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Beach Vortices near Stepped Topography

A.K. Hinds, E.R. Johnson, N.R. McDonald
University College London (hinds@math.ucl.ac.uk)

The motion of ideal shallow water vortices near rectilinear stepped topography is studied without background rotation. Firstly, finite area monopolar vortices which propagate steadily parallel to the step, without change of shape are found. Solutions are obtained numerically and are unique for a given volume and centre of vorticity. Time-dependent integrations show that these vortices are robust: flows initialized with a V-state remain close to the V-state and flows initialized with a circular vortex shed vorticity to approach a V-state. The translational velocity of the vortices is shown to be finite and, unlike that of a singular line vortex, not to increase without limit as the centre of vorticity approaches the escarpment.

Second, the motion of a pair of line vortices is found using Hamiltonian techniques with similar trajectories found for vortex patches using contour dynamics. A comparison between the two trajectories is found to be close provided vortex patch centroids are sufficiently far away from the escarpment. For given constants of motion (energy, linear impulse and circulation) the path each vortex is found to be unique in relative distance variables (up to translations in the x-plane). Furthermore, for special values of the constants of motion, vortex pairs which propagate steadily parallel to the escarpment without deformation (dipole equilibrium states) exist even when the circulation of each vortex has the same sign.