Interactive comment on "Transferring the concept of minimum energy expenditure from river networks to subsurface flow patterns" *by* S. Hergarten et al.

S. Hergarten et al.

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Dear Martijn,

many thanks for spending so much effort on reviewing our manuscript. I think you are right in most aspects you mentioned.

As you stated in your first point, the presented theory only holds for laminar flow. It will be best to add a short section on turbulent flow with a brief sketch of theory for Darcy-Weisbach and a discussion. A fully developed turbulent flow field will result in an exponent γ in Eq. (4) that is larger than that of laminar flow, but still smaller than

one. So the structure of the optimal flow patterns should be similar. The transition from laminar to turbulent flow is, of course, more complicated. Here we can expect a rapid increase of friction at a given discharge, so that optimization may be limited to regions within the domain.

Your argument with the three small networks is also true. However, at that point we thought of focused flow on a lower level, namely tree-like structures compared to arbitrary graphs. The idea was just that splitting up the discharge of one site to more than one flow target is energetically unfavorable, justifying the conjecture that each site has a unique flow target. In this sense, all your three examples are focused flow, and we did not intend to find the best among them at this level. I think we can write this more clearly in the revised version.

Most of the rest of you comments can also be easily addressed in a revised version. The only point where I am still uncertain is the relationship of minimum energy expenditure to maximum dissipation of free energy. I must admit that I still do not understand why both are equivalent, but there is some time to think about it.

Again, many thanks,

Stefan

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