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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Controls of macropore network characteristics on preferential solute transport" *by* M. Larsbo et al.

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Reply to anonymous Referee #1

-First we would like to thank the reviewer for his/her interest in our study and for constructive suggestions for clarifications and improvements. We have addressed all comments below and will make the necessary corrections in the manuscript when all reviewers have posted their comments.

The manuscript shows interesting relations between the connectivity of the soil macropore network imaged with X-ray CT and preferential solute transport. The manuscript is relevant for readers of HESS. The methodology used is of high quality and shows the experience of the authors in the field of preferential flow and macropore flow. The

results are sound and well described. The observation that smaller macroporosities with poorer connectivity exhibits the higher preferentiality (nicely illustrated in Fig. 9) is interesting. Regarding Fig. 9 I feel that there is a strong link with the percolation theory, as it also predicts preferential features for intermediate connectivity. I recommend the authors to look in particular at Fig. 7 of Berkowitz and Balberg (1993).

-We agree that there are interesting links between our study and percolation theory. The schematic model presented in fig. 9 can be interpreted in a percolation theory framework. Going from 9a to 9b we are approaching the percolation threshold from above and going from 9b to 9c we end up below the percolation threshold. We will add text describing this and relevant references to the discussion of fig 9.

I have some minor comments: Title: I find it a bit generic the use of network characteristics. What characteristics and what control? Why not connectivity? Or something more specific.

-We are looking at a large number of macropore network characteristics (presented in table 2). Since these characteristics are strongly inter-correlated (fig. 5) we do not want to focus on only one or a few of them in the title.

-We agree that the word "control" is vague. We have decided to change the title to "Relationships between macropore network characteristics and the degree of preferential transport".

Abstract: I recommend to state more clearly what are the objectives and hypotheses of this work. In particular there is no hypothesis formulation – the same for the introduction.

-We will make the objectives given in the introduction more specific by stating that the macropore network characteristics included 'measures of local connectivity and global continuity'. We have also replaced 'non-reactive tracer transport' with 'the degree of preferential transport of a non-reactive tracer'.

-We will also rephrase the first sentence of the abstract to 'The objective of this study was to determine the relationships between. . .'

-There are many papers published in HESS which do not have a hypothesis formulation. We do not think that it would improve the paper.

Page 9559, line 1-2: will the soil structure change after drainage. What was the water content during the X-ray CT? Was the soil dry to allow better visualization of the pores?

-The columns were drained by gravity meaning that the base of the column was saturated after drainage and the top of the column was at about -18 cm pressure head. We assume that the macropore system is unchanged by drainage to these rather wet conditions.

-We will add a sentence to the text explaining this.

Page 9559, line 7: give reference for the use of the 5% arrival time.

-The references are given at the end of the sentence.

Page 9563, line 5: Would the definition of macropores as pores with diameter larger than 484.4 microns affect the analysis? What would you obtain choosing anther diameter? Please, discuss it.

-The size of the smallest visible pore will influence the measures of the pore network. This is perhaps most obvious for global continuity. As smaller pores become visible the probability that the top and bottom of the column are connected increases. Pores larger than 0.3-0.5 mm are often classified as macropores (Jarvis, 2007). The size of the smallest visible pore in our case was 484.4 um (given by experimental constraints). The visible pores in our study can, therefore, be considered macropores. The focus of our study was effects of macropore network characteristics on preferential transport. A study of effects of different size classes, although interesting, was beyond the scope of this study.

-It is already mentioned on P9571L10-12 that "Characteristics of the pores with sizes below the resolution of the images are also likely to influence solute transport".

Age 9566, line 1-2: Can this be caused by the small size of the sample compared to the largest pore cluster? In other words is it a problem of REV? If a macropore cluster spans through the entire domain, of course the fraction of macroporsity consisting of the largest pore increases. What would happen with a larger sample?

-We do not think the positive correlation between the total macroporosity and the fraction of the total macropore volume found in the largest pore cluster is dependent on the size of the sample. Such a correlation should be found for any sample size given that the macropore network "fills" the sample space to a large extent which was the case in our study. As the macroporosity increases, the probability that individual separate macropore clusters connect with one another and coalesce into larger clusters must increase regardless of sample size.

Page 9567, line 1-2: Please, add some discussion.

-We are not aware of any studies that discuss how the maximum relative concentration (i.e. peak height) is related to the pore system characteristics. We will add this information to the text. In our study and in the study by Koestel et al. (2011), the maximum relative concentration was not correlated to the 5% arrival time.

Page 9568, line 19-20: probably the main reason is the higher diffusional time into the larger aggregates.

-We are not sure we understand this comment. Yes, it would take longer to reach solute equilibrium between macropores and aggregates for soils with larger aggregates because the distance for diffusion is larger. However, the diffusion rate across aggregate walls per surface area will be higher for larger aggregates since the concentration gradients will decrease slower. The smaller solute exchange between macropores and soil matrix for soils with larger aggregates is, hence, an effect of smaller surface area.

References Berkowitz and Balberg 1993. Water Resources Research Vol. 29 Nr. 4 Pages 775-794.

References Jarvis, N. J.: A review of non-equilibrium water flow and solute transport in soil macropores: principles, controlling factors and consequences for water quality, Eur. J. Soil Sci., 58, 523–546, 2007.

Koestel, J. K., Moeys, J., and Jarvis, N. J.: Evaluation of nonparametric shape measures for solute breakthrough curves, Vadose Zone J., 10, 1261–1275, 2011.

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