# Organic carbon

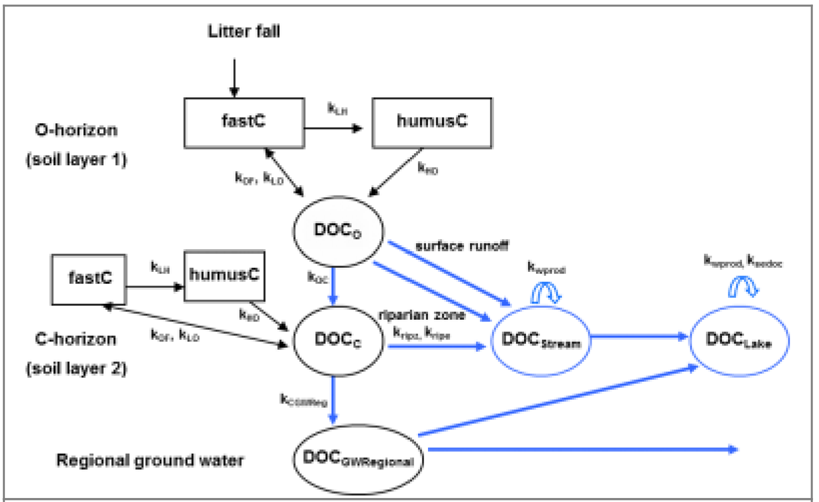


Figure 1: Schematic figure of the TOC-model.

## Source of organic material

Litter production leads to the production of organic material, which increases levels *fastC* in top two layers in soil. The organic carbon litter fall is determined by crop *resc* (*kg/ha/yr*) gives a daily supplement to the pool during the number of days determined by parameter litterdays.

### Links to relevantprocedures in the code

| Modules (file) | Procedures |
|---|---|
| npc_soil_processes (npc_soil_proc.f90) | soil_carbon_processes |

## Soil processes

### Soil pools – initial values

The initial pool size is dependent on land use and is determined by the user in the file par.txt. The parameters (*humusc1*, *humusc2*, *humusc3*, *fastc1*, *fastc2*, *fastc3*) give OC content of the three soil layers. The unit for these parameter values is *mg/m3*. With this information, the pools the size in the different layers are calculated. The model transforms pools into the unit *kg/km2* by taking into account the thickness in the layers.

### Common functions

Many soil processes depend on temperature and soil moisture. These use the same functions as for nitrogen and phosphorus. Organic carbon soil transformations (production of humusC from fastC, turnover of fastC, and turnover of humusC) use the soil moisture function with parameters given by the user instead of the coefficients described for nutrients. The coefficient thetalow is replaced by the land-use dependent parameter *ocsoilslp*, and the coefficient satact is replaced by land-use dependent parameter *ocsoilsat*.

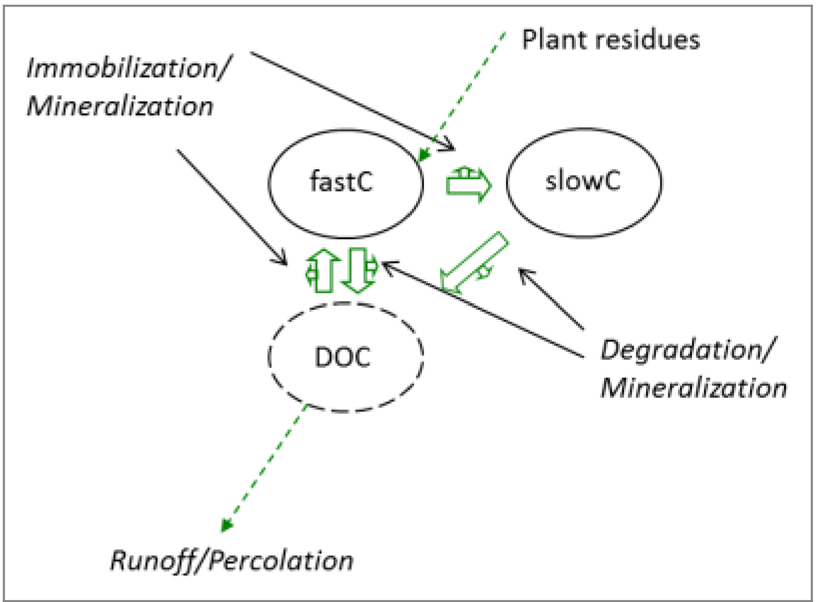


Figure 21: Organic carbon processes in soil.

### Production of humusC from fastC

Some of the litter fall (added to fastC) is converted into humus. This means that the model has a transformation of fastC to humusC in the uppermost soil layer.

In the other layers (*k*) is also a transition from fastC to humusC. The loss of fastC does not all go to humusC but a proportion (parameter *minc*) is mineralized. The transformation depends on soil moisture and temperature, amount of *fastC* and vegetation dependent parameter *klh*.

$$littertohumus\left(k\right)=klh\times tmpfcn\left(k\right)\times smfcn\left(k\right)\times fastC\left(k\right)$$

### Turnover of fastC

Turnover of fastC is a sink for fastC and a source of dissolved OC in soil water in all soil layers (*k* = 1-3). The loss of fastC does not all go to the OC, but a proportion (parameter *minc*) is mineralized. Turnover (*transfC*, *mg/m2/d*) depends on a general parameter (*klo*), the temperature function (*tempfcn*), humidity function (*smfcn*) and the pool of fastC (*fastC*).

$$transfC\left(k\right)=klo\times tempfcn\left(k\right)\times smfcn\left(k\right)\times fastC\left(k\right)$$

In dry conditions a flow in the opposite direction can also occur. The transformation of OC to fastC is a decrease of OC and a source of fastC in all soil layers (*k* = 1-3). The loss of OC is not all to fastC but a proportion (parameter *minc*) is mineralized. Turnover (*doctofast*, mg/m2/d) depends on a general parameter (*kof*) and the pool of OC (*OCpool*). The flow is limited that the soil layer temperature must be less than 5 °C, the soil moisture (*sm*) must be less than field capacity and moisture function (*smfcn*) must be less than the parameter *koflim*.

$$doctofast\left(k\right)=kof\times OCpool\left(k\right)$$

### Turnover of humusC

Turnover of humusC is a sink for humusC and a source of OC in all soil layers (k = 1.3). The loss of humusC does not all go to the DOC, but a proportion (parameter *minc*) is mineralized. Turnover (*transhC*, *mg/m2/d*) depends on a general parameter (*kho*), temperature function (*tempfcn*), humidity function (*smfcn*) and the pool of humusC (*humusC*).

$$transhC\left(k\right)=kho\times tempfcn\left(k\right)\times smfcn\left(k\right)\times humusC\left(k\right)$$

### Percolation

Organic carbon is lost from the soil water as it flows down through the soil layers and where it is dissipated to become a regional groundwater flow. The decrease in concentration depends on soil moisture and temperature and a calibration parameter.

$$conc=conc\times\left(1\text{-}par\times tmpfcn\times smfcn\right)$$

The soil moisture function and temperature function are the general functions described for soil processes. Percolation uses the coefficients for soil moisture function, not the parameters as the transformations. The parameter *par* in the equation is called *kcgwreg* for regional groundwater flow formation and *koc* for percolation between soil layers. Both are general parameters.

### Links to relevantprocedures in the code

| Modules (file) | Procedures | Section |
|---|---|---|
| npc_soil_processes (npc_soil_proc.f90) | initiate_soil_npc | initial values |
| | soil_carbon_processes | production of humusC from fastC, turnover |
| | soil_carbon_pool_transformations | |
| | doc_percolation_reduction | percolation |

# Riparian zone

Runoff from soil layers flows through a riparian zone before it reaches the local river. Surface runoff and drainage water from drainage pipes reaches the local river without passing through the riparian zone. In the riparian zone the levels of OC are affected, while flows remain unchanged. The change depends on soil temperature, class altitude (*elev* (in masl)), the water table (*gwat*) and its recent change, season and soil moisture (*sm*). The runoff concentration (*conc(i)*) of each soillayer (*k*) increases with the factor:

$$f\left(k\right)=1+ripz\Box tmpfcn\left(k\right)\Box\left(\frac{elev}{100}\right)\Box f_{grw}\Box f_{season}\Box f_{sm}$$

$$conc\left(k\right)=f\Box conc\left(k\right),\quad k=1..3$$

The temperature function (*tmpfcn*) is the usual of soil processes (see above). The following equations describe the other process functions:

$$f_{grw} = e^{ripe \cdot gwat}$$

$$f_{season} = \begin{cases} rips & autumn \\ 1 & otherwise \end{cases}$$

$$f_{sm} = \begin{cases} 0 & sm \le wp \\ f_2(sm) & wp < sm < wp \\ satact & sm \ge pw \end{cases}$$

$$f_2(sm) = \begin{cases} \min\left(1, satact + (1 - satact) \cdot \frac{pw - sm}{d \cdot \Theta_{upp}}, \frac{sm - wp}{d \cdot \Theta_{low}}\right) & rising\,grw \\ \min\left(1, satact + (1 - satact) \cdot \frac{pw - sm}{d \cdot \Theta_{upp}}, satact \cdot \frac{sm - wp}{d \cdot \Theta_{low}}\right) & sinking\,grw \end{cases}$$

Three general parameters can be changed; *ripz* which determines the overall level of increase in concentration in the riparian zone, *ripe* which determines the groundwater level dependence, and *rips* which determines the seasonal influence. Season division is determined by ten-day and twenty-day averages of air temperature (T10, T20). Autumn is defined as the period when T10 is less than T20. The soil moisture function is different for an increasing (rising) and sinking ground water table (figure 2). It contains coefficients $\Theta_{upp} = 0.12$ , $\Theta_{low} = 0.08$ and saturation (*satact* = 0.6). It depends on the soil moisture of all layers together (*sm*) and the water-holding capacity parameters; *wp* - wilting border and *pw* - total pore volume, in fractions of total soil layer thickness (*d*).

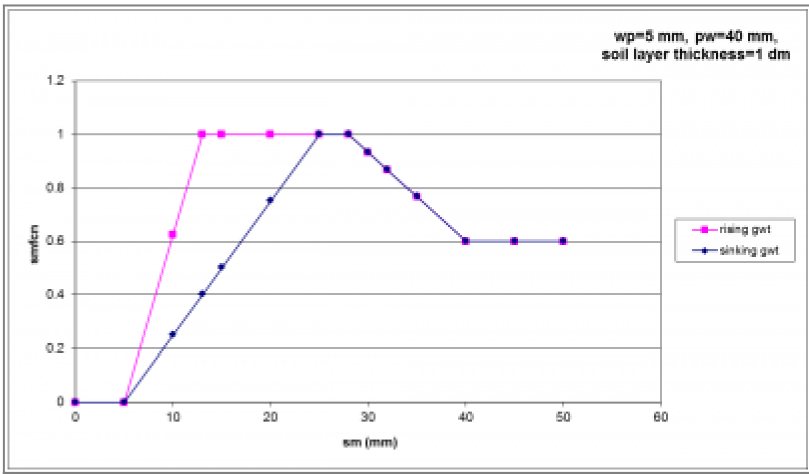


Figure 2: Example of riparian zone soil moisture function, and the dependence on changes in the groundwater levels.

## Links to relevantprocedures in the code

| Modules (file) | Procedures |
|---|---|
| npc_soil_processes (npc_soil_proc.f90) | class_riparian_zone_processes |
| | riparian_moisture_factor |

# Rivers and lakes

## Primary production and mineralization

Primary production is a source of organic carbon in rivers and lakes, while mineralization is a sink. Primary production and mineralization is calculated the same way as for nitrogen, but with its own calibration parameter (*wprodc*). The potential carbon transformation (*minprodCpot*, kg / day) is proportional to the potential nitrogen transformation (*minprodNpot*, see NP section) with a transformation rate that depends on the carbon-nitrogen ratio (*NCratio* = 5.7). The calculated mineralization of organic carbon is limited to a maximum of 50% of the available OC pool. The parameters that affect the process of organic carbon are the rate parameter *wprod* and the lake region dependent parameter *TPmean*. If phosphorus is not modelled a long-term average total phosphorus concentration as a lake region dependent parameter (*tpmean*) is used. If set, the long-term average concentration is reduced by the general parameter *limsedPP* before using it in the concentration function.

$$tmpfcn1 = \frac{watertemp}{20.}$$

$$tmpfcn2 = \frac{\left(T10 - T20\right)}{5.}$$

$$tmpfcn = tmpfcn1 \times tmpfcn2$$

$$TPfcn = \frac{\left(TPconc - limsedPP\right)}{\left(TPconc - limsedPP + halfsatTPwater\right)}$$

$$minprodNpot = wprodc \times TPfcn \times tmpfcn \times area$$

$$minprodCpot = minprodNpot \times NCratio$$

## Sedimentation

Sedimentation in lakes is a sink for OC and works the same way as for organic nitrogen and particulate phosphorus. Sedimentation (*sedOC*, *kg/day*) is calculated as a function of water concentration and lake area (*area*). The parameter *sedoc* is general or can be specified for each lake.

$$sedOC = sedoc \times waterconcOC \times area$$

## Links to relevant procedures in the code

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<tr><td>calculate_lake_tpmean</td></tr>
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