

BSH-ERGOM (of HBM-ERGOM) (v2017) Documentation

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1 Introduction

This is an automatically generated description of the ecosystem model BSH-ERGOM (of HBM-ERGOM) version v2017 . 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 stoichiometric 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 stoichiometric 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	
amm	ammonium (mol/kg)
nit	nitrate (mol/kg)
phos	phosphate (mol/kg)
sil	silicate (mol/kg)
dia	diatoms (mol/kg)
vertical speed =	-0.2 m/day
opacity =	1.0 m ² /mol
flag	flagellates (mol/kg)
opacity =	1.0 m ² /mol
cyano	cyano bacteria (mol/kg)
vertical speed =	0.1 m/day
opacity =	1.0 m ² /mol
mez	meso zooplankton (mol/kg)
miz	micro zooplakton (mol/kg)
det	Detritus (mol/kg)
vertical speed =	-1.5 m/day
opacity =	1.0 m ² /mol
dets	S-Detritus (mol/kg)
vertical speed =	-1.5 m/day
ldon	ldon is the labile DON fraction (mol/kg)
oxy	Oxygen (mol/kg)
amm_with_totatmos_N	ammonium; containing (mol/kg)
nit_with_totatmos_N	nitrate; containing (mol/kg)
continued on next page...	

Tracers in the water column only, continued from previous page

dia_with_totatmos_N diatoms; containing (mol/kg)
vertical speed = -0.2 m/day

flag_with_totatmos_N flagellates; containing (mol/kg)

cyano_with_totatmos_N cyano bacteria; containing (mol/kg)
vertical speed = 0.1 m/day

mez_with_totatmos_N meso zooplankton; containing (mol/kg)

miz_with_totatmos_N micro zooplakton; containing (mol/kg)

det_with_totatmos_N Detritus; containing (mol/kg)
vertical speed = -1.5 m/day

ldon_with_totatmos_N ldon is the labile DON fraction; containing (mol/kg)

amm_with_agri_N ammonium; containing (mol/kg)

nit_with_agri_N nitrate; containing (mol/kg)

dia_with_agri_N diatoms; containing (mol/kg)
vertical speed = -0.2 m/day

flag_with_agri_N flagellates; containing (mol/kg)

cyano_with_agri_N cyano bacteria; containing (mol/kg)
vertical speed = 0.1 m/day

mez_with_agri_N meso zooplankton; containing (mol/kg)

miz_with_agri_N micro zooplakton; containing (mol/kg)

det_with_agri_N Detritus; containing (mol/kg)
vertical speed = -1.5 m/day

ldon_with_agri_N ldon is the labile DON fraction; containing (mol/kg)

Tracers in water and pore water

Tracers in fluff and sediment

nitr nitrogen in the sediment (mol/m²)

continued on next page...

Tracers in fluff and sediment, continued from previous page**sili silicate in the sediment (mol/m²)****nitrogen in the sediment; containing (mol/m²)**
nittr_with_totatmos_N**nittr_with_agri_N nitrogen in the sediment; containing (mol/m²)**

3 Description of model processes, ordered by process type

3.1 Process type standard

Processes
nitrification (sediment only) [mol/m²/day] $\text{ONnitr} \cdot \text{NOR} \cdot \text{oxy} + \text{amm} \rightarrow$ $\text{fnitr} \cdot \text{recs} \cdot \text{nitr} \cdot \text{theta}(\text{oxy})$ $\text{nitrification_amm_se}$ $=$
mineralization of benthic nitrogen, mmol N/m²/d (sediment only) [mol/m²/day] $\text{nitr} + \text{ldn_N_sed} \cdot \text{nit} + \text{NOR} \cdot \text{ldn_O_sed} \cdot \text{oxy} \rightarrow \text{amm} + \text{rfr} \cdot \text{one_pburial} \cdot \text{phos}$ $\text{recs} \cdot \text{nitr}$ $\text{mineralization_nitr_}$ $=$
mineralization of benthic silicate, mmol N/m²/d (sediment only) [mol/m²/day] $\text{sili} \rightarrow$ $\text{recs} \cdot \text{sili}$ $\text{mineralization_sili_}$ $=$
Grazing of micro-zooplankton on diatoms [mol/kg/day] $\text{dia} \rightarrow \text{miz} + \text{rfs} \cdot \text{dets}$ $\text{grazing_miz_on_dia} \text{ mizprefdia} \cdot \text{miztotgraz} \cdot \text{miz} \cdot \text{dia}$ $=$
Grazing of micro-zooplankton on flagellates [mol/kg/day] $\text{flag} \rightarrow \text{miz}$ $\text{grazing_miz_on_flag} \text{ mizprefflag} \cdot \text{miztotgraz} \cdot \text{miz} \cdot \text{flag}$ $=$
Grazing of micro-zooplankton on cyano [mol/kg/day] $\text{cyano} \rightarrow \text{miz}$ $\text{mizprefcyano} \cdot \text{miztotgraz} \cdot \text{miz} \cdot \text{cyano}$ $\text{grazing_miz_on_cyanc}$ $=$
respiration of micro-zooplankton [mol/kg/day] $\text{NOR} \cdot \text{ONamup} \cdot \text{oxy} + \text{miz} \rightarrow \text{ldon_frac} \cdot \text{ldon} + (\text{one} - \text{ldon_frac}) \cdot \text{amm} + \text{rfr} \cdot \text{phos}$
continued on next page...

Processes, continued from previous page

```
respiration_miz = ln_miz * miz_totgraz * food_miz * miz
```

mortality of micro-zooplankton [mol/kg/day]

```
miz -> det
```

```
mortality_miz = tld_miz * miz
```

Grazing of meso-zooplankton on diatoms [mol/kg/day]

```
dia -> mez + rfs*dets
```

```
grazing_mez_on_dia = mez_prefdia * mez_totgraz * mez * dia
```

Grazing of meso-zooplankton on flagellates [mol/kg/day]

```
flag -> mez
```

```
grazing_mez_on_flag = mez_prefflag * mez_totgraz * mez * flag
```

Grazing of meso-zooplankton on cyano [mol/kg/day]

```
cyano -> mez
```

```
grazing_mez_on_cyano = mez_prefcyano * mez_totgraz * mez * cyano
```

Grazing of meso-zooplankton on micro-zooplankton [mol/kg/day]

```
miz -> mez
```

```
grazing_mez_on_miz = mez_prefmiz * mez_totgraz * mez * miz
```

respiration of meso-zooplankton [mol/kg/day]

```
NOR*ONamup*oxy + mez -> rfr*phos + (one-ldon_frac)*amm + ldon_frac*ldon
```

```
respiration_mez = ln_mez * mez_totgraz * food_mez * mez
```

mortality of meso-zooplankton [mol/kg/day]

```
mez -> det
```

```
mortality_mez = tld_mez * mez
```

uptake of ammonium (, phosphate and silicate) by diatoms [mol/kg/day]

```
rfs*sil + rfr*phos + amm -> NOR*ONamup*oxy + dia
```

```
uptake_amm_by_dia = rp * (dia+p0) * amm * invdin_eps
```

uptake of nitrate (, phosphate and silicate) by diatoms [mol/kg/day]

```
rfs*sil + rfr*phos + nit -> NOR*ONniup*oxy + dia
```

```
uptake_nit_by_dia = rp * (dia+p0) * nit * invdin_eps
```

respiration of diatoms [mol/kg/day]

```
dia + NOR*ONamup*oxy -> ldon_frac*ldon + (one-ldon_frac)*amm + rfr*phos + rfs*sil
```

continued on next page...

Processes, continued from previous page

```
respiration_dia = lpn * dia
```

mortality of diatoms [mol/kg/day]

```
dia -> det + rfs*dets
```

```
mortality_dia = lpd * dia
```

uptake of ammonium (and phosphate) by flagellates [mol/kg/day]

```
rfr*phos + amm -> flag + NOR*ONamup*oxy
```

```
uptake_amm_by_flag rf * (flag+f0) * amm * invdin_eps  
=
```

uptake of nitrate (and phosphate) by flagellates [mol/kg/day]

```
nit + rfr*phos -> flag + NOR*ONniup*oxy
```

```
uptake_nit_by_flat rf * (flag+f0) * nit * invdin_eps  
=
```

respiration of flagellates [mol/kg/day]

```
flag + NOR*ONamup*oxy -> ldon_frac*ldon + (one-ldon_frac)*amm + rfr*phos
```

```
respiration_flag = lpn * flag
```

mortality of flagellates [mol/kg/day]

```
flag -> det
```

```
mortality_flag = lpd * flag
```

uptake of phosphate by cyano bacteria [mol/kg/day]

```
rfr*phos -> NOR*ONamup*oxy + cyano
```

```
rb * (cyano + b0)
```

```
uptake_phos_by_cyano
```

```
=
```

respiration of cyano bacteria [mol/kg/day]

```
NOR*ONamup*oxy + cyano -> rfr*phos + (one-ldon_frac)*amm + ldon_frac*ldon
```

```
respiration_cyano = lpn * cyano
```

mortality of cyano bacteria [mol/kg/day]

```
cyano -> det
```

```
mortality_cyano = lpd * cyano
```

recycling of detritus [mol/kg/day]

```
det + ldn_N*nit + NOR*ldn_0*oxy -> amm + rfr*phos
```

```
ldn * det
```

```
recycling_detritus_t
```

```
=
```

recycling of detritus [mol/kg/day]

```
dets -> sil
```

continued on next page...

Processes, continued from previous page

```

lds * dets
recycling_detritus_t
=

```

```

nitrification [mol/kg/day]
NOR*ONitr*oxy + amm -> nit
nitrification =    nf * amm

```

```

degradation of lDON [mol/kg/day]
ldon -> amm
degradation_ldon = ldon_tor * ldon

```

```

nitrification; sub-process for totatmos nitrogen (sediment only) [mol/m2/day]
->
    nitrification_amm_sed * ((1.0)*(1)*
nitrification_amm_sed_max(0.0,min(1.0,amm_with_totatmos_N/max(0.00000000001,amm))
=
    )) / ((1.0)*(1))

```

```

mineralization of bentic nitrogen, mmol N/m2/d; sub-process for totatmos
nitrogen (sediment only) [mol/m2/day]
-> amm_with_totatmos_N
    mineralization_nitr_sed * ((1.0)*(1)*
mineralization_nitr_max(0.0,min(1.0,nitr_with_totatmos_N/max(0.00000000001,nitr)
=
    ))+(ldn_N_sed)*(1)*
    max(0.0,min(1.0,nit_with_totatmos_N/max(0.00000000001,nit))
    )) / ((1.0)*(1)+(ldn_N_sed)*(1))

```

```

Grazing of micro-zooplankton on diatoms; sub-process for totatmos nitrogen
[mol/kg/day]
-> miz_with_totatmos_N
    grazing_miz_on_dia * ((1.0)*(1)*
grazing_miz_on_dia_max(0.0,min(1.0,dia_with_totatmos_N/max(0.00000000001,dia))
=
    )) / ((1.0)*(1))

```

```

Grazing of micro-zooplankton on flagellates; sub-process for totatmos nitrogen
[mol/kg/day]
-> miz_with_totatmos_N
    grazing_miz_on_flag * ((1.0)*(1)*
grazing_miz_on_flag_max(0.0,min(1.0,flag_with_totatmos_N/max(0.00000000001,flag)
=
    ))) / ((1.0)*(1))

```

```

Grazing of micro-zooplankton on cyano; sub-process for totatmos nitrogen
[mol/kg/day]
-> miz_with_totatmos_N
    grazing_miz_on_cyano * ((1.0)*(1)*
grazing_miz_on_cyano_max(0.0,min(1.0,cyano_with_totatmos_N/max(0.00000000001,cyano)
=
    ))) / ((1.0)*(1))

```

continued on next page...

Processes, continued from previous page

respiration of micro-zooplankton; sub-process for totatmos nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_totatmos_N + (one-ldon_frac)*amm_with_totatmos_N
      respiration_miz * ((1.0)*(1)*
respiration_miz_totatmax(0.0,min(1.0,miz_with_totatmos_N/max(0.00000000001,miz))
=
      )) / ((1.0)*(1))
```

mortality of micro-zooplankton; sub-process for totatmos nitrogen [mol/kg/day]

```
-> det_with_totatmos_N
      mortality_miz * ((1.0)*(1)*
mortality_miz_totatmax(0.0,min(1.0,miz_with_totatmos_N/max(0.00000000001,miz))
=
      )) / ((1.0)*(1))
```

Grazing of meso-zooplankton on diatoms; sub-process for totatmos nitrogen [mol/kg/day]

```
-> mez_with_totatmos_N
      grazing_mez_on_dia * ((1.0)*(1)*
grazing_mez_on_dia_tmax(0.0,min(1.0,dia_with_totatmos_N/max(0.00000000001,dia))
=
      )) / ((1.0)*(1))
```

Grazing of meso-zooplankton on flagellates; sub-process for totatmos nitrogen [mol/kg/day]

```
-> mez_with_totatmos_N
      grazing_mez_on_flag * ((1.0)*(1)*
grazing_mez_on_flag_max(0.0,min(1.0,flag_with_totatmos_N/max(0.00000000001,flag)
=
      ))) / ((1.0)*(1))
```

Grazing of meso-zooplankton on cyano; sub-process for totatmos nitrogen [mol/kg/day]

```
-> mez_with_totatmos_N
      grazing_mez_on_cyano * ((1.0)*(1)*
grazing_mez_on_cyano_max(0.0,min(1.0,cyano_with_totatmos_N/max(0.00000000001,cyano)
=
      ))) / ((1.0)*(1))
```

Grazing of meso-zooplankton on micro-zooplankton; sub-process for totatmos nitrogen [mol/kg/day]

```
-> mez_with_totatmos_N
      grazing_mez_on_miz * ((1.0)*(1)*
grazing_mez_on_miz_tmax(0.0,min(1.0,miz_with_totatmos_N/max(0.00000000001,miz))
=
      )) / ((1.0)*(1))
```

respiration of meso-zooplankton; sub-process for totatmos nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_totatmos_N + (one-ldon_frac)*amm_with_totatmos_N
      respiration_mez * ((1.0)*(1)*
respiration_mez_totatmax(0.0,min(1.0,mez_with_totatmos_N/max(0.00000000001,mez))
=
      )) / ((1.0)*(1))
```

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Processes, continued from previous page

mortality of meso-zooplankton; sub-process for totatmos nitrogen [mol/kg/day]

```
-> det_with_totatmos_N
      mortality_mez * ((1.0)*(1)*
mortality_mez_totatmax(0.0,min(1.0,mez_with_totatmos_N/max(0.00000000001,mez))
=
      )) / ((1.0)*(1))
```

uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for totatmos nitrogen [mol/kg/day]

```
-> dia_with_totatmos_N
      uptake_amm_by_dia * ((1.0)*(1)*
uptake_amm_by_dia_tmax(0.0,min(1.0,amm_with_totatmos_N/max(0.00000000001,amm))
=
      )) / ((1.0)*(1))
```

uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for totatmos nitrogen [mol/kg/day]

```
-> dia_with_totatmos_N
      uptake_nit_by_dia * ((1.0)*(1)*
uptake_nit_by_dia_tmax(0.0,min(1.0,nit_with_totatmos_N/max(0.00000000001,nit))
=
      )) / ((1.0)*(1))
```

respiration of diatoms; sub-process for totatmos nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_totatmos_N + (one-ldon_frac)*amm_with_totatmos_N
      respiration_dia * ((1.0)*(1)*
respiration_dia_totatmax(0.0,min(1.0,dia_with_totatmos_N/max(0.00000000001,dia))
=
      )) / ((1.0)*(1))
```

mortality of diatoms; sub-process for totatmos nitrogen [mol/kg/day]

```
-> det_with_totatmos_N
      mortality_dia * ((1.0)*(1)*
mortality_dia_totatmax(0.0,min(1.0,dia_with_totatmos_N/max(0.00000000001,dia))
=
      )) / ((1.0)*(1))
```

uptake of ammonium (and phosphate) by flagellates; sub-process for totatmos nitrogen [mol/kg/day]

```
-> flag_with_totatmos_N
      uptake_amm_by_flag * ((1.0)*(1)*
uptake_amm_by_flag_tmax(0.0,min(1.0,amm_with_totatmos_N/max(0.00000000001,amm))
=
      )) / ((1.0)*(1))
```

uptake of nitrate (and phosphate) by flagellates; sub-process for totatmos nitrogen [mol/kg/day]

```
-> flag_with_totatmos_N
      uptake_nit_by_flat * ((1.0)*(1)*
uptake_nit_by_flat_tmax(0.0,min(1.0,nit_with_totatmos_N/max(0.00000000001,nit))
=
      )) / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

respiration of flagellates; sub-process for totatmos nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_totatmos_N + (one-ldon_frac)*amm_with_totatmos_N
      respiration_flag * ((1.0)*(1)*
respiration_flag_totmax(0.0,min(1.0,flag_with_totatmos_N/max(0.00000000001,flag)
=
      ))) / ((1.0)*(1))
```

mortality of flagellates; sub-process for totatmos nitrogen [mol/kg/day]

```
-> det_with_totatmos_N
      mortality_flag * ((1.0)*(1)*
mortality_flag_totatmax(0.0,min(1.0,flag_with_totatmos_N/max(0.00000000001,flag)
=
      ))) / ((1.0)*(1))
```

respiration of cyano bacteria; sub-process for totatmos nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_totatmos_N + (one-ldon_frac)*amm_with_totatmos_N
      respiration_cyano * ((1.0)*(1)*
respiration_cyano_tmax(0.0,min(1.0,cyano_with_totatmos_N/max(0.00000000001,cyano)
=
      ))) / ((1.0)*(1))
```

mortality of cyano bacteria; sub-process for totatmos nitrogen [mol/kg/day]

```
-> det_with_totatmos_N
      mortality_cyano * ((1.0)*(1)*
mortality_cyano_totamax(0.0,min(1.0,cyano_with_totatmos_N/max(0.00000000001,cyano)
=
      ))) / ((1.0)*(1))
```

recycling of detritus; sub-process for totatmos nitrogen [mol/kg/day]

```
-> amm_with_totatmos_N
      recycling_detritus_to_n * ((1.0)*(1)*
recycling_detritus_tmax(0.0,min(1.0,det_with_totatmos_N/max(0.00000000001,det))
=
      )+(ldn_N)*(1)*
      max(0.0,min(1.0,nit_with_totatmos_N/max(0.00000000001,nit))
      )) / ((1.0)*(1)+(ldn_N)*(1))
```

nitrification; sub-process for totatmos nitrogen [mol/kg/day]

```
-> nit_with_totatmos_N
      nitrification * ((1.0)*(1)*
nitrification_totatmax(0.0,min(1.0,amm_with_totatmos_N/max(0.00000000001,amm))
=
      )) / ((1.0)*(1))
```

degradation of lDON; sub-process for totatmos nitrogen [mol/kg/day]

```
-> amm_with_totatmos_N
      degradation_ldon * ((1.0)*(1)*
degradation_ldon_totmax(0.0,min(1.0,ldon_with_totatmos_N/max(0.00000000001,ldon)
=
      ))) / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

nitrification; sub-process for agri nitrogen (sediment only) [mol/m²/day]

```
->
      nitrification_amm_sed * ((1.0)*(1)*
nitrification_amm_sedmax(0.0,min(1.0,amm_with_agri_N/max(0.00000000001,amm)))) /
=
      ((1.0)*(1))
```

mineralization of bentic nitrogen, mmol N/m²/d; sub-process for agri nitrogen (sediment only) [mol/m²/day]

```
-> amm_with_agri_N
      mineralization_nitr_sed * ((1.0)*(1)*
mineralization_nitr_max(0.0,min(1.0,nitr_with_agri_N/max(0.00000000001,nitr)))+
=
      (ldn_N_sed)*(1)*
      max(0.0,min(1.0,nit_with_agri_N/max(0.00000000001,nit)))) /
      ((1.0)*(1)+(ldn_N_sed)*(1))
```

Grazing of micro-zooplankton on diatoms; sub-process for agri nitrogen [mol/kg/day]

```
-> miz_with_agri_N
      grazing_miz_on_dia * ((1.0)*(1)*
grazing_miz_on_dia_amax(0.0,min(1.0,dia_with_agri_N/max(0.00000000001,dia)))) /
=
      ((1.0)*(1))
```

Grazing of micro-zooplankton on flagellates; sub-process for agri nitrogen [mol/kg/day]

```
-> miz_with_agri_N
      grazing_miz_on_flag * ((1.0)*(1)*
grazing_miz_on_flag_max(0.0,min(1.0,flag_with_agri_N/max(0.00000000001,flag))))
=
      / ((1.0)*(1))
```

Grazing of micro-zooplankton on cyano; sub-process for agri nitrogen [mol/kg/day]

```
-> miz_with_agri_N
      grazing_miz_on_cyano * ((1.0)*(1)*
grazing_miz_on_cyano_max(0.0,min(1.0,cyano_with_agri_N/max(0.00000000001,cyano)))
=
      )) / ((1.0)*(1))
```

respiration of micro-zooplankton; sub-process for agri nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_agri_N + (one-ldon_frac)*amm_with_agri_N
      respiration_miz * ((1.0)*(1)*
respiration_miz_agri_max(0.0,min(1.0,miz_with_agri_N/max(0.00000000001,miz)))) /
=
      ((1.0)*(1))
```

mortality of micro-zooplankton; sub-process for agri nitrogen [mol/kg/day]

continued on next page...

Processes, continued from previous page

```

-> det_with_agri_N
      mortality_miz * ((1.0)*(1)*
mortality_miz_agri_Nmax(0.0,min(1.0,miz_with_agri_N/max(0.00000000001,miz)))) /
=      ((1.0)*(1))

```

Grazing of meso-zooplankton on diatoms; sub-process for agri nitrogen

[mol/kg/day]

```

-> mez_with_agri_N
      grazing_mez_on_dia * ((1.0)*(1)*
grazing_mez_on_dia_max(0.0,min(1.0,dia_with_agri_N/max(0.00000000001,dia)))) /
=      ((1.0)*(1))

```

Grazing of meso-zooplankton on flagellates; sub-process for agri nitrogen

[mol/kg/day]

```

-> mez_with_agri_N
      grazing_mez_on_flag * ((1.0)*(1)*
grazing_mez_on_flag_max(0.0,min(1.0,flag_with_agri_N/max(0.00000000001,flag))))
=      / ((1.0)*(1))

```

Grazing of meso-zooplankton on cyano; sub-process for agri nitrogen [mol/kg/day]

```

-> mez_with_agri_N
      grazing_mez_on_cyano * ((1.0)*(1)*
grazing_mez_on_cyano_max(0.0,min(1.0,cyano_with_agri_N/max(0.00000000001,cyano)))
=      )) / ((1.0)*(1))

```

Grazing of meso-zooplankton on micro-zooplankton; sub-process for agri nitrogen

[mol/kg/day]

```

-> mez_with_agri_N
      grazing_mez_on_miz * ((1.0)*(1)*
grazing_mez_on_miz_max(0.0,min(1.0,miz_with_agri_N/max(0.00000000001,miz)))) /
=      ((1.0)*(1))

```

respiration of meso-zooplankton; sub-process for agri nitrogen [mol/kg/day]

```

-> ldon_frac*ldon_with_agri_N + (one-ldon_frac)*amm_with_agri_N
      respiration_mez * ((1.0)*(1)*
respiration_mez_agri_Nmax(0.0,min(1.0,mez_with_agri_N/max(0.00000000001,mez)))) /
=      ((1.0)*(1))

```

mortality of meso-zooplankton; sub-process for agri nitrogen [mol/kg/day]

```

-> det_with_agri_N
      mortality_mez * ((1.0)*(1)*
mortality_mez_agri_Nmax(0.0,min(1.0,mez_with_agri_N/max(0.00000000001,mez)))) /
=      ((1.0)*(1))

```

continued on next page...

Processes, continued from previous page

uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for agri nitrogen [mol/kg/day]

```
-> dia_with_agri_N
      uptake_amm_by_dia * ((1.0)*(1)*
uptake_amm_by_dia_agmax(0.0,min(1.0,amm_with_agri_N/max(0.00000000001,amm)))) /
=
      ((1.0)*(1))
```

uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for agri nitrogen [mol/kg/day]

```
-> dia_with_agri_N
      uptake_nit_by_dia * ((1.0)*(1)*
uptake_nit_by_dia_agmax(0.0,min(1.0,nit_with_agri_N/max(0.00000000001,nit)))) /
=
      ((1.0)*(1))
```

respiration of diatoms; sub-process for agri nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_agri_N + (one-ldon_frac)*amm_with_agri_N
      respiration_dia * ((1.0)*(1)*
respiration_dia_agrimax(0.0,min(1.0,dia_with_agri_N/max(0.00000000001,dia)))) /
=
      ((1.0)*(1))
```

mortality of diatoms; sub-process for agri nitrogen [mol/kg/day]

```
-> det_with_agri_N
      mortality_dia * ((1.0)*(1)*
mortality_dia_agri_Nmax(0.0,min(1.0,dia_with_agri_N/max(0.00000000001,dia)))) /
=
      ((1.0)*(1))
```

uptake of ammonium (and phosphate) by flagellates; sub-process for agri nitrogen [mol/kg/day]

```
-> flag_with_agri_N
      uptake_amm_by_flag * ((1.0)*(1)*
uptake_amm_by_flag_amax(0.0,min(1.0,amm_with_agri_N/max(0.00000000001,amm)))) /
=
      ((1.0)*(1))
```

uptake of nitrate (and phosphate) by flagellates; sub-process for agri nitrogen [mol/kg/day]

```
-> flag_with_agri_N
      uptake_nit_by_flat * ((1.0)*(1)*
uptake_nit_by_flat_amax(0.0,min(1.0,nit_with_agri_N/max(0.00000000001,nit)))) /
=
      ((1.0)*(1))
```

respiration of flagellates; sub-process for agri nitrogen [mol/kg/day]

```
-> ldon_frac*ldon_with_agri_N + (one-ldon_frac)*amm_with_agri_N
      respiration_flag * ((1.0)*(1)*
respiration_flag_agmax(0.0,min(1.0,flag_with_agri_N/max(0.00000000001,flag))))
=
      / ((1.0)*(1))
```

continued on next page...

Processes, continued from previous page

mortality of flagellates; sub-process for agri nitrogen [mol/kg/day]

```

-> det_with_agri_N
      mortality_flag * ((1.0)*(1)*
mortality_flag_agri_max(0.0,min(1.0,flag_with_agri_N/max(0.00000000001,flag))))
=
      / ((1.0)*(1))

```

respiration of cyano bacteria; sub-process for agri nitrogen [mol/kg/day]

```

-> ldon_frac*ldon_with_agri_N + (one-ldon_frac)*amm_with_agri_N
      respiration_cyano * ((1.0)*(1)*
respiration_cyano_agmax(0.0,min(1.0,cyano_with_agri_N/max(0.00000000001,cyano)))
=
      )) / ((1.0)*(1))

```

mortality of cyano bacteria; sub-process for agri nitrogen [mol/kg/day]

```

-> det_with_agri_N
      mortality_cyano * ((1.0)*(1)*
mortality_cyano_agrimax(0.0,min(1.0,cyano_with_agri_N/max(0.00000000001,cyano)))
=
      )) / ((1.0)*(1))

```

recycling of detritus; sub-process for agri nitrogen [mol/kg/day]

```

-> amm_with_agri_N
      recycling_detritus_to_n * ((1.0)*(1)*
recycling_detritus_tmax(0.0,min(1.0,det_with_agri_N/max(0.00000000001,det)))+
=
      (ldn_N)*(1)*
      max(0.0,min(1.0,nit_with_agri_N/max(0.00000000001,nit)))) /
      ((1.0)*(1)+(ldn_N)*(1))

```

nitrification; sub-process for agri nitrogen [mol/kg/day]

```

-> nit_with_agri_N
      nitrification * ((1.0)*(1)*
nitrification_agri_Nmax(0.0,min(1.0,amm_with_agri_N/max(0.00000000001,amm)))) /
=
      ((1.0)*(1))

```

degradation of lDON; sub-process for agri nitrogen [mol/kg/day]

```

-> amm_with_agri_N
      degradation_ldon * ((1.0)*(1)*
degradation_ldon_agmax(0.0,min(1.0,ldon_with_agri_N/max(0.00000000001,ldon))))
=
      / ((1.0)*(1))

```

Auxiliary variables

```

Kspburial2 =      Kspburial*Kspburial

```

```

oxy2 =      oxy*oxy

```

continued on next page...

Auxiliary variables, continued from previous page

auxiliary for calculating mineralization and nitrification

```
recs = exp(q10_rec*bottemp) * (theta(oxy)*dn_sed + (1.0-
theta(oxy))*dn_sed_anox)
```

using nitrate (and sulphate) to oxidize benthic organic material

```
denitscal = (1.0-theta(oxy)) * nit/(ksdenit+nit)
```

Under oxic conditions benthic OM is oxidated by oxygen. Under anoxic conditions benthic OM is oxidated by nitrate, if available. Otherwise by sulfate as negative o2

```
ldn_N_sed = NNdenit * denitscal
```

Under oxic conditions benthic OM is oxidated by oxygen. Under anoxic conditions benthic OM is oxidated by nitrate, if available. Otherwise by sulfate as negative o2

```
ldn_O_sed = ONamup * (one - denitscal)
```

Phosphate is buried under oxic conditions but no P burial under anoxic conditions

```
one_pburial = 1.0 - theta(oxy) * pfrac * oxy2 * (oxy2 + Kspburial2)
```

nutrient limitation phosphate

```
nutlimc = phos*phos/(albrfr2+phos*phos)
```

ratio of optimal light for bluegreen

```
ppikb = min(lightk/min_ocyano1,one)
```

uptake rate of cyano

```
rb = rb0*min(nutlimc, ppikb*exp(one-ppikb))*four/(four +
exp(cyanotl1 - temp))*(atan(-sali+cyanosul)/pi+half)
```

nutrient limitation phosphate or nitrogen

```
nutlimf = min(((amm+nit)*(amm+nit))/(alphaf2+(amm+nit)*(amm+nit)),
nutlimc)
```

ratio of optimal light for flagellats

```
ppikf = min(lightk/min_oflag1,one)
```

uptake rate of flag

```
rf = rf0*min(nutlimf,ppikf*exp(one-ppikf))*flagtsc*exp(flagtll*
temp)
```

nutrient limitation phosphate, nitrogen or silicate

```
nutlimd = min(nutlimf, sil*sil/(alprfs2+sil*sil))
```

ratio of optimal light for diatoms

```
ppikp = min(lightk/min_odial,one)
```

continued on next page...

Auxiliary variables, continued from previous page

uptake rate of dia

$rp = rp0 * \min(nutlimd, ppikp * \exp(one - ppikp))$

nitrification rate

$nf = rnit * oxy / (ksnit + oxy) * \exp(anit * temp)$

More help variables

$foodmez = mezprefdia * dia + mezprefflag * flag + mezprefcyano * cyano + mezprefmiz * miz$

help variable

$temp2 = temp * temp$

mez grazing temperature dependece

$mezgt = half + mez_tscale * temp2 / (meztck + temp2)$

food dependent grazing; these have been divided by food; mezfgrazf2 low compared to paper

$mezgscal = mezgraz * foodmez / (foodmez * foodmez + mezgrazf * mezgrazf)$

total mez grazin

$meztotgraz = mezgscal * mezgt$

More help variables

$foodmiz = mizprefdia * dia + mizprefflag * flag + mizprefcyano * cyano$

miz grazing temperature dependece

$mizgt = one + temp2 / (miztk + temp2)$

food dependent grazing; these have been divided by food

$mizgscal = mizgraz * foodmiz / (foodmiz * foodmiz + mizgrazf * mizgrazf)$

total miz grazing

$miztotgraz = mizgscal * mizgt$

phytoplankton respiration loss rate (to inorg. compounds)

$lpn = nb$

respiration of nitrate under hypoxic conditions; else = 0.0

$ldn_N = zero$

less hydrogen sulphite formation under hypoxic conditions; else = ONamup

$ldn_O = ONamup$

continued on next page...

Auxiliary variables, continued from previous page

phytoplankton respiration loss rate (to detritus)

lpd = deltao

meso zoo plankton loss rates (mortality)

tldmez = $\text{ldmez} + \text{mezcl} * \text{mez}$

micro zoo plankton loss rates (mortality)

tldmiz = ldmiz

factor for detritus recycling rates (lds and ldn)

fac = $\exp(\text{q10_rec} * \text{temp})$

detritus recycling rate (nitrogen, D => Amm)

ldn = $\text{dn} * \text{fac}$

detritus recycling rate (silicate, Ds => S)

lds = $\text{ds} * \text{fac}$

total inorganic N inversed and eps

invdin_eps = $\text{one} / (\text{nit} + \text{amm} + \text{eps})$

Constants

Loss rate P to N

nb = 0.01

Loss Rate PP to D

deltao = 0.02

Loss Rate Detritus to N

dn = 0.01

Loss Rate S-Detritus to S

ds = 0.004

Half-sat. inhib NO3 denit

ksdenit = 0.1

Half-sat. O2 nitrification

ksnit = 0.01

Max nitrification rate at T0

rnit = 0.1

Max dia uptake rate at T0

continued on next page...

Constants, continued from previous page	
rp0 =	1.0
Max Flag uptake rate at T0	
rf0 =	0.7
Max cyano uptake rate at T0	
rb0 =	0.5
Lower T limit Cyanos	
cyanotll =	15.0
Upper S limit Cyanos	
cyanosul =	12.0
flag temp scaling	
flagtll =	0.06
flag temp dep.	
flagtsc =	0.8
background values dia	
p0 =	0.001
Background values flag	
f0 =	0.001
Background values cyano	
b0 =	0.001
Min opt. dia light W/m2	
min_odial =	75.0
Min opt. flag light W/m2	
min_oflagl =	75.0
Min opt. cyan light W/m2	
min_ocyanol =	75.0
Recycling temp dep [/degC]	
q10_rec =	0.15
Nitrification temp dep[/degC]	
anit =	0.11
continued on next page...	

Constants, continued from previous page	
Stoichiometric O/N ratio nitr	
ONnitr =	2.0
Stoichiometric Norg/Nit denit	
NNdenit =	5.3
Stoech. O/N ratio nitr uptake	
ONniup =	8.625
Stoech. O/N ratio amm up/rel	
ONamup =	6.625
Redfield Ratio S/N	
rfs =	0.94
Redfield Ratio P/N	
rfr =	0.072
Half-saturation p burial Oxygen dependance	
Kspburial =	0.1
Fraction of recycled N nitrified in sediment	
fnitr =	0.4
Loss Rate Sediment to N	
dn_sed =	0.01
Loss Rate Sed. to N, anoxia	
dn_sed_anox =	0.005
Recycling temp dep sed. [/C]	
q10_recs =	0.15
Nnorm/Onorm	
NOR =	0.012
zero	
zero =	0.0
one	
one =	1.0
four	
four =	4.0
continued on next page...	

Constants, continued from previous page

half

half = 0.5

dummy

ldn_N_sed = 0.0

dummy

ldn_0_sed = 0.0

dummy

one_pburial = 0.0

dummy

ldn_N = 0.0

dummy

ldn_0 = 0.0

Mesozoopl. grazing constant

mezgraz = 0.2

Microzoopl. grazing constant

mizgraz = 0.4

Mesozoopl. food dep. constant

mezgrazf = 0.4

Microzoopl. food dep. const

mizgrazf = 0.2

Microzoopl. grazing temp dep.

miztk = 150.0

Mezozoopl. grazing temp dep.

meztk = 150.0

Mezozoopl. temp scaling

mez_tscale = 2.0

Mesozoopl. closure

mezcl = 0.02

Mesozoopl. mortality

continued on next page...

Constants, continued from previous page	
ldmez =	0.02
Microzoopl. mortality	
ldmiz =	0.05
Mesozoopl. excretion	
lnmez =	0.45
Microzoopl. excretion	
lnmiz =	0.3
Preference of mezoo on dia	
mezprefdia =	1.0
Preference of mezoo on flag	
mezprefflag =	0.3
Preference of mezoo on cyano	
mezprefcyano =	0.3
Preference of mezoo on mizoo	
mezprefmiz =	1.0
Preference of mizoo on dia	
mizprefdia =	0.3
Preference of mizoo on flag	
mizprefflag =	1.0
Preference of mizoo on cyano	
mizprefcyano =	0.3
Fraction of produced IDON	
ldon_frac =	0.1
IDON turning over rate [1/d]	
ldon_tor =	0.03
Process limitation factors	

4 Tracer equations

Tracer equations	
Change of: ammonium	
$\frac{d}{dt} \text{ amm} =$	
+ mineralization_nitr_sed/(cgt_cN/m2/d cgt_density)	mineralization of benthic nitrogen, mmol
+ (respiration_miz)*((one- ldon_frac))	respiration of micro-zooplankton
+ (respiration_mez)*((one- ldon_frac))	respiration of meso-zooplankton
+ (respiration_dia)*((one- ldon_frac))	respiration of diatoms
+ (respiration_flag)*((one- ldon_frac))	respiration of flagellates
+ (respiration_cyano)*((one- ldon_frac))	respiration of cyano bacteria
+ recycling_detritus_to_n	recycling of detritus
+ degradation_ldon	degradation of LDON
- nitrification_amm_sed/(cgt_cel cgt_density)	nitrification
- uptake_amm_by_dia	uptake of ammonium (, phosphate and silicate) by diatoms
- uptake_amm_by_flag	uptake of ammonium (and phosphate) by flagellates
- nitrification	nitrification
continued on next page...	

Tracer equations, continued from previous page

Change of: nitrate

$$\frac{d}{dt} \text{nit} =$$

+ nitrification	nitrification
- (mineralization_nitr_sed)* (ldn_N_sed)/(cgt_cellheight* cgt_density)	mineralization of bentic nitrogen, mmol N/m2/d
- uptake_nit_by_dia	uptake of nitrate (, phosphate and silicate) by diatoms
- uptake_nit_by_flat	uptake of nitrate (and phosphate) by flagellates
- (recycling_detritus_to_n)* (ldn_N)	recycling of detritus

Change of: phosphate

$$\frac{d}{dt} \text{phos} =$$

+ (mineralization_nitr_sed)* (rfr*one_pburial) /(cgt_cellheight*cgt_density)	mineralization of bentic nitrogen, mmol N/m2/d
+ (respiration_miz)*(rfr)	respiration of micro-zooplankton
+ (respiration_mez)*(rfr)	respiration of meso-zooplankton
+ (respiration_dia)*(rfr)	respiration of diatoms
+ (respiration_flag)*(rfr)	respiration of flagelattes
+ (respiration_cyano)*(rfr)	respiration of cyano bacteria
+ (recycling_detritus_to_n)* (rfr)	recycling of detritus
- (uptake_amm_by_dia)*(rfr)	uptake of ammonium (, phosphate and silicate) by diatoms
- (uptake_nit_by_dia)*(rfr)	uptake of nitrate (, phosphate and silicate) by diatoms
- (uptake_amm_by_flag)*(rfr)	uptake of ammonium (and phosphate) by flagellates

continued on next page...

Tracer equations, continued from previous page

- (uptake_nit_by_flat)*(rfr) uptake of nitrate (and phosphate) by flagellates
- (uptake_phos_by_cyano)*(rfr) uptake of phosphate by cyano bacteria

Change of: silicate $\frac{d}{dt} \text{sil} =$

- + (respiration_dia)*(rfs) respiration of diatoms
- + recycling_detritus_to_sil recycling of detritus
- (uptake_amm_by_dia)*(rfs) uptake of ammonium (, phosphate and silicate) by diatoms
- (uptake_nit_by_dia)*(rfs) uptake of nitrate (, phosphate and silicate) by diatoms

Change of: diatoms $\frac{d}{dt} \text{dia} =$

- + uptake_amm_by_dia uptake of ammonium (, phosphate and silicate) by diatoms
- + uptake_nit_by_dia uptake of nitrate (, phosphate and silicate) by diatoms
- grazing_miz_on_dia Grazing of micro-zooplankton on diatoms
- grazing_mez_on_dia Grazing of meso-zooplankton on diatoms
- respiration_dia respiration of diatoms
- mortality_dia mortality of diatoms

Change of: flagellates $\frac{d}{dt} \text{flag} =$

- + uptake_amm_by_flag uptake of ammonium (and phosphate) by flagellates
- + uptake_nit_by_flat uptake of nitrate (and phosphate) by flagellates

continued on next page...

Tracer equations, continued from previous page

- grazing_miz_on_flag	Grazing of micro-zooplankton on flagellates
- grazing_mez_on_flag	Grazing of meso-zooplankton on flagellates
- respiration_flag	respiration of flagellates
- mortality_flag	mortality of flagellates

Change of: cyano bacteria

$\frac{d}{dt}$ cyano =	
+ uptake_phos_by_cyano	uptake of phosphate by cyano bacteria
- grazing_miz_on_cyano	Grazing of micro-zooplankton on cyano
- grazing_mez_on_cyano	Grazing of meso-zooplankton on cyano
- respiration_cyano	respiration of cyano bacteria
- mortality_cyano	mortality of cyano bacteria

Change of: meso zooplankton

$\frac{d}{dt}$ mez =	
+ grazing_mez_on_dia	Grazing of meso-zooplankton on diatoms
+ grazing_mez_on_flag	Grazing of meso-zooplankton on flagellates
+ grazing_mez_on_cyano	Grazing of meso-zooplankton on cyano
+ grazing_mez_on_miz	Grazing of meso-zooplankton on micro-zooplankton
- respiration_mez	respiration of meso-zooplankton
- mortality_mez	mortality of meso-zooplankton

Change of: micro zooplakton

$\frac{d}{dt}$ miz =	
+ grazing_miz_on_dia	Grazing of micro-zooplankton on diatoms
+ grazing_miz_on_flag	Grazing of micro-zooplankton on flagellates

continued on next page...

Tracer equations, continued from previous page

+ grazing_miz_on_cyano	Grazing of micro-zooplankton on cyano
- respiration_miz	respiration of micro-zooplankton
- mortality_miz	mortality of micro-zooplankton
- grazing_mez_on_miz	Grazing of meso-zooplankton on micro-zooplankton

Change of: Detritus

 $\frac{d}{dt} \text{det} =$

+ mortality_miz	mortality of micro-zooplankton
+ mortality_mez	mortality of meso-zooplankton
+ mortality_dia	mortality of diatoms
+ mortality_flag	mortality of flagellates
+ mortality_cyano	mortality of cyano bacteria
- recycling_detritus_to_n	recycling of detritus

Change of: S-Detritus

 $\frac{d}{dt} \text{dets} =$

+ (grazing_miz_on_dia)*(rfs)	Grazing of micro-zooplankton on diatoms
+ (grazing_mez_on_dia)*(rfs)	Grazing of meso-zooplankton on diatoms
+ (mortality_dia)*(rfs)	mortality of diatoms
- recycling_detritus_to_sil	recycling of detritus

Change of: ldon is the labile DON fraction

 $\frac{d}{dt} \text{ldon} =$

+ (respiration_miz)*(ldon_frac)	respiration of micro-zooplankton
+ (respiration_mez)*(ldon_frac)	respiration of meso-zooplankton

continued on next page...

Tracer equations, continued from previous page

+ (respiration_dia)*(ldon_frac)	respiration of diatoms
+ (respiration_flag)*(ldon_frac)	respiration of flagellates
+ (respiration_cyano)*(ldon_frac)	respiration of cyano bacteria
- degradation_ldon	degradation of IDON

Change of: Oxygen

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

+ (uptake_amm_by_dia)*(NOR* ONamup)	uptake of ammonium (, phosphate and silicate) by diatoms
+ (uptake_nit_by_dia)*(NOR* ONniup)	uptake of nitrate (, phosphate and silicate) by diatoms
+ (uptake_amm_by_flag)*(NOR* ONamup)	uptake of ammonium (and phosphate) by flagellates
+ (uptake_nit_by_flat)*(NOR* ONniup)	uptake of nitrate (and phosphate) by flagellates
+ (uptake_phos_by_cyano)*(NOR*ONamup)	uptake of phosphate by cyano bacteria
- (nitrification_amm_sed)*((ONnitr*NOR)/(cgt_cellheight* cgt_density)	nitrification
- (mineralization_nitr_sed)*(NOR*ldn_0_sed) /(cgt_cellheight*cgt_density)	mineralization of benthic nitrogen, mmol N/m ² /d
- (respiration_miz)*(NOR* ONamup)	respiration of micro-zooplankton
- (respiration_mez)*(NOR* ONamup)	respiration of meso-zooplankton
- (respiration_dia)*(NOR* ONamup)	respiration of diatoms

continued on next page...

Tracer equations, continued from previous page

- (respiration_flag)*(NOR*ONamup) respiration of flagellates
- (respiration_cyano)*(NOR*ONamup) respiration of cyano bacteria
- (recycling_detritus_to_n)*(NOR*ldn_0) recycling of detritus
- (nitrification)*(NOR*ONnitr) nitrification

Change of: nitrogen in the sediment

$$\frac{d}{dt} \text{ nitr} =$$

- mineralization_nitr_sed mineralization of benthic nitrogen, mmol N/m²/d

Change of: silicate in the sediment

$$\frac{d}{dt} \text{ sili} =$$

- mineralization_sili_sed mineralization of benthic silicate, mmol N/m²/d

Change of: reduced nitrogen

$$\frac{d}{dt} \text{ nred} =$$

Change of: oxidized nitrogen

$$\frac{d}{dt} \text{ nox} =$$

Change of: oxidized phosphorus (phosphate)

$$\frac{d}{dt} \text{ pox} =$$

Change of: ammonium; containing

$$\frac{d}{dt} \text{ amm_with_totatmos_N} =$$

- + mineralization of benthic nitrogen, mmol mineralization_nitr_sed_totatmN/m²/d; sub-process for totatmos nitrogen cgt_density)
- + respiration of micro-zooplankton; sub-process (respiration_miz_totatmos_N)* for totatmos nitrogen ((one-ldon_frac))

continued on next page...

Tracer equations, continued from previous page

```

+                                respiration of meso-zooplankton; sub-process
(respiration_mez_totatmos_N)* for totatmos nitrogen
((one-ldon_frac))

+                                respiration of diatoms; sub-process for
(respiration_dia_totatmos_N)* totatmos nitrogen
((one-ldon_frac))

+                                respiration of flagelattes; sub-process for
(respiration_flag_totatmos_N) totatmos nitrogen
*((one-ldon_frac))

+                                respiration of cyano bacteria; sub-process for
(respiration_cyano_totatmos_N)totatmos nitrogen
*((one-ldon_frac))

+                                recycling of detritus; sub-process for totatmos
recycling_detritus_to_n_totatmitrogen

+ degradation_ldon_totatmos_N degradation of lDON; sub-process for totatmos
nitrogen

-                                nitrification
nitrification_amm_sed/(cgt_cel
cgt_density)*
max(0.0,min(1.0,amm_with_totat
))

- uptake_amm_by_dia*            uptake of ammonium (, phosphate and silicate)
max(0.0,min(1.0,amm_with_totatby diatoms
))

- uptake_amm_by_flag*          uptake of ammonium (and phosphate) by
max(0.0,min(1.0,amm_with_totatflagellates
))

- nitrification*               nitrification
max(0.0,min(1.0,amm_with_totat
))

```

Change of: nitrate; containing

```

 $\frac{d}{dt}$  nit_with_totatmos_N =
+ nitrification_totatmos_N    nitrification; sub-process for totatmos nitrogen

```

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Tracer equations, continued from previous page

```

- (mineralization_nitr_sed)* mineralization of benthic nitrogen, mmol
(ldn_N_sed)/(cgt_cellheight* N/m2/d
cgt_density)*
max(0.0,min(1.0,nit_with_totat
))

- uptake_nit_by_dia*          uptake of nitrate (, phosphate and silicate) by
max(0.0,min(1.0,nit_with_totatdiatoms
))

- uptake_nit_by_flat*        uptake of nitrate (and phosphate) by flagellates
max(0.0,min(1.0,nit_with_totat
))

- (recycling_detritus_to_n)* recycling of detritus
(ldn_N)*
max(0.0,min(1.0,nit_with_totat
))

```

Change of: diatoms; containing

```

 $\frac{d}{dt}$  dia_with_totatmos_N =
+          uptake of ammonium (, phosphate and silicate)
uptake_amm_by_dia_totatmos_N by diatoms; sub-process for totatmos nitrogen

+          uptake of nitrate (, phosphate and silicate) by
uptake_nit_by_dia_totatmos_N diatoms; sub-process for totatmos nitrogen

- grazing_miz_on_dia*        Grazing of micro-zooplankton on diatoms
max(0.0,min(1.0,dia_with_totat
))

- grazing_mez_on_dia*        Grazing of meso-zooplankton on diatoms
max(0.0,min(1.0,dia_with_totat
))

- respiration_dia*          respiration of diatoms
max(0.0,min(1.0,dia_with_totat
))

- mortality_dia*            mortality of diatoms
max(0.0,min(1.0,dia_with_totat
))

```

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Tracer equations, continued from previous page

Change of: flagellates; containing

```

 $\frac{d}{dt}$  flag_with_totatmos_N =
    +                               uptake of ammonium (and phosphate) by
    uptake_amm_by_flag_totatmos_N flagellates; sub-process for totatmos nitrogen

    +                               uptake of nitrate (and phosphate) by
    uptake_nit_by_flat_totatmos_N flagellates; sub-process for totatmos nitrogen

    - grazing_miz_on_flag*          Grazing of micro-zooplankton on flagellates
    max(0.0,min(1.0,flag_with_totatmos_N))

    - grazing_mez_on_flag*          Grazing of meso-zooplankton on flagellates
    max(0.0,min(1.0,flag_with_totatmos_N))

    - respiration_flag*             respiration of flagellates
    max(0.0,min(1.0,flag_with_totatmos_N))

    - mortality_flag*               mortality of flagellates
    max(0.0,min(1.0,flag_with_totatmos_N))

```

Change of: cyano bacteria; containing

```

 $\frac{d}{dt}$  cyano_with_totatmos_N =
    - grazing_miz_on_cyano*          Grazing of micro-zooplankton on cyano
    max(0.0,min(1.0,cyano_with_totatmos_N))

    - grazing_mez_on_cyano*          Grazing of meso-zooplankton on cyano
    max(0.0,min(1.0,cyano_with_totatmos_N))

    - respiration_cyano*             respiration of cyano bacteria
    max(0.0,min(1.0,cyano_with_totatmos_N))

    - mortality_cyano*               mortality of cyano bacteria
    max(0.0,min(1.0,cyano_with_totatmos_N))

```

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Tracer equations, continued from previous page

Change of: meso zooplankton; containing

$$\begin{aligned}
\frac{d}{dt} \text{mez_with_totatmos_N} = & \\
& + \text{grazing_mez_on_dia_totatmos_N} \quad \text{Grazing of meso-zooplankton on diatoms; sub-process for totatmos nitrogen} \\
& + \text{grazing_mez_on_flag_totatmos_N} \quad \text{Grazing of meso-zooplankton on flagellates; sub-process for totatmos nitrogen} \\
& + \text{grazing_mez_on_cyano_totatmos_process} \quad \text{Grazing of meso-zooplankton on cyano; sub-process for totatmos nitrogen} \\
& + \text{grazing_mez_on_miz_totatmos_N} \quad \text{Grazing of meso-zooplankton on micro-zooplankton; sub-process for totatmos nitrogen} \\
& - \text{respiration_mez*} \quad \text{respiration of meso-zooplankton} \\
& \text{max}(0.0, \text{min}(1.0, \text{mez_with_totatmos_N})) \\
& - \text{mortality_mez*} \quad \text{mortality of meso-zooplankton} \\
& \text{max}(0.0, \text{min}(1.0, \text{mez_with_totatmos_N}))
\end{aligned}$$

Change of: micro zooplakton; containing

$$\begin{aligned}
\frac{d}{dt} \text{miz_with_totatmos_N} = & \\
& + \text{grazing_miz_on_dia_totatmos_N} \quad \text{Grazing of micro-zooplankton on diatoms; sub-process for totatmos nitrogen} \\
& + \text{grazing_miz_on_flag_totatmos_N} \quad \text{Grazing of micro-zooplankton on flagellates; sub-process for totatmos nitrogen} \\
& + \text{grazing_miz_on_cyano_totatmos_process} \quad \text{Grazing of micro-zooplankton on cyano; sub-process for totatmos nitrogen} \\
& - \text{respiration_miz*} \quad \text{respiration of micro-zooplankton} \\
& \text{max}(0.0, \text{min}(1.0, \text{miz_with_totatmos_N})) \\
& - \text{mortality_miz*} \quad \text{mortality of micro-zooplankton} \\
& \text{max}(0.0, \text{min}(1.0, \text{miz_with_totatmos_N}))
\end{aligned}$$

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Tracer equations, continued from previous page

```
- grazing_mez_on_miz*      Grazing of meso-zooplankton on micro-
max(0.0,min(1.0,miz_with_totatzooplankton
))
```

Change of: Detritus; containing

```
 $\frac{d}{dt}$  det_with_totatmos_N =
+ mortality_miz_totatmos_N    mortality of micro-zooplankton; sub-process for
                                totatmos nitrogen

+ mortality_mez_totatmos_N    mortality of meso-zooplankton; sub-process for
                                totatmos nitrogen

+ mortality_dia_totatmos_N    mortality of diatoms; sub-process for totatmos
                                nitrogen

+ mortality_flag_totatmos_N   mortality of flagellates; sub-process for
                                totatmos nitrogen

+ mortality_cyano_totatmos_N  mortality of cyano bacteria; sub-process for
                                totatmos nitrogen

- recycling_detritus_to_n*    recycling of detritus
max(0.0,min(1.0,det_with_totat
))
```

Change of: ldon is the labile DON fraction; containing

```
 $\frac{d}{dt}$  ldon_with_totatmos_N =
+                                respiration of micro-zooplankton; sub-process
(respiration_miz_totatmos_N)* for totatmos nitrogen
(ldon_frac)

+                                respiration of meso-zooplankton; sub-process
(respiration_mez_totatmos_N)* for totatmos nitrogen
(ldon_frac)

+                                respiration of diatoms; sub-process for
(respiration_dia_totatmos_N)* totatmos nitrogen
(ldon_frac)

+                                respiration of flagelattes; sub-process for
(respiration_flag_totatmos_N) totatmos nitrogen
*(ldon_frac)
```

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Tracer equations, continued from previous page

```

+                                respiration of cyano bacteria; sub-process for
(respiration_cyano_totatmos_N)totatmos nitrogen
*(ldon_frac)

- degradation_ldon*            degradation of IDON
max(0.0,min(1.0,ldon_with_totatmos_N/m2/d
))

```

Change of: nitrogen in the sediment; containing

```

 $\frac{d}{dt}$  nitr_with_totatmos_N =
- mineralization_nitr_sed*      mineralization of bentic nitrogen, mmol
max(0.0,min(1.0,nitr_with_totatmos_N/m2/d
))

```

Change of: reduced nitrogen; containing

```

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

```

Change of: oxidized nitrogen; containing

```

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

```

Change of: ammonium; containing

```

 $\frac{d}{dt}$  amm_with_agri_N =
+                                mineralization of bentic nitrogen, mmol
mineralization_nitr_sed_agri_N/m2/d; sub-process for agri nitrogen
cgt_density)

+ (respiration_miz_agri_N)*      respiration of micro-zooplankton; sub-process
((one-ldon_frac))              for agri nitrogen

+ (respiration_mez_agri_N)*      respiration of meso-zooplankton; sub-process
((one-ldon_frac))              for agri nitrogen

+ (respiration_dia_agri_N)*      respiration of diatoms; sub-process for agri
((one-ldon_frac))              nitrogen

+ (respiration_flag_agri_N)*     respiration of flagelattes; sub-process for agri
((one-ldon_frac))              nitrogen

+ (respiration_cyano_agri_N)*    respiration of cyano bacteria; sub-process for
((one-ldon_frac))              agri nitrogen

+                                recycling of detritus; sub-process for agri
recycling_detritus_to_n_agri_N nitrogen

```

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Tracer equations, continued from previous page

```

+ degradation_ldon_agri_N      degradation of LDON; sub-process for agri
                                nitrogen

-                                nitrification
nitrification_amm_sed/(cgt_cel
cgt_density)*
max(0.0,min(1.0,amm_with_agri_
))

- uptake_amm_by_dia*           uptake of ammonium (, phosphate and silicate)
max(0.0,min(1.0,amm_with_agri_by diatoms
))

- uptake_amm_by_flag*          uptake of ammonium (and phosphate) by
max(0.0,min(1.0,amm_with_agri_flagellates
))

- nitrification*               nitrification
max(0.0,min(1.0,amm_with_agri_
))

```

Change of: nitrate; containing

```

 $\frac{d}{dt}$  nit_with_agri_N =
+ nitrification_agri_N          nitrification; sub-process for agri nitrogen

- (mineralization_nitr_sed)*    mineralization of benthic nitrogen, mmol
(ldn_N_sed)/(cgt_cellheight*   N/m2/d
cgt_density)*
max(0.0,min(1.0,nit_with_agri_
))

- uptake_nit_by_dia*            uptake of nitrate (, phosphate and silicate) by
max(0.0,min(1.0,nit_with_agri_diatoms
))

- uptake_nit_by_flat*           uptake of nitrate (and phosphate) by flagellates
max(0.0,min(1.0,nit_with_agri_
))

- (recycling_detritus_to_n)*    recycling of detritus
(ldn_N)*
max(0.0,min(1.0,nit_with_agri_
))

```

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Tracer equations, continued from previous page

Change of: diatoms; containing

$$\begin{aligned} \frac{d}{dt} \text{dia_with_agri_N} = & \\ & + \text{uptake_amm_by_dia_agri_N} \quad \text{uptake of ammonium (, phosphate and silicate) by diatoms; sub-process for agri nitrogen} \\ & + \text{uptake_nit_by_dia_agri_N} \quad \text{uptake of nitrate (, phosphate and silicate) by diatoms; sub-process for agri nitrogen} \\ & - \text{grazing_miz_on_dia*} \quad \text{Grazing of micro-zooplankton on diatoms} \\ & \quad \text{max(0.0,min(1.0,dia_with_agri_} \\ & \quad \text{))} \\ & - \text{grazing_mez_on_dia*} \quad \text{Grazing of meso-zooplankton on diatoms} \\ & \quad \text{max(0.0,min(1.0,dia_with_agri_} \\ & \quad \text{))} \\ & - \text{respiration_dia*} \quad \text{respiration of diatoms} \\ & \quad \text{max(0.0,min(1.0,dia_with_agri_} \\ & \quad \text{))} \\ & - \text{mortality_dia*} \quad \text{mortality of diatoms} \\ & \quad \text{max(0.0,min(1.0,dia_with_agri_} \\ & \quad \text{))} \end{aligned}$$

Change of: flagellates; containing

$$\begin{aligned} \frac{d}{dt} \text{flag_with_agri_N} = & \\ & + \text{uptake_amm_by_flag_agri_N} \quad \text{uptake of ammonium (and phosphate) by flagellates; sub-process for agri nitrogen} \\ & + \text{uptake_nit_by_flat_agri_N} \quad \text{uptake of nitrate (and phosphate) by flagellates; sub-process for agri nitrogen} \\ & - \text{grazing_miz_on_flag*} \quad \text{Grazing of micro-zooplankton on flagellates} \\ & \quad \text{max(0.0,min(1.0,flag_with_agri} \\ & \quad \text{))} \\ & - \text{grazing_mez_on_flag*} \quad \text{Grazing of meso-zooplankton on flagellates} \\ & \quad \text{max(0.0,min(1.0,flag_with_agri} \\ & \quad \text{))} \\ & - \text{respiration_flag*} \quad \text{respiration of flagelattes} \\ & \quad \text{max(0.0,min(1.0,flag_with_agri} \\ & \quad \text{))} \end{aligned}$$

continued on next page...

Tracer equations, continued from previous page

```

- mortality_flag*          mortality of flagellates
max(0.0,min(1.0,flag_with_agri
))

```

Change of: cyano bacteria; containing

$$\frac{d}{dt} \text{cyano_with_agri_N} =$$

```

- grazing_miz_on_cyano*      Grazing of micro-zooplankton on cyano
max(0.0,min(1.0,cyano_with_agr
))

- grazing_mez_on_cyano*      Grazing of meso-zooplankton on cyano
max(0.0,min(1.0,cyano_with_agr
))

- respiration_cyano*        respiration of cyano bacteria
max(0.0,min(1.0,cyano_with_agr
))

- mortality_cyano*          mortality of cyano bacteria
max(0.0,min(1.0,cyano_with_agr
))

```

Change of: meso zooplankton; containing

$$\frac{d}{dt} \text{mez_with_agri_N} =$$

```

+ grazing_mez_on_dia_agri_N  Grazing of meso-zooplankton on diatoms; sub-
                             process for agri nitrogen

+ grazing_mez_on_flag_agri_N Grazing of meso-zooplankton on flaggelates;
                             sub-process for agri nitrogen

+ grazing_mez_on_cyano_agri_N Grazing of meso-zooplankton on cyano; sub-
                             process for agri nitrogen

+ grazing_mez_on_miz_agri_N  Grazing of meso-zooplankton on micro-
                             zooplankton; sub-process for agri nitrogen

- respiration_mez*          respiration of meso-zooplankton
max(0.0,min(1.0,mez_with_agri_
))

- mortality_mez*            mortality of meso-zooplankton
max(0.0,min(1.0,mez_with_agri_
))

```

continued on next page...

Tracer equations, continued from previous page

Change of: micro zooplakton; containing

$$\begin{aligned}
\frac{d}{dt} \text{miz_with_agri_N} = & \\
& + \text{grazing_miz_on_dia_agri_N} \quad \text{Grazing of micro-zooplankton on diatoms; sub-} \\
& \quad \text{process for agri nitrogen} \\
& + \text{grazing_miz_on_flag_agri_N} \quad \text{Grazing of micro-zooplankton on flagellates; sub-} \\
& \quad \text{process for agri nitrogen} \\
& + \text{grazing_miz_on_cyano_agri_N} \quad \text{Grazing of micro-zooplankton on cyano; sub-} \\
& \quad \text{process for agri nitrogen} \\
& - \text{respiration_miz*} \quad \text{respiration of micro-zooplankton} \\
& \quad \text{max}(0.0, \text{min}(1.0, \text{miz_with_agri_} \\
& \quad \text{))} \\
& - \text{mortality_miz*} \quad \text{mortality of micro-zooplankton} \\
& \quad \text{max}(0.0, \text{min}(1.0, \text{miz_with_agri_} \\
& \quad \text{))} \\
& - \text{grazing_mez_on_miz*} \quad \text{Grazing of meso-zooplankton on micro-} \\
& \quad \text{max}(0.0, \text{min}(1.0, \text{miz_with_agri_zooplankton} \\
& \quad \text{))}
\end{aligned}$$

Change of: Detritus; containing

$$\begin{aligned}
\frac{d}{dt} \text{det_with_agri_N} = & \\
& + \text{mortality_miz_agri_N} \quad \text{mortality of micro-zooplankton; sub-process for} \\
& \quad \text{agri nitrogen} \\
& + \text{mortality_mez_agri_N} \quad \text{mortality of meso-zooplankton; sub-process for} \\
& \quad \text{agri nitrogen} \\
& + \text{mortality_dia_agri_N} \quad \text{mortality of diatoms; sub-process for agri} \\
& \quad \text{nitrogen} \\
& + \text{mortality_flag_agri_N} \quad \text{mortality of flagellates; sub-process for agri} \\
& \quad \text{nitrogen} \\
& + \text{mortality_cyano_agri_N} \quad \text{mortality of cyano bacteria; sub-process for} \\
& \quad \text{agri nitrogen} \\
& - \text{recycling_detritus_to_n*} \quad \text{recycling of detritus} \\
& \quad \text{max}(0.0, \text{min}(1.0, \text{det_with_agri_} \\
& \quad \text{))}
\end{aligned}$$

continued on next page...

Tracer equations, continued from previous page

Change of: ldon is the labile DON fraction; containing

$$\begin{aligned}
\frac{d}{dt} \text{ldon_with_agri_N} = & \\
& + (\text{respiration_miz_agri_N}) * (\text{ldon_frac}) \quad \text{respiration of micro-zooplankton; sub-process for agri nitrogen} \\
& + (\text{respiration_mez_agri_N}) * (\text{ldon_frac}) \quad \text{respiration of meso-zooplankton; sub-process for agri nitrogen} \\
& + (\text{respiration_dia_agri_N}) * (\text{ldon_frac}) \quad \text{respiration of diatoms; sub-process for agri nitrogen} \\
& + (\text{respiration_flag_agri_N}) * (\text{ldon_frac}) \quad \text{respiration of flagelattes; sub-process for agri nitrogen} \\
& + (\text{respiration_cyano_agri_N}) * (\text{ldon_frac}) \quad \text{respiration of cyano bacteria; sub-process for agri nitrogen} \\
& - \text{degradation_ldon} * \text{max}(0.0, \text{min}(1.0, \text{ldon_with_agri_N})) \quad \text{degradation of lDON}
\end{aligned}$$

Change of: nitr in the sediment; containing

$$\begin{aligned}
\frac{d}{dt} \text{nitr_with_agri_N} = & \\
& - \text{mineralization_nitr_sed} * \text{max}(0.0, \text{min}(1.0, \text{nitr_with_agri_N}/\text{m2}/\text{d})) \quad \text{mineralization of bentic nitrogen, mmol}
\end{aligned}$$

Change of: nred reduced nitrogen; containing

$$\frac{d}{dt} \text{nred_with_agri_N} =$$

Change of: nox oxidized nitrogen; containing

$$\frac{d}{dt} \text{nox_with_agri_N} =$$