Stability Analysis of the Labrador Current

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Mooring observations and model simulations point to an instability of the Labrador Current (LC) during winter, with enhanced eddy kinetic energy (EKE) at periods between 2 and 5 days and much less EKE during other seasons. Linear stability analysis using vertical shear and stratification from the model reveals three dominant modes of instability in the LC: 1) a balanced interior mode with along-flow wavelengths of about 30–45 km, phase velocities of 0.3 m s^{-1}, maximal growth rates of 1 day^{-1}, and surface-intensified but deep-reaching amplitudes; 2) a balanced shallow mode with along-flow wavelengths of about 0.3–1.5 km, phase velocities of 0.55 m s^{-1}, about 3 times larger growth rates, but amplitudes confined to the mixed layer (ML); and 3) an unbalanced symmetric mode with the largest growth rates, vanishing phase speeds, and along-flow structure, and very small cross-flow wavelengths, also confined to the ML. Both balanced modes are akin to baroclinic instability but operate at moderate-to-small Richardson numbers Ri with much larger growth rates as for the quasigeostrophic limit of $Ri \gg 1$. The interior mode is found to be responsible for the instability of the LC during winter. Weak stratification and enhanced vertical shear due to local buoyancy loss and the advection of convective water masses from the interior result in small Ri within the LC and up to 3 times larger growth rates of the interior mode in March compared to summer and fall conditions. Both the shallow and the symmetric modes are not resolved by the model, but it is suggested that they might also play an important role for the instability in the LC and for lateral mixing.