Supplement of

Seasonal to interannual variabilities of sea-air CO_2 exchange across Tropical Maritime Continent indicated by eddy-permitting coupled OGCM experiment

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S1: Formulation of low-trophic ecosystem model

Model employed in this study is primarily based on food web dynamic module in Nakamura et al. (2018) which uses governing equation from Kawamiya et al. (1995) and Kishi et al. (2001). The model simulates material transformation in oceanic low-trophic ecosystem level comprised of organic matter production by phytoplankton and zooplankton, mainly in the surface ocean, and remineralization/decomposition of organic matter across the depth. We extended the governing equation by introducing additional variables such as total dissolved inorganic carbon and total alkalinity which further can be used in calculating the sea surface pCO_2 and sea-air CO_2 flux. Calcification and $CaCO_3$ dissolution processes also explicitly calculated in this model. Compared with the initial form of governing equation, this model uses the carbon (C) as its main currency which held in constant C:N:P ratio. Other molecular ratio such as $N:O_2$ and $C:O_2$ also set to be constant. Modification from previous models results in 17 prognostic variables that calculated in each time step of the simulation experiment as shown in Table S1.

Table S1: Prognostic variables calculated in model

Variable	Description
Phytoplankton_01 (Phy_1)	Phytoplankton functional type 1 carbon biomass, assigned as diatom (μmolC L^{-1})
Phytoplankton_02 (Phy_2)	Phytoplankton functional type 2 carbon biomass, assigned as coccolithophore (μmolC L^{-1})
Phytoplankton_03 (Phy_3)	Phytoplankton functional type 3 carbon biomass, assigned as dinoflagellate (μmolC L^{-1})

Zooplankton	Zooplankton carbon biomass (μmolC L^{-1})
DIC	Total dissolved inorganic carbon (μmol kg^{-1})
Alkalinity	Total alkalinity (μmol kg^{-1})
DO	Dissolved Oxygen (μmol L^{-1})
PO4	Phosphate (μmol L^{-1})
NO3	Nitrate (μmol L^{-1})
NH4	Ammonium (μmol L^{-1})
DOC	Dissolved organic carbon, labile type (μmolC L^{-1})
DON	Dissolved organic nitrogen, labile type (μmolN L^{-1})
DOP	Dissolved organic phosphorus, labile type (μmolP L^{-1})
POC	Particulate organic carbon, detritus type (μmolC L^{-1})
PON	Particulate organic nitrogen, detritus type (μmolN L^{-1})
POP	Particulate organic phosphorus, detritus type (μmolP L^{-1})
CaCO3	Calcium carbonate (μmol L^{-1})

Net photosynthesis rate (P_{Net}) of each phytoplankton type is function of water temperature (T), photon flux density (I), nutrient limitation (A), and phytoplankton biomass concentration (Phy). The maximum photosynthesis rate at 0°C (P_0), optimum light intensity (I_0), nutrient half-saturation state (K_{NH4}, K_{NO3}, K_{PO4}) for each phytoplankton type are shown in Table 1. Net photosynthesis by phytoplankton results in nutrient uptake and oxygen release.

Gross photosynthetic rate

$$\mathrm{P_{Gross}} = \mathrm{P_0} \times \mathrm{e}^{(\mathrm{b_P} \times \mathrm{T})} \times \tanh\left(\frac{\mathrm{I}}{\mathrm{I_0}}\right) \times \mathrm{Phy}$$

Net photosynthetic rate

$$\mathrm{P_{Net}} = \mathrm{P_{Gross}} \times \mathrm{A}$$

$$\mathrm{A} = \mathrm{Min}\left(\frac{\mathrm{NH4}}{\mathrm{NH4} + \mathrm{K_{NH4}}} + \frac{\mathrm{NO3}}{(\mathrm{NO3} + \mathrm{K_{NO3}})} \times \mathrm{e}^{(-\psi \times \mathrm{NH4})}, \frac{\mathrm{PO4}}{\mathrm{PO4} + \mathrm{K_{PO4}}}\right)$$

Organic material excretion rate of each phytoplankton type is calculated as differences between gross photosynthetic rate and net photosynthetic rate. Excreted organic material directly supply the labile dissolved organic matter (DOM) pool.

$$\mathrm{DOC_{Excretion}} = \mathrm{P_{Gross}} - \mathrm{P_{Net}}$$

$$\mathrm{DOP_{Excretion}} = \mathrm{DOC_{Excretion}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{DON}_{\mathrm{Excretion}} = \mathrm{DOC}_{\mathrm{Excretion}} \times \frac{1}{\mathrm{r}_{\mathrm{C:N}}}$$

Both phytoplankton respiration rate ($\mathrm{R}_{\mathrm{Phy}}$) and mortality rate ($\mathrm{M}_{\mathrm{Phy}}$) are defined as function of water temperature and phytoplankton biomass concentration. Dead biomass of phytoplankton supplies the detritus particulate organic matter (POM) pool and immediately sink into deeper portion of the water column. We set the sinking velocity of the detritus POM as a constant of 23.3 m day^{-1}. Input to calcium carbonate pool (CaCO3) was calculated as fraction of coccolithophore dead biomass following formulation in Krumhardt et al. (2017, 2019). The fraction ($\mathrm{r}_{\mathrm{C:CaCO_3}}$) here is function of water temperature, dissolved CO_2 concentration, and nutrient limitation. Similar to POM, the $CaCO_3$ particles immediately sink into deeper layer with velocity of 22 m day^{-1}. The sinking velocity of detritus POM and $CaCO_3$ particles here are within range observed in previous studies (Jansen et al., 2002; McDonnell and Buesseler, 2010).

Phytoplankton respiration rate

$$\mathrm{R}_{\mathrm{Phy}} = \mathrm{R}_{0,\mathrm{Phy}} \times \mathrm{e}^{(\mathrm{b}_{\mathrm{R,Phy}} \times \mathrm{T})} \times \mathrm{Phy}$$

Net O_2 production rate from phytoplankton net photosynthesis and respiration

$$\mathrm{DO}_{\mathrm{Net,Phy}} = \left(\mathrm{P}_{\mathrm{Net}} - \mathrm{R}_{\mathrm{Phy}}\right) \times \frac{1}{\mathrm{r}_{\mathrm{C:O_2}}}$$

Phytoplankton mortality rate (Immediately enter POM pool)

$$\mathrm{POC}_{\mathrm{Mortality,Phy}} = \mathrm{M}_{\mathrm{Phy}} = \mathrm{M}_{0,\mathrm{Phy}} \times \mathrm{e}^{(\mathrm{b}_{\mathrm{M.Phy}} \times \mathrm{T})} \times \mathrm{Phy}^2$$

$$\mathrm{POP}_{\mathrm{Mortality,Phy}} = \mathrm{M}_{\mathrm{Phy}} \times \frac{1}{\mathrm{r}_{\mathrm{C:P}}}$$

$$\mathrm{PON}_{\mathrm{Mortality,Phy}} = \mathrm{M}_{\mathrm{Phy}} \times \frac{1}{\mathrm{r}_{\mathrm{C:N}}}$$

$CaCO_3$ particle production rate from coccolithophore dead biomass

$$\mathrm{CaCO3}_{\mathrm{coccolithophore}} = \mathrm{r}_{\mathrm{C:CaCO_3}} \times \mathrm{M}_{\mathrm{Phy,Coccolithophore}}$$

$$\mathrm{r}_{\mathrm{C:CaCO_3}} = 1.21 - \left(0.0136 \times \mathrm{CO}_{2(\mathrm{aq})}\right) + 0.48 \times (1 - \mathrm{A}) \quad \text{For } \mathrm{T} \geq 11℃$$

$$\mathrm{r}_{\mathrm{C:CaCO_3}} = (0.104 \times \mathrm{T}) - \left(0.0136 \times \mathrm{CO}_{2(\mathrm{aq})}\right) + 0.48 \times (1 - \mathrm{A}) \quad \text{For } \mathrm{T} < 11℃$$

Nutrient uptake related to phytoplankton photosynthesis reaction and respiration calculated using below formula. Negative and positive value in the calculation indicates nutrient uptake and release, respectively.

$$\mathrm{DIC}_{\mathrm{uptake}} = \left(-\mathrm{P}_{\mathrm{Net}} + \mathrm{R}_{\mathrm{Phy}}\right)$$

$$\mathrm{PO4}_{\mathrm{uptake}} = \left(-\mathrm{P}_{\mathrm{Net}} + \mathrm{R}_{\mathrm{Phy}}\right) \times \frac{1}{\mathrm{r}_{\mathrm{C:P}}}$$

$$\mathrm{NH4_{uptake}} = \left(-\mathrm{P_{Net}} + \mathrm{R_{Phy}}\right) \times \frac{1}{\mathrm{r_{C:N}}} \times \left(\frac{\frac{\mathrm{NH4}}{\mathrm{NH4} + \mathrm{K_{NH4}}}}{\frac{\mathrm{NH4}}{\mathrm{NH4} + \mathrm{K_{NH4}}} + \frac{\mathrm{NO3}}{(\mathrm{NO3} + \mathrm{K_{NO3}})} \times \mathrm{e}^{(-\psi \times \mathrm{NH4})}} \right)$$

$$\mathrm{NO3_{uptake}} = \left(-\mathrm{P_{Net}} + \mathrm{R_{Phy}}\right) \times \frac{1}{\mathrm{r_{C:N}}} \times \left(\frac{\frac{\mathrm{NO3}}{(\mathrm{NO3} + \mathrm{K_{NO3}})} \times \mathrm{e}^{(-\psi \times \mathrm{NH4})}}{\frac{\mathrm{NH4}}{\mathrm{NH4} + \mathrm{K_{NH4}}} + \frac{\mathrm{NO3}}{(\mathrm{NO3} + \mathrm{K_{NO3}})} \times \mathrm{e}^{(-\psi \times \mathrm{NH4})}} \right)$$

Phytoplankton grazing rate by zooplankton ($\mathrm{G_{Zoo,Phy}}$), in addition being controlled water temperature also controlled by phytoplankton grazing threshold value (Phy*) defined in Table 1. Grazing efficiency ($\varepsilon_{\mathrm{Zoo,Phy}}$) was introduced which determine particulate organic matter egested from the process.

Phytoplankton grazing by zooplankton

$$\mathrm{G_{Zoo,Phy}} = \mathrm{G_{0,Phy}} \times \mathrm{e}^{\left(\mathrm{b_{G,Phy}} \times \mathrm{T}\right)} \times \left(1 - \mathrm{e}^{\lambda(\mathrm{Phy}^{*} - \mathrm{Phy})}\right) \times \mathrm{Zoo} \times \varepsilon_{\mathrm{Zoo,Phy}}$$

POM egestion by zooplankton

$$\mathrm{POC_{Egestion}} = \mathrm{G_{Zoo,Phy}} \times \left(1 - \varepsilon_{\mathrm{Zoo,Phy}}\right)$$

$$\mathrm{POP_{Egestion}} = \mathrm{G_{Zoo,Phy}} \times \left(1 - \varepsilon_{\mathrm{Zoo,Phy}}\right) \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{PON_{Egestion}} = \mathrm{G_{Zoo,Phy}} \times \left(1 - \varepsilon_{\mathrm{Zoo,Phy}}\right) \times \frac{1}{\mathrm{r_{C:N}}}$$

In addition to the phytoplankton, zooplankton in this model also consumes dissolved organic matter ($\mathrm{G_{Zoo,DOM}}$) and particulate organic matter ($\mathrm{G_{Zoo,POM}}$). Similarly, the POM and DOM grazing by phytoplankton are constrained by grazing efficiency ($\varepsilon_{\mathrm{Zoo,POM}}$, $\varepsilon_{\mathrm{Zoo,DOM}}$).

DOM grazing by zooplankton

$$\mathrm{G_{Zoo,DOC}} = \mathrm{G_{0,DOC}} \times \mathrm{e}^{\left(\mathrm{b_{G,DOC}} \times \mathrm{T}\right)} \times \mathrm{DOC} \times \mathrm{Zoo} \times \varepsilon_{\mathrm{Zoo,DOM}}$$

$$\mathrm{G_{Zoo,DOP}} = \mathrm{G_{Zoo,DOC}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{G_{Zoo,DON}} = \mathrm{G_{Zoo,DON}} \times \frac{1}{\mathrm{r_{C:N}}}$$

POM grazing by zooplankton

$$\mathrm{G_{Zoo,POC}} = \mathrm{G_{0,POC}} \times \mathrm{e}^{\left(\mathrm{b_{G,POC}} \times \mathrm{T}\right)} \times \mathrm{POC} \times \mathrm{Zoo} \times \varepsilon_{\mathrm{Zoo,POM}}$$

$$\mathrm{G_{Zoo,POP}} = \mathrm{G_{Zoo,POC}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{G_{Zoo,PON}} = \mathrm{G_{Zoo,POC}} \times \frac{1}{\mathrm{r_{C:N}}}$$

Respiration rate ($\mathrm{R_{Zoo}}$) and mortality rate ($\mathrm{M_{Zoo}}$) for zooplankton follows the same equation as in Phytoplankton. A tiny fraction of zooplankton dead biomass also goes into CaCO3 pool with static fraction value followed Ishizu et al. (2019,2020).

Zooplankton respiration rate

$$\mathrm{R_{Zoo}} = \mathrm{R_{0,Zoo}} \times \mathrm{e}^{(\mathrm{b_{R,Zoo}} \times \mathrm{T})} \times \mathrm{Zoo}$$

Oxygen uptake rate by zooplankton respiration

$$\mathrm{DO_{Net,Zoo}} = -\mathrm{R_{Zoo}} \times \frac{1}{\mathrm{r_{C:O_2}}}$$

Zooplankton mortality rate

$$\mathrm{POC_{Mortality,Zoo}} = \mathrm{M_{Zoo}} = \mathrm{M_{0,Zoo}} \times \mathrm{e}^{(\mathrm{b_{M.Zoo}} \times \mathrm{T})} \times \mathrm{Zoo}^2$$

$$\mathrm{POP_{Mortality,Zoo}} = \mathrm{POC_{Mortality,Zoo}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{PON_{Mortality,Zoo}} = \mathrm{POC_{Mortality,Zoo}} \times \frac{1}{\mathrm{r_{C:N}}}$$

$CaCO_3$ input from zooplankton dead biomass

$$\mathrm{CaCO3_{zooplankton}} = 0.035 \times \mathrm{M_{Zoo}}$$

Decomposition of organic matter ($\mathrm{D_{POM\rightarrow DIM}}, \mathrm{D_{POM\rightarrow DOM}}, \mathrm{D_{DOM\rightarrow DIM}}$) from phytoplankton and zooplankton reaction calculated as function of water temperature. Oxygen was consumed in this process.

Decomposition from POM to DIM

$$\mathrm{D_{POC\rightarrow DIC}} = \mathrm{D_{0,POC\rightarrow DIC}} \times \mathrm{e}^{(\mathrm{b_{D,POC-DIC}} \times \mathrm{T})} \times \mathrm{POC}$$

$$\mathrm{D_{POP\rightarrow PO4}} = \mathrm{D_{POC\rightarrow DIC}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{D_{PON\rightarrow NH4}} = \mathrm{D_{POC\rightarrow DIC}} \times \frac{1}{\mathrm{r_{C:N}}}$$

Oxygen uptake by decomposition of POM→DIM

$$\mathrm{DO_{POM\rightarrow DIM}} = -\mathrm{D_{POC\rightarrow DIC}} \times \frac{1}{\mathrm{r_{C:O_2}}}$$

Decomposition from POM to DOM

$$\mathrm{D_{POC\rightarrow DOC}} = \mathrm{D_{0,POC\rightarrow DOC}} \times \mathrm{e}^{(\mathrm{b_{D,POC-DOC}} \times \mathrm{T})} \times \mathrm{POC}$$

$$\mathrm{D_{POP\rightarrow DOP}} = \mathrm{D_{POC\rightarrow DOC}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{D_{PON\rightarrow DON}} = \mathrm{D_{POC\rightarrow DOC}} \times \frac{1}{\mathrm{r_{C:N}}}$$

Oxygen uptake by decomposition of POM→DOM

$$\mathrm{DO_{POM\rightarrow DOM}} = -\mathrm{D_{POC\rightarrow DOC}} \times \frac{1}{\mathrm{r_{C:O_2}}}$$

Decomposition from DOM to DIM

$$\mathrm{D_{DOC\rightarrow DIC}} = \mathrm{D_{0,DOC\rightarrow DIC}} \times \mathrm{e}^{(\mathrm{b_{D,DOC}} \times \mathrm{T})} \times \mathrm{DOC}$$

$$\mathrm{D_{DOP\rightarrow PO4}} = \mathrm{D_{DOC\rightarrow DIC}} \times \frac{1}{\mathrm{r_{C:P}}}$$

$$\mathrm{D_{DON\rightarrow NH4}} = \mathrm{D_{DOC\rightarrow DIC}} \times \frac{1}{\mathrm{r_{C:N}}}$$

Oxygen uptake by decomposition of DOM→DIM

$$\mathrm{DO_{DOM\rightarrow DIM}} = -\mathrm{D_{DOC\rightarrow DIC}} \times \frac{1}{\mathrm{r_{C:O_2}}}$$

Dissolution of $CaCO_3$ particle was calculated by applying the first-order reaction equation. Calcite saturation state (Ω) is calculated as function of carbonate ion concentration, water temperature, and salinity following Mucci and Morse (1984). Net change in $CaCO_3$ caused by this food web dynamics now can be calculated as sum between $CaCO_3$ dissolution and input from both zooplankton and phytoplankton.

$$\mathrm{Dissolution} = 10 \times (1 - \Omega) \times \mathrm{CaCO3}$$

$$\frac{\partial}{\partial t}(\mathrm{CaCO3}) = \mathrm{CaCO3input} - \mathrm{Dissolution}$$

Nitrate in the model resupplied through nitrification of ammonium which consumes oxygen during the process

$$\mathrm{Nitrification} = \mathrm{k_{Nit}} \times \mathrm{e}^{(\mathrm{b_N} \times \mathrm{T})} \times \mathrm{NH4}$$

$$\mathrm{DO_{Nit}} = -\mathrm{Nitrification} \times \frac{1}{\mathrm{r_{N:O_2}}}$$

Results from above equations are used in following mass balance equations which determine the net change of each prognostic variable during model integration. We follow assumption in Ishizu et al. (2019, 2020) on the fraction in dissolved inorganic nitrogen (NH4 and NO3 in this model) which corresponds to changes in alkalinity.

Phytoplankton and zooplankton carbon biomass balance equation

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{Phytoplankton}) = \mathrm{P_{Net}} - \mathrm{R_{Phy}} - \mathrm{M_{Phy}} - \mathrm{G_{Zoo,Phy}}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{Zooplankton}) = -\mathrm{R_{Phy}} - \mathrm{M_{Phy}} + \mathrm{G_{Zoo,Phy}} + \mathrm{G_{Zoo,POC}} + \mathrm{G_{Zoo,DOC}}$$

Detritus POM mass balance equation

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{POC}) = \mathrm{POC}_{\mathrm{Mortality,Phy}} + \mathrm{POC}_{\mathrm{Mortality,Zoo}} + \mathrm{POC}_{\mathrm{Egestion}} - \mathrm{G}_{\mathrm{Zoo,POC}} - \mathrm{D}_{\mathrm{POC}\to\mathrm{DIC}} - \mathrm{D}_{\mathrm{POC}\to\mathrm{DOC}}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{POP}) = \mathrm{POP}_{\mathrm{Mortality,Phy}} + \mathrm{POP}_{\mathrm{Mortality,Zoo}} + \mathrm{POP}_{\mathrm{Egestion}} - \mathrm{G}_{\mathrm{Zoo,POP}} - \mathrm{D}_{\mathrm{POP}\to\mathrm{PO4}} - \mathrm{D}_{\mathrm{POP}\to\mathrm{DOP}}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{PON}) = \mathrm{PON}_{\mathrm{Mortality,Phy}} + \mathrm{PON}_{\mathrm{Mortality,Zoo}} + \mathrm{PON}_{\mathrm{Egestion}} - \mathrm{G}_{\mathrm{Zoo,PON}} - \mathrm{D}_{\mathrm{PON}\to\mathrm{NH4}} - \mathrm{D}_{\mathrm{PON}\to\mathrm{DON}}$$

Labile DOM mass balance equation

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{DOC}) = \mathrm{DOC}_{\mathrm{Excretion}} + \mathrm{D}_{\mathrm{POC}\to\mathrm{DOC}} - \mathrm{G}_{\mathrm{Zoo,DOC}} - \mathrm{D}_{\mathrm{DOC}\to\mathrm{DIC}}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{DOP}) = \mathrm{DOP}_{\mathrm{Excretion}} + \mathrm{D}_{\mathrm{POP}\to\mathrm{DOP}} - \mathrm{G}_{\mathrm{Zoo,DOP}} - \mathrm{D}_{\mathrm{DOP}\to\mathrm{PO4}}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{DON}) = \mathrm{DON}_{\mathrm{Excretion}} + \mathrm{D}_{\mathrm{PON}\to\mathrm{DON}} - \mathrm{G}_{\mathrm{Zoo,DON}} - \mathrm{D}_{\mathrm{DON}\to\mathrm{NH4}}$$

Inorganic material compound mass balance equation

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{DIC}) = \mathrm{DIC}_{\mathrm{uptake}} + \mathrm{D}_{\mathrm{POC}\to\mathrm{DIC}} + \mathrm{D}_{\mathrm{DOC}\to\mathrm{DIC}} - \frac{\partial}{\partial \mathrm{t}}(\mathrm{CaCO3})$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{PO4}) = \mathrm{PO4}_{\mathrm{uptake}} + \mathrm{D}_{\mathrm{POP}\to\mathrm{PO4}} + \mathrm{D}_{\mathrm{DOP}\to\mathrm{PO4}}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{NH4}) = \mathrm{NH4}_{\mathrm{uptake}} + \mathrm{D}_{\mathrm{PON}\to\mathrm{NH4}} + \mathrm{D}_{\mathrm{DON}\to\mathrm{NH4}} - \mathrm{Nitrification}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{NO3}) = \mathrm{NO3}_{\mathrm{uptake}} + \mathrm{Nitrification}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{Alkalinity}) = -2 \times \frac{\partial}{\partial \mathrm{t}}(\mathrm{CaCO3}) - 0.001 \times \left(\frac{\partial}{\partial \mathrm{t}}(\mathrm{NH4}) + \frac{\partial}{\partial \mathrm{t}}(\mathrm{NO3})\right)$$

Dissolved oxygen mass balance equation

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{DO}) = \mathrm{DO}_{\mathrm{Net,Phy}} + \mathrm{DO}_{\mathrm{Net,Zoo}} + \mathrm{DO}_{\mathrm{POM}\to\mathrm{DIM}} + \mathrm{DO}_{\mathrm{POM}\to\mathrm{DOM}} + \mathrm{DO}_{\mathrm{DOM}\to\mathrm{DIM}} + \mathrm{DO}_{\mathrm{Nit}}$$

Necessary parameters value for model calculation are provided in Table S2.

Table S2: Summary of other model parameters not shown in Table 1

Parameter	Description	Value

b_P	Temperature coefficient for phytoplankton photosynthesis, uniformly set across all phytoplankton type (in ^{o}C^{-1})	0.069
ψ	Ammonium inhibition coefficient (in L µmolC^{-1})	0.010
$R_{0,Phy}$	Maximum phytoplankton respiration rate at 0^{o}C, uniformly set across all phytoplankton type (in day^{-1})	0.030
$b_{R,Phy}$	Temperature coefficient for phytoplankton respiration, uniformly set across all phytoplankton type (in ^{o}C^{-1})	0.052
$M_{0,Phy}$	Maximum mortality rate at 0^{o}C, set uniformly across all phytoplankton type (in µmol^{-1} day^{-1})	0.006
$b_{M.Phy}$	Temperature coefficient for phytoplankton mortality, set uniformly across all phytoplankton type (in ^{o}C^{-1})	0.069
$b_{G,Phy}$	Temperature coefficient for phytoplankton grazing by zooplankton, uniformly set across all phytoplankton type (in ^{o}C^{-1})	0.069
$\varepsilon_{Zoo,Phy}$	Phytoplankton grazing efficiency	0.300
λ	Zooplankton Ivlev constant (in µmolC L^{-1})	0.211
$G_{0,DOC}$	DOC grazing rate by zooplankton at 0^{o}C (in day-1)	0.100
$b_{G,DOC}$	Temperature coefficient for DOC grazing by zooplankton (in ^{o}C^{-1})	0.069
$\varepsilon_{Zoo,DOM}$	DOM grazing efficiency	0.010
$G_{0,POC}$	POC grazing rate by zooplankton at 0^{o}C (in day-1)	0.100
$b_{G,POC}$	Temperature coefficient for POC grazing by zooplankton (in ^{o}C^{-1})	0.069
$\varepsilon_{Zoo,POM}$	POM grazing efficiency	0.100
$R_{0,Zoo}$	Temperature coefficient for zooplankton respiration (in ^{o}C^{-1})	0.005
$D_{0,POC\rightarrow DIC}$	POC to DIC decomposition rate at 0^{o}C (in day-1)	0.003
$b_{D,POC\rightarrow DIC}$	Temperature coefficient for POC to DIC decomposition (in ^{o}C^{-1})	0.069
$D_{0,POC\rightarrow DOC}$	POC to DOC decomposition rate at 0^{o}C (in day-1)	0.003
$b_{D,POC\rightarrow DOC}$	Temperature coefficient for POC to DOC decomposition (in ^{o}C^{-1})	0.069
$D_{0,DOC\rightarrow DIC}$	DOC to DIC decomposition rate at 0^{o}C (in day-1)	0.003
$b_{DOC\rightarrow DIC}$	Temperature coefficient for DOC to DIC decomposition (in ^{o}C^{-1})	0.069
k_{Nit}	Nitrification rate at 0^{o}C	0.030
b_N	Temperature coefficient for nitrification	0.069
$r_{C:N}$	C:N ratio	9.2
$r_{C:P}$	C:P ratio	131.9

$r_{C:O_2}$	C:O_2 ratio	117/170
$r_{N:O_2}$	N:O_2 ratio	16/170