The Role of Salt Sources in Density-Dependent Flow

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ABSTRACT
In groundwater variable density problems, the fluid can be viewed as consisting of two components: water and salt. Fluid mass balance is given by the flow equation, which, consequently, must account for both salt and water sources. However, most of the density-dependent flow simulation codes neglect the salt sources that do not come dissolved in water when establishing fluid mass balance. Here such salt sources will be called pure salt sources to distinguish them from the mixed salt and water sources and as an analogy with pure water. Pure salt sources can have their origin either in internal processes such as chemical reactions, dissolution or precipitation, or in the boundary conditions. Pure salt boundary sources occur when water flux is prescribed to be zero and either the salt flux (Neumann boundary conditions) or the concentration (Dirichlet boundary conditions) is prescribed at the boundary. Consistency between flow and transport boundary conditions is required, which is not always accomplished. In this work, pure salt sources are considered in fluid mass balance and the effects on the resulting flow regime and concentration distribution are explored. Two test cases are used to illustrate the role of pure salt sources. The first one is the saltwater bucket problem, which deals with the addition of salt to a close domain. It shows that neglecting pure salt sources in the flow equation causes heads to fall, which is physically inconsistent with an increase of mass. The second one is the Elder problem, which shows that acknowledging the presence of pure salt sources reduces fingering but increases substantially overall salt transport and causes the fluid to flow out through the prescribed head boundaries. It also gives an insight into the use of analogies between heat and salt transport problems.

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