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# Anisotropy and scaling of the hydro-thermal behavior in a rough fracture

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The thermal exchange of the pilot plant for Enhanced Geothermal Systems (EGS) like the one in Soultz-sous-Forêts, France, is led through open fractures in granite. Rough joints in natural rocks commonly present self affine aperture fields. This complexity affects the fluid transport in these joints and the heat exchange between the flowing fluid and the surrounding fractured rock [1]. For instance, the fracture roughness potentially induces channeling (preferential path) effects. We have noticed that this channeling is strongly affected by the largest scales of the aperture (long range correlation). A key question, for a given aperture field, is how to retain a small number of parameters allowing to build a simple model, and to still describe the hydraulic and thermal properties correctly. This is indeed of highest importance as, until now, the geometry of the underground fractures is not accessible in details.

We propose to restrict the number of parameters about the fracture geometry by filtering the aperture field in Fourier domain: small scale variations are removed while we only keep the large scale correlations. We will show that, doing so, it is still possible to describe accurately the hydraulic and thermal properties, averaged at the fracture scale. In this study, the hydraulic and thermal flows are solved in laminar regime on the basis of the Stokes equation and lubrication approximations. We quantify the hydraulic and the thermal behavior using the hydraulic aperture, and a so called thermal aperture, which are respectively linked to the macroscopic hydraulic transmissivity and the heat efficiency. Keeping only few Fourier modes (four modes on top of the average) allows to reach already an accuracy of 8% on the hydraulic and the thermal apertures. A detailed study is numerically performed for the convergence of these properties as function of the number $n$ of large scale modes. Decreasing power laws, $err \propto n^{-2}$, are obtained to model the error between the hydro-thermal behavior obtained within the full self-affine and the low-pass apertures, as function of the number of large scale modes.

[1] Neuville, A., Toussaint, R., and Schmittbuhl, J. (2010). Hydro-thermal flows in a self-affine rough fracture. Physical Review E, 82, 036317.