

Thoughts on Ocean Iron Fertilization

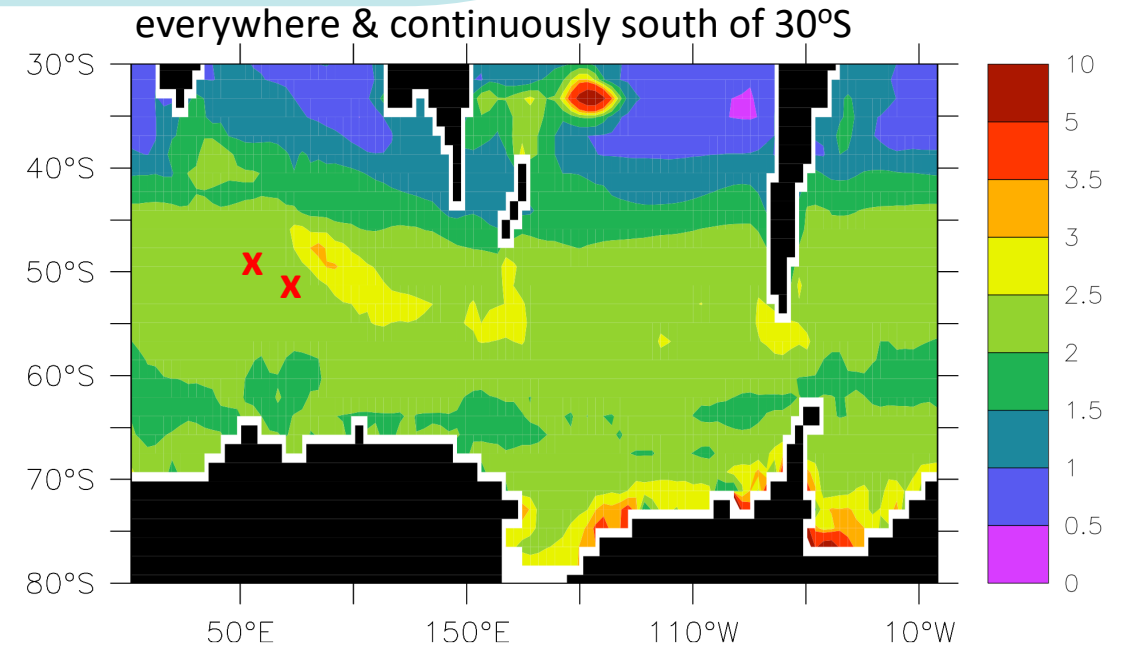
Issues related to non-local effects, oxygen and long timescales

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Thoughts on Ocean Iron Fertilization

Issues related to non-local effects, oxygen and long timescales

- Southern Ocean iron fertilization
- Natural analogue:
Kerguelen Plateau & Crozet Islands:
Export fluxes 2-3 times larger than in
adjacent non-fertilized regions
- Model experiments with phytoplankton
growth rate tuned (doubled) to achieve
2-3 times increase in export flux
- “Redfield” ocean, except for
denitrification & N₂ fixation



Ratio of POC export in 1st year of OIF simulation to control run.

Caveats:

- Don't account for effects other than phyto growth rate increase
- Don't model fate of Fe

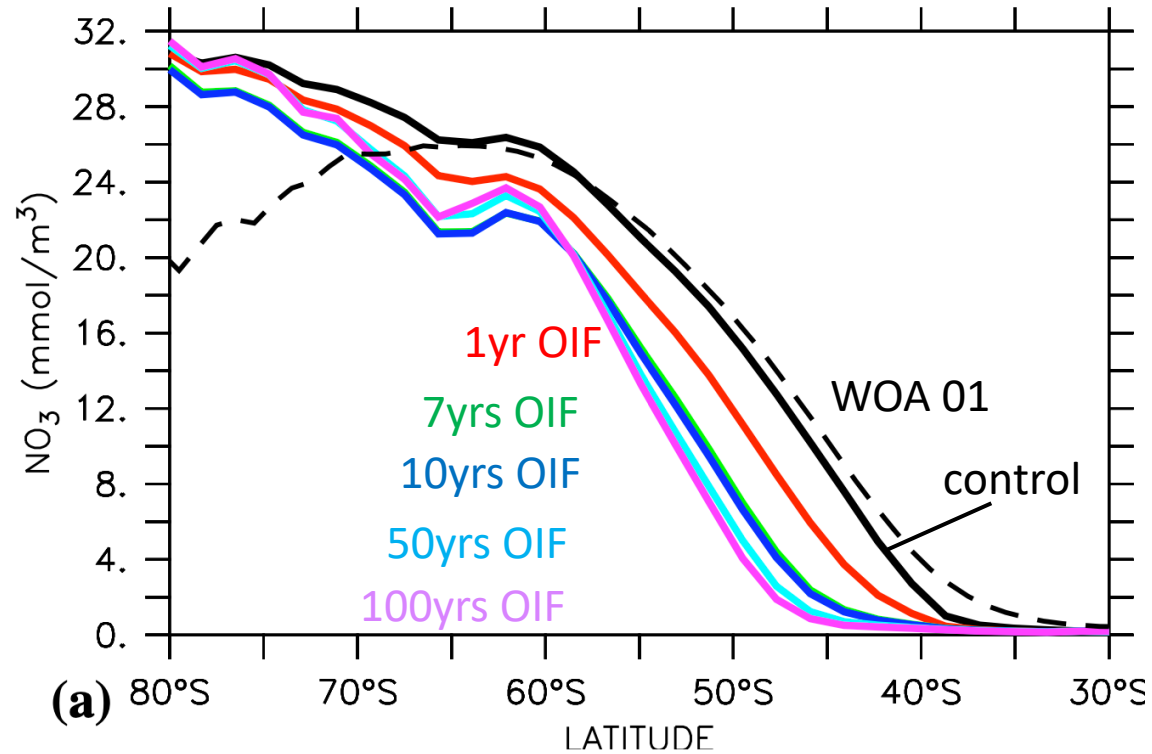
(Oschlies et al., Biogeosciences 2010)

Southern Ocean Iron Fertilization

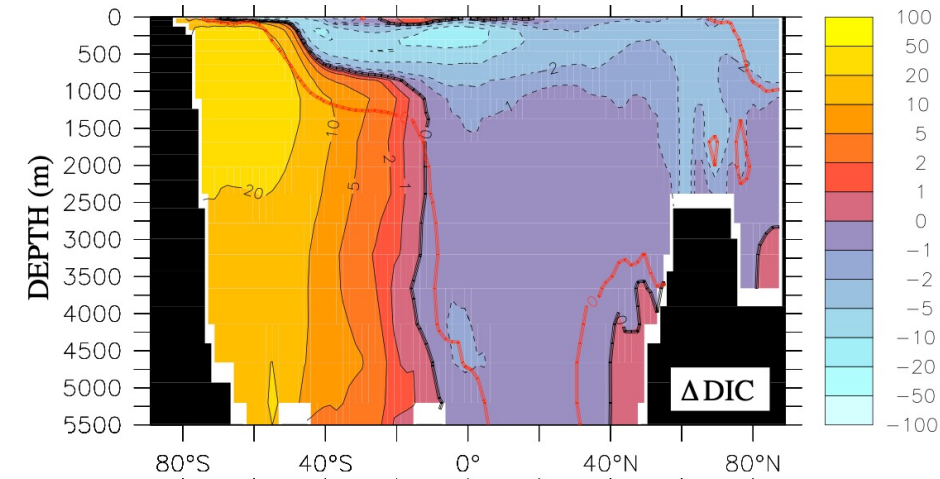
long-term effects on biogeochemistry

After 100 yrs OIF:
Impacts on global
biogeochemistry

Impacts on surface NO_3^-



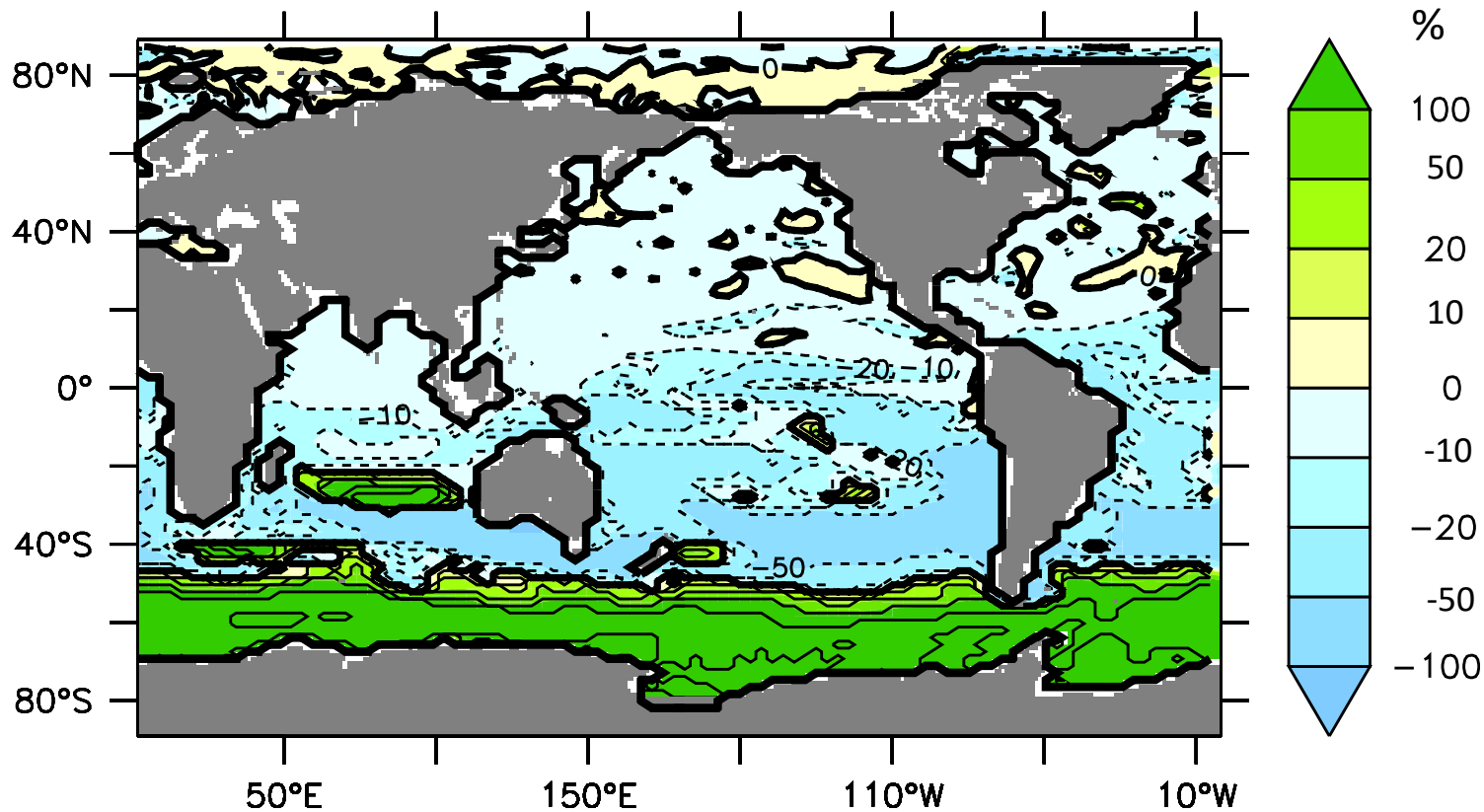
ocean acidification



Southern Ocean Iron Fertilization

nutrient robbing

- Global effects on **marine biological productivity**, after 100 yrs of OIF

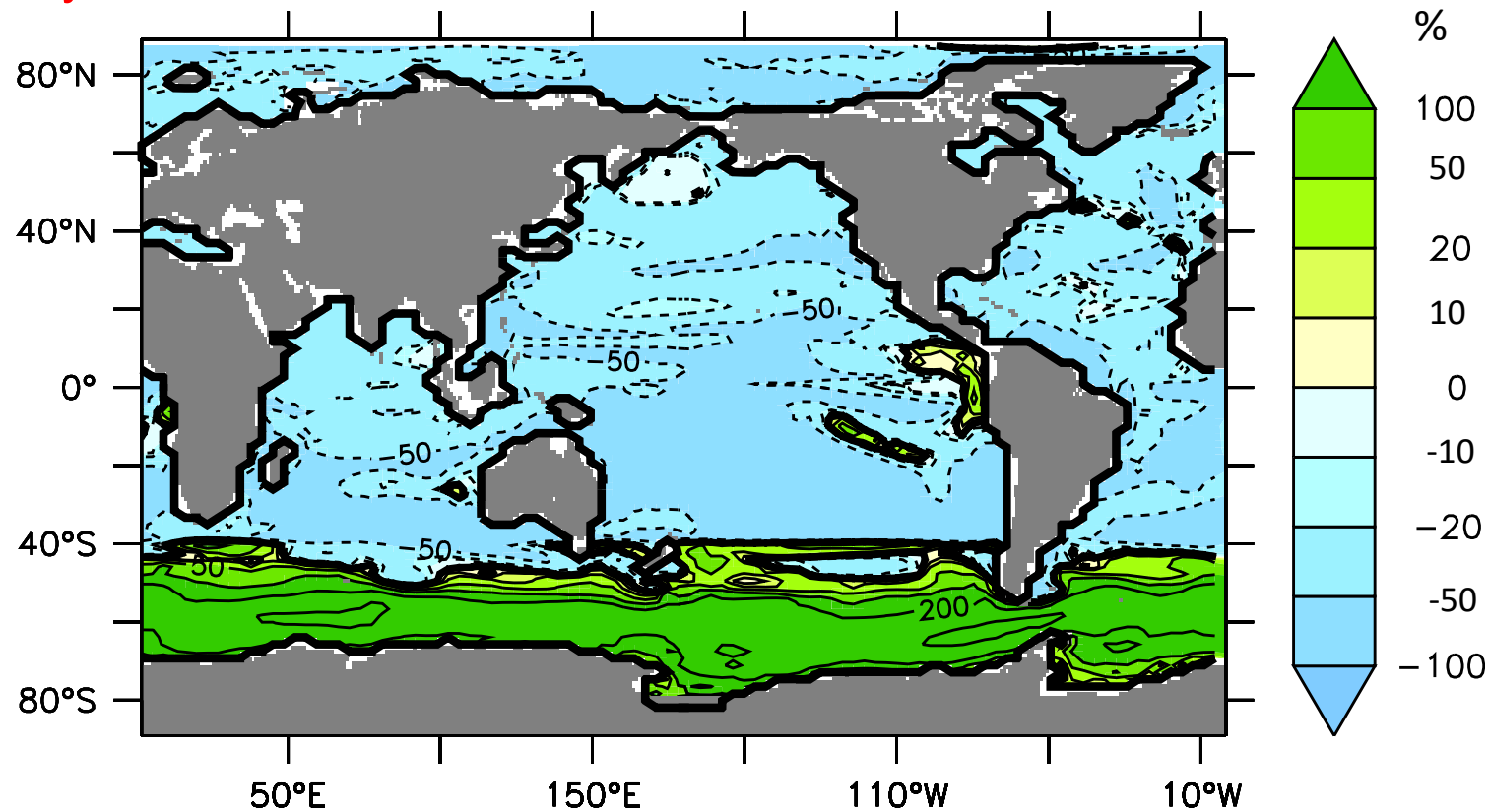


Result of nutrient robbing
~ 10-50% decline in NPP
over much of unfertilized
areas of SH

Southern Ocean Iron Fertilization

nutrient robbing

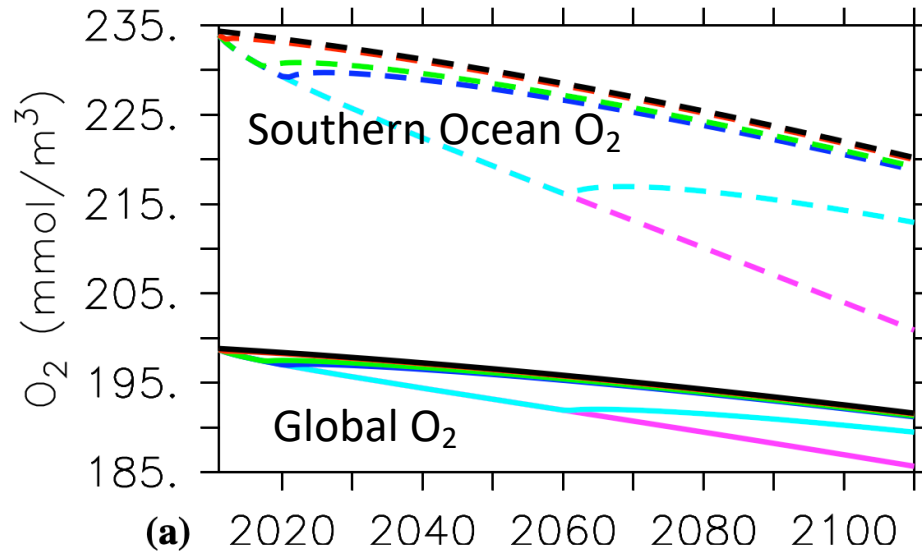
- Substantial reduction in biological productivity almost everywhere, after 1000yrs of OIF



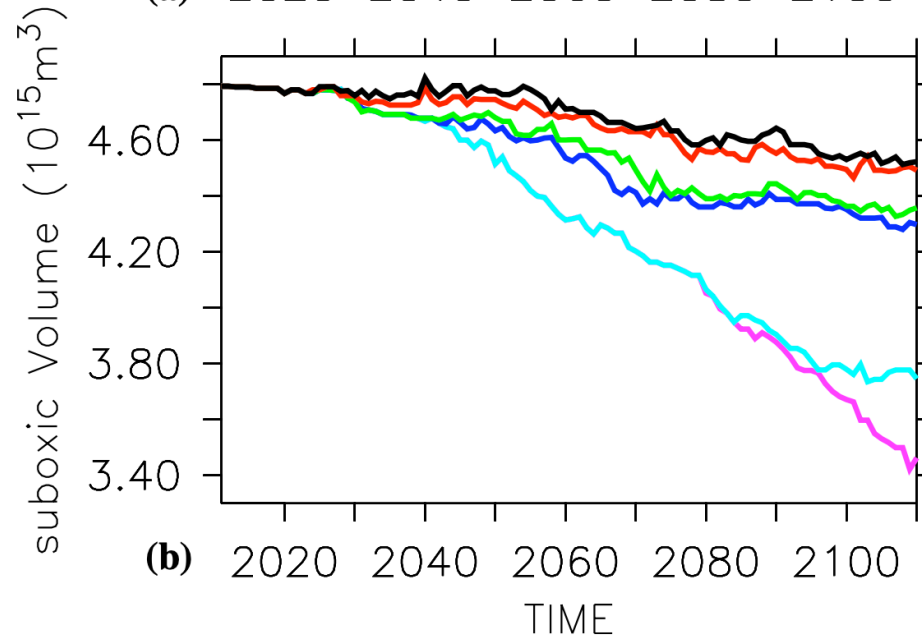
Effects of nutrient robbing
increase with time

Southern Ocean Iron Fertilization

impacts on O₂



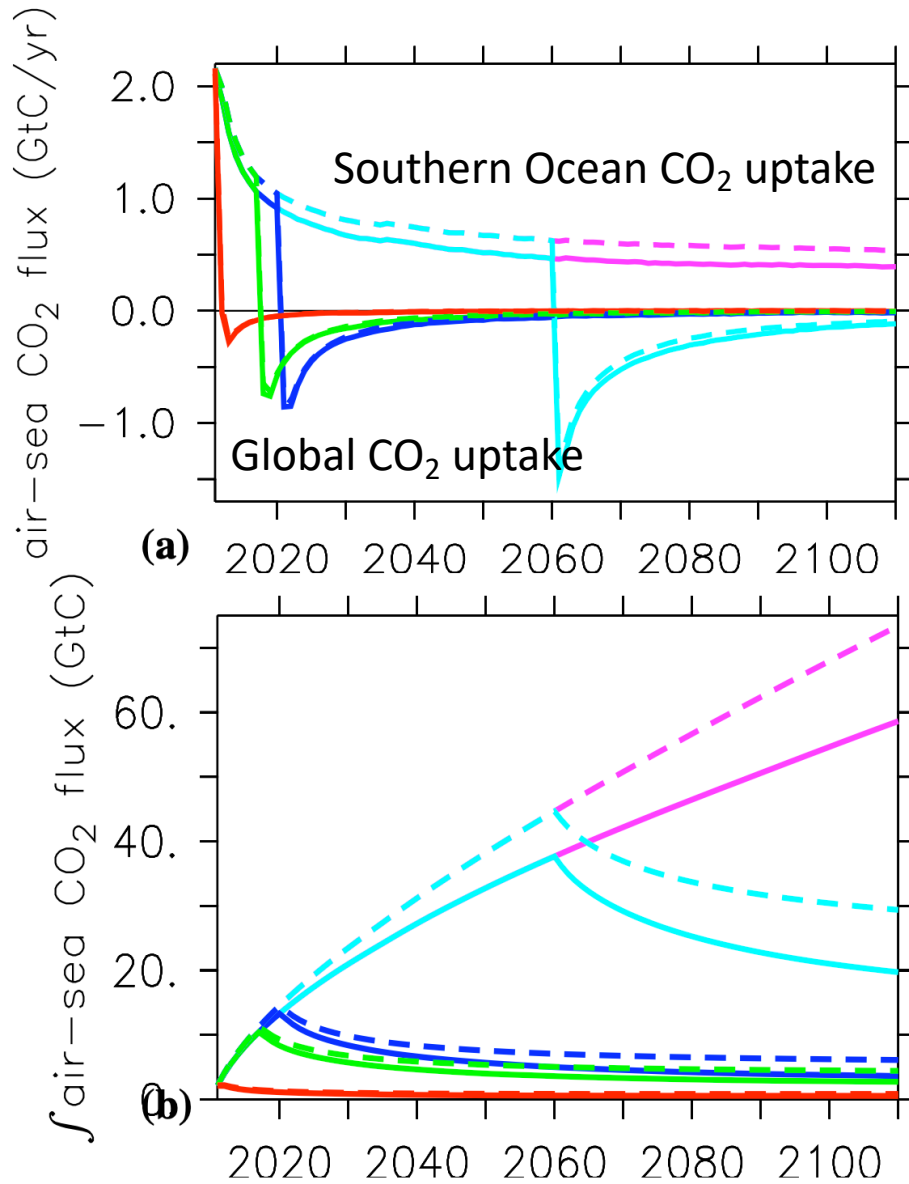
- Substantial **deoxygenation**, mostly in the Southern Ocean



- Volume of suboxic waters (< 5 μ M)
Tropical OMZs shrink!

Southern Ocean Iron Fertilization

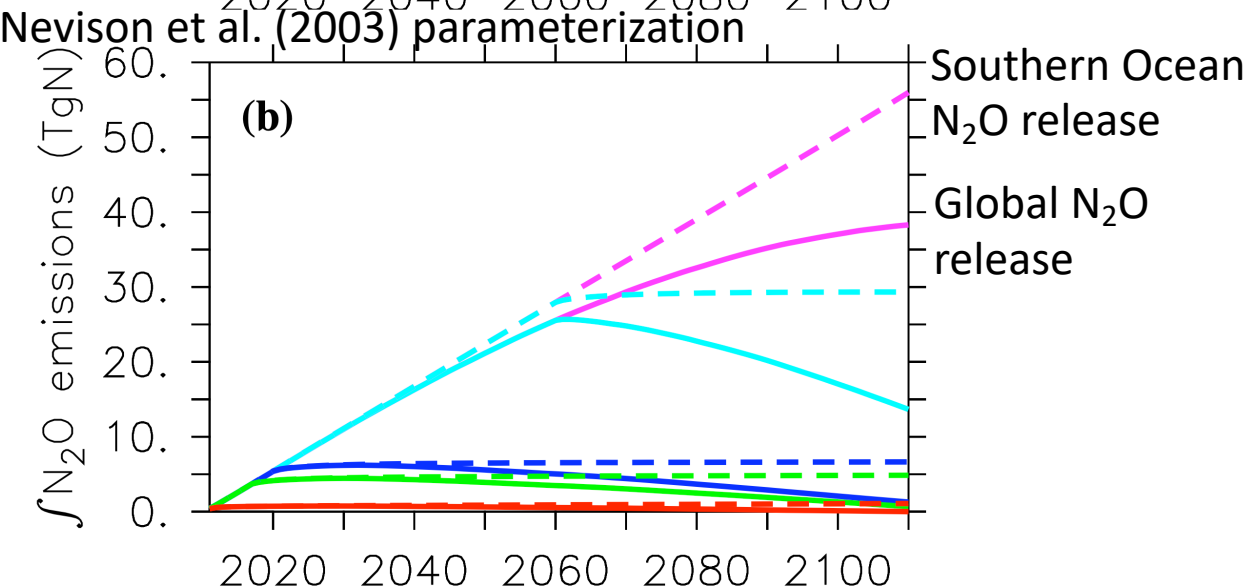
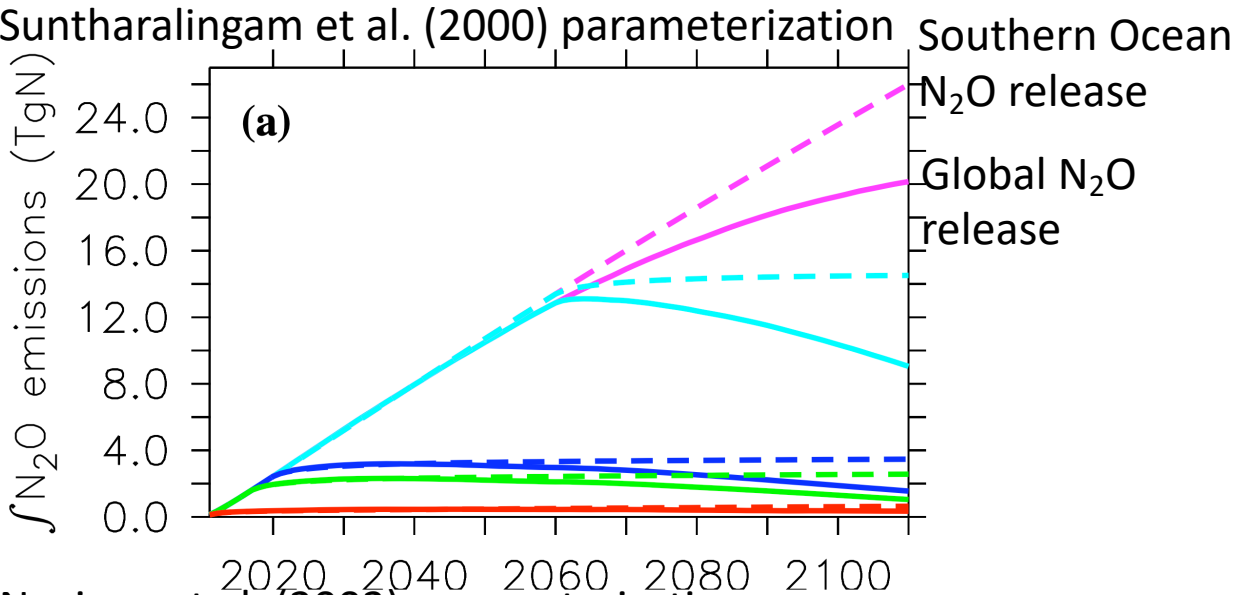
impacts on air-sea CO₂ fluxes



- CO₂ uptake decreases with time,
 - CO₂ release after termination of OIF
-
- Local CO₂ uptake partially compensated by reduced CO₂ uptake elsewhere (20% effect)
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- Upon termination of OIF, about half of initially sequestered CO₂ is released back to the atmosphere within decades

Southern Ocean Iron Fertilization

impact of marine N_2O emissions



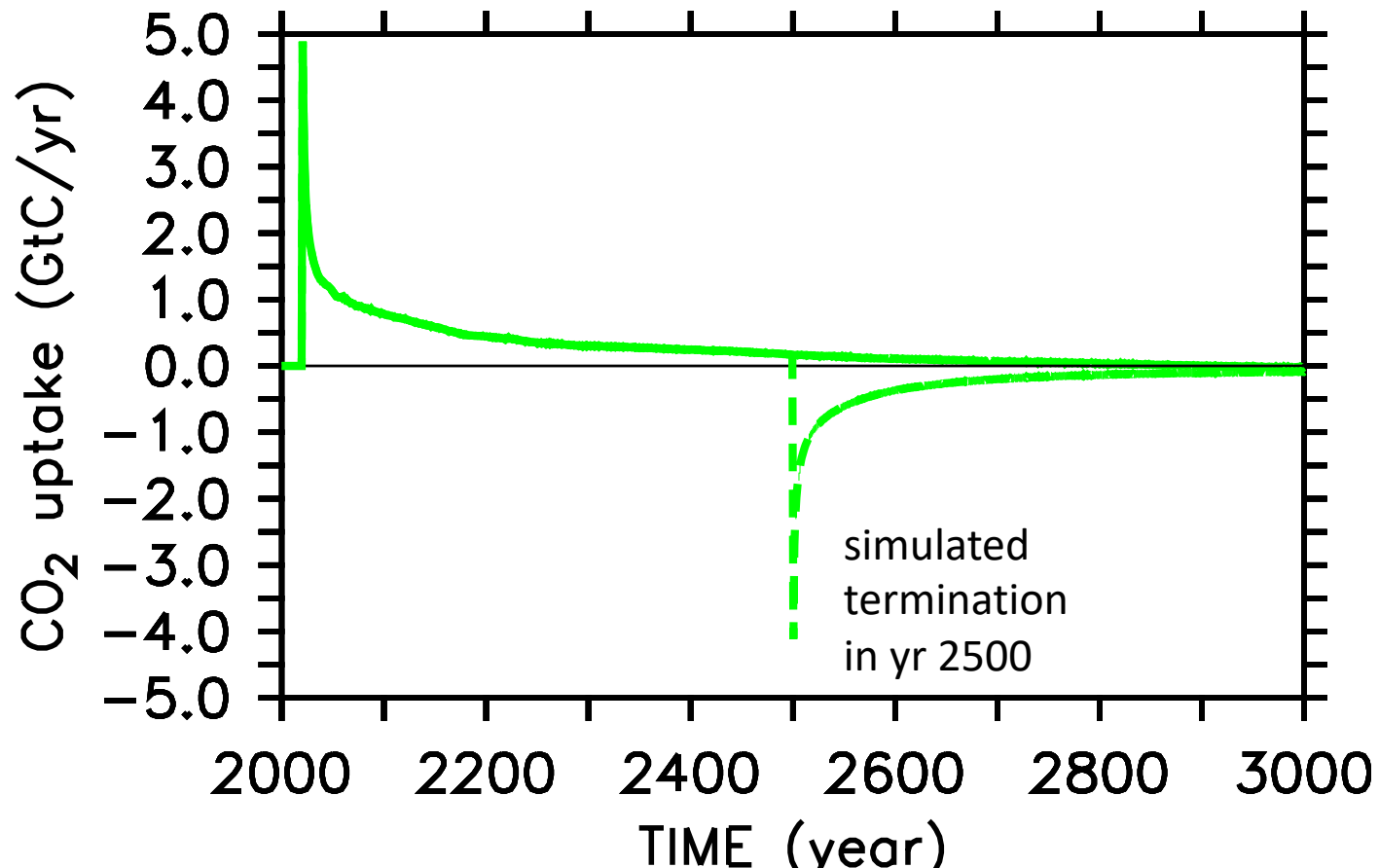
OIF-induced global N_2O emissions, according to model parameterizations:

- constant increase in Southern Ocean,
- increasing decline elsewhere (shrinking OMZs)
- offset 5-9% of OIF-induced CO_2 uptake

Southern Ocean Iron Fertilization

"Termination effects"

- Eventual saturation of OIF-induced marine carbon sink



OIF becomes less effective with time

More and more OIF is needed to compensate leakage of OIF-induced respired carbon.

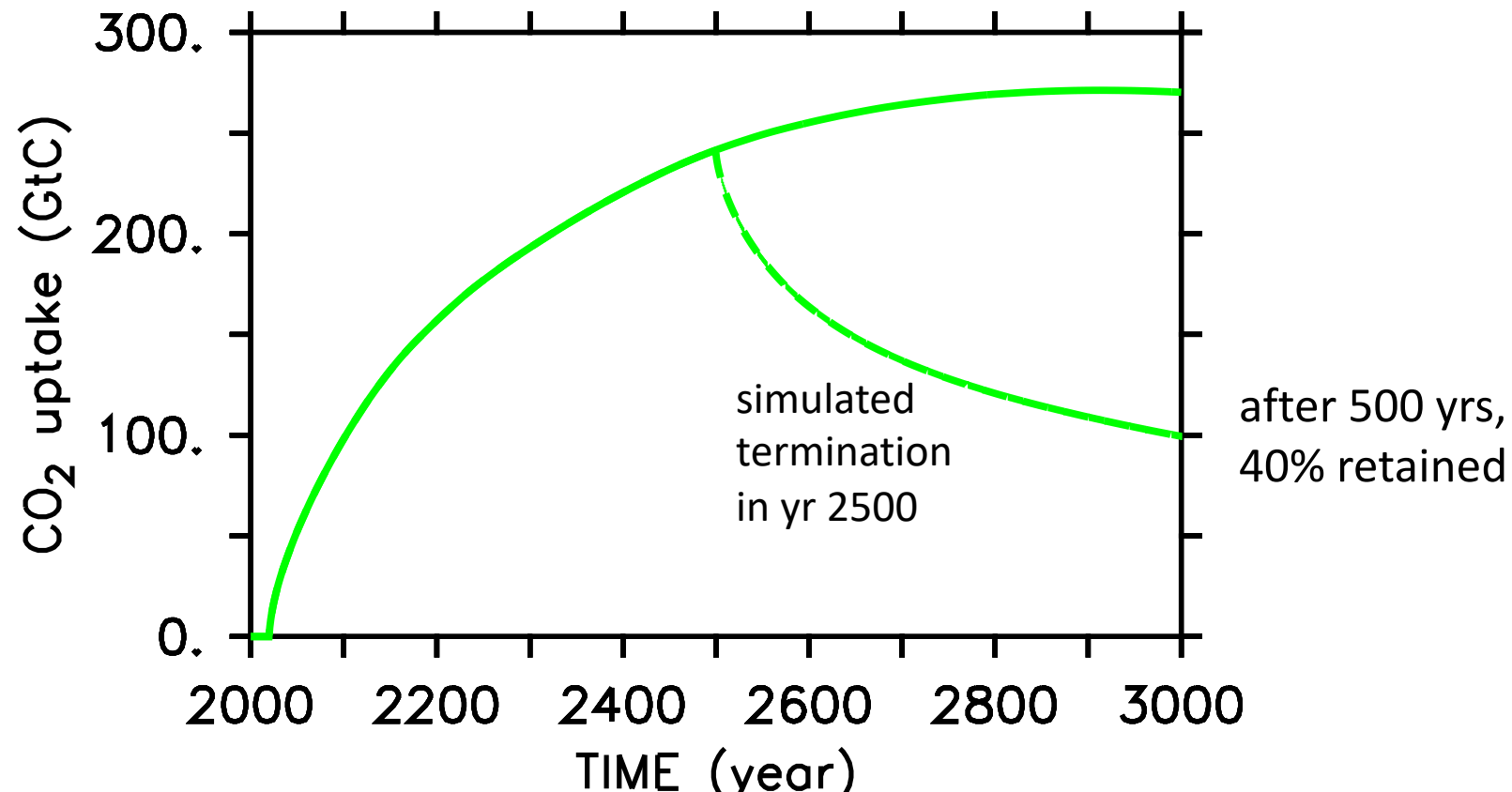
"Termination effect" of OIF!

Southern Ocean Iron Fertilization

“Termination effects”

- Eventual saturation of OIF-induced marine carbon sink

- substantial long-term leakage



Conclusions

- > According to simple Redfield models, Southern Ocean OIF can sequester GtC/yr for centuries
- > About half of initially sequestered C will escape to the atmosphere upon termination of OIF, within decades.
- > Long-term remote effects: nutrient robbing, ocean deoxygenation, ocean acidification (more severe at depth, less severe in surface ocean).
- > Fine-tuning of deployment areas may increase storage efficiency and permanence & reduce some side effects