The Dependence of Tidal Effects Including Internal Tides and Mixing on Latitude

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The effects of latitude on internal tides, internal waves and mixing were investigated using Regional Ocean Modeling System (ROMS) simulations by shifting a small domain with a seamount from 20.6° to 28.6° S. The critical latitude is the latitude where the inertial frequency equals the tidal frequency, which for the K_1 constituent is 30° and O_1 is 27.6°. Linear internal wave theory says that internal tides are trapped and will not propagate poleward of their respective critical latitudes. The same topography and hydrography from Barcoo Seamount off New South Wales collected during SS0906 were used in all simulations.
The largest diurnal tides occurred near the critical latitudes and for 3-6° equatorward of critical latitude. The diurnal internal tides equatorward of the diurnal critical latitudes propagated in beams in agreement with linear theory. At the diurnal critical latitudes, diurnal energy peaked. Poleward of critical latitude, the diurnal internal waves had a signature which encompassed more of the water column vertically and they did not propagate in a beam-like pattern. By 8° poleward of the K_1 critical latitude, critical latitude effects had ceased. Poleward of the diurnal critical latitudes, significant diurnal internal tidal energy shifted to the semidiurnal constituents, harmonics, and high frequencies. As a result, semidiurnal internal tidal energy peaked just poleward of the diurnal critical latitude, as did energy at the tidal harmonic frequencies, 3, 4, 6, 8, cpd. Bispectra confirmed these energy transfers. Tidal residuals, mean velocities generated by the tides, were latitude and depth dependent, with the largest residuals near the critical latitudes and within 6 $^\circ$ poleward of them. The latitudes 4-6° poleward of the K_1 critical latitude had the highest vertical temperature diffusivities along the flanks of the seamount and they showed the largest temperature changes in the neighbourhood of the permanent pycnocline, 500-100 m depth. The average diffusivities of both temperature and momentum increased with increasing latitude until near the critical latitude, where they dipped at both critical latitudes. Poleward of the critical latitudes, the diffusivities peaked 4° poleward of the K_1 critical latitude and then decreased with increasing latitude. Due to vertical shifts in the location of the higher diffusivities, changes in potential temperature and salinity were significantly larger and of the opposite sign for the latitudes 4-6° poleward of the K_1 critical latitude than for the other latitudes.

Keywords: mixing, internal tides, critical latitude

