Report on the manuscript “Identification of Parameter Importance for Benzene Transport in the Unsaturated Zone Using Global Sensitivity Analysis” submitted to *Hydrology and Earth System Sciences.*

It is my pleasure to review the manuscript entitled “Identification of Parameter Importance for Benzene Transport in the Unsaturated Zone Using Global Sensitivity Analysis”. How to accurately quantify the parameter importance in the complex contaminant transport models has always been an important topic in groundwater research. In this study, GSA methods of Morris and Sobol were implemented to investigate the important parameter for benzene transport model in the unsaturated zone.

I believe this paper is well written with high quality and good logic. I would be in favor of publication after the author addressed the comments given below.

Major Comments:

1. In the section 2.3.2, I believe authors should provide more details about the calculation process and algorithm implemented for the Sobol indices. And I believe it is too obvious that the sample sizes were dramatically different for different problems since they were calculating different variances based on different models, it is unnecessary to list these different size numbers.
2. I am not sure why the authors focused on the crashed simulations; it seems to be the problem of numerical model instead of sensitivity analysis problem. And the differences of GSA results using different methods to fulfill these “bad” input samples are more like pure numerical fluctuations to me.
3. In the section 3.2, have the authors tried the geostatistics tools to build different samples of heterogeneous media structure? I don’t understand how the different samples representing the vadose zone media were generated. For the sentence in line 464, I believe Dai et al., (2017) has done some similar work and please check if it is helpful to improve this research for the heterogeneous media structure generation through geostatistics implementation.

Minor Comments:

1. Line 84-85: I don't think these reference papers are all focus on the sensitivity analysis for the unsaturated zone.
2. Line 90: I don't understand the term "properties of benzene itself", what properties?
3. Line 99-100: I believe authors should provide more details about these two methods, especially about their algorithms, in the introduction.
4. Line 103-104: please provide some references, I don't know this is a common problem.
5. Some formats of titles of subsections are incorrect or inconsistent, please check all of them.

Reference

H. Dai， X. Chen*, M. Ye, X. Song, and J. M. Zachara, A Geostatistics-Informed Hierarchical Sensitivity Analysis Method for Complex Groundwater Flow and Transport Modeling, *Water Resources Research*, 2017, 53(5), 4327-4343.