GEOSCIENCES MODEL DEVELOPMENT

GMD-2019-286: MFIT 1.0.0: Multiflow inversion of tracer breakthrough curves in fractured and karst aquifers

Firstly, thank you for the opportunity to review this interesting manuscript matching the field of tracing hydrology. Jacques Bodin presents a new software for BTC´s fitting of artificial tracer tests in karst and fractured aquifers. The software compiles four transport models able to advance in the simulation of single/multiple and long-tailed curve shapes. Individual models proceed from the modification of previous analytical and numerical solutions and two of them are novel since they couple the multiflow approach (several 1-D independent channels) with the double-porosity concept. Additionally, an advanced optimization interface using PEST tools is also included in the modelling package.

From my opinion, advances in the field of artificial tracing tests must be oriented to gain new insights about solute transport dynamics through highly heterogeneous media from the test design with new injection-sampling strategies, but also from the more precise interpretation of karst conduit system geometry. Further efforts are expected to better explain BTCs resulting from hydrodynamic processes other than advection and dispersion, considering a clear focus on physical processes rather than achieving a suitable mathematical/numerical model framework. Therefore, the new development of novel software for BTC´s fitting is considered a notable advance in the karst community, as it is the case of the present manuscript. The huge computation works performed by the author are noticeable to achieve transport analytical/numerical solutions to physically reproduce multi-peaks and long-tailed curves. Overall, the integration with an optimization module is increasingly demanded in such type of model approach to avoid trial-error direct simulations and very often the consequent lack of accurate results.

However, my major criticism is focused on the code verification, in particular in the BTCs selected for the comparative analysis of simulation results. The five synthetic BTCs generated fail in both the relatively simple curve morphologies and the test duration. Since the four proposed models try to better fit multi-peaks and long-tailed curve shapes, the multimodal curves obtained from real field experiences show more marked/pronounced peaks (very often reaching relatively quite similar tracer concentration, as twin peaks) and the long-tailed ones (even with higher concentrations slowly decreasing along the lower slope ending curve segments) use to be recordered during much more prolonged tests (>100 hours). So, I would recommend incorporates and/or replacing new synthetic BTCs representing more adapted-to-reality morphologies. This will deeply test the code efficiency under more realistic and non-ideal (Fickian) transport dynamics. Regarding the modeled BTCs from the HES experimental site, they also display short tracer test duration and local transport dynamics. Some questions arise me, what about longer –multi-kilometers- karst connections and their expected very often long-tailed BTCs? and, what about the degree of flow diversion in anastomosed/ forked karst conduit systems and their associated multi-peak BTCs? I agree with the proposed pathway decomposition in multi-single channel scheme but, how the flow diversion in one or several of them and where (close to the injection point or to the end of the master conduit) may condition the obtained BTC shape?

Moreover, I miss complementary numerical results such as transport parameters and their discussion (i.e. sensitivity analysis) for a deeper comparative analysis of simulation results in section 5. The recovery rate of the injected tracer for the three examined BTCs would be

helpful to the reader to have information about how many tracer mass has been lost during the test. This will help to understand the potential role of rock matrix or stagnant zones in the karst circuit by which anomalous transport is reflected as multi-peaks or long-tailed BTC shapes.

In terms of format, I have to say that the manuscript is generally well structured and balanced (regarding its principal sections), as well as correctly written in English language and no substantial grammatical deficiencies has been observed throughout the manuscript. Besides, I recommend adding at the early sections a glossary of acronyms and parameters described throughout the text.

In summary, I consider that the paper in its present form is suitable for its publishing in GEOSCIENCES MODEL DEVELOPMENT journal only if suggested recommendations incorporate to this version of the manuscript.

Point-to-point comments:

Page 12: Table 2, test 4 >>> "Partitioning coefficient (ß)" instead of "Fraction of mobile water (ψ)"?

Page 12: Table 2, test 4 >>> "Mass transfer coefficient" instead of "Omega coefficient"?