Solid Earth
Discussions

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Interactive comment on "Methods and uncertainty-estimations of 3D structural modelling in crystalline rocks: A case study" *by* Raphael Schneeberger et al.

Anonymous Referee #2

Received and published: 11 July 2017

=== Overall quality and general comments ===

I believe that this is a good and well-written work that should be published. An advantage of this paper is the use of high-resolution structural data (within sub-surface tunnel) to validate models built from field data and and to validate modelling techniques. However, there are several corrections that need to be made. Most significantly, a number of the figures need to be improved. Discussion and conclusion should also be rewritten to match the goals presented in the introduction. However, I'm confident that this can be fixed satisfactorily.

=== Specific comments ===

S1: In the introduction, the authors state three main goals (Page 3, line 11): (i) development of an extrapolation workflow for different techniques, (ii) estimation of related uncertainties, (iii) design and application of a probabilistic approach to validate the generated models. The first two goals are not completly clear to me. The third point is clearly tackled within the article and seems to be the most interesting part of the paper. It is not clear to me if the goal is to validate some of the generated models using posterior information (i.e. crossing faults are unlikely), or if the goal is to choose which of the extrapolation technique is the most accurate in this context. I am not sure that the development of extrapolation techniques to build surfaces from points is the goal this paper. Futhermore, the two first points of the conclusion (lineament maps are sensitive to erosion and structural mapping highlight three fault families) are not related to the main subject of the paper. I think refocusing the discussion and the conclusion on the questions stated in the introduction would be beneficial.

S2: The extrapolation methods (Page 7, Line 25) should be described more accurately. Delaunay triangulation is a meshing algorithm that give a triangulation from several points. It provides a surfacic interpolation between points, but no extrapolation. Using only points from the trace of the fault on the surface to compute the dip is highly sensitive to noise (because point are nearly aligned along a line).

S3: Data at depth are not integrated during structural modelling, and are use as posterior data by computing the misfit between observations and model. This is always the case for data that can not be integrated as constraints during structural modelling (flow simulations, geophysical data). However, in this case, fault observations at depth could be integrated as control points during interpolation. The choice to use them as posterior data should be explain.

S4: Figure 2, 5, 7, 9, 10, 11, 14: images and text contain within images are too small to be read. This is a major problem for Figure 10: I can not read the results. 3D illustrations provided in the Supplement are not called within the core of the paper.

= Page 2 = Page 2, line 11: Where does these 6 per cent come from? I only see this number in the abstract and in the conclusion?

Page 2, Line 23: As you use explicit modeling approaches in this article, maybe you could remove the differences between implicit and explicit methods. You could also spend more time reviewing existing stochastic and deterministic modeling methods. This might be usefull before presenting your deterministic modeling method informed by probability.

Page 2, Line 40: "extrapolation represents the main uncertainty within 3D structural modelling". This may not always be the case. Hollund et al, 2002 shows that sub-seismic faults represent a large uncertainty in flow simulation. More generally, when working with sparse or low-resolution data, the topology of the fault network (number of fault and their connectivity) is highly uncertain and strongly impact flow simulations [Cherpeau et al, 2012; Cherpeau et al, 2015; Julio et al, 2015].

= Page 3 = Line 8: "Most of these published studies were performed where [...] tectonic setting is rather simple". The word "simple" is rather subjective and might offend people who have been/are working on this topic.

Line 12: (TYPO) Development -> development

Line 14: "to validate the generated model". It is not clear to me if you want to validate one of the generated structural models, or if you want to validate one of the 3 structural modeling method (field data/Delaunay/moment of inertia)

= Page 4 = Line 1: title should be after the figure to be visible.

= Page 6 = Figure 3: This figure is not clear. It can not be understood without reading carefully the text. Action verb might could used to distinguish input and output (lineament maps, structural map, best model) from what you do (Modeling 3D structure, Computing degree of misfit...). Caption should be extended.

= Page 7 = Line 3: How many lineaments do you have?

Line 32: (BIBLIO) Fernandez 2005 does not details the Move ribbon tool but a method to find a plane orientation from a point cloud. A distinction between the method, and it software implementation would be more precise. Futhermore, it is always difficult to derive a plane orientation from points aligned along a line (intersection between the topography and the fault). The eigenvalues found should help to detect when point are aligned along a line. This does not seems to be used within the paper (see specific comment S2).

Line 38 and Figure 4: Could you provide the analytical formula used to compute the degree of fit?

= Page 8 = Figure 4: what does URL means?

Figure 4: Could you provide the formula used to derive a degree of fit from angular and distance misfit?

= Page 9 = Figure 6: Is the whole workflow two-dimensional like presented in this Figure, and as suggested by the use of Bentley-Ottman algorithm? In this case, specify it.

= Page 13 =

Line 11: Unclear if the projection depth is defined for the whole model or for each fault. Is it constant for all faults (i.e. =minimum(fault trace's length, 1000m)) or drawn randomly within a distribution?

= Page 14 = Line 8: Why do you make this assumption that faults do not cross at large-scale? Is it common for this geological setting?

= Page 15 = Figure 12: Could you highlight incision and exfoliation joints? Resolution is a low.

= Page 16 = Line 32: Implicit modeling can also be used to extrapolate surface from points, and does not require statistical approximatoin to represents surface. It could

also be used to get the fault geometries. The meaning of these sentences is unclear. See Collon et al., EAGE Paris, 2017 for a short review of Implicit and Explicit modelling (3D Geomodelling in Structurally Complex Areas-Implicit vs. Explicit representations, Collon et al., 2017)

= Page 17 = Line 3: The definitions of fault thickness is ambiguous (does it mean damage zone or fault core as defined by Torabi et al., 2011). Furthermore, if it can not be used in this case, this short paragraph could be removed.

= Page 19 = Figure 15: Acronym MAP is not used, and could be mingled with "map"... Remove it for simplicity.

Interactive comment on Solid Earth Discuss., https://doi.org/10.5194/se-2017-47, 2017.