RECENT DEVELOPMENTS OF THE POROUSMULTIPHASEFOAM TOOLBOX

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Understanding and modeling multiphase flow in porous media is a major point of interest for various applications, from hydrological issues (flow in aquifer for example) to industrial process (oil production, filtration processes). The native/original implementation of porous media flows in OpenFOAM is handled as a penalization term included in the momentum equations which cannot handle the main features of multiphase flow in porous media. Based on this observation, the porousMultiphaseFoam toolbox [1, 2] has been developed and proposed to the community for the first time in 2014 (OpenFOAM workshop 9). Its first release contained two solvers (for iso- and anisotropic porous media) using the two most known relationships for modeling capillary pressure and relative permeabilities Brooks and Corey [3] and Van Genuchten[4]) and two boundary conditions for imposing Darcy velocity (all compiled as external libraries). In recent years, several new features has been developed and included in the toolbox.

Developments have been made both on the existing solvers and towards new physics. In a first stage to improve both the stability and the efficiency of simulations, we implement some characteristic numbers (Todd and Coats) more suitable to for porous multiphase flow to compute stable time step than the classical Courant Numbers. We also evaluate their performance according to the type of the flow (gravity, viscous or capillary-driven flows) in order to provide some practical advices to the toolbox's users [5].

In a second part, the toolbox has been extended to the specific cases of groundwater flows solving the Richards' equation. In this approach, the pressure gradient of the non-wetting phase is neglected which allows to solve only the liquid phase mass conservation. This approach is particularly useful when studying groundwater flows at the scale of the watershed. Each time iteration is solved using a Picard's algorithm to allow larger time-steps. A new boundary condition has been developed for that case in order to impose the water height on the lateral boundaries. This dedicated solver has been tested on a real case (with topographic dataset and infiltration data overtime) as illustrated on figure 1.

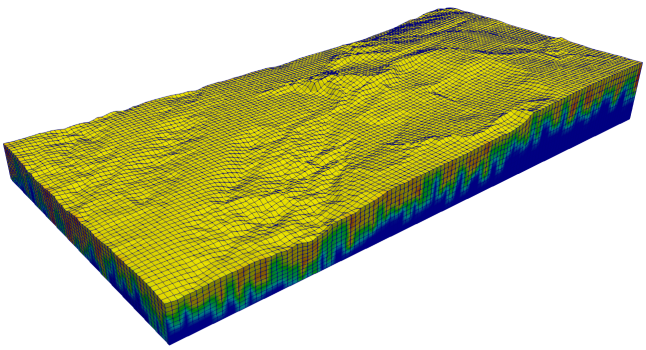

Figure 1: groundWaterFoam – Water saturation field of groundwater flow with infiltration on real topographic dataset.

In a third part, the impesFoam solver initially dedicated to two-phase flow has been extend to three-phase flow (triImpesFoam) to simulate a hydrocarbon pollution scenario. New three-phase capillary and relative permeability model (Parker and Lenhard [6]) have been implemented to handle the oil-water-air system. The application case was to study the contamination of a groundwater flow by a leak of gasoline (figure 2).

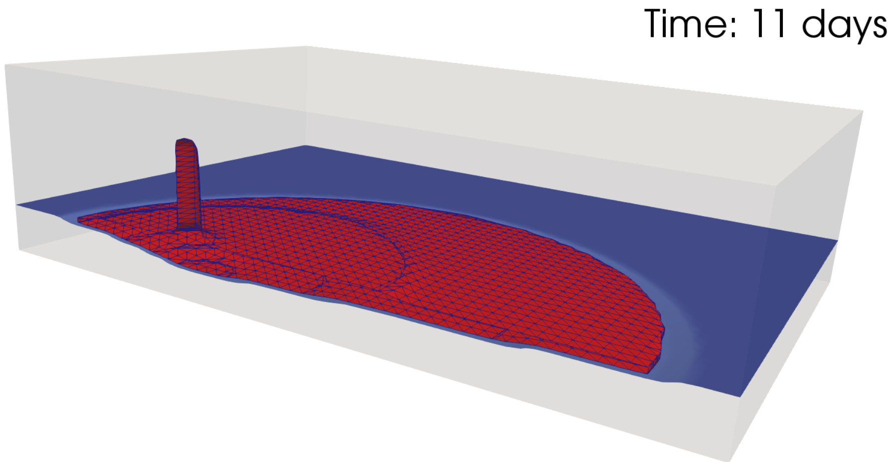

Figure 2: triImpesFoam – Oil leak over groundwater flows (oil-saturated area in red, water-saturated area in blue).

References

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