EGU21-9273
https://doi.org/10.5194/egusphere-egu21-9273
EGU General Assembly 2021
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Removal of a dense bottom layer by a gravity current

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We investigate the removal of a dense bottom layer by a gravity current, via Navier-Stokes Boussinesq simulations. The problem is governed by a dimensionless thickness parameter for the bottom layer, and by the ratio of two density differences. A quasisteady gravity current propagates along the interface and displaces some of the dense bottom fluid, which accumulates ahead of the gravity current and forms an undular bore or a series of internal gravity waves. Depending on the ratio of the gravity current front velocity to the linear shallow-water wave velocity, we observe small-amplitude waves or a train of steep, nonlinear internal waves. We develop a self-contained model based on the conservation principles for mass and vorticity that does not require empirical closure assumptions. This model is able to predict the gravity current height and the internal wave or bore velocity, generally to within about 10% accuracy. An energy budget analysis provides information on the rates at which potential energy is converted into kinetic energy and then dissipated, and on the processes by which energy is transferred from the gravity current fluid to the dense and ambient fluids. We observe that the energy content of thicker and denser bottom layers grows more rapidly.