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Solid Earth Discussions

Interactive comment on "Actors, actions and uncertainties: Optimizing decision making based on 3-D structural geological models" *by* Fabian Antonio Stamm et al.

Fabian Antonio Stamm et al.

fabian.stamm@rwth-aachen.de

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RC2 (Anonymous Referee # 2)

This is an interesting and original contribution on simulating uncertainties and their impact on decision making in a structural hydrocarbon trap. Monte Carlo error propagations and Markov Chain Monte Carlo sampling are used to consider the probability of different trap volume models based on stated uncertainties. Loss functions are used to explore potential decision making scenarios for high-risk and low-risk users. The technique has great potential to be used, with addition of more parameters, for hydrocarbon

exploration and other geoscience applications.

- We thank the reviewer for this positive and motivating comment!

The main strengths of the paper are that it is tightly focused on a specific and important problem, it builds up the methods and results in logical step-wise sections, and it contains useful and clear figures to clarify key inputs/findings. The main weaknesses are that it is written in a fairly inaccessible way, with key elements and some assumptions undefined, and that it does not look beyond the broader applications beyond the specific one used.

- Thank you for pointing out that the description of the approach is difficult to understand in the current form! We actually had a more extensive description about the design of the loss functions in a previous draft version of the manuscript and we realize now that it will be very beneficial to include it again - with concrete examples and corresponding figures explaining suitable choices. We will include this section again in a revised version of the manuscript.

There a few ways that it could be made more accessible to a non-specialist in decision analysis (discussed below) and some general editing would shorten the text and increase its clarity.

General: For reviewing, it would be much better to have continuous line numbers to refer to rather than numbering resetting back to 1 on each page, also every line rather than every 5th line should be numbered.

- We agree - this setting has been the default in the LaTeX template that we used - we will change it in the revision for easier editing.

Lots of instances of unnecessary modifiers e.g. line 10 (P1), line 3-4 (P4), convoluted sentences (e.g. line 2-4, P9) and redundant words (e.g. line 20 P12, line 4, P19) make the text difficult to access. Many of these could be drastically simplified, making the text shorter and more accessible.

- Thank you very much for your constructive remarks, and especially for highlighting the strengths and weaknesses you identified. You pointed out numerous valid concerns. We will consider them while revising the manuscript to make it more concise and accessible to the reader.

The word 'actor' is used throughout and in the title. It would be good to define the term in the context used early on. I see that it is commonly used in the decision sciences as a synonym for the more widely-understood term 'decision maker' or 'user', and seems to represent the human element of the process. However, in line 2 (P9) the phrase 'the case of an actor or decision maker' is used, suggesting that the two are different –perhaps actor has a very specific meaning here, which should be made clear. In line11 (P9), for example, the 'actor' would like to know the trap volume. Use of actor in this context seems obscure, and would be better replaced with a common word representing the human element in decision analysis like worker/geologist/company/user. Line15 (P17) reports observations of the behaviour of the modelled actors – reflecting that actors are a non-human element of the modelling (e.g. Fig. 3). Please clarify.

- We will in particular clarify the definition of 'actor', which we use interchangeably with 'decision maker', earlier in the text. The customized loss function approach is

aimed to include and translate human aspects, such as subjective preferences, so that they are automatically taken into account in the decision-making step applied to modeling. We will also emphasize the link to actual human roles such as experts, geologists and companies.

Several other key concepts, terms and abbreviations are used throughout, but not all are clearly defined. It would be beneficial to place the work in the framework of such definitions.

The use of the hydrocarbon sector as an application for geological modelling is sensible. However, no other options are mentioned. What might other sectors be, and what modelling problems could be solved in the same way (perhaps things like nuclear waste disposal, landslide susceptibility)?

- The suggestion to broaden the view and consider other sectors for potential application of this approach is very justified, particularly considering cases that involve special risk situations. We will evaluate which parallels can be drawn in other fields, but also how application may differ, and include this to a reasonable extent.

Throughout, volumetrics are discussed in the sense of 'trap volume' – which is appropriate and supported by the parameters used. However, there is one instance of the term 'reservoir volume', and there is consideration, in section 2.3, of OOIP. This indicates that actual hydrocarbon reserves are a key outcome of the analysis. But converting from a trap volume to a reserve volume of course involves extra parameters such as porosity, net:gross ratios, water saturation etc. These factors and their uncertainties may be as important or more important than the overall trap volume. While it is reasonable that other factors aren't included in the present modelling, it would be beneficial to mention them, justify their omission, and perhaps consider how they might be

integrated in a future iteration of the model. I think they are alluded to in Fig 7 (reservoir and recovery parameters) but these should be made explicit, given the geologic focus of the topic.

- In a previous version of this work, we had included the full OOIP equation and assumed the trap volume (in this simplified example) to essentially replace the net rock volume (A$*$ h). We omitted this to keep the manuscript short and put focus on the loss function approach. However, it is a valid point that the OOIP equation should be represented, especially for maintaining the link to real-world geological applications.

Lines 6-8 (P6). Is there actually an independent uncertainty related to fault offset? Since that parameter can only be inferred indirectly via stratigraphic surface picks, I would argue that there is no additional uncertainty on either the hanging wall or footwall beyond what has already been accounted for by the surface uncertainty (which is the sole observational basis for fault offset). It would be useful to see a short descriptive justification for including this additional uncertainty. The significance of this parameter is clear in Fig. 5, where the smaller probabilities of hanging wall seal and reservoir result (I think) from the additional uncertainty applied. If this extra uncertainty is not justified (I think it is not), then it places the subsequent results in doubt.

- The fault offset uncertainty was introduced for additional model variability and complexity. We agree that it lacks justification if we assume a more realistic exploration scenario. Furthermore, we now recognized that we implemented a higher degree of complexity than needed and are considering to present a much simpler example (omitting fault offset uncertainty) in a revised version, to not distract from the central propositions of our work.

Line 14 (P6) OOIP/OOIG – presumably this should be OOIP/OGIP instead?

Line 25 (P6). SSF is not defined. I suspect it may be 'shale smear factor' (used without the abbreviation in line 19 (P18)). Please define accordingly.

Line 18 (P13). 'Low but positive volumes' – is a negative volume possible/meaningful? If not, simply use 'low volumes'.

A few minor typos throughout (e.g. line 24 (P18) should read: an individual's..., line 29 (P18) should read: to what extent...). Please check and amend generally.

- We overall find your comments and corrections to be highly useful to improve the manuscript.

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