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Energetics of long internal gravity waves in large lakes

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ABSTRACT: An analytical model is used to determine dispersion relations and the ratio of potential to kinetic energy in linear basin-scale internal waves in lakes affected by the earth’s rotation. It is shown that the wave frequency and energy partitioning in elliptic lakes are dependent only on the direction of propagation relative to the earth’s rotation, the aspect ratio, the horizontal mode (azimuthal and radial), and the Burger number ($S_i = c_i / Lf$, where c_i is the nonrotating phase speed, L is a length scale that characterizes the lake dimension, and f is the Coriolis parameter). For the cyclonic (rotating in the same direction as the earth’s rotation), lowest radial mode (a Kelvin wave for small S_i and a Poincare´ wave for large S_i), the total potential to kinetic energy ratio was always greater than unity for all azimuthal modes. For all other radial modes (Poincare´ waves for all S_i), both cyclonic and anticyclonic, the ratio is substantially less than unity, especially as the Burger number decreases. The results demonstrate that basin-scale Poincare´ waves follow the same rotation-gravity balance as unbounded plane progressive Poincare´ waves, in which rotation plays an increasingly important role as the Burger number decreases. The solutions are applied to field experiments conducted in Lake Kinneret (Israel) to determine the dissipation timescale of the basin-scale internal waves. It is further shown that features of the spatial structure of isopycnal displacement and velocity scales may be inferred from a single station that measures potential energy fluctuations.

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