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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Contributions to uncertainty related to hydrostratigraphic modeling using Multiple-Point Statistics" *by* Adrian A. S. Barfod et al.

Anonymous Referee #1

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Review of "Contributions to uncertainty related to hydrostratigraphic modeling using Multiple-Point Statistics"

By Adrian A.S. Barfod, Troels N. Vilhelmsen, Flemming Jørgensen, Anders V. Christiansen, Julien Straubhaar and Ingelise Møller.

The main subject of the article is studying the impact of datasets used to do hydrostratigraphic modeling with the MPS framework. The authors build a "Base Case" using snesim approach, with a cognitive model as Training Image (TI), borehole data as hard data and geophysical resistivity data (SkyTEM) as soft data. Then, they present different modeling cases: using a different TI, using an incomplete resisitivity grid instead

of a full resistivity grid, using borehole data as soft data instead of hard data, inverting resistivity data with a sharp inversion model instead of a smooth inversion model. The authors assess qualitatively and quantitatively the impact of changing each of these parameters.

The main contribution of the article is the method to compare quantitatively the great number of geostatistical realizations (400). The method used is based on Analysis of Distance, with the Euclidean Distance Transform (EDT) algorithm applied to measure the "distances" between realizations. The distances serve as measures of similarity between the different cases and also between cases and the TI. According to the reviewed article, the EDT is straight forward method to assess the dissimilarity between realizations that can help in the quantification of the uncertainty of the 2D and 3D models. The smaller the distance, the more similar the realizations and thus, the smaller the impact of the changed parameter on the modeling results. It is a contribution because not many hydrogeology articles are found on the "metrics" for comparing geostatistical realizations. Plus, distance measures are discussed on MPS literature but for their use in pattern modeling from training images (Gregoire Mariethoz and Caers, 2015; Honarkhan, 2011), not for their use in uncertainty estimation. In the recent book from Mariethoz and Caers (2015), called "Multiple-point geostatistics: stochastic modeling with training images" the use of distance transforms for uncertainty purposes is not mentioned. Furthermore, in the review papers on MPS methodology, the study of the sensitivity of the model prediction to TIs and underlying datasets is suggested as an important research avenue (Hu and Chugunova, 2008).

The paper is well written, with good story-telling. Even though several cases are presented, the structure is logical and the discussion about the results of each case is clear thanks to the images presented. I would agree with the publication of this article because the method seems to be a contribution with the uncertainty appraisal of the MPS results.

Comment #1:

Although the proposition to use distances to assess uncertainties is interesting, it seems to me that the simple EDT is not the most adequate to capture the differences between realizations. To give one example, in figure 9 we can see that the results from “Case 1a” and “Case 1b” are very different (basically, sand to the west and clay to the east for Case 1b while Case 1a is heterogeneous in the whole model). Nevertheless, in figure 11 both cases present the same distance to the cognitive geological model. The qualitative assessment by visual means remains necessary. Did you consider using more robust methods for comparing patterns in images which take into account the positioning of the events (spatial relations) and that are less affected by scaling, rotation and translation (e.g. SIFT, IMED)?

Comment #2:

On the Kasted TI and the conceptual TI we observe channels filled with one facies, without internal variation. How come there are these intercalations of sand and clays in the simulation results?

Comment #3:

As mentioned in the discussion, the global target proportions of the units could have been replaced by the vertical proportions. It would have been interesting to see the results of these realizations with the vertical proportions, but I understand that the authors don’t have them (time constraints?). What are the statistics of the results? How are those global proportions respected in each case? How the change of the parameters impacts the global target statistics?

Comment #4:

The article relies on other papers for most of the methodology, but still gives some small descriptions. Nevertheless, nothing is presented on the Direct Sampling Method used for filling the gaps on the resistivity grid. This seems to be missing in the methodology. Also, the choice of the Tau value for resistivity and boreholes (2 and 1) is not argued or

referenced. Why 2 for resistivity and 1 for boreholes?

Comment #5:

What could the authors infer about the impact of the datasets in areas where data is less dense? The study case in Denmark has good data coverage, both for geophysical surveys and for borehole data.

Technical comments:

It is not indicated what “SkyTEM” stands for.

Page 4: “Two approaches are taken”? . . . we are exçpecting a second approach

Page 7: Realizations THAT reflect the real world

Page 15 : if the grid is too sparse, then limited or no information is present which can help reconstruct missing patterns is present (repetition of “is present”)

Page 29: “increased”

Page 21: comparing a “realization” (no “s”)

Page 35: Journel, A. G.: "Combining Knowledge From Diverse Sources: An Alternative to Traditional Data, , 34(5), 2002". (The name of the Journal is missing, “Mathematical Geology”)

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