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Interactive comment on "The hydraulic efficiency of single fractures: Correcting the cubic law parameterization for self-affine surface roughness and fracture closure" *by* Maximilian O. Kottwitz et al.

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Review of the manuscript "The hydraulic efficiency of single fractures: Correcting the cubic law parameterization for self-affine surface roughness and fracture closure" / https://doi.org/10.5194/se-2019-190

In the presented study, a non-dimensional fracture roughness quantification-scheme is acquired, opposing effective surface S area against relative fracture closure R. This is used to capture deviations from the cubic law as a function of quantified fracture

roughness, here termed hydraulic efficiencies.

The paper presents the approximation of a correction factor for the cubic law depending on S and R. Since S and R are only depending on geometrical properties of the fracture surface (which could be determined by real measurement), the presented approach for correcting the cubic law parameterization seems highly applicable.

Besides the scientific significance the paper is well written, structured, and the reference list is adequate. I suggest accepting the paper after minor revisions.

General comments: The general focus of the paper is to present a correction factor for the cubic law in the R-S space. This by its own is of particular interest. In contrast, all simulations were performed with a pressure difference of 0.01 Pa and laminar flow conditions are assumed. This opens the question, are the correction factors the same (in R-S space) for other pressure gradients and therefore other flow velocities.

Although, a non-dimensional fracture roughness quantification-scheme is acquired, the authors could indicate the dimensions of their simulations. This would help to understand at which scale the correction scheme is applicable. Values of length, height, mean aperture, etc. should be mentioned either as absolute or relative values.

This comment is the most important one. As mentioned before the presented approach seems highly applicable. Unfortunately, the proof with real data is missing. It would be nice to use, e.g. laboratory measurements, to proof the presented approach. If no data are available, we could provide surface scans with a resolution of 50 μm and related fracture permeability measurements. Furthermore, aperture distribution, mean aperture, contact area are known. The authors could show how they determine the S-R-values and can subsequently compare the corrected permeability values with the measurements. (contact: Guido Blöcher, bloech@gfz-potsdam.de)

Specific comments: P1L2: Replace "Yet" with "In contrast".

P1L9: Here a sentence regarding the dimension of the simulation (length, width, and aperture) should be added.

P3L75: What means: low Reynolds numbers and low-pressure gradients? The authors should provide ranges where the presented approach is applicable.

P3L81: What is effective fluid viscosity? μ is the dynamic fluid velocity.

Figure 2: The vertical axis has no axis label. It seems it indicates the aperture. Since the aperture is provided by the color code, a 2D image would be sufficient.

P6L126: Often φ indicates the porosity but not here. I suggest using another symbol than φ to indicate the correction factor.

P6L128: For S = 1 and R = 0 we would mimic flow between parallel plates. For this situation, the correction factor should be one and the cubic law could validate the simulation. This validation was done but is somehow hidden in figure 5. The authors should emphasis that this simple check was performed.

P6L135: Why a representation of the matrix is required? Only the fracture is simulated and the boundary condition is a non-slipping boundary. It is not clear why the complete matrix-fracture-system is considered.

P6L136-138: The sentence seems to be incomplete and should be rewritten. Furthermore, the macroscopic flow direction (y-direction) should be mentioned.

P6L141: This is an integration of v_y over the total volume and not a volume integral. Since v_x and v_z should be small compared to v_y these quantities could be used to determine v ÌĚ.

P6L144: The dynamic viscosity is denoted with η before it was μ.

Table 1: The number of parameter combinations for group 1 is given to be 400. If I multiply the n_g1 (4*4*4*5) it should be 360. Furthermore, the fracture configurations for group 1 should be 360*r_g1=7200 but only 6400 are mentioned in the table caption.

P8L1: Again, values about the fracture aperture and the representation by the voxels is missing.

P8L173: 12800 flow simulations are mentioned assuming 6400 fracture configurations. If comment 12 is corrected or explained the authors should revise the number of flow simulations (14400).

P9L194: In case the authors decided for another symbol than φ, they should correct the symbol here.

Figure 5: The figure is fine in color mode but almost no difference between blue and red is visible in greyscale mode. Maybe, the color scheme can be adjusted.

P13L240: Please add a space after closure.

Figure9: The mean error norm was obtained for the considered fractures and applied boundary conditions. The authors should discuss if this error norm changes for other flow regimes regarding Reynold number, flow velocity, pressure gradients, etc..

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