

Hydrol. Earth Syst. Sci. Discuss., author comment AC2  
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## Reply on RC2

Chloé Fandel et al.

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Author comment on "Improving understanding of groundwater flow in an alpine karst system by reconstructing its geologic history using conduit network model ensembles" by Chloé Fandel et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-280-AC2>, 2022

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We do not agree with the assessment of the paper in RC2. This comment appears to be based on a fundamental misunderstanding of the principles underlying the work presented in this paper. The referee comment is also very long (and we do appreciate the time and effort invested by the reviewer). If required, we could answer on every single comment. However, for reasons of clarity and comprehensibility, we prefer to answer only the main points and hope to clear up the misunderstanding at hand in this way.

Comment: This paper is not a new contribution because the same work was already presented in two previous papers.

Response: We disagree. This paper is indeed the third in a series, each of which builds on the preceding work. Some minor repetition is therefore necessary so that readers unfamiliar with the first two papers can understand the third. The work presented in this paper is, however, completely novel and fundamentally different from the work presented in the previous two papers. The first paper was focused on developing modeling capabilities in the Gottesacker karst system, while the second one was focused on developing anisotropic fast marching methods for conduit simulations. This paper focuses on applying these methods to understand the geologic history and conduit evolution of the Gottesacker karst system. This is the first time that a stochastic conduit simulation algorithm has been applied to questions about past geologic conditions. Usually, simulations focus on projecting conduit maps based on the geologic setting, whereas here we attempt to reconstruct the geologic evolution based on conduit maps. This is also only the second application of anisotropic fast marching algorithms for conduit simulation. To our knowledge, no other published work uses anisotropic fast marching algorithms to simulate conduits, nor does any published work use conduit simulations to understand past geologic conditions.

Comment: The stochastic modeling approach used in the paper is not appropriate for the hypothesis testing it is applied to in this study because: a) the modeling does not add any information that was not available from topographic maps and spring locations; and b) the model is 2D while the real conduits are 3D.

Response: We disagree. Point a) This comment seems to indicate that it is obvious, without doing any simulations, which of the hypotheses presented in our paper is most

likely to be correct, which is, however, not the case. The comment also suggests that the stochastic element of the simulations does not add any useful information, which is also not correct. As described in the paper and in our responses to RC1, the fracture network affects the conduit simulations, and there are significant differences in different parts of the study area in the level of agreement across the ensemble of simulated conduit networks. In some areas, each simulation in the ensemble gave a different path, resulting in a swath across which the presence of a conduit is roughly equiprobable, and orientation of that conduit is difficult to pinpoint. In other areas, almost all the simulations agree, indicating a higher degree of certainty about where the conduit is most likely to be and what orientation it is in. In our simulations of our two hypotheses, none of the conduits simulated under scenario 1 match the mapped conduits, while the conduits simulated under scenario 2 are tightly clustered around the mapped conduits. This increases our confidence in our results, whereas if the ensembles had been spread out, we would have less confidence in our results.

Point b) This comment seems to miss a key point. The model used in this paper, although it yields only a 2D conduit map, is in fact closer to a "two and half dimensional" model, because the elevations of the inlets and outlets are considered, as is the topographic gradient of the catchment. The comment asks why we have not used other algorithms which are 3D, such as SKS, presented by Borghi et al. (2012). We in fact did use SKS as a starting point. However, the existing 3D conduit simulation algorithms such as SKS are isotropic and do not perform well in catchments with steep gradients. Our anisotropic 2D version is currently better-able to capture the three-dimensional conduit network than the isotropic 3D algorithm.

To summarize, we find that the points made in RC2 are based on a misinterpretation of our work, and we disagree with the comment's assessment of our paper. Beyond this disagreement, we thank the reviewer who made a very thorough and serious review of the paper. Many of the other comments can easily be taken into account in a revised version of the paper to improve clarity and avoid such misinterpretation.