Geoscientific
Model Development
Discussions

Interactive comment on "Porosity and Permeability Prediction through Forward Stratigraphic Simulations Using GPM™ and Petrel™: Application in Shallow Marine Depositional Settings" by Daniel Otoo and David Hodgetts

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This review is for the manuscript entitled: "Porosity and Permeability Prediction through Forward Stratigraphic Simulations Using GPM^{TM} and Petrel^{TM}: Application in Shallow Marine Depositional Settings" by Daniel Otoo and David Hodgetts

This manuscript describes and applies a good method to generate Forward Stratigraphic Models (FSM) to aid uncertainty reduction and complement stochastic reser-

voir modelling methods. The general concept presented is explained well, but there are some key issues that should be addressed. In my opinion, the manuscript requires major revisions and I have included several constructive comments below. It is my hope the authors take these onboard before final publication in Geoscientific Model Development.

General comments: There are many cases where imprecise language is used that resulted in superfluous words and unclear statements. Less is more when describing modelling methods as many readers will not be familiar with the software or methods used. I have made some suggestions in the Line comments below, but not all have been addressed in this review.

Care should be taken to re-read the manuscript carefully for grammatical errors, missing and misspelled words. Consistent English spellings should be used throughout the manuscript. Appropriate in-text citation style should be used and maintained throughout the manuscript. For example – line 88: "...in some studies (e.g. Delft3D-FlowTM; Rijin & Walstra, (2003); DIONISOSTM Burges et al. (2008)).

Where possible, the author should guide readers to appropriate figures. As it stands, not enough references to figures are made.

A paragraph with a detailed description of how GPM works would be beneficial to readers. This would fit well within the section title "Process Modeling in GPM". I have not used GPM, but if it follows similar principles to other FSM approaches, this should be explained. References to other FSM software is mentioned, but detail of how GPM generates the resultant models should be explained. For example, the 'steady flow process' should be explained like what has been done in Otoo & Hodgetts (2019). This should be used as guidance for the manuscript here. Including the diffusion equation as stated in the authors reply is a good step and should be integrated into this paragraph. I fully appreciate the ease of transitioning from GPM into Petrel, and is a valid reason, but more is required.

Statistical validation of why the number of modelling scenarios were chosen would be good to include. For this to be reproducible (which should be the aim), anyone that reads this should have a clear idea as to why 20 scenarios were chosen so this method can be repeated in other studies.

I feel the manuscript in its current form does not include enough technical detail to clearly describe GPM and the resultant models thereof. Further precise, succinct, and clear explanations are suggested to be added to this manuscript. If others will see the value in the methods discussed herein, then they will want to know how you achieved the results by giving the detail of the modelling software would be beneficial for reproducibility.

Finally, I would advise the authors to not mention any 'future studies' or further work. This manuscript should stand alone and showcase the modelling methods presented rather than putting a final statement about what they want/are going to do in the future.

Line comments:

Line 14: "where" should be used instead of "were"

Line 15: "accommodation space" is not a widely accepted term anymore, instead please use "accommodation".

Line 5: delete "can" and "these" from the statement.

Line: 6-10: These statements do not make much sense, even with the suggested revision by the author. I would suggest something like "Typically, reservoir modelling procedures require continued property modification until a satisfactory match to known subsurface data is achieved. However, acquisition of subsurface data is costly, thus prohibitive to data collection and reservoir model conditioning."

Line: 16: This is repeated throughout the manuscript, the statement 'most likely' does not fit with the assertions made in a scientific manuscript. Integration of FSM's with stochastic modelling techniques will improve reservoir characterisation because they

more accurately simulate the geology than other methods.

Line 41: I presume the author means 'tidal' processes. If so, "tidal" is a more appropriate term to use in this instance.

Line 41: Riverine is not a term used often in literature to describe fluvial processes. Please use the term 'fluvial' in stead of riverine.

Line 73: "twenty four suite of well data" should be changed to something like: "and a suite of 24 wells that comprise of.."

Line 76: The author states that a variety of geological features (grain size, sedimentary structures etc) "play a significant part of reservoir petrophysics". This is an important statement given the nature of the study, but this point should be elaborated. A sentence is all that is needed.

Line 101: The second sentence should start with "For example.."

Line 106: Remove "space" from "accommodation space" – 'space' is implied in 'accommodation'.

Line 108: This sentence should be broken into two, there isn't a need for a semicolon. In fact, I would recommend that the manuscript be carefully reviewed to exclude semicolons as they create long sentences.

Line 164: I am not sure the correct figure is cited here. Should it be Fig. 4d?

Line 164-166: This statement needs a reference. Which shallow marine depositional sequence? The one presented by Folkestad and Sature (2006)? If so, please note the appropriate reference.

Line 176-178: This sentence should be condensed. Careful attention should be paid to grammatical errors and misspellings.

Lines 180-183: This sentence needs to be condensed. High N/G zones are known to

be the best reservoir quality zones/units. Instead focus on what those zones are from the previous work and data.

Line 184: Replace "Statoil" with "Equinor".

Line 195: please change the current statement to '... extended to represent lithofacies...'

Line 197: Please use a colon to start the list

Line 197: Please use commas to aid sentence flow.

Line 203: please change the current statement to 'Typically, pillars join corresponding...' as there are more words than necessary

Line 203-205: This sentence should be condensed. For example, it's not necessary to include the nomenclature of 'corner point gridding' in this context.

Line 205: Please remove 'is' from the statement.

Line 205: What is the major direction that the cells are aligned? I.e. what is the major orientation of the faults?

Line 211: This sentence should be broken up into two statements and a clearer definition of layers is required.

Line 212: What is the cell thickness? Are they constant across the model? How were they defined to control the vertical scale?

Line 215: Colon instead of semicolon should be used.

Line 215: What is meant by 'finer' cells? Please be more precise with the scale you are referring to. Porosity and Permeability Modelling

Line 223: What is the original cell size if it was compressed by 75%? This statement is unclear.

Line 227: replace 'wells to correspond' with 'wells that correspond'.

Line 229: 'actual well' should be deleted and just what is in brackets should be used. 'known data'

Line 230: Where the petrophysical properties guided by any trend data? Facies information? How were the values populated in the model?

Line 237: Please be more explicit as to what you mean by 80m and 120m? Is this TD of the well? MD? Or are they 80m and 120m spaced apart?

Line 242: Please define SW. This I presume means Synthetic Well?

Lines 253-257: Figure 5 referenced need to have annotations which reflect the results discussed. For example, a line that indicates the MFS surface would be beneficial to readers.

Line 258: A reference is required here with this statement. Please also remove 'space' and only just 'accommodation'

Line 262: Singular 'literature' should be used.

Line 264: A word is missing here. Possibly 'Volve dataset' is meant here?

Line 265: Singular use of 'well' is suggested as a revision to the statement.

Line 269: A word is missing in between 'such model'.

Line 270: Singular use of 'validation' is suggested.

Line 272: I'm not sure what is mean by 'modal distribution'? Do the authors mean multi-modal distribution? Normal distribution? I would suggest calculated the statistical model of the original Volve porosity model and then the models of the validation wells.

Line 274-275: This statement needs to be reworded. Are the authors saying that stratigraphic inclination remains constant within the zones, or just other variogram parameters?

Line 277-281: This sentence is too long. Please break it into smaller, clearer sentences. Are the authors suggesting that the FSM is reasonable? Or are they suggesting that the permeability models should be conditioned to known subsurface data? This sentence should be a statement about the results of the model and what is suggested as uncertainties to consider when using these types of modelling methods.

Line 282: Singular use of Discussion

Line295-297: Sequence stratigraphy is a key component to lithofacies distribution characterisation, yes. This sentence should be condensed and reworded.

Line 298: Please use the plural 'matches' instead of 'match'.

Line 302: remove 'of'

Line 304: I would suggest you use 'data' instead of 'dataset'

Line 304: Please use the past tense of 'understand'.

Line 314-315: This sentence is too long. Please split into two statements for clarity.

Line 320: remote 'rather' from the sentence, this is an important statement in the manuscript.

Table comments:

Table 1: The extent of the identified facies should be clarified. For example, Facies A1 is currently stated to be less than 6 km and greater than 29km, when in fact it should be between 6 km and 29 km. ("l = 6 km to 29 km" is sufficient). This change should be made throughout the table.

Figure comments:

I would suggest changing the colourmap on several of the figures. The current colourmap (rainbow) can cause misinterpretation of the data (https://agilescientific.com/blog/2017/12/14/no-more-rainbows), and they are not

suitable for people who are have difficult seeing certain colours (colour blind). Please see these blog posts to why the 'jet' or 'rainbow' colour palette should not be used: https://mycarta.wordpress.com/2012/05/12/the-rainbow-is-dead-long-live-the-rainbow-part-1/. Further, please change the colours in the property models that are more colour blind friendly. The same font choice should be used for all text written in the figure. Currently there are at least two styles.

Figure 4 & 5: These figures are too small to see appropriate detail and is very important for the story of the manuscript. These should be a landscape-oriented figures . Figure 5: Annotations in 5d to guide the reader of the results would be beneficial here. A cartoon with annotations would also be good here that illustrate clinoform progradation events and the SB/MFS events.

Figure 6: There should be a legend and key associated with this figure - I don't know what the colours represent.

Figure 7: This figure is also too small and should be oriented to landscape. Please see my comment above about colourmap choice – 'jet' and 'rainbow' should be avoided if possible. Please consider revising the colourmaps.

Figure 10: The variograms are too small to read the text. I would suggest making this a full-page figure so the data can be read appropriately.

Figure 12: These histograms are too small and make the data difficult to read and interpret.