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An adaptive finite element approach to modelling sediment laden density currents

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Modelling sediment-laden density currents at real-world scales is a challenging task. Here we present Fluidity, which uses dynamic adaptive re-meshing to reduce computational costs whilst maintaining sufficient resolution where and when it is required. This allows small-scale processes to be captured in large scale simulations.

Density currents, also known as gravity or buoyancy currents, occur wherever two fluids with different densities meet. They can occur at scales of up to hundred kilometres in the ocean when continental shelves collapse. This process releases large quantities of sediment into the ocean which increase the bulk density of the fluid to form a density current. These currents can carry sediment hundreds of kilometres, at speeds of up to a hundred kilometres per hour, over the sea bed. They can be tsunamigenic and they have the potential to cause significant damage to submarine infrastructure, such as submarine telecommunications cables or oil and gas infrastructure. They are also a key process for movement of organic material into the depths of the ocean. Due to this, they play an important role in the global carbon cycle on the Earth, forming a significant component of the stratigraphic record, and their deposits can form useful sources of important hydrocarbons.

Modelling large scale sediment laden density currents is a very challenging problem. Particles within the current are suspended by turbulence that occurs at length scales that are several orders of magnitude smaller than the size of the current. Models that resolve the vertical structure of the flow require a very large, highly resolved mesh, and substantial computing power to solve. Here, we verify our adaptive model by comparison with a set of laboratory experiments by Gladstone et al. [1998] on the propagation and sediment deposition of bidisperse gravity currents. Comparisons are also made with fixed mesh solutions, and it is shown that accuracy can be maintained with fewer elements, and with significantly shorter run times, using a dynamic adaptive mesh approach.