D. Burdige: Below I've outlined replies to your comments.

1. (5448, 10-11) – The word "sediment" is on both sides of the parenthetical statement with the grain size information. I don't think the second one is needed.

Deleted the word "sediment" from sentence

2. (5450, 10-11)
– If the sediments were sieved to remove macrofauna (5448, 14), why is bioturbation included in the model?

We didn't include bioturbation in the simulations. This was an error and the text has been removed.

3. (5451, 9-10) – What was the basis for a 75%/25% partitioning of the organic matter into a fast-decaying and a slow decaying component?
We have referenced the rationale of the 25/75% fractionation of organic matter k values from Westrich and Berner (1984)

4. (5451, 22) – I was surprised there was no discussion in this section about how carbonate chemistry is handled in the model equations. If this is presented in an earlier paper then only a brief discussion is necessary (something akin to the length of the discussion in section 2.2). If it's not presented elsewhere, it needs to be clearly presented here.
We have now discussed the carbonate and acid-base species clearly as outline in this added text:

"The set of acid-base reactions governing the pH dynamics in the pore water includes the carbonate, borate, sulfide and water equilibria. The impact of dissociation reactions involving phosphate, ammonium, silicate and dissolved organic compounds was assumed negligible. The associated total alkalinity and total species are hence defined as:

$$A_T = \left[HCO_3^-\right] + 2\left[CO_3^{2-}\right] + \left[B(OH)_4^-\right] + \left[HS^-\right] + \left[OH^-\right] - \left[H^+\right]$$

$$SumCO2 = \left[CO_2\right] + \left[HCO_3^-\right] + \left[CO_3^{2-}\right]$$

$$SumBOH3 = \left[B(OH)_3\right] + \left[B(OH)_4^-\right]$$

$$SumH2S = \left[HS^-\right] + \left[H_2S\right]$$

The associated equilibrium constants were calculated as a function of temperature and salinity using AquaEnv, a dedicated R-package for acid-base and CO2 system calculations (Hofmann et al., 2010). Specifically, for the carbonate equilibria, we used the relationships provided by Millero et al. (2006)."

5. (5455, 16-17) – "dissolved organic carbon" is by itself not a process.
This needs to be clarified.
Changed to "dissolved organic carbon *release*"

6. (5455, 23-25) – Net alkalinity production is the balance between gross alkalinity production by, e.g., the reaction listed here, and alkalinity

consumption/acid production, by e.g., sulfide oxidation. Thus I'm not sure that strictly speaking this sentence is correct. 7. Related to this, I wonder if for completeness there needs to be a brief section on alkalinity consuming reactions. These are discussed throughout the rest of the text and are an equally important part of the story being told here..

We have included some extra text explaining oxidation reactions and explained how net sulfur reduction is the process which leads to net alkalinity production.

8. In section 4.2 I think it is important to note that here you are really talking about net processes, since any alkalinity production during inundation is offset by alkalinity consumption/acid production that may occur when the sediments are exposed and O2 input is enhanced. In this experimental study, early on alkalinity production is greater than consumption, but later on in the experiments (as is noted on lines 23-25) the balance shifts and consumption exceeds production. Explicitly talking about net processes associated with the dynamics of the system would, in my opinion, improve the overall discussion and more strongly point out the links between physical processes (periodic exposure and inundation) and biogeochemical reactions in the sediments.

We have changed this paragraph to reflect net alkalinity fluxes, in line with section 4.1

9. (5456, 23) – Is this H2S stored in the pore waters? If so, you may want to be more explicit.

Changed "H2S in sediment" to "H2S in sediment pore waters"

10. (5456, 23-24) – I assume "This flux" is an alkalinity flux. Again, you may want to be more explicit.

There are several instances in which we have clarified "flux" as being "alkalinity flux"

11. (5457, 8) – The linear relationship mentioned here is not evident from Fig. 4 (although we can see the positive relationship between the two). I'm not sure if an additional figure is needed to show this, or if the authors can simply re-write this sentence.

We've decided it's not worth putting in another figure, but have changed the text to make this statement more clear without the need for one.

12. (5457,14) – I'm not sure what "In the first instance" means here.

Changed "in the first instance" to "Initially we thought that"

13. (5457,15) – Where are the model results showing alkalinity production (flux ?) increased as piston velocity decreased? This seems like an important result that should be shown.

We haven't included an extra figure as we feel this would be too much considering this isn't a major focus, but we've given a value - "there was an increase in alkalinity production by 7% as the piston velocity was decreased from 5 to 0.05 (data not shown)"

14. (5457, 20) - It seems a little odd to talk here about the "remainder" of the simulations, since they have already been discussed. Might it better to move section 4.3 up in the text?

Section 4.3 has been moved up to 4.2 to correct the chronological inconsistency.

15. (5458, 3) – "exported to the atmosphere versus alkalinity" is an incomplete phrase.

15. "exported to the atmosphere versus alkalinity" has been changed to "exported to the atmosphere (as CO_2) versus the ocean (as alkalinity)"

16. (5458, 11) – Which profile are you referring to?
The word “profile” has been deleted

17. (5458, 15) – I think I would be explicit that this sink for sulfide is the sediment pore waters.
We have made it explicit that sulfide is stored in the “sediment pore waters”, rather than the “sediment”.

18. Figure 2 a. Are there any significant difference in the observed behavior here between the +OM and -OM incubated cores, or in the model simulation before and after OM addition? Is it worth discussing this (regardless of the observations)? b. Rather than “Lab experiments” I would say “incubated cores (this study)”.
Change lab experiments to incubated cores. Also, we’ve now annotated this figure to show that it includes both + and – OM. Clearly, prior to OM addition, the data points in the low flux area are the –OM incubations)

19. Figure 4
– The model treatments are referred to differently in the text (5457, 8) and in the figure caption. While its pretty obvious which is which, it might be better to be consistent within the manuscript.
We have changed “respiration rate” to “mineralisation rate” in the figure to match better the text description.

Thank you for your thoughtful comments, and constructive criticism.

P. Faber and co-authors