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Geoscientific Model Development
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Discussions

Interactive comment on "Direct numerical simulations of particle-laden density currents with adaptive, discontinuous finite elements" *by* S. D. Parkinson et al.

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The authors thank the referee for providing this review. They agree that some changes and clarification would improve the manuscript. We would propose to make the revisions outlined below for submission to Geoscientific Model Development. Each item starts with the reviewer's comment.

1 Specific comments

1. *It is stated in the Introduction that particle-laden currents density currents can occur at scales up to several 1000's of kilometres, yet has this been shown? We know that submarine channels and submarine fans extend over thousands of kilometres and therefore such flows can carry sediment over such distances (as noted by the authors), but it is less clear if the flows at any one time fill the entire channel for such lengths, or whether longitudinally shorter currents traverse these systems over time.*

The authors agree with this comment and think that the sentence is a little misleading. Combined with a comment received from another reviewer concerning this sentence, we have modified the sentence to read as follows

> A single submarine particle-laden density currents can involve $100km^3$ of sediment (Talling et al., 2007). That is approximately ten times the sediment flux into the ocean from all of the Earth's rivers combined (Talling et al., 2007). They can travel for hundreds of kilometres over the sea bed at speeds of tens of metres per second (Heezen and Ewing, 1952).

2. *It is stated in the introduction that density currents play an important role in the global carbon cycle. Can references be added to support this statement? Is the role of density currents in the carbon cycle sufficiently well known or should this statement be modified by adding a caveat along the lines of 'may' play an important role. . .?*

This sentence is intended as a leader into the next. Through being one of the key processes for moving organic matter from the continental shelf to the deep ocean we propose that turbidity currents do play an important role in the global carbon cycle.

We do not feel that this sentence is hugely important in the context and propose adjusting it to clear up any ambiguity such that it reads as

> Density currents are a key process for the movement of sediment around our planet (Talling et al., 2012). They form a significant component of the stratigraphic record ...

The next two questions are answered together

3. *Can further comparison be made between the modelling of sedimentation and the model of De Rooij and Dalziel (2001)? The model here is nominally closer to De Rooij and Dalziel (2001) as it incorporates erosion, yet it is considerably worse than either of the two models that do not incorporate this aspect.*

and

4. *Can a fluidity model without erosion be added on to figure 11 by way of comparison? This may help show if there is a problem with the erosion model. It does look at present as if the erosion model does not replicate reality, why is this?*

The three-dimensional simulation presented in this paper is expensive. The reviewers agree that it would be helpful to be able to directly compare results from the Fluidity simulations with and without erosion, but it is not felt that the information gained by doing this is essential for this paper. We would suggest that the return on investment that an additional simulation would provide would not be sufficient to warrant performing another simulation without erosion.

We do agree that more comment can be made as to the success of the erosion algorithm and about how the deposit profile matches against the experimental results of De Rooij and Dalziel (2009). We propose the following adjustment to the analysis of Figure 11

> An important diagnostic for applications is the final deposit profile from a particle-laden density current. Figure 11 shows the span-wise averaged deposit profile from the three-dimensional Fluidity simulation compared against those of previous modellers, and also from the experiments of De Rooij and Dalziel (2009). A good match is observed in the peak deposit height of $\eta \approx 0.12$ at $x \approx 4$ between all of the models and the experimental results.
>
> There is a notable variation in deposit depths near the lock-gate. All models show a smaller deposit depth in this region when compared to the experimental results. The reason for this is unclear and explanations can only be speculative. One potential cause may be that the sediment in the experimental set up had already begun to settle before the lock-gate was released. This may also help to explain the slightly shorter run-out distance resulting from a reduced initial potential energy. Alternatively, there may be processes occurring in the laboratory that are not accurately captured by the computational models.
>
> The results from Fluidity are further from the measured results than the other models in this region. The inclusion of an erosion algorithm is the likely cause of this. The experimental measurements show larger deposits than all of the models upstream, and smaller deposits downstream. Erosional processes will predominately decrease upstream deposits and increase downstream deposits, and hence would increase this discrepancy if applied to any of the models. In addition to this, the erosion algorithm is not configured correctly to match the De Rooij and Dalziel (2009) experiment. $R_p \approx 1$ for the De Rooij and Dalziel (2009) experiment, in comparison to $R_p \approx 20$ in the Fluidity simulation. This will result in significantly more erosion in the simulation than is likely to have occurred in the experiment.

2 Technical comments

We agree with all of the technical comments made and will make the changes requested. Concerning the De Rooij and Dalziel (2009) reference, we will contact the publisher and ask them to include book title and editors. We will also add an acknowledgement to the reviewers for helping to improve the manuscript.

Thank you again for a thorough and thought provoking review.

References

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Interactive comment on Geosci. Model Dev. Discuss., 7, 3219, 2014.