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Circulation around a "skirted" island

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Assessing the role of planetary scale islands in the dynamics of the ocean circulation is both of intrinsic fluid mechanical interest and of practical importance. Until now, investigations of this problem have idealized the island as an interior “hole” in the oceanic basin whose boundaries are vertical walls. Here we take up the question of the effect of topography in the region bounding the island. We represent topography as a simple continental slope “skirt” in which the depth of the ocean linearly varies from zero at the island to the full (and constant) ocean depth at some distance both east and west of the island, which we otherwise idealize as a thin linear barrier oriented north-south.

In addition to providing a possibly more realistic representation of the island topography, the presence of the skirt also introduces fundamental changes in the dynamics. When the depth change is strong enough the isolines of potential vorticity will tend to wrap around the island and close on themselves. When this closure happens a free geostrophic mode is possible in which the motion can freely circulate along the closed potential vorticity contours and the nature of the circulation alters dramatically.

We study the circulation around the “skirted” island with a forced, dissipative shallow water numerical model, whose results are compared to those of laboratory experiments made with the sliced-cylinder device. We also develop an approximate analytic theory, in the linear limit, that to a large measure clarifies and explains key features of the numerical experiments with weak and moderate forcing.

We conclude with a survey of results from strongly nonlinear experiments that exhibit rich time-dependent dynamics.