Dear Mr. Carrera,

Thank you for your interest and work with improving the manuscript. We really appreciate the input, and the fact that you can see the relevance and potential of the research contained in the paper.

We have decided to revise the paper according to as many of your comments as possible, since this will help to improve the paper even more.

Best,
Adrian S. Barfod

Response to editor comments, hess-2017-734

Firstly, the authors would like to thank the editor, Jesus Carrera, for taking his time to read the manuscript and providing detailed and constructive comments. The comments, questions and suggestions are addressed in the following response.

*EC: Editor Comments
*AC: Author Comments

NOTE: All line numbers in this document refer to the revised paper and not the "manuscript changes document" or any previously submitted versions of this paper.

Response to editor comments

General comments:
'Dear authors,

The paper is good. You were lucky in having three thorough positive reviewers and you have responded in kind, leading to an improved paper. Moreover, the topic you address is important (I have often wondered about many of the questions you respond). I am left with many questions, but this may reflect the complexity of your goal. Therefore, I conclude that it has a great potential (although you never know whether a paper is going to have a large impact, and while uncertainty is recognized as important by all, few actually care much; I'd recommend you to present your results in congresses). I share below with you some of the possible improvements that come to my mind after reading the final version (the list is long, but most comments are very easy to handle).

Do not take these comments as compulsory in any way, but rather as an invitation to have a final thorough reading while feeling free to write your thoughts out and hopefully transform a good paper into an excellent one (but, please, if you change things, let me know what you have changed to facilitate my life!).

Excellent job!

Jesus.'

EC1: *Line 56 "only 410 boreholes" sounds weird for most of us (I have never had 410 borehole descriptions!)… especially considering that in the abstract you do not mention the spatial extent of the study area. When I realize that the surface area is 45 km2, or some 10 "good" boreholes per km2, I conclude that the density is exceptionally high. While it is clear that the geological complexity is such that a deterministic description is not possible, I still believe that "only 410 boreholes" is inappropriate.*
The fact that "The borehole lithology logs infer local changes in the immediate vicinity of the boreholes" depends on the geological setting, which you have not yet described (in the end, I believe the statement is true in your case).

AC1: That is a good point. We do generally have a high borehole density in Denmark compared to other places in the world and often forget this fact.

Changes to the manuscript:
Line 57: The word "only" has now been dropped.
Lines 58-59: The sentence has been modified so that it is clear that we are talking about areas with a high degree of geological heterogeneity.

EC2: *Line 59: "Finally, the importance of the TI was studied. An example was presented where an alternative geological model from a neighboring area was used to simulate hydrostratigraphic models" does not read well (it is not clear to me what the "finally" refers to). Perhaps better "The importance of the TI was studied. An example was presented …" or "The importance of the TI was studied through an example where an alternative geological model from a neighboring area was used to simulate hydrostratigraphic models'*

AC2: Agreed, revision has been carried out.

Changes to the manuscript:
Line 60: The word "finally" has now been dropped and the word "also" has been added so the sentence now reads: "The importance of the TI was also studied."

EC3: *'Line 77-78. The statement "E.g. indicating different levels of uncertainty in different subparts of the model domain" should perhaps be in parentheses (e.g., indicating different levels of uncertainty in different subparts of the model domain).'*

AC3: Agreed.

Changes to the manuscript:
Line 79-80: The sentence has been put in a parenthesis as suggested.

EC4: *'Line 83. My standard references for MPG (I prefer MPG to MPS, which suggest discrete multivariate distributions) are those of Strebelle (2002) and Mariethoz and Renard (2010). You cite both in the text later, but I find surprising your choice here. The first time I read your paper I had to go to the references to ascertain that you were indeed talking about what I call MPG.'*

AC4: We are not referring to articles which present the MPS/MPG methods themselves, but rather studies where MPS/MPG has been used to create stochastic models of the subsurface. We will specify this in the text

Changes to the manuscript:
Line 85-86: added: "where ensembles of models are produced,"

EC5: *'Lines 88-100: The structure of a paper is always arguable, but I believe that this paragraph belongs better in the "methods" section than in the introduction. Usually, the introduction is used for revising the state of the*

art, so as to motivate the objectives of the paper. In your case, the motivation and objectives are clear and well established, but this paragraph looks awkward in the introduction as you discuss methods and the site, both of which are described later. I realize that this type of change is tedious and may introduce other "losses" of logic, but I still invite you to consider revising the structure of the introduction and methods. The same can be said about line 111, or lines 121-122. In all these cases, you identify sources of uncertainty and say how you are going to address it. The end result is that, after reading the introduction, the reader is left with a mixture of loss of confidence in geological modeling and a somewhat vague feeling that you are going to somehow assess them. I invite you to consider revising all sources of uncertainty to conclude that the objective of the paper is to assess their impact on the uncertainty of the geological model and, then, describe in a compact manner how you are going to do it (perhaps in an itemized way).'

AC5: We agree that this might improve the manuscript and will therefore try to accommodate the issues mentioned in relation to the introduction.

Changes to the manuscript:
Line 115: The statement which refers to the presentation of both cases, with and without reconstructing the geophysical data, has been removed.
Line 124: The statement describing the specific method of dividing the boreholes into quality groups has been removed.
Lines 131-137: The paragraph describing the overall goal of the study/research has been removed and parts of it has been re-used for compiling a paragraph describing the goals of the study in a more general way, without discussing the specific methods or the Kasted site.

EC6: Line 104: "provide" instead of "provides"

AC6: Agreed.

Changes to the manuscript:
Line 111: "provide" now replaces the word "provides"

EC7: Line 105: "Resolution decreases with depth, and diminishes at a specific depth, which is dependent on the geophysical method" reads weird. Perhaps better "Resolution decreases with depth, specially beyond a specific depth, which is dependent on the geophysical method"

AC7: The sentence should be corrected.

Changes to the manuscript:
Lines 109-110: The sentence now reads "Resolution decreases with depth, especially beyond a specific depth, which is dependent on the geophysical method." as suggested.

EC8: Line 153: I do not know what you mean by "tunnel valleys"

AC8: The term "tunnel valley" is synonymous with buried valley, however, we do agree that it is simpler to just use the same term throughout the paper.

Changes to the manuscript:
Line 147: The usage of the word "tunnel valley" has now been replaced by the word "buried valley"

EC9: Figure 1: Readers that do not know SKYTEM may be confused about Figure 1C. I assume that the blue lines are the trajectories of SkyTEM flights, you may want to say so (instead of soundings) in the caption and identify them with a blue line (instead of a dot) in the legend.

AC9: The blue "lines" are actually the sounding locations (dots) which are spaced so close that it looks like a line, therefore, since the legend represents the actual sounding locations, we believe that this is the most accurate way of portraying the data, though we see you point and add a note on it in the figure caption

Changes to the manuscript:

Line 164-165: The following text was added: *"Note, that the SkyTEM soundings are sampled so dense that the dots marking each individual sounding merge into blue lines.***"**

EC10: Line 176: I would not say "The TI thus provides a conceptual geological understanding". If by conceptual understanding, one means a qualitative description of the site and its origins, the TI provides neither. To me, the "conceptual geological understanding" is what you provide in lines 147-150. Although the TI can be based on geological understanding (and, as such, it is indeed a conceptual statement), the TI provides simply a quantitative description of the expected (often only small scale) spatial variability patterns of the random function of interest (in your case textural description).

AC10: The conceptual geology can also be thought of as the specific geological patterns/architecture which we wish to represent in our hydrostratigraphic model, e.g. buried valleys. If the TI contains a series of buried valleys then the statistics and quantitative description contained in the TI describes the conceptual geology.

Changes to the manuscript:
The comment didn't result in any changes.

EC11: Section 3: I realize that you have made an effort at improving the structure of Section 3, and I think that further improvement is possible (structure is important for Cartesian people like me and, I assume, most of the readers understanding section 3). Specifically, snesim and DS are two methods for doing MPS, while the tau approach is a method to combine conditional probabilities. Therefore, including the tau-model as a subsection of snesim is misleading. You may choose: 3.1 MPS; 3.1.1 snesim; 3.1.2 DS; 3.2 tau model. You may also choose: 3.1 MPS: snesim; 3.2 MPS: DS; 3.3 tau model. The latter may be better for your goal because you appear to have chosen (for reasons that are not clear to me to use DS and snesim for different goals).

AC11: That is a very good point, the manuscript will be changes accordingly.

Changes to the manuscript:
Section 3: The section has been changed according to option 1: 3.1 MPS; 3.1.1 snesim; 3.1.2 DS; 3.2 Tau model

EC12: The tau model: the description of the tau model can also be improved. The one you make is somewhat abstract (Journel style), which may be appropriate for a statistical journal but should be made clearer for a hydrological journal: Possible improvements include:

- The tau value can be used to qualify the degree of redundancy among data sets (see www.ccgalberta.com/ccgresources/.../2003-130-naivebayes.pdf)
- Use a bold face for Di data events (as used in eq. 1). Also, explain what data events are. At first, I thought it referred to actual data sets (e.g., core logs), but later it appears to refer to probability grids (a concept you may define as well)
- In line 210, you should define x_i as distances from a given realization of A to its true value.
- Line 212: the statement "where the tau values are assigned as follows: [τ1,τ2]" does not really describe how tau values are assigned.

AC12: We would like to keep the abstract description if possible, since this describes the actual equations used in this particular study.

The issue with bold face letters representing the has been fixed many times but Word keeps changing the equations to being bold face. We should be able to handle this during publication.

Defining that x_i as the distance from a given realization of A to its true value seems very confusing since the term distance in this case refers to the inverse of the probability as opposed to the Euclidean distances defined in the rest of the paper.

Changes to the manuscript:
Lines 213-214: The definition of a data event has been added
Line 225: The sentence now reads: "where the tau values are: [τ_1,τ_2]".

EC13: Line 259: K was already defined in line 248 (you do not need to define it again).

AC13: Good point, we would like to avoid such repetitions

Changes to the manuscript:
Line 255: The definition of K has been removed.

EC14: Line 276: You do not need the comma after (2003).

AC14: Okay

Changes to the manuscript:
Line 271: The comma has now been dropped

EC15: Consider addressing comment 2 of reviewer 1 (actually your response) in the manuscript.

AC15: The comment is a good discussion point and has been added to the discussion.

Changes to the manuscript:

Lines 696-705: A paragraph discussing the presence of small-scale patterns in the resulting realizations has been added