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Geoscientific Model Development Discussions

Interactive comment on "Quantitative stratigraphic analysis in a source-to-sink numerical framework" *by* Xuesong Ding et al.

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(General comments) Comment 1: This paper describes the results of a numerical experiment focusing on erosion and sedimentation along a continental margin and the stratigraphic analysis of the model deposits. Unlike most previous modelling studies, the erosional evolution of the sediment source area is coupled with sedimentation along the coast. I think it is overall well-written, nicely illustrated, to the point, and, most importantly, an interesting and valuable contribution to the modelling and sequence stratigraphic literature. It illustrates well the power and elegance of the pyBadlands modelling package. In addition, it is hard to overestimate the value of having easy access to both the modelling software and the scripts that were used to generate the model in the paper.

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Response: We acknowledge the reviewer's appreciation of the importance and value of this work.

(Specific comments) Comment 2: Although the authors convincingly show how the trajectory analysis and accommodation succession approaches can be applied to the model results, both manually and in an automated way, and they conclude that the accommodation succession method is more robust, they do not spell out suggestions for practitioners of stratigraphic interpretation. Is a manual approach good / reliable enough? Is it possible to automate the interpretation of actual sections, not just model sections? Should the idea of using dA/dS (as opposed to, let's say, dA-dS) be entirely abandoned? Is it acceptable to talk about dA and dS without specifying what they exactly mean and quantifying them? There seems to be a good opportunity to expand on these issues in the Discussion section.

Response: Thank you for raising these insightful questions. In the Discussion, we added detailed comparisons of stratigraphic interpretations resulting from different approaches and then proposed suggestions for practical applications (Page 15, from line 7; Page 16, lines 1-2). The manual application of the accommodation succession method provides reliable interpretations, while the trajectory analysis depends on time-dependent processes such as thermal subsidence. It is possible to automate the interpretation of actual sections using the shelf-edge trajectory analysis. Again, we showed that corrections of time-dependent processes would be required beforehand. Also, constraints from stratal geometry would be useful to correct possible modifications of shoreline/shelf-edge trajectories by contributing processes. We did not intend to replace dA/dS with dA-dS. We used dA-dS because in our calculation dS could be zero. We clearly stated the meaning of both dA and dS. Due to difficulties in quantifying the "true" dA and dS, we used relative sea level change and sedimentation rate at the time-dependent shoreline as proxies for dA and dS to quantify the competing between dA and dS through time.

Comment 3: In many, maybe most cases the purpose of stratigraphic interpretation

is not just subdivision into meaningful units, but a reconstruction of different forcing parameters / signals. How do the models and analysis shown here perform in this regard? E.g., can the dA-dS curve (Figure 7d) be used as a proxy for sea level? What is the significance of the ∼2 Ma phase shift between the two? This could be the subject of another paper, but it is probably worth exploring it briefly here as well.

Response: Applying the objective accommodation succession method makes it possible to reconstruct the evolution of dA/dS. We correlated the timing and development of stratigraphic units with eustatic sea level changes and sediment supply, and found that the dA-dS curve (Figure 8d) has similar changing trends to the rate of eustatic sea level change (Figure 4b). This suggests that the evolution of dA-dS is a proxy for the derivative of sea level change with respect to time, rather than a direct proxy for sea level change. Discrepancies of <0.5 Myr are observed between the dA-dS curve and the rate of eustatic sea level change curve, which are likely to be related to the temporal resolution (=Âă0.5ÂăMyr) used to compute dA-dS.

Comment 4: The analysis assumes that a single cross section through the model is representative of the whole model / continental margin. The model setup makes it likely that this is indeed the case, but it would be useful to show how similar / dissimilar are other cross sections. Would the analysis of s different section come up with a very similar result? What if there are a significant number of delta lobe avulsions? Again, I realize that a detailed investigation of this could form the subject of another paper, but this question should be addressed. In its current form, this study seems to wholeheartedly encourage sequence stratigraphic interpretation based on single dip sections; yet many real-life deltas are highly three-dimensional and single cross sections do not record the history of the entire system.

Response: Thank you for raising this important point. In the Discussion, we added a new figure (Page 17, Figure 10) that shows five dip-oriented cross-sections and two along-strike cross-sections. The accumulation of depositional environments (Figure 10a) and stratal thickness (Figure 10b) are reconstructed on these cross-sections. We

observed notable differences in the stratal thickness along-strike, while the formation of stratigraphic surfaces is laterally consistent.

(Technical corrections) Comment 5: Page 1, lines 2-4 (and throughout the paper): I am not sure that it is worth reiterating the idea of dA/dS as a key parameter in stratigraphy. You end up using dA-dS anyway; and dA is defined here as the rate of relative sea level change, dS as sedimentation rate. Why not refer to the actual parameters used?

Response: dA/dS is the most widely-used way to analyse the competition between the rate of change of accommodation creation (dA) and the rate of change of sediment supply (dS). As dS can be zero at the shoreline in our model predictions, we use dA-dS instead. The concept of dA/dS is useful, although it remains challenging to quantify this indicator. Future work could comprehensively explore the interplay between accommodation and sediment supply, especially in 3D depositional systems.

Comment 6: Page 2, line 8 – 'tectonics' instead of 'tectonic'

Response: We changed 'tectonic' to 'tectonics' (Page 2, line 8).

Comment 7: Page 2, line 9 – cut 'to stratigraphic interpretations'

Response: We rephrased the sentence (Page 2, lines 9-11).

Comment 8: Page 3, line 2 – 'automate' instead of 'automatise'

Response: We rephrased the sentence (Page 3, lines 12-14).

Comment 9: Page 3, line 6 – 'interpretation' instead of 'interpretations'

Response: We reorganized the configuration of sections by combing the previous section 2 and section 3 into the current section 2 - 'Quantitative stratigraphic analysis in pyBadlands' (Page 3, line 18). The figures within the previous sections 2 and 3 were rearranged accordingly.

Comment 10: Page 3, line 12 – 'designed the trajectory analysis technique'

Response: We rephrased the sentence (Page 3, lines 27-28).

Comment 11: Page 4, line 3 – 'First,' instead of 'Firstly'

Response: We changed 'Firstly' to 'First' (Page 3, line 26).

Comment 12: Page 4, line 8 – 'the topographic contour that corresponds to sea level'

Response: We changed the text 'the topographic contour equals to sea level' to 'the topographic contour that corresponds to sea level' (Page 5, line 7).

Comment 13: Page 4, line 9 – 'a critical slope of 0.025 degrees.'

Response: We modified the text 'a critical slope 0.025 degree' to 'a critical slope of 0.025 degrees' (Page 5, lines 7-8).

Comment 14: Page 6, lines 7-9 – probably should mention that the model setup focuses on sea level changes, as both climate (precipitation) and subsidence patterns are kept constant. Sediment input increases through time, but it does not vary periodically as sea level does.

Response: We modified that paragraph to 'Considering that this study focuses on long-term stratigraphic evolution related with sea level changes, both climate and subsidence patterns are kept constant. Climate is assumed to be directly related to precipitation with a spatially and temporally uniform precipitation rate of 2.0 m/yr over 30 Myr. Sediment input varies through time, depending on the dynamic evolution of source area.' (Page 7, lines 5-8).

Comment 15: Page 6, line 10 – 'sequence development' instead of 'sequences development'.

Response: We changed 'sequences development' to 'sequence development' (Page 7, line 9).

Comment 16: Page 9, figure 5 – what is the horizontal scale in (b)? Tickmarks do not

match those in (c). Stratigraphic columns in (d) do not seem to match the ones in (a).

Response: We modified Figure 5 based on this comment (Page 9, Figure 5). Furthermore, we split the original Figure 5 into two figures (Figure 5 and Figure 6). In Figure 5 (Page 9), we presented snapshots of stratal stacking patterns at 10 Myr, 20 Myr and 30 Myr. The Wheeler diagram was moved to Figure 6 (Page 10), and was rebuilt to be 3D by adding the information of stratal thickness (Figure 6b). In Figure 6, we also showed the stratal thickness within the stratal stacking pattern (Figure 6a).

Comment 17: Page 9, line 2 – 'three stratigraphic cycles' (?) instead of 'three cyclical vertical stacking' Comment 18: Page 9, line 3 – 'apparent in' instead of 'apparent on'

Comment 19: Page 9, lines 4-5 – cut 'the vertical stacking pattern'

Response: We removed the result of vertical stacking patterns.

Comment 20: Page 10, line 1 – 'Interpretation' instead of 'Interpretations'

Response: We changed 'interpretations' to 'interpretation' (Page 11, line 9).

Comment 21: Page 10, line 2 – 'both the trajectory' instead of 'both trajectory'

Response: We changed 'both trajectory' to 'both the trajectory' (Page 11, line 10).

Comment 22: Page 10, line 7 – 'difficult to pick' instead of 'difficult to be picked'

Response: We modified 'difficult to be picked' to 'difficult to pick' (Page 11, line 14).

Comment 23: Page 10, line 9 – 'According to lateral and vertical shifts of the shelf edge through time,'

Response: We modified the text 'According to its lateral and vertical shifts through time' to 'According to lateral and vertical shifts of the shelf edge through time' (Page 11, line 16).

Comment 24: Page 10, line 29 – 'We call this trajectory type the "descending. . .'

Response: We changed ‘name’ to ‘call this trajectory type’ (Page 13, line 3).

Comment 25: Page 11, figure 6 – is the first segment of the first ATC trajectory really ascending in (d)? Seems descending to me.

Response: Thank you for pointing this out. We re-examined the shelf-edge trajectory and agreed that the shelf-edge is descending from 3.5-5.5 Myr, and therefore expanded the subdivision of DTC from 0-3.5 Myr to 0-5.5 Myr (Page 12, Figure 7b, 7d).

Comment 26: Page 12, line 2 – ‘Next, we. . .’ instead of ‘We then. . .’

Response: We changed ‘We then’ to ‘Next, we’ (Page 13, line 9).

Comment 27: Page 12, line 5 – ‘. . .clinoforms do not develop with these model settings.’ instead of ‘clinoforms are not well generated in this model setting.’

Response: We changed ‘clinoforms are not well generated in this model setting’ to ‘clinoforms do not develop with these model settings’ (Page 13, lines 12-13).

Comment 28: Page 12, line 7 – ‘progradational (P)’ instead of ‘progradation (P)’

Response: We changed ‘progradation (P)’ to ‘progradational (P)’ (Page 13, line 14).

Comment 29: Page 14, line 3 – ‘from the final output’ instead of ‘from final output’

Response: We rephrased the sentence (Page 15, lines 13-14).

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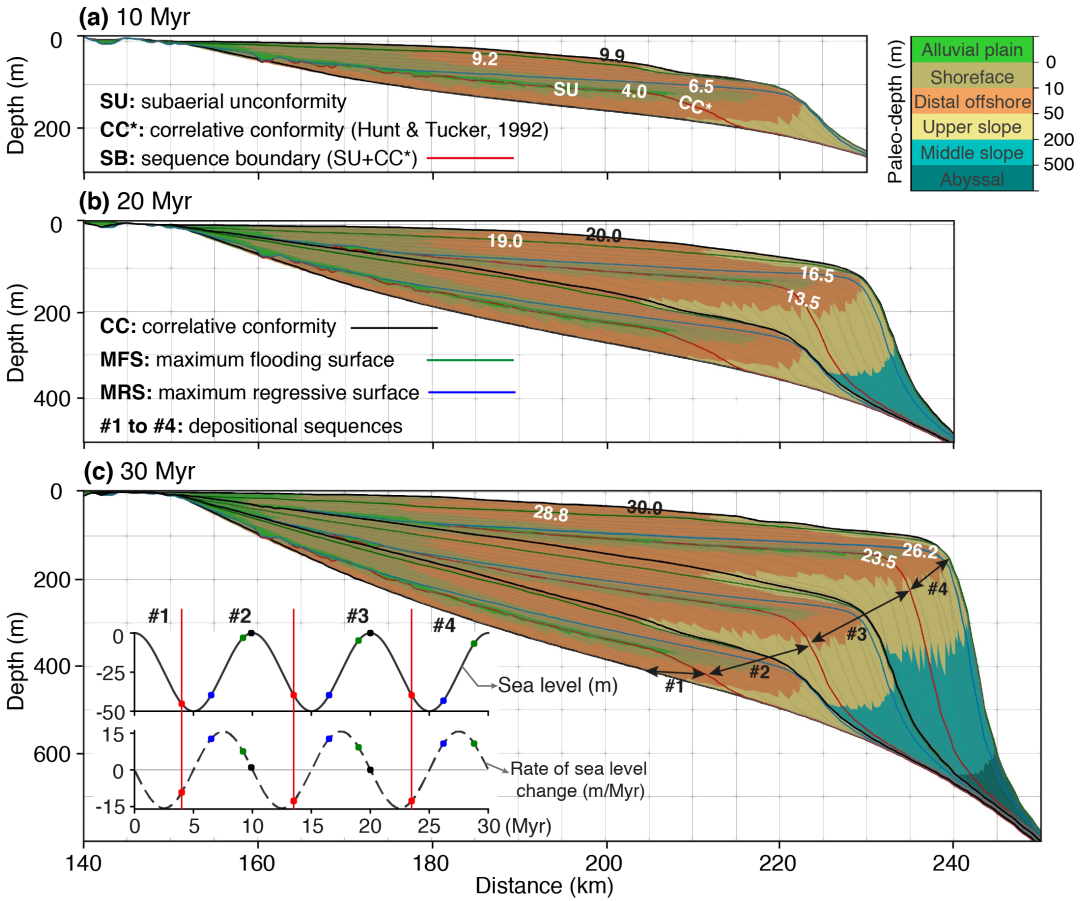

Fig. 1. Figure 5

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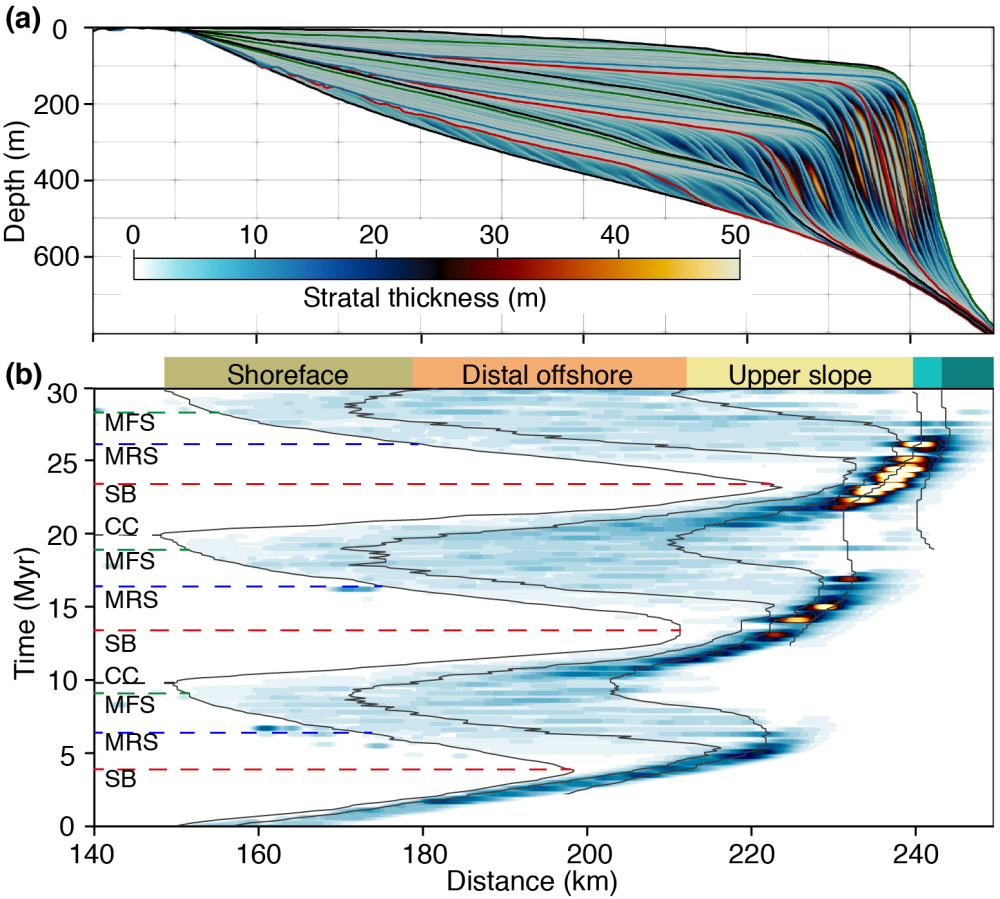

Fig. 2. Figure 6

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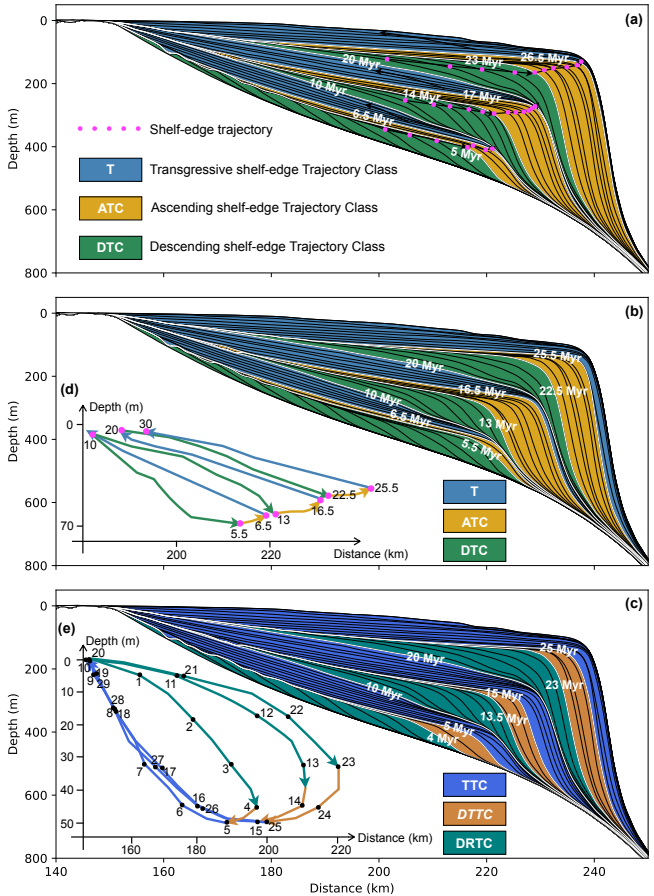

Fig. 3. Figure 7

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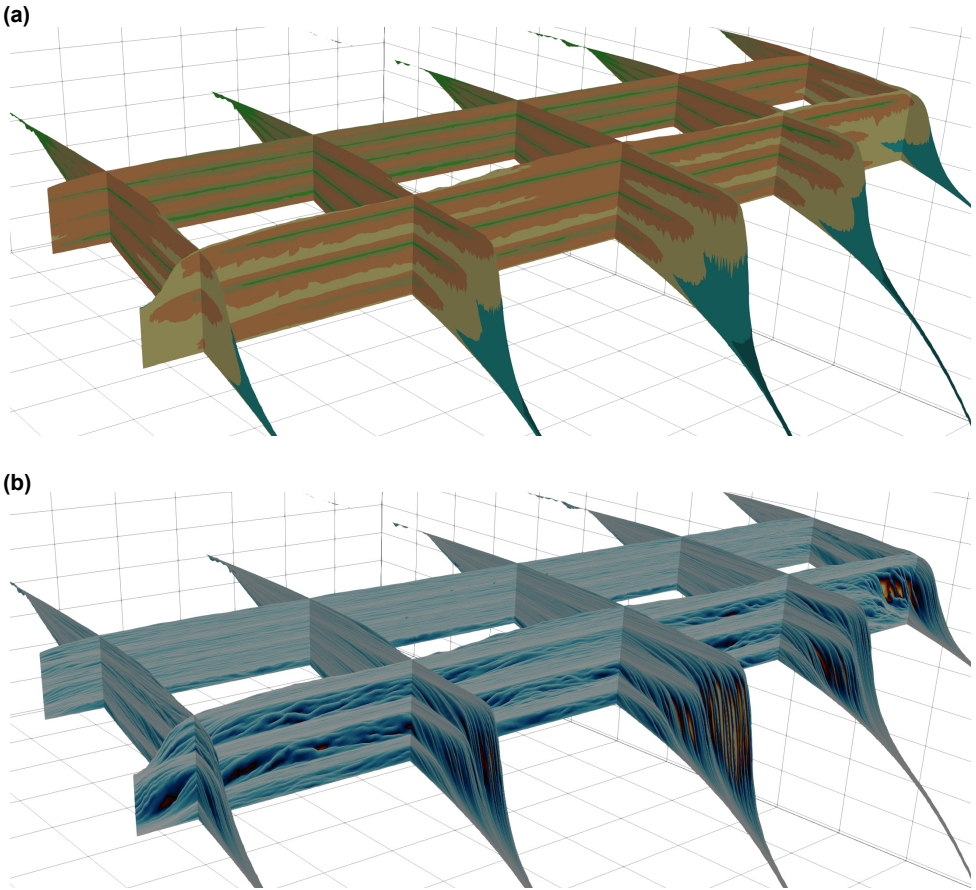

Fig. 4. Figure 10