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Characterising a rock fracture rough surface using spatial continuity and kriging: a new approach to meshing coupled thermo–hydraulic–mechanical–chemical (THMC) models

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Abstract. Fluid flow through low permeability rocks is mainly accomplished through fractures. In order to model fluid flow, coupled thermo–hydraulic–mechanical–chemical (THMC) numerical models are used, which rely on fracture surface representations to construct a distribution model of the empty space (aperture) between the two fracture faces.

The traditionally used statistical representations of fracture surfaces often overlook spatial continuity (SC), i.e. how well correlated points are in direction and distance. Examples are the fractures' aperture distribution random sampling to the joint roughness coefficient. This may result in a poor representation of the aperture distribution and thus a poor model.

The first aim of this study is to investigate the possibility of characterising a fracture surface roughness using its SC parameters, an upscaled fracture surface and ordinary kriging (OK) interpolation algorithm. This method provides better control over the aperture model creation, which will have implications for its complexity and computation times. The second aim is to utilise the SC information and the distribution of a fracture in order to extrapolate (i.e. blind predict) the distribution of the fracture where no observations exist. A statistical analysis was performed in a greywacke in order to acquire the parameters necessary to describe the SC of the fracture surface topography. The surface was then interpolated using the OK algorithm. These parameters and the surface distribution will be used to inform the OK algorithm to extrapolate the fracture to where no data has yet been acquired. A reasonable match between the kriged and original surfaces has been achieved and the fit quantified by analysing the error between the two and by R^2, which offer positive measurements of methodological quality. The aperture can easily be calculated from the difference between both complementary surfaces. The aperture between the two original fracture surfaces versus the two kriged fracture surfaces was also quantified and compared, yielding good results. This method may provide a new alternative to current storing and computing solutions for fracture representation, especially in aperture distribution calculation for coupled THMC numerical models and simulations. To verify advances in accuracy and computing times for this method, results between models derived from the original versus kriging aperture data will have to be compared. Another potential applicability of the SC information is to know a priori from any modelling which directions are those of Darcy's flow and which are the directions of the highest and lowest dilation rates with shearing, which will have to be confirmed with future planned modelling work.