ERGOM (2.00a1 experimental POCN, POCP) Documentation

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Contents

1 Introduction

This is an automatically generated description of the ecosystem model ERGOM version 2.00a1 experimental POCN, POCP . Model formulation is provided by text files in compliance with the rules of the Code Generation Tool (CGT) by Hagen Radtke (see www.ergom.net).

The model consists of a set of state variables, the so called tracers. They are defined and described in Chapter 2.

The following Chapter 3 is the main part of this model description document, since it describes the processes which change the tracer concentrations over time. They are defined analog to chemical processes, two components describe their action:

- A process equation which describes the transformation from precursors (on the left-hand side) to products (on the right-hand side), and
- a turnover rate, describing how fast the process runs.

The rate at which a process changes a tracer can then easily be determined by multiplying the process turnover rate with the stochiometric ratio in which it consumes or produces the tracer according to the reaction equation.

We structured the documentation into different process types to keep the documentation readable. So all processes belonging to one type (e.g. phytoplankton assimilation) are listed together with their constants and auxiliary variables they depend on. This means that some constants, such as stochiometric ratios, will occur several times in this documentation, making it longer. We take this compromise for the sake of readability, keeping all information required to understand a specific process in its own section.

The classical way of describing an ecosystem model is by giving the tracer equations. We still do this in the last chapter for the sake of completeness, but rather suggest to stick to Chapter 3 to understand the model, and see Chapter 4 as a supplement only.

2 Description of model state variables (tracers)

Tracers in the water column only	
t_n2	**dissolved molecular nitrogen (mol/kg)**
t_o2	**dissolved oxygen (mol/kg)**
t_dic	**dissolved inorganic carbon, treated as carbon dioxide (mol/kg)**
t_nh4	**ammonium (mol/kg)**
t_no3	**nitrate (mol/kg)**
t_po4	**phosphate (mol/kg)**
t_spp	**small-cell phytoplankton (mol/kg)**
opacity =	58.0 m^2/mol
t_zoo	**zooplankton (mol/kg)**
t_h2s	**hydrogen sulfide (mol/kg)**
t_sul	**sulfur (mol/kg)**
t_alk	**total alkalinity (mol/kg)**
t_doc	**dissolved organic carbon (mol/kg)**
t_dop	**phosphorus in dissolved organic carbon in Redfield ratio (mol/kg)**
total_atmos_tot_N	**total__atmos__tot__N (mol/kg)**
total_atmos_ship_N	**total__atmos__ship__N (mol/kg)**
t_n2_with_atmos_tot	**dissolved molecular nitrogen; containing nitrogen from (total) atmospheric deposition (mol/kg)**
t_nh4_with_atmos_tot	**ammonium; containing nitrogen from (total) atmospheric deposition (mol/kg)**

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Tracers in the water column only, continued from previous page	
t_no3_with_atmos_tot	**nitrate; containing nitrogen from (total) atmospheric deposition (mol/kg)**
t_spp_with_atmos_tot	**small-cell phytoplankton; containing nitrogen from (total) atmospheric deposition (mol/kg)**
t_zoo_with_atmos_tot	**zooplankton; containing nitrogen from (total) atmospheric deposition (mol/kg)**
t_n2_with_atmos_ship	**dissolved molecular nitrogen; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
t_nh4_with_atmos_shi	**ammonium; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
t_no3_with_atmos_shi	**nitrate; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
t_spp_with_atmos_shi	**small-cell phytoplankton; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
t_zoo_with_atmos_shi	**zooplankton; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
t_ipw	**suspended iron phosphate (mol/kg)**
vertical speed =	-1.0 m/day
t_pocn_with_atmos_to	**nitrogen in particulate organic carbon in Redfield ratio; containing nitrogen from (total) atmospheric deposition (mol/kg)**
vertical speed =	-0.1 m/day
t_lpp_with_atmos_tot	**large-cell phytoplankton; containing nitrogen from (total) atmospheric deposition (mol/kg)**
vertical speed =	-0.5 m/day
t_don_with_atmos_tot	**nitrogen in dissolved organic carbon in Redfield ratio; containing nitrogen from (total) atmospheric deposition (mol/kg)**

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Tracers in the water column only, continued from previous page	
vertical speed =	-0.1 m/day
t_cya_with_atmos_tot	**diazotroph cyanobacteria; containing nitrogen from (total) atmospheric deposition (mol/kg)**
vertical speed =	1.0 m/day
t_det_with_atmos_tot	**detritus; containing nitrogen from (total) atmospheric deposition (mol/kg)**
vertical speed =	-4.5 m/day
t_lpp	**large-cell phytoplankton (mol/kg)**
vertical speed =	-0.5 m/day
opacity =	58.0 m^2/mol
t_don	**nitrogen in dissolved organic carbon in Redfield ratio (mol/kg)**
vertical speed =	-0.1 m/day
opacity =	12.6 m^2/mol
t_cya	**diazotroph cyanobacteria (mol/kg)**
vertical speed =	1.0 m/day
opacity =	58.0 m^2/mol
t_det	**detritus (mol/kg)**
vertical speed =	-4.5 m/day
opacity =	53.2 m^2/mol
t_poc	**particulate organic carbon (mol/kg)**
vertical speed =	-0.2 m/day
t_pocp	**phosphorus in particulate organic carbon in Redfield ratio (mol/kg)**
vertical speed =	-0.1 m/day
t_pocn	**nitrogen in particulate organic carbon in Redfield ratio (mol/kg)**
vertical speed =	-0.1 m/day
t_pocn_with_atmos_sh	**nitrogen in particulate organic carbon in Redfield ratio; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
vertical speed =	-0.1 m/day
t_lpp_with_atmos_shi	**large-cell phytoplankton; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**

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Tracers in the water column only, continued from previous page	
vertical speed =	-0.5 m/day
t_don_with_atmos_shi	**nitrogen in dissolved organic carbon in Redfield ratio; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
vertical speed =	-0.1 m/day
t_cya_with_atmos_shi	**diazotroph cyanobacteria; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
vertical speed =	1.0 m/day
t_det_with_atmos_shi	**detritus; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/kg)**
vertical speed =	-4.5 m/day

Tracers in water and pore water	

Tracers in fluff and sediment	
t_sed	**sediment detritus (mol/m^2)**
t_ips	**iron phosphate in sediment (mol/m^2)**
t_sed_poc	**sediment particular carbon (mol/m^2)**
t_sed_pocn	**sediment particular organic N+C (mol/m^2)**
t_sed_pocp	**sediment particular organic P+C (mol/m^2)**
total_atmos_tot_N_at	**total__atmos__tot__N__at__bottom (mol/m^2)**
total_atmos_ship_N_a	**total__atmos__ship__N__at__bottom (mol/m^2)**
t_sed_with_atmos_tot	**sediment detritus; containing nitrogen from (total) atmospheric deposition (mol/m^2)**
t_sed_pocn_with_atmo	**sediment particular organic N+C; containing nitrogen from (total) atmospheric deposition (mol/m^2)**
t_sed_with_atmos_shi	**sediment detritus; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/m^2)**
t_sed_pocn_with_atmo	**sediment particular organic N+C; containing nitrogen from atmospheric deposition, which has been previously emitted by ships (mol/m^2)**

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Tracers in fluff and sediment, continued from previous page

3 Description of model processes, ordered by process type

3.1 Process type BGC/benthic/bioresuspension

Processes
bio resuspension of sedimentary detritus (sediment only) [mol/m^2/day]
`t_sed -> t_det`
`p_sed_biores_det = (r_biores*exp(-0.02*cgt_bottomdepth)*sed_active)* lim_t_o2_6*lim_t_sed_20`
bio resuspension of iron PO4 (sediment only) [mol/m^2/day]
`t_ips -> t_ipw`
`p_ips_biores_ipw = (r_biores*exp(-0.02*cgt_bottomdepth)*t_ips)*lim_t_o2_6* lim_t_ips_22`
bio resuspension of sedimentary poc (sediment only) [mol/m^2/day]
`t_sed_poc -> t_poc`
`p_sed_biores_poc = (r_biores*exp(-0.02*cgt_bottomdepth)*poc_active)* lim_t_o2_6*lim_t_sed_poc_21`
bio resuspension of sedimentary pocn (sediment only) [mol/m^2/day]
`t_sed_pocn -> t_pocn`
`p_sed_biores_pocn = (r_biores*exp(-0.02*cgt_bottomdepth)*pocn_active)* lim_t_o2_6*lim_t_sed_pocn_26`
bio resuspension of sedimentary pocp (sediment only) [mol/m^2/day]
`t_sed_pocp -> t_pocp`
`p_sed_biores_pocp = (r_biores*exp(-0.02*cgt_bottomdepth)*pocp_active)* lim_t_o2_6*lim_t_sed_pocp_27`
bio resuspension of sedimentary detritus; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]
`-> t_det_with_atmos_tot_N`
`p_sed_biores_det_atm = p_sed_biores_det * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_tot_N/max(0.00000000001,t_sed) ))) / ((1.0)*(1))`
bio resuspension of sedimentary pocn; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]
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Processes, continued from previous page	
-> t_pocn_with_atmos_tot_N	
p_sed_biores_pocn_atmax =	p_sed_biores_pocn * ((1.0)*(1)*max(0.0,min(1.0,t_sed_pocn_with_atmos_tot_N/max(0.00000000001,t_sed_pocn)))) / ((1.0)*(1))
bio resuspension of sedimentary detritus; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]	
-> t_det_with_atmos_ship_N	
p_sed_biores_det_atmmax =	p_sed_biores_det * ((1.0)*(1)*max(0.0,min(1.0,t_sed_with_atmos_ship_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))
bio resuspension of sedimentary pocn; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]	
-> t_pocn_with_atmos_ship_N	
p_sed_biores_pocn_atmax =	p_sed_biores_pocn * ((1.0)*(1)*max(0.0,min(1.0,t_sed_pocn_with_atmos_ship_N/max(0.00000000001,t_sed_pocn))) / ((1.0)*(1))

Auxiliary variables	
total carbon in sediment layer [mol/m2]**	
sed_tot =	t_sed*rfr_c + t_sed_poc + t_sed_pocn*rfr_c + t_sed_pocp*rfr_cp
total carbon in active sediment layer [mol/m2]**	
sed_tot_active =	max(0.0,min(sed_tot,sed_max*rfr_c))
detritus in active sediment layer [mol/m2]**	
sed_active =	sed_tot_active * t_sed/sed_tot
poc in active sediment layer [mol/m2]**	
poc_active =	sed_tot_active * t_sed_poc/sed_tot
pocn in active sediment layer [mol/m2]**	
pocn_active =	sed_tot_active * t_sed_pocn/sed_tot
pocp in active sediment layer [mol/m2]**	
pocp_active =	sed_tot_active * t_sed_pocp/sed_tot

Constants	
oxygen half-saturation constant for recycling of sediment detritus using oxygen [mol/kg]	
o2_min_sed_resp =	0.000064952
bio-resuspension rate [1/day]	
r_biores =	0.015

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Constants, continued from previous page	
redfield ratio C/N	
rfr_c =	6.625
redfield ratio C/P	
rfr_cp =	106.0
maximum sediment detritus concentration that feels erosion [mol/m2]**	
sed_max =	1.0

Process limitation factors	
lim_t_o2_6 =	t_o2*t_o2/(t_o2*t_o2+o2_min_sed_resp*o2_min_sed_resp)
lim_t_sed_20 =	theta(t_sed-0.0)
lim_t_ips_22 =	theta(t_ips-0.0)
lim_t_sed_poc_21 =	theta(t_sed_poc-0.0)
lim_t_sed_pocn_26 =	theta(t_sed_pocn-0.0)
lim_t_sed_pocp_27 =	theta(t_sed_pocp-0.0)

3.2 Process type BGC/benthic/mineralisation

Processes
recycling of sedimentary detritus to ammonium using oxygen (respiration) (sediment only) [mol/m^2/day]
`0.8125*h3oplus + 6.625*t_o2 + t_sed -> 7.4375*h2o + rfr_c*t_dic + rfr_p*t_po4 + t_nh4`
`p_sed_resp_nh4 = (lr_sed_rec*sed_active)*lim_t_o2_2*lim_t_sed_20`
coupled nitrification and denitrification after mineralization of detritus in oxic sediments (sediment only) [mol/m^2/day]
`0.75*t_o2 + t_nh4 -> 0.5*t_n2 + h3oplus + 0.5*h2o`
`p_nh4_nitdenit_n2 = (frac_denit_sed*p_sed_resp_nh4*theta(t_o2-5.0e-6))* lim_t_o2_2*lim_t_nh4_11`
recycling of sedimentary detritus to ammonium using nitrate (denitrification) (sediment only) [mol/m^2/day]
`6.1125*h3oplus + t_sed -> 15.3875*h2o + t_nh4 + rfr_p*t_po4 + rfr_c*t_dic`
`p_sed_denit_nh4_noN2 = (lr_sed_rec*sed_active)*(1.0-lim_t_o2_2)*lim_t_no3_3* lim_t_sed_20`
recycling of sedimentary detritus to ammonium using nitrate (denitrification) (sediment only) [mol/m^2/day]
`5.3*t_no3 -> 2.65*t_n2`
`p_sed_denit_nh4_wiN2 = (lr_sed_rec*sed_active)*(1.0-lim_t_o2_2)*lim_t_no3_3`
recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction) (sediment only) [mol/m^2/day]
`7.4375*h3oplus + 3.3125*so4 + t_sed -> 14.0625*h2o + 3.3125*t_h2s + rfr_c*t_dic + rfr_p*t_po4 + t_nh4`
`p_sed_sulf_nh4 = (lr_sed_rec*sed_active)*(1.0-lim_t_o2_2)*(1.0-lim_t_no3_3)* lim_t_sed_20`
recycling of sedimentary poc to dic using oxygen (respiration) (sediment only) [mol/m^2/day]
`t_sed_poc + t_o2 -> t_dic + h2o`
`p_sed_poc_resp = (lr_sed_rec*poc_active)*lim_t_sed_poc_21*lim_t_o2_2`
recycling of sedimentary poc to dic using nitrate (denitrification) (sediment only) [mol/m^2/day]
`t_sed_poc + 0.8*h3oplus + 0.8*t_no3 -> t_dic + 0.4*t_n2 + 2.2*h2o`
`p_sed_poc_denit = (lr_sed_rec*poc_active)*(1.0-lim_t_o2_2)*lim_t_no3_3* lim_t_sed_poc_21`
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Processes, continued from previous page

recycling of sedimentary poc to dic using sulfate (sulfate reduction) (sediment only) [mol/m^2/day]

```
h3oplus + 0.5*so4 + t_sed_poc -> 2.0*h2o + 0.5*t_h2s + t_dic
p_sed_poc_sulf =    (lr_sed_rec*poc_active)*(1.0-lim_t_o2_2)*(1.0-lim_t_no3_3)*
                    lim_t_sed_poc_21
```

recycling of sedimentary pocn to dic and NH4 using oxygen (respiration) (sediment only) [mol/m^2/day]

```
0.5*h3oplus + t_sed_pocn + 6.625*t_o2 -> 0.5*ohminus + t_nh4 + 6.625*t_dic +
6.625*h2o
p_sed_pocn_resp =   (lr_sed_rec*pocn_active)*lim_t_sed_pocn_26*lim_t_o2_2
```

recycling of sedimentary pocp to dic and PO4 using oxygen (respiration) (sediment only) [mol/m^2/day]

```
106*t_o2 + t_sed_pocp + 3*h2o -> 3*h3oplus + 106*t_dic + t_po4 + 106*h2o
p_sed_pocp_resp =   (lr_sed_rec*pocp_active)*lim_t_o2_2*lim_t_sed_pocp_27
```

recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification) (sediment only) [mol/m^2/day]

```
5.8*h2o + t_sed_pocn -> 0.5*ohminus + 14.575*h2o + t_nh4 + 6.625*t_dic
                    (lr_sed_rec*pocn_active)*(1.0-lim_t_o2_2)*lim_t_no3_3*
p_sed_pocn_denit_noNlim_t_sed_pocn_26
=
```

recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification) (sediment only) [mol/m^2/day]

```
5.3*t_no3 -> 2.65*t_n2
                    (lr_sed_rec*pocn_active)*(1.0-lim_t_o2_2)*lim_t_no3_3
p_sed_pocn_denit_wiN
=
```

recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification) (sediment only) [mol/m^2/day]

```
t_sed_pocp + 3*ohminus + 84.8*h3oplus + 84.8*t_no3 -> 106*t_dic + t_po4 + 42.4*
t_n2 + 236.2*h2o
p_sed_pocp_denit =  (lr_sed_rec*pocp_active)*(1.0-lim_t_o2_2)*lim_t_no3_3*
                    lim_t_sed_pocp_27
```

recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction) (sediment only) [mol/m^2/day]

```
t_pocn + 3.3125*SO4 + 7.125*h3oplus -> 6.625*t_dic + t_nh4 + 3.3125*t_h2s +
13.25*H2O + 0.5*ohminus
p_sed_pocn_sulf =   (lr_sed_rec*pocn_active)*(1.0-lim_t_o2_2)*(1.0-lim_t_no3_3)
                    *lim_t_pocn_14
```

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Processes, continued from previous page

recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction) (sediment only) [mol/m^2/day]

```
3*ohminus + 106*h3oplus + 53*so4 + t_pocp -> t_po4 + 53*t_h2s + 215*h2o + 106*
t_dic
p_sed_pocp_sulf =   (lr_sed_rec*pocp_active)*(1.0-lim_t_o2_2)*(1.0-lim_t_no3_3)
                    *lim_t_pocp_13
```

coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments (sediment only) [mol/m^2/day]

```
t_nh4 + 0.75*t_o2 -> 0.5*h2o + h3oplus + 0.5*t_n2
                    (frac_denit_sed*p_sed_pocn_resp*theta(t_o2-5.0e-6))*
p_nh4_nitdenit_pocn_lim_t_nh4_11*lim_t_o2_2
=
```

recycling of sedimentary detritus to ammonium using oxygen (respiration); sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]

```
 -> t_nh4_with_atmos_tot_N
                    p_sed_resp_nh4 * ((1.0)*(1)*
p_sed_resp_nh4_atmosmax(0.0,min(1.0,t_sed_with_atmos_tot_N/max(0.00000000001,t_sed)
=                   ))) / ((1.0)*(1))
```

recycling of sedimentary detritus to ammonium using nitrate (denitrification); sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]

```
 -> t_nh4_with_atmos_tot_N
                    p_sed_denit_nh4_noN2 * ((1.0)*(1)*
p_sed_denit_nh4_noN2max(0.0,min(1.0,t_sed_with_atmos_tot_N/max(0.00000000001,t_sed)
=                   ))) / ((1.0)*(1))
```

recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction); sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]

```
 -> t_nh4_with_atmos_tot_N
                    p_sed_sulf_nh4 * ((1.0)*(1)*
p_sed_sulf_nh4_atmosmax(0.0,min(1.0,t_sed_with_atmos_tot_N/max(0.00000000001,t_sed)
=                   ))) / ((1.0)*(1))
```

recycling of sedimentary pocn to dic and NH4 using oxygen (respiration); sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]

```
 -> t_nh4_with_atmos_tot_N
                    p_sed_pocn_resp * ((1.0)*(1)*
p_sed_pocn_resp_atmomax(0.0,min(1.0,t_sed_pocn_with_atmos_tot_N/max(0.00000000001,t_sed_pocn)
=                   ))) / ((1.0)*(1))
```

recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification); sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]

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Processes, continued from previous page	
-> t_nh4_with_atmos_tot_N	
p_sed_pocn_denit_noN =	p_sed_pocn_denit_noN2 * ((1.0)*(1)* max(0.0,min(1.0,t_sed_pocn_with_atmos_tot_N/max(0.00000000001,t_sed_pocn)))) / ((1.0)*(1))

recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction); sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]

-> t_nh4_with_atmos_tot_N	
p_sed_pocn_sulf_atmo =	p_sed_pocn_sulf * ((1.0)*(1)* max(0.0,min(1.0,t_pocn_with_atmos_tot_N/max(0.00000000001,t_pocn)))) / ((1.0)*(1))

recycling of sedimentary detritus to ammonium using oxygen (respiration); sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

-> t_nh4_with_atmos_ship_N	
p_sed_resp_nh4_atmos =	p_sed_resp_nh4 * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_ship_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))

recycling of sedimentary detritus to ammonium using nitrate (denitrification); sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

-> t_nh4_with_atmos_ship_N	
p_sed_denit_nh4_noN2 =	p_sed_denit_nh4_noN2 * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_ship_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))

recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction); sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

-> t_nh4_with_atmos_ship_N	
p_sed_sulf_nh4_atmos =	p_sed_sulf_nh4 * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_ship_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))

recycling of sedimentary pocn to dic and NH4 using oxygen (respiration); sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

-> t_nh4_with_atmos_ship_N	
p_sed_pocn_resp_atmo =	p_sed_pocn_resp * ((1.0)*(1)* max(0.0,min(1.0,t_sed_pocn_with_atmos_ship_N/max(0.00000000001,t_sed_pocn))) / ((1.0)*(1))

recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification); sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

-> t_nh4_with_atmos_ship_N	
p_sed_pocn_denit_noN =	p_sed_pocn_denit_noN2 * ((1.0)*(1)* max(0.0,min(1.0,t_sed_pocn_with_atmos_ship_N/max(0.00000000001,t_sed_pocn))) / ((1.0)*(1))

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Processes, continued from previous page

recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction); sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

```
 -> t_nh4_with_atmos_ship_N
                     p_sed_pocn_sulf * ((1.0)*(1)*
p_sed_pocn_sulf_atmomax(0.0,min(1.0,t_pocn_with_atmos_ship_N/max(0.00000000001,t_pocn)
=                    ))) / ((1.0)*(1))
```

Auxiliary variables

fraction of ammonium that is immediately nitrified and denitrified after remineralization in oxic sediments

```
frac_denit_sed =    frac_denit_scal*(0.5+0.5*exp(-0.01*cgt_bottomdepth))
```

total carbon in sediment layer [mol/m2]**

```
sed_tot =           t_sed*rfr_c + t_sed_poc + t_sed_pocn*rfr_c + t_sed_pocp*
                    rfr_cp
```

total carbon in active sediment layer [mol/m2]**

```
sed_tot_active =    max(0.0,min(sed_tot,sed_max*rfr_c))
```

detritus in active sediment layer [mol/m2]**

```
sed_active =        sed_tot_active * t_sed/sed_tot
```

recycling rate of sediment detritus, limited by oxygen [1/d]

```
lr_sed_rec =        r_sed_rec*exp(q10_sed_rec*cgt_temp)*(1.0-reduced_rec*
                    theta(2*t_h2s-t_o2))
```

poc in active sediment layer [mol/m2]**

```
poc_active =        sed_tot_active * t_sed_poc/sed_tot
```

pocn in active sediment layer [mol/m2]**

```
pocn_active =       sed_tot_active * t_sed_pocn/sed_tot
```

pocp in active sediment layer [mol/m2]**

```
pocp_active =       sed_tot_active * t_sed_pocp/sed_tot
```

Constants

nitrate half-saturation concentration for denitrification in the water column [mol/kg]

```
no3_min_sed_denit = 1.423E-7
```

q10 rule factor for detritus recycling in the sediment [1/K]

```
q10_sed_rec =       0.175
```

maximum recycling rate of sediment to ammonium [1/day]

continued on next page...

Constants, continued from previous page	
r_sed_rec =	0.002
redfield ratio C/N	
rfr_c =	6.625
redfield ratio P/N	
rfr_p =	0.0625
redfield ratio C/P	
rfr_cp =	106.0
maximum sediment detritus concentration that feels erosion [mol/m2]**	
sed_max =	1.0
scaling frac_denit_sed	
frac_denit_scal =	1.0
decrease recycling in sed under anoxia by reduce_rec	
reduced_rec =	0.8

Process limitation factors	
lim_t_o2_2 =	theta(t_o2-0.0)
lim_t_nh4_11 =	theta(t_nh4-0.0)
lim_t_no3_3 =	t_no3*t_no3/(t_no3*t_no3+no3_min_sed_denit* no3_min_sed_denit)
lim_t_sed_20 =	theta(t_sed-0.0)
lim_t_sed_poc_21 =	theta(t_sed_poc-0.0)
lim_t_sed_pocn_26 =	theta(t_sed_pocn-0.0)
lim_t_sed_pocp_27 =	theta(t_sed_pocp-0.0)
lim_t_pocp_13 =	theta(t_pocp-0.0)
lim_t_pocn_14 =	theta(t_pocn-0.0)

3.3 Process type BGC/benthic/P_retention

Processes
retention of phosphate in the sediment under oxic conditions (sediment only) [mol/m^2/day]
`rfr_p*fe3plus + rfr_p*t_po4 -> rfr_p*t_ips`
`p_po4_retent_ips = (p_sed_resp_nh4*frac_po4retent)*lim_t_o2_4*lim_t_po4_9`
liberation of phosphate from the sediment under anoxic conditions (sediment only) [mol/m^2/day]
`t_ips -> t_po4 + fe3plus`
`p_ips_liber_po4 = (t_ips*r_ips_liber)*lim_t_h2s_5*lim_t_ips_22`

Auxiliary variables
fraction of phosphate which is retained as iron-bound phosphate instead of being released after mineralization in the sediment [1]
`frac_po4retent = ret_po4_1 + ret_po4_2*theta(cgt_latitude-60.75)`

Constants
minimum h2s concentration for liberation of iron phosphate from the sediment [mol/kg]
`h2s_min_po4_liber = 1.0E-6`
oxygen half-saturation concentration for retension of phosphate during sediment denitrification [mol/kg]
`o2_min_po4_retent = 0.0000375`
PO4 liberation rate under anoxic conditions [1/day]
`r_ips_liber = 0.1`
redfield ratio P/N
`rfr_p = 0.0625`
PO4 retension in oxic sediments
`ret_po4_1 = 0.15`
additional PO4 retension in oxic sediments of the Bothnian Sea
`ret_po4_2 = 0.5`

Process limitation factors	
`lim_t_o2_4 =`	`t_o2*t_o2/(t_o2*t_o2+o2_min_po4_retent*o2_min_po4_retent)`
`lim_t_po4_9 =`	`theta(t_po4-0.0)`
`lim_t_h2s_5 =`	`theta(t_h2s-h2s_min_po4_liber)`

continued on next page...

Process limitation factors, continued from previous page	
`lim_t_ips_22 =`	`theta(t_ips-0.0)`

3.4 Process type BGC/pelagic/mineralisation

Processes	
recycling of POC using nitrate (denitrification) [mol/kg/day]	
t_poc + 0.8*t_no3 + 0.8*h3oplus -> t_dic + 2.2*h2o + 0.4*t_n2	
p_poc_denit =	(t_poc*r_poc_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1*lim_t_poc_12
Mineralization of POC, e-acceptor sulfate (sulfate reduction) [mol/kg/day]	
h3oplus + 0.5*so4 + t_poc -> 2*h2o + 0.5*t_h2s + t_dic	
p_poc_sulf =	(t_poc*r_poc_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_poc_12
respiration of POCP [mol/kg/day]	
3*H2O + t_pocp + 106*t_o2 -> 3*h3oplus + 106*H2O + t_po4 + 106*t_dic	
p_pocp_resp =	(t_pocp * lr_pocp * exp(q10_det_rec * cgt_temp))*lim_t_o2_0*lim_t_pocp_13
recycling of POC using nitrate (denitrification) [mol/kg/day]	
3*ohminus + 84.8*h3oplus + 84.8*t_no3 + t_pocp -> t_po4 + 42.4*t_n2 + 236.2*H2O + 106*t_dic	
p_pocp_denit =	(t_pocp*r_pocp_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1*lim_t_pocp_13
Mineralization of POC, e-acceptor sulfate (sulfate reduction) [mol/kg/day]	
3*ohminus + 106*h3oplus + 53*so4 + t_pocp -> t_po4 + 53*t_h2s + 215*h2o + 106*t_dic	
p_pocp_sulf =	(t_pocp*r_pocp_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_pocp_13
respiration of POCN [mol/kg/day]	
t_pocn + 6.625*t_o2 + 0.5*h3oplus -> 6.625*t_dic + t_nh4 + 6.625*H2O + 0.5*ohminus	
p_pocn_resp =	(t_pocn * lr_pocn * exp(q10_det_rec * cgt_temp))*lim_t_o2_0*lim_t_pocn_14
recycling of POCN using nitrate (denitrification) [mol/kg/day]	
t_pocn + 5.8*h3oplus -> 6.625*t_dic + t_nh4 + 14.575*H2O + 0.5*ohminus	
p_pocn_denit_noN2 =	(t_pocn*r_pocn_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1*lim_t_pocn_14
recycling of POCN using nitrate (denitrification) [mol/kg/day]	
5.3*t_no3 -> 2.65*t_n2	
p_pocn_denit_wiN2 =	(t_pocn*r_pocn_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1

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Processes, continued from previous page

Mineralization of POCN, e-acceptor sulfate (sulfate reduction) [mol/kg/day]

7.125*h3oplus + 3.3125*SO4 + t_pocn -> 0.5*ohminus + 13.25*H2O + 3.3125*t_h2s + t_nh4 + 6.625*t_dic

p_pocn_sulf = (t_pocn*r_pocn_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_pocn_14

recycling of detritus using oxygen (respiration) [mol/kg/day]

0.8125*h3oplus + 6.625*t_o2 + t_det -> 7.4375*h2o + rfr_c*t_dic + rfr_p*t_po4 + t_nh4

p_det_resp_nh4 = (t_det*r_det_rec*exp(q10_det_rec*cgt_temp))*lim_t_o2_0*lim_t_det_19

recycling of detritus using nitrate (denitrification) [mol/kg/day]

6.1125*h3oplus + 5.3*t_no3 + t_det -> rfr_c*t_dic + rfr_p*t_po4 + t_nh4 + 15.3875*h2o + 2.65*t_n2

p_det_denit_nh4 = (t_det*r_det_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1*lim_t_det_19

recycling of detritus using sulfate (sulfate reduction) [mol/kg/day]

t_det + 3.3125*so4 + 7.4375*h3oplus -> t_nh4 + rfr_p*t_po4 + rfr_c*t_dic + 3.3125*t_h2s + 14.0625*h2o

p_det_sulf_nh4 = (t_det*r_det_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_det_19

recycling of DOC using nitrate (denitrification) [mol/kg/day]

t_doc + 0.8*t_no3 + 0.8*h3oplus -> t_dic + 2.2*h2o + 0.4*t_n2

p_doc_denit = (t_doc*r_doc_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1*lim_t_doc_28

Mineralization of DOC, e-acceptor sulfate (sulfate reduction) [mol/kg/day]

h3oplus + 0.5*so4 + t_doc -> 2*h2o + 0.5*t_h2s + t_dic

p_doc_sulf = (t_doc*r_doc_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_doc_28

respiration of DOP [mol/kg/day]

106*t_o2 + t_dop + 3*H2O -> 106*t_dic + t_po4 + 106*H2O + 3*h3oplus

p_dop_resp = (t_dop * lr_dop * exp(q10_det_rec * cgt_temp))*lim_t_o2_0*lim_t_dop_29

recycling of DOP using nitrate (denitrification) [mol/kg/day]

t_dop + 84.8*t_no3 + 84.8*h3oplus + 3*ohminus -> 106*t_dic + 236.2*H2O + 42.4*t_n2 + t_po4

p_dop_denit = (t_dop*r_dop_rec*exp(q10_det_rec*cgt_temp))*(1.0-lim_t_o2_0)*lim_t_no3_1*lim_t_dop_29

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Processes, continued from previous page

Mineralization of DOP, e-acceptor sulfate (sulfate reduction) [mol/kg/day]

```
t_dop + 53*so4 + 106*h3oplus + 3*ohminus -> 106*t_dic + 215*h2o + 53*t_h2s +
t_po4
p_dop_sulf =        (t_dop*r_dop_rec*exp(q10_det_rec*cgt_temp))*(1.0-
                    lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_dop_29
```

respiration of DON [mol/kg/day]

```
t_don + 6.625*t_o2 + 0.5*h3oplus -> 6.625*t_dic + t_nh4 + 6.625*H2O + 0.5*
ohminus
p_don_resp =        (t_don * lr_don * exp(q10_det_rec * cgt_temp))*lim_t_o2_0*
                    lim_t_don_30
```

recycling of DON using nitrate (denitrification) [mol/kg/day]

```
t_don + 5.8*h3oplus -> 6.625*t_dic + t_nh4 + 14.575*H2O + 0.5*ohminus
p_don_denit_noN2 =  (t_don*r_don_rec*exp(q10_det_rec*cgt_temp))*(1.0-
                    lim_t_o2_0)*lim_t_no3_1*lim_t_don_30
```

recycling of DON using nitrate (denitrification) [mol/kg/day]

```
5.3*t_no3 -> 2.65*t_n2
p_don_denit_wiN2 =  (t_don*r_don_rec*exp(q10_det_rec*cgt_temp))*(1.0-
                    lim_t_o2_0)*lim_t_no3_1
```

Mineralization of DON, e-acceptor sulfate (sulfate reduction) [mol/kg/day]

```
t_don + 3.3125*SO4 + 7.125*h3oplus -> 6.625*t_dic + t_nh4 + 3.3125*t_h2s +
13.25*H2O + 0.5*ohminus
p_don_sulf =        (t_don*r_don_rec*exp(q10_det_rec*cgt_temp))*(1.0-
                    lim_t_o2_0)*(1.0-lim_t_no3_1)*lim_t_don_30
```

respiration of POCN; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_tot_N
                    p_pocn_resp * ((1.0)*(1)*
p_pocn_resp_atmos_tomax(0.0,min(1.0,t_pocn_with_atmos_tot_N/max(0.00000000001,t_pocn)
=                   ))) / ((1.0)*(1))
```

recycling of POCN using nitrate (denitrification); sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_tot_N
                    p_pocn_denit_noN2 * ((1.0)*(1)*
p_pocn_denit_noN2_atmax(0.0,min(1.0,t_pocn_with_atmos_tot_N/max(0.00000000001,t_pocn)
=                   ))) / ((1.0)*(1))
```

Mineralization of POCN, e-acceptor sulfate (sulfate reduction); sub-process for atmos_tot nitrogen [mol/kg/day]

continued on next page...

Processes, continued from previous page	
-> t_nh4_with_atmos_tot_N	
p_pocn_sulf_atmos_tot =	p_pocn_sulf * ((1.0)*(1)* max(0.0,min(1.0,t_pocn_with_atmos_tot_N/max(0.00000000001,t_pocn)))) / ((1.0)*(1))

recycling of detritus using oxygen (respiration); sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_nh4_with_atmos_tot_N	
p_det_resp_nh4_atmos =	p_det_resp_nh4 * ((1.0)*(1)* max(0.0,min(1.0,t_det_with_atmos_tot_N/max(0.00000000001,t_det)))) / ((1.0)*(1))

recycling of detritus using sulfate (sulfate reduction); sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_nh4_with_atmos_tot_N	
p_det_sulf_nh4_atmos =	p_det_sulf_nh4 * ((1.0)*(1)* max(0.0,min(1.0,t_det_with_atmos_tot_N/max(0.00000000001,t_det)))) / ((1.0)*(1))

respiration of DON; sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_nh4_with_atmos_tot_N	
p_don_resp_atmos_tot =	p_don_resp * ((1.0)*(1)* max(0.0,min(1.0,t_don_with_atmos_tot_N/max(0.00000000001,t_don)))) / ((1.0)*(1))

recycling of DON using nitrate (denitrification); sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_nh4_with_atmos_tot_N	
p_don_denit_noN2_atm =	p_don_denit_noN2 * ((1.0)*(1)* max(0.0,min(1.0,t_don_with_atmos_tot_N/max(0.00000000001,t_don)))) / ((1.0)*(1))

Mineralization of DON, e-acceptor sulfate (sulfate reduction); sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_nh4_with_atmos_tot_N	
p_don_sulf_atmos_tot =	p_don_sulf * ((1.0)*(1)* max(0.0,min(1.0,t_don_with_atmos_tot_N/max(0.00000000001,t_don)))) / ((1.0)*(1))

respiration of POCN; sub-process for atmos_ship nitrogen [mol/kg/day]

-> t_nh4_with_atmos_ship_N	
p_pocn_resp_atmos_sh =	p_pocn_resp * ((1.0)*(1)* max(0.0,min(1.0,t_pocn_with_atmos_ship_N/max(0.00000000001,t_pocn)))) / ((1.0)*(1))

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Processes, continued from previous page

recycling of POCN using nitrate (denitrification); sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_ship_N
                    p_pocn_denit_noN2 * ((1.0)*(1)*
p_pocn_denit_noN2_atmax(0.0,min(1.0,t_pocn_with_atmos_ship_N/max(0.00000000001,t_pocn)
=                   ))) / ((1.0)*(1))
```

Mineralization of POCN, e-acceptor sulfate (sulfate reduction); sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_ship_N
                    p_pocn_sulf * ((1.0)*(1)*
p_pocn_sulf_atmos_shmax(0.0,min(1.0,t_pocn_with_atmos_ship_N/max(0.00000000001,t_pocn)
=                   ))) / ((1.0)*(1))
```

recycling of detritus using oxygen (respiration); sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_ship_N
                    p_det_resp_nh4 * ((1.0)*(1)*
p_det_resp_nh4_atmosmax(0.0,min(1.0,t_det_with_atmos_ship_N/max(0.00000000001,t_det)
=                   ))) / ((1.0)*(1))
```

recycling of detritus using sulfate (sulfate reduction); sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_ship_N
                    p_det_sulf_nh4 * ((1.0)*(1)*
p_det_sulf_nh4_atmosmax(0.0,min(1.0,t_det_with_atmos_ship_N/max(0.00000000001,t_det)
=                   ))) / ((1.0)*(1))
```

respiration of DON; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_ship_N
                    p_don_resp * ((1.0)*(1)*
p_don_resp_atmos_shimax(0.0,min(1.0,t_don_with_atmos_ship_N/max(0.00000000001,t_don)
=                   ))) / ((1.0)*(1))
```

recycling of DON using nitrate (denitrification); sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_nh4_with_atmos_ship_N
                    p_don_denit_noN2 * ((1.0)*(1)*
p_don_denit_noN2_atmmax(0.0,min(1.0,t_don_with_atmos_ship_N/max(0.00000000001,t_don)
=                   ))) / ((1.0)*(1))
```

Mineralization of DON, e-acceptor sulfate (sulfate reduction); sub-process for atmos_ship nitrogen [mol/kg/day]

continued on next page...

Processes, continued from previous page	
-> t_nh4_with_atmos_ship_N	
p_don_sulf_atmos_shi=	p_don_sulf * ((1.0)*(1)* max(0.0,min(1.0,t_don_with_atmos_ship_N/max(0.00000000001,t_don)))) / ((1.0)*(1))

Auxiliary variables	
dissolved inorganic nitrogen [mol/kg]	
din =	t_no3+t_nh4
squared DIN [mol2/kg2]	
din_sq =	din*din
squared phosphate [mol2/kg**2]**	
po4_sq =	t_po4*t_po4
modifies pocp recycling towards Refield ratio if PO4 is depleted	
ref_p_sw =	(1 - (po4_sq/(rfr_p*din_min_lpp*rfr_p*din_min_lpp+po4_sq))) /(1+exp(6.0*(1-din/(t_po4/rfr_p+epsilon))))
modifies pocn recycling towards Refield ratio if DIN is depleted	
ref_n_sw =	(1 - (din_sq/(din_min_lpp*din_min_lpp+din_sq)))/(1+exp(6.0* (1-t_po4/rfr_p/(din+epsilon))))
add an additional POCP recycling if PO4 below Redfield but sufficient DIN	
lr_pocp =	r_pocp_rec*(1 + fac_enh_rec*ref_p_sw)
add an additional DOP recycling if PO4 is below Redfield but sufficient DIN	
lr_dop =	r_dop_rec*(1 + fac_enh_rec*ref_p_sw)
add an additional POCN recycling if DIN below Redfield but sufficient PO4	
lr_pocn =	r_pocn_rec*(1 + fac_enh_rec*ref_n_sw)
add an additional DON recycling if DIN below Redfield but sufficient PO4	
lr_don =	r_don_rec*(1 + fac_enh_rec*ref_n_sw)

Constants	
DIN half saturation constant for large-cell phytoplankton growth [mol/kg]	
din_min_lpp =	1.0E-6
no division by 0	
epsilon =	4.5E-17
minimum no3 concentration for recycling of detritus using nitrate (denitrification)	
no3_min_det_denit =	1.0E-9

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Constants, continued from previous page	
oxygen half-saturation constant for detritus recycling [mol/kg]	
`o2_min_det_resp =`	`1.0E-6`
q10 rule factor for recycling [1/K]	
`q10_det_rec =`	`0.15`
recycling rate (detritus to ammonium) at 0°C [1/day]	
`r_det_rec =`	`0.003`
redfield ratio C/N	
`rfr_c =`	`6.625`
redfield ratio P/N	
`rfr_p =`	`0.0625`
recycling rate (poc to dic) at 0°C [1/day]	
`r_poc_rec =`	`0.003`
recycling rate (pocp to dic and po4) at 0°C [1/day]	
`r_pocp_rec =`	`0.002`
recycling rate (pocn to dic and nh4) at 0°C [1/day]	
`r_pocn_rec =`	`0.002`
enhance recyclig of DON,POCN/DOP,POCP in case of limiting DIN/DIP	
`fac_enh_rec =`	`10.0`
recycling rate (doc to dic) at 0°C [1/day]	
`r_doc_rec =`	`0.001`
recycling rate (don to dic and NH4) at 0°C [1/day]	
`r_don_rec =`	`0.001`
recycling rate (dop to dic and PO4) at 0°C [1/day]	
`r_dop_rec =`	`0.001`

Process limitation factors	
`lim_t_o2_0 =`	`1.0-exp(-t_o2/o2_min_det_resp)`
`lim_t_no3_1 =`	`1.0-exp(-t_no3/no3_min_det_denit)`
`lim_t_doc_28 =`	`theta(t_doc-0.0)`
`lim_t_dop_29 =`	`theta(t_dop-0.0)`
`lim_t_don_30 =`	`theta(t_don-0.0)`

continued on next page...

Process limitation factors, continued from previous page	
`lim_t_det_19 =`	`theta(t_det-0.0)`
`lim_t_poc_12 =`	`theta(t_poc-0.0)`
`lim_t_pocp_13 =`	`theta(t_pocp-0.0)`
`lim_t_pocn_14 =`	`theta(t_pocn-0.0)`

3.5 Process type BGC/pelagic/phytoplankton

Processes

assimilation of nitrate by large-cell phytoplankton [mol/kg/day]

```
1.1875*h3oplus + 6.4375*h2o + rfr_c*t_dic + rfr_p*t_po4 + t_no3 -> 8.625*t_o2 +
t_lpp
p_no3_assim_lpp =   (lpp_plus_lpp0*lr_assim_lpp*t_no3/(din+epsilon))*
                    lim_t_dic_8*lim_t_po4_9*lim_t_no3_10
```

assimilation of ammonium by large-cell phytoplankton [mol/kg/day]

```
t_nh4 + rfr_p*t_po4 + rfr_c*t_dic + 7.4375*h2o -> t_lpp + 6.625*t_o2 + 0.8125*
h3oplus
p_nh4_assim_lpp =   (lpp_plus_lpp0*lr_assim_lpp*t_nh4/(din+epsilon))*
                    lim_t_nh4_11*lim_t_po4_9*lim_t_dic_8
```

assimilation of nitrate by small-cell phytoplankton [mol/kg/day]

```
1.1875*h3oplus + 6.4375*h2o + rfr_c*t_dic + rfr_p*t_po4 + t_no3 -> 8.625*t_o2 +
t_spp
p_no3_assim_spp =   (spp_plus_spp0*lr_assim_spp*t_no3/(din+epsilon))*
                    lim_t_dic_8*lim_t_po4_9*lim_t_no3_10
```

assimilation of ammonium by small-cell phytoplankton [mol/kg/day]

```
t_nh4 + rfr_p*t_po4 + rfr_c*t_dic + 7.4375*h2o -> t_spp + 6.625*t_o2 + 0.8125*
h3oplus
p_nh4_assim_spp =   (spp_plus_spp0*lr_assim_spp*t_nh4/(din+epsilon))*
                    lim_t_nh4_11*lim_t_po4_9*lim_t_dic_8
```

fixation of dinitrogen by diazotroph cyanobacteria [mol/kg/day]

```
7.9375*h2o + rfr_c*t_dic + rfr_p*t_po4 + 0.5*t_n2 + 0.1875*h3oplus -> 7.375*
t_o2 + t_cya
p_n2_assim_cya =    (cya_plus_cya0*lr_assim_cya)*lim_t_dic_8*lim_t_po4_9*
                    lim_t_n2_7
```

Production of DOC by LPP [mol/kg/day]

```
t_dic + h2o -> t_doc + t_o2
p_assim_lpp_doc =   (rfr_c * t_lpp * lr_assim_lpp_doc)*lim_t_dic_8
```

Production of DOC by SPP [mol/kg/day]

```
t_dic + h2o -> t_doc + t_o2
p_assim_spp_doc =   (rfr_c * t_spp * lr_assim_spp_doc)*lim_t_dic_8
```

Production of POC by CYA [mol/kg/day]

```
t_dic + h2o -> t_doc + t_o2
p_assim_cya_doc =   (rfr_c * t_cya * lr_assim_cya_doc)*lim_t_dic_8
```

continued on next page...

Processes, continued from previous page	
Production of DOP by LPP [mol/kg/day]	
106*t_dic + t_po4 + 106*h2o + 3*h3oplus -> t_dop + 106*t_o2 + 3*h2o	
p_assim_lpp_dop =	(rfr_p * t_lpp * lr_assim_lpp_dop)*lim_t_dic_8*lim_t_po4_9
Production of DOP by SPP [mol/kg/day]	
3*h3oplus + 106*h2o + t_po4 + 106*t_dic -> 3*h2o + 106*t_o2 + t_dop	
p_assim_spp_dop =	(rfr_p * t_spp * lr_assim_spp_dop)*lim_t_po4_9*lim_t_dic_8
Production of DON by LPP [mol/kg/day]	
6.625*t_dic + t_nh4 + 6.625*H20 + ohminus -> t_don + 6.625*t_o2 + H20	
p_nh4_assim_lpp_don =	(t_lpp * lr_assim_lpp_don*t_nh4/(din+epsilon))*lim_t_dic_8* lim_t_nh4_11
Production of DON by LPP [mol/kg/day]	
h3oplus + 6.625*H20 + t_no3 + 6.625*t_dic -> 8.625*t_o2 + t_don	
p_no3_assim_lpp_don =	(t_lpp * lr_assim_lpp_don*t_no3/(din+epsilon))* lim_t_no3_10*lim_t_dic_8
Production of DON by SPP [mol/kg/day]	
ohminus + 6.625*H20 + t_nh4 + 6.625*t_dic -> H20 + 6.625*t_o2 + t_don	
p_nh4_assim_spp_don =	(t_spp * lr_assim_spp_don*t_nh4/(din+epsilon))* lim_t_nh4_11*lim_t_dic_8
Production of DON by SPP [mol/kg/day]	
6.625*t_dic + t_no3 + 6.625*H20 + h3oplus -> t_don + 8.625*t_o2	
p_no3_assim_spp_don =	(t_spp * lr_assim_spp_don*t_no3/(din+epsilon))*lim_t_dic_8* lim_t_no3_10
respiration of POC [mol/kg/day]	
t_o2 + t_poc -> h2o + t_dic	
p_poc_resp =	(t_poc * r_poc_rec * exp(q10_det_rec * cgt_temp))* lim_t_o2_0*lim_t_poc_12
respiration of large-cell phytoplankton [mol/kg/day]	
0.8125*h3oplus + 6.625*t_o2 + t_lpp -> 7.4375*h2o + rfr_c*t_dic + rfr_p*t_po4 + (1-don_fraction)*t_nh4 + don_fraction*t_don	
p_lpp_resp_nh4 =	(t_lpp*r_lpp_resp)*lim_t_o2_2*lim_t_lpp_15
respiration of small-cell phytoplankton [mol/kg/day]	
t_spp + 6.625*t_o2 + 0.8125*h3oplus -> don_fraction*t_don + (1-don_fraction)* t_nh4 + rfr_p*t_po4 + rfr_c*t_dic + 7.4375*h2o	
p_spp_resp_nh4 =	(t_spp*r_spp_resp)*lim_t_spp_16*lim_t_o2_2
respiration of diazotroph cyanobacteria [mol/kg/day]	
t_cya + 6.625*t_o2 + 0.8125*h3oplus -> (1-don_fraction)*t_nh4 + don_fraction* t_don + rfr_p*t_po4 + rfr_c*t_dic + 7.4375*h2o	

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Processes, continued from previous page	
p_cya_resp_nh4 =	(t_cya*r_cya_resp)*lim_t_cya_17*lim_t_o2_2

mortality of large-cell phytoplankton [mol/kg/day]	
t_lpp -> t_det	
p_lpp_mort_det =	(t_lpp*r_pp_mort*(1+9*theta(5.0e-6-t_o2)))*lim_t_lpp_15

mortality of small-scale phytoplankton [mol/kg/day]	
t_spp -> t_det	
p_spp_mort_det =	(t_spp*r_pp_mort*(1+9*theta(5.0e-6-t_o2)))*lim_t_spp_16

mortality of diazotroph cyanobacteria [mol/kg/day]	
t_cya -> t_det	
p_cya_mort_det =	(t_cya*r_pp_mort*(1+9*theta(5.0e-6-t_o2)))*lim_t_cya_17

mortality of diazotroph cyanobacteria due to strong turbulence [mol/kg/day]	
t_cya -> t_det	
p_cya_mort_det_diff =	(t_cya*r_pp_mort*(r_cya_mort_diff*theta(cgt_diffusivity-r_cya_mort_thresh)))*lim_t_cya_17

respiration of DOC [mol/kg/day]	
t_doc + t_o2 -> t_dic + h2o	
p_doc_resp =	(t_doc * r_doc_rec * exp(q10_doc_rec * cgt_temp))* lim_t_o2_0*lim_t_doc_28

assimilation of nitrate by large-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]	
-> t_lpp_with_atmos_tot_N	
p_no3_assim_lpp_atmo =	p_no3_assim_lpp * ((1.0)*(1)*max(0.0,min(1.0,t_no3_with_atmos_tot_N/max(0.00000000001,t_no3)))) / ((1.0)*(1))

assimilation of ammonium by large-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]	
-> t_lpp_with_atmos_tot_N	
p_nh4_assim_lpp_atmo =	p_nh4_assim_lpp * ((1.0)*(1)*max(0.0,min(1.0,t_nh4_with_atmos_tot_N/max(0.00000000001,t_nh4)))) / ((1.0)*(1))

assimilation of nitrate by small-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]	
-> t_spp_with_atmos_tot_N	
p_no3_assim_spp_atmo =	p_no3_assim_spp * ((1.0)*(1)*max(0.0,min(1.0,t_no3_with_atmos_tot_N/max(0.00000000001,t_no3)))) / ((1.0)*(1))

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Processes, continued from previous page

assimilation of ammonium by small-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_spp_with_atmos_tot_N
                       p_nh4_assim_spp * ((1.0)*(1)*
p_nh4_assim_spp_atmomax(0.0,min(1.0,t_nh4_with_atmos_tot_N/max(0.00000000001,t_nh4)
=                      ))) / ((1.0)*(1))
```

Production of DON by LPP; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_tot_N
                       p_nh4_assim_lpp_don * ((1.0)*(1)*
p_nh4_assim_lpp_don_max(0.0,min(1.0,t_nh4_with_atmos_tot_N/max(0.00000000001,t_nh4)
=                      ))) / ((1.0)*(1))
```

Production of DON by LPP; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_tot_N
                       p_no3_assim_lpp_don * ((1.0)*(1)*
p_no3_assim_lpp_don_max(0.0,min(1.0,t_no3_with_atmos_tot_N/max(0.00000000001,t_no3)
=                      ))) / ((1.0)*(1))
```

Production of DON by SPP; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_tot_N
                       p_nh4_assim_spp_don * ((1.0)*(1)*
p_nh4_assim_spp_don_max(0.0,min(1.0,t_nh4_with_atmos_tot_N/max(0.00000000001,t_nh4)
=                      ))) / ((1.0)*(1))
```

Production of DON by SPP; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_tot_N
                       p_no3_assim_spp_don * ((1.0)*(1)*
p_no3_assim_spp_don_max(0.0,min(1.0,t_no3_with_atmos_tot_N/max(0.00000000001,t_no3)
=                      ))) / ((1.0)*(1))
```

respiration of large-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> don_fraction*t_don_with_atmos_tot_N + (1-don_fraction)*
t_nh4_with_atmos_tot_N
                       p_lpp_resp_nh4 * ((1.0)*(1)*
p_lpp_resp_nh4_atmosmax(0.0,min(1.0,t_lpp_with_atmos_tot_N/max(0.00000000001,t_lpp)
=                      ))) / ((1.0)*(1))
```

respiration of small-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]

```
 -> don_fraction*t_don_with_atmos_tot_N + (1-don_fraction)*
t_nh4_with_atmos_tot_N
```

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Processes, continued from previous page	
p_spp_resp_nh4_atmos =	p_spp_resp_nh4 * ((1.0)*(1)* max(0.0,min(1.0,t_spp_with_atmos_tot_N/max(0.00000000001,t_spp)))) / ((1.0)*(1))

respiration of diazotroph cyanobacteria; sub-process for atmos_tot nitrogen [mol/kg/day]

-> (1-don_fraction)*t_nh4_with_atmos_tot_N + don_fraction* t_don_with_atmos_tot_N

p_cya_resp_nh4_atmos =	p_cya_resp_nh4 * ((1.0)*(1)* max(0.0,min(1.0,t_cya_with_atmos_tot_N/max(0.00000000001,t_cya)))) / ((1.0)*(1))

mortality of large-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_det_with_atmos_tot_N

p_lpp_mort_det_atmos =	p_lpp_mort_det * ((1.0)*(1)* max(0.0,min(1.0,t_lpp_with_atmos_tot_N/max(0.00000000001,t_lpp)))) / ((1.0)*(1))

mortality of small-scale phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_det_with_atmos_tot_N

p_spp_mort_det_atmos =	p_spp_mort_det * ((1.0)*(1)* max(0.0,min(1.0,t_spp_with_atmos_tot_N/max(0.00000000001,t_spp)))) / ((1.0)*(1))

mortality of diazotroph cyanobacteria; sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_det_with_atmos_tot_N

p_cya_mort_det_atmos =	p_cya_mort_det * ((1.0)*(1)* max(0.0,min(1.0,t_cya_with_atmos_tot_N/max(0.00000000001,t_cya)))) / ((1.0)*(1))

mortality of diazotroph cyanobacteria due to strong turbulence; sub-process for atmos_tot nitrogen [mol/kg/day]

-> t_det_with_atmos_tot_N

p_cya_mort_det_diff_ =	p_cya_mort_det_diff * ((1.0)*(1)* max(0.0,min(1.0,t_cya_with_atmos_tot_N/max(0.00000000001,t_cya)))) / ((1.0)*(1))

assimilation of nitrate by large-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

-> t_lpp_with_atmos_ship_N

p_no3_assim_lpp_atmo =	p_no3_assim_lpp * ((1.0)*(1)* max(0.0,min(1.0,t_no3_with_atmos_ship_N/max(0.00000000001,t_no3)))) / ((1.0)*(1))

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Processes, continued from previous page

assimilation of ammonium by large-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_lpp_with_atmos_ship_N
                        p_nh4_assim_lpp * ((1.0)*(1)*
p_nh4_assim_lpp_atmomax(0.0,min(1.0,t_nh4_with_atmos_ship_N/max(0.00000000001,t_nh4)
=                       ))) / ((1.0)*(1))
```

assimilation of nitrate by small-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_spp_with_atmos_ship_N
                        p_no3_assim_spp * ((1.0)*(1)*
p_no3_assim_spp_atmomax(0.0,min(1.0,t_no3_with_atmos_ship_N/max(0.00000000001,t_no3)
=                       ))) / ((1.0)*(1))
```

assimilation of ammonium by small-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_spp_with_atmos_ship_N
                        p_nh4_assim_spp * ((1.0)*(1)*
p_nh4_assim_spp_atmomax(0.0,min(1.0,t_nh4_with_atmos_ship_N/max(0.00000000001,t_nh4)
=                       ))) / ((1.0)*(1))
```

Production of DON by LPP; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_ship_N
                        p_nh4_assim_lpp_don * ((1.0)*(1)*
p_nh4_assim_lpp_don_max(0.0,min(1.0,t_nh4_with_atmos_ship_N/max(0.00000000001,t_nh4)
=                       ))) / ((1.0)*(1))
```

Production of DON by LPP; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_ship_N
                        p_no3_assim_lpp_don * ((1.0)*(1)*
p_no3_assim_lpp_don_max(0.0,min(1.0,t_no3_with_atmos_ship_N/max(0.00000000001,t_no3)
=                       ))) / ((1.0)*(1))
```

Production of DON by SPP; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_ship_N
                        p_nh4_assim_spp_don * ((1.0)*(1)*
p_nh4_assim_spp_don_max(0.0,min(1.0,t_nh4_with_atmos_ship_N/max(0.00000000001,t_nh4)
=                       ))) / ((1.0)*(1))
```

Production of DON by SPP; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_don_with_atmos_ship_N
                        p_no3_assim_spp_don * ((1.0)*(1)*
p_no3_assim_spp_don_max(0.0,min(1.0,t_no3_with_atmos_ship_N/max(0.00000000001,t_no3)
=                       ))) / ((1.0)*(1))
```

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Processes, continued from previous page

respiration of large-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> don_fraction*t_don_with_atmos_ship_N + (1-don_fraction)*
t_nh4_with_atmos_ship_N
                        p_lpp_resp_nh4 * ((1.0)*(1)*
p_lpp_resp_nh4_atmosmax(0.0,min(1.0,t_lpp_with_atmos_ship_N/max(0.00000000001,t_lpp)
=                       ))) / ((1.0)*(1))
```

respiration of small-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> don_fraction*t_don_with_atmos_ship_N + (1-don_fraction)*
t_nh4_with_atmos_ship_N
                        p_spp_resp_nh4 * ((1.0)*(1)*
p_spp_resp_nh4_atmosmax(0.0,min(1.0,t_spp_with_atmos_ship_N/max(0.00000000001,t_spp)
=                       ))) / ((1.0)*(1))
```

respiration of diazotroph cyanobacteria; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> (1-don_fraction)*t_nh4_with_atmos_ship_N + don_fraction*
t_don_with_atmos_ship_N
                        p_cya_resp_nh4 * ((1.0)*(1)*
p_cya_resp_nh4_atmosmax(0.0,min(1.0,t_cya_with_atmos_ship_N/max(0.00000000001,t_cya)
=                       ))) / ((1.0)*(1))
```

mortality of large-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_det_with_atmos_ship_N
                        p_lpp_mort_det * ((1.0)*(1)*
p_lpp_mort_det_atmosmax(0.0,min(1.0,t_lpp_with_atmos_ship_N/max(0.00000000001,t_lpp)
=                       ))) / ((1.0)*(1))
```

mortality of small-scale phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_det_with_atmos_ship_N
                        p_spp_mort_det * ((1.0)*(1)*
p_spp_mort_det_atmosmax(0.0,min(1.0,t_spp_with_atmos_ship_N/max(0.00000000001,t_spp)
=                       ))) / ((1.0)*(1))
```

mortality of diazotroph cyanobacteria; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_det_with_atmos_ship_N
                        p_cya_mort_det * ((1.0)*(1)*
p_cya_mort_det_atmosmax(0.0,min(1.0,t_cya_with_atmos_ship_N/max(0.00000000001,t_cya)
=                       ))) / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

mortality of diazotroph cyanobacteria due to strong turbulence; sub-process for atmos_ship nitrogen [mol/kg/day]

```
 -> t_det_with_atmos_ship_N
                    p_cya_mort_det_diff * ((1.0)*(1)*
p_cya_mort_det_diff_max(0.0,min(1.0,t_cya_with_atmos_ship_N/max(0.00000000001,t_cya)
=                   ))) / ((1.0)*(1))
```

Auxiliary variables

square of positive temperature [°C * °C]

```
temp_sq =           max(0.0,cgt_temp)*max(0.0,cgt_temp)
```

dissolved inorganic nitrogen [mol/kg]

```
din =               t_no3+t_nh4
```

squared DIN [mol2/kg2]

```
din_sq =            din*din
```

squared phosphate [mol2/kg**2]**

```
po4_sq =            t_po4*t_po4
```

large-cell phytoplankton plus seed concentration [mol/kg]

```
lpp_plus_lpp0 =     t_lpp+lpp0
```

small-cell phytoplankton plus seed concentration [mol/kg]

```
spp_plus_spp0 =     t_spp+spp0
```

diazotroph cyanobacteria plus seed concentration [mol/kg]

```
cya_plus_cya0 =     t_cya+cya0
```

light limitation factor for large-cell phytoplankton growth [1]

```
temp1 =             max(cgt_light/2.0,light_opt_lpp)
lim_light_lpp =     cgt_light/temp1*exp(1-cgt_light/temp1)
```

light limitation factor for small-cell phytoplankton growth [1]

```
temp1 =             max(cgt_light/2.0,light_opt_spp)
lim_light_spp =     cgt_light/temp1*exp(1-cgt_light/temp1)
```

light limitation factor for diazotroph cyanobacteria growth [1]

```
temp1 =             max(cgt_light/2.0,light_opt_cya)
lim_light_cya =     cgt_light/temp1*exp(1-cgt_light/temp1)
```

growth rate of large-cell phytoplankton, limited by DIN, DIP, light and oxygen [1/day]

continued on next page...

Auxiliary variables, continued from previous page	
lr_assim_lpp =	r_lpp_assim*theta(t_o2-2*t_h2s)*min(din_sq/(din_sq+din_min_lpp*din_min_lpp),min(po4_sq/(po4_sq+din_min_lpp*din_min_lpp*rfr_p*rfr_p),lim_light_lpp))
production rate of DOC by LPP	
lr_assim_lpp_doc =	fac_doc_assim * r_lpp_assim * theta(t_o2-2*t_h2s) * min(max(1 - din_sq/(din_sq+din_min_lpp*din_min_lpp),1 - po4_sq/(din_min_lpp*din_min_lpp*rfr_p*rfr_p + po4_sq)), lim_light_lpp)
production rate of POC by SPP	
lr_assim_spp_doc =	fac_doc_assim * r_spp_assim * theta(t_o2-2*t_h2s) * min(max(1 - din_sq/(din_sq+din_min_spp*din_min_spp),1 - po4_sq/(din_min_spp*din_min_spp*rfr_p*rfr_p + po4_sq)), lim_light_spp)*(1+temp_sq/(temp_sq+temp_min_spp*temp_min_spp))
production rate of POC by CYA	
lr_assim_cya_doc =	fac_doc_assim * r_cya_assim*theta(t_o2-2*t_h2s)*min(1 - po4_sq/(po4_sq+dip_min_cya*dip_min_cya),lim_light_cya)*(1/(1+exp(temp_min_cya-cgt_temp)))*(1/(1+exp(cgt_sali-sali_max_cya)))*(1/(1+exp(sali_min_cya-cgt_sali)))
growth rate of small-cell phytoplankton, limited by DIN, DIP, light, oxygen and temperature [1/day]	
lr_assim_spp =	r_spp_assim*theta(t_o2-2*t_h2s)*min(din_sq/(din_sq+din_min_spp*din_min_spp),min(po4_sq/(po4_sq+din_min_spp*din_min_spp*rfr_p*rfr_p),lim_light_spp))*(1+temp_sq/(temp_sq+temp_min_spp*temp_min_spp))
growth rate of diazotroph cyanobacteria, limited by DIP, light, oxygen, temperature and salinity [1/day]	
lr_assim_cya =	r_cya_assim*theta(t_o2-2*t_h2s)*min(po4_sq/(po4_sq+dip_min_cya*dip_min_cya),lim_light_cya)*(1/(1+exp(temp_min_cya-cgt_temp)))*(1/(1+exp(cgt_sali-sali_max_cya)))*(1/(1+exp(sali_min_cya-cgt_sali)))
production rate of POCP by LPP	
lr_assim_lpp_dop =	fac_dop_assim * r_lpp_assim * theta(t_o2-2*t_h2s) * min(min(1 - din_sq/(din_sq+din_min_lpp*din_min_lpp),po4_sq/(din_min_lpp*din_min_lpp*rfr_p*rfr_p + po4_sq)), lim_light_lpp)

continued on next page...

Auxiliary variables, continued from previous page

production rate of POCP by SPP

```
lr_assim_spp_dop =  fac_dop_assim * r_spp_assim * theta(t_o2-2*t_h2s) *
                    min(min(1 - din_sq/(din_sq+din_min_spp*din_min_spp)
                    ,po4_sq/(din_min_spp*din_min_spp*rfr_p*rfr_p + po4_sq)),
                    lim_light_spp)*(1+temp_sq/(temp_sq+temp_min_spp*
                    temp_min_spp))
```

production rate of POCN by LPP

```
lr_assim_lpp_don =  fac_don_assim * r_lpp_assim * theta(t_o2-2*t_h2s) *
                    min(min(din_sq/(din_sq+din_min_lpp*din_min_lpp),1 -
                    po4_sq/(din_min_lpp*din_min_lpp*rfr_p*rfr_p + po4_sq)),
                    lim_light_lpp)
```

production rate of POCN by SPP

```
lr_assim_spp_don =  fac_don_assim * r_spp_assim * theta(t_o2-2*t_h2s) *
                    min(min(din_sq/(din_sq+din_min_spp*din_min_spp),1 -
                    po4_sq/(din_min_spp*din_min_spp*rfr_p*rfr_p + po4_sq)),
                    lim_light_spp)*(1+temp_sq/(temp_sq+temp_min_spp*
                    temp_min_spp))
```

Constants

seed concentration for diazotroph cyanobacteria [mol/kg]

```
cya0 =              9.0E-8
```

DIN half saturation constant for large-cell phytoplankton growth [mol/kg]

```
din_min_lpp =       1.0E-6
```

DIN half saturation constant for small-cell phytoplankton growth [mol/kg]

```
din_min_spp =       1.6E-7
```

DIP half saturation constant for diazotroph cyanobacteria growth [mol/kg]

```
dip_min_cya =       1.0E-8
```

no division by 0

```
epsilon =           4.5E-17
```

optimal light for diazotroph cyanobacteria growth [W/m2]**

```
light_opt_cya =     50.0
```

optimal light for large-cell phytoplankton growth [W/m2]**

```
light_opt_lpp =     35.0
```

optimal light for small-cell phytoplankton growth [W/m2]**

```
light_opt_spp =     50.0
```

continued on next page. . .

Constants, continued from previous page
seed concentration for large-cell phytoplankton [mol/kg]
`lpp0 = 4.5E-9`
oxygen half-saturation constant for detritus recycling [mol/kg]
`o2_min_det_resp = 1.0E-6`
q10 rule factor for recycling [1/K]
`q10_det_rec = 0.15`
q10 rule factor for DOC recycling [1/K]
`q10_doc_rec = 0.069`
maximum rate for nutrient uptake of diazotroph cyanobacteria [1/day]
`r_cya_assim = 0.75`
respiration rate of cyanobacteria to ammonium [1/day]
`r_cya_resp = 0.01`
maximum rate for nutrient uptake of large-cell phytoplankton [1/day]
`r_lpp_assim = 1.38`
respiration rate of large phytoplankton to ammonium [1/day]
`r_lpp_resp = 0.075`
mortality rate of phytoplankton [1/day]
`r_pp_mort = 0.03`
enhanced cya mortality due to strong turbulence
`r_cya_mort_diff = 40.0`
diffusivity threshold for enhanced cyano mortality
`r_cya_mort_thresh = 0.02`
maximum rate for nutrient uptake of small-cell phytoplankton [1/day]
`r_spp_assim = 0.4`
respiration rate of small phytoplankton to ammonium [1/day]
`r_spp_resp = 0.0175`
redfield ratio C/N
`rfr_c = 6.625`
redfield ratio P/N
continued on next page...

Constants, continued from previous page	
rfr_p =	0.0625
upper salinity limit - diazotroph cyanobacteria [psu]	
sali_max_cya =	8.0
lower salinity limit - diazotroph cyanobacteria [psu]	
sali_min_cya =	4.0
seed concentration for small-cell phytoplankton [mol/kg]	
spp0 =	4.5E-9
lower temperature limit - diazotroph cyanobacteria [°C]	
temp_min_cya =	13.5
lower temperature limit - small-cell phytoplankton [°C]	
temp_min_spp =	10.0
fraction of DON in respiration products	
don_fraction =	0.0
recycling rate (poc to dic) at 0°C [1/day]	
r_poc_rec =	0.003
factor modifying assimilation rate for POC production	
fac_doc_assim =	1.0
factor modifying assimilation rate for POCP production	
fac_dop_assim =	0.5
factor modifying assimilation rate for POCN production	
fac_don_assim =	1.0
recycling rate (doc to dic) at 0°C [1/day]	
r_doc_rec =	0.001

Process limitation factors	
lim_t_n2_7 =	theta(t_n2-0.0)
lim_t_o2_0 =	1.0-exp(-t_o2/o2_min_det_resp)
lim_t_o2_2 =	theta(t_o2-0.0)
lim_t_dic_8 =	theta(t_dic-0.0)
lim_t_nh4_11 =	theta(t_nh4-0.0)

continued on next page...

Process limitation factors, continued from previous page	
`lim_t_no3_10 =`	`theta(t_no3-0.0)`
`lim_t_po4_9 =`	`theta(t_po4-0.0)`
`lim_t_spp_16 =`	`theta(t_spp-0.0)`
`lim_t_doc_28 =`	`theta(t_doc-0.0)`
`lim_t_lpp_15 =`	`theta(t_lpp-0.0)`
`lim_t_cya_17 =`	`theta(t_cya-0.0)`
`lim_t_poc_12 =`	`theta(t_poc-0.0)`

3.6 Process type BGC/pelagic/reoxidation

Processes	
nitrification [mol/kg/day]	
`h2o + 2*t_o2 + t_nh4 -> 2*h3oplus + t_no3`	
`p_nh4_nit_no3 =`	`(t_nh4*r_nh4_nitrif*exp(q10_nit*cgt_temp))*lim_t_o2_2* lim_t_nh4_11`
oxidation of hydrogen sulfide with oxygen [mol/kg/day]	
`t_h2s + 0.5*t_o2 -> t_sul + h2o`	
`p_h2s_oxo2_sul =`	`(t_h2s*t_o2*k_h2s_o2*exp(q10_h2s*cgt_temp))*lim_t_h2s_23* lim_t_o2_2`
oxidation of hydrogen sulfide with nitrate [mol/kg/day]	
`t_h2s + 0.4*t_no3 + 0.4*h3oplus -> t_sul + 1.6*h2o + 0.2*t_n2`	
`p_h2s_oxno3_sul =`	`(t_h2s*t_no3*k_h2s_no3*exp(q10_h2s*cgt_temp))*lim_t_h2s_23* lim_t_no3_10`
oxidation of elemental sulfur with oxygen [mol/kg/day]	
`3*h2o + 1.5*t_o2 + t_sul -> 2*h3oplus + so4`	
`p_sul_oxo2_so4 =`	`(t_sul*t_o2*k_sul_o2*exp(q10_h2s*cgt_temp))*lim_t_o2_2* lim_t_sul_24`
oxidation of elemental sulfur with nitrate [mol/kg/day]	
`t_sul + 1.2*t_no3 + 1.2*h2o -> so4 + 0.8*h3oplus + 0.6*t_n2`	
`p_sul_oxno3_so4 =`	`(t_sul*t_no3*k_sul_no3*exp(q10_h2s*cgt_temp))*lim_t_sul_24* lim_t_no3_10`
nitrification; sub-process for atmos_tot nitrogen [mol/kg/day]	
`-> t_no3_with_atmos_tot_N`	
`p_nh4_nit_no3_atmos_tot_N =`	`p_nh4_nit_no3 * ((1.0)*(1)* max(0.0,min(1.0,t_nh4_with_atmos_tot_N/max(0.00000000001,t_nh4) ))) / ((1.0)*(1))`
nitrification; sub-process for atmos_ship nitrogen [mol/kg/day]	
`-> t_no3_with_atmos_ship_N`	
`p_nh4_nit_no3_atmos_ship_N =`	`p_nh4_nit_no3 * ((1.0)*(1)* max(0.0,min(1.0,t_nh4_with_atmos_ship_N/max(0.00000000001,t_nh4) ))) / ((1.0)*(1))`

Auxiliary variables

Constants	
reaction constant h2s oxidation with no3 [kg/mol/day]	
`k_h2s_no3 =`	`800000.0`
reaction constant h2s oxidation with o2 [kg/mol/day]	
`k_h2s_o2 =`	`800000.0`

continued on next page. . .

Constants, continued from previous page	
reaction constant sul oxidation with no3 [kg/mol/day]	
`k_sul_no3 =`	`20000.0`
reaction constant sul oxidation with o2 [kg/mol/day]	
`k_sul_o2 =`	`20000.0`
q10 rule factor for oxidation of h2s and sul [1/K]	
`q10_h2s =`	`0.0693`
q10 rule factor for nitrification [1/K]	
`q10_nit =`	`0.11`
nitrification rate at 0°C [1/day]	
`r_nh4_nitrif =`	`0.05`

Process limitation factors	
`lim_t_o2_2 =`	`theta(t_o2-0.0)`
`lim_t_nh4_11 =`	`theta(t_nh4-0.0)`
`lim_t_no3_10 =`	`theta(t_no3-0.0)`
`lim_t_h2s_23 =`	`theta(t_h2s-0.0)`
`lim_t_sul_24 =`	`theta(t_sul-0.0)`

3.7 Process type BGC/pelagic/zooplankton

Processes	
grazing of zooplankton eating large-cell phytoplankton [mol/kg/day]	
`t_lpp -> t_zoo`	
`p_lpp_graz_zoo =`	`((t_zoo+zoo0)*lr_graz_zoo*t_lpp/max(food_zoo,epsilon))* lim_t_lpp_15`
grazing of zooplankton eating small-cell phytoplankton [mol/kg/day]	
`t_spp -> t_zoo`	
`p_spp_graz_zoo =`	`((t_zoo+zoo0)*lr_graz_zoo*t_spp/max(food_zoo,epsilon))* lim_t_spp_16`
grazing of zooplankton eating diazotroph cyanobacteria [mol/kg/day]	
`t_cya -> t_zoo`	
`p_cya_graz_zoo =`	`((t_zoo+zoo0)*lr_graz_zoo*(0.5*t_cya)/max(food_zoo,epsilon) )*lim_t_cya_17`
respiration of zooplankton [mol/kg/day]	
`t_zoo + 6.625*t_o2 + 0.8125*h3oplus -> don_fraction*t_don + (1-don_fraction)* t_nh4 + rfr_p*t_po4 + rfr_c*t_dic + 7.4375*h2o`	
`p_zoo_resp_nh4 =`	`(zoo_eff*r_zoo_resp)*lim_t_zoo_18*lim_t_o2_2`
mortality of zooplankton [mol/kg/day]	
`t_zoo -> t_det`	
`p_zoo_mort_det =`	`(zoo_eff*r_zoo_mort*(1+9*theta(5.0e-6-t_o2)))*lim_t_zoo_18`
grazing of zooplankton eating large-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]	
`-> t_zoo_with_atmos_tot_N`	
`p_lpp_graz_zoo_atmos =`	`p_lpp_graz_zoo * ((1.0)*(1)* max(0.0,min(1.0,t_lpp_with_atmos_tot_N/max(0.00000000001,t_lpp) ))) / ((1.0)*(1))`
grazing of zooplankton eating small-cell phytoplankton; sub-process for atmos_tot nitrogen [mol/kg/day]	
`-> t_zoo_with_atmos_tot_N`	
`p_spp_graz_zoo_atmos =`	`p_spp_graz_zoo * ((1.0)*(1)* max(0.0,min(1.0,t_spp_with_atmos_tot_N/max(0.00000000001,t_spp) ))) / ((1.0)*(1))`
grazing of zooplankton eating diazotroph cyanobacteria; sub-process for atmos_tot nitrogen [mol/kg/day]	
`-> t_zoo_with_atmos_tot_N`	
`p_cya_graz_zoo_atmos =`	`p_cya_graz_zoo * ((1.0)*(1)* max(0.0,min(1.0,t_cya_with_atmos_tot_N/max(0.00000000001,t_cya) ))) / ((1.0)*(1))`

continued on next page...

Processes, continued from previous page

respiration of zooplankton; sub-process for atmos_tot nitrogen [mol/kg/day]
-> don_fraction*t_don_with_atmos_tot_N + (1-don_fraction)*t_nh4_with_atmos_tot_N

```
p_zoo_resp_nh4_atmos = p_zoo_resp_nh4 * ((1.0)*(1)*max(0.0,min(1.0,t_zoo_with_atmos_tot_N/max(0.00000000001,t_zoo)))) / ((1.0)*(1))
```

mortality of zooplankton; sub-process for atmos_tot nitrogen [mol/kg/day]
-> t_det_with_atmos_tot_N

```
p_zoo_mort_det_atmos = p_zoo_mort_det * ((1.0)*(1)*max(0.0,min(1.0,t_zoo_with_atmos_tot_N/max(0.00000000001,t_zoo)))) / ((1.0)*(1))
```

grazing of zooplankton eating large-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]
-> t_zoo_with_atmos_ship_N

```
p_lpp_graz_zoo_atmos = p_lpp_graz_zoo * ((1.0)*(1)*max(0.0,min(1.0,t_lpp_with_atmos_ship_N/max(0.00000000001,t_lpp)))) / ((1.0)*(1))
```

grazing of zooplankton eating small-cell phytoplankton; sub-process for atmos_ship nitrogen [mol/kg/day]
-> t_zoo_with_atmos_ship_N

```
p_spp_graz_zoo_atmos = p_spp_graz_zoo * ((1.0)*(1)*max(0.0,min(1.0,t_spp_with_atmos_ship_N/max(0.00000000001,t_spp)))) / ((1.0)*(1))
```

grazing of zooplankton eating diazotroph cyanobacteria; sub-process for atmos_ship nitrogen [mol/kg/day]
-> t_zoo_with_atmos_ship_N

```
p_cya_graz_zoo_atmos = p_cya_graz_zoo * ((1.0)*(1)*max(0.0,min(1.0,t_cya_with_atmos_ship_N/max(0.00000000001,t_cya)))) / ((1.0)*(1))
```

respiration of zooplankton; sub-process for atmos_ship nitrogen [mol/kg/day]
-> don_fraction*t_don_with_atmos_ship_N + (1-don_fraction)*t_nh4_with_atmos_ship_N

```
p_zoo_resp_nh4_atmos = p_zoo_resp_nh4 * ((1.0)*(1)*max(0.0,min(1.0,t_zoo_with_atmos_ship_N/max(0.00000000001,t_zoo)))) / ((1.0)*(1))
```

mortality of zooplankton; sub-process for atmos_ship nitrogen [mol/kg/day]
-> t_det_with_atmos_ship_N

continued on next page…

Processes, continued from previous page	
p_zoo_mort_det_atmos =	p_zoo_mort_det * ((1.0)*(1)* max(0.0,min(1.0,t_zoo_with_atmos_ship_N/max(0.00000000001,t_zoo)))) / ((1.0)*(1))

Auxiliary variables

square of positive temperature [°C * °C]

temp_sq = max(0.0,cgt_temp)*max(0.0,cgt_temp)

effectice zooplankton concentration assumed for mortality and respiration process [mol/kg]

zoo_eff = t_zoo*t_zoo/zoo_cl

suitable food for zooplankton (weighted with food preferences) [mol/kg]

food_zoo = t_lpp+t_spp+0.5*t_cya

growth rate of zooplankton, limited by food, oxygen and temperature [1/day]

lr_graz_zoo = r_zoo_graz*(1-exp(-food_zoo*food_zoo/(food_min_zoo* food_min_zoo)))*theta(t_o2-2*t_h2s)*(1.0+ temp_sq/(temp_opt_zoo*temp_opt_zoo)*exp(2.0-cgt_temp* 2.0/temp_opt_zoo))

Constants

no division by 0

epsilon = 4.5E-17

Ivlev phytoplankton concentration for zooplankton grazing [mol/kg]

food_min_zoo = 4.108E-6

maximum zooplankton grazing rate [1/day]

r_zoo_graz = 0.5

mortality rate of zooplankton [1/day]

r_zoo_mort = 0.03

respiration rate of zooplankton [1/day]

r_zoo_resp = 0.01

redfield ratio C/N

rfr_c = 6.625

redfield ratio P/N

rfr_p = 0.0625

optimal temperature for zooplankton grazing [°C]

continued on next page...

Constants, continued from previous page	
`temp_opt_zoo =`	`20.0`
seed concentration for zooplankton [mol/kg]	
`zoo0 =`	`4.5E-9`
zooplankton closure parameter [mol/kg]	
`zoo_cl =`	`9.0E-8`
fraction of DON in respiration products	
`don_fraction =`	`0.0`

Process limitation factors	
`lim_t_o2_2 =`	`theta(t_o2-0.0)`
`lim_t_spp_16 =`	`theta(t_spp-0.0)`
`lim_t_zoo_18 =`	`theta(t_zoo-0.0)`
`lim_t_lpp_15 =`	`theta(t_lpp-0.0)`
`lim_t_cya_17 =`	`theta(t_cya-0.0)`

3.8 Process type gas_exchange

Processes	
Auxiliary variables	
absolute temperature [K]	
temp_k =	cgt_temp + 273.15
temporary value assumed for pH [1]	
ph_temp =	0.0-log(h3o)/log(10.0)
calculated iteratively, 10 iterations, initial value = 0.0	
self-ionization constant of Water [mol2/kg2]	
k_water =	exp(-13847.26 / temp_k + 148.96502 - 23.6521 * log(temp_k) + (118.67/temp_k - 5.977 + 1.0495 * log(temp_k)) * sqrt(cgt_sali) - 0.01615 * cgt_sali)
Solubility of CO2 [mol/kg/Pa]	
k0_co2 =	exp(9345.17 / temp_k - 60.2409 + 23.3585 * (log(temp_k) - 4.605170186) + cgt_sali*(0.023517 - 0.00023656 * temp_k + 0.00000047036 *temp_k*temp_k))/101325.0
Acid dissociation constant CO2 + 2 H2O <-> HCO3- + H3O+ [mol/kg]	
k1_co2 =	power(10.0,(-3633.86 / temp_k + 61.2172 - 9.6777 * log(temp_k) + 0.011555 * cgt_sali - 0.0001152 * cgt_sali * cgt_sali))
Acid dissociation constant HCO3- + H2O <-> [CO3 2-] + H3O+ [mol/kg]	
k2_co2 =	power(10.0,(-471.78 / temp_k - 25.929 + 3.16967 * log(temp_k) + 0.01781 * cgt_sali - 0.0001122 * cgt_sali * cgt_sali))
Acid dissociation constant of boric acid [mol/kg]	
k_boron =	exp((-8966.9 - 2890.53*sqrt(cgt_sali) - 77.942*cgt_sali + 1.728*cgt_sali*sqrt(cgt_sali) - 0.0996*cgt_sali*cgt_sali) / temp_k + 148.0248 + 137.1942*sqrt(cgt_sali) + 1.62142* cgt_sali + (-24.4344 - 25.085*sqrt(cgt_sali) - 0.2474* cgt_sali)*log(temp_k) + 0.053105*sqrt(cgt_sali)*temp_k)
Acid dissociation constant H3PO4 + H2O <-> [H2PO4 -] + H3O+ [mol/kg]	
k1_po4 =	exp(-4576.752/temp_k + 115.525 - 18.453*log(temp_k) + (0.69171 - 106.736/temp_k)*sqrt(cgt_sali) - (0.01844 + 0.65643/temp_k)*cgt_sali)
Acid dissociation constant [H2PO4 -] + H2O+ <-> [HPO4 2-] + H3O+ [mol/kg]	
k2_po4 =	exp(-8814.715/temp_k + 172.0883 - 27.927*log(temp_k) + (1.35660 - 160.340/temp_k)*sqrt(cgt_sali) - (0.05778 - 0.37335/temp_k)*cgt_sali)

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Auxiliary variables, continued from previous page

Acid dissociation constant [HPO4 2-] + H2O <-> [PO4 3-] + H3O+ [mol/kg]
k3_po4 = exp(-3070.75/temp_k - 18.141 + (2.81197 + 17.27039/temp_k) *sqrt(cgt_sali) - (0.09984 + 44.99486/temp_k)*cgt_sali)

Acid dissociation constant H2S + H2O <-> HS- + H3O+ [mol/kg]
k1_h2s = exp(-3131.42/temp_k + 5.818 + 0.368* (power(max(0.0,cgt_sali),(1.0/3.0))))

total concentration of boron [mol/kg]
boron_total = 0.000416 * cgt_sali/35.0

boron alkalinity [mol/kg]
alk_boron = boron_total * k_boron / (k_boron + h3o)
calculated iteratively, 10 iterations, initial value = 0.0

hydrogen sulfide alkalinity [mol/kg]
alk_h2s = t_h2s * k1_h2s / (k1_h2s + h3o)
calculated iteratively, 10 iterations, initial value = 0.0

water alkalinity [mol/kg]
alk_water = k_water / h3o - h3o
calculated iteratively, 10 iterations, initial value = 0.0

denominator in phosphate alkalinity formula [mol3/kg3]
alk_po4_denominator = (h3o*h3o*h3o + k1_po4*h3o*h3o + k1_po4*k2_po4*h3o + k1_po4* k2_po4*k3_po4)
calculated iteratively, 10 iterations, initial value = 0.0

phosphate alkalinity [mol/kg]
alk_po4 = t_po4*(k1_po4*k2_po4*h3o + 2.0*k1_po4*k2_po4*k3_po4 - h3o* h3o*h3o) / alk_po4_denominator
calculated iteratively, 10 iterations, initial value = 0.0

denominator in carbonate alkalinity formula [mol2/kg2]
alk_co2_denominator = (h3o*h3o + k1_co2*h3o + k1_co2*k2_co2)
calculated iteratively, 10 iterations, initial value = 0.0

carbonate alkalinity [mol/kg]
alk_co2 = t_dic*k1_co2*(h3o+2*k2_co2)/alk_co2_denominator
calculated iteratively, 10 iterations, initial value = 0.0

error in total alkalinity calculation at the assumed pH [mol/kg]

continued on next page...

Auxiliary variables, continued from previous page	
`alk_residual =`	`t_alk - alk_co2 - alk_po4 - alk_boron - alk_h2s - alk_water`
calculated iteratively, 10 iterations, initial value = `0.0`	
derivative of phosphate alkalinity with respect to h3o [1]	
`dalkp_dh3o =`	`t_po4*(0.0-k1_po4*h3o*h3o*h3o*h3o-4*k1_po4*k2_po4*h3o*h3o*h3o-(k1_po4*k1_po4*k2_po4+9*k1_po4*k2_po4*k3_po4)*h3o*h3o-4*k1_po4*k1_po4*k2_po4*k3_po4*h3o-k1_po4*k1_po4*k2_po4*k2_po4*k3_po4)/(alk_po4_denominator*alk_po4_denominator)`
calculated iteratively, 10 iterations, initial value = `0.0`	
derivative of carbonate alkalinity with respect to h3o [1]	
`dalkc_dh3o =`	`t_dic*(0.0-k1_co2*h3o*h3o-k1_co2*k1_co2*k2_co2-4*k1_co2*k2_co2*h3o)/(alk_co2_denominator*alk_co2_denominator)`
calculated iteratively, 10 iterations, initial value = `0.0`	
derivative of residual_alk with respect to pH [mol/kg]	
`dalkresidual_dpH =`	`0.0-log(10.0)*h3o*(alk_boron/(k_boron+h3o)+alk_h2s/(k1_h2s+h3o)+k_water/(h3o*h3o)+1-dalkp_dh3o-dalkc_dh3o)`
calculated iteratively, 10 iterations, initial value = `0.0`	
newly determined pH value [1]	
`temp1 =`	`alk_residual/dalkresidual_dpH`
`ph =`	`ph_temp - temp1 + theta(abs(temp1) - 1)*0.5*temp1`
calculated iteratively, 10 iterations, initial value = `0.0`	
h3o ion concentration [mol/kg]	
`h3o =`	`power(10.0,0.0-max(1.0,min(13.0,ph)))`
calculated iteratively, 10 iterations, initial value = `1.0e-8`	
co2 partial pressure [Pa]	
`pco2 =`	`t_dic / k0_co2 / (1 + k1_co2/h3o + k1_co2*k2_co2/h3o/h3o)`
oxygen saturation concentration [mol/kg]	
`o2_sat =`	`(10.18e0+((5.306e-3-4.8725e-5*cgt_temp)*cgt_temp-0.2785e0)*cgt_temp+cgt_sali*((2.2258e-3+(4.39e-7*cgt_temp-4.645e-5)*cgt_temp)*cgt_temp-6.33e-2))*44.66e0*1e-6`
dissolved molecular nitrogen saturation concentration [mol/kg]	
`temp1 =`	`log((298.15-cgt_temp)/(273.15+cgt_temp))`
`temp2 =`	`temp1*temp1`
`temp3 =`	`temp2*temp1`
`n2_sat =`	`1e-6*exp(6.42931 + 2.92704*temp1 + 4.32531*temp2 + 4.69149*temp3 + cgt_sali*(0.0 -7.44129e-3 - 8.02566e-3*temp1 - 1.46775e-2*temp2))`

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Auxiliary variables, continued from previous page

Constants

atmospheric partial pressure of CO2 [Pa]

`patm_co2 = 38.0`

piston velocity for co2 surface flux [m/d]

`w_co2_stf = 4.0`

piston velocity for n2 surface flux [m/d]

`w_n2_stf = 5.0`

piston velocity for oxygen surface flux [m/d]

`w_o2_stf = 5.0`

Process limitation factors

`lim_t_n2_7 = theta(t_n2-0.0)`

`lim_t_o2_2 = theta(t_o2-0.0)`

`lim_t_dic_8 = theta(t_dic-0.0)`

3.9 Process type physics/erosion

Processes	
sedimentary detritus erosion (sediment only) [mol/m^2/day]	
t_sed -> t_det	
p_sed_ero_det =	(erosion_is_active*r_sed_ero*sed_active)*lim_t_sed_20
erosion of iron PO4 (sediment only) [mol/m^2/day]	
t_ips -> t_ipw	
p_ips_ero_ipw =	(erosion_is_active*r_ips_ero*t_ips)*lim_t_ips_22
sedimentary poc erosion (sediment only) [mol/m^2/day]	
t_sed_poc -> t_poc	
p_sed_ero_poc =	(erosion_is_active*r_sed_ero*poc_active)*lim_t_sed_poc_21
sedimentary pocn erosion (sediment only) [mol/m^2/day]	
t_sed_pocn -> t_pocn	
p_sed_ero_pocn =	(erosion_is_active*r_sed_ero*pocn_active)*lim_t_sed_pocn_26
sedimentary pocp erosion (sediment only) [mol/m^2/day]	
t_sed_pocp -> t_pocp	
p_sed_ero_pocp =	(erosion_is_active*r_sed_ero*pocp_active)*lim_t_sed_pocp_27
sedimentary detritus erosion; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]	
-> t_det_with_atmos_tot_N	
p_sed_ero_det_atmos =	p_sed_ero_det * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_tot_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))
sedimentary pocn erosion; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]	
-> t_pocn_with_atmos_tot_N	
p_sed_ero_pocn_atmos =	p_sed_ero_pocn * ((1.0)*(1)* max(0.0,min(1.0,t_sed_pocn_with_atmos_tot_N/max(0.00000000001,t_sed_pocn)))) / ((1.0)*(1))
sedimentary detritus erosion; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]	
-> t_det_with_atmos_ship_N	
p_sed_ero_det_atmos =	p_sed_ero_det * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_ship_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))

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Processes, continued from previous page

sedimentary pocn erosion; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

```
 -> t_pocn_with_atmos_ship_N
                    p_sed_ero_pocn * ((1.0)*(1)*
p_sed_ero_pocn_atmosmax(0.0,min(1.0,t_sed_pocn_with_atmos_ship_N/max(0.00000000001,t_sed_pocn
=                   ))) / ((1.0)*(1))
```

Auxiliary variables

total carbon in sediment layer [mol/m2]**

```
sed_tot =           t_sed*rfr_c + t_sed_poc + t_sed_pocn*rfr_c + t_sed_pocp*
                    rfr_cp
```

total carbon in active sediment layer [mol/m2]**

```
sed_tot_active =    max(0.0,min(sed_tot,sed_max*rfr_c))
```

detritus in active sediment layer [mol/m2]**

```
sed_active =        sed_tot_active * t_sed/sed_tot
```

switch (1=erosion, 0=no erosion) which depends on the combined bottom stress of currents and waves

```
erosion_is_active = theta(cgt_current_wave_stress - critical_stress)
```

poc in active sediment layer [mol/m2]**

```
poc_active =        sed_tot_active * t_sed_poc/sed_tot
```

pocn in active sediment layer [mol/m2]**

```
pocn_active =       sed_tot_active * t_sed_pocn/sed_tot
```

pocp in active sediment layer [mol/m2]**

```
pocp_active =       sed_tot_active * t_sed_pocp/sed_tot
```

Constants

critical shear stress for sediment erosion [N/m2]

```
critical_stress =   0.016
```

erosion rate for iron PO4 [1/day]

```
r_ips_ero =         6.0
```

maximum sediment detritus erosion rate [1/day]

```
r_sed_ero =         6.0
```

redfield ratio C/N

```
rfr_c =             6.625
```

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Constants, continued from previous page	
redfield ratio C/P	
`rfr_cp =`	`106.0`
maximum sediment detritus concentration that feels erosion [mol/m2]**	
`sed_max =`	`1.0`

Process limitation factors	
`lim_t_sed_20 =`	`theta(t_sed-0.0)`
`lim_t_ips_22 =`	`theta(t_ips-0.0)`
`lim_t_sed_poc_21 =`	`theta(t_sed_poc-0.0)`
`lim_t_sed_pocn_26 =`	`theta(t_sed_pocn-0.0)`
`lim_t_sed_pocp_27 =`	`theta(t_sed_pocp-0.0)`

3.10 Process type physics/parametrization_deep_burial

Processes	
burial of detritus deeper than max_sed (sediment only) [mol/m^2/day]	
`t_sed ->`	
`p_sed_burial =`	`((sed_tot-sed_tot_active)/cgt_timestep*t_sed/sed_tot)* lim_t_sed_20`
burial of iron PO4 (sediment only) [mol/m^2/day]	
`t_ips ->`	
`p_ips_burial =`	`(ips_eff*r_ips_burial*sed_tot_active/rfr_c/sed_max)* lim_t_ips_22`
burial of poc deeper than max_sed (sediment only) [mol/m^2/day]	
`t_sed_poc ->`	
`p_poc_burial =`	`((sed_tot-sed_tot_active)/cgt_timestep*t_sed_poc/sed_tot)* lim_t_sed_poc_21`
burial of pocn deeper than max_sed (sediment only) [mol/m^2/day]	
`t_sed_pocn ->`	
`p_pocn_burial =`	`((sed_tot-sed_tot_active)/cgt_timestep*t_sed_pocn/sed_tot)* lim_t_sed_pocn_26`
burial of pocp deeper than max_sed (sediment only) [mol/m^2/day]	
`t_sed_pocp ->`	
`p_pocp_burial =`	`((sed_tot-sed_tot_active)/cgt_timestep*t_sed_pocp/sed_tot)* lim_t_sed_pocp_27`
burial of detritus deeper than max_sed; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]	
`->`	
`p_sed_burial_atmos_t =`	`p_sed_burial * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_tot_N/max(0.00000000001,t_sed) ))) / ((1.0)*(1))`
burial of pocn deeper than max_sed; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]	
`->`	
`p_pocn_burial_atmos_ =`	`p_pocn_burial * ((1.0)*(1)* max(0.0,min(1.0,t_sed_pocn_with_atmos_tot_N/max(0.00000000001,t_sed_pocn) ))) / ((1.0)*(1))`
burial of detritus deeper than max_sed; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]	

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Processes, continued from previous page	
->	
p_sed_burial_atmos_s =	p_sed_burial * ((1.0)*(1)* max(0.0,min(1.0,t_sed_with_atmos_ship_N/max(0.00000000001,t_sed)))) / ((1.0)*(1))

burial of pocn deeper than max_sed; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]

->	
p_pocn_burial_atmos_ =	p_pocn_burial * ((1.0)*(1)* max(0.0,min(1.0,t_sed_pocn_with_atmos_ship_N/max(0.00000000001,t_sed_pocn)))) / ((1.0)*(1))

Auxiliary variables

total carbon in sediment layer [mol/m2]**

```
sed_tot =          t_sed*rfr_c + t_sed_poc + t_sed_pocn*rfr_c + t_sed_pocp*
                   rfr_cp
```

total carbon in active sediment layer [mol/m2]**

```
sed_tot_active =   max(0.0,min(sed_tot,sed_max*rfr_c))
```

effective concentration of iron phosphate in the sediment assumed for burial (enhanced burial above a threshold) [mol/m2]**

```
ips_eff =          max(t_ips,t_ips+t_ips*(t_ips-ips_threshold)/ips_cl)
```

Constants

threshold for increased PO4 burial [mol/m2]**

```
ips_threshold =    0.1
```

iron phosphate in sediment closure parameter [mol/m2]

```
ips_cl =           0.02025
```

final burial rate for PO4 [1/day]

```
r_ips_burial =     0.0018
```

redfield ratio C/N

```
rfr_c =            6.625
```

redfield ratio C/P

```
rfr_cp =           106.0
```

maximum sediment detritus concentration that feels erosion [mol/m2]**

```
sed_max =          1.0
```

Process limitation factors

```
lim_t_sed_20 =     theta(t_sed-0.0)
```

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Process limitation factors, continued from previous page	
lim_t_ips_22 =	theta(t_ips-0.0)
lim_t_sed_poc_21 =	theta(t_sed_poc-0.0)
lim_t_sed_pocn_26 =	theta(t_sed_pocn-0.0)
lim_t_sed_pocp_27 =	theta(t_sed_pocp-0.0)

3.11 Process type physics/sedimentation

Processes	
detritus sedimentation (sediment only) [mol/m^2/day]	
t_det -> t_sed	
p_det_sedi_sed =	((1.0-erosion_is_active)*(0.0-w_det_sedi)*t_det* cgt_density)*lim_t_det_19
sedimentation of iron PO4 (sediment only) [mol/m^2/day]	
t_ipw -> t_ips	
p_ipw_sedi_ips =	((1.0-erosion_is_active)*(0.0-w_ipw_sedi)*t_ipw* cgt_density)*lim_t_ipw_25
poc sedimentation (sediment only) [mol/m^2/day]	
t_poc -> t_sed_poc	
p_poc_sedi_sed =	((1.0-erosion_is_active)*(0.0-w_poc_sedi)*t_poc* cgt_density)*lim_t_poc_12
pocn sedimentation (sediment only) [mol/m^2/day]	
t_pocn -> t_sed_pocn	
p_pocn_sedi_sed =	((1.0-erosion_is_active)*(0.0-w_pocn_sedi)*t_pocn* cgt_density)*lim_t_pocn_14
pocp sedimentation (sediment only) [mol/m^2/day]	
t_pocp -> t_sed_pocp	
p_pocp_sedi_sed =	((1.0-erosion_is_active)*(0.0-w_pocp_sedi)*t_pocp* cgt_density)*lim_t_pocp_13
detritus sedimentation; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]	
-> t_sed_with_atmos_tot_N	
p_det_sedi_sed_atmos =	p_det_sedi_sed * ((1.0)*(1)* max(0.0,min(1.0,t_det_with_atmos_tot_N/max(0.00000000001,t_det)))) / ((1.0)*(1))
pocn sedimentation; sub-process for atmos_tot nitrogen (sediment only) [mol/m^2/day]	
-> t_sed_pocn_with_atmos_tot_N	
p_pocn_sedi_sed_atmo =	p_pocn_sedi_sed * ((1.0)*(1)* max(0.0,min(1.0,t_pocn_with_atmos_tot_N/max(0.00000000001,t_pocn)))) / ((1.0)*(1))
detritus sedimentation; sub-process for atmos_ship nitrogen (sediment only) [mol/m^2/day]	

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Processes, continued from previous page	
-> t_sed_with_atmos_ship_N	
p_det_sedi_sed_atmos =	p_det_sedi_sed * ((1.0)*(1)* max(0.0,min(1.0,t_det_with_atmos_ship_N/max(0.00000000001,t_det)))) / ((1.0)*(1))
pocn sedimentation; sub-process for atmos_ship nitrogen (sediment only) [mol/m²/day]	
-> t_sed_pocn_with_atmos_ship_N	
p_pocn_sedi_sed_atmo =	p_pocn_sedi_sed * ((1.0)*(1)* max(0.0,min(1.0,t_pocn_with_atmos_ship_N/max(0.00000000001,t_pocn)))) / ((1.0)*(1))

Auxiliary variables
switch (1=erosion, 0=no erosion) which depends on the combined bottom stress of currents and waves
erosion_is_active = theta(cgt_current_wave_stress - critical_stress)

Constants	
critical shear stress for sediment erosion [N/m2]	
critical_stress =	0.016
sedimentation velocity (negative for downward) [m/day]	
w_det_sedi =	-2.25
sedimentation velocity for iron PO4 [m/day]	
w_ipw_sedi =	-0.5
sedimentation velocity (negative for downward) [m/day]	
w_poc_sedi =	-0.1
sedimentation velocity (negative for downward) [m/day]	
w_pocp_sedi =	-0.05
sedimentation velocity (negative for downward) [m/day]	
w_pocn_sedi =	-0.05

Process limitation factors	
lim_t_ipw_25 =	theta(t_ipw-0.0)
lim_t_det_19 =	theta(t_det-0.0)
lim_t_poc_12 =	theta(t_poc-0.0)
lim_t_pocp_13 =	theta(t_pocp-0.0)

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Process limitation factors, continued from previous page	
lim_t_pocn_14 =	theta(t_pocn-0.0)

3.12 Process type standard

Processes	
particle formation from DOC [mol/kg/day]	
t_doc -> t_poc	
p_doc2pco =	(t_doc * r_doc2poc)*lim_t_doc_28
particle formation from DOP [mol/kg/day]	
t_dop -> t_pocp	
p_dop2pocp =	(t_dop * r_dop2pocp)*lim_t_dop_29
particle formation from DON [mol/kg/day]	
t_don -> t_pocn	
p_don2pocn =	(t_don * r_don2pocn)*lim_t_don_30
particle formation from DON; sub-process for atmos_tot nitrogen [mol/kg/day]	
-> t_pocn_with_atmos_tot_N	
p_don2pocn_atmos_tot =	p_don2pocn * ((1.0)*(1)* max(0.0,min(1.0,t_don_with_atmos_tot_N/max(0.00000000001,t_don)))) / ((1.0)*(1))
particle formation from DON; sub-process for atmos_ship nitrogen [mol/kg/day]	
-> t_pocn_with_atmos_ship_N	
p_don2pocn_atmos_shi =	p_don2pocn * ((1.0)*(1)* max(0.0,min(1.0,t_don_with_atmos_ship_N/max(0.00000000001,t_don)))) / ((1.0)*(1))

Auxiliary variables	

Constants	
POC formation rate	
r_doc2poc =	0.01
POCN formation rate	
r_don2pocn =	0.01
POCP formation rate	
r_dop2pocp =	0.01

Process limitation factors	
lim_t_doc_28 =	theta(t_doc-0.0)
lim_t_dop_29 =	theta(t_dop-0.0)
lim_t_don_30 =	theta(t_don-0.0)

4 Tracer equations

Tracer equations	
Change of: dissolved molecular nitrogen	
$\frac{d}{dt}$ t_n2 =	
+ (p_poc_denit)*(0.4)	recycling of POC using nitrate (denitrification)
+ (p_pocp_denit)*(42.4)	recycling of POC using nitrate (denitrification)
+ (p_pocn_denit_wiN2)*(2.65)	recycling of POCN using nitrate (denitrification)
+ (p_det_denit_nh4)*(2.65)	recycling of detritus using nitrate (denitrification)
+ (p_nh4_nitdenit_n2)*(0.5) /(cgt_cellheight*cgt_density)	coupled nitrification and denitrification after mineralization of detritus in oxic sediments
+ (p_sed_denit_nh4_wiN2)* (2.65)/(cgt_cellheight* cgt_density)	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
+ (p_sed_poc_denit)*(0.4) /(cgt_cellheight*cgt_density)	recycling of sedimentary poc to dic using nitrate (denitrification)
+ (p_h2s_oxno3_sul)*(0.2)	oxidation of hydrogen sulfide with nitrate
+ (p_sul_oxno3_so4)*(0.6)	oxidation of elemental sulfur with nitrate
+ (p_sed_pocn_denit_wiN2)* (2.65)/(cgt_cellheight* cgt_density)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)
+ (p_sed_pocp_denit)*(42.4) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)
+ (p_nh4_nitdenit_pocn_n2)* (0.5)/(cgt_cellheight* cgt_density)	coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments

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Tracer equations, continued from previous page	
+ (p_doc_denit)*(0.4)	recycling of DOC using nitrate (denitrification)
+ (p_dop_denit)*(42.4)	recycling of DOP using nitrate (denitrification)
+ (p_don_denit_wiN2)*(2.65)	recycling of DON using nitrate (denitrification)
- (p_n2_assim_cya)*(0.5)	fixation of dinitrogen by diazotroph cyanobacteria

Change of: dissolved oxygen

$\frac{d}{dt}$ t_o2 =

+ (p_no3_assim_lpp)*(8.625)	assimilation of nitrate by large-cell phytoplankton
+ (p_nh4_assim_lpp)*(6.625)	assimilation of ammonium by large-cell phytoplankton
+ (p_no3_assim_spp)*(8.625)	assimilation of nitrate by small-cell phytoplankton
+ (p_nh4_assim_spp)*(6.625)	assimilation of ammonium by small-cell phytoplankton
+ (p_n2_assim_cya)*(7.375)	fixation of dinitrogen by diazotroph cyanobacteria
+ p_assim_lpp_doc	Production of DOC by LPP
+ p_assim_spp_doc	Production of DOC by SPP
+ p_assim_cya_doc	Production of POC by CYA
+ (p_assim_lpp_dop)*(106)	Production of DOP by LPP
+ (p_assim_spp_dop)*(106)	Production of DOP by SPP
+ (p_nh4_assim_lpp_don)*(6.625)	Production of DON by LPP
+ (p_no3_assim_lpp_don)*(8.625)	Production of DON by LPP

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Tracer equations, continued from previous page	
+ (p_nh4_assim_spp_don)* (6.625)	Production of DON by SPP
+ (p_no3_assim_spp_don)* (8.625)	Production of DON by SPP
- p_poc_resp	respiration of POC
- (p_pocp_resp)*(106)	respiration of POCP
- (p_pocn_resp)*(6.625)	respiration of POCN
- (p_lpp_resp_nh4)*(6.625)	respiration of large-cell phytoplankton
- (p_spp_resp_nh4)*(6.625)	respiration of small-cell phytoplankton
- (p_cya_resp_nh4)*(6.625)	respiration of diazotroph cyanobacteria
- (p_zoo_resp_nh4)*(6.625)	respiration of zooplankton
- (p_nh4_nit_no3)*(2)	nitrification
- (p_det_resp_nh4)*(6.625)	recycling of detritus using oxygen (respiration)
- (p_sed_resp_nh4)*(6.625) /(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using oxygen (respiration)
- (p_nh4_nitdenit_n2)*(0.75) /(cgt_cellheight*cgt_density)	coupled nitrification and denitrification after mineralization of detritus in oxic sediments
- p_sed_poc_resp/(cgt_cellheight cgt_density)	recycling of sedimentary poc to dic using oxygen (respiration)
- (p_h2s_oxo2_sul)*(0.5)	oxidation of hydrogen sulfide with oxygen
- (p_sul_oxo2_so4)*(1.5)	oxidation of elemental sulfur with oxygen
- (p_sed_pocn_resp)*(6.625) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration)
- (p_sed_pocp_resp)*(106) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using oxygen (respiration)
- (p_nh4_nitdenit_pocn_n2)* (0.75)/(cgt_cellheight* cgt_density)	coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments

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Tracer equations, continued from previous page

`- p_doc_resp`	respiration of DOC
`- (p_dop_resp)*(106)`	respiration of DOP
`- (p_don_resp)*(6.625)`	respiration of DON

Change of: dissolved inorganic carbon, treated as carbon dioxide

$\frac{d}{dt}$ `t_dic` =

`+ p_poc_resp`	respiration of POC
`+ p_poc_denit`	recycling of POC using nitrate (denitrification)
`+ p_poc_sulf`	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
`+ (p_pocp_resp)*(106)`	respiration of POCP
`+ (p_pocp_denit)*(106)`	recycling of POC using nitrate (denitrification)
`+ (p_pocp_sulf)*(106)`	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
`+ (p_pocn_resp)*(6.625)`	respiration of POCN
`+ (p_pocn_denit_noN2)*(6.625)`	recycling of POCN using nitrate (denitrification)
`+ (p_pocn_sulf)*(6.625)`	Mineralization of POCN, e-acceptor sulfate (sulfate reduction)
`+ (p_lpp_resp_nh4)*(rfr_c)`	respiration of large-cell phytoplankton
`+ (p_spp_resp_nh4)*(rfr_c)`	respiration of small-cell phytoplankton
`+ (p_cya_resp_nh4)*(rfr_c)`	respiration of diazotroph cyanobacteria
`+ (p_zoo_resp_nh4)*(rfr_c)`	respiration of zooplankton
`+ (p_det_resp_nh4)*(rfr_c)`	recycling of detritus using oxygen (respiration)
`+ (p_det_denit_nh4)*(rfr_c)`	recycling of detritus using nitrate (denitrification)

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Tracer equations, continued from previous page	
+ (p_det_sulf_nh4)*(rfr_c)	recycling of detritus using sulfate (sulfate reduction)
+ (p_sed_resp_nh4)*(rfr_c) /(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using oxygen (respiration)
+ (p_sed_denit_nh4_noN2)* (rfr_c)/(cgt_cellheight* cgt_density)	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
+ (p_sed_sulf_nh4)*(rfr_c) /(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)
+ p_sed_poc_resp/(cgt_cellheight* cgt_density)	recycling of sedimentary poc to dic using oxygen (respiration)
+ p_sed_poc_denit/(cgt_cellheight* cgt_density)	recycling of sedimentary poc to dic using nitrate (denitrification)
+ p_sed_poc_sulf/(cgt_cellheight* cgt_density)	recycling of sedimentary poc to dic using sulfate (sulfate reduction)
+ (p_sed_pocn_resp)*(6.625) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration)
+ (p_sed_pocp_resp)*(106) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using oxygen (respiration)
+ (p_sed_pocn_denit_noN2)* (6.625)/(cgt_cellheight* cgt_density)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)
+ (p_sed_pocp_denit)*(106) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)
+ (p_sed_pocn_sulf)*(6.625) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction)
+ (p_sed_pocp_sulf)*(106) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction)

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Tracer equations, continued from previous page	
+ p_doc_resp	respiration of DOC
+ p_doc_denit	recycling of DOC using nitrate (denitrification)
+ p_doc_sulf	Mineralization of DOC, e-acceptor sulfate (sulfate reduction)
+ (p_dop_resp)*(106)	respiration of DOP
+ (p_dop_denit)*(106)	recycling of DOP using nitrate (denitrification)
+ (p_dop_sulf)*(106)	Mineralization of DOP, e-acceptor sulfate (sulfate reduction)
+ (p_don_resp)*(6.625)	respiration of DON
+ (p_don_denit_noN2)*(6.625)	recycling of DON using nitrate (denitrification)
+ (p_don_sulf)*(6.625)	Mineralization of DON, e-acceptor sulfate (sulfate reduction)
- (p_no3_assim_lpp)*(rfr_c)	assimilation of nitrate by large-cell phytoplankton
- (p_nh4_assim_lpp)*(rfr_c)	assimilation of ammonium by large-cell phytoplankton
- (p_no3_assim_spp)*(rfr_c)	assimilation of nitrate by small-cell phytoplankton
- (p_nh4_assim_spp)*(rfr_c)	assimilation of ammonium by small-cell phytoplankton
- (p_n2_assim_cya)*(rfr_c)	fixation of dinitrogen by diazotroph cyanobacteria
- p_assim_lpp_doc	Production of DOC by LPP
- p_assim_spp_doc	Production of DOC by SPP
- p_assim_cya_doc	Production of POC by CYA
- (p_assim_lpp_dop)*(106)	Production of DOP by LPP

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Tracer equations, continued from previous page	
- (p_assim_spp_dop)*(106)	Production of DOP by SPP
- (p_nh4_assim_lpp_don)*(6.625)	Production of DON by LPP
- (p_no3_assim_lpp_don)*(6.625)	Production of DON by LPP
- (p_nh4_assim_spp_don)*(6.625)	Production of DON by SPP
- (p_no3_assim_spp_don)*(6.625)	Production of DON by SPP

Change of: ammonium

$\frac{d}{dt}$ t_nh4 =

+ p_pocn_resp	respiration of POCN
+ p_pocn_denit_noN2	recycling of POCN using nitrate (denitrification)
+ p_pocn_sulf	Mineralization of POCN, e-acceptor sulfate (sulfate reduction)
+ (p_lpp_resp_nh4)*((1-don_fraction))	respiration of large-cell phytoplankton
+ (p_spp_resp_nh4)*((1-don_fraction))	respiration of small-cell phytoplankton
+ (p_cya_resp_nh4)*((1-don_fraction))	respiration of diazotroph cyanobacteria
+ (p_zoo_resp_nh4)*((1-don_fraction))	respiration of zooplankton
+ p_det_resp_nh4	recycling of detritus using oxygen (respiration)
+ p_det_denit_nh4	recycling of detritus using nitrate (denitrification)
+ p_det_sulf_nh4	recycling of detritus using sulfate (sulfate reduction)

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Tracer equations, continued from previous page

+ p_sed_resp_nh4/(cgt_cellheight cgt_density)	recycling of sedimentary detritus to ammonium using oxygen (respiration)
+ p_sed_denit_nh4_noN2/(cgt_cel cgt_density)	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
+ p_sed_sulf_nh4/(cgt_cellheight cgt_density)	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)
+ p_sed_pocn_resp/(cgt_cellheig cgt_density)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration)
+ p_sed_pocn_denit_noN2/(cgt_cel cgt_density)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)
+ p_sed_pocn_sulf/(cgt_cellheig cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction)
+ p_don_resp	respiration of DON
+ p_don_denit_noN2	recycling of DON using nitrate (denitrification)
+ p_don_sulf	Mineralization of DON, e-acceptor sulfate (sulfate reduction)
- p_nh4_assim_lpp	assimilation of ammonium by large-cell phytoplankton
- p_nh4_assim_spp	assimilation of ammonium by small-cell phytoplankton
- p_nh4_assim_lpp_don	Production of DON by LPP
- p_nh4_assim_spp_don	Production of DON by SPP
- p_nh4_nit_no3	nitrification
- p_nh4_nitdenit_n2/(cgt_cellhei cgt_density)	coupled nitrification and denitrification after mineralization of detritus in oxic sediments

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Tracer equations, continued from previous page

- p_nh4_nitdenit_pocn_n2/(cgt_ce cgt_density)	coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments

Change of: nitrate

$\frac{d}{dt}$ t_no3 =

+ p_nh4_nit_no3	nitrification
- p_no3_assim_lpp	assimilation of nitrate by large-cell phytoplankton
- p_no3_assim_spp	assimilation of nitrate by small-cell phytoplankton
- p_no3_assim_lpp_don	Production of DON by LPP
- p_no3_assim_spp_don	Production of DON by SPP
- (p_poc_denit)*(0.8)	recycling of POC using nitrate (denitrification)
- (p_pocp_denit)*(84.8)	recycling of POC using nitrate (denitrification)
- (p_pocn_denit_wiN2)*(5.3)	recycling of POCN using nitrate (denitrification)
- (p_det_denit_nh4)*(5.3)	recycling of detritus using nitrate (denitrification)
- (p_sed_denit_nh4_wiN2)*(5.3)/(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
- (p_sed_poc_denit)*(0.8)/(cgt_cellheight*cgt_density)	recycling of sedimentary poc to dic using nitrate (denitrification)
- (p_h2s_oxno3_sul)*(0.4)	oxidation of hydrogen sulfide with nitrate
- (p_sul_oxno3_so4)*(1.2)	oxidation of elemental sulfur with nitrate
- (p_sed_pocn_denit_wiN2)*(5.3)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)

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Tracer equations, continued from previous page

`- (p_sed_pocp_denit)*(84.8) /(cgt_cellheight*cgt_density)`	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)
`- (p_doc_denit)*(0.8)`	recycling of DOC using nitrate (denitrification)
`- (p_dop_denit)*(84.8)`	recycling of DOP using nitrate (denitrification)
`- (p_don_denit_wiN2)*(5.3)`	recycling of DON using nitrate (denitrification)

Change of: phosphate

$\frac{d}{dt}$ `t_po4` =

`+ p_pocp_resp`	respiration of POCP
`+ p_pocp_denit`	recycling of POC using nitrate (denitrification)
`+ p_pocp_sulf`	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
`+ (p_lpp_resp_nh4)*(rfr_p)`	respiration of large-cell phytoplankton
`+ (p_spp_resp_nh4)*(rfr_p)`	respiration of small-cell phytoplankton
`+ (p_cya_resp_nh4)*(rfr_p)`	respiration of diazotroph cyanobacteria
`+ (p_zoo_resp_nh4)*(rfr_p)`	respiration of zooplankton
`+ (p_det_resp_nh4)*(rfr_p)`	recycling of detritus using oxygen (respiration)
`+ (p_det_denit_nh4)*(rfr_p)`	recycling of detritus using nitrate (denitrification)
`+ (p_det_sulf_nh4)*(rfr_p)`	recycling of detritus using sulfate (sulfate reduction)
`+ (p_sed_resp_nh4)*(rfr_p) /(cgt_cellheight*cgt_density)`	recycling of sedimentary detritus to ammonium using oxygen (respiration)
`+ (p_sed_denit_nh4_noN2)* (rfr_p)/(cgt_cellheight* cgt_density)`	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
`+ (p_sed_sulf_nh4)*(rfr_p) /(cgt_cellheight*cgt_density)`	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)

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Tracer equations, continued from previous page	
+ p_ips_liber_po4/(cgt_cellheigh cgt_density)	liberation of phosphate from the sediment under anoxic conditions
+ p_sed_pocp_resp/(cgt_cellheigh cgt_density)	recycling of sedimentary pocp to dic and PO4 using oxygen (respiration)
+ p_sed_pocp_denit/(cgt_cellheig cgt_density)	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)
+ p_sed_pocp_sulf/(cgt_cellheigh cgt_density)	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction)
+ p_dop_resp	respiration of DOP
+ p_dop_denit	recycling of DOP using nitrate (denitrification)
+ p_dop_sulf	Mineralization of DOP, e-acceptor sulfate (sulfate reduction)
- (p_no3_assim_lpp)*(rfr_p)	assimilation of nitrate by large-cell phytoplankton
- (p_nh4_assim_lpp)*(rfr_p)	assimilation of ammonium by large-cell phytoplankton
- (p_no3_assim_spp)*(rfr_p)	assimilation of nitrate by small-cell phytoplankton
- (p_nh4_assim_spp)*(rfr_p)	assimilation of ammonium by small-cell phytoplankton
- (p_n2_assim_cya)*(rfr_p)	fixation of dinitrogen by diazotroph cyanobacteria
- p_assim_lpp_dop	Production of DOP by LPP
- p_assim_spp_dop	Production of DOP by SPP
- (p_po4_retent_ips)*(rfr_p) /(cgt_cellheight*cgt_density)	retention of phosphate in the sediment under oxic conditions

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Tracer equations, continued from previous page

Change of: small-cell phytoplankton

$\frac{d}{dt}$ `t_spp` =

`+ p_no3_assim_spp`	assimilation of nitrate by small-cell phytoplankton
`+ p_nh4_assim_spp`	assimilation of ammonium by small-cell phytoplankton
`- p_spp_graz_zoo`	grazing of zooplankton eating small-cell phytoplankton
`- p_spp_resp_nh4`	respiration of small-cell phytoplankton
`- p_spp_mort_det`	mortality of small-scale phytoplankton

Change of: zooplankton

$\frac{d}{dt}$ `t_zoo` =

`+ p_lpp_graz_zoo`	grazing of zooplankton eating large-cell phytoplankton
`+ p_spp_graz_zoo`	grazing of zooplankton eating small-cell phytoplankton
`+ p_cya_graz_zoo`	grazing of zooplankton eating diazotroph cyanobacteria
`- p_zoo_resp_nh4`	respiration of zooplankton
`- p_zoo_mort_det`	mortality of zooplankton

Change of: hydrogen sulfide

$\frac{d}{dt}$ `t_h2s` =

`+ (p_poc_sulf)*(0.5)`	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
`+ (p_pocp_sulf)*(53)`	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
`+ (p_pocn_sulf)*(3.3125)`	Mineralization of POCN, e-acceptor sulfate (sulfate reduction)

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Tracer equations, continued from previous page

+ (p_det_sulf_nh4)*(3.3125)	recycling of detritus using sulfate (sulfate reduction)
+ (p_sed_sulf_nh4)*(3.3125) /(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)
+ (p_sed_poc_sulf)*(0.5) /(cgt_cellheight*cgt_density)	recycling of sedimentary poc to dic using sulfate (sulfate reduction)
+ (p_sed_pocn_sulf)*(3.3125) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction)
+ (p_sed_pocp_sulf)*(53) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction)
+ (p_doc_sulf)*(0.5)	Mineralization of DOC, e-acceptor sulfate (sulfate reduction)
+ (p_dop_sulf)*(53)	Mineralization of DOP, e-acceptor sulfate (sulfate reduction)
+ (p_don_sulf)*(3.3125)	Mineralization of DON, e-acceptor sulfate (sulfate reduction)
- p_h2s_oxo2_sul	oxidation of hydrogen sulfide with oxygen
- p_h2s_oxno3_sul	oxidation of hydrogen sulfide with nitrate

Change of: sulfur

$\frac{d}{dt}$ t_sul =

+ p_h2s_oxo2_sul	oxidation of hydrogen sulfide with oxygen
+ p_h2s_oxno3_sul	oxidation of hydrogen sulfide with nitrate
- p_sul_oxo2_so4	oxidation of elemental sulfur with oxygen
- p_sul_oxno3_so4	oxidation of elemental sulfur with nitrate

Change of: total alkalinity

$\frac{d}{dt}$ t_alk =

+ (1)*(p_pocn_resp)*(0.5)	respiration of POCN (produces ohminus)

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Tracer equations, continued from previous page	
+ (1)*(p_pocn_denit_noN2)*(0.5)	recycling of POCN using nitrate (denitrification) (produces ohminus)
+ (1)*(p_pocn_sulf)*(0.5)	Mineralization of POCN, e-acceptor sulfate (sulfate reduction) (produces ohminus)
+ (1)*(p_sed_pocn_resp)*(0.5)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration) (produces ohminus)
+ (1)*(p_sed_pocn_denit_noN2)*(0.5)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification) (produces ohminus)
+ (1)*(p_sed_pocn_sulf)*(0.5)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction) (produces ohminus)
+ (1)*(p_don_resp)*(0.5)	respiration of DON (produces ohminus)
+ (1)*(p_don_denit_noN2)*(0.5)	recycling of DON using nitrate (denitrification) (produces ohminus)
+ (1)*(p_don_sulf)*(0.5)	Mineralization of DON, e-acceptor sulfate (sulfate reduction) (produces ohminus)
- (1)*(p_nh4_assim_lpp_don)	Production of DON by LPP (consumes ohminus)
- (1)*(p_nh4_assim_spp_don)	Production of DON by SPP (consumes ohminus)
- (1)*(p_pocp_denit)*(3)	recycling of POC using nitrate (denitrification) (consumes ohminus)
- (1)*(p_pocp_sulf)*(3)	Mineralization of POC, e-acceptor sulfate (sulfate reduction) (consumes ohminus)
- (1)*(p_sed_pocp_denit)*(3)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification) (consumes ohminus)
- (1)*(p_sed_pocp_sulf)*(3)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction) (consumes ohminus)

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Tracer equations, continued from previous page	
- (1)*(p_dop_denit)*(3)	recycling of DOP using nitrate (denitrification) (consumes ohminus)
- (1)*(p_dop_sulf)*(3)	Mineralization of DOP, e-acceptor sulfate (sulfate reduction) (consumes ohminus)
+ (-1)*(p_nh4_assim_lpp)* (0.8125)	assimilation of ammonium by large-cell phytoplankton (produces h3oplus)
+ (-1)*(p_nh4_assim_spp)* (0.8125)	assimilation of ammonium by small-cell phytoplankton (produces h3oplus)
+ (-1)*(p_pocp_resp)*(3)	respiration of POCP (produces h3oplus)
+ (-1)*(p_nh4_nit_no3)*(2)	nitrification (produces h3oplus)
+ (-1)*(p_nh4_nitdenit_n2) /(cgt_cellheight*cgt_density)	coupled nitrification and denitrification after mineralization of detritus in oxic sediments (produces h3oplus)
+ (-1)*(p_sul_oxo2_so4)*(2)	oxidation of elemental sulfur with oxygen (produces h3oplus)
+ (-1)*(p_sul_oxno3_so4)* (0.8)	oxidation of elemental sulfur with nitrate (produces h3oplus)
+ (-1)*(p_sed_pocp_resp)*(3) /(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using oxygen (respiration) (produces h3oplus)
+ (-1)* (p_nh4_nitdenit_pocn_n2) /(cgt_cellheight*cgt_density)	coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments (produces h3oplus)
+ (-1)*(p_dop_resp)*(3)	respiration of DOP (produces h3oplus)
- (-1)*(p_no3_assim_lpp)* (1.1875)	assimilation of nitrate by large-cell phytoplankton (consumes h3oplus)
- (-1)*(p_no3_assim_spp)* (1.1875)	assimilation of nitrate by small-cell phytoplankton (consumes h3oplus)
- (-1)*(p_n2_assim_cya)* (0.1875)	fixation of dinitrogen by diazotroph cyanobacteria (consumes h3oplus)

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Tracer equations, continued from previous page	
- (-1)*(p_assim_lpp_dop)*(3)	Production of DOP by LPP (consumes h3oplus)
- (-1)*(p_assim_spp_dop)*(3)	Production of DOP by SPP (consumes h3oplus)
- (-1)*(p_no3_assim_lpp_don)	Production of DON by LPP (consumes h3oplus)
- (-1)*(p_no3_assim_spp_don)	Production of DON by SPP (consumes h3oplus)
- (-1)*(p_poc_denit)*(0.8)	recycling of POC using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_poc_sulf)	Mineralization of POC, e-acceptor sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_pocp_denit)*(84.8)	recycling of POC using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_pocp_sulf)*(106)	Mineralization of POC, e-acceptor sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_pocn_resp)*(0.5)	respiration of POCN (consumes h3oplus)
- (-1)*(p_pocn_denit_noN2)*(5.8)	recycling of POCN using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_pocn_sulf)*(7.125)	Mineralization of POCN, e-acceptor sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_lpp_resp_nh4)*(0.8125)	respiration of large-cell phytoplankton (consumes h3oplus)
- (-1)*(p_spp_resp_nh4)*(0.8125)	respiration of small-cell phytoplankton (consumes h3oplus)
- (-1)*(p_cya_resp_nh4)*(0.8125)	respiration of diazotroph cyanobacteria (consumes h3oplus)
- (-1)*(p_zoo_resp_nh4)*(0.8125)	respiration of zooplankton (consumes h3oplus)

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Tracer equations, continued from previous page	
- (-1)*(p_det_resp_nh4)*(0.8125)	recycling of detritus using oxygen (respiration) (consumes h3oplus)
- (-1)*(p_det_denit_nh4)*(6.1125)	recycling of detritus using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_det_sulf_nh4)*(7.4375)	recycling of detritus using sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_sed_resp_nh4)*(0.8125)/(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using oxygen (respiration) (consumes h3oplus)
- (-1)*(p_sed_denit_nh4_noN2)*(6.1125)/(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_sed_sulf_nh4)*(7.4375)/(cgt_cellheight*cgt_density)	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_sed_poc_denit)*(0.8)/(cgt_cellheight*cgt_density)	recycling of sedimentary poc to dic using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_sed_poc_sulf)/(cgt_cellheight*cgt_density)	recycling of sedimentary poc to dic using sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_h2s_oxno3_sul)*(0.4)	oxidation of hydrogen sulfide with nitrate (consumes h3oplus)
- (-1)*(p_sed_pocn_resp)*(0.5)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration) (consumes h3oplus)
- (-1)*(p_sed_pocp_denit)*(84.8)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_sed_pocn_sulf)*(7.125)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction) (consumes h3oplus)

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Tracer equations, continued from previous page	
- (-1)*(p_sed_pocp_sulf)*(106)/(cgt_cellheight*cgt_density)	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_doc_denit)*(0.8)	recycling of DOC using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_doc_sulf)	Mineralization of DOC, e-acceptor sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_dop_denit)*(84.8)	recycling of DOP using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_dop_sulf)*(106)	Mineralization of DOP, e-acceptor sulfate (sulfate reduction) (consumes h3oplus)
- (-1)*(p_don_resp)*(0.5)	respiration of DON (consumes h3oplus)
- (-1)*(p_don_denit_noN2)*(5.8)	recycling of DON using nitrate (denitrification) (consumes h3oplus)
- (-1)*(p_don_sulf)*(7.125)	Mineralization of DON, e-acceptor sulfate (sulfate reduction) (consumes h3oplus)
+ (2)*(p_pocp_resp)	respiration of POCP (produces t_po4)
+ (2)*(p_pocp_denit)	recycling of POC using nitrate (denitrification) (produces t_po4)
+ (2)*(p_pocp_sulf)	Mineralization of POC, e-acceptor sulfate (sulfate reduction) (produces t_po4)
+ (2)*(p_lpp_resp_nh4)*(rfr_p)	respiration of large-cell phytoplankton (produces t_po4)
+ (2)*(p_spp_resp_nh4)*(rfr_p)	respiration of small-cell phytoplankton (produces t_po4)
+ (2)*(p_cya_resp_nh4)*(rfr_p)	respiration of diazotroph cyanobacteria (produces t_po4)
+ (2)*(p_zoo_resp_nh4)*(rfr_p)	respiration of zooplankton (produces t_po4)

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Tracer equations, continued from previous page	
`+ (2)*(p_det_resp_nh4)*(rfr_p)`	recycling of detritus using oxygen (respiration) (produces t_po4)
`+ (2)*(p_det_denit_nh4)*(rfr_p)`	recycling of detritus using nitrate (denitrification) (produces t_po4)
`+ (2)*(p_det_sulf_nh4)*(rfr_p)`	recycling of detritus using sulfate (sulfate reduction) (produces t_po4)
`+ (2)*(p_sed_resp_nh4)*(rfr_p)/(cgt_cellheight*cgt_density)`	recycling of sedimentary detritus to ammonium using oxygen (respiration) (produces t_po4)
`+ (2)*(p_sed_denit_nh4_noN2)*(rfr_p)/(cgt_cellheight*cgt_density)`	recycling of sedimentary detritus to ammonium using nitrate (denitrification) (produces t_po4)
`+ (2)*(p_sed_sulf_nh4)*(rfr_p)/(cgt_cellheight*cgt_density)`	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction) (produces t_po4)
`+ (2)*(p_ips_liber_po4)/(cgt_cellheight*cgt_density)`	liberation of phosphate from the sediment under anoxic conditions (produces t_po4)
`+ (2)*(p_sed_pocp_resp)/(cgt_cellheight*cgt_density)`	recycling of sedimentary pocp to dic and PO4 using oxygen (respiration) (produces t_po4)
`+ (2)*(p_sed_pocp_denit)/(cgt_cellheight*cgt_density)`	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification) (produces t_po4)
`+ (2)*(p_sed_pocp_sulf)/(cgt_cellheight*cgt_density)`	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction) (produces t_po4)
`+ (2)*(p_dop_resp)`	respiration of DOP (produces t_po4)
`+ (2)*(p_dop_denit)`	recycling of DOP using nitrate (denitrification) (produces t_po4)
`+ (2)*(p_dop_sulf)`	Mineralization of DOP, e-acceptor sulfate (sulfate reduction) (produces t_po4)
`- (2)*(p_no3_assim_lpp)*(rfr_p)`	assimilation of nitrate by large-cell phytoplankton (consumes t_po4)

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Tracer equations, continued from previous page	
- (2)*(p_nh4_assim_lpp)*(rfr_p)	assimilation of ammonium by large-cell phytoplankton (consumes t_po4)
- (2)*(p_no3_assim_spp)*(rfr_p)	assimilation of nitrate by small-cell phytoplankton (consumes t_po4)
- (2)*(p_nh4_assim_spp)*(rfr_p)	assimilation of ammonium by small-cell phytoplankton (consumes t_po4)
- (2)*(p_n2_assim_cya)*(rfr_p)	fixation of dinitrogen by diazotroph cyanobacteria (consumes t_po4)
- (2)*(p_assim_lpp_dop)	Production of DOP by LPP (consumes t_po4)
- (2)*(p_assim_spp_dop)	Production of DOP by SPP (consumes t_po4)
- (2)*(p_po4_retent_ips)*(rfr_p)/(cgt_cellheight*cgt_density)	retention of phosphate in the sediment under oxic conditions (consumes t_po4)

Change of: sediment detritus

$\frac{d}{dt}$ t_sed =

+ p_det_sedi_sed	detritus sedimentation
- p_sed_resp_nh4	recycling of sedimentary detritus to ammonium using oxygen (respiration)
- p_sed_denit_nh4_noN2	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
- p_sed_sulf_nh4	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)
- p_sed_ero_det	sedimentary detritus erosion
- p_sed_biores_det	bio resuspension of sedimentary detritus
- p_sed_burial	burial of detritus deeper than max_sed

Change of: iron phosphate in sediment

$\frac{d}{dt}$ t_ips =

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Tracer equations, continued from previous page	
+ (p_po4_retent_ips)*(rfr_p)	retention of phosphate in the sediment under oxic conditions
+ p_ipw_sedi_ips	sedimentation of iron PO4
- p_ips_liber_po4	liberation of phosphate from the sediment under anoxic conditions
- p_ips_ero_ipw	erosion of iron PO4
- p_ips_biores_ipw	bio resuspension of iron PO4
- p_ips_burial	burial of iron PO4

Change of: dissolved organic carbon

$\frac{d}{dt}$ t_doc =

+ p_assim_lpp_doc	Production of DOC by LPP
+ p_assim_spp_doc	Production of DOC by SPP
+ p_assim_cya_doc	Production of POC by CYA
- p_doc2pco	particle formation from DOC
- p_doc_resp	respiration of DOC
- p_doc_denit	recycling of DOC using nitrate (denitrification)
- p_doc_sulf	Mineralization of DOC, e-acceptor sulfate (sulfate reduction)

Change of: phosphorus in dissolved organic carbon in Redfield ratio

$\frac{d}{dt}$ t_dop =

+ p_assim_lpp_dop	Production of DOP by LPP
+ p_assim_spp_dop	Production of DOP by SPP
- p_dop2pocp	particle formation from DOP
- p_dop_resp	respiration of DOP
- p_dop_denit	recycling of DOP using nitrate (denitrification)

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Tracer equations, continued from previous page

- p_dop_sulf	Mineralization of DOP, e-acceptor sulfate (sulfate reduction)

Change of: sediment particular carbon

$\frac{d}{dt}$ t_sed_poc =

+ p_poc_sedi_sed	poc sedimentation
- p_sed_poc_resp	recycling of sedimentary poc to dic using oxygen (respiration)
- p_sed_poc_denit	recycling of sedimentary poc to dic using nitrate (denitrification)
- p_sed_poc_sulf	recycling of sedimentary poc to dic using sulfate (sulfate reduction)
- p_sed_ero_poc	sedimentary poc erosion
- p_sed_biores_poc	bio resuspension of sedimentary poc
- p_poc_burial	burial of poc deeper than max_sed

Change of: sediment particular organic N+C

$\frac{d}{dt}$ t_sed_pocn =

+ p_pocn_sedi_sed	pocn sedimentation
- p_sed_ero_pocn	sedimentary pocn erosion
- p_sed_biores_pocn	bio resuspension of sedimentary pocn
- p_pocn_burial	burial of pocn deeper than max_sed
- p_sed_pocn_resp	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration)
- p_sed_pocn_denit_noN2	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)

Change of: sediment particular organic P+C

$\frac{d}{dt}$ t_sed_pocp =

continued on next page...

Tracer equations, continued from previous page	
+ p_pocp_sedi_sed	pocp sedimentation
- p_sed_ero_pocp	sedimentary pocp erosion
- p_sed_biores_pocp	bio resuspension of sedimentary pocp
- p_pocp_burial	burial of pocp deeper than max_sed
- p_sed_pocp_resp	recycling of sedimentary pocp to dic and PO4 using oxygen (respiration)
- p_sed_pocp_denit	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)

Change of: total_atmos_tot_N

$\frac{d}{dt}$ total_atmos_tot_N =

Change of: total_atmos_tot_N_at_bottom

$\frac{d}{dt}$ total_atmos_tot_N_at_bottom =

Change of: total_atmos_ship_N

$\frac{d}{dt}$ total_atmos_ship_N =

Change of: total_atmos_ship_N_at_bottom

$\frac{d}{dt}$ total_atmos_ship_N_at_bottom =

Change of: dissolved molecular nitrogen; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_n2_with_atmos_tot_N =

- (p_n2_assim_cya)*(0.5)* max(0.0,min(1.0,t_n2_with_atmc))	fixation of dinitrogen by diazotroph cyanobacteria

Change of: ammonium; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_nh4_with_atmos_tot_N =

+ p_pocn_resp_atmos_tot_N	respiration of POCN; sub-process for atmos_tot nitrogen
+ p_pocn_denit_noN2_atmos_tot_N	recycling of POCN using nitrate (denitrification); sub-process for atmos_tot nitrogen

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Tracer equations, continued from previous page

`+ p_pocn_sulf_atmos_tot_N`	Mineralization of POCN, e-acceptor sulfate (sulfate reduction); sub-process for atmos_tot nitrogen
`+ (p_lpp_resp_nh4_atmos_tot_N)* ((1-don_fraction))`	respiration of large-cell phytoplankton; sub-process for atmos_tot nitrogen
`+ (p_spp_resp_nh4_atmos_tot_N)* ((1-don_fraction))`	respiration of small-cell phytoplankton; sub-process for atmos_tot nitrogen
`+ (p_cya_resp_nh4_atmos_tot_N)* ((1-don_fraction))`	respiration of diazotroph cyanobacteria; sub-process for atmos_tot nitrogen
`+ (p_zoo_resp_nh4_atmos_tot_N)* ((1-don_fraction))`	respiration of zooplankton; sub-process for atmos_tot nitrogen
`+ p_det_resp_nh4_atmos_tot_N`	recycling of detritus using oxygen (respiration); sub-process for atmos_tot nitrogen
`+ p_det_sulf_nh4_atmos_tot_N`	recycling of detritus using sulfate (sulfate reduction); sub-process for atmos_tot nitrogen
`+ p_sed_resp_nh4_atmos_tot_N/(cg cgt_density)`	recycling of sedimentary detritus to ammonium using oxygen (respiration); sub-process for atmos_tot nitrogen
`+ p_sed_denit_nh4_noN2_atmos_tot cgt_density)`	recycling of sedimentary detritus to ammonium using nitrate (denitrification); sub-process for atmos_tot nitrogen
`+ p_sed_sulf_nh4_atmos_tot_N/(cg cgt_density)`	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction); sub-process for atmos_tot nitrogen
`+ p_sed_pocn_resp_atmos_tot_N/(c cgt_density)`	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration); sub-process for atmos_tot nitrogen
`+ p_sed_pocn_denit_noN2_atmos_t cgt_density)`	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification); sub-process for atmos_tot nitrogen

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Tracer equations, continued from previous page	
+ p_sed_pocn_sulf_atmos_tot_N/(c cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction); sub-process for atmos_tot nitrogen
+ p_don_resp_atmos_tot_N	respiration of DON; sub-process for atmos_tot nitrogen
+ p_don_denit_noN2_atmos_tot_N	recycling of DON using nitrate (denitrification) ; sub-process for atmos_tot nitrogen
+ p_don_sulf_atmos_tot_N	Mineralization of DON, e-acceptor sulfate (sulfate reduction); sub-process for atmos_tot nitrogen
- p_nh4_assim_lpp* max(0.0,min(1.0,t_nh4_with_atm))	assimilation of ammonium by large-cell phytoplankton
- p_nh4_assim_spp* max(0.0,min(1.0,t_nh4_with_atm))	assimilation of ammonium by small-cell phytoplankton
- p_nh4_assim_lpp_don* max(0.0,min(1.0,t_nh4_with_atm))	Production of DON by LPP
- p_nh4_assim_spp_don* max(0.0,min(1.0,t_nh4_with_atm))	Production of DON by SPP
- p_nh4_nit_no3* max(0.0,min(1.0,t_nh4_with_atm))	nitrification
- p_nh4_nitdenit_n2/(cgt_cellhei cgt_density)* max(0.0,min(1.0,t_nh4_with_atm))	coupled nitrification and denitrification after mineralization of detritus in oxic sediments
- p_nh4_nitdenit_pocn_n2/(cgt_ce cgt_density)* max(0.0,min(1.0,t_nh4_with_atm))	coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments

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Tracer equations, continued from previous page

Change of: nitrate; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_no3_with_atmos_tot_N =

+ p_nh4_nit_no3_atmos_tot_N	nitrification; sub-process for atmos_tot nitrogen
- p_no3_assim_lpp* max(0.0,min(1.0,t_no3_with_atm))	assimilation of nitrate by large-cell phytoplankton
- p_no3_assim_spp* max(0.0,min(1.0,t_no3_with_atm))	assimilation of nitrate by small-cell phytoplankton
- p_no3_assim_lpp_don* max(0.0,min(1.0,t_no3_with_atm))	Production of DON by LPP
- p_no3_assim_spp_don* max(0.0,min(1.0,t_no3_with_atm))	Production of DON by SPP
- (p_poc_denit)*(0.8)* max(0.0,min(1.0,t_no3_with_atm))	recycling of POC using nitrate (denitrification)
- (p_pocp_denit)*(84.8)* max(0.0,min(1.0,t_no3_with_atm))	recycling of POC using nitrate (denitrification)
- (p_pocn_denit_wiN2)*(5.3)* max(0.0,min(1.0,t_no3_with_atm))	recycling of POCN using nitrate (denitrification)
- (p_det_denit_nh4)*(5.3)* max(0.0,min(1.0,t_no3_with_atm))	recycling of detritus using nitrate (denitrification)
- (p_sed_denit_nh4_wiN2)* (5.3)/(cgt_cellheight* cgt_density)* max(0.0,min(1.0,t_no3_with_atm))	recycling of sedimentary detritus to ammonium using nitrate (denitrification)

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Tracer equations, continued from previous page

- (p_sed_poc_denit)*(0.8) /(cgt_cellheight*cgt_density) * max(0.0,min(1.0,t_no3_with_atm))	recycling of sedimentary poc to dic using nitrate (denitrification)
- (p_h2s_oxno3_sul)*(0.4)* max(0.0,min(1.0,t_no3_with_atm))	oxidation of hydrogen sulfide with nitrate
- (p_sul_oxno3_so4)*(1.2)* max(0.0,min(1.0,t_no3_with_atm))	oxidation of elemental sulfur with nitrate
- (p_sed_pocn_denit_wiN2)* (5.3)/(cgt_cellheight* cgt_density)* max(0.0,min(1.0,t_no3_with_atm))	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)
- (p_sed_pocp_denit)*(84.8) /(cgt_cellheight*cgt_density) * max(0.0,min(1.0,t_no3_with_atm))	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)
- (p_doc_denit)*(0.8)* max(0.0,min(1.0,t_no3_with_atm))	recycling of DOC using nitrate (denitrification)
- (p_dop_denit)*(84.8)* max(0.0,min(1.0,t_no3_with_atm))	recycling of DOP using nitrate (denitrification)
- (p_don_denit_wiN2)*(5.3)* max(0.0,min(1.0,t_no3_with_atm))	recycling of DON using nitrate (denitrification)

Change of: small-cell phytoplankton; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_spp_with_atmos_tot_N =

+ p_no3_assim_spp_atmos_tot_N	assimilation of nitrate by small-cell phytoplankton; sub-process for atmos_tot nitrogen

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Tracer equations, continued from previous page	
+ p_nh4_assim_spp_atmos_tot_N	assimilation of ammonium by small-cell phytoplankton; sub-process for atmos_tot nitrogen
- p_spp_graz_zoo* max(0.0,min(1.0,t_spp_with_atm))	grazing of zooplankton eating small-cell phytoplankton
- p_spp_resp_nh4* max(0.0,min(1.0,t_spp_with_atm))	respiration of small-cell phytoplankton
- p_spp_mort_det* max(0.0,min(1.0,t_spp_with_atm))	mortality of small-scale phytoplankton

Change of: zooplankton; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_zoo_with_atmos_tot_N =

+ p_lpp_graz_zoo_atmos_tot_N	grazing of zooplankton eating large-cell phytoplankton; sub-process for atmos_tot nitrogen
+ p_spp_graz_zoo_atmos_tot_N	grazing of zooplankton eating small-cell phytoplankton; sub-process for atmos_tot nitrogen
+ p_cya_graz_zoo_atmos_tot_N	grazing of zooplankton eating diazotroph cyanobacteria; sub-process for atmos_tot nitrogen
- p_zoo_resp_nh4* max(0.0,min(1.0,t_zoo_with_atm))	respiration of zooplankton
- p_zoo_mort_det* max(0.0,min(1.0,t_zoo_with_atm))	mortality of zooplankton

Change of: sediment detritus; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_sed_with_atmos_tot_N =

+ p_det_sedi_sed_atmos_tot_N	detritus sedimentation; sub-process for atmos_tot nitrogen

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Tracer equations, continued from previous page	
- p_sed_resp_nh4* max(0.0,min(1.0,t_sed_with_atm))	recycling of sedimentary detritus to ammonium using oxygen (respiration)
- p_sed_denit_nh4_noN2* max(0.0,min(1.0,t_sed_with_atm))	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
- p_sed_sulf_nh4* max(0.0,min(1.0,t_sed_with_atm))	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)
- p_sed_ero_det* max(0.0,min(1.0,t_sed_with_atm))	sedimentary detritus erosion
- p_sed_biores_det* max(0.0,min(1.0,t_sed_with_atm))	bio resuspension of sedimentary detritus
- p_sed_burial* max(0.0,min(1.0,t_sed_with_atm))	burial of detritus deeper than max_sed

Change of: sediment particular organic N+C; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_sed_pocn_with_atmos_tot_N =

+ p_pocn_sedi_sed_atmos_tot_N	pocn sedimentation; sub-process for atmos_tot nitrogen
- p_sed_ero_pocn* max(0.0,min(1.0,t_sed_pocn_wit ɔcn)))	sedimentary pocn erosion
- p_sed_biores_pocn* max(0.0,min(1.0,t_sed_pocn_wit ɔcn)))	bio resuspension of sedimentary pocn
- p_pocn_burial* max(0.0,min(1.0,t_sed_pocn_wit ɔcn)))	burial of pocn deeper than max_sed

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Tracer equations, continued from previous page	
- p_sed_pocn_resp* max(0.0,min(1.0,t_sed_pocn_wit)) ocn)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration)
- p_sed_pocn_denit_noN2* max(0.0,min(1.0,t_sed_pocn_wit)) ocn)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)

Change of: dissolved molecular nitrogen; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_n2_with_atmos_ship_N =

- (p_n2_assim_cya)*(0.5)* max(0.0,min(1.0,t_n2_with_atmo))	fixation of dinitrogen by diazotroph cyanobacteria

Change of: ammonium; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_nh4_with_atmos_ship_N =

+ p_pocn_resp_atmos_ship_N	respiration of POCN; sub-process for atmos_ship nitrogen
+ p_pocn_denit_noN2_atmos_ship_N	recycling of POCN using nitrate (denitrification); sub-process for atmos_ship nitrogen
+ p_pocn_sulf_atmos_ship_N	Mineralization of POCN, e-acceptor sulfate (sulfate reduction); sub-process for atmos_ship nitrogen
+ (p_lpp_resp_nh4_atmos_ship_N) *((1-don_fraction))	respiration of large-cell phytoplankton; sub-process for atmos_ship nitrogen
+ (p_spp_resp_nh4_atmos_ship_N) *((1-don_fraction))	respiration of small-cell phytoplankton; sub-process for atmos_ship nitrogen
+ (p_cya_resp_nh4_atmos_ship_N) *((1-don_fraction))	respiration of diazotroph cyanobacteria; sub-process for atmos_ship nitrogen

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Tracer equations, continued from previous page	
+ (p_zoo_resp_nh4_atmos_ship_N) *((1-don_fraction))	respiration of zooplankton; sub-process for atmos_ship nitrogen
+ p_det_resp_nh4_atmos_ship_N	recycling of detritus using oxygen (respiration); sub-process for atmos_ship nitrogen
+ p_det_sulf_nh4_atmos_ship_N	recycling of detritus using sulfate (sulfate reduction); sub-process for atmos_ship nitrogen
+ p_sed_resp_nh4_atmos_ship_N/(cgt_density)	recycling of sedimentary detritus to ammonium using oxygen (respiration); sub-process for atmos_ship nitrogen
+ p_sed_denit_nh4_noN2_atmos_shi cgt_density)	recycling of sedimentary detritus to ammonium using nitrate (denitrification); sub-process for atmos_ship nitrogen
+ p_sed_sulf_nh4_atmos_ship_N/(cgt_density)	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction); sub-process for atmos_ship nitrogen
+ p_sed_pocn_resp_atmos_ship_N/(cgt_density)	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration); sub-process for atmos_ship nitrogen
+ p_sed_pocn_denit_noN2_atmos_sh cgt_density)	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification); sub-process for atmos_ship nitrogen
+ p_sed_pocn_sulf_atmos_ship_N/(cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction); sub-process for atmos_ship nitrogen
+ p_don_resp_atmos_ship_N	respiration of DON; sub-process for atmos_ship nitrogen
+ p_don_denit_noN2_atmos_ship_N	recycling of DON using nitrate (denitrification) ; sub-process for atmos_ship nitrogen
+ p_don_sulf_atmos_ship_N	Mineralization of DON, e-acceptor sulfate (sulfate reduction); sub-process for atmos_ship nitrogen

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Tracer equations, continued from previous page	
- p_nh4_assim_lpp* max(0.0,min(1.0,t_nh4_with_atm))	assimilation of ammonium by large-cell phytoplankton
- p_nh4_assim_spp* max(0.0,min(1.0,t_nh4_with_atm))	assimilation of ammonium by small-cell phytoplankton
- p_nh4_assim_lpp_don* max(0.0,min(1.0,t_nh4_with_atm))	Production of DON by LPP
- p_nh4_assim_spp_don* max(0.0,min(1.0,t_nh4_with_atm))	Production of DON by SPP
- p_nh4_nit_no3* max(0.0,min(1.0,t_nh4_with_atm))	nitrification
- p_nh4_nitdenit_n2/(cgt_cellhei cgt_density)* max(0.0,min(1.0,t_nh4_with_atm))	coupled nitrification and denitrification after mineralization of detritus in oxic sediments
- p_nh4_nitdenit_pocn_n2/(cgt_ce cgt_density)* max(0.0,min(1.0,t_nh4_with_atm))	coupled nitrification and denitrification after mineralization of pocn-detritus in oxic sediments

Change of: nitrate; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_no3_with_atmos_ship_N =

+ p_nh4_nit_no3_atmos_ship_N	nitrification; sub-process for atmos_ship nitrogen
- p_no3_assim_lpp* max(0.0,min(1.0,t_no3_with_atm))	assimilation of nitrate by large-cell phytoplankton
- p_no3_assim_spp* max(0.0,min(1.0,t_no3_with_atm))	assimilation of nitrate by small-cell phytoplankton

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Tracer equations, continued from previous page	
`- p_no3_assim_lpp_don* max(0.0,min(1.0,t_no3_with_atm ))`	Production of DON by LPP
`- p_no3_assim_spp_don* max(0.0,min(1.0,t_no3_with_atm ))`	Production of DON by SPP
`- (p_poc_denit)*(0.8)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of POC using nitrate (denitrification)
`- (p_pocp_denit)*(84.8)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of POC using nitrate (denitrification)
`- (p_pocn_denit_wiN2)*(5.3)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of POCN using nitrate (denitrification)
`- (p_det_denit_nh4)*(5.3)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of detritus using nitrate (denitrification)
`- (p_sed_denit_nh4_wiN2)* (5.3)/(cgt_cellheight* cgt_density)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of sedimentary detritus to ammonium using nitrate (denitrification)
`- (p_sed_poc_denit)*(0.8) /(cgt_cellheight*cgt_density) * max(0.0,min(1.0,t_no3_with_atm ))`	recycling of sedimentary poc to dic using nitrate (denitrification)
`- (p_h2s_oxno3_sul)*(0.4)* max(0.0,min(1.0,t_no3_with_atm ))`	oxidation of hydrogen sulfide with nitrate
`- (p_sul_oxno3_so4)*(1.2)* max(0.0,min(1.0,t_no3_with_atm ))`	oxidation of elemental sulfur with nitrate

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Tracer equations, continued from previous page

`- (p_sed_pocn_denit_wiN2)* (5.3)/(cgt_cellheight* cgt_density)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)
`- (p_sed_pocp_denit)*(84.8) /(cgt_cellheight*cgt_density) * max(0.0,min(1.0,t_no3_with_atm ))`	recycling of sedimentary pocp to dic and PO4 using nitrate (denitrification)
`- (p_doc_denit)*(0.8)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of DOC using nitrate (denitrification)
`- (p_dop_denit)*(84.8)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of DOP using nitrate (denitrification)
`- (p_don_denit_wiN2)*(5.3)* max(0.0,min(1.0,t_no3_with_atm ))`	recycling of DON using nitrate (denitrification)

Change of: small-cell phytoplankton; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_spp_with_atmos_ship_N =

`+ p_no3_assim_spp_atmos_ship_N`	assimilation of nitrate by small-cell phytoplankton; sub-process for atmos_ship nitrogen
`+ p_nh4_assim_spp_atmos_ship_N`	assimilation of ammonium by small-cell phytoplankton; sub-process for atmos_ship nitrogen
`- p_spp_graz_zoo* max(0.0,min(1.0,t_spp_with_atm ))`	grazing of zooplankton eating small-cell phytoplankton
`- p_spp_resp_nh4* max(0.0,min(1.0,t_spp_with_atm ))`	respiration of small-cell phytoplankton

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Tracer equations, continued from previous page

- p_spp_mort_det* max(0.0,min(1.0,t_spp_with_atm))	mortality of small-scale phytoplankton

Change of: zooplankton; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_zoo_with_atmos_ship_N =

+ p_lpp_graz_zoo_atmos_ship_N	grazing of zooplankton eating large-cell phytoplankton; sub-process for atmos_ship nitrogen
+ p_spp_graz_zoo_atmos_ship_N	grazing of zooplankton eating small-cell phytoplankton; sub-process for atmos_ship nitrogen
+ p_cya_graz_zoo_atmos_ship_N	grazing of zooplankton eating diazotroph cyanobacteria; sub-process for atmos_ship nitrogen
- p_zoo_resp_nh4* max(0.0,min(1.0,t_zoo_with_atm))	respiration of zooplankton
- p_zoo_mort_det* max(0.0,min(1.0,t_zoo_with_atm))	mortality of zooplankton

Change of: sediment detritus; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_sed_with_atmos_ship_N =

+ p_det_sedi_sed_atmos_ship_N	detritus sedimentation; sub-process for atmos_ship nitrogen
- p_sed_resp_nh4* max(0.0,min(1.0,t_sed_with_atm))	recycling of sedimentary detritus to ammonium using oxygen (respiration)
- p_sed_denit_nh4_noN2* max(0.0,min(1.0,t_sed_with_atm))	recycling of sedimentary detritus to ammonium using nitrate (denitrification)

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Tracer equations, continued from previous page	
- p_sed_sulf_nh4* max(0.0,min(1.0,t_sed_with_atm))	recycling of sedimentary detritus to ammonium using sulfate (sulfate reduction)
- p_sed_ero_det* max(0.0,min(1.0,t_sed_with_atm))	sedimentary detritus erosion
- p_sed_biores_det* max(0.0,min(1.0,t_sed_with_atm))	bio resuspension of sedimentary detritus
- p_sed_burial* max(0.0,min(1.0,t_sed_with_atm))	burial of detritus deeper than max_sed

Change of: sediment particular organic N+C; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_sed_pocn_with_atmos_ship_N =

+ p_pocn_sedi_sed_atmos_ship_N	pocn sedimentation; sub-process for atmos_ship nitrogen
- p_sed_ero_pocn* max(0.0,min(1.0,t_sed_pocn_wit ... pocn)))	sedimentary pocn erosion
- p_sed_biores_pocn* max(0.0,min(1.0,t_sed_pocn_wit ... pocn)))	bio resuspension of sedimentary pocn
- p_pocn_burial* max(0.0,min(1.0,t_sed_pocn_wit ... pocn)))	burial of pocn deeper than max_sed
- p_sed_pocn_resp* max(0.0,min(1.0,t_sed_pocn_wit ... pocn)))	recycling of sedimentary pocn to dic and NH4 using oxygen (respiration)
- p_sed_pocn_denit_noN2* max(0.0,min(1.0,t_sed_pocn_wit ... pocn)))	recycling of sedimentary pocn to dic and NH4 using nitrate (denitrification)

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Tracer equations, continued from previous page

Change of: suspended iron phosphate

$\frac{d}{dt}$ t_ipw =

+ p_ips_ero_ipw/(cgt_cellheight* cgt_density)	erosion of iron PO4
+ p_ips_biores_ipw/(cgt_cellheig cgt_density)	bio resuspension of iron PO4
- p_ipw_sedi_ips/(cgt_cellheight cgt_density)	sedimentation of iron PO4

Change of: nitrogen in particulate organic carbon in Redfield ratio; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_pocn_with_atmos_tot_N =

+ p_sed_ero_pocn_atmos_tot_N/(cg cgt_density)	sedimentary pocn erosion; sub-process for atmos_tot nitrogen
+ p_sed_biores_pocn_atmos_tot_N/ cgt_density)	bio resuspension of sedimentary pocn; sub-process for atmos_tot nitrogen
+ p_don2pocn_atmos_tot_N	particle formation from DON; sub-process for atmos_tot nitrogen
- p_pocn_resp* max(0.0,min(1.0,t_pocn_with_at))	respiration of POCN
- p_pocn_denit_noN2* max(0.0,min(1.0,t_pocn_with_at))	recycling of POCN using nitrate (denitrification)
- p_pocn_sulf* max(0.0,min(1.0,t_pocn_with_at))	Mineralization of POCN, e-acceptor sulfate (sulfate reduction)
- p_pocn_sedi_sed/(cgt_cellheigh cgt_density)* max(0.0,min(1.0,t_pocn_with_at))	pocn sedimentation

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Tracer equations, continued from previous page

- p_sed_pocn_sulf/(cgt_cellheight*cgt_density)*max(0.0,min(1.0,t_pocn_with_at))	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction)

Change of: large-cell phytoplankton; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_lpp_with_atmos_tot_N =

+ p_no3_assim_lpp_atmos_tot_N	assimilation of nitrate by large-cell phytoplankton; sub-process for atmos_tot nitrogen
+ p_nh4_assim_lpp_atmos_tot_N	assimilation of ammonium by large-cell phytoplankton; sub-process for atmos_tot nitrogen
- p_lpp_graz_zoo*max(0.0,min(1.0,t_lpp_with_atm))	grazing of zooplankton eating large-cell phytoplankton
- p_lpp_resp_nh4*max(0.0,min(1.0,t_lpp_with_atm))	respiration of large-cell phytoplankton
- p_lpp_mort_det*max(0.0,min(1.0,t_lpp_with_atm))	mortality of large-cell phytoplankton

Change of: nitrogen in dissolved organic carbon in Redfield ratio; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_don_with_atmos_tot_N =

+ p_nh4_assim_lpp_don_atmos_tot_	Production of DON by LPP; sub-process for atmos_tot nitrogen
+ p_no3_assim_lpp_don_atmos_tot_	Production of DON by LPP; sub-process for atmos_tot nitrogen
+ p_nh4_assim_spp_don_atmos_tot_	Production of DON by SPP; sub-process for atmos_tot nitrogen
+ p_no3_assim_spp_don_atmos_tot_	Production of DON by SPP; sub-process for atmos_tot nitrogen

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Tracer equations, continued from previous page	
+ (p_lpp_resp_nh4_atmos_tot_N)* (don_fraction)	respiration of large-cell phytoplankton; sub-process for atmos_tot nitrogen
+ (p_spp_resp_nh4_atmos_tot_N)* (don_fraction)	respiration of small-cell phytoplankton; sub-process for atmos_tot nitrogen
+ (p_cya_resp_nh4_atmos_tot_N)* (don_fraction)	respiration of diazotroph cyanobacteria; sub-process for atmos_tot nitrogen
+ (p_zoo_resp_nh4_atmos_tot_N)* (don_fraction)	respiration of zooplankton; sub-process for atmos_tot nitrogen
- p_don2pocn* max(0.0,min(1.0,t_don_with_atm))	particle formation from DON
- p_don_resp* max(0.0,min(1.0,t_don_with_atm))	respiration of DON
- p_don_denit_noN2* max(0.0,min(1.0,t_don_with_atm))	recycling of DON using nitrate (denitrification)
- p_don_sulf* max(0.0,min(1.0,t_don_with_atm))	Mineralization of DON, e-acceptor sulfate (sulfate reduction)

Change of: diazotroph cyanobacteria; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_cya_with_atmos_tot_N =

- p_cya_graz_zoo* max(0.0,min(1.0,t_cya_with_atm))	grazing of zooplankton eating diazotroph cyanobacteria
- p_cya_resp_nh4* max(0.0,min(1.0,t_cya_with_atm))	respiration of diazotroph cyanobacteria

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Tracer equations, continued from previous page	
- p_cya_mort_det* max(0.0,min(1.0,t_cya_with_atm))	mortality of diazotroph cyanobacteria
- p_cya_mort_det_diff* max(0.0,min(1.0,t_cya_with_atm))	mortality of diazotroph cyanobacteria due to strong turbulence

Change of: detritus; containing nitrogen from (total) atmospheric deposition

$\frac{d}{dt}$ t_det_with_atmos_tot_N =

+ p_lpp_mort_det_atmos_tot_N	mortality of large-cell phytoplankton; sub-process for atmos_tot nitrogen
+ p_spp_mort_det_atmos_tot_N	mortality of small-scale phytoplankton; sub-process for atmos_tot nitrogen
+ p_cya_mort_det_atmos_tot_N	mortality of diazotroph cyanobacteria; sub-process for atmos_tot nitrogen
+ p_cya_mort_det_diff_atmos_tot_	mortality of diazotroph cyanobacteria due to strong turbulence; sub-process for atmos_tot nitrogen
+ p_zoo_mort_det_atmos_tot_N	mortality of zooplankton; sub-process for atmos_tot nitrogen
+ p_sed_ero_det_atmos_tot_N/(cgt cgt_density)	sedimentary detritus erosion; sub-process for atmos_tot nitrogen
+ p_sed_biores_det_atmos_tot_N/(cgt_density)	bio resuspension of sedimentary detritus; sub-process for atmos_tot nitrogen
- p_det_resp_nh4* max(0.0,min(1.0,t_det_with_atm))	recycling of detritus using oxygen (respiration)
- p_det_denit_nh4* max(0.0,min(1.0,t_det_with_atm))	recycling of detritus using nitrate (denitrification)

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Tracer equations, continued from previous page	
- p_det_sulf_nh4* max(0.0,min(1.0,t_det_with_atm))	recycling of detritus using sulfate (sulfate reduction)
- p_det_sedi_sed/(cgt_cellheight cgt_density)* max(0.0,min(1.0,t_det_with_atm))	detritus sedimentation

Change of: large-cell phytoplankton

$\frac{d}{dt}$ t_lpp =

+ p_no3_assim_lpp	assimilation of nitrate by large-cell phytoplankton
+ p_nh4_assim_lpp	assimilation of ammonium by large-cell phytoplankton
- p_lpp_graz_zoo	grazing of zooplankton eating large-cell phytoplankton
- p_lpp_resp_nh4	respiration of large-cell phytoplankton
- p_lpp_mort_det	mortality of large-cell phytoplankton

Change of: nitrogen in dissolved organic carbon in Redfield ratio

$\frac{d}{dt}$ t_don =

+ p_nh4_assim_lpp_don	Production of DON by LPP
+ p_no3_assim_lpp_don	Production of DON by LPP
+ p_nh4_assim_spp_don	Production of DON by SPP
+ p_no3_assim_spp_don	Production of DON by SPP
+ (p_lpp_resp_nh4)* (don_fraction)	respiration of large-cell phytoplankton
+ (p_spp_resp_nh4)* (don_fraction)	respiration of small-cell phytoplankton
+ (p_cya_resp_nh4)* (don_fraction)	respiration of diazotroph cyanobacteria

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Tracer equations, continued from previous page	
+ (p_zoo_resp_nh4)* (don_fraction)	respiration of zooplankton
- p_don2pocn	particle formation from DON
- p_don_resp	respiration of DON
- p_don_denit_noN2	recycling of DON using nitrate (denitrification)
- p_don_sulf	Mineralization of DON, e-acceptor sulfate (sulfate reduction)

Change of: diazotroph cyanobacteria

$\frac{d}{dt}$ t_cya =

+ p_n2_assim_cya	fixation of dinitrogen by diazotroph cyanobacteria
- p_cya_graz_zoo	grazing of zooplankton eating diazotroph cyanobacteria
- p_cya_resp_nh4	respiration of diazotroph cyanobacteria
- p_cya_mort_det	mortality of diazotroph cyanobacteria
- p_cya_mort_det_diff	mortality of diazotroph cyanobacteria due to strong turbulence

Change of: detritus

$\frac{d}{dt}$ t_det =

+ p_lpp_mort_det	mortality of large-cell phytoplankton
+ p_spp_mort_det	mortality of small-scale phytoplankton
+ p_cya_mort_det	mortality of diazotroph cyanobacteria
+ p_cya_mort_det_diff	mortality of diazotroph cyanobacteria due to strong turbulence
+ p_zoo_mort_det	mortality of zooplankton
+ p_sed_ero_det/(cgt_cellheight* cgt_density)	sedimentary detritus erosion

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Tracer equations, continued from previous page

+ p_sed_biores_det/(cgt_cellheig cgt_density)	bio resuspension of sedimentary detritus
- p_det_resp_nh4	recycling of detritus using oxygen (respiration)
- p_det_denit_nh4	recycling of detritus using nitrate (denitrification)
- p_det_sulf_nh4	recycling of detritus using sulfate (sulfate reduction)
- p_det_sedi_sed/(cgt_cellheight cgt_density)	detritus sedimentation

Change of: particulate organic carbon

$\frac{d}{dt}$ t_poc =

+ p_sed_ero_poc/(cgt_cellheight* cgt_density)	sedimentary poc erosion
+ p_sed_biores_poc/(cgt_cellheig cgt_density)	bio resuspension of sedimentary poc
+ p_doc2pco	particle formation from DOC
- p_poc_resp	respiration of POC
- p_poc_denit	recycling of POC using nitrate (denitrification)
- p_poc_sulf	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
- p_poc_sedi_sed/(cgt_cellheight cgt_density)	poc sedimentation

Change of: phosphorus in particulate organic carbon in Redfield ratio

$\frac{d}{dt}$ t_pocp =

+ p_sed_ero_pocp/(cgt_cellheight cgt_density)	sedimentary pocp erosion

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Tracer equations, continued from previous page	
+ p_sed_biores_pocp/(cgt_cellhei cgt_density)	bio resuspension of sedimentary pocp
+ p_dop2pocp	particle formation from DOP
- p_pocp_resp	respiration of POCP
- p_pocp_denit	recycling of POC using nitrate (denitrification)
- p_pocp_sulf	Mineralization of POC, e-acceptor sulfate (sulfate reduction)
- p_pocp_sedi_sed/(cgt_cellheigh cgt_density)	pocp sedimentation
- p_sed_pocp_sulf/(cgt_cellheig cgt_density)	recycling of sedimentary pocp to dic and PO4 using sulfate (sulfate reduction)

Change of: nitrogen in particulate organic carbon in Redfield ratio

$\frac{d}{dt}$ t_pocn =

+ p_sed_ero_pocn/(cgt_cellheight cgt_density)	sedimentary pocn erosion
+ p_sed_biores_pocn/(cgt_cellhei cgt_density)	bio resuspension of sedimentary pocn
+ p_don2pocn	particle formation from DON
- p_pocn_resp	respiration of POCN
- p_pocn_denit_noN2	recycling of POCN using nitrate (denitrification)
- p_pocn_sulf	Mineralization of POCN, e-acceptor sulfate (sulfate reduction)
- p_pocn_sedi_sed/(cgt_cellheigh cgt_density)	pocn sedimentation

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Tracer equations, continued from previous page

- p_sed_pocn_sulf/(cgt_cellheigh cgt_density)	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction)

Change of: nitrogen in particulate organic carbon in Redfield ratio; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_pocn_with_atmos_ship_N =

+ p_sed_ero_pocn_atmos_ship_N/(c cgt_density)	sedimentary pocn erosion; sub-process for atmos_ship nitrogen
+ p_sed_biores_pocn_atmos_ship_N cgt_density)	bio resuspension of sedimentary pocn; sub-process for atmos_ship nitrogen
+ p_don2pocn_atmos_ship_N	particle formation from DON; sub-process for atmos_ship nitrogen
- p_pocn_resp* max(0.0,min(1.0,t_pocn_with_at))	respiration of POCN
- p_pocn_denit_noN2* max(0.0,min(1.0,t_pocn_with_at))	recycling of POCN using nitrate (denitrification)
- p_pocn_sulf* max(0.0,min(1.0,t_pocn_with_at))	Mineralization of POCN, e-acceptor sulfate (sulfate reduction)
- p_pocn_sedi_sed/(cgt_cellheigh cgt_density)* max(0.0,min(1.0,t_pocn_with_at))	pocn sedimentation
- p_sed_pocn_sulf/(cgt_cellheigh cgt_density)* max(0.0,min(1.0,t_pocn_with_at))	recycling of sedimentary pocn to dic and NH4 using sulfate (sulfate reduction)

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Tracer equations, continued from previous page

Change of: large-cell phytoplankton; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_lpp_with_atmos_ship_N =

Term	Description
+ p_no3_assim_lpp_atmos_ship_N	assimilation of nitrate by large-cell phytoplankton; sub-process for atmos_ship nitrogen
+ p_nh4_assim_lpp_atmos_ship_N	assimilation of ammonium by large-cell phytoplankton; sub-process for atmos_ship nitrogen
- p_lpp_graz_zoo* max(0.0,min(1.0,t_lpp_with_atm))	grazing of zooplankton eating large-cell phytoplankton
- p_lpp_resp_nh4* max(0.0,min(1.0,t_lpp_with_atm))	respiration of large-cell phytoplankton
- p_lpp_mort_det* max(0.0,min(1.0,t_lpp_with_atm))	mortality of large-cell phytoplankton

Change of: nitrogen in dissolved organic carbon in Redfield ratio; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_don_with_atmos_ship_N =

Term	Description
+ p_nh4_assim_lpp_don_atmos_ship	Production of DON by LPP; sub-process for atmos_ship nitrogen
+ p_no3_assim_lpp_don_atmos_ship	Production of DON by LPP; sub-process for atmos_ship nitrogen
+ p_nh4_assim_spp_don_atmos_ship	Production of DON by SPP; sub-process for atmos_ship nitrogen
+ p_no3_assim_spp_don_atmos_ship	Production of DON by SPP; sub-process for atmos_ship nitrogen
+ (p_lpp_resp_nh4_atmos_ship_N) *(don_fraction)	respiration of large-cell phytoplankton; sub-process for atmos_ship nitrogen

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Tracer equations, continued from previous page

+ (p_spp_resp_nh4_atmos_ship_N) *(don_fraction)	respiration of small-cell phytoplankton; sub-process for atmos_ship nitrogen
+ (p_cya_resp_nh4_atmos_ship_N) *(don_fraction)	respiration of diazotroph cyanobacteria; sub-process for atmos_ship nitrogen
+ (p_zoo_resp_nh4_atmos_ship_N) *(don_fraction)	respiration of zooplankton; sub-process for atmos_ship nitrogen
- p_don2pocn* max(0.0,min(1.0,t_don_with_atm))	particle formation from DON
- p_don_resp* max(0.0,min(1.0,t_don_with_atm))	respiration of DON
- p_don_denit_noN2* max(0.0,min(1.0,t_don_with_atm))	recycling of DON using nitrate (denitrification)
- p_don_sulf* max(0.0,min(1.0,t_don_with_atm))	Mineralization of DON, e-acceptor sulfate (sulfate reduction)

Change of: diazotroph cyanobacteria; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_cya_with_atmos_ship_N =

- p_cya_graz_zoo* max(0.0,min(1.0,t_cya_with_atm))	grazing of zooplankton eating diazotroph cyanobacteria
- p_cya_resp_nh4* max(0.0,min(1.0,t_cya_with_atm))	respiration of diazotroph cyanobacteria
- p_cya_mort_det* max(0.0,min(1.0,t_cya_with_atm))	mortality of diazotroph cyanobacteria

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Tracer equations, continued from previous page	
- p_cya_mort_det_diff* max(0.0,min(1.0,t_cya_with_atm))	mortality of diazotroph cyanobacteria due to strong turbulence

Change of: detritus; containing nitrogen from atmospheric deposition, which has been previously emitted by ships

$\frac{d}{dt}$ t_det_with_atmos_ship_N =

+ p_lpp_mort_det_atmos_ship_N	mortality of large-cell phytoplankton; sub-process for atmos_ship nitrogen
+ p_spp_mort_det_atmos_ship_N	mortality of small-scale phytoplankton; sub-process for atmos_ship nitrogen
+ p_cya_mort_det_atmos_ship_N	mortality of diazotroph cyanobacteria; sub-process for atmos_ship nitrogen
+ p_cya_mort_det_diff_atmos_ship	mortality of diazotroph cyanobacteria due to strong turbulence; sub-process for atmos_ship nitrogen
+ p_zoo_mort_det_atmos_ship_N	mortality of zooplankton; sub-process for atmos_ship nitrogen
+ p_sed_ero_det_atmos_ship_N/(cg cgt_density)	sedimentary detritus erosion; sub-process for atmos_ship nitrogen
+ p_sed_biores_det_atmos_ship_N/ cgt_density)	bio resuspension of sedimentary detritus; sub-process for atmos_ship nitrogen
- p_det_resp_nh4* max(0.0,min(1.0,t_det_with_atm))	recycling of detritus using oxygen (respiration)
- p_det_denit_nh4* max(0.0,min(1.0,t_det_with_atm))	recycling of detritus using nitrate (denitrification)
- p_det_sulf_nh4* max(0.0,min(1.0,t_det_with_atm))	recycling of detritus using sulfate (sulfate reduction)

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Tracer equations, continued from previous page	
`- p_det_sedi_sed/(cgt_cellheight cgt_density)* max(0.0,min(1.0,t_det_with_atm ))`	detritus sedimentation