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On the dispersion relation of westward propagating signals in the oceans

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An intriguing feature of the dispersion relation of oceanic westward propagating signals as observed in zonal wavenumber/frequency spectra of satellite altimeter data is the apparent nondispersive character of the signals at high wavenumbers, which contrasts with the predictions of the standard linear theory for baroclinic Rossby waves. In this work, the theory for dispersive Rossby waves previously derived by Killworth and Blundell (2004,2005) is re-examined in the context of Quasi-Geostrophic theory with the aim of understanding the behaviour of Rossby wave dispersion at high wavenumbers in presence of topographic effects and a background zonal mean flow. The main result is the explicit demonstration that the presence of the mean flow makes Rossby waves nondispersive at high wavenumbers, the nondispersive phase speed being that of the minimum velocity along the vertical. Although the nondispersive character of the waves predicted by the extended linear theory is in qualitative agreement with the observed dispersion characteristics of westward propagating signals, the corresponding nondispersive phase speeds appear too low to actually account for observations. Moreover, the vertical structure of the extended linear Rossby wave modes appears quite unrealistic at high wavenumbers, suggesting that such modes probably do not exist in the oceans. These results lend support to the idea that nonlinear effects are probably essential to account for the apparent nondispersive character of westward propagation at high wavenumbers.