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Topographic steering of dense overflow plumes by canyons and ridges

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Large-scale dense bottom currents are geostrophic to leading order, with the main flow direction along the continental slope. Bottom friction makes the water descend to greater depths, but only at a small angle to the horizontal. Here the effect of submarine ridges and canyons that intersects the slope is considered. By leaning against the ridge/canyon wall it is possible for the dense water to flow downhill, perpendicular to the depth contours, even though the first order dynamics are geostrophic. The requirement for downward flow next to the ridge/ in the canyon is that the frictional transport that it induces is sufficiently large to counteract geostrophic advection along the isobaths and out of the ridge/canyon region.

An analytical model describing such flows is presented, and expressions for the transport capacity (the maximal amount of water that can be channeled downslope) of ridges and canyons with idealized geometries are derived.

The theoretical results are compared to results from laboratory experiments, in which dense gravity currents in rotating vee-shaped canyons and ridges have been studied. Velocity measurements and visualizations of the dense layer interface are presented, showing relatively good agreement with theory.

The relevance of the findings to the Filchner Overflow Plume, Antarctica, is discussed and it is suggested that the observed partition of the dense Ice Shelf Water plume is due to the presence of a ridge and a canyon on the continental slope west of the Filchner sill.