Solid Earth Discussions

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Comment on se-2020-208

Anonymous Referee #1

Referee comment on "Investigating the effects of intersection flow localization in equivalent-continuum-based upscaling of flow in discrete fracture networks" by Maximilian O. Kottwitz et al., Solid Earth Discuss., https://doi.org/10.5194/se-2020-208-RC1, 2021

In the manuscript "Equivalent continuum-based upscaling of flow in discrete fracture networks: The fracture-and-pipe model" Kottwitz and co-workers present a novel method of determining effective permeability representations of fracture networks using an "equivalent continuum model" approach. Flow in fracture networks have been extensively studied using many different approach. Yet, the authors identified and analyzed a shortcoming in previous approaches in that they study how important flow localization at fracture intersection is for determining effective permeabilities. In doing so, the authors make a substantial and insightful contribution to the field.
The paper is very well written and the scientific methods are well explained. I only have a few minor comments and suggestions that the authors may want to consider prior to publication

Scope and implications:
The one major comment I have is about scope. The authors very clearly lay out their theoretical and numerical arguments. What I was missing is a bit more on the scope and on how useful their methodology is for characterizing natural systems. Such a discussion should include a short review of how well and on which scales fracture networks can be characterized in the first place (e.g by geophysical methods and/or imaging techniques). I am mainly thinking about scales here. My understanding is that if samples can be CT-scanned (e.g. mm to cm-scales) direct flow simulations that resolve the actual fracture geometries would be performed without simplifying the fractures as simple geometric entities. Here flow at fracture intersections would be naturally resolved. On larger scales, the apertures of fractures are very hard to determine and consequently fractures are often represented in models as reduced-order elements – the DFN approach. It remained a bit unclear to me for which input datasets and flow simulation approaches, flow localization at fracture intersection really needs to be considered in the way the authors describe.
The authors address these points in the discussion and conclusion sections, where they talk about system sizes but I think it would help the reader if the authors expanded this discussion.
Another point that the authors may want to discuss is if their effective permeability models also preserve other properties, like e.g. break-through times, spatial pressure variations, and solute transport pattern. It's a bit outside the scope of the paper, so the authors do not need to do this – I just kept thinking that break-through times would

probably be affected for fracture networks where ILF matters.

Minor technical points:
l. 7: It’s not really a problem to include matrix properties in full Stokes simulations. All major CFD packages involve multi-physics solvers that can handle energy or mass exchange between solid and fluid regions. Maybe unnecessary to make this statement here?
l. 12: I assume the authors coined the term “intersection flow localizations (IFL)” if so, please make it clear that this is your invention and not something that’s established in the literature.
l. 28f: Maybe expand this, to make it clear how natural fracture networks can be characterized?
l. 64: Are you sure pflotran and modflow have these shortcomings?
Equation 4: Shouldn’t there be a length scale over which the pressure drop deltaP occurs?
l. 256: Maybe expand what’s in this SKB 2010 reference? This is the only place where you talk about naturally systems; I think it would help to be more specific.
l. 390: are these really nodal velocities? Or rather cell (integration point) velocities (as stated in the next line)?