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Dynamics of long baroclinic Rossby waves along 26°N in the Atlantic

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The dynamics of long baroclinic Rossby waves along 26°N in the Atlantic is investigated using a new theory, an idealized model, and an ocean general circulation model (OGCM). The theory is based on vertical mode decomposition of the conservation equations of mass and momentum in the presence of (steep) topography. Each vertical mode Rossby wave propagates independently along contours of (Coriolis parameter) / (corresponding equivalent depth) in the absence of topographic interaction between vertical modes, but the topographic interaction alters the propagation characteristics and vertical structure. Neglecting wave directionality, scaling analysis shows that topographic interaction is important even in a relatively flat part of the basin. The theory is applied to zonally-varying, meridionally periodic one-dimensional (1D) modeling with realistic zonal bathymetry and Ekman forcing. This simple model shows that the barotropic and first baroclinic Rossby waves tend to travel together, with the phase speed close to that of the first mode, due to strong topographic interactions. The results of the 1D model are compared to vertical modal amplitudes extracted from more realistic OGCM results. The two models show similar features for the barotropic and first baroclinic modes. For example, their phase speeds are similar, and the amplitudes increase on the mid-Atlantic ridge for the barotropic mode and in the west of the mid-Atlantic ridge for the first baroclinic mode. However, in the OGCM, second baroclinic mode Rossby waves have comparable amplitudes to the first baroclinic mode, which suggests the existence of essential factors other than winds and topography. Furthermore, the 1D model misses large-amplitude events caused by waves (or fronts) propagating towards south-southwest direction. The implications of baroclinic Rossby waves on the strength of the meridional overturning circulation will be discussed.