Review of Lovecchio & Lenton

The simple model presented by the authors confirms that the remineralization length has a strong impact on ocean productivity and oxygenation. Due to the simplicity of their model, the authors are able to fully explore the parameter space. The main conclusions of the manuscript are, hence, valid within the limits given by the model architecture. The revised manuscript is in much better shape than the original version. Nevertheless, there are a few remaining issues that should be addressed in a further revision of the manuscript:

The local concentrations of organic particles suspended in the water column (SP_{org} and LP_{org}) are employed to calculate rates of coagulation, export, organic matter degradation and organic matter deposition at the seafloor. However, SP_{org} and LP_{org} do not appear as state variables in Tab. 1. On page 5, lines 1 -8, the authors explain that SP_{org} and LP_{org} are redistributed in the water column by gravitational sinking and calculated implicitly but they do not fully explain how SP_{org} and LP_{org} are constrained. The authors should better explain how these important variables are derived and specify the equations that they employ to calculate SP_{org} and LP_{org} in their model.

The authors assume that organic matter is converted into methane when oxygen is depleted. They deliberately neglect denitrification and the reduction of iron and sulfate in their model. This is a major limitation because the system behavior (e.g. changes in ocean productivity, dissolved and atmospheric oxygen) may change drastically when these processes are considered (Wallmann, Flogel et al. 2019). The authors should add a section/sentence to chapter 5.1 (Model limitations) to explain that the model outcomes would change drastically when other redox pathways and nutrients (nitrogen, iron) would be considered in the modeling.

The authors assume that anaerobic degradation is faster than aerobic degradation (page 6, line 30, $fe_{an} > 1$). This assumption is valid for organic P (P_{org}) but studies on the degradation kinetics of particulate organic carbon (POC) show that POC degradation either declines under anoxic conditions or proceeds at a rate similar to that observed in the presence of oxygen (Hedges, Hu et al. 1999, Burdige 2007, Dale, Sommer et al. 2015). The authors should explain and clearly specify that $fe_{an} > 1$ is valid only for P_{org} degradation but not for POC degradation. Since the product of anaerobic POC degradation (methane) is assumed to contribute to the consumption of oxygen in the atmosphere (Eq. 17), the authors should separate P_{org} and POC degradation in their model and employ $fe_{an} \leq 1$ to simulate POC degradation.

References

Burdige, D. J. (2007). "Preservation of organic matter in marine sediments: Controls, mechanisms, and an imbalance in sediment organic carbon budgets?" Chem. Rev. **107**: 467-485.

Dale, A. W., S. Sommer, U. Lomnitz, I. Montes, T. Treude, V. Liebetrau, J. Gier, C. Hensen, M. Dengler, K. Stolpovsky, L. D. Bryant and K. Wallmann (2015). "Organic carbon production, mineralisation and preservation on the Peruvian margin." Biogeosciences **12**: 1537-1559.

Hedges, J. I., F. S. Hu, A. H. Devol, H. E. Hartnett, E. Tsamakis and R. G. Keil (1999). "Sedimentary organic matter preservation: A test for selective degradation under oxic conditions." American Journal of Science **299**(7-9): 529-555.

Wallmann, K., S. Flogel, F. Scholz, A. W. Dale, T. P. Kemena, S. Steinig and W. Kuhnt (2019). "Periodic changes in the Cretaceous ocean and climate caused by marine redox see-saw." Nature Geoscience **12**(6): 456- 462.