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Passage of a barotropic vortex through a gap

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We study the flow consisting of a current that advects a vortex towards a gap in a wall. This is an idealization of flows observed in the world oceans, for example in the various passages of the Lesser Antilles and in the Yucatan Channel. The vortex evolution and the transport properties are studied as a function of three non-dimensional parameters related to the vortex intensity, the vortex initial position, and the gap's span. The flow evolution is computed numerically with a two-dimensional, inviscid model. The vortex is observed to behave in one of the following ways: it passes completely through the gap, it splits and only a fraction passes, or it stays entirely in the upstream side of the wall. In each of these regimes transport and mixing are analyzed using the lagrangian flow geometry, finite-size Lyapunov exponents and residence times of fluid particles. Laboratory experiments are performed in a homogeneous, rotating fluid. In the region of parameter space that lead to total passage of the vortex there is good agreement between the evolution observed in the laboratory and that simulated by the model. In the regions of parameter space that lead to partial passage and full blockage the agreement is good only until the generation of vorticity on the walls becomes important.