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Eddy-driven upwelling at the Middle Atlantic Bight shelf-break front

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The Eastern US continental shelf is one of the most ecologically productive regions of the North Atlantic, but its productivity and biogeochemical cycles are highly dependent on the exchange of water across the quasi-permanent density front at the shelf break. We explore a new dynamical mechanism for the nonlinear interaction of submesoscale shelf eddies and the shelf break jet. By evolving a three-dimensional numerical model from an initial state that mimics typical early-spring conditions, we find that small amplitude vorticity variations over the shelf grow through baroclinic instability and move offshore into the frontal region. Localized transient upwelling allows a fraction of the bottom nutrient-rich shelf waters to enter the euphotic zone. This three-dimensional mechanism is shown to create vertical velocities of O(10m/day) that match the observations. The offshore net horizontal Lagrangian displacement is about 2 to 4 km/day during several days.