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Entrainment process at the base of the upper ocean layer in an upwelling filament area

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Entrainment is responsible for the deepening of the mixed layer and controls the transport of momentum, heat, salinity and nutrients across the interface between the turbulent mixed layer and non-turbulent layer below. This process, which is not yet well understood, can be mechanically forced by wind stirring and buoyancy forced through vertical heat fluxes. In strongly dynamical areas such as eastern boundary upwelling systems and their associated filaments, entrainment rates can also be influenced by vertical shear at the base of the mixed layer that may results from advected baroclinic instabilities. We investigate these processes in the Northwest African upwelling region and Cape Ghir filament using CTD, XBT, ADCP, a meteorological station on board for the wind data and heat flux measurements taken during October 2010, as well as one of the first microturbulent profile (TurboMAP) measurements taken in this area in order to obtain the TKE dissipation rate. We find that buoyancy production dominates over the wind induced mixing in the mixed layer of this region as indicate the Monin Obukhov length scale. To determine entrainment rates we compare four parameterizations based on the turbulent kinetic energy (TKE) balance and one based on the relation of the bulk Richardson number. Although there is no clear consensus between these four parameterizations, they provide evidence that vertical shear at the base of the mixed layer acts to enhance the entrainment rate, especially at stations effected by the upwelling filament or mesoscalar structures. We further compare the measured TKE dissipation rates to those parameterized of Gaspar (1988) and Deardorff (1983). Moreover, some relevant aspect relative to the study of turbulent process in the upper ocean layer, such as the choice of an algorithm or criteria to find the mixed layer depth and the difference between mixing and mixed layer are addressed.
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