Response to interactive comment by Anonymous Referee #3 on "Cohesive and mixed sediment in the Regional Ocean Modeling System (ROMS v3.6) implemented in the Coupled Ocean Atmosphere Wave Sediment-Transport Modeling System (COAWST r1179)" by Christopher R. Sherwood et al. Comment received 20 March 2018.

The authors thank Anonymous Referee #3 for comments on our manuscript. Here, we respond to those comments and indicate changes we have made in the manuscript to address them. Referee comments are reproduced in ***bold+italics***; our response is in plain text.

OVERVIEW OF THE MS: This manuscript describes and demonstrates algorithms for treating fine and cohesive sediment that have been implemented in the Regional Ocean Modeling System (ROMS). These include: floc dynamics (aggregation and disaggregation in the water column); changes in floc characteristics in the seabed; erosion and deposition of cohesive and mixed (combination of cohesive and non-cohesive) sediment; and biodiffusive mixing of bed sediment. These routines supplement existing non-cohesive sediment modules, thereby increasing our ability to model fine-grained and mixed-sediment environments. Additionally, the manuscript describes changes to the sediment bed-layering scheme that improve the fidelity of the modeled stratigraphic record. Finally, the manuscript provides examples of these modules implemented in idealized test cases and a realistic application.

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MY REVIEW COMMENTS: I see these finding to be very interesting and of great importance, especially for coastal environmental management, where the accurate prediction of the movement and transport of both purely cohesive and mixed sediments is vital, for issues such as navigational waterways and water quality. The manuscript is generally well written and correctly structured, some relevant illustrations, and an appropriate range of relevant literature cited and referenced. The study aims and objectives are clearly defined on pp 4. However, the following points need to be addressed in detail, before this manuscript can be considered for publication.

Well written abstract. I would like to see a few more key quantitative findings reported there, in particular in terms of typical SSC levels and hydrodynamic ranges assessed by the model, plus some key model output values. I would also suggest doing the same for the Conclusion (pp30-31).

This suggestion touches on an important question: over what range of conditions is the model applicable? Strictly speaking, the model applies to dilute suspensions at high Reynolds number (fully turbulent flow). SSC must be low enough that particle influences on turbulence dissipation can be neglected (Hsu et al., 2003), and certainly low enough that the flow is approximately inviscid Newtonian. We have not quantified the sediment concentrations or range of hydrodynamic parameters that ensure these conditions, but a common boundary for fluid mud (where viscoplastic properties become important) is 10 kg/m3 (Einstein and Krone, 1962; Kirby, 1988). We initialized runs with concentrations up to that limit to investigate equilibrium floc diameters (Section 3.1.2 and Fig. 3c). The units on Fig 5a are incorrect and have been corrected on the revised ms…these are integrated SS inventories over a depth of 20 m, and should have units of kg/m2…the maximum concentrations near the bed were about 5.4 kg/m3. Most of the simulations we presented were run with much lower concentrations of ~0.2 to 2 kg/m3 (Fig 3a,b; Fig 4; Fig 8).

Because we did not explicitly explore the range of model applicability, we would prefer not to quote numbers in the Abstract or Conclusion, but we have added text to the discussion to clarify the conditions under which the model should apply.

In Section 2 – Model Processes: I would like to see a little more background on sediment transport process theory. This would assist the reader with fundamentals behind how the new model opporates.

In Section 2.2 – Floc Processes: again, I think this section would benefit by having some brief flocculation theory review presented before the floc model description.

The main focus of the paper is to describe the modeling methods we have implemented. Source papers that can provide a more complete background have been added, and a paragraph providing more background on the floc model approach has been added to Section 2, as described below.

I think it would be good to briefly outline the range of different approaches used in flocculation modeling, and why the approach used in this model was chosen.

Good suggestion. We added a paragraph in Section 2 describing the difference between distribution-based and class-size-based models and a justification for our choice of a class-size-based approach. This paragraph also cites references to some of the classic papers for settling-velocity modeling, including Van Leussen (1998), Winterwerp (2006), Manning and Dyer (2007), Khelifa and Hill (2006) and Soulsby et al. (2013). I think this helps put our approach in context.

Other aspects that I would like to see further updated in the manuscript, are slight updates with the Introduction section, where specific aspects could be further strengthened. I would like to recommend including some of the following references in the Introduction literature review. This would significantly strengthen the literature reviewed in the manuscript. These would provide links to recent research findings that would provide synergy and context for the research reported in this manuscript. It would be good if aspects of the following publications were included in the Discussion. These four publications provide additional insights into cohesive sediment flocculation and associated settling dynamics, together with applied modelling:

- Mehta, A.J., Manning, A.J. and Khare, Y.P. (2014). A Note on the Krone deposition equation and significance of floc aggregation. Marine Geology, 354, 34-39, doi.org/10.1016/j.margeo.2014.04.002.

We have added a sentence citing this paper in Section 1.2

- Mietta, F., Chassagne, C., Manning, A.J. and Winterwerp, J.C. (2009). Influence of shear rate, organic matter content, pH and salinity on mud flocculation. Ocean Dynamics, 59, 751-763, doi: 10.1007/s10236-009- 0231-4.

We have added these to the References and cited it in the section of the Discussion where we itemize processes that are not included in our model.

- Soulsby, R.L., Manning, A.J., Spearman, J. and Whitehouse, R.J.S. (2013). Settling velocity and mass settling flux of flocculated estuarine sediments. Marine Geology, doi.org/10.1016/j.margeo.2013.04.006.

This paper is cited on line 61.

- Winterwerp, J.C., Manning, A.J., Martens, C., de Mulder, T., and Vanlede, J. (2006). A heuristic formula for turbulence induced flocculation of cohesive sediment. Estuarine, Coastal and Shelf Science, 68, 195-207.

This paper is cited on line 38.

These two publications have demonstrated the importance of biological cohesion on bed sediments, as this has an important role on erosion threshold and bio-stability:

-Malarkey, J., Baas, J.H., Hope, J.A., Aspden, R.J., Parsons, D.R., Peakall, J., Paterson, D.M., Schindler, R.J., Ye, L., Lichtman, I.D., Bass, S.J., Davies, A.G., Manning, A.J., Thorne, P.D. (2015). The pervasive role of biological cohesion in bedform development. Nature Communications, DOI: 10.1038/ncomms7257

. - Parsons, D.R., Schindler, R.J., Hope, J.A., Malarkey, J., Baas, J.H., Peakall, J., Manning, A.J., Ye, L., Simmons, S., Paterson, D.M., Aspden, R.J., Bass, S.J., Davies, A.G., Lichtman, I.D. and Thorne, P.D. (2016). The role of biophysical cohesion on subaqueous bed form size. Geophysical Research Letters, 43, doi:10.1002/2016GL067667.

These papers deal with biological cohesion of normally non-cohesive sediment. This is a process that is not addressed by our model. We have added these references and cited them in the section of the Discussion where we itemize processes that are not included in the model.

This publication provides good general overviews of cohesive sediment dynamics:

-Mehta, A.J. (2014). An Introduction to Hydraulics of Fine Sediment Transport, World

Scientific, Hackensack, N. J.

This book is cited on line 33 and elsewhere in the manuscript.

Although the manuscript mentions mixed sediments in Section 2.5, it reports very little about the effects of mixed sediment flocculation. As much of the model application could be utilized in areas where there are sand / silt / clay, and biological cohesions, the manuscript would benefit from the citation of some of these recent key publications on the flocculation processes of cohesive and mixed fine-grained sediment suspension, as these outline key processes relating to these suspended sediment types:

**** Manning, A.J., Baugh, J.V., Spearman, J.R., Pidduck, E.L. and Whitehouse, R.J.S. (2011). The settling dynamics of flocculating mud:sand mixtures: Part 1 – Empirical algorithm development. Ocean Dynamics, INTERCOH 2009 special issue, doi:***

10.1007/s10236-011-0394-7.

**** Manning, A.J., Baugh, J.V., Spearman, J. and Whitehouse, R.J.S. (2010). Flocculation Settling Characteristics of Mud:Sand Mixtures. Ocean Dynamics, doi: 10.1007/s10236-009-0251-0.***

**** Spearman, J.R., Manning, A.J. and Whitehouse, R.J.S. (2011). The settling dynamics of flocculating mud:sand mixtures: Part 2 – Numerical modelling. Ocean Dynamics, doi: 10.1007/s10236-011- 0385-8.***

We have added the following text to the Discussion: "It is important to note that the mass settling fluxes of mixed (sand + mud) suspensions may be overestimated if their interactions are not considered, as is the case in the approach taken here (Manning et al., 2010, Manning et al., 2011)." We also added two references to the citations (Spearman et al., 2011 was previously cited on line 63 of the manuscript).

In terms of the erosion-depositional cycle, Spearman and Manning (2008) have demonstrated that the threshold shear stresses for both deposition and erosion can operate simultaneously, in order to correctly mass-balance accretion and erosion levels of cohesive sediments during tidal cycles in shallow water locations. I would like to see this commented on within the context of your own study findings.

- Spearman, J. and Manning, A.J. (2008). On the significance of mud transport algorithms for the modelling of intertidal flats. In: T. Kudusa, H. Yamanishi, J. Spearman and J.Z. Gailani, (Eds.), Sediment and Ecohydraulics - Proc. in Marine Science 9, Amsterdam: Elsevier, pp. 411-430, ISBN: 978-0-444-53184-1.

This process is incorporated in the model and described in Section 2.2.1 (now 2.3.1). We have cited this paper in that section.

I would like to see the Discussion (Section 5) expanded slightly, with some comparisons made with other commonly used sediment transport modeling approaches. Some quatification (also in a summary Table) to these comparisons would be helpful. This could advise the reader on where significant improvements and advances have been made with this new modeling approach. It would also be good to comment on the possible limitations on this new modeling approach.

We have compared the model results for individual processes with results of others (e.g., flocculation and biodiffusion in this paper; bedload transport in Warner et al., 2008). We have touched on the significant improvements we feel this model offers. We think that quantitative comparison of our results with other models is beyond the scope of this paper, but we hope that future efforts may undertake this. We have not changed the manuscript to address this comment.

In summary, I think these findings are significant and are worthy of publication in GMD.

We thank the referee for providing input; we feel that this has helped us improve the paper.