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

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Dear Stamm et al.,

I think that this submission tackles a challenge that has eluded many practitioners so far by bridging geological uncertainty and decision-making in a quantitative way. I have read the manuscript with interest, and there are a few comments that I would like to make where it relates to my expertise or experience.

I feel that the introduction might not review existing work in sufficient depth. Previous studies use Monte-Carlo simulations using geological measurement uncertainty



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to produce series of models that respect geological plausibility filters and topological laws while honouring said geological measurements, subject to their uncertainty levels. Some of the previous works I refer to are cited in a reference given in the text (Wellmann and Caumon (2018)), but I think that they deserve to be mentioned directly in your manuscript. The review of geological uncertainty highlighting how it is addressed (or, actually, not always really addressed) at the different stages of the workflow by Jessell et al. (2018) also has its place in the introduction. I also think that works by Schneeberger et al. (2017) and Schweizer et al. (2017) may be contributions that relate to the topics covered here.

My argument is that since uncertainty estimation in geological modelling is one of the essential building blocks of this manuscript, the review of the literature should not be as restrictive. It covers a field of active research and should incorporate other works following ideas from Wellmann et al. (2010) such as Pakyuz-Charrier et al. (2018a), who perform Monte-Carlo simulations following the general idea developed in the previous paragraph using a 'Monte Carlo Uncertainty Estimator'. Besides, their work also utilise the implicit modelling framework of Calcagno et al. (2008) and considers the lithologies' apparition frequency. On another note, since the drilling of wells is the one key to successful prospect development in both conventional and shale hydrocarbon contexts (maybe to the exception of bitumen sands), it might worth mentioning that uncertainty in well trajectory and measurements has been recognised as an issue, and addressed using the same framework relying on Monte-Carlo simulations (Pakyuz-Charrier et al. (2018b)). One last thing about probabilistic geological modelling. I think that this area of the geosciences has seen more developments in hard rock scenarios than in basin studies, which should be accounted for when targeting oil and gas studies.

Another aspect of oil and gas exploration which is essential to exploration success is seismic modelling. P10 and P90, which you rightly mention as being commonly used for uncertainty evaluation and decision making, are, more often than not, derived at least in part from such modelling. The field of stochastic/probabilistic seismic inver-





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sion has been gaining traction in oil and gas E&P industry for some time now (many examples are available in the literature), while uncertainty in seismic interpretation is gaining interest (see for instance Bond (2015), Alcalde et al. (2017), and Solid Earth Discussion manuscripts by Schaaf and Bond (2019) and Bárbara et al. (2019), both of which postdate your submission). The same applies, to a certain extent, to the study of uncertainty and geological risk management using electromagnetic methods in hydrocarbon frontier exploration (see for instance Meju (2019) and Baltar and Roth (2013)).

Last, practical applications and underlying hypotheses. In deriving 'geological' models from the interpretation of seismic data, which is often constrained by well information, geoscientists need to consider the lateral and vertical resolution of their imaging. In such cases, uncertainty is heteroscedastic and is a function of a number of parameters such as data fold, frequencies, S/N ratio, etc. It is not trivial to estimate, in particular knowing that dipping structures are much more uncertain than horizontal ones. In short, I think that the role that geophysics plays in imaging, uncertainty and prospect evaluation in the oil and gas E&P should at least be stated briefly, and not completely absent from the text as it is currently the case, which I find a little bit surprising. Someone might wonder what data are used to derive the geometry and location of structural traps in this kind of conventional play, and even the predefined uncertainty levels in positioning, if not mostly seismic and borehole data.

Notwithstanding the comments above, I find this submission interesting, and I think that it is worth a journal publication. I will be looking forward to seeing the revised version of the manuscript.

I hope that my criticism will be helpful and constructive,

Best regards,

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