Ocean deoxygenation and its impact on marine organic carbon burial

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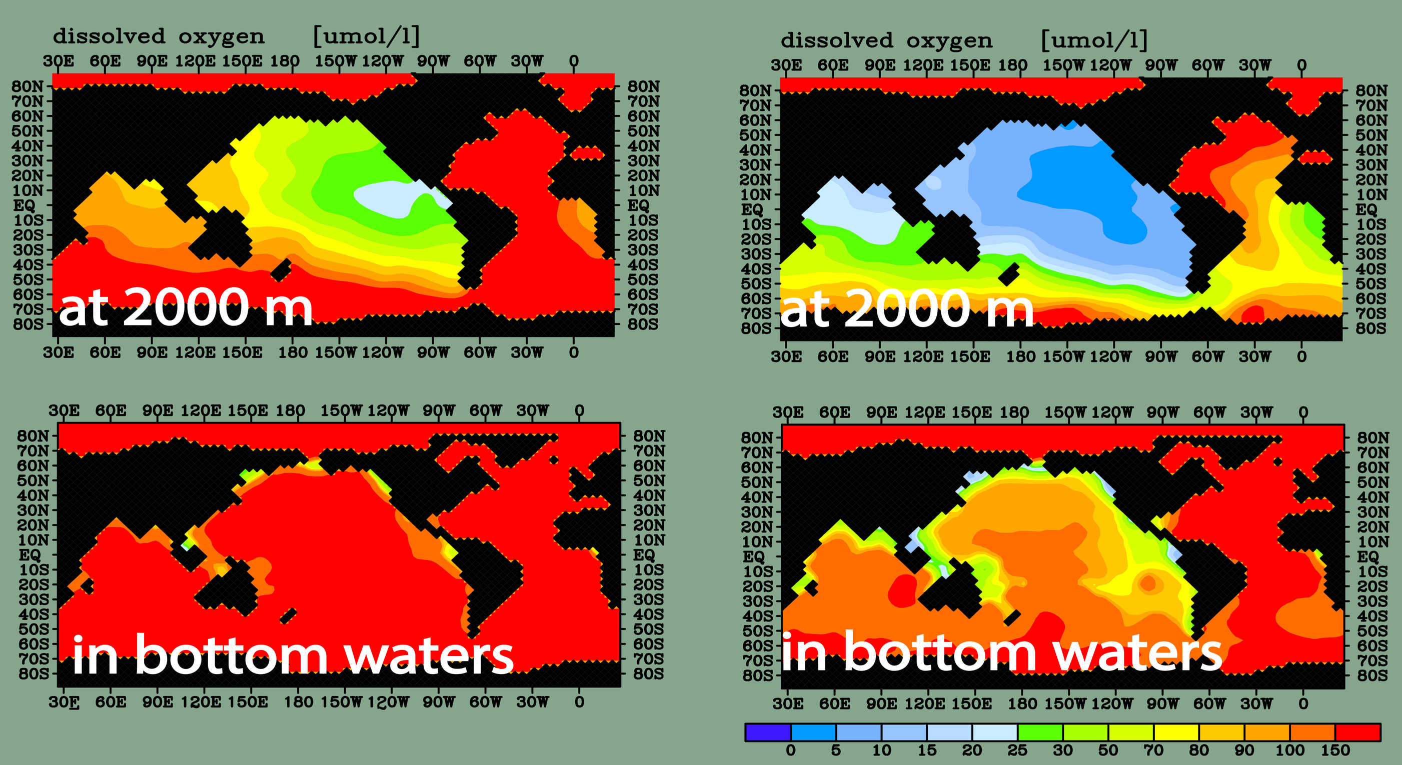
Oxygen deficient zones (ODZs) in the ocean are currently expanding. This has led to the suggestion that the ocean is on the edge of anoxia [1]. Ocean deoxygenation has the potential to enhance organic carbon (C) burial in sediments and may act as a feedback on global warming.

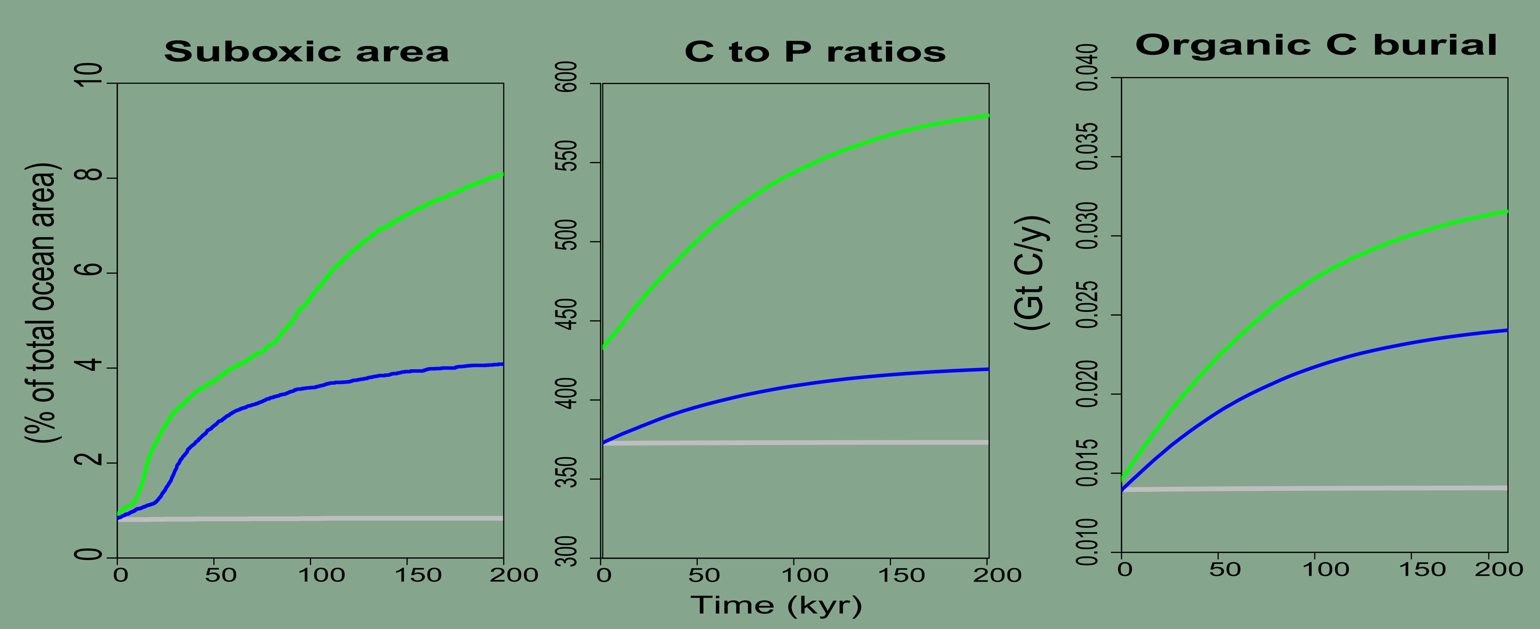
In this study, we use an ocean biogeochemical model coupled to a general ocean circulation model (HAMOCC2) to assess the impact of ocean deoxygenation on organic C burial in the modern ocean on a time scale of 200 kyr. We focus on scenarios with increased riverine inputs of phosphorus (P) and redox sensitive P burial **(section A and B)**.

We compare our results with those of a model built for the Cretaceous Oceanic Anoxic Event (OAE2) in the proto-North Atlantic [2,3] (**section C, D and E**).

A. Dissolved oxygen in the modern ocean (left) and after 200 kyr of doubling the riverine input of P (right)



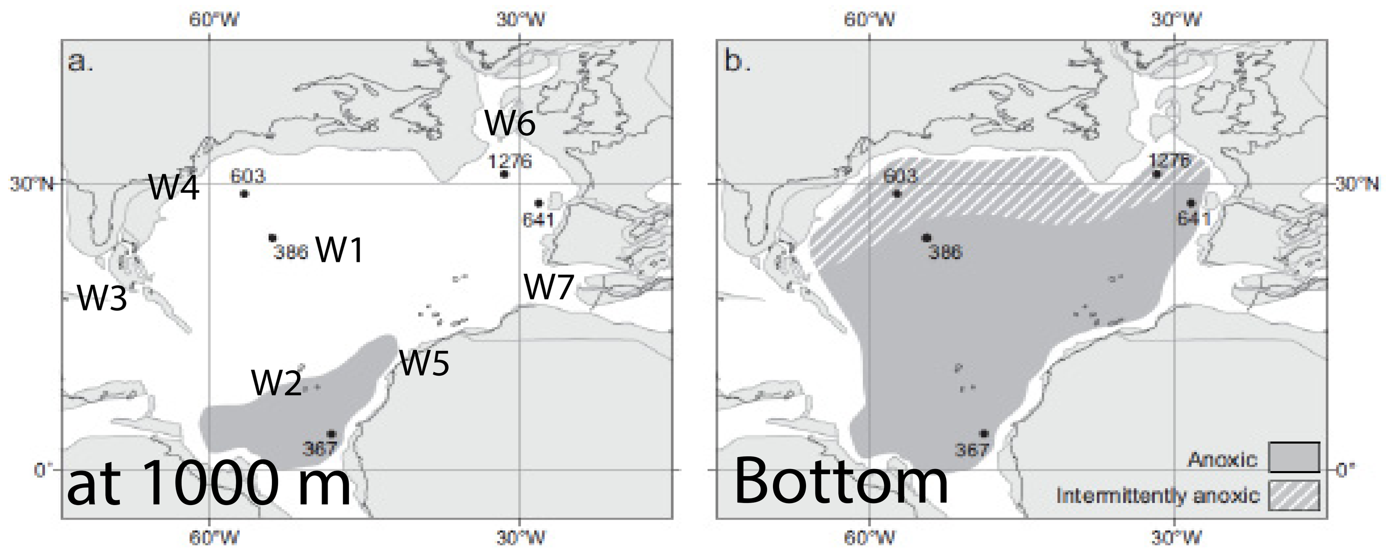
B. Organic carbon burial, C to P ratios of burried organic matter and suboxic area



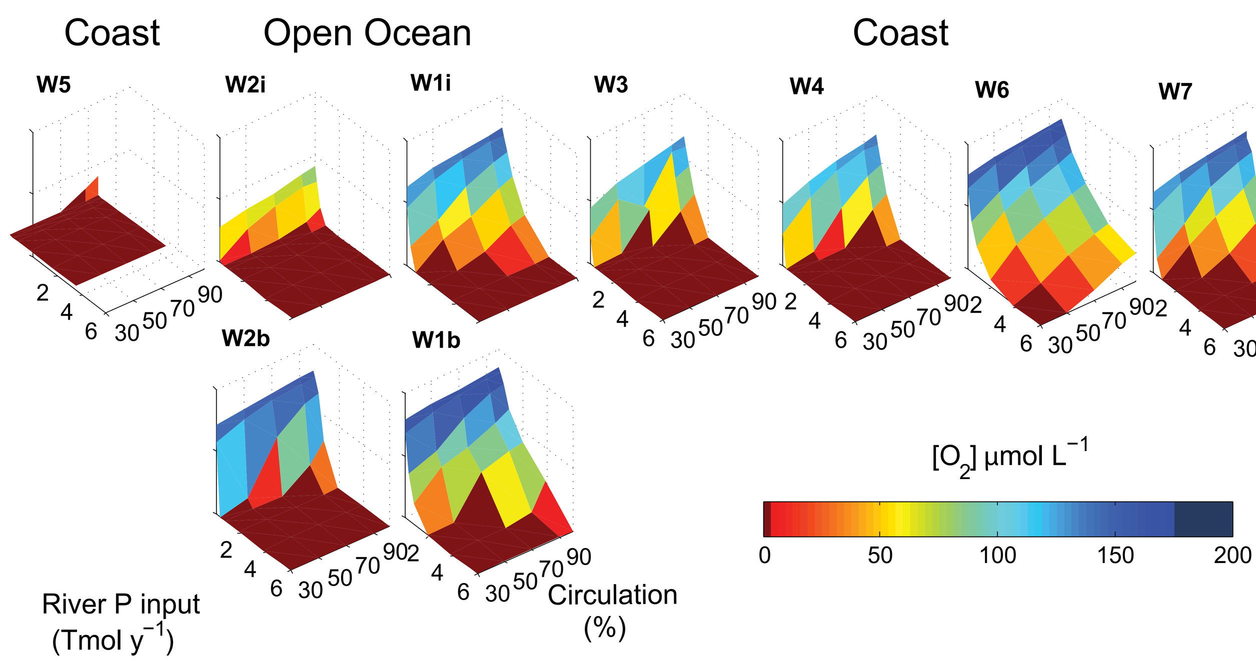
Control run simulating the modern ocean (control)
Control run with 2x riverine input of P (run1)
Control run with enhanced P recyling and 2.5x riverine input of P(run2)

Model results show that it is difficult to drive the modern ocean to anoxia with the current ocean circulation. In our scenarios, at most ca. 8% of the ocean floor will become suboxic (O2 < 12 uM).

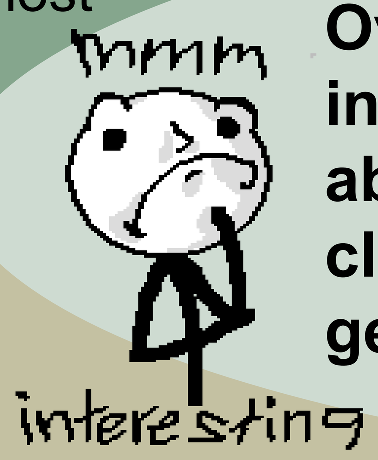
C. Anoxic waters in the Proto-North Atlatic during OAE2



D. Oxygen sensitivity in the Proto-North Atlantic to changes in riverine input of P and ocean circulation

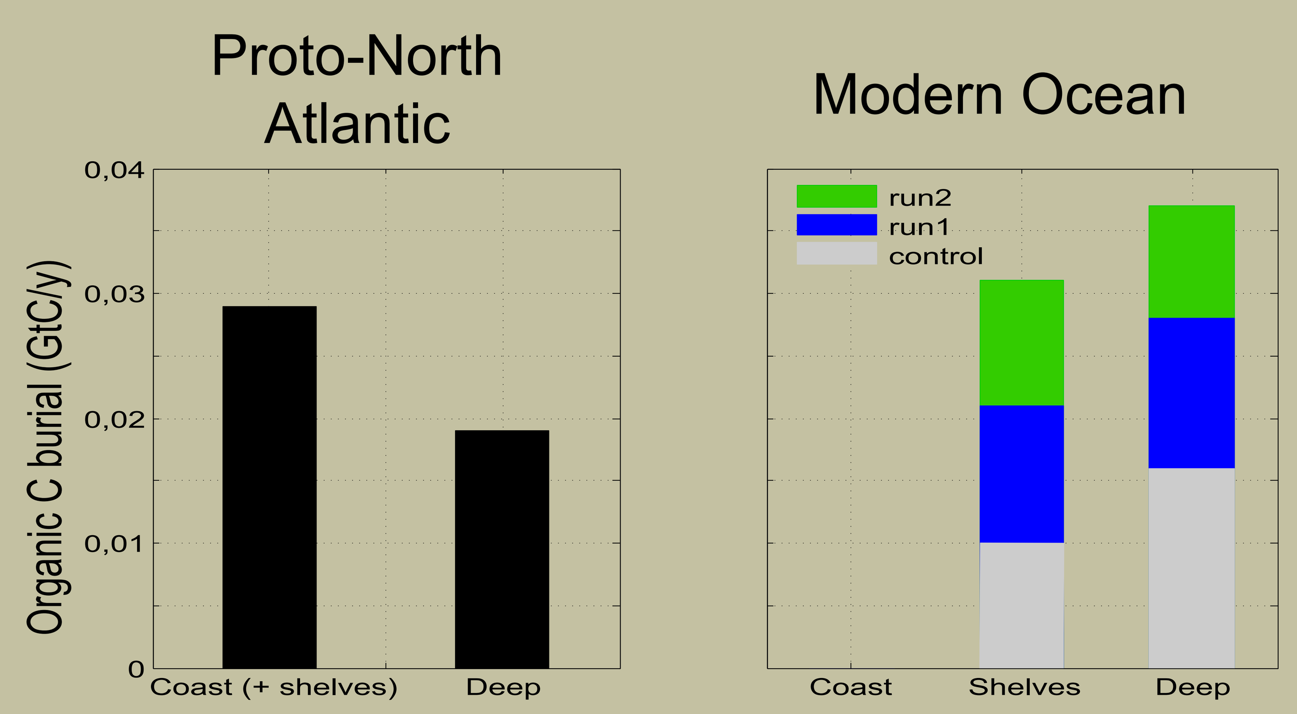


The bottom waters in the central open ocean (W1) can only become anoxic when circulation is reduced by at least 20% and high P inputs enter the basin. Therfore, only a combination of factors can lead to sustained, widespread anoxia.



Over a period of 200 kyrs, ocean deoxygenation due to increased riverine input of P can lead to a burial of about 5200 Pg of C in a scenario with strong P recycling. This falls within the range of predicted anthropogenic C emissions.

E. Organic Carbon burial in the past compared to that of modern ocean



Organic C burial in simulations of both proto-North Atlantic and modern ocean are of the same order of magnitude.

Conclusion

- Our model results show that, while ODZs expand significantly with increasing riverine input of P, it is difficult to drive the modern ocean to anoxia with the current ocean circulation. This contradicts the suggestion that the modern ocean is on the edge of anoxia.

- Comparison of our results to those for Cretaceous OAE2, suggests that only a combination of factors can lead to sustained, widespread anoxia and that besides a high nutrient availability, a change in ocean circulation is required.

- Organic C burial on timescale such as studied here could contribute to the drawdown of atmospheric CO2.

[1]: Watson, A. J. (2016). Oceans on the edge of anoxia. Science, 354(6319), 1529-1530.
[2]: van Helmond, N. A., Ruvalcaba Baroni, I., Sluijs, A., Sinninghe Damsté, J. S., & Slomp, C. P. (2014). Spatial extent and degree of oxygen depletion in the deep proto-North Atlantic basin during Oceanic Anoxic Event 2. Geochemistry, Geophysics, Geosystems, 15(11), 4254-4266.
[3]: Ruvalcaba Baroni, I., Topper, R. P. M., van Helmond, N. A. G. M., Brinkhuis, H., & Slomp, C. P. (2014). Biogeochemistry of the North Atlantic during oceanic anoxic event 2: role of changes in ocean circulation and phosphorus input. BioGeosciences, 11(4), 977-993.