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Internal waves in transcritical, rotating flow over topography

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The flow of a one-and-a-half layer fluid over an obstacle, of nondimensional height M relative to the lower layer depth, is investigated in the presence of rotation, the magnitude of which is measured by a nondimensional parameter B (inverse Burger number). The transcritical regime in which the Froude number F, the ratio of the flow speed to the interfacial gravity wave speed, is close to unity is considered in the shallow water (low aspect ratio) limit. A similarity theory, describing the behaviour of nonlinear internal waves generated on the interface between the layers is developed for weakly rotating flow over a small isolated obstacle ($M \to 0$). The behaviour is shown to depend on the parameters $\Gamma = (F-1)M^{-2/3}$ and $\nu = B^{1/2}M^{-1/3}$. The flow pattern in this regime is determined by a nonlinear equation in which Γ and ν appear explicitly, termed here the 'rotating transcritical small disturbance equation' (rTSD). The flow exhibits several qualitatively new behaviours, one important result being that, for weakly supercritical oncoming flow with sufficiently strong rotation, hydraulic jumps appear downstream of the obstacle prior to developing upstream as in the case of non-rotating flow. Numerical results are compared with results from a shock-capturing shallow water model, and the theory is shown to give good quantitative predictions of flow patterns at finite obstacle height (at least up to $M = 0.4$).