Seafloor hydrothermal systems have a significant impact on Earth’s global heat and chemical budgets; however, many aspects of the transport mechanisms are not well understood. This lack of understanding arises in part because seafloor hydrothermal systems often exhibit two-phase flow. Two-phase flow and transport in multi-component systems are very complex, and our knowledge of dynamic processes associated with phase transition in NaCl-H2O hydrothermal systems is very limited. Consequently, a comprehensive understanding of heat/salt/chemical transport involving two-phase fluid flow in seafloor hydrothermal systems will likely require numerical simulation.

To address this need we have developed a finite difference simulator GTHSW (Georgia Tech hydrothermal seawater) for numerical modeling of two-phase fluid flow and heat/salt transport in hydrothermal systems. Seafloor hydrothermal systems are assumed to consist of a non-uniform porous medium containing NaCl-H2O fluids with variable salinity. The fluid flow and transport in these systems are described by a set of fluid mass, salt, and heat conservation equations based on assumptions of Darcy’s flow and thermodynamic equilibrium between the phases and thermal equilibrium between fluids and porous media. These equations are solved for pressure, temperature and salinity, which can uniquely define the state of the NaCl-H2O system through an equation of state (EOS) that is available to the public. The current version is for two-dimensional models with flexible boundary conditions. Both sequential and parallel are available to others for use or testing.

In addition to describing the numerical simulator we will present examples of its utility. We first consider the problem of a heat pipe. In this classical counterflow problem with no net mass flux, the low density, high enthalpy vapor phase transports heat upward, as the dense, low enthalpy liquid descends under the action of gravity. Although steady state heat pipes can exist in pure water systems, we show that in NaCl-H2O systems heat pipes are inherently unstable. We then investigate counterflow problems in which there is a net upward mass flux. These problems simulate high-temperature two-phase venting on the seafloor. Finally, we consider two-dimensional problems. Such models are useful for studying the formation of deep saline brines in both seafloor hydrothermal systems and continental systems such as the Salton Sea geothermal system in California.