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Supporting Information for

**Assimilation of ocean-colour plankton functional types to improve marine ecosystem simulations**

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**Introduction**

We report here additional figures relative to the skill assessment of the assimilation of plankton functional types (PFTs), for areas of the model domain other than the upper-shelf waters (Figure S1). We report also some additional figures relative to the numerical experiment presented in the Appendix 1 of the paper, for completeness (Figures S2 and S3). The numerical experiment consisted in the assimilation of total chlorophyll from ocean colour into a configuration of the model ERSEM that used the parameterization by Blackford et al. [2004] , instead of the novel parameterization by Butenschön et al [2016] (see the differences between the two parameterizations in Table S1).

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Figure S1. Comparison of the skills of the reanalysis (circle) and reference (squares) simulations in estimating in situ biogeochemical and PFT data measured in different areas of the model domain: A) Coastal waters: biogeochemical and physical variables; B) deeper-shelf waters: biogeochemical and physical variables; C) upper-ocean waters: biogeochemical and physical variables; D) upper-ocean waters: PFT data; E) upper-ocean waters: PFT data excluding dinoflagellates; F) deeper-ocean waters: biogeochemical and physical variables. The notation of the variables is defined in Figure 6 of the manuscript. The robust metrics represented in the skill diagrams are defined in Section 2.4 of the Methods.

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Figure S2. Percentage changes of reference RMSD when assimilating total chlorophyll using the new Butenschön et al. [2016] (left) and previous Blackford et al. [2004] (right) parameterizations. The numbers indicate the percentage of the shelf area where assimilation improved (deteriorated) the reference simulation.

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| New Parametrization of the PFTs | Previous parameterization of the PFTs |
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Figure S3: Density scatterplots of the log-transformed chlorophyll concentration of PFTs (y-axis, clockwise: diatoms, nanoplankton, dinoflagellates, picoplankton) versus total chlorophyll (x-axis, ChlTot). The concentrations are ensembles forecasts in the assimilative simulations for year 1998 using the new [*Butenschön et al.*, 2016] and previous [*Blackford et al*., 2004] parameterization of the PFTs in ERSEM. The plots of picoplankton are shown also in Figure A3 of Appendix 1 in the paper.

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| --- | --- | --- | --- |
| Parameter | Notation | a | b |
| Initial slope of PI-curve for diatoms[mg C m^2 /mg Chl/W/d] | alphaP1X | 4.00E+00 | 2.98E+00 |
| Initial slope of PI-curve for nanophytoplankton [mg C m^2 /mg Chl/W/d] | alphaP2X | 5.00E+00 | 2.98E+00 |
| Initial slope of PI-curve for picophytoplankton [mg C m^2 /mg Chl/W/d] | alphaP3X | 6.00E+00 | 2.98E+00 |
| Initial slope of PI-curve for microphytoplankton [mg C m^2 /mg Chl/W/d] | alphaP4X | 3.00E+00 | 2.98E+00 |
| Photo-inhibition parameter for diatoms [mg C m^2 /mg Chl/W/d] | betaP1X | 7.00E-02 | 2.00E-02 |
| Photo-inhibition parameter for nanophytoplankton [mg C m^2 /mg Chl/W/d] | betaP2X | 1.00E-01 | 2.00E-02 |
| Photo-inhibition parameter for picophytoplankton [mg C m^2 /mg Chl/W/d] | betaP3X | 1.20E-01 | 2.00E-02 |
| Photo-inhibition parameter for microphytoplankton [mg C m^2 /mg Chl/W/d] | betaP4X | 6.00E-02 | 2.00E-02 |
| Michaelis-Menten constant for Silicate limitation [mmol Si/m^3] | chP1sX | 2.00E-01 | 3.00E-01 |
| Level of nutrient limitation below which diatoms subside | esNIP1X | 7.00E-01 | 7.00E-01 |
| Level of nutrient limitation below which medium size phytoplankton subsides | esNIP2X | 7.00E-01 | 7.50E-01 |
| Level of nutrient limitation below which small phytoplankton subsides | esNIP3X | 7.00E-01 | 7.50E-01 |
| Level of nutrient limitation below which large phytoplankton subsides | esNIP4X | 7.00E-01 | 7.50E-01 |
| photosynthetically available fraction of irradiation | peir\_eowX | 5.00E-01 | 5.00E-01 |
| Maximal effective chlorophyll to carbon photosynthesis ratio of diatoms [mg Chl/mg C] | phimP1X | 6.00E-02 | 3.50E-02 |
| Maximal effective chlorophyll to carbon photosynthesis ratio of nanophytoplankton [mg Chl/mg C] | phimP2X | 2.50E-02 | 3.50E-02 |
| Maximal effective chlorophyll to carbon photosynthesis ratio of picophytoplankton [mg Chl/mg C] | phimP3X | 1.50E-02 | 3.50E-02 |
| Maximal effective chlorophyll to carbon photosynthesis ratio of microphytoplankton [mg Chl/mg C] | phimP4X | 4.50E-02 | 3.50E-02 |
| Excreted fraction of primary production by diatoms | pu\_eaP1X | 2.00E-01 | 5.00E-02 |
| Excreted fraction of primary production by medium size phytoplankton | pu\_eaP2X | 2.00E-01 | 2.00E-01 |
| Excreted fraction of primary production by small phytoplankton | pu\_eaP3X | 2.00E-01 | 2.00E-01 |
| Excreted fraction of primary production by large phytoplankton | pu\_eaP4X | 2.00E-01 | 5.00E-02 |
| Respired fraction of primary production by diatoms (activity respiration) | pu\_raP1X | 2.00E-01 | 1.00E-01 |
| Respired fraction of primary production by medium size phytoplankton (activity respiration) | pu\_raP2X | 2.00E-01 | 2.50E-01 |
| Respired fraction of primary production by small phytoplankton (activity respiration) | pu\_raP3X | 2.00E-01 | 2.50E-01 |
| Respired fraction of primary production by large phytoplankton (activity respiration) | pu\_raP4X | 2.00E-01 | 2.50E-01 |
| Regulating temperature factor Q10 for diatoms | q10P1X | 2.00E+00 | 2.00E+00 |
| Regulating temperature factor Q10 for medium size phytoplankton | q10P2X | 2.00E+00 | 2.00E+00 |
| Regulating temperature factor Q10 for small phytoplankton | q10P3X | 2.00E+00 | 2.00E+00 |
| Regulating temperature factor Q10 for large phytoplankton | q10P4X | 2.00E+00 | 2.00E+00 |
| Minimal iron to carbon ratio of diatoms [umol Fe/mg C] | qflP1cX | 5.00E-05 | 2.50E-04 |
| Minimal iron to carbon ratio of medium size phytoplankton [umol Fe/mg C] | qflP2cX | 1.00E-04 | 9.00E-05 |
| Minimal iron to carbon ratio of small phytoplankton [umol Fe/mg C] | qflP3cX | 1.50E-04 | 5.00E-05 |
| Minimal iron to carbon ratio of large phytoplankton [umol Fe/mg C] | qflP4cX | 5.00E-05 | 2.50E-04 |
| Maximal/optimal iron to carbon ratio of diatoms [umol Fe/mg C] | qfRP1cX | 5.00E-04 | 5.00E-04 |
| Maximal/optimal iron to carbon ratio of medium size phytoplankton [umol Fe/mg C] | qfRP2cX | 3.00E-04 | 3.00E-04 |
| Maximal/optimal iron to carbon ratio of small phytoplankton [umol Fe/mg C] | qfRP3cX | 5.00E-04 | 5.00E-04 |
| Maximal/optimal iron to carbon ratio of large phytoplankton [umol Fe/mg C] | qfRP4cX | 5.00E-04 | 5.00E-04 |
| Minimal nitrogen to carbon ratio for diatoms [mmol N/mg C] | qnlP1cX | 4.20E-03 | 6.87E-03 |
| Parameter | Notation | a | b |
| Minimal nitrogen to carbon ratio for medium size phytoplankton [mmol N/mg C] | qnlP2cX | 5.00E-03 | 6.87E-03 |
| Minimal nitrogen to carbon ratio for small phytoplankton [mmol N/mg C] | qnlP3cX | 6.00E-03 | 6.87E-03 |
| Minimal nitrogen to carbon ratio for large phytoplankton [mmol N/mg C] | qnlP4cX | 4.20E-03 | 6.87E-03 |
| Inverse Redfield ratio of nitrogen to carbon [mmol N/mg C] | qnRPIcX | 1.26E-02 | 1.26E-02 |
| Minimal phosphorus to carbon ratio for diatoms [mmol P/mg C] | qplP1cX | 1.00E-04 | 4.29E-04 |
| Minimal phosphorus to carbon ratio for medium size phytoplankton [mmol P/mg C] | qplP2cX | 2.25E-04 | 4.29E-04 |
| Minimal phosphorus to carbon ratio for small phytoplankton [mmol P/mg C] | qplP3cX | 3.50E-04 | 4.29E-04 |
| Minimal phosphorus to carbon ratio for large phytoplankton [mmol P/mg C] | qplP4cX | 1.00E-04 | 4.29E-04 |
| Inverse Redfield ratio of Phosphorus to carbon [mmol P/mg C] | qpRPIcX | 7.86E-04 | 7.86E-04 |
| Maximal silicon to carbon ratio of diatoms [mmol Si/mg C] | qsP1cX | 1.18E-02 | 3.00E-02 |
| Nitrate affinity of diatoms [m^3/mg C/d] | quP1n3X | 2.50E-03 | 2.50E-03 |
| Ammonium affinity of diatoms [m^3/mg C/d] | quP1n4X | 2.50E-03 | 1.00E-02 |
| Nitrate affinity of medium size phytoplankton [m^3/mg C/d] | quP2n3X | 4.00E-03 | 2.50E-03 |
| Ammonium affinity of medium size phytoplankton [m^3/mg C/d] | quP2n4X | 4.00E-03 | 1.00E-02 |
| Nitrate affinity of small phytoplankton [m^3/mg C/d] | quP3n3X | 6.00E-03 | 2.50E-03 |
| Ammonium affinity of small phytoplankton [m^3/mg C/d] | quP3n4X | 7.00E-03 | 2.00E-02 |
| Nitrate affinity of large phytoplankton [m^3/mg C/d] | quP4n3X | 2.00E-03 | 2.50E-03 |
| Ammonium affinity of large phytoplankton [m^3/mg C/d] | quP4n4X | 2.00E-03 | 1.00E-02 |
| Specific affinity constant of diatoms for iron [m^3/mg C/d] | qurP1fX | 3.00E-04 | 4.00E-04 |
| Phosphate affinity of diatoms [m^3/mg C/d] | qurP1pX | 3.00E-03 | 2.50E-03 |
| Specific affinity constant of medium size phytoplankton for iron [m^3/mg C/d] | qurP2fX | 4.00E-04 | 4.00E-04 |
| Phosphate affinity of medium size phytoplankton [m^3/mg C/d] | qurP2pX | 4.00E-03 | 2.50E-03 |
| Specific affinity constant of small phytoplankton for iron [m^3/mg C/d] | qurP3fX | 6.00E-04 | 4.00E-04 |
| Phosphate affinity of small phytoplankton [m^3/mg C/d] | qurP3pX | 6.00E-03 | 2.50E-03 |
| Specific affinity constant of large phytoplankton for iron [m^3/mg C/d] | qurP4fX | 2.00E-04 | 4.00E-04 |
| Phosphate affinity of large phytoplankton [m^3/mg C/d] | qurP4pX | 2.00E-03 | 2.50E-03 |
| Maximal subsiding velocity of diatoms [m/d] | resP1mX | 5.00E+00 | 5.00E+00 |
| Maximal subsiding velocity of medium size phytoplankton [m/d] | resP2mX | 0.00E+00 | 0.00E+00 |
| Maximal subsiding velocity of small phytoplankton [m/d] | resP3mX | 0.00E+00 | 0.00E+00 |
| Maximal subsiding velocity of large phytoplankton [m/d] | resP4mX | 5.00E+00 | 5.00E+00 |
| 1.1 of minimal specific lysis rate of diatoms [1/d] | sdoP1X | 5.00E-02 | 5.00E-02 |
| 1.1 of minimal specific lysis rate of medium size phytoplankton [1/d] | sdoP2X | 5.00E-02 | 5.00E-02 |
| 1.1 of minimal specific lysis rate of small phytoplankton [1/d] | sdoP3X | 5.50E-02 | 5.00E-02 |
| 1.1 of minimal specific lysis rate of large phytoplankton [1/d] | sdoP4X | 4.50E-02 | 5.00E-02 |
| Specific tendency of luxury uptake of nutrients towards maximum quota (1/d) | sNPlux | 1.00E+00 | 1.00E+00 |
| Specific rest respiration of diatoms at reference temperature [1/d] | srsP1X | 4.00E-02 | 5.00E-02 |
| Specific rest respiration of medium size phytoplankton at reference temperature [1/d] | srsP2X | 4.00E-02 | 5.00E-02 |
| Specific rest respiration of small phytoplankton at reference temperature [1/d] | srsP3X | 4.50E-02 | 5.00E-02 |
| Specific rest respiration of large phytoplankton at reference temperature [1/d] | srsP4X | 3.50E-02 | 5.00E-02 |
| Specific maximal productivity of diatoms at reference temperature [1/d] | sumP1X | 1.38E+00 | 2.50E+00 |
| Parameter | Notation | a | b |
| Specific maximal productivity of medium size phytoplankton at reference temperature [1/d] | sumP2X | 1.63E+00 | 2.70E+00 |
| Specific maximal productivity of small phytoplankton at reference temperature [1/d] | sumP3X | 2.00E+00 | 3.30E+00 |
| Specific maximal productivity of large phytoplankton at reference temperature [1/d] | sumP4X | 1.13E+00 | 1.50E+00 |
| Factor of qpRPIcX giving the threshold for phosphorus limitation of diatoms | xqcP1nX | 1.00E+00 | 1.00E+00 |
| Factor of qnRPIcX giving the threshold for nitrogen limitation of diatoms | xqcP1pX | 1.00E+00 | 1.00E+00 |
| Factor of qpRPIcX giving the threshold for phosphorus limitation of medium size phytoplankton | xqcP2nX | 1.00E+00 | 1.00E+00 |
| Factor of qnRPIcX giving the threshold for nitrogen limitation of medium size phytoplankton | xqcP2pX | 1.00E+00 | 1.00E+00 |
| Factor of qpRPIcX giving the threshold for phosphorus limitation of small phytoplankton | xqcP3nX | 1.00E+00 | 1.00E+00 |
| Factor of qnRPIcX giving the threshold for nitrogen limitation of small phytoplankton | xqcP3pX | 1.00E+00 | 1.00E+00 |
| Factor of qpRPIcX giving the threshold for phosphorus limitation of large phytoplankton | xqcP4nX | 1.00E+00 | 1.00E+00 |
| Factor of qnRPIcX giving the threshold for nitrogen limitation of large phytoplankton | xqcP4pX | 1.00E+00 | 1.00E+00 |
| Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for diatoms | xqnP1X | 1.08E+00 | 2.00E+00 |
| Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for medium size phytoplankton | xqnP2X | 1.08E+00 | 2.00E+00 |
| Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for small phytoplankton | xqnP3X | 1.05E+00 | 2.00E+00 |
| Factor of qnRPIcX giving the maximal nitrogen to carbon ratio for large phytoplankton | xqnP4X | 1.10E+00 | 2.00E+00 |
| Factor of qpRPIcX giving the maximal phosphorus to carbon ratio for diatoms | xqpP1X | 2.00E+00 | 2.00E+00 |
| Factor of qpRPIcX giving the maximal phosphorus to carbon ratio for medium size phytoplankton | xqpP2X | 2.00E+00 | 2.00E+00 |
| Factor of qpRPIcX giving the maximal phosphorus to carbon ratio for small phytoplankton | xqpP3X | 1.50E+00 | 2.00E+00 |
| Factor of qpRPIcX giving the maximal phosphorus to carbon ratio for large phytoplankton | xqpP4X | 2.70E+00 | 2.00E+00 |

Table S1. Parameterization of the PFTs in (a) Butenschön et al. [2016] and (b) in Blackford et al. [2004].