Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-140-RC2, 2020

Geoscientific Model Development Discussions

Interactive comment on "*HydrothermalFoam* v1.0: a 3-D hydro-thermo-transport model for natural submarine hydrothermal systems" *by* Zhikui Guo et al.

Matteo Cerminara (Referee)

matteo.cerminara@gmail.com

Received and published: 13 September 2020

The paper "HydrothermalFoam v1.0: a 3-D hydro-thermo-transport model for natural submarine hydrothermal systems" describes the implementation in the OpenFOAM infrastructure of the Darcy model for a compressible fluid in a porous medium. Fluid and solid media are considered in local equilibrium. The paper describes the corresponding partial differential equations for the balance of mass, momentum, and energy; their boundary conditions; and the equation of state for pure water in a single phase, either in subcritical or supercritical conditions. The algorithm is described in a clear way, taking advantage of the high level C++ programming style used by OpenFOAM. The

Printer-friendly version

Discussion paper

code is open-source and multiplatform, thanks to the adoption of Docker. It can easily be downloaded from a number of different repositories. A number of test cases and benchmarks are described clearly and can be used to test the code. I think that the paper is well written and that it is worth of publication, after some necessary revision.

General comments

My main concerns are related to two points: 1) Model formulation. I think that the energy balance equation is not correct; 2) Description of model assumptions and application limits. The assumptions behind the model should be clearly listed. In particular, the physical conditions where the local equilibrium holds should be characterized using the typical time of the dynamics of the process and the thermal equilibrium typical time scale.

Specific comments

Table 1, definition of the time step: If possible, write times in lowercase, otherwise they can be confused with temperature.

Eq. (2): This is not an equation. "= 0" is missing

Eq. (4): This equation is correct even in the compressible regime but only if the rock porosity, density and heat capacity are constant in time, and if the fluid heat capacity is constant both in space and time. These assumptions should be stated explicitly in the text. However, I am afraid that the assumptions on the fluid heat capacity are not fulfilled in this paper, because Cp_f is treated as a VolScalarField, and also because a detailed thermodynamics for water is used (Figure 1, L113 and Listing 4). In this Lagrangian formulation, to correclty consider the variability of the fluid heat capacity, a term proportional to its partial time derivative and another proportional to its gradient should be added.

L111: Given a certain resolution, the typical time scale for which this approximation holds should be given. For example, using the data in Table 1, the given rock ther-

mal diffusivity is lambda_r/(Cp_r*rho_r) $\sim$ 6e-7 mˆ2/s. This means that, roughly, the typical thermal equilibrium time for a resolution of 100 m is order of 500 years. Thus, for the approximation to hold, the typical time of the dynamics at this resolution should be larger than, roughly, 500 years. In other words, the equilibrium time is related to the natural time step used by the simulation. The regime where this equilibrium assumption holds should be given, to allow the user to use the code in its proper regime of approximations. For an example on this issue, see Remark 2.1 in: Cerminara, M., & Fasano, A. (2012). Modeling the dynamics of a geothermal reservoir fed by gravity driven flow through overstanding saturated rocks. Journal of Volcanology and Geothermal Research, 233–234, 37–54. https://doi.org/10.1016/j.jvolgeores.2012.03.005

L123: The description is not following the terms order in Eq. (5). Please correct this.

Eq. (6): This reformulation iterates the problem with the spatial variations of the fluid heat capacity, see comment above on Eq. (4) and below on Eq. (7).

Eq. (7): The term proportional to the divergence of (rho_f*Cp_f*U) should not be present when the spatial dependence of the fluid heat capacity is correctly taken into account. A term for its temporal dependence is still missing.

L171: Here should be clearly stated that the EOS is used in the single phase regime, no phase transition is admitted in this formulation.

L119: Usually in OpenFOAM, spatial schemes are first or second order, not high order. Using the upwind interpolation makes the code first order in space. Some word on the time scheme used is also needed.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-140, 2020.

Printer-friendly version

Discussion paper