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Quantification of Upwelling through Steep Continental Shelf Canyons

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Submarine canyons that cut into the continental shelf are regions of enhanced upwelling during coast-wide upwelling events. Enhanced upwelling can occur due to four different processes: time dependence- the strength of shelf-flow is increasing allowing cross-isobath flow, advection- the small spatial scales of the canyon allow strong flow to cross-isobaths, isobath convergence- isobath convergence in the region of the canyon allows cross-isobath flow and a new process that appears to be related to internal waves which allows cross-isobath flow near the mouth of the canyon. We will briefly review these different types of upwelling, the flow patterns and dynamics associated with each.

Then we will focus on the usually dominant advection-driven upwelling. The depth of upwelling and flux through the canyons quantifies this exchange between the shelf and the open ocean. Scaling analysis that relate these quantities to the strength of the flow, stratification, Coriolis parameter and topographic shape parameters allow their estimation in the absence of a full numerical simulation or a detailed field study of a specific canyon. Here we add the impact of the continental shelf slope to the scaling and test the scaling using a three-dimensional primitive equation model over 18 distinct geometries. The impact of the continental shelf is significant for real canyons with changes in the depth of upwelling of 20% and of the flux of upwelling of 65%. Including the continental slope, the depth of upwelling (as given by the three-dimensional model) can be estimated to within 10% and the upwelling flux (as given by the three-dimensional model) within 25%.