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The upstream spreading of bottom-trapped plumes

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It is well known that numerical simulations of freshwater discharges produce plumes that spread in the direction opposite to that of the propagation of coastally trapped waves (the upstream direction). The lack of a theory explaining these motions in unforced environments deemed the numerical results suspect. Thus, it became a common practice in numerical studies to add a downstream mean flow to arrest the development of upstream flows. This approach is generally unjustified and it remains a matter of interest to determine if the upstream displacement produced by models is a geophysical phenomenon or a consequence of erroneous assumptions in the model set up. In this presentation we use the results of highly idealized numerical experiments to investigate these matters. We show that this phenomenon is associated with the geostrophic adjustment of the discharge and that "upstream" motion is endemic to the baroclinic structure of bottom trapped plumes. We also show that downstream" displacements are generated by the cross-shelf barotropic pressure gradient generated by the propagation of coastally trapped waves. Sensitivity experiments indicate that the speed of upstream propagation and density structure of the plume is affected by bottom friction, the slope of the bottom and the magnitude of the density anomaly. Bottom friction, in particular, slows down the progression of the plume and changes its density structure producing a more homogeneous downstream region and a more stratified upstream region.