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Heat and mass transfer in soil

- *Goal*: Studying prehistoric fires, we deal with a problem of heat diffusion in a water saturated heterogeneous porous medium that presents inherent difficulties associated with the non-linearity of the interface conditions, due to the phase change between liquid water and its vapor. The main goal is mainly to determine the time of lighting of these fires, only from burned traces inside the soil. So, we are looking to fast and accurate code in order to solve inverse problem.

  Contrary to the natural superficial water evaporation in soil, which has been intensively studied in hydrology, in our case the huge values of temperature and heat flux on the soil leads to a strong coupling between heat transfer and water vapor flow inside the porous medium.

  The classical Apparent Heat Capacity (AHC) formulation has been extended for all the physical properties involved in our problem, via a completely continuous description, so that the computational domain need not to be split into the dry part (where vapor flows) and the wet part (involving liquid at rest). As a result, the whole set of equation is a Differential Algebraic system of Equations (DAE).

- *Main results*: Preliminary results concerned the reduction of the whole set of equations to the classic Stefan problem in 1D, in order to compare numerical results with analytic solutions. The Latent Heat Accumulation approach, combining a rolling mesh technique, has been implemented using a vertex-centered FV formulation and tested in [1]. The AHC approach, which leads to stiff equations, has been solved by the method of lines and a BDF solver for the resulting ODE system [2]. Jacobian matrix has been derived by hand and coded in a sparse structure. Sparse algebra inside the modified BDF solver uses UMFPACK.
  New results have been obtained recently for the complete problem, by using a DAE solver, for both 1D and 2D geometries.

- *References*:

  [1] M. Muhieddine and É. Canot, *Recursive mesh refinement for vertex centered FVM applied to a 1-D phase-change problem*, 5th International Symposium on Finite Volumes for Complex Applications, Aussois, France, June 9-13, 2008
  http://www.irisa.fr/sage/edouard/publis/FVCA5_Aussois_2008.pdf

  [2] M. Muhieddine, É. Canot and R. March, *Numerical solution of a 1-D time-dependent phase change problem*, Fifth ECCOMAS, Venice, Italy, June 30-July 5, 2008
  http://www.irisa.fr/sage/edouard/publis/ECCOMAS_Venise_2008.pdf