Anthropogenic Fe and N deposition alters the ecosystem and carbon balance of the Southern Indian Ocean

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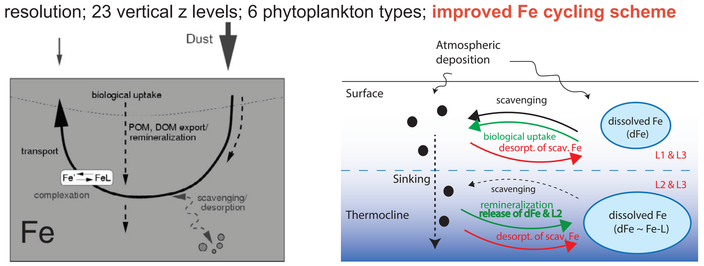
Question and model description

- Phytoplankton growth in the Indian Ocean is generally limited by macronutrients (N, P) in the north and by micronutrient (Fe) in the south.
- **Question:** How the ecosystem and carbon balance in this region will respond to an increasing anthropogenic N and Fe deposition?
- Address this question in an ecosytem model (Dutkiewicz et al., 2014): 3 degree horizontal resolution; 23 vertical z levels; 6 phytoplankton types; **improved Fe cycling scheme**

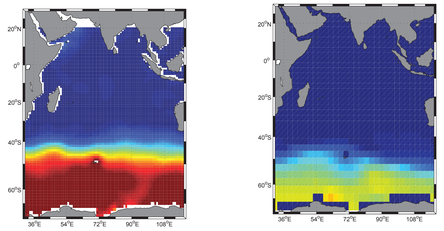


Old model Fe scheme (Parekh et al., 2005; Dutkiewicz et al., 2014): 1 uniformly distributed ligand class; dissolved Fe scavenged by organic particles only
New Fe scheme (Pham and Ito, 2018, 2019): 3 spatially vary ligand classes (biologically produced L1, particle remineralized L2, and refractory L3); release of scavenged Fe from organic and inorganic particles

Model validation

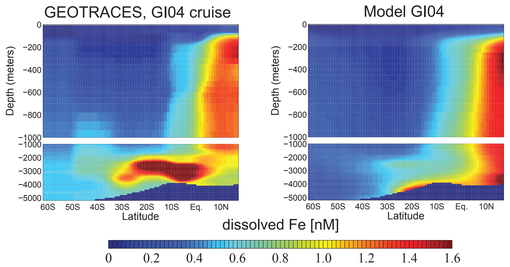
WOA

Model

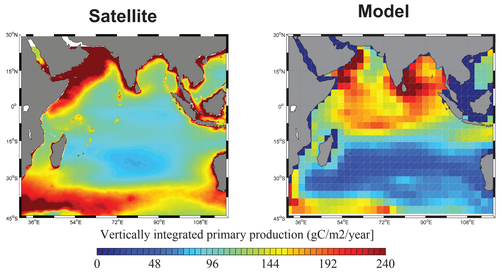


surface NO3- concentration (mmol/m3)
0 5 10 15 20 25

Model underestimates the nutrient concentration in the Southern Ocean but captures essential features of the nutrient distribution



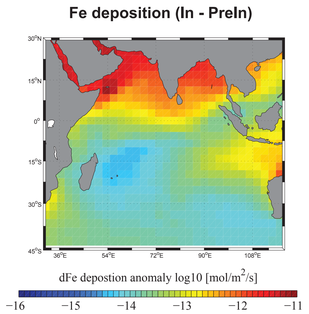
Model reproduces major features of the Fe distribution along the GI04 Indian Ocean transect

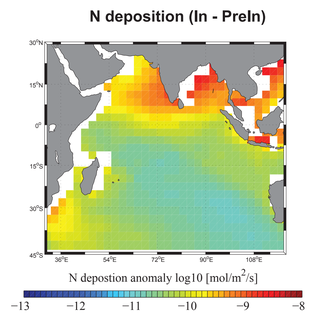


Despite some biases, our model starts capturing some features of the primary production observed by the satellite

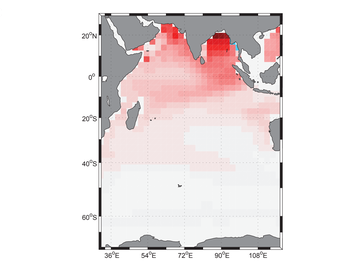
Model experiments

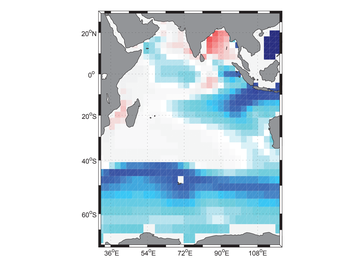
- The model was first spun up under the pre-industrial deposition of N and Fe for 1000 years (PreIn run)
- The model then ran under the industrial N and Fe deposition (Ind run) for another 1000 years

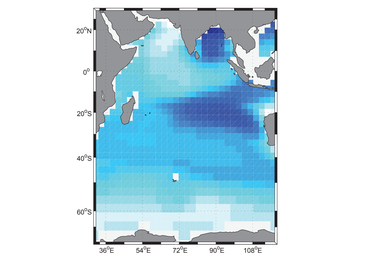


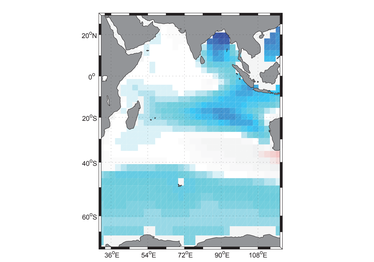


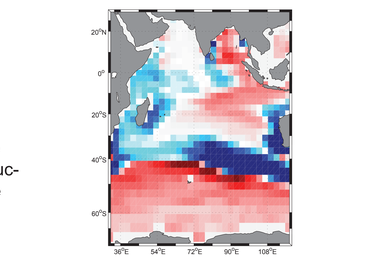
- Analyzing the difference in nutrient fields, biological production, and carbon uptake of the Ind run relative to the PreIn run (Ind - PreIn)

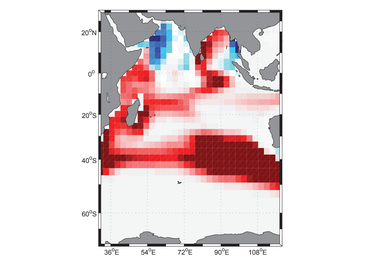






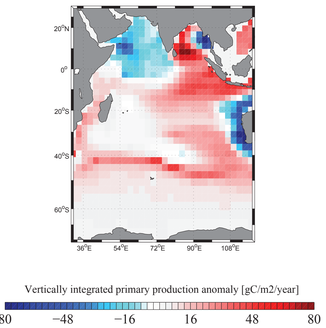


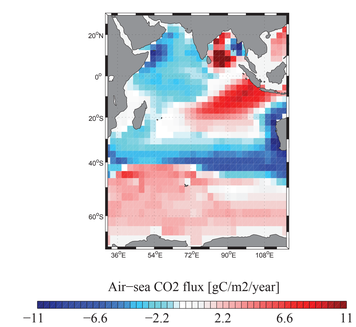




Discussion

- Increased Fe deposition stimulates diatom productivity of the southern Indian Ocean poleward of 40°S
- Diatom production weakens along 40°S due to the P depletion and it is outcompeted by coccolithophores, which has a lower P demand

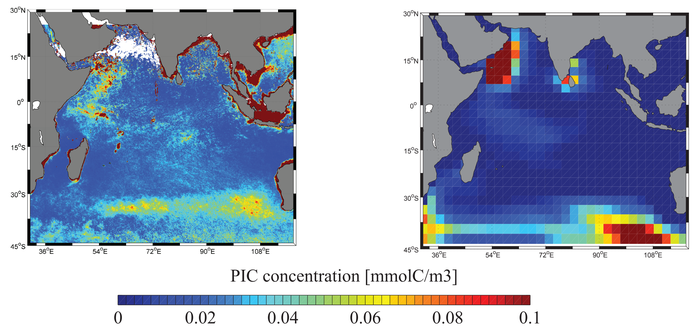




- These changes in diatom and coccolithophores production weaken the organic pump and strengthen the carbonate pump, increasing the carbon uptake in the poleward of 40°S and decreasing it in the equatorward

Satellite

Model



- The simulated enhancement in the coccolithophores production coincides with the satellite observation of elevated calcite production

References

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