorous mixing. Estimates of gradient Richardson number confirmed the likelihood of mixing/entrainment not only at the offshore edge of the plume, but also in the proximity of the observed steps. We inferred that these thermohaline steps were tidal fronts which underwent geostrophic adjustment and were advected offshore by the superimposed Ekman drift. We present theoretical considerations and scaling analysis delineating the formation of the observed interior fronts. Our analysis defines a parameter space favorable for interior front formation in terms of riverine freshwater discharge and the tidal plume salinity anomaly (the latter represents mixing effects). Scaling analysis suggests that enhanced mixing and entrainment at the observed interior fronts can be caused by superposition of geostrophic and wind-induced shear.