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On Cabbeling and Thermobaricity in the Surface Mixed Layer

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The surface mixed layer (ML) and dynamics play a leading role in atmosphere–ocean fluxes, and thereby Earth's climate. Despite being very weakly stratified or vertically homogeneous, the O(100) m deep ML exhibits substantial horizontal gradients of temperature and salinity, making it an ideal location for cabbeling and thermobaric processes. These processes can increase local density differences within the ML, thus generating available potential energy and enhancing atmosphere–ocean exchanges. Understanding the effects of these processes in the ML provides insight into their climatic significance. A recent simplified, yet realistic, equation of state for seawater allows the local effects of cabbeling and thermobaricity to be estimated analytically as functions of the local temperature gradient and ML depth. We use this simplified framework to examine the effects of cabbeling and thermobaricity in a ML climatology product. Both cabbeling and thermobaricity predominantly occur in the ML poleward of 30°. The effect of thermobaricity in the ML is basin-scale and winter intensified. Cabbeling in the ML is perennial and localized to zonally-coherent regions associated with temperature fronts, such as the Antarctic Circumpolar Current and the Kuroshio and Gulf Stream Extensions. For latitudes between 40°–50° in both hemispheres, the zonally-averaged effects of cabbeling and thermobaricity in the ML can account for over 15% of the total meridional density difference.