1 Supplementary figures

1.1 Nutrient flux distributions

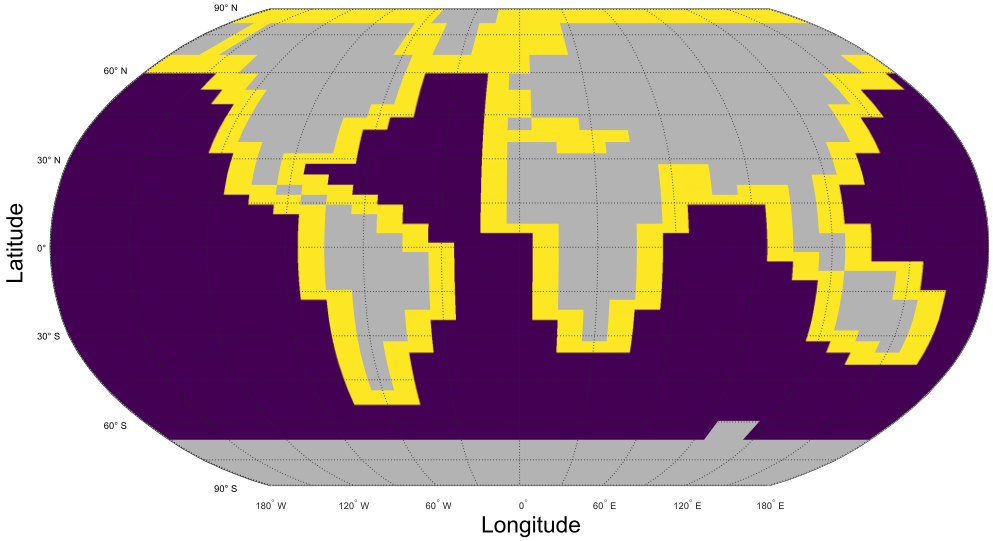


Figure S1 Spatial distribution of surface nutrient input fluxes. This spatial distribution is applied to riverine phosphate (RP) and riverine nitrate (RN). Those cells adjacent to land (excluding Antarctica) and coloured yellow receive the input flux; all other cells, coloured dark blue, do not receive the input flux. The total input flux is distributed evenly to those cells (coloured yellow) that receive it.

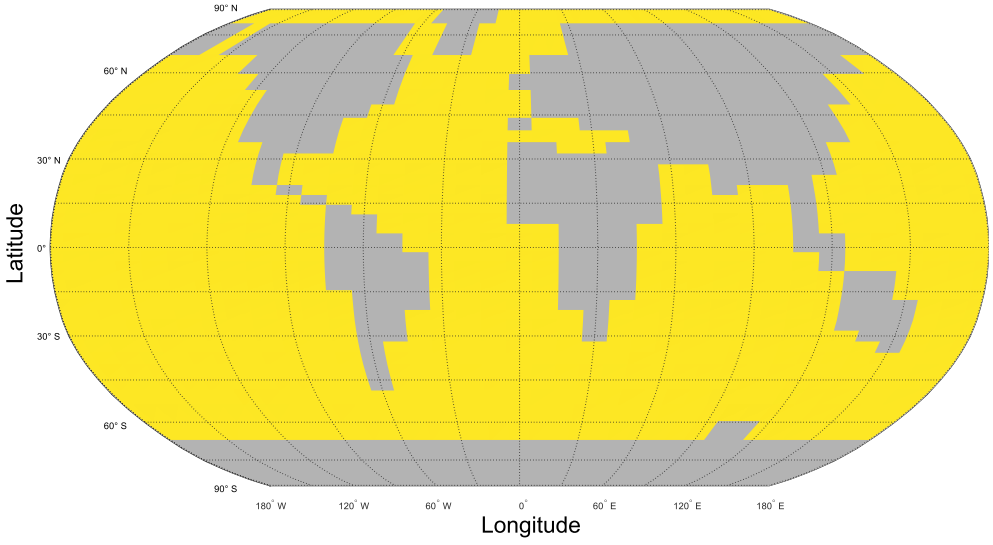


Figure S2 Spatial distribution of seafloor nutrient input flux. This spatial distribution is applied to benthic (seafloor) iron (BFe). All cells immediately above the seafloor receive the input flux. The total input flux is distributed evenly to those cells (coloured yellow) that receive it.

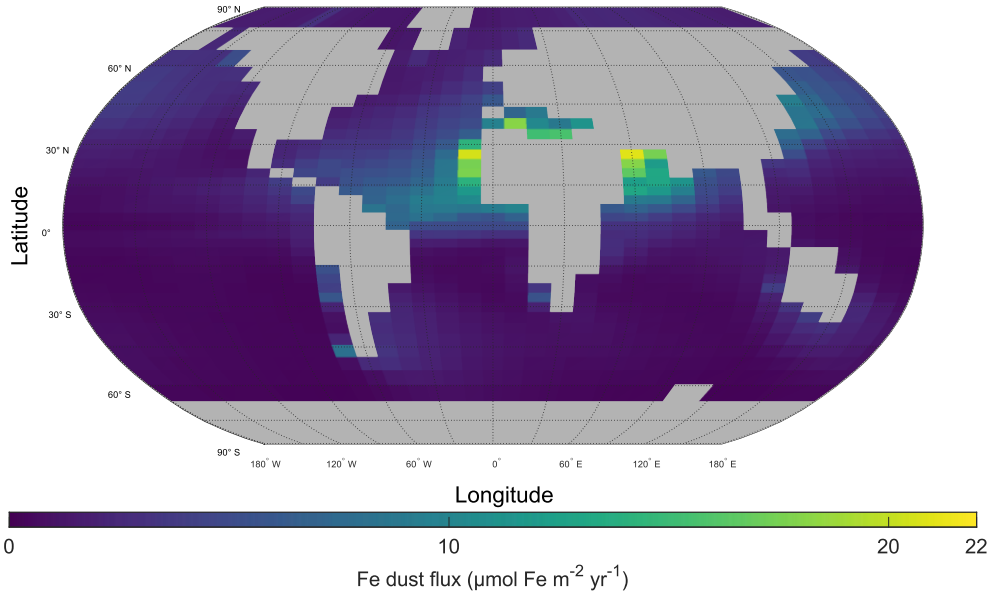


Figure S3 Spatial distribution of surface dust input flux of iron. This spatial distribution is applied to dust iron (DDFe). All cells at the surface receive the input flux, but in greatly varying degrees according to the colour shown (distribution based on a re-gridding from Mahowald et al. (2006)). The implementation in NutGEnIE is as described in Matsumoto et al. (2013) The total input flux is distributed unevenly across the ocean surface, with little or none going to those cells coloured dark blue and large amounts to those coloured yellow.

1.2 Age of water.

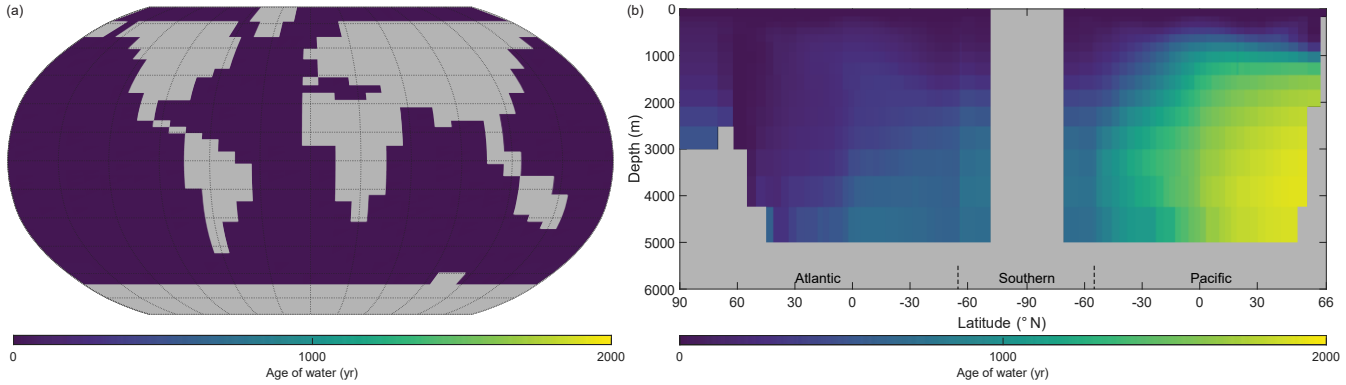


Figure S4 Annual mean age of water (years since ventilation). (a) NutGEnIE surface, as surface layer is in contact with atmosphere age is zero for all cells. (b) NutGEnIE thermohaline transect zonal mean.

1.3 Spin up experiment end state.

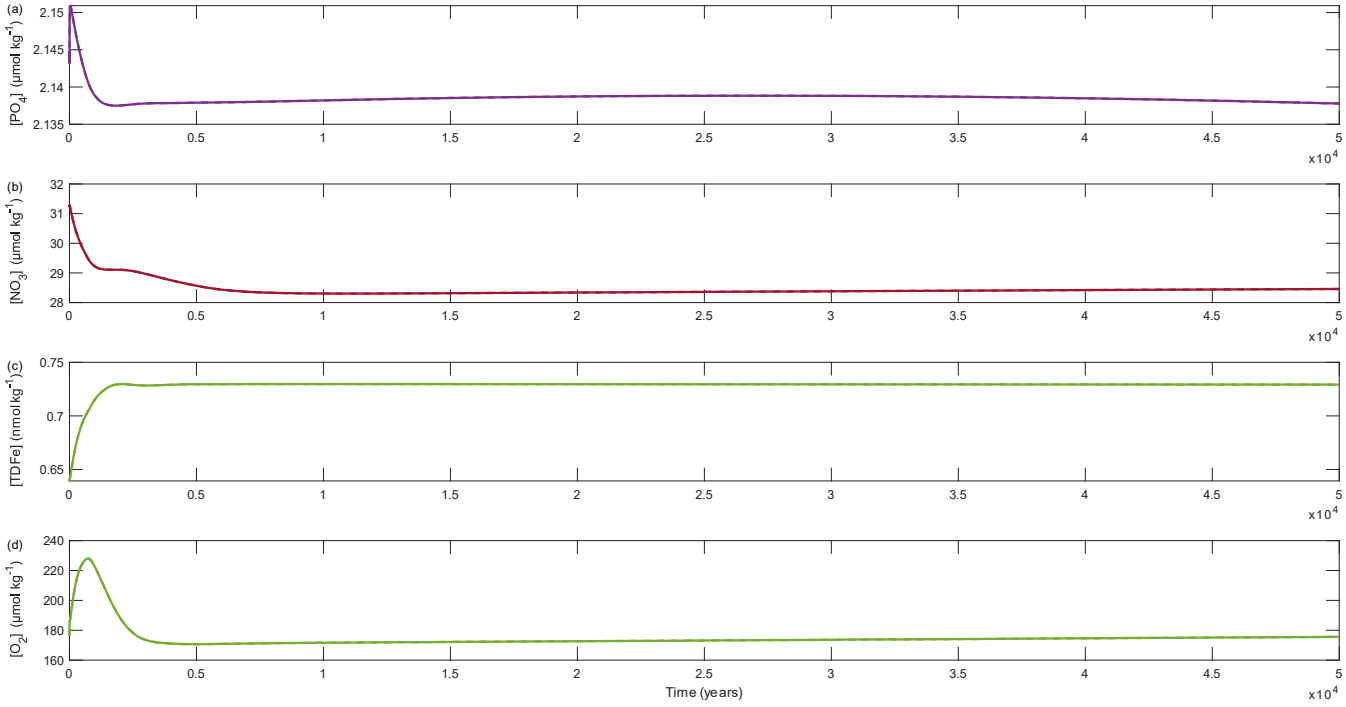


Figure S5 Concentrations of nutrients and dissolved oxygen during 50 kyr NutGEnIE spin up experiment. (a) global mean $[PO_4]$ μmol kg^{-1}. (b) global mean $[NO_3]$ μmol kg^{-1}. (c) global mean [TDFe] nmol kg^{-1}. (d) global mean $[O_2]$ μmol kg^{-1}.

1.4 Iron depth profiles.

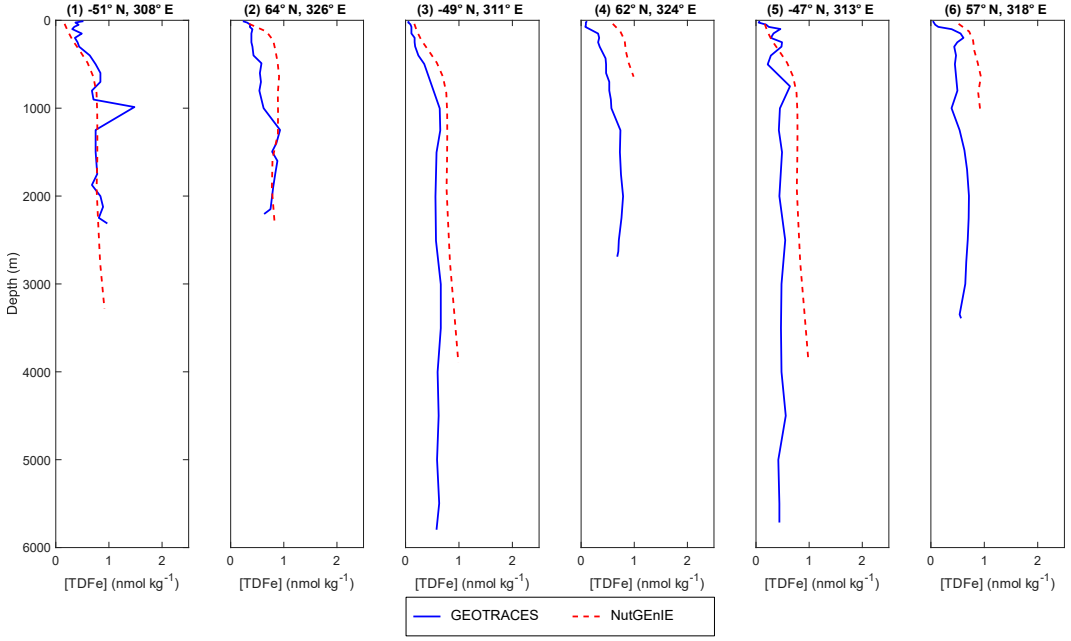


Figure S6 Iron depth profiles for GEOTRACES cruise GA02 1 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

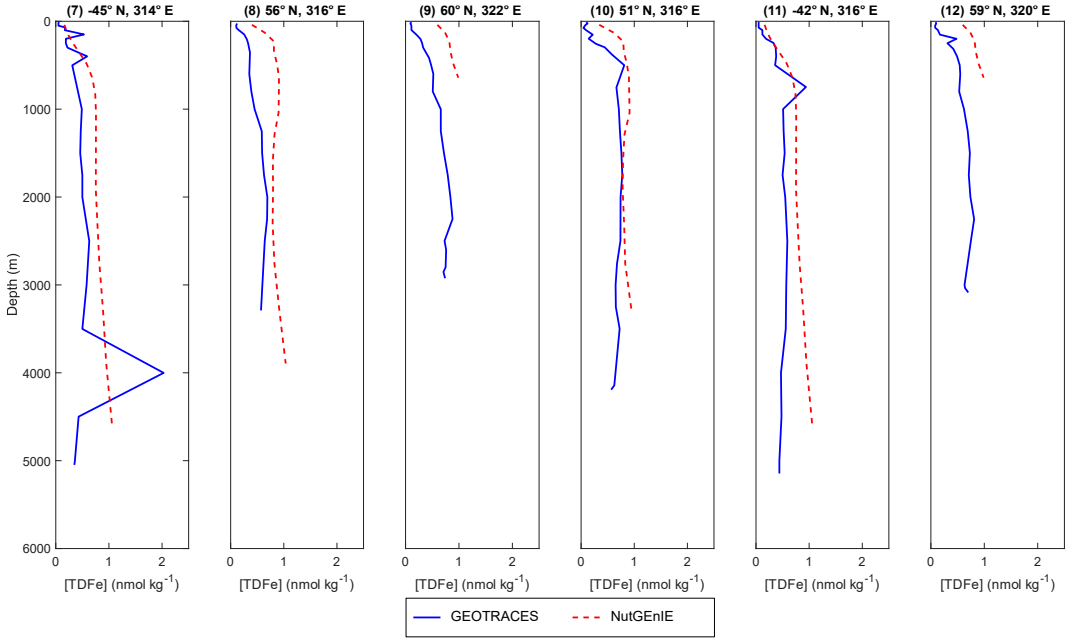


Figure S7 Iron depth profiles for GEOTRACES cruise GA02 2 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

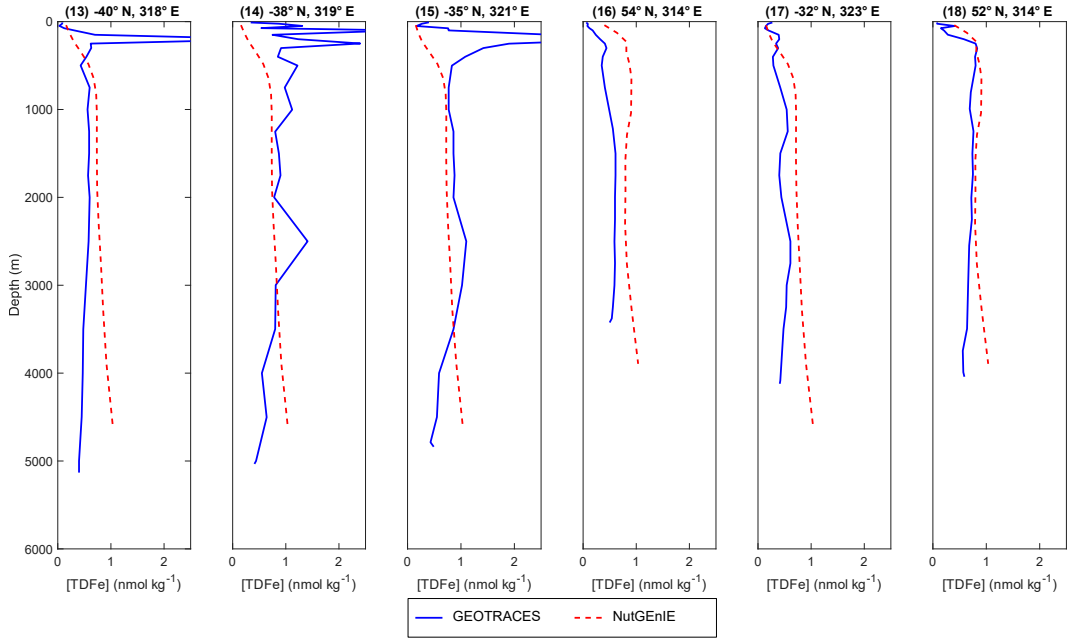


Figure S8 Iron depth profiles for GEOTRACES cruise GA02 3 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

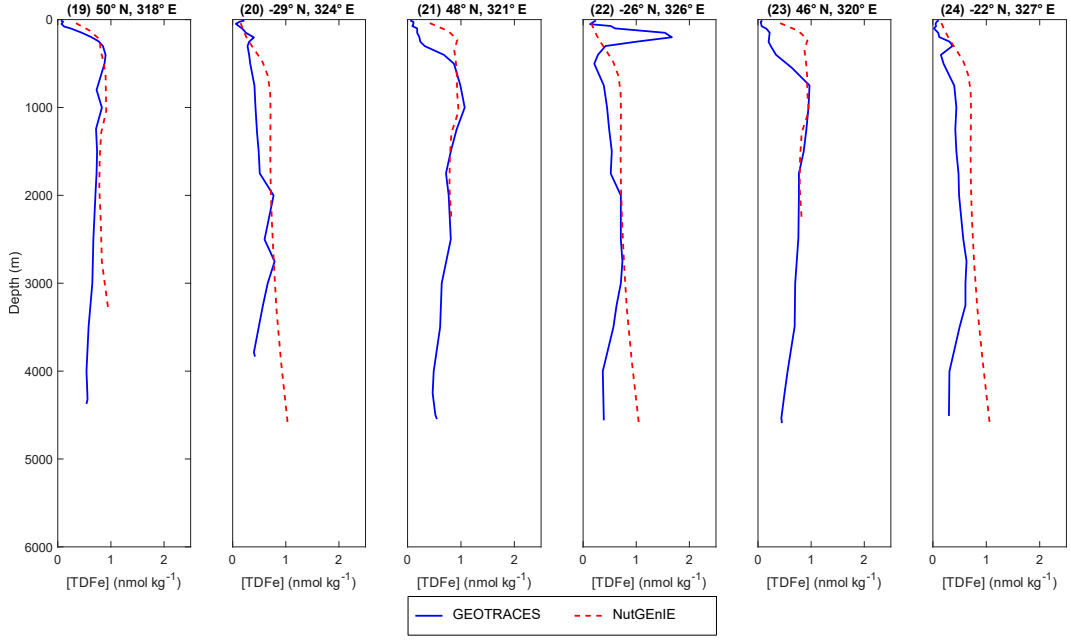


Figure S9 Iron depth profiles for GEOTRACES cruise GA02 4 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnI [TDFe].

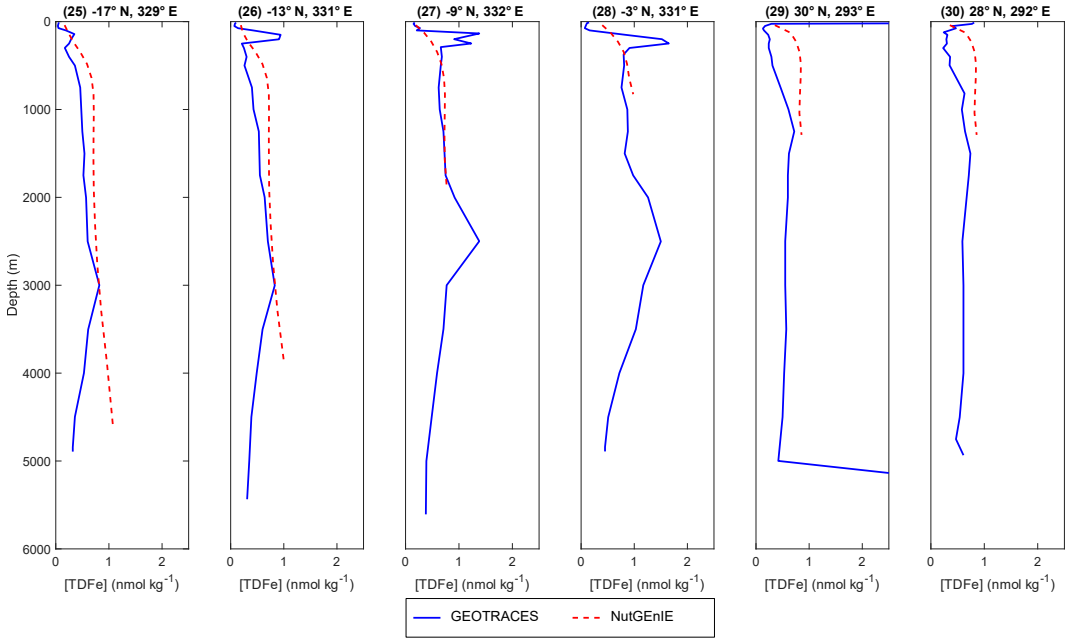


Figure S10 Iron depth profiles for GEOTRACES cruise GA02 5 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

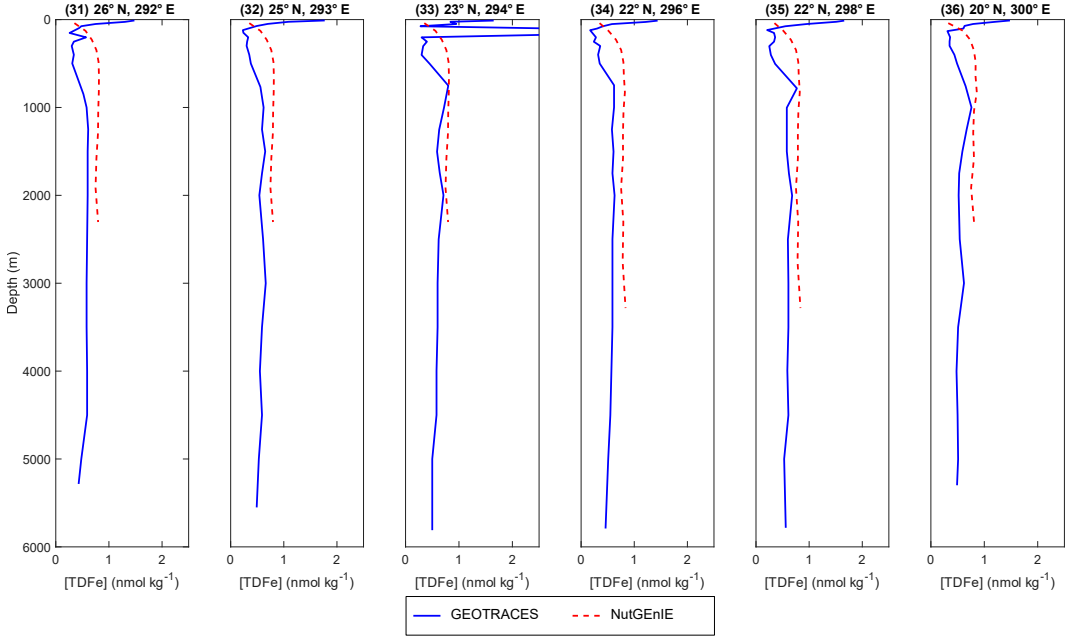


Figure S11 Iron depth profiles for GEOTRACES cruise GA02 6 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

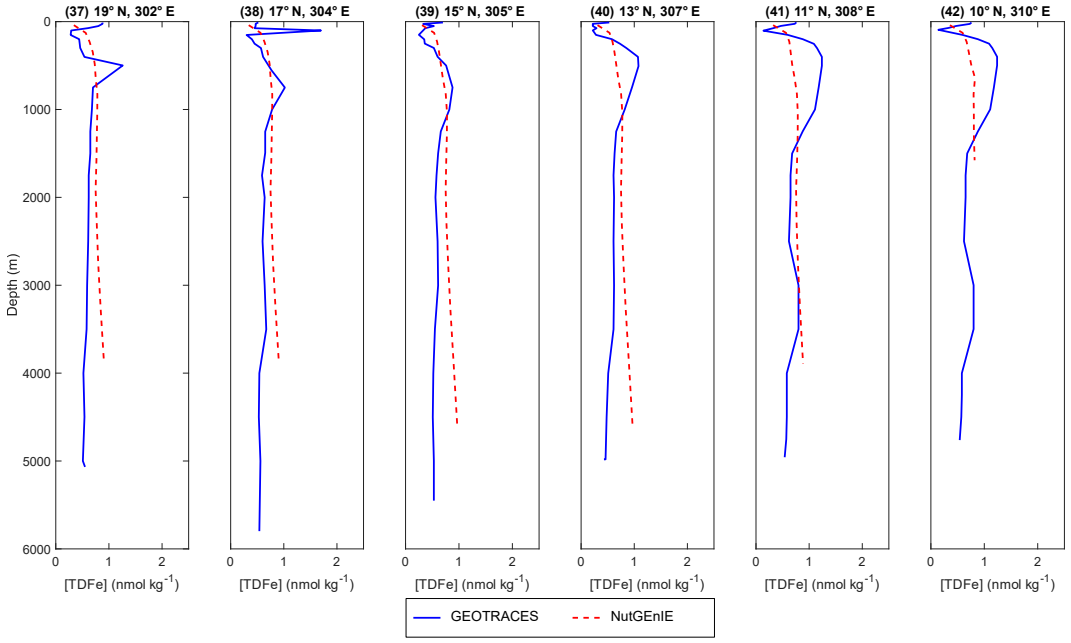


Figure S12 Iron depth profiles for GEOTRACES cruise GA02 7 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

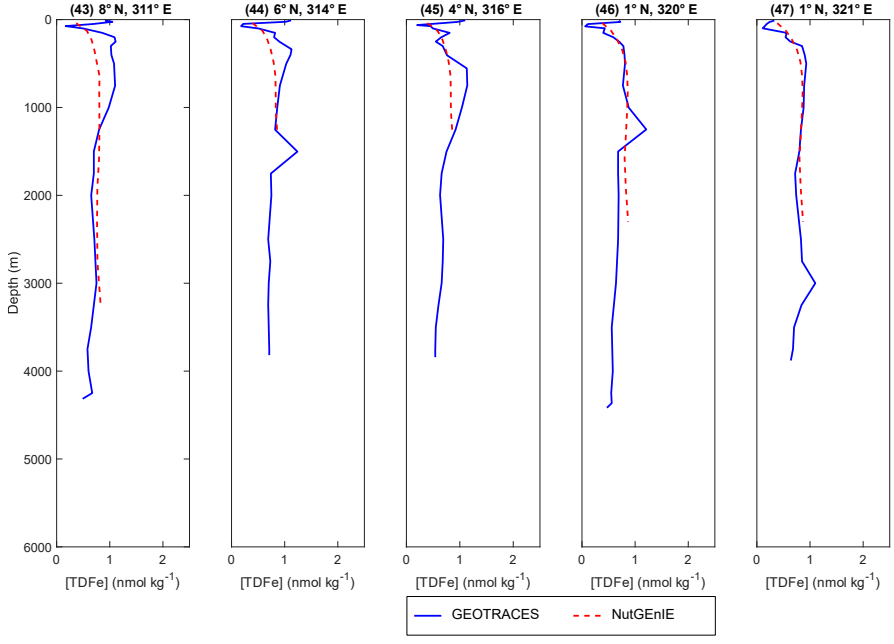


Figure S13 Iron depth profiles for GEOTRACES cruise GA02 8 of 8. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

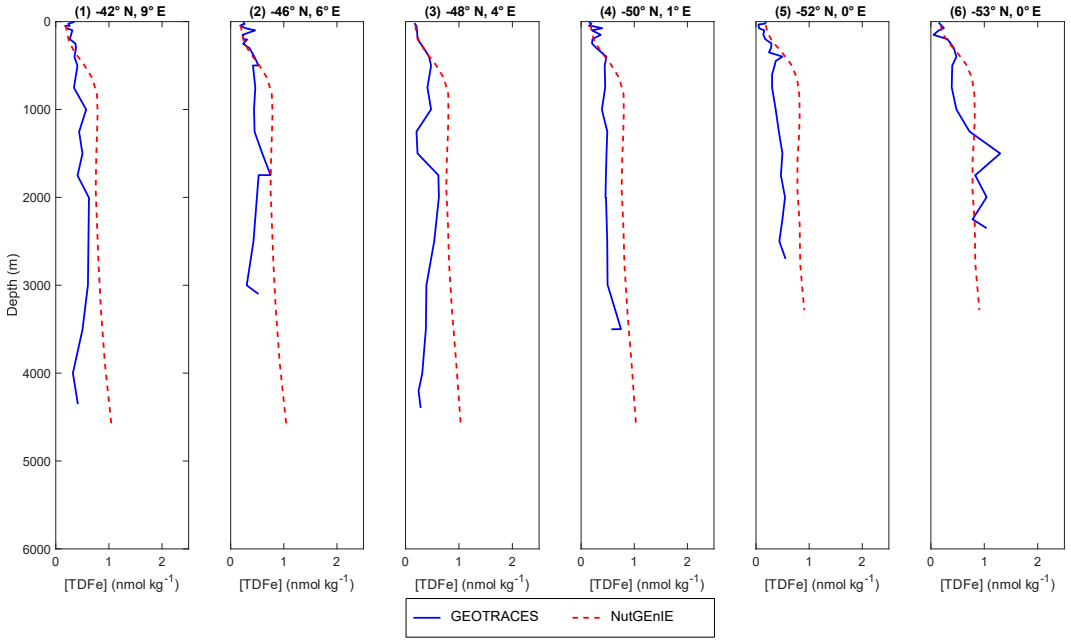


Figure S14 Iron depth profiles for GEOTRACES cruise GIPY05 1 of 6. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

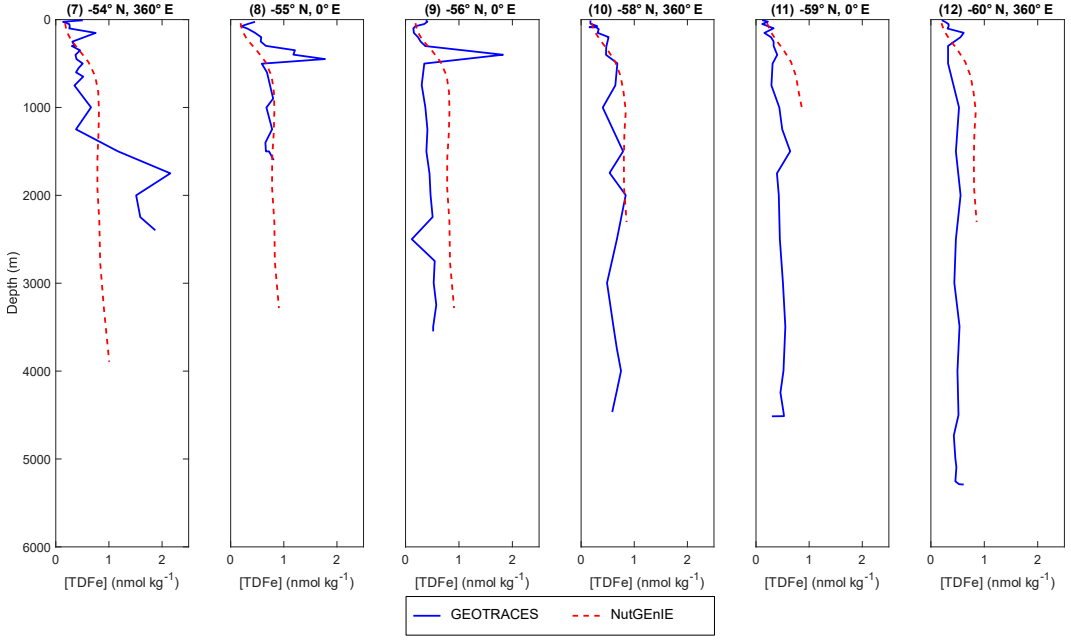


Figure S15 Iron depth profiles for GEOTRACES cruise GIPY05 2 of 6. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

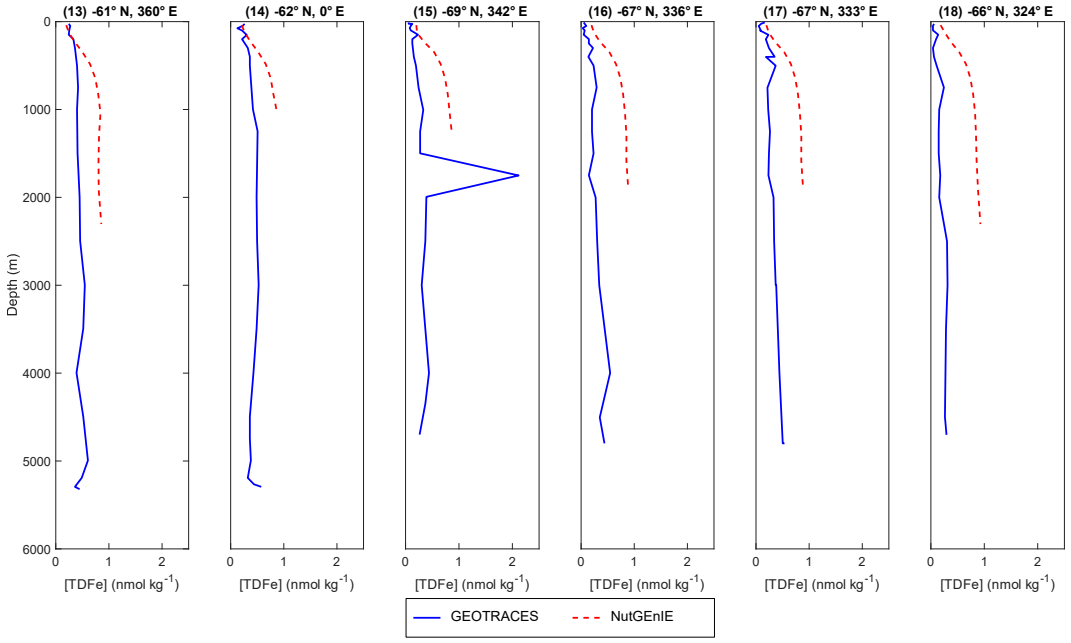
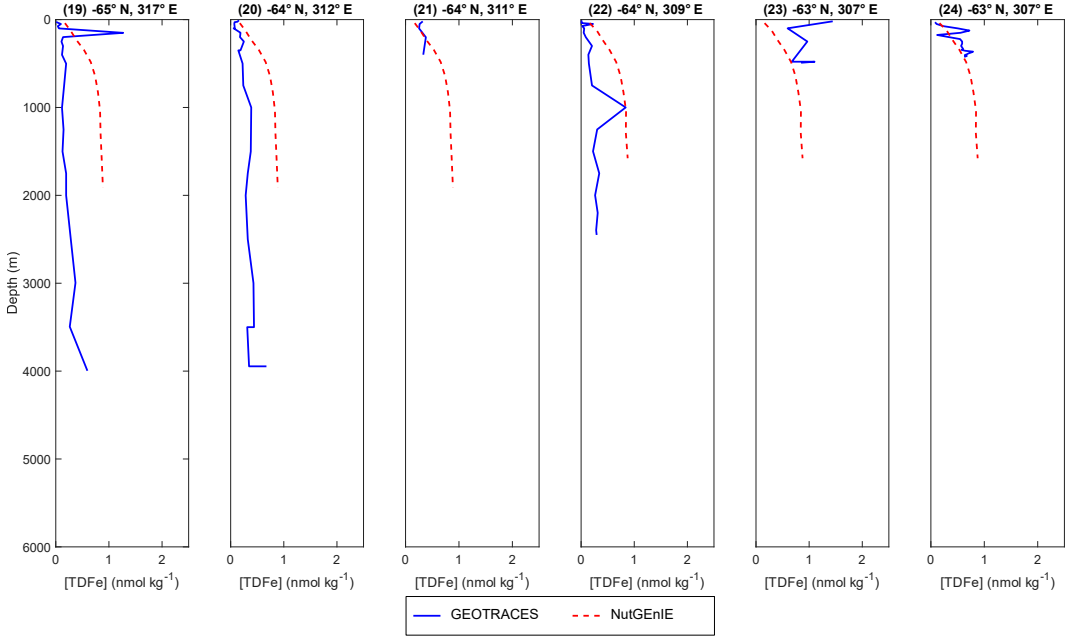


Figure S16 Iron depth profiles for GEOTRACES cruise GIPY05 3 of 6. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].



60 **Figure S17 Iron depth profiles for GEOTRACES cruise GIPY05 4 of 6.** Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

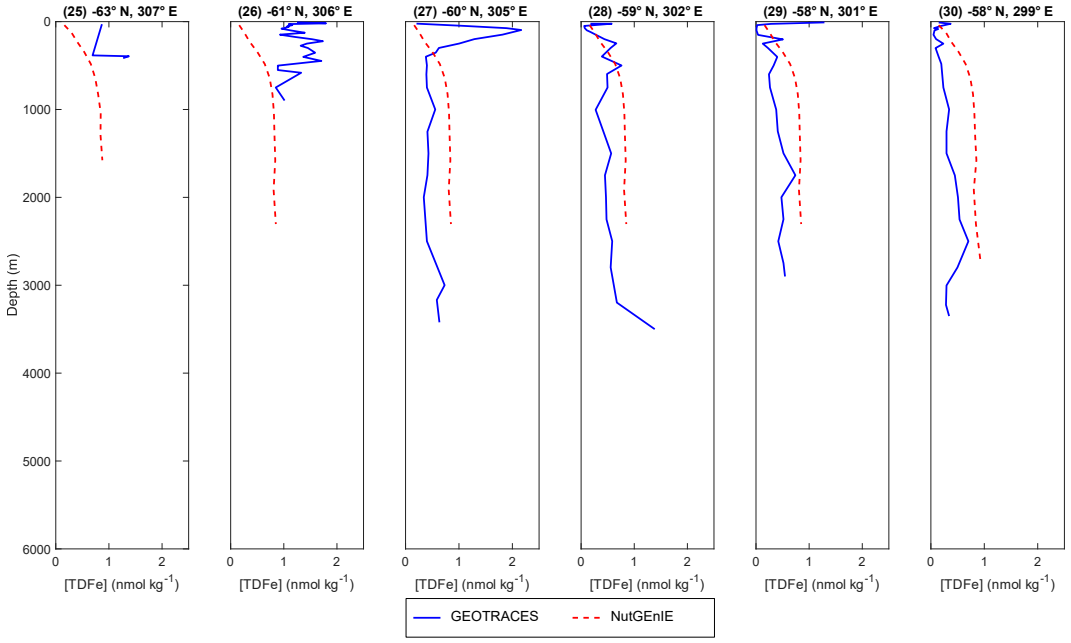


Figure S18 Iron depth profiles for GEOTRACES cruise GIPY05 5 of 6. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

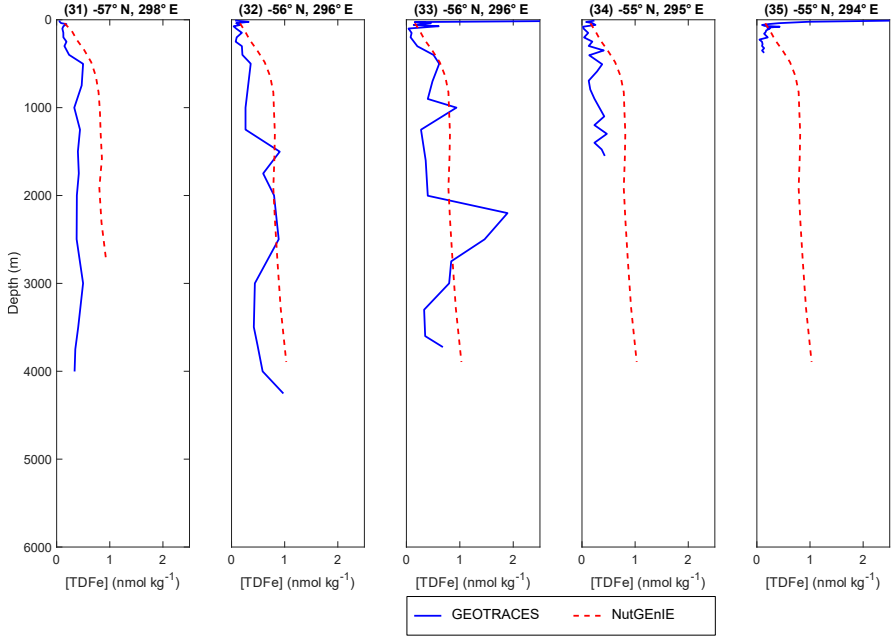


Figure S19 Iron depth profiles for GEOTRACES cruise GIPY05 6 of 6. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

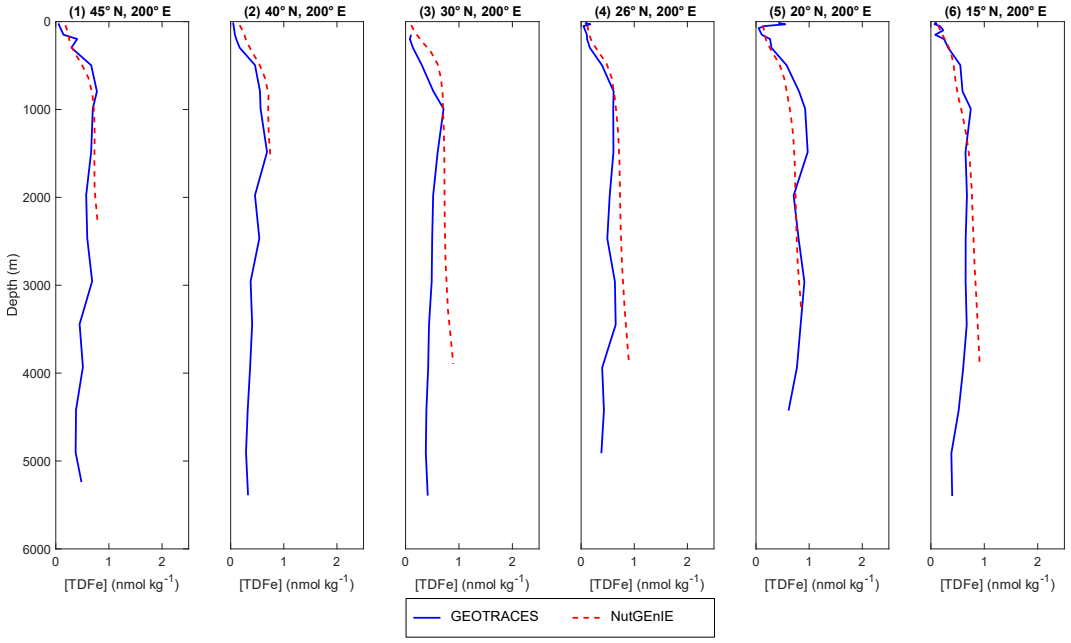


Figure S20 Iron depth profiles for GEOTRACES cruise GPc06 1 of 2. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

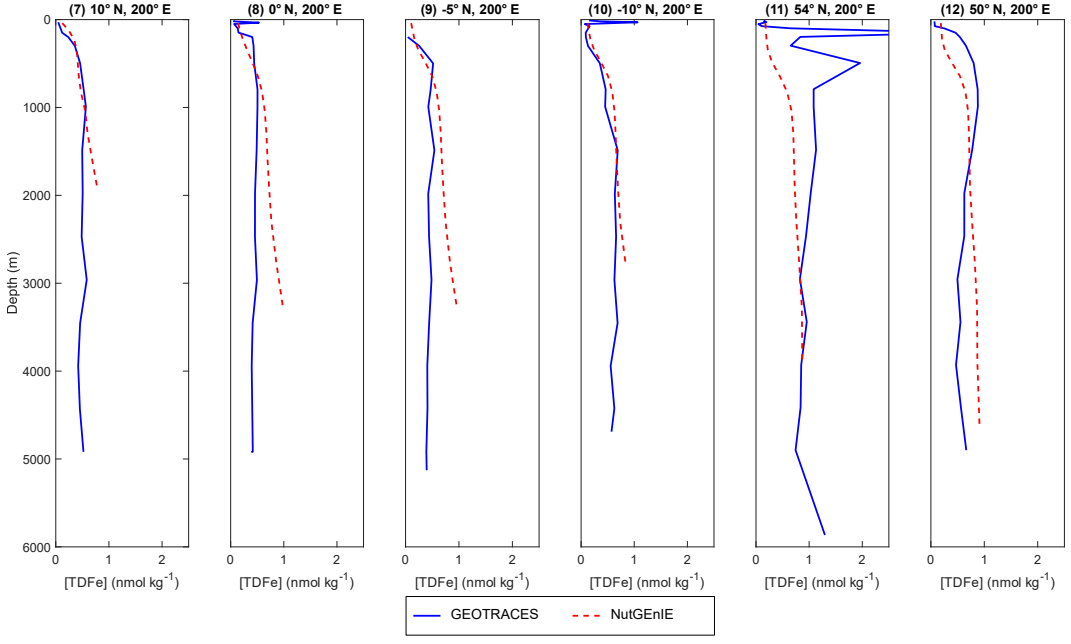


Figure S21 Iron depth profiles for GEOTRACES cruise GPc06 2 of 2. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

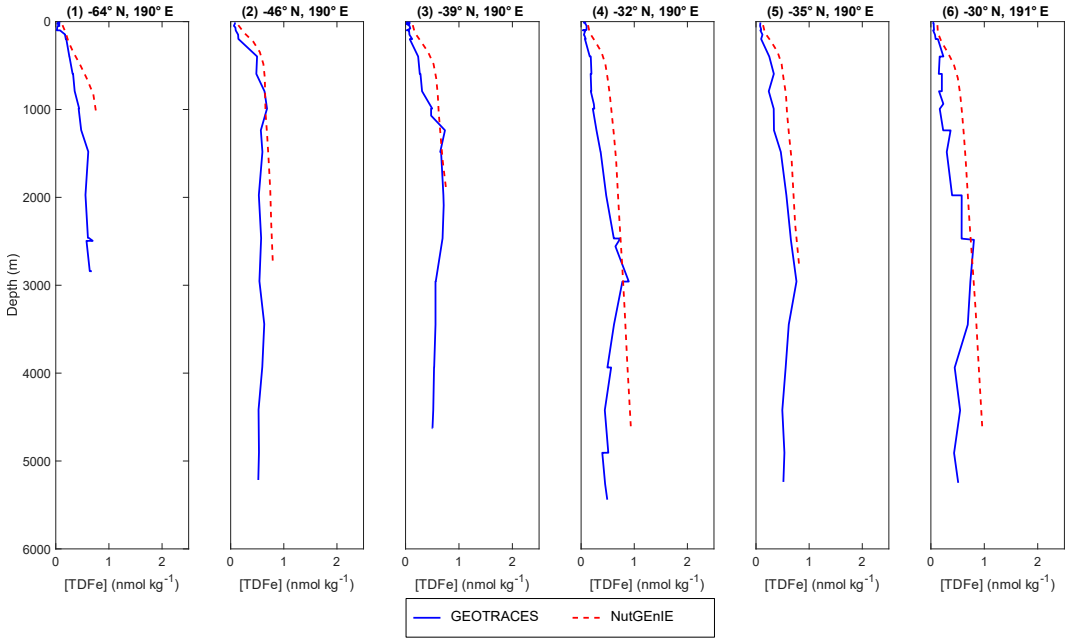


Figure S22 Iron depth profiles for GEOTRACES cruise GP19 1 of 3. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

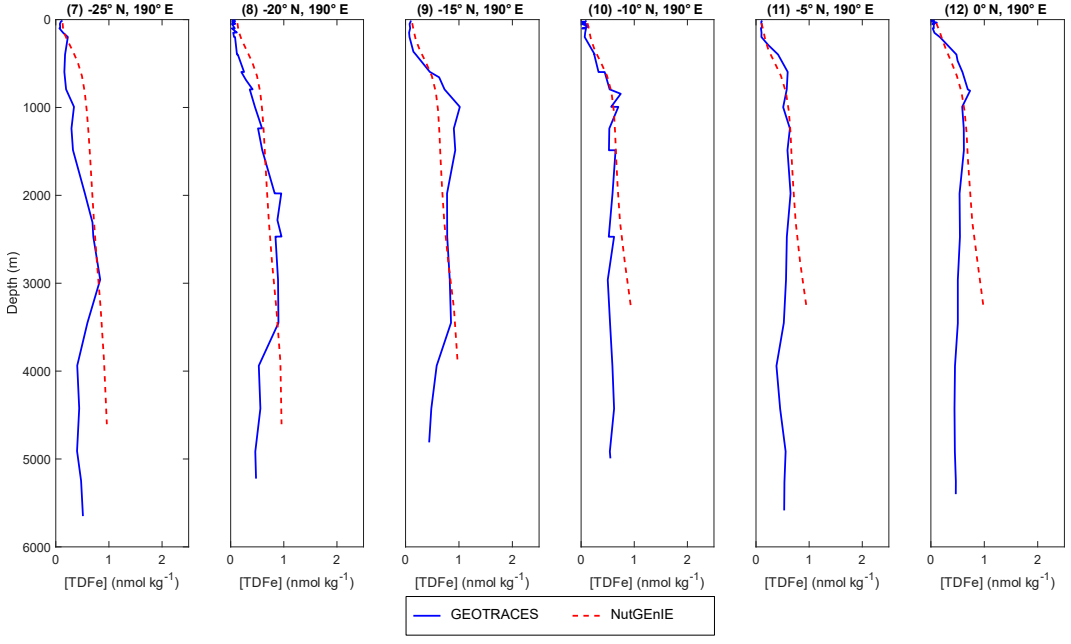


Figure S23 Iron depth profiles for GEOTRACES cruise GP19 2 of 3. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

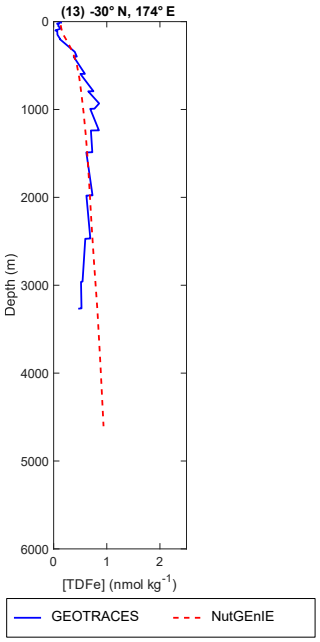


Figure S24 Iron depth profiles for GEOTRACES cruise GP19 3 of 3. Total dissolved iron (TDFe) in nmol kg^{-1}. Blue line represents GEOTRACES observations of [TDFe], red dashed line represents NutGEnIE [TDFe].

1.5 NutGEnIE iron spatial distributions

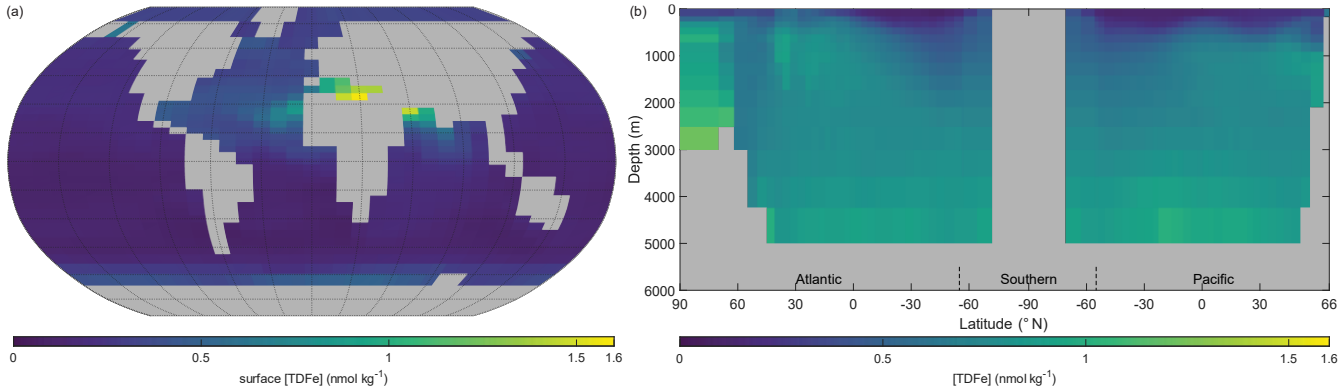


Figure S25 Annual mean global iron concentration ([TDFe]). (a) NutGEnIE surface [TDFe]. (b) NutGEnIE thermohaline transect zonal mean [TDFe]. [TDFe] in nmol kg^{-1}.

1.6 Statistical validation – histograms.

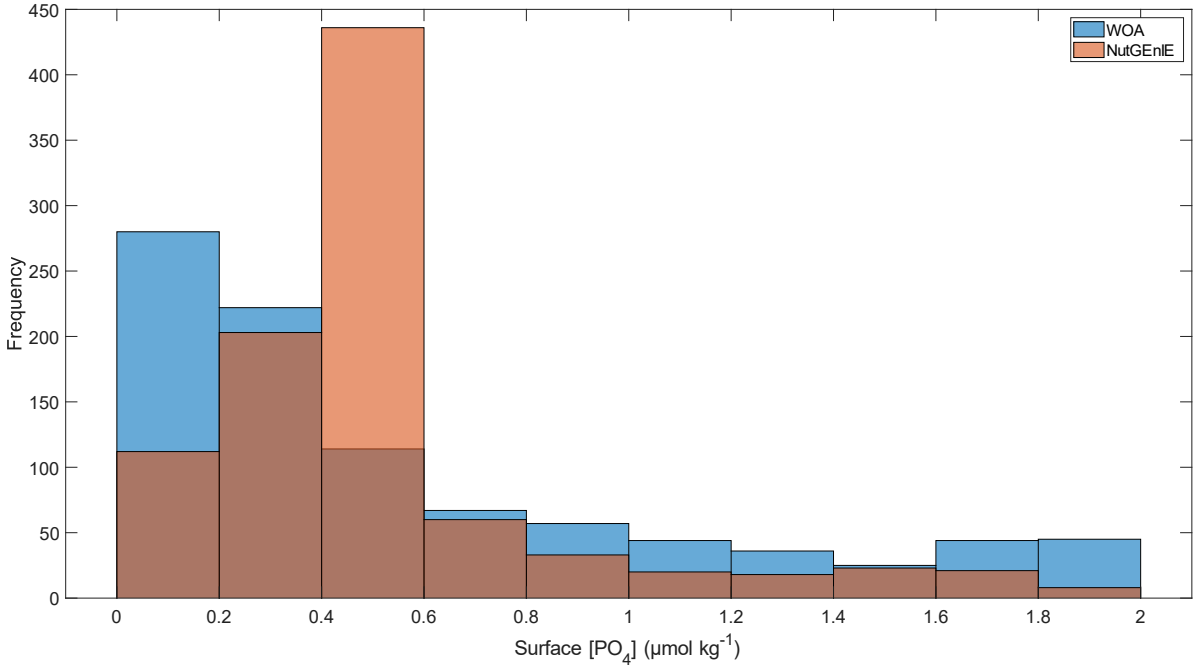


Figure S26 Histogram of NutGEnIE and WOA surface [PO_4]. NutGEnIE shown in orange, WOA shown in blue. Concentration values in µmol kg^{-1}.

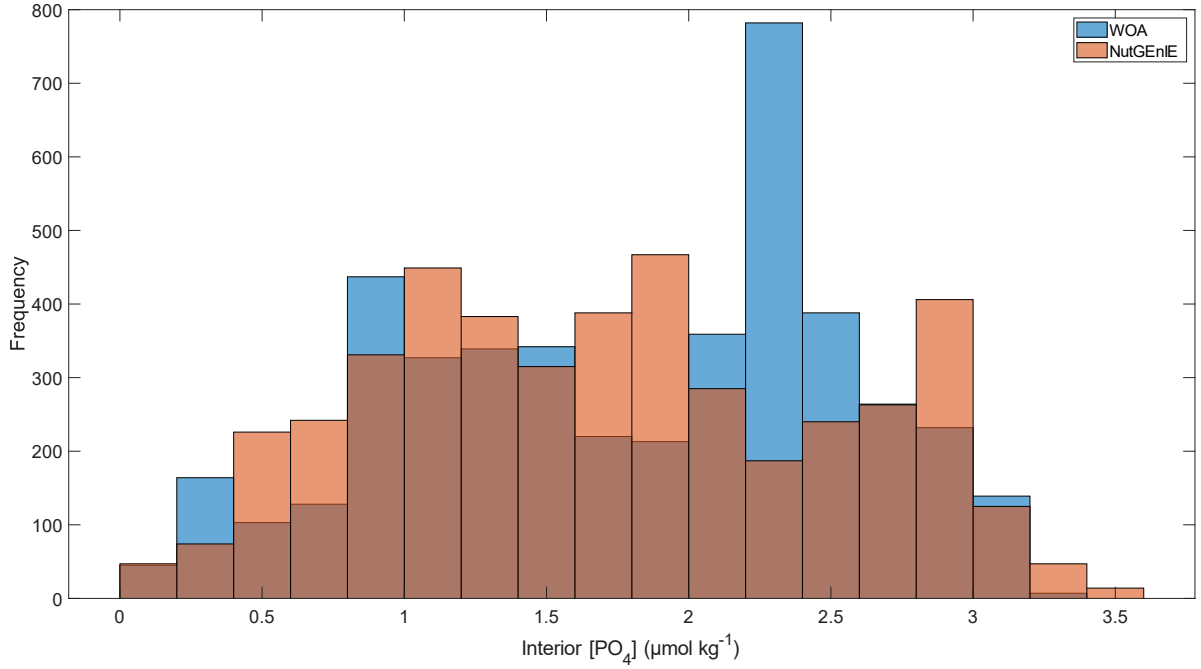


Figure S27 Histogram of NutGEnIE and WOA interior [PO_4]. NutGEnIE shown in orange, WOA shown in blue. Concentration values in µmol kg^{-1}.

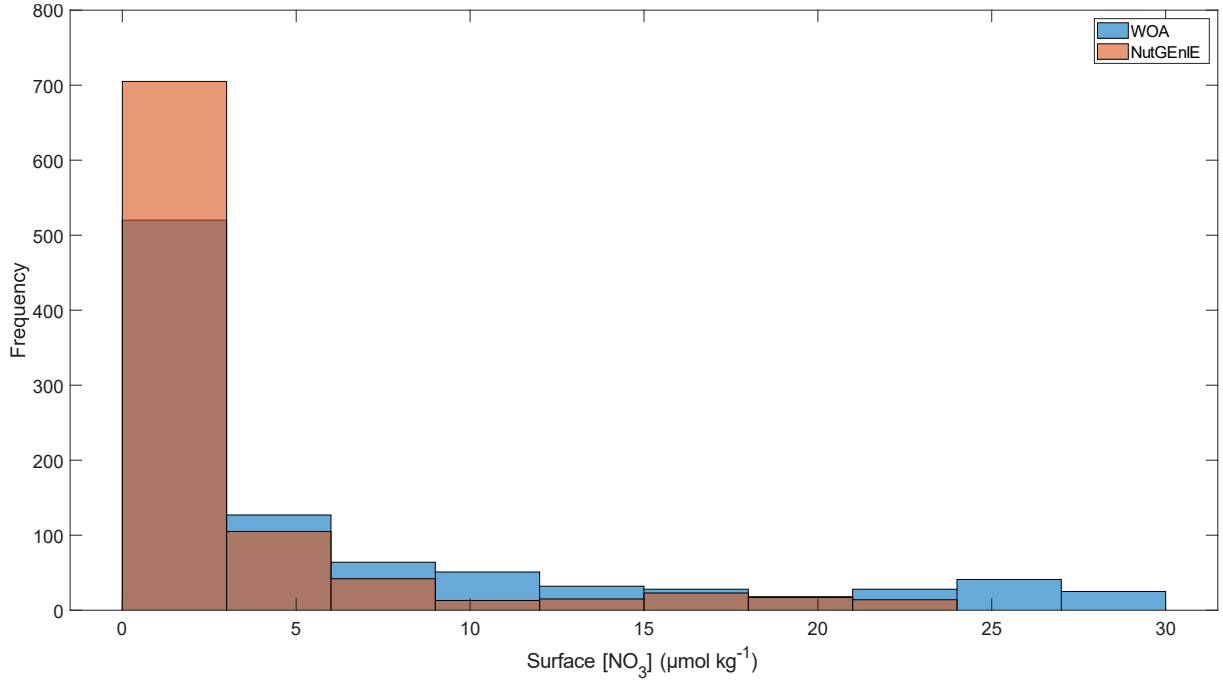


Figure S28 Histogram of NutGEnIE and WOA surface [NO_3]. NutGEnIE shown in orange, WOA shown in blue. Concentration values in µmol kg^{-1}.

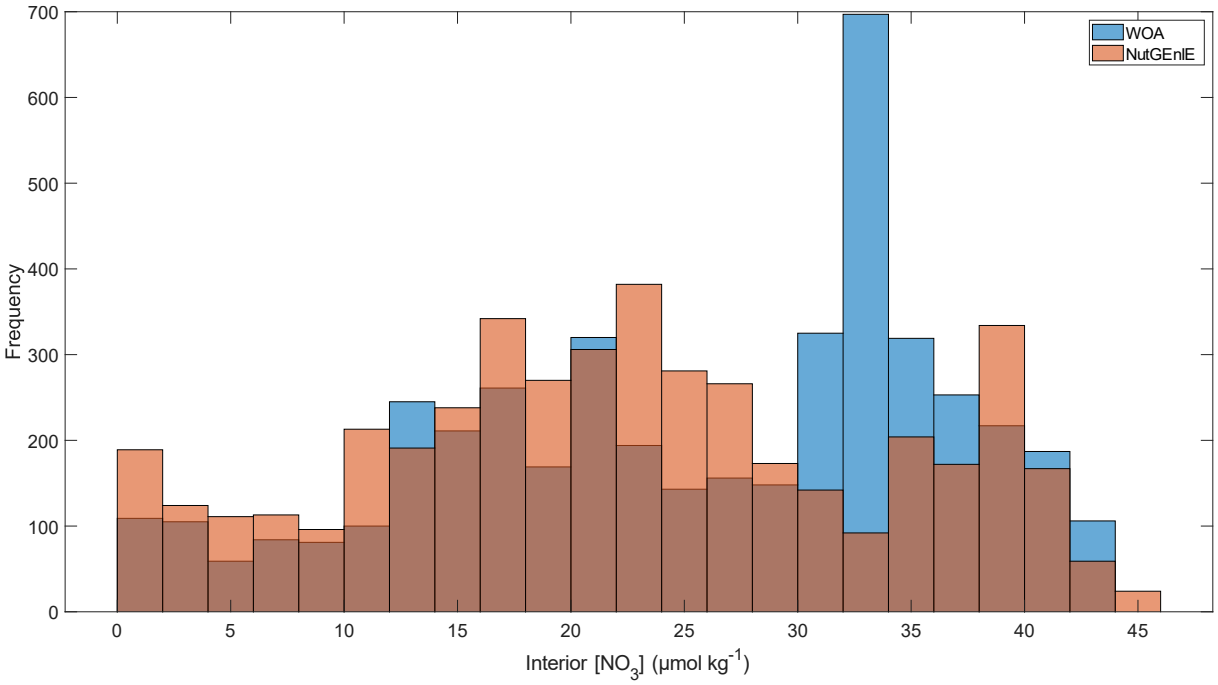


Figure S29 Histogram of NutGEnIE and WOA interior [NO_3]. NutGEnIE shown in orange, WOA shown in blue. Concentration values in µmol kg^{-1}.

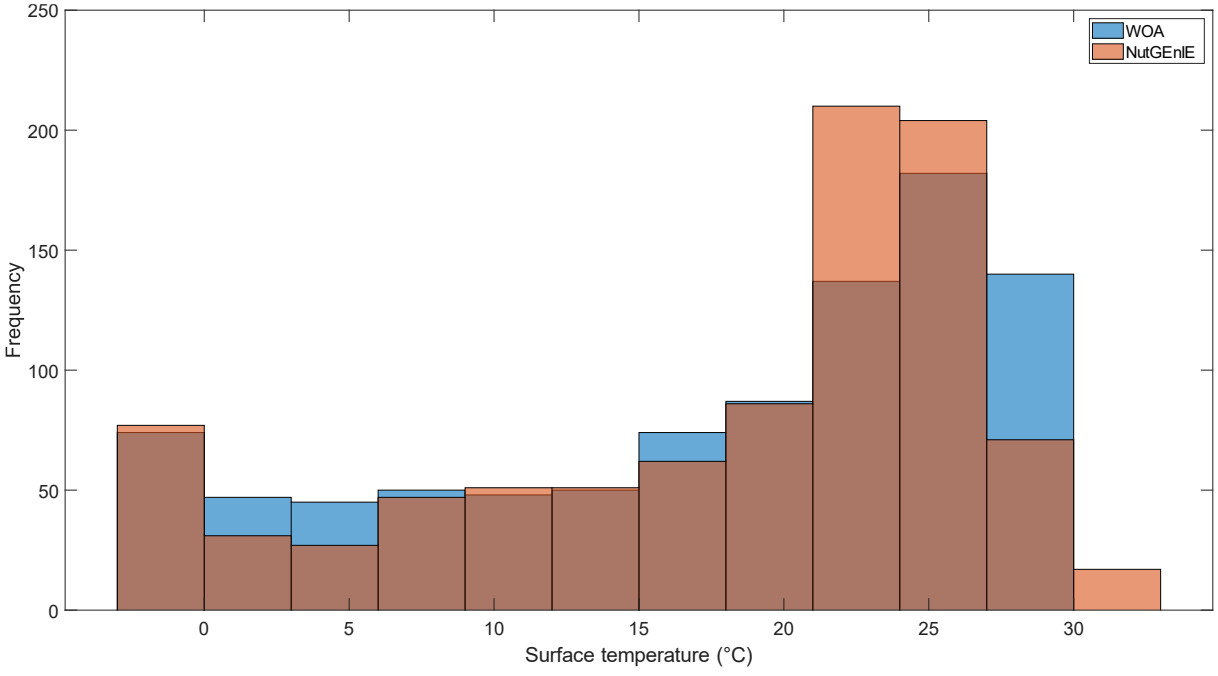


Figure S30 Histogram of NutGEnIE and WOA surface temperature. NutGEnIE shown in orange, WOA shown in blue. Temperature values in °C.

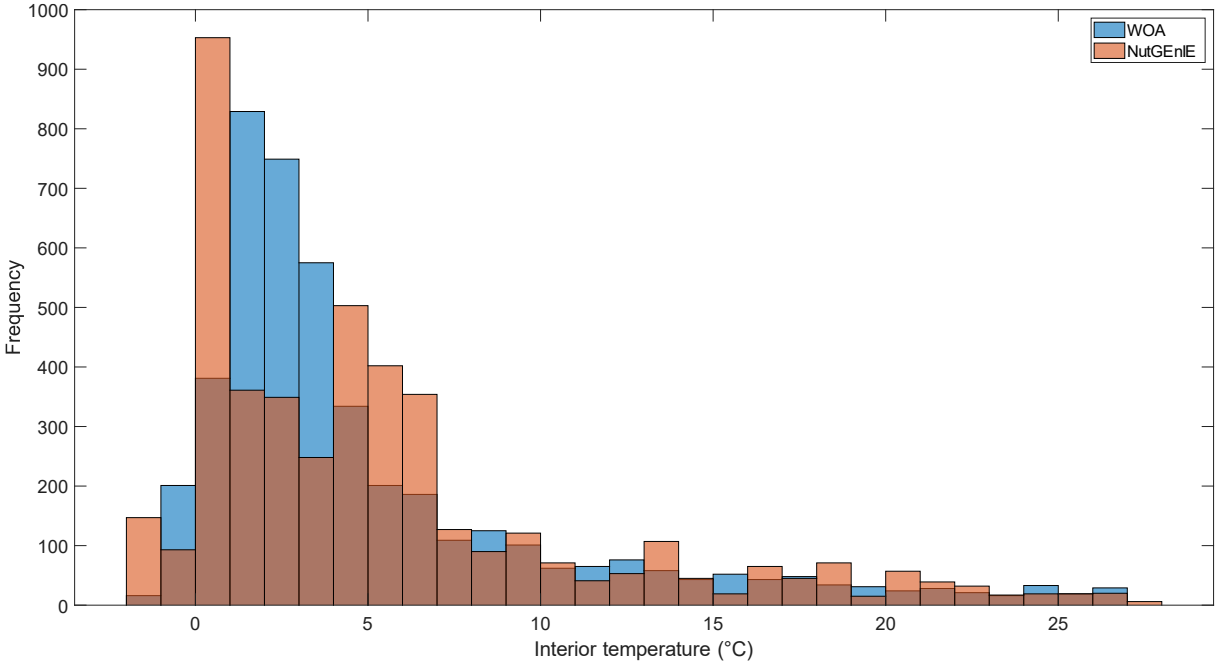


Figure S31 Histogram of NutGEnIE and WOA interior temperature. NutGEnIE shown in orange, WOA shown in blue. Temperature values in °C.

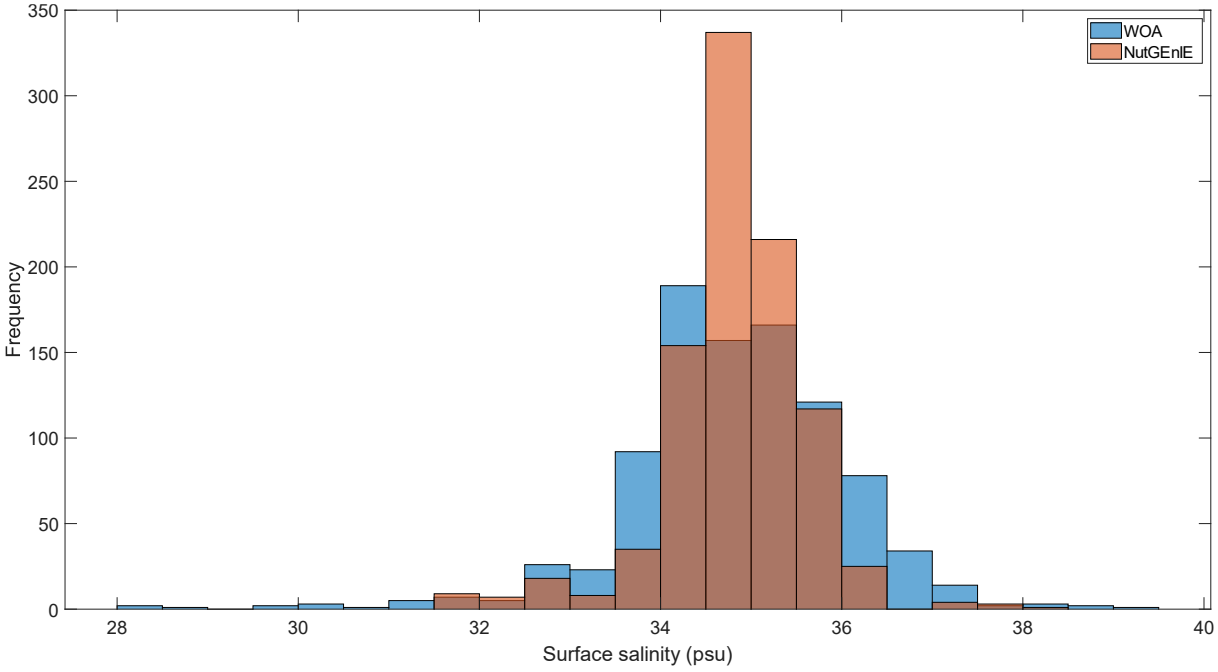


Figure S32 Histogram of NutGEnIE and WOA surface salinity. NutGEnIE shown in orange, WOA shown in blue. Salinity values in psu.

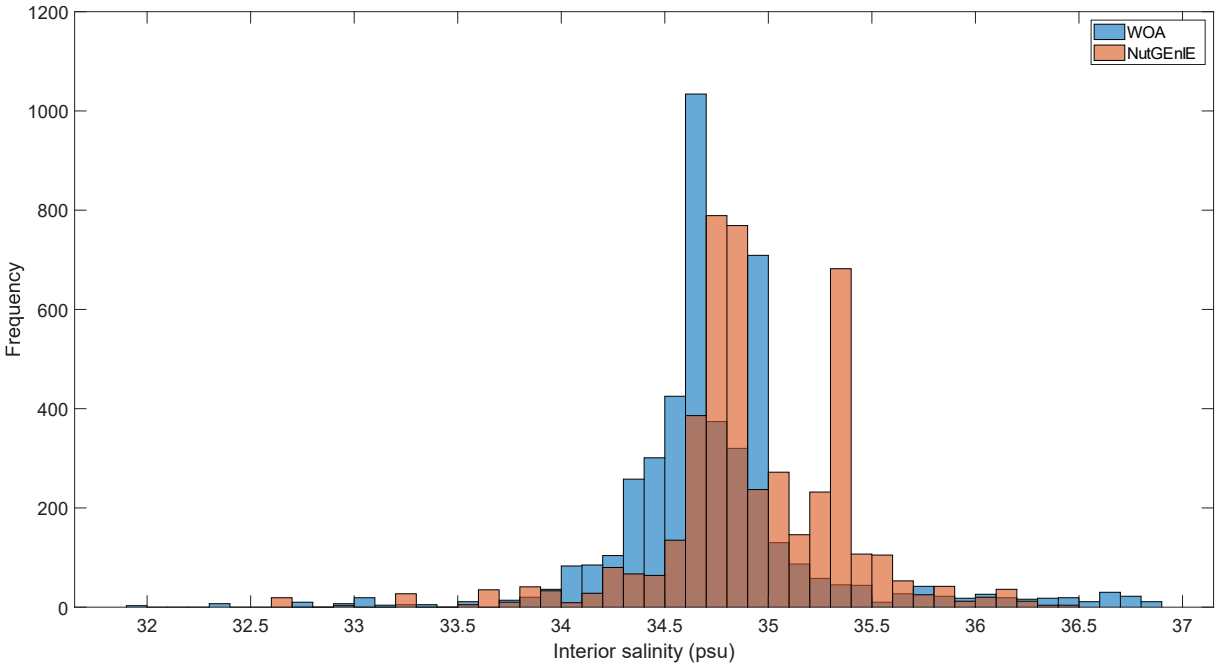


Figure S33 Histogram of NutGEnIE and WOA interior salinity. NutGEnIE shown in orange, WOA shown in blue. Salinity values in psu.

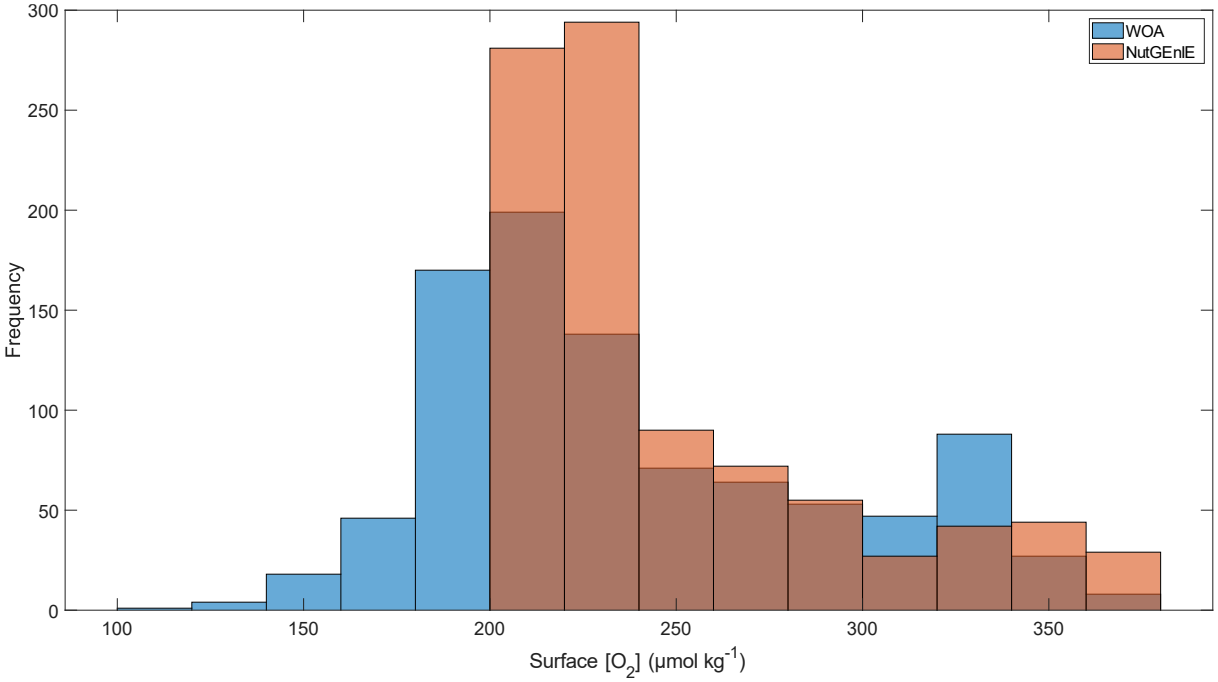


Figure S34 Histogram of NutGEnIE and WOA surface [O_2]. NutGEnIE shown in orange, WOA shown in blue. Concentration values in µmol kg^{-1}.

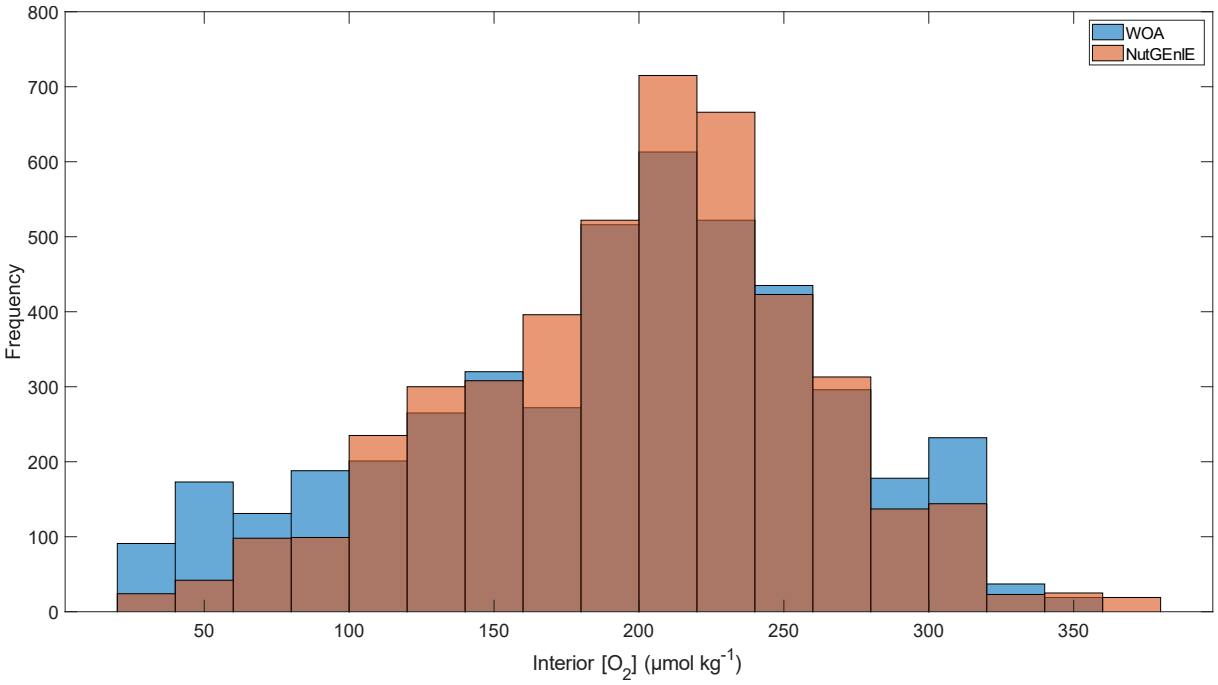


Figure S35 Histogram of NutGEnIE and WOA interior [O_2]. NutGEnIE shown in orange, WOA shown in blue. Concentration values in µmol kg^{-1}.

1.7 Ocean productivity.

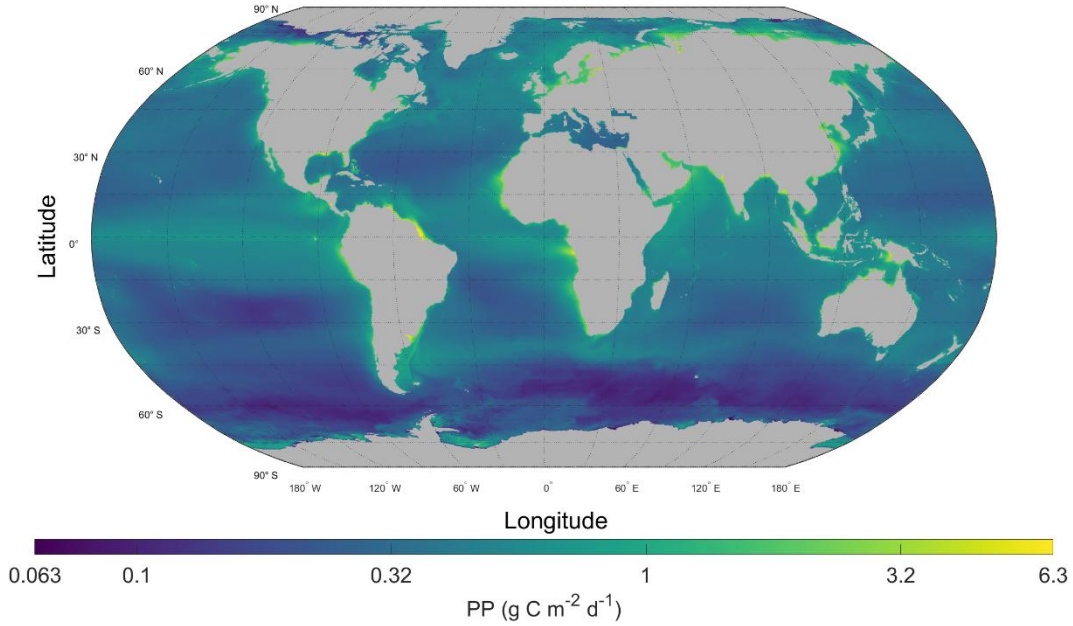


Figure S36 Annual mean global primary production. Based on the dataset from Oregon State University Ocean Productivity (Ocean Productivity, 2024). In this figure the dataset has not been re-gridded to match the NutGEnIE grid.

1.8 Nutrient uptake limiting factors.

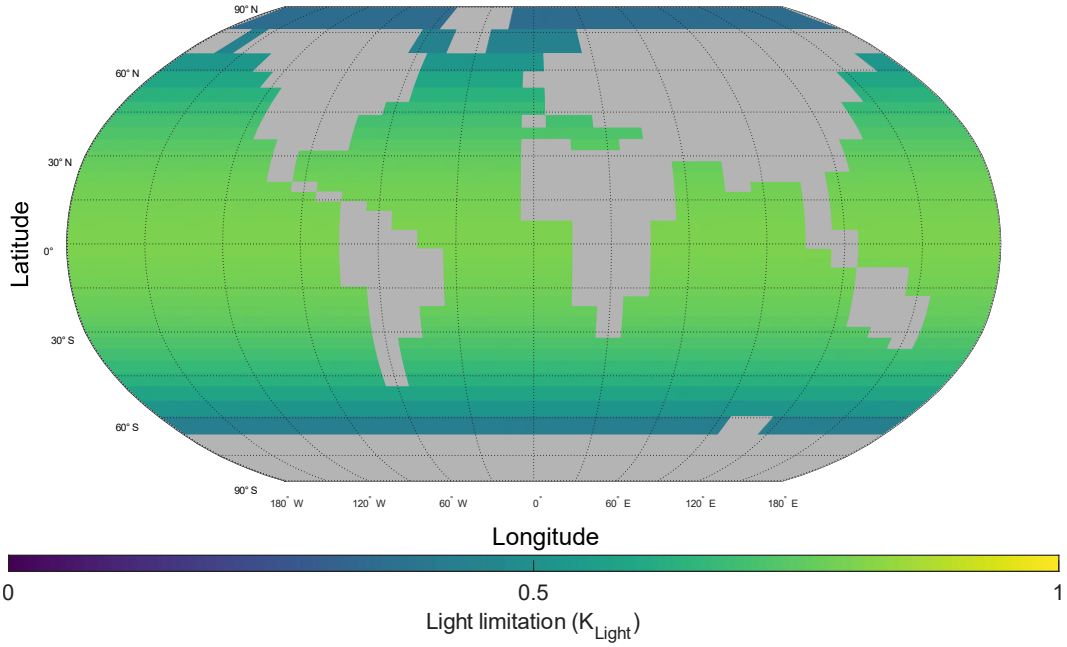


Figure S37 Spatial variation of light limiting factor for nutrient uptake. For other phytoplankton and diazotrophs. Lower values indicate that light is more limiting to nutrient uptake.

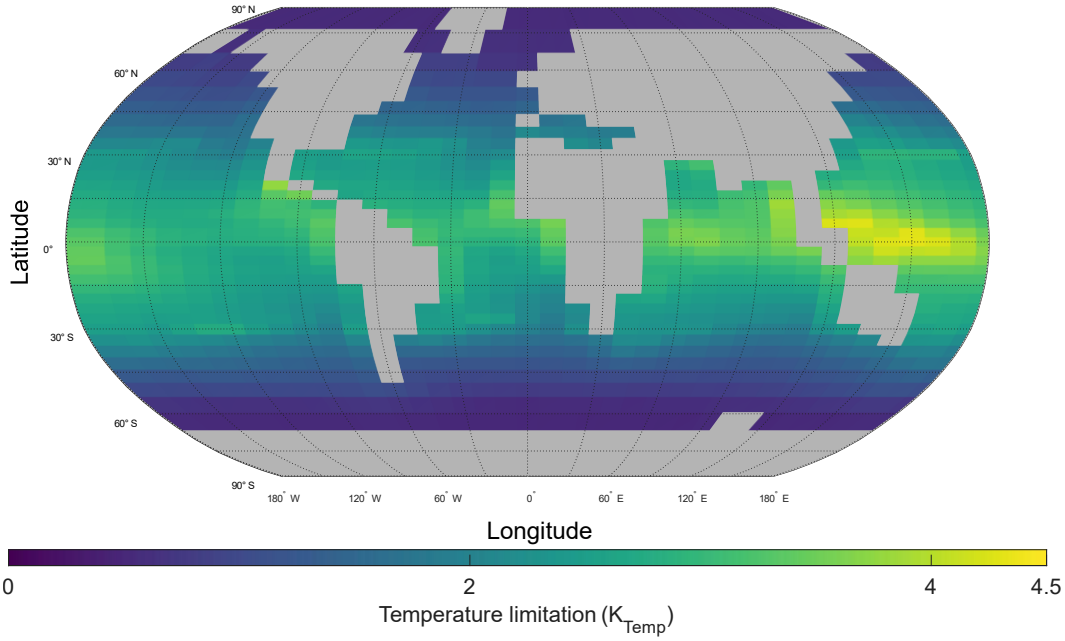


Figure S38 Spatial variation of temperature limiting factor for nutrient uptake. For other phytoplankton and diazotrophs. Lower values indicate that temperature is more limiting to nutrient uptake.

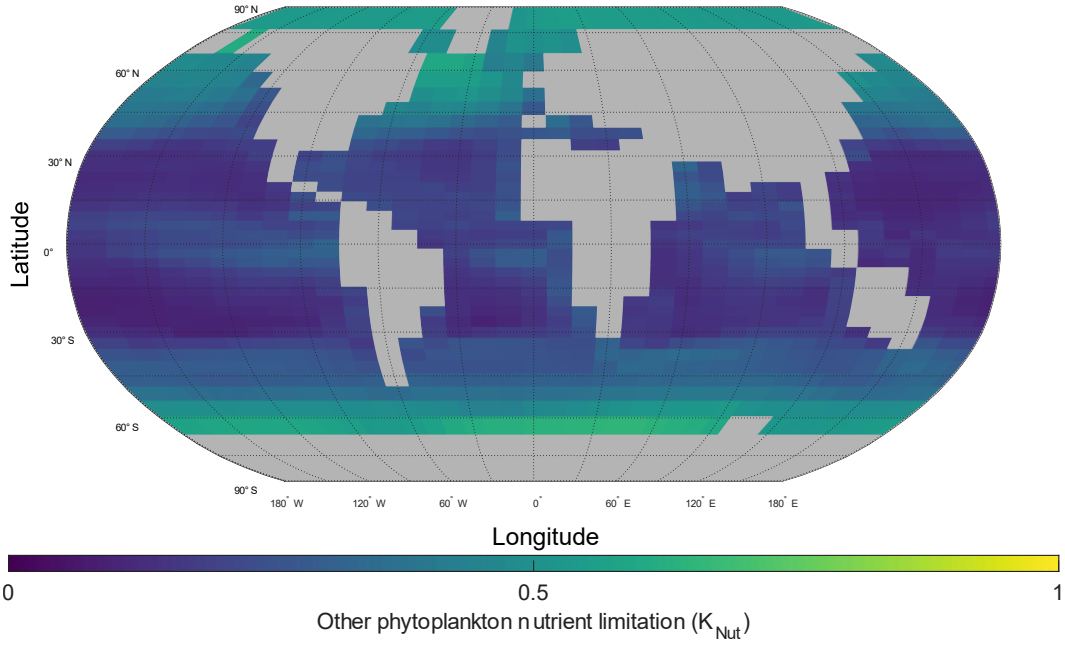
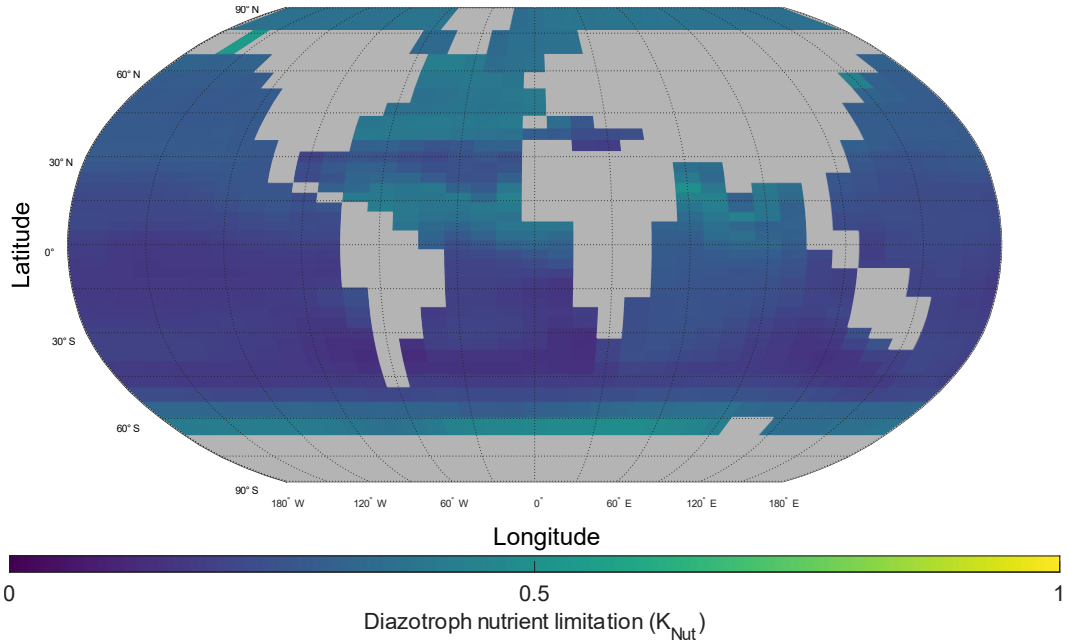


Figure S39 Spatial variation of nutrient limiting factor for nutrient uptake by other phytoplankton. For other phytoplankton. Lower values indicate that nutrient supply is more limiting to nutrient uptake by other phytoplankton.



135 **Figure S40 Spatial variation of nutrient limiting factor for nutrient uptake by diazotrophs**. For diazotrophs. Lower values indicate that nutrient supply is more limiting to nutrient uptake by other diazotrophs.

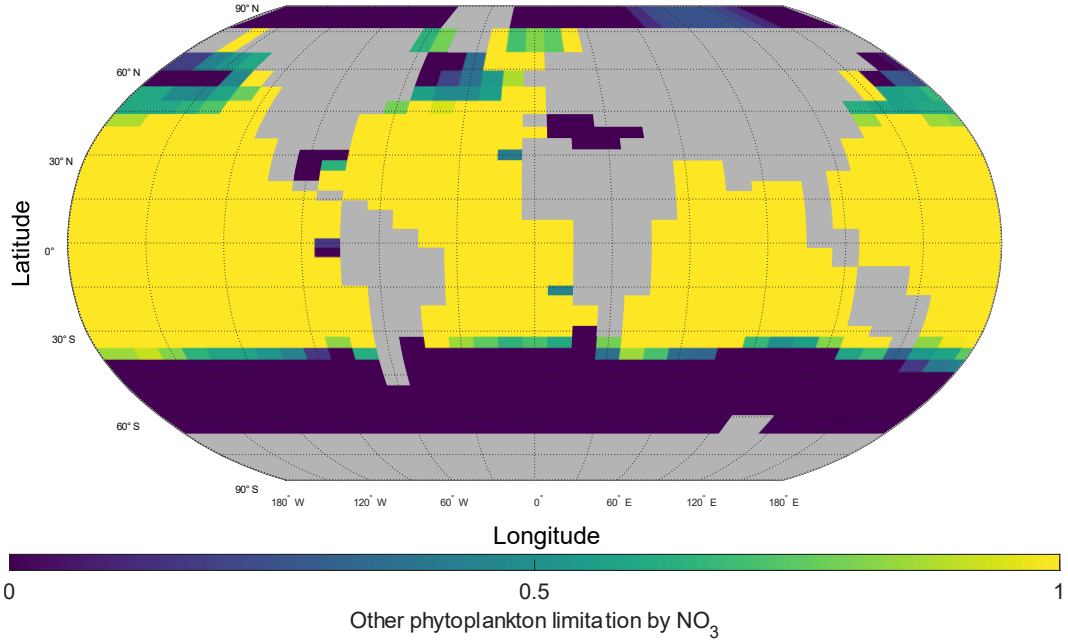


Figure S41 Spatial variation of NO_3 limitation for nutrient uptake by other phytoplankton. For other phytoplankton. 0 = no NO_3 limitation, 0.5 = NO_3 limitation 50 % of time, 1 = NO_3 limitation 100 % of time.

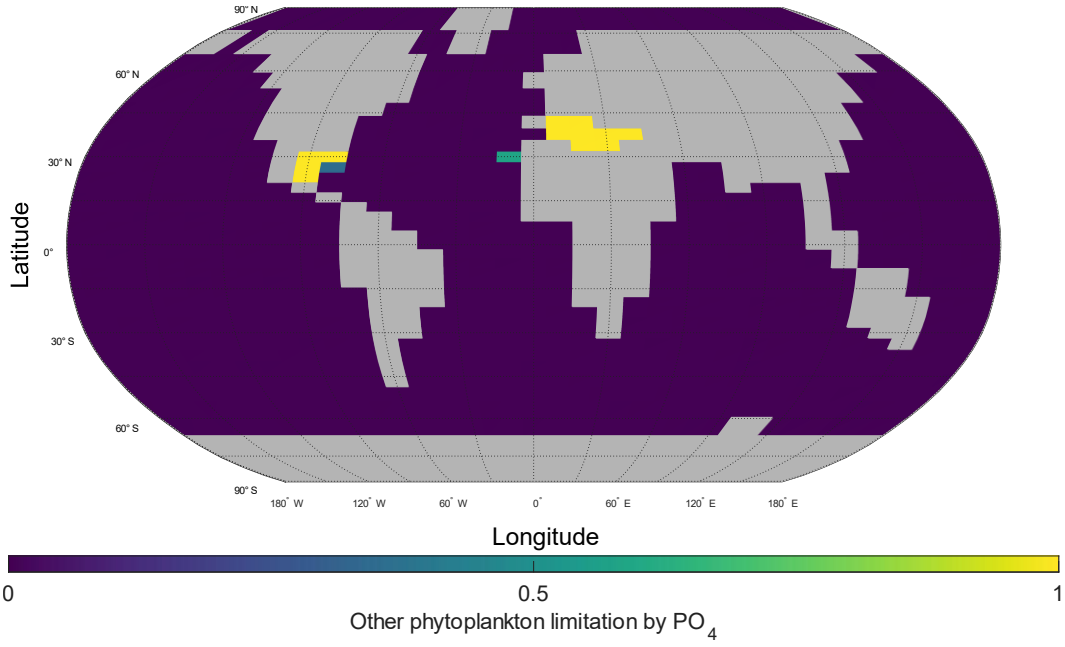


Figure S42 Spatial variation of PO_4 limitation for nutrient uptake by other phytoplankton. For other phytoplankton. 0 = no PO_4 limitation, 0.5 = PO_4 limitation 50 % of time, 1 = PO_4 limitation 100 % of time.

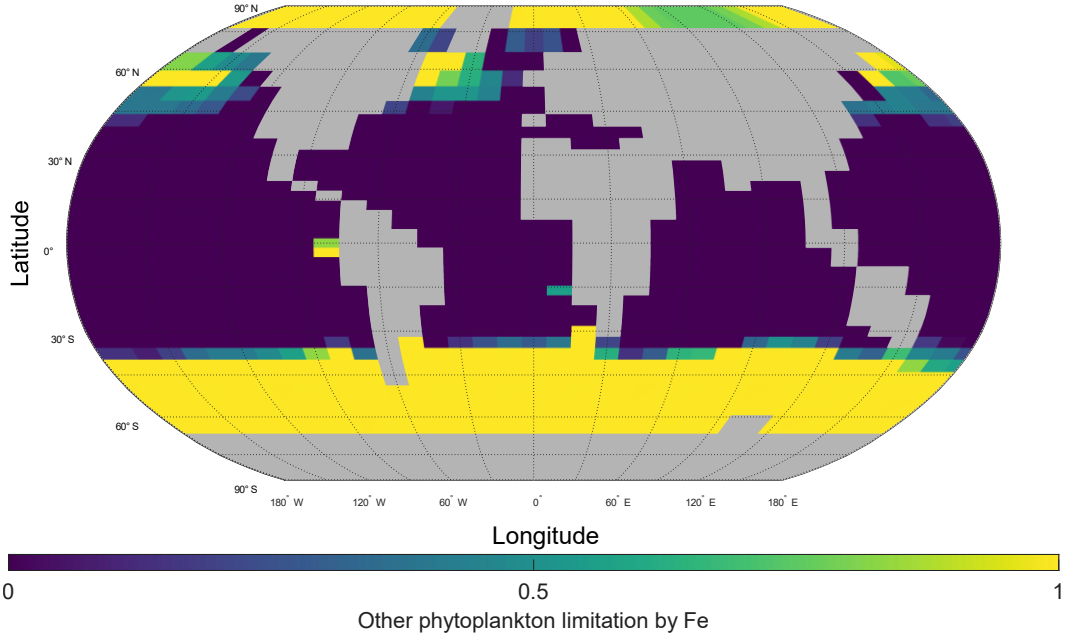


Figure S43 Spatial variation of Fe limitation for nutrient uptake by other phytoplankton. For other phytoplankton. 0 = no Fe limitation, 0.5 = Fe limitation 50 % of time, 1 = Fe limitation 100 % of time.

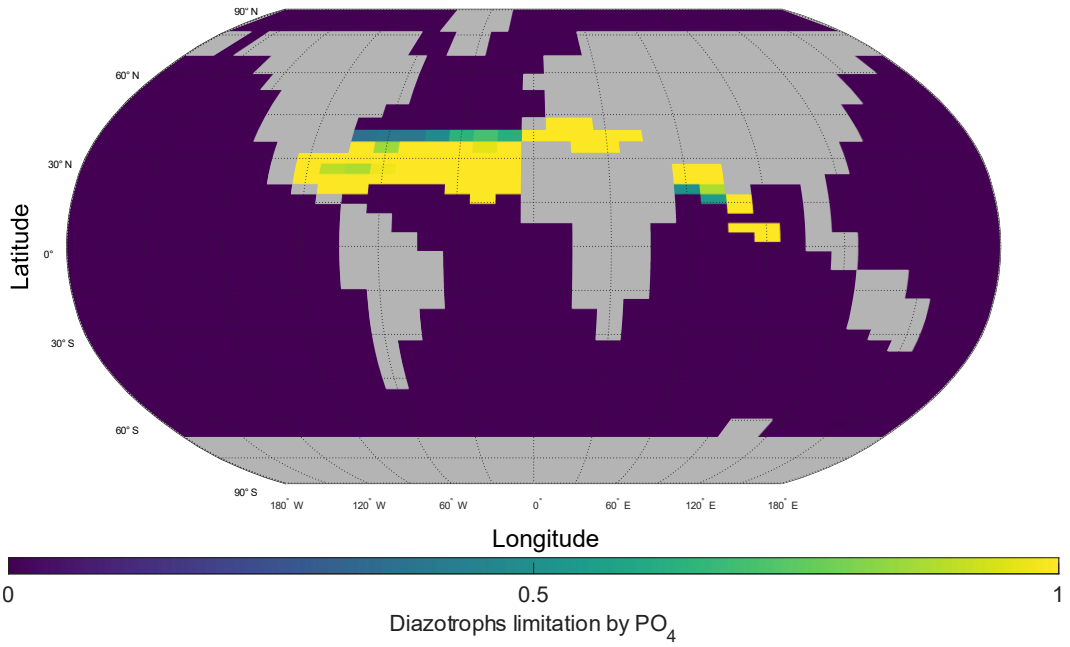


Figure S44 Spatial variation of PO_4 limitation for nutrient uptake by other diazotrophs. For diazotrophs. 0 = no PO_4 limitation, 0.5 = PO_4 limitation 50 % of time, 1 = PO_4 limitation 100 % of time.

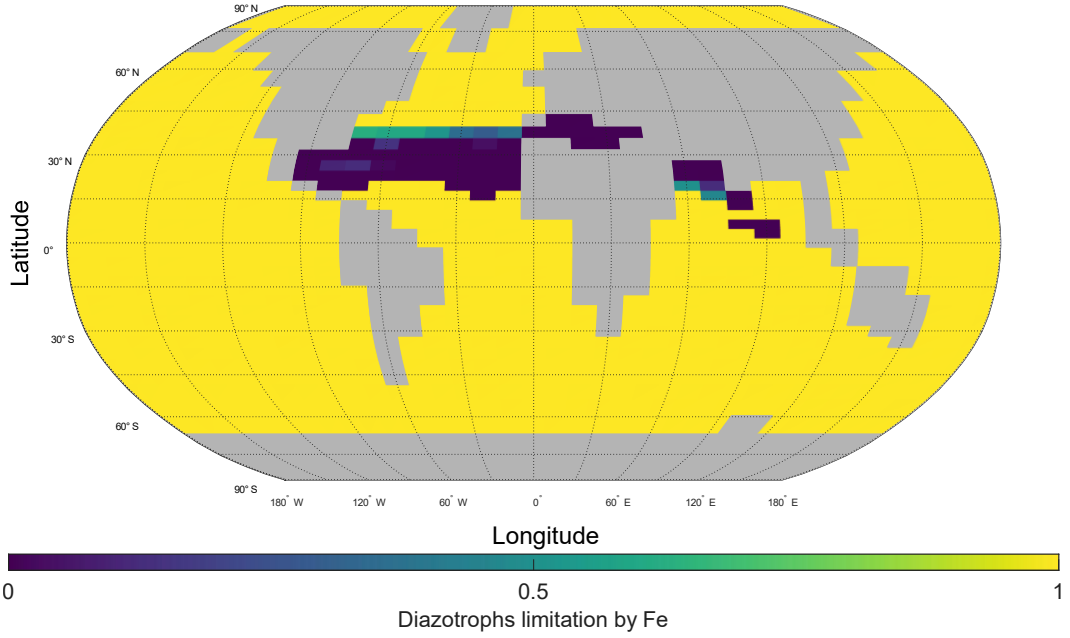


Figure S45 Spatial variation of Fe limitation for nutrient uptake by diazotrophs. For diazotrophs. 0 = no Fe limitation, 0.5 = Fe limitation 50 % of time, 1 = Fe limitation 100 % of time.

1.9 Spatial variation of nutrient limiting values.

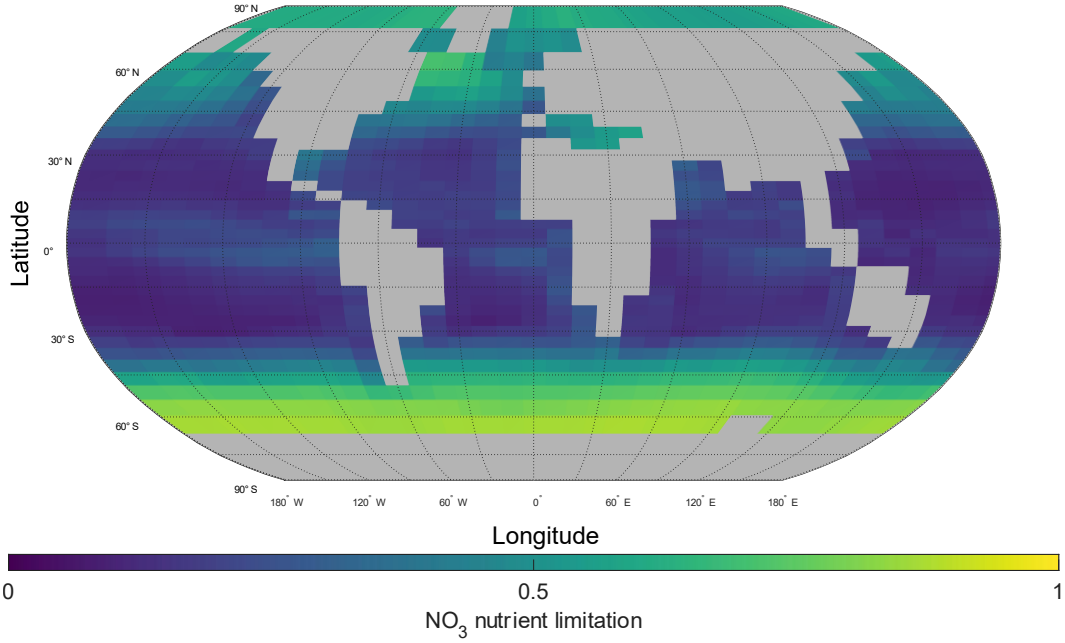


Figure S46 Spatial variation of NO_3 limitation value. Limitation value for NO_3 is calculated by $\frac{\mathbf{DIN}}{\mathbf{DIN+K_N}}$.

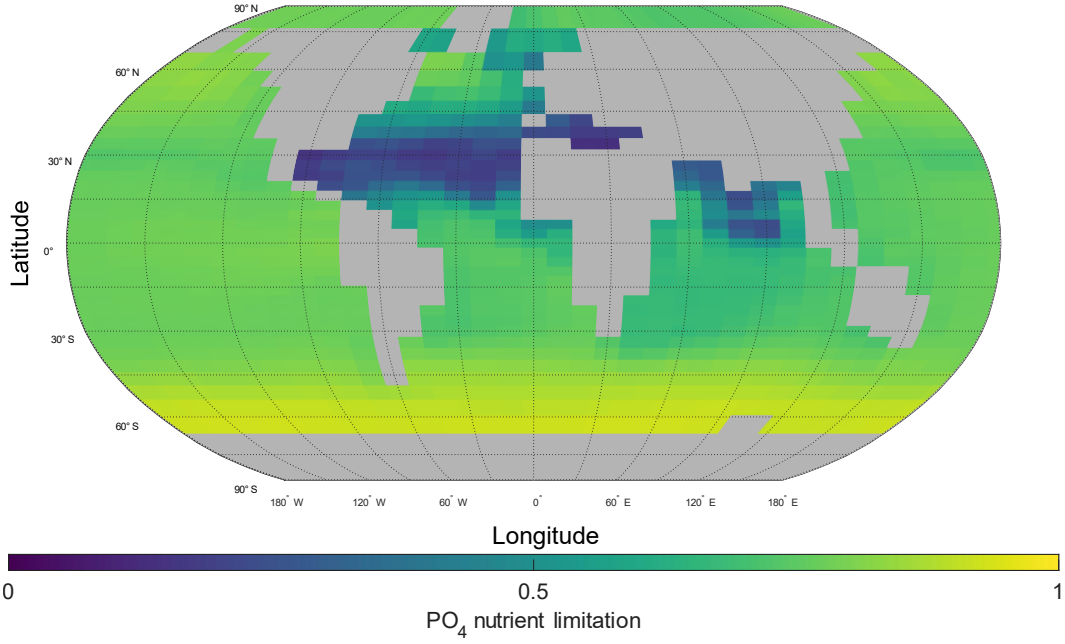


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Figure S47 Spatial variation of PO_4 limitation value. Limitation value for PO_4 is calculated by $\frac{\mathbf{PO_4}}{\mathbf{PO_4+K_P}}$.

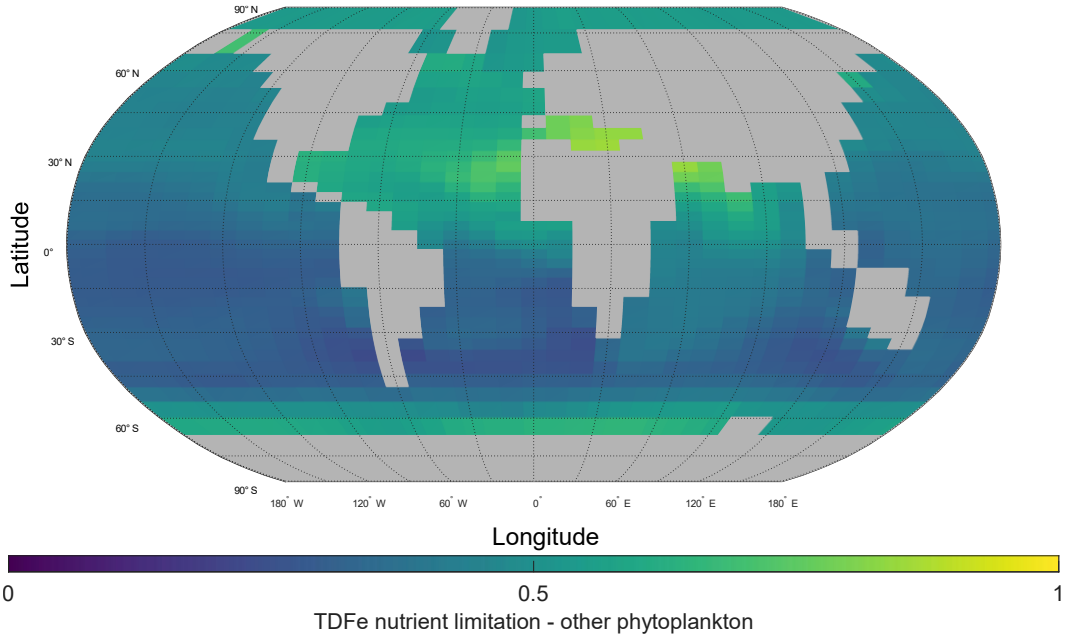

Figure S48 Spatial variation of Fe limitation value for other phytoplankton. Limitation value for Fe is calculated by $\frac{\mathbf{Fe}}{\mathbf{Fe+K_{Fe}}}$.

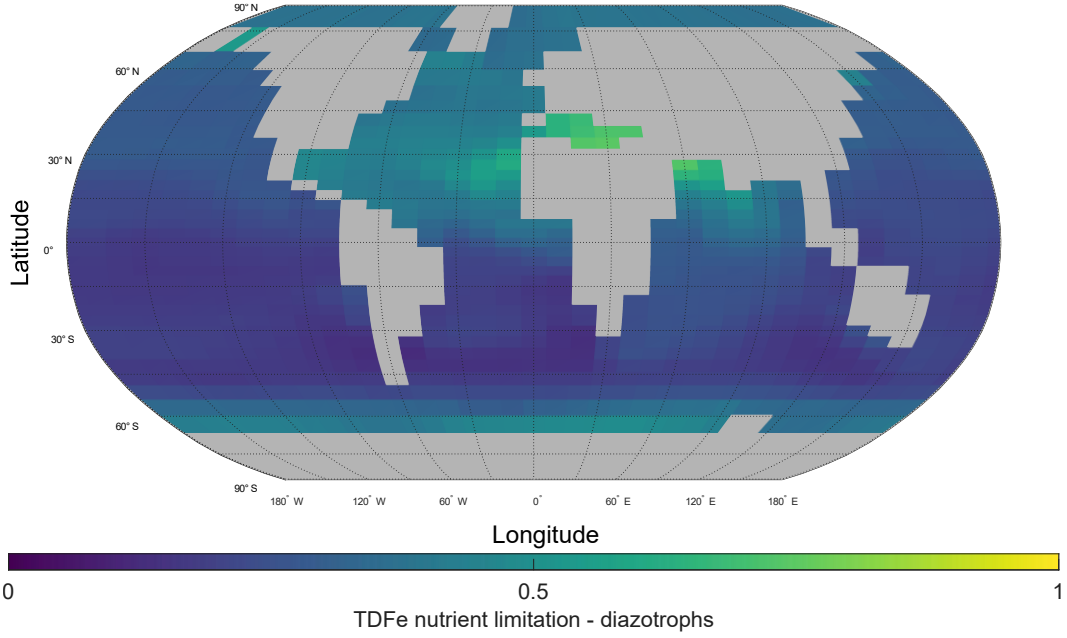

Figure S49 Spatial variation of Fe limitation value for diazotrophs. Limitation value for Fe is calculated by $\frac{\mathbf{Fe}}{\mathbf{Fe+K_{Fe}^{Diaz}}}$.

2 Supplementary tables

Table S1 Depth of NutGEnIE ocean layers. The depth (m) at the base of each layer, with 1 being the surface layer and 16 the deepest possible layer.

layer	Base of layer (m)
1	80.84
2	174.75
3	283.85
4	410.58
5	557.80
6	728.83
7	927.51
8	1158.31
9	1426.43
10	1737.90
11	2099.73
12	2520.05
13	3008.34
14	3575.57
15	4234.52
16	5000.00

References

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