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Strain-induced shear instability in Liverpool Bay

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Liverpool Bay is a shallow subsection of the eastern Irish Sea with large tides (10 m), which drive strong tidal currents (1 ms-1). The Bay is heavily influenced by large freshwater inputs from several Welsh and English rivers that maintain a strong and persistent horizontal density gradient. This gradient interacts with the sheared tidal currents to strain freshwater over denser pelagic water on a semi-diurnal frequency. This Strain-Induced-Periodic-Stratification (SIPS) has important implications on vertical and horizontal mixing. The subtle interaction between stratification and turbulence in this complex environment is shown to be of critical importance to freshwater transport, and subsequently the fate of associated biogeochemical and pollutant pathways. Recent work identified an asymmetry of current ellipses due to SIPS that increases shear instability in the halocline with the potential to enhance diapycnal mixing. Here, we use data from a short, high intensity process study which reveals this mid-water mechanism maintains prolonged periods of sub-critical gradient Richardson number (Ri $\leq \frac{1}{4}$) that suggests shear instability is likely. A time series of measurements from a microstructure profiler identifies the associated increase in turbulence is short lived and 'patchy' but sufficient to promote diapycnal mixing. The significance of this mixing process is further investigated by comparing our findings with long-term observations from the Liverpool Bay Coastal Observatory. We identify that the conditions for shear instability during SIPS are regularly met and suggest that this process contributes to the current underestimates of near coastal mixing observed in regional models. To assist our understanding of the observed processes and to test the current capability of turbulence 'closure schemes' we employ a one-dimensional numerical model to investigate the physical mechanisms driving diapycnal mixing in Liverpool Bay.