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Freshwater transport in the coastal buoyancy-driven current affected by variable downwelling-favorable winds

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A typical feature of coastal circulation in mid- and high latitudes is the existence of buoyancy-driven currents originating from multiple or continuous sources of fresh (or brackish) water and propagating downstream, in the direction of a Kelvin wave. The examples include the Alaska Coastal Current (ACC), the East Greenland Coastal Current, the Norwegian Coastal Current, and the coastal current in the Gulf of Maine. These systems are affected by wind forcing, and previous studies found that downwelling-favorable winds trap buoyant water near the coast, steepen the isopycnals, and enhance the downstream velocity and freshwater transport in the coastal current. In this study we present a series of numerical experiments demonstrating that under certain conditions the downwelling favorable winds reduce the downstream freshwater transport compared to no-wind conditions due to some freshwater being transported offshore. These situations include:

1. Light average wind stresses (0.025 Pa or less), especially when the wind varies alongshore. The offshore freshwater transport is eddy-driven and is enhanced in the areas of converging wind stress. Eddy generation is associated with the wind-induced deepening of a buoyant layer near the coast. When the surface boundary layer is thin under light wind, this deepening translates into an enhanced vertical shear of the alongshore current through the thermal wind balance (geostrophic shear).

2. The cyclonic atmospheric system coming ashore builds up a sea level bulge at the coast upstream from the cyclone's center. This high pressure forms a filament transporting the freshwater offshore along the upstream flank of the cyclone.

We apply the Regional Ocean Modeling System (ROMS) configured as a periodic channel and forced by multiple freshwater sources in the central part of the domain, and by the downwelling-favorable wind stress, both constant and variable. In particular, a moving cyclonic atmospheric system in the gradient wind balance is prescribed analytically. The model configuration is reminiscent of the ACC conditions, but the results are applicable to other shelves of the World Ocean as well.