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The upwelling of downwelling currents

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The term “downwelling currents” refers to currents with a downslope mass flux in the bottom boundary layer. Examples are the Malvinas and Southland Currents in the southern hemisphere and the Oyashio in the northern hemisphere. Although many of these currents generate the same type of highly productive ecosystems that is associated with upwelling regimes the mechanism that may drive such upwelling remains unclear. In this article we postulate that the interaction between a downwelling current and the continental slope generates shelfbreak upwelling. The proposed mechanism is relatively simple. As a downwelling current flows along the continental slope, bottom friction and lateral diffusion spread it onto the neighboring shelf, thus generating alongshelf pressure gradients and a cross-shelf circulation pattern that leads to shelfbreak upwelling. At difference with previous studies of shelfbreak dynamics the shelfbreak upwelling in the proposed model is not controlled by the downslope buoyancy flux associated with the presence of a shelf current, but by the alongshelf pressure gradient associated with the presence of a slope current. As our experiments demonstrate shelfbreak upwelling will occur in flat-bottomed domains or even in the absence of a bottom boundary layer. The shelfbreak upwelling, moreover, is not evidence of the separation of the bottom boundary layer, but of the downstream divergence of the slope currents and its magnitude is proportional to the volume transport of that current. To prove our hypothesis we present the results of a series of process-oriented numerical experiments.