

Aquifer Physics Modes for Hydrogeological Modeling - an Application of the COMSOL Physics Builder

E. Holzbecher¹

¹Georg-August Universität Göttingen, Göttingen, Germany

Abstract

Although there are porous media and subsurface flow modes available in a toolbox of COMSOL Multiphysics®, some common requirements in hydrogeological models can not be easily accessed in the graphical user interface. Most crucially, there is no distinction between confined and unconfined situations for permeable layers, so called aquifers. Using the Physics Builder for such distinctions aquifer physics modes are constructed that enable hydrogeologists to work with COMSOL Multiphysics® as they are used to from other specialized software for hydrogeological modeling.

Using specialized modelling software the hydrogeologist usually does not recognize the differences in the partial differential equations, when choosing either confined or unconfined situations. However applying a general fluid solver, as the one implemented in COMSOL Multiphysics®, that has to be taken into account. In order to enable hydrogeological modelling without the need to work with differential equations, the aquifer modes were developed, which allow to choose confined or unconfined modelling approaches just by mouse-click (see Figure 1). There are two modes: 'confaq' and 'unconfaq'.

Using the Physics Builder we enable the user to model aquifers in 1D or 2D domains. It is possible to enter additional domain features, like recharge, boundary features for head and flow, and point features for wells and head (see Figure 2). Both aquifer modes can be used for steady or transient modeling. Multi-aquifer systems can be set-up easily using aquifer couplings.

For the demonstration of the performance of the new modes we choose the flow pattern towards a well in a 1D regional flow field as a benchmark example. The flownet is depicted in Figure 3. We compare results with the analytical solution.

In addition we present two further physics modes for the steady state situation. The 'aq'-mode is capable of modelling flow situations, in which there is the condition change from confined to unconfined or vice versa. This has the advantage that the user does not have to know about the confined/ unconfined situation in the aquifer beforehand. The outcome of the different aquifer modes is compared in an example.

Using the streamfunction mode the boundary conditions have to be defined in a different way. For example total fluxes can be specified at open boundaries, leaving the local velocity

distribution along the edge open to the model. Another advantage is that exact flow net patterns can be obtained, with equal fluxes between streamlines. We demonstrate this for a regional flow pattern in a cross-section through a basin (see Figure4).

Figures used in the abstract

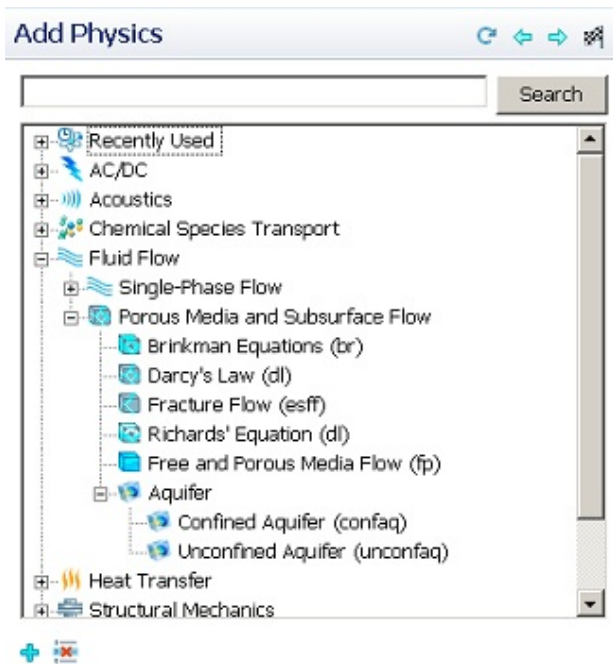


Figure 1: 'Add Physics' options: selection of aquifer modes

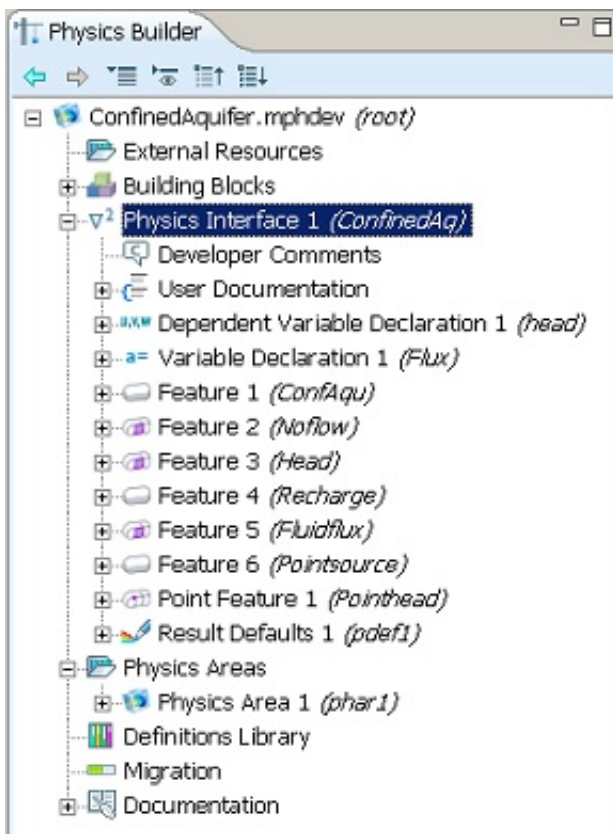


Figure 2: Physics Builder tree for aquifer modes

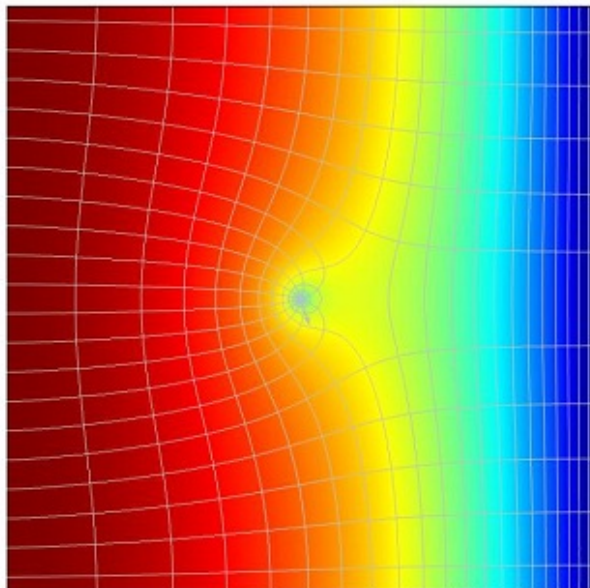


Figure 3: Flow towards a well in an unconfined aquifer; flownet consisting of streamlines and isopleths

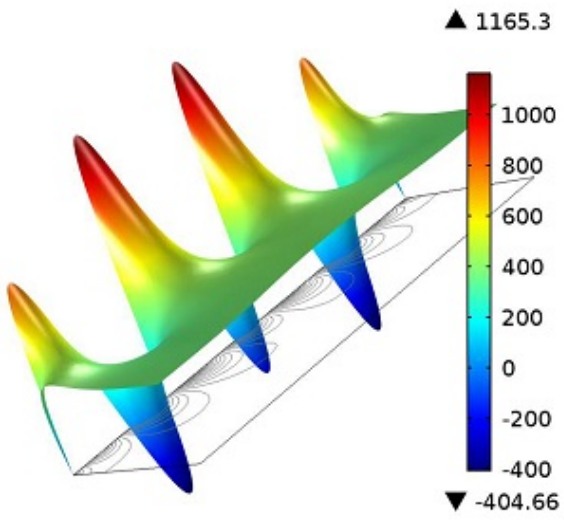


Figure 4: Streamfunction mode application