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On a new benchmark for the simulation of saltwater intrusion

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To date, many different benchmark problems for density-driven flow are available. Benchmarks are necessary to validate numerical models. The benchmark by Henry (1964) measures a saltwater wedge, intruding into a freshwater aquifer in a rectangular model. The Henry (1964) problem of saltwater intrusion is one of the most applied benchmarks in hydrogeology. Modelling saltwater intrusion will be of major importance in the future because investigating the impact of groundwater overexploitation, climate change or sea level rise are of key concern.

The worthiness of the Henry (1964) problem was questioned by Simpson and Clement (2003), who compared density-coupled and density-uncoupled simulations. Density-uncoupling was achieved by neglecting density effects in the governing equations, and by considering density effects only in the flow boundary conditions. As both of their simulations showed similar results, Simpson and Clement (2003) concluded that flow patterns of the Henry (1964) problem are largely dictated by the applied flow boundary conditions and density-dependent effects are not adequately represented in the Henry (1964) problem.

In the present study, we compare numerical simulations of the physical benchmark of a freshwater lens by Stoeckl and Houben (2012) to the Henry (1964) problem. In this new benchmark, the development of a freshwater lens under an island is simulated by applying freshwater recharge to the model top. Results indicate that density-uncoupling significantly alters the flow patterns of fresh- and saltwater. This leads to the conclusion that next to the boundary conditions applied, density-dependent effects are important to correctly simulate the flow dynamics of a freshwater lens.