



Supplement of

Irreversible phytoplankton community shifts over Subpolar North Atlantic in response to CO₂ forcing

Dong-Geon Lee et al.

Correspondence to: Jong-Seong Kug (jskug@snu.ac.kr)

The copyright of individual parts of the supplement might differ from the article licence.

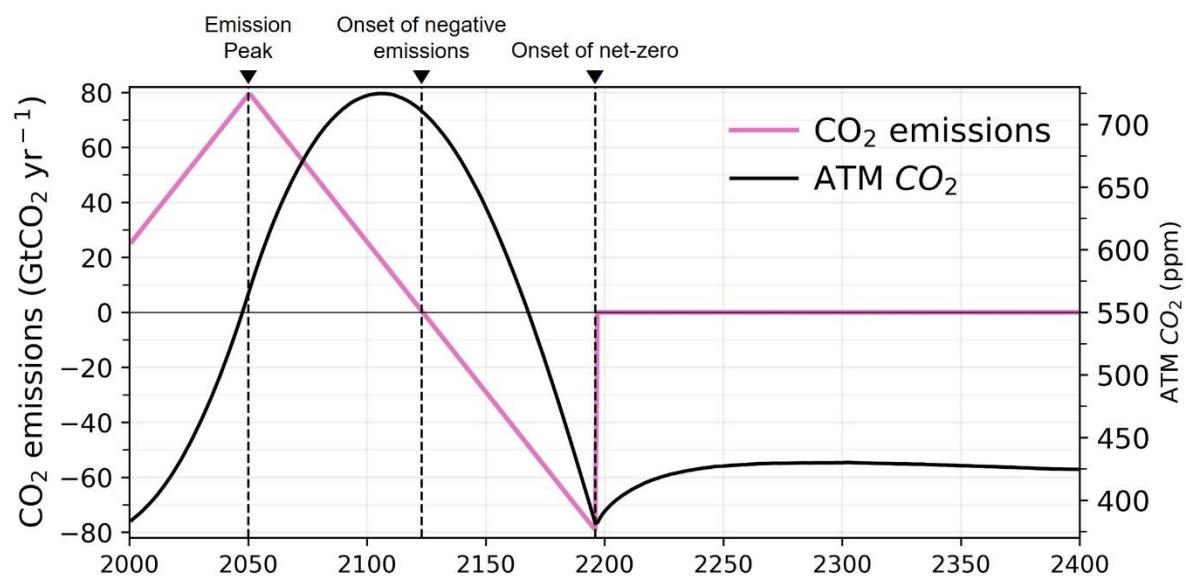


Figure S1. Time series of annual anthropogenic CO₂ emissions (pink), and annual mean atmospheric CO₂ concentration (black). The peak of anthropogenic emissions, the onset of negative emissions and net-zero are indicated by the black dashed vertical line.

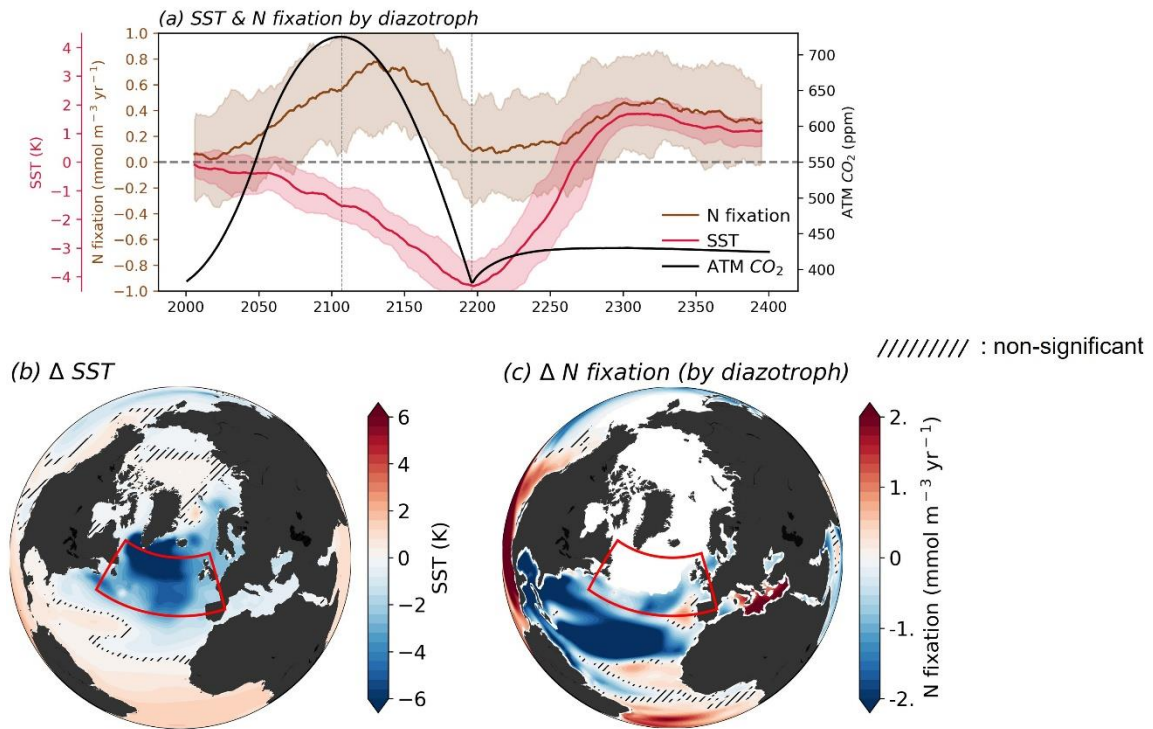


Figure S2. a, Time series of Sea Surface Temperature (SST; red plot) and Nitrogen (N; brown plot) fixation by diazotrophs. All plots are drawn in 11-year moving averages. Shading indicates the range of minimum-maximum values between ensembles. Differences in **b**, SST and **c**, N fixation between CO₂ down and climatology periods. Red boxes indicate the Subpolar North Atlantic (SPNA) region, which is the research area in this study.

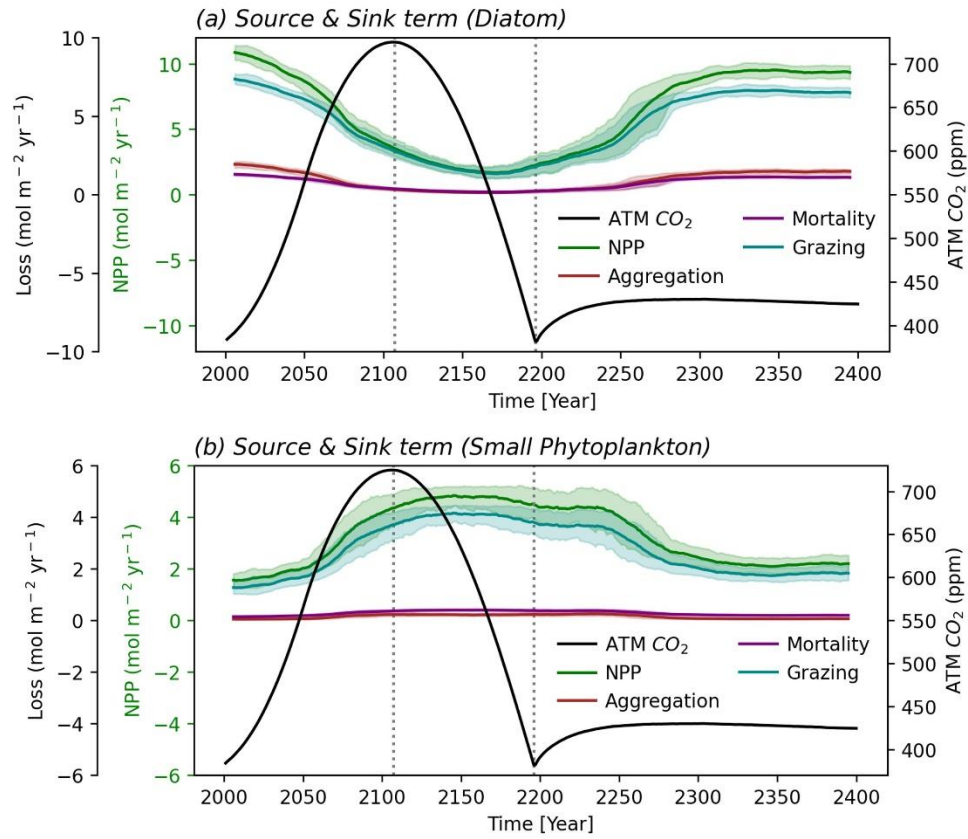
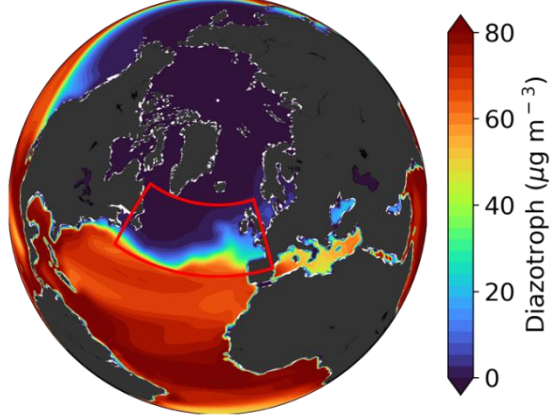


Figure S3. Source and sink terms for both **a**, diatoms and **b**, small phytoplankton in the SPNA region.

(a) *Diazotroph*



(b) *N fixation by diazotroph*

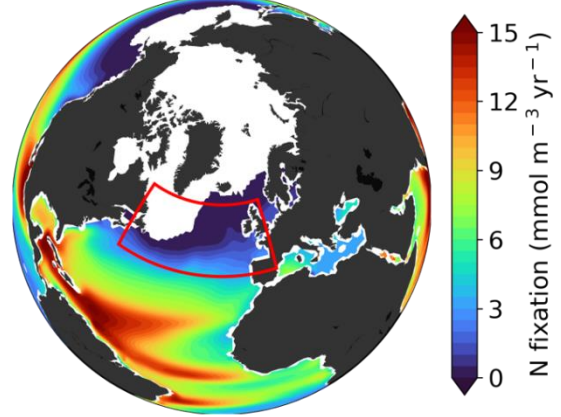


Figure S4. **a**, Diazotroph concentration and **b**, N fixation by diazotrophs during the climatology period.

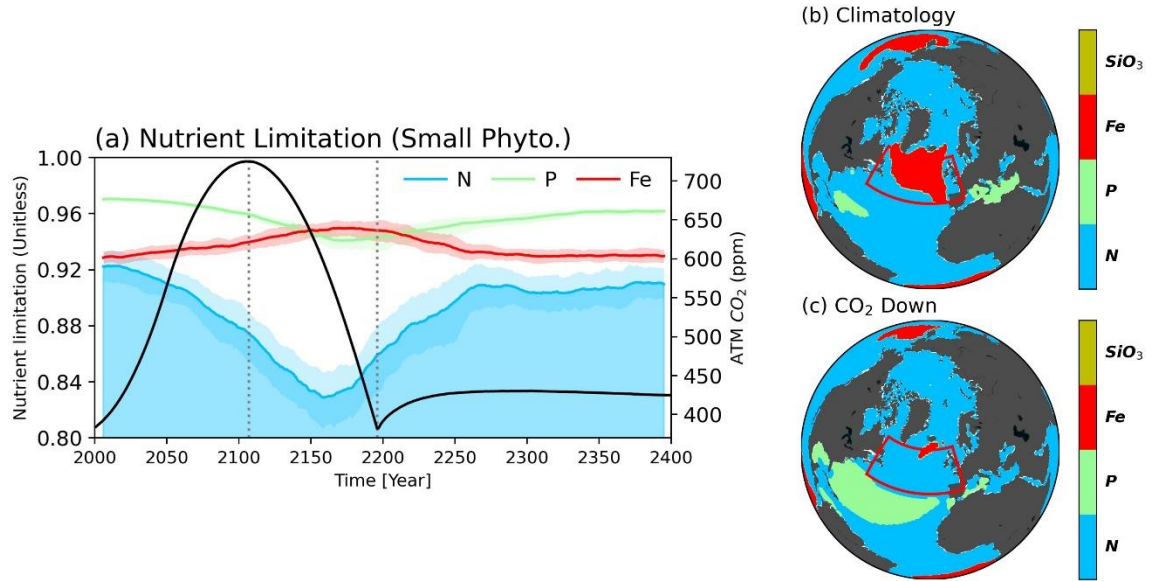


Figure S5. a, Nutrient limitation of small phytoplankton for three nutrients (N; sky-blue, Phosphorus (P); light-green, Iron (Fe); red). All plots are drawn in 11-year moving averages and shading indicates the range of minimum-maximum values between ensembles. **b-c**, Nutrient limitation distribution of small phytoplankton during both climatology and CO₂ down period.

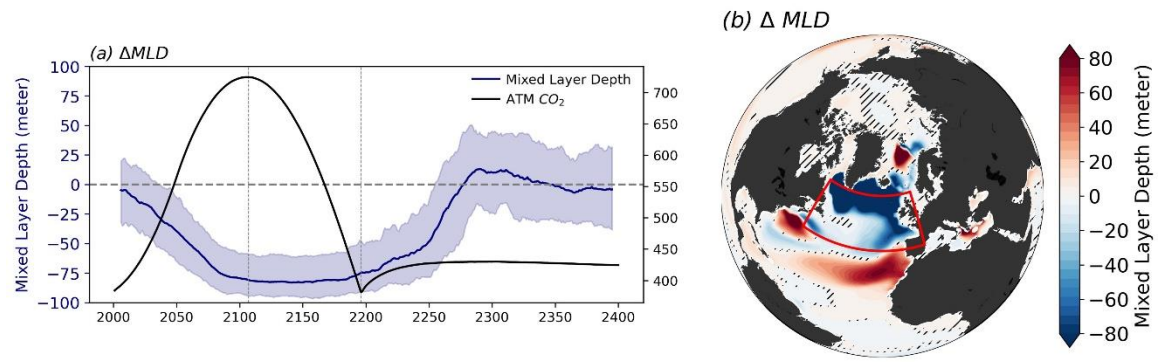


Figure S6. a, Time series of changes in Mixed Layer Depth (MLD) in the SPNA region compared to initial level (2001-year) and the **b,** difference in MLD between CO_2 down and climatology periods.

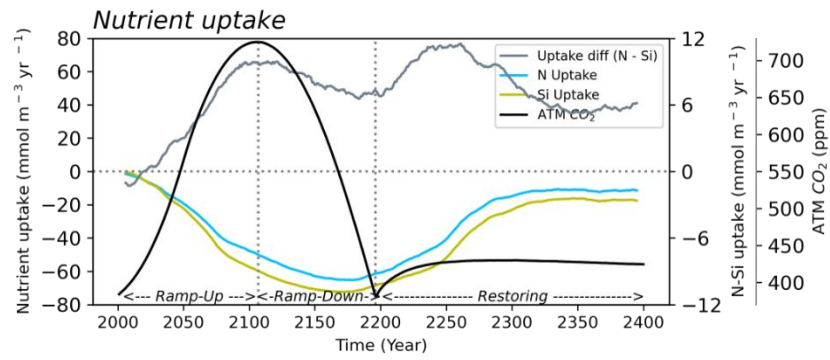


Figure S7. Time series of the changes in the magnitude of nutrient uptake of Silicate (Si; dark-khaki) and N (sky-blue) compared to initial level (2001-year). The gray color indicates the changes in difference between N uptake and Si uptake compared to the initial level (2001-year).

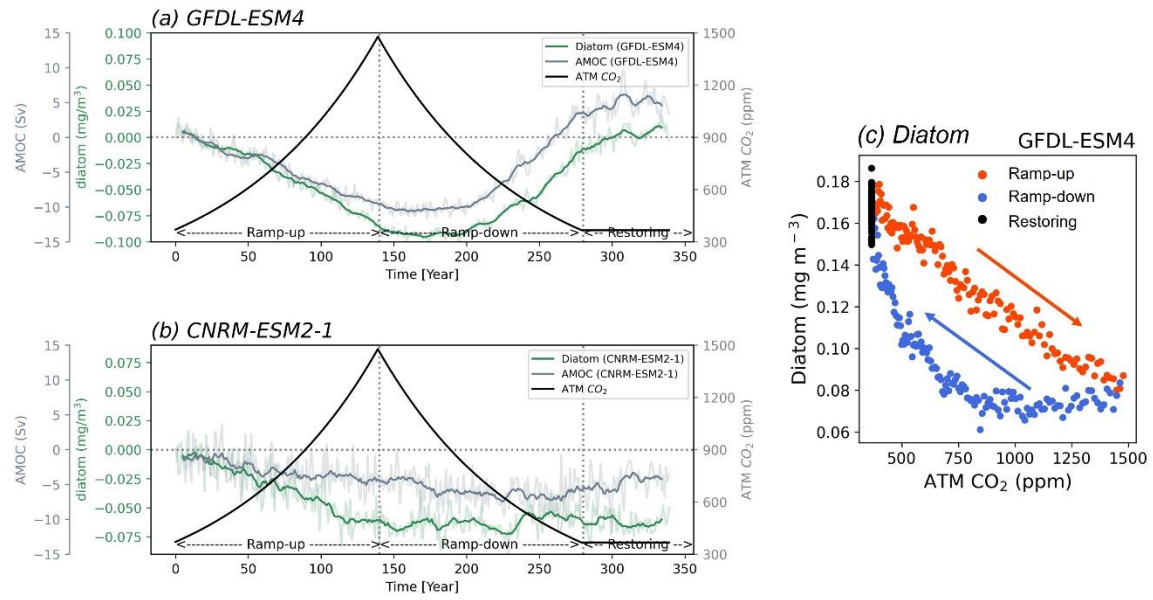


Figure S8. Time series of changes in the AMOC strength and surface diatom concentrations compared to the initial level for two Earth System Models (ESMs); **a**, GFDL-ESM4 and **b**, CNRM-ESM2-1. Light gray color indicates the AMOC strength for both ESMs. Light green colors indicate the surface diatom concentrations for both ESMs. The thick colored plots are plotted in 11-year moving averages. **c**, Changes in SPNA area-averaged diatom concentrations (y-axis) corresponding to global mean atmospheric CO₂ concentration (x-axis) in the GFDL-ESM4. The colors in scatters indicate the 3 periods (CO₂ Ramp-up period; orange, CO₂ Ramp-down period; blue, Restoring; black).