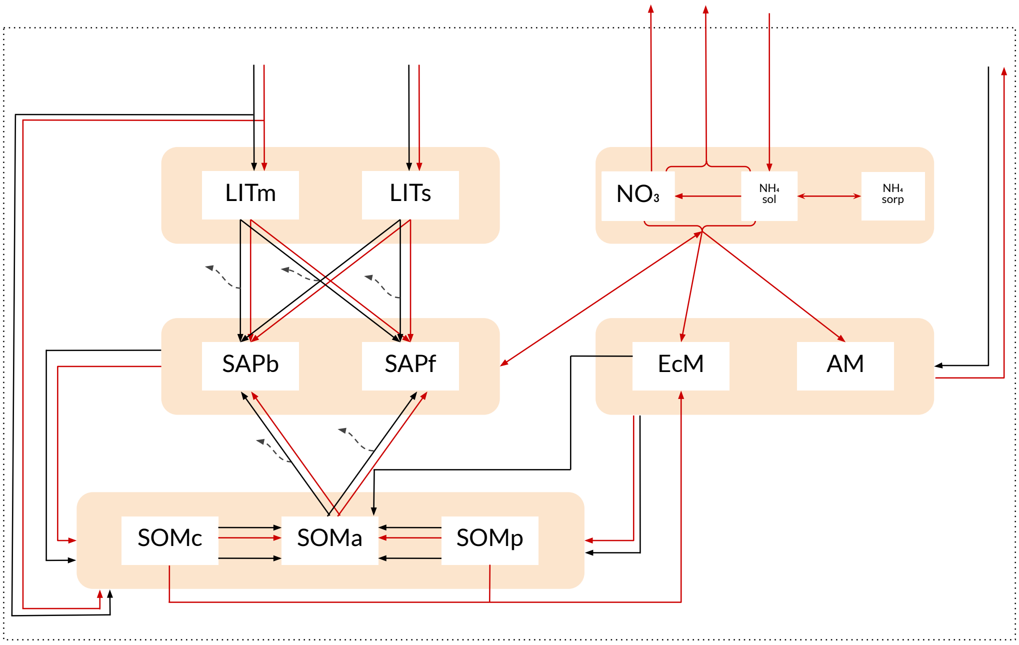


Figure 1: Schematic showing both C and N flows for each layer of the model. Black arrows indicate carbon fluxes ($gCm^{-3}h^{-1}$ while red arrows indicate nitrgen fluxes ($gNm^{-3}h^{-1}$)).

0.1 Model Description

The model is based on the MIMICS framework where microbial groups, litter and soil organic matter is represented as separate pools. The model needs litter production rates, photosynthetically derived C to mychorriza and N deposition as input. Simulations are run with an hourly timestep. Fig. 1 shows the model structure, Table 1 and Table 2 gives the change equations for each pool in the system.

0.1.1 Model Structure

The discretized vertical layers of the model follows the same structure as CLM [`https://escomp.github.io/ctsm-docs/versions/master/html/tech_note/Ecosystem/CLM50_Tech_Note_Ecosystem.html#vertical-discretization`]. During a timestep, the flows between the different pools within the layers area calculated first, then a diffusion equation determines transport between layers within pools. This section first describes the different pools and the flows between them, then the vertical transport. [CHANGE!]

Table 1: Change equations for the carbon pools in the model. These rates are calculated for each vertical layer (subscript dropped from equations for readability). Units for pool C_{pool}: gCm^{-3} and $FC_{donor,reciver}$: $gCm^{-3}h^{-1}$. Details about the fluxes are found in Table 3.

Eqn	Stores	Growth rates	Sources	Sinks
(a)	Metabolic litter	$dC_{LITm}/dt =$	$FC_{Veg,LITm}$	$-FC_{LITm,SAPb} - FC_{LITm,SAPf}$
(b)	Structural litter	$dC_{LITs}/dt =$	$FC_{Veg,LITs}$	$-FC_{LITs,SAPb} - FC_{LITs,SAPf}$
(c)	Saprotrophic bacteria	$dC_{SAPb}/dt =$	$CUE_b(FC_{LITm,SAPb} + FC_{LITs,SAPb} + FC_{SOMa,SAPb})$	$-FC_{SAPb,SOMp} - FC_{SAPb,SOMa} - FC_{SAPb,SOMc}$
(d)	Saprotrophic fungi	$dC_{SAPf}/dt =$	$CUE_f(FC_{LITm,SAPf} + FC_{LITs,SAPf} + FC_{SOMa,SAPf})$	$-FC_{SAPf,SOMp} - FC_{SAPf,SOMa} - FC_{SAPf,SOMc}$
(e)	Ectomycorrhiza biomass	$dC_{EcM}/dt =$	$CUE_m \cdot FC_{Veg,EcM}$	$-FC_{EcM,SOMp} - FC_{EcM,SOMa} - FC_{EcM,SOMc}$
				$-FC_{enzEcM,SOMa}$
(f)	Arbuscular mycorrhiza biomass	$dC_{AM}/dt =$	$CUE_m \cdot FC_{Veg,AM}$	$-FC_{AM,SOMp} - FC_{AM,SOMa} - FC_{AM,SOMc}$
(g)	Physically protected SOM	$dC_{SOMp}/dt =$	$FC_{Veg,SOMp} + FC_{SAPb,SOMp} + FC_{SAPf,SOMp}$	
			$+FC_{EcM,SOMp} + FC_{AM,SOMp}$	$-FC_{SOMp,SOMa} - FC_{EcMdecompSOMp}$
(h)	Chemically protected SOM	$dC_{SOMc}/dt =$	$FC_{Veg,SOMc} + FC_{SAPb,SOMc} + FC_{SAPf,SOMc}$	
			$+FC_{EcM,SOMc} + FC_{AM,SOMc}$	$-FC_{SOMc,SOMa} - FC_{EcMdecompSOMc}$
(i)	SOM available	$dC_{SOMa}/dt =$	$FC_{Veg,SOMa} + FC_{SAPb,SOMa} + FC_{SAPf,SOMa}$	
			$+FC_{EcM,SOMa} + FC_{AM,SOMa}$	
			$+FC_{SOMp,SOMa} + FC_{SOMc,SOMa} + FC_{enzEcM,SOMa}$	
			$+FC_{EcMdecompSOMc} + FC_{EcMdecompSOMp}$	$-FC_{SOMa,SAPb} - FC_{SOMa,SAPf}$
	Net Carbon change:	$dC/dt =$	$FC_{Veg,LITm} + FC_{Veg,LITs} + FC_{Veg,SOMp} + FC_{Veg,SOMc}$	
			$+FC_{Veg,SOMa} + CUE_m \cdot (FC_{Veg,EcM} + FC_{Veg,AM})$	$-(1 - CUE_b)(FC_{LITm,SAPb} + FC_{LITs,SAPb} + FC_{SOMa,SAPb})$
				$-(1 - CUE_f)(FC_{LITm,SAPf} + FC_{LITs,SAPf} + FC_{SOMa,SAPf})$

Table 2: Change equations for the nitrogen pools in the model. These rates are calculated for each vertical layer (subscript dropped from equations for readability). Units for pool N_{pool}: gNm^{-3} and $FN_{donor,reciver}$: $gNm^{-3}h^{-1}$. Details about the fluxes are found in Table 4.

Eqn	Stores	Growth rates	Sources	Sinks	Exchange
(j)	Metabolic litter	$dN_{LITm}/dt =$	$FN_{Veg,LITm}$	$-FN_{LITm,SAPb} - FN_{LITm,SAPf}$	
(k)	Structural litter	$dN_{LITs}/dt =$	$FN_{Veg,LITs}$	$-FN_{LITs,SAPb} - FN_{LITs,SAPf}$	
(l)	Saprotrophic bacteria	$dN_{SAPb}/dt =$	$NUE(FN_{LITm,SAPb} + FN_{LITs,SAPb} + FN_{SOMa,SAPb})$	$-FN_{SAPb,SOMp} - FN_{SAPb,SOMa} - FN_{SAPb,SOMc}$	$+FN_{IN,SAPb}$
(m)	Saprotrophic fungi	$dN_{SAPf}/dt =$	$NUE(FN_{LITm,SAPf} + FN_{LITs,SAPf} + FN_{SOMa,SAPf})$	$-FN_{SAPf,SOMp} - FN_{SAPf,SOMa} - FN_{SAPf,SOMc}$	$+FN_{IN,SAPf}$
(n)	Ectomycorrhiza	$dN_{EcM}/dt =$	$FN_{IN,EcM} + FN_{SOMp,EcM} + FN_{SOMc,EcM}$	$-FN_{EcM,SOMp} - FN_{EcM,SOMa} - FN_{EcM,SOMc}$	
				$-FN_{EcM,Veg}$	
(o)	Arbuscular mycorrhiza	$dN_{AM}/dt =$	$FN_{IN,AM}$	$-FN_{AM,SOMp} - FN_{AM,SOMa} - FN_{AM,SOMc}$	
				$-FN_{AM,Veg}$	
(p)	Physically protected SOM	$dN_{SOMp}/dt =$	$FN_{SAPb,SOMp} + FN_{SAPf,SOMp}$		
			$+FN_{EcM,SOMp} + FN_{AM,SOMp}$	$-FN_{SOMp,SOMa} - FN_{SOMp,EcM}$	
(q)	Chemically protected SOM	$dN_{SOMc}/dt =$	$FN_{SAPb,SOMc} + FN_{SAPf,SOMc}$		
			$+FN_{EcM,SOMc} + FN_{AM,SOMc}$	$-FN_{SOMc,SOMa} - FN_{SOMc,EcM}$	
(r)	SOM available	$dN_{SOMa}/dt =$	$FN_{SAPb,SOMa} + FN_{SAPf,SOMa}$		
			$+FN_{SOMp,SOMa} + FN_{SOMc,SOMa}$		
			$+FN_{EcM,SOMa} + FN_{AM,SOMa}$	$-FN_{SOMa,SAPb} - FN_{SOMa,SAPf}$	
(s)	Ammonium, solved	$dN_{NH4_{sol}}/dt =$	$DEP + (1 - NUE)(FN_{uptake,sap})^1$	$-f_{NH4}(FN_{IN,EcM} + FN_{IN,AM} + FN_{IN,Veg})$	$-f_{NH4}(FN_{IN,SAPb} + FN_{IN,SAPf})$
					$+FN_{sol,sorp}$
(t)	Ammonium, sorbed	$dN_{NH4_{sorp}}/dt =$			$-FN_{sol,sorp}$
(u)	Nitrate	$dN_{NO3}/dt =$	$NITRIF$	$-LEACH-$	
				$(1 - f_{NH4})(FN_{IN,EcM} + FN_{IN,AM} + FN_{IN,Veg})$	$-(1 - f_{NH4})(FN_{IN,SAPb} + FN_{IN,SAPf})$
	Net Nitrogen change:	$dN/dt =$	$DEP + FN_{Veg,LITm} + FN_{Veg,LITs}$	$-LEACH - FN_{IN,Veg} - FN_{EcM,Veg} - FN_{AM,Veg}$	

0.1.1.1 Vertical transport The user choose if the model should simulate the soil column as one unit, or to divide the column into discrete vertical layers. If you chose a vertical distribution, you can also chose how many layers the column is divided into. Each layer includes a set of the pools described above. Within time step the fluxes between the pools (the ones illustrated in Fig. 2a and 2b) are calculated and applied first, then the vertical transport is calculated and applied. This transport is calculated as a simple diffusion equation between adjacent layers. The algorithm used is based on Eq. 6.18 and 6.20 from Soetaert and Herman (2009).

0.1.1.2 Saprotrophs We separate between saprotrophic fungi and bacteria. Reverse Michaelis Menten kinetics determines the rates at which saprotrophs decomposes C in the two litter pools, and the available SOM, see Eq. C9-C14 in Table 3 and N9-N14 in Table 4. The N fluxes are determined by the C:N ratio of the substrate pools. A fraction of the decomposed C is directly removed from the system as heterotrophic respiration (HR). The respired fraction is determined by the Carbon Use Efficiencies for layer j, $CUE_{b,j}$ and $CUE_{f,j}$ which have maximum values of 0.5 [UPDATE], but can ble lower under low nutrient conditions (see below).

Only a fraction of the N released during decomposition is available to the saprotrophs, determined by what we call the saprotroph Nitrogen Use Efficiency (NUE). The other fraction (1-NUE) is directly converted to NH4. We use a constant value of NUE=0.7. The C:N ratio of the saprotrophs is assumed to be constant ($CN_b = 5$ and $CN_f = 8$, Table 5). To ensure that this ratio is fulfilled in each layer and timestep, N is exchanged between the saprotrophs and the inorganic pools, N37 and N38 in Table 4 and Fig. 2b. N37 and N38 can be positive or negative, depending on the N availability in the layer.

A first calculation of fluxes N37 and N38 gives the optimal exchange fluxes if enough N is available in the current layer and timestep. Here, the flux rates below is per layer, but subscript, j, is ommited for simplicity.

$$FN_{IN,SAPb} = N_{demand,b} - N_{uptake,b} \tag{1}$$

$$FN_{IN,SAPf} = N_{demand,f} - N_{uptake,f} \tag{2}$$

where, with x representing b (bacteria) or f (fungi)

$$N_{demand,x} = \frac{CUE_x \cdot (FC_{LITm,SAPx} + FC_{LITs,SAPx} + FC_{SOMa,SAPx})}{CN_x} \tag{3}$$

$$N_{uptake,x} = NUE \cdot (FN_{LITm,SAPx} + FN_{LITs,SAPx} + FN_{SOMa,SAPx}) \tag{4}$$

This results in one of four possibilities:

1. Both Eq. 1 and 2 are positive, meaning both groups will immobilize inorganic N. In this case we check if there is enough available inorganic N to fulfill the need from both pools. If there is enough N, the two equations, 1 and 2, will be used unchanged. If not; The CUE is reduced so that the saprotrophs utilize all N that is available to them:

$$CUE_b = \frac{(f_b \cdot N_{for\_sap} + N_{uptake,b} \cdot dt) \cdot CN_b}{(FC_{LITm,SAPb} + FC_{LITs,SAPb} + FC_{SOMa,SAPb}) \cdot dt} \tag{5}$$

$$CUE_f = \frac{((1 - f_b) \cdot N_{for\_sap} + N_{uptake,f} \cdot dt) \cdot CN_f}{(FC_{LITm,SAPf} + FC_{LITs,SAPf} + FC_{SOMa,SAPf}) \cdot dt} \tag{6}$$

   where f_b determines the division of the available inorganic N between bacteria and fungi, and is calculated as:

$$f_b = N_{INSAPb}/(N_{INSAPb} + N_{INSAPf}) \tag{7}$$

   This reduces the CUE enough to maintain the C:N ratios under the prevailing conditions, and the resulting exchange rates is:

$$FN_{IN,SAPb} = f_b \cdot N_{for\_sap} \tag{8}$$

$$FN_{IN,SAPf} = (1 - f_b) \cdot N_{for\_sap} \tag{9}$$

   where N_{for_sap} is inorganic N in the form of $NO3$ or $NH4$ in soil solution. [refer to inorganic N section for description of available inorganic N?]

2. Both N37 and N38 are negative, meaning both groups will mineralize inorganic N:

$$N_{IN,SAPx} = N_{demand,x} - N_{uptake,x} < 0$$

   The mineralized N will enter the [desorbed? er det riktig ord?] $NH4$ pool.

3. N37 is negative and N38 is positive. In this case bacteria can access the N mineralized by fungi if needed.

4. N37 is positive and N38 is negative . In this case fungi can access the N mineralized by bacteria if needed.

Saprotrophic necromass is transferred to the SOM pools, and is partitioned between the three pools based on clay content of the soil and metabolic fraction [som i MIMICS. Hvorfor brukes metabolic fraction her?](Eq. C20-C25 and N20-N25).

0.1.1.3 Mycorrhiza The model version used in this study represent two different mycorrhizal associations: Ectomycorrhiza (EcM) and arbuscular mycorrhiza (AM). The model is built to also facilitate ericoid mycorrhizal activity in the future. How the incoming carbon (Eq. C31 and C32) is partitioned between EcM and AM is determined dynamically through a Return Of Investment (ROI) function based on the method from (Sulman et al., 2019) [They also got it from someone, find source.]. The partition between EcM and AM is determined by

$$f_{alloc,j} = \frac{ROI_{i,j}}{ROI_{tot,j}} \tag{10}$$

where $ROI_{i,j}$ is the return of investment from mycorrhizal type i (EcM or AM) in soil layer j;

$$ROI_{i,j} = \frac{N_{aqired,i,j} \cdot \tau_i \epsilon_i}{C_{i,j}} \tag{11}$$

For EcM $N_{aquired,EcM,j} = N26 + N27 + N28$ while for AM $N_{AM,j} = N29$. τ_i is the turnover time of association i, while ϵ_i is the growth efficency for mycorrhizal association i. EcM can access N from the protected pools, SOMp and SOMc (mining for N). By releasing enzymes (modeled as a fraction, f_{enz}, of the incoming C going directly to SOMa, C30), EcM gets N via N16 and N17, and at the same time makes some C available, C16 and C17. EcM can also access inorganic N via N28. The arbuscular mycorrhiza can only take up N from the inorganic pools (N13). Mycorrhizal necromass enters the SOM pools with constant rates, C26-C34 and N26-N34.

0.1.1.4 Litter As in MIMICS (Wieder et al., 2015) and ORCHIDEE-SOM (Camino-Serrano et al., 2018), we separate between metabolic (labile) litter mainly originated from leafs and fine roots, and structural litter, including coarse woody debris. Incoming C and N to litter pools comes from CLM-BGC simulations, see Table 6. Matter is lost from the litter pools through saprotrophic decomposition.

0.1.1.5 SOM For soil organic matter, we follow the MIMICS approach (Wieder et al., 2015) with two SOM pools that are protected (physicochemically and chemically) from saprotrophic decomposition, and one pool that is available for decomposition. A small portion (5%) [CHANGE] of metabolic litter input goes directly to the SOM pools (C3-C5 and N3-N5).[Elin:] [What realistic process is this representing?] As in MIMICS, desorption and oxidation moves organic matter from physicochemically and chemically protected pools to the available pool (C12,C13,N12,N13). During ectomycorrhizal mining we assume that a fraction of C from enzyme production ends up in the available SOM pool

(C30). The mining process is expected to make protected C more available. This is represented by the rates C26 and C27 that moves a fraction of the liberated *Elin:* [(?)] carbon from a protected to an available state. It is assumed that all N from the mining process is utilized by ectomycorrhiza (N26 and N27).

0.1.1.6 Inorganic Nitrogen Inorganic N is divided between $NO3$ and $NH4$ in solution, and $NH4$ sorbed to soil particles. [Need more elaboration]. N from atmospheric deposition enters as $NH4$ in solution (similar to CLM) where it can undergo nitrification to $NO3$. Only $NO3$ is exposed to leaching. Leaching is based on the CLM algoritm, where it is calculated as a function of drainage. Both $NH4$ and $NO3$ can be taken up by mycorrhiza or directly by plant (since the model is decoupled, direct plant uptake is only a constant loss rate in the model for now). Within a time step, the different processes affecting inorganic N happens in a sequence: 1) Deposition and leaching 2) nitrification 3) N from decomposition 4) uptake by plant 5) uptake by mycorrhiza 6) exchange with saprotrophs (either immobilization or mineralization) 7) Sorption-desorption algorithm. [refer to relevant sections]

Elin: [En del av det nitrogenet sap "mister" under dekomponeringen vil de få tilgang til senere i tidsskrittet? Er det ok?]

0.1.2 Parameterizations

Rate equations are given in Table 3 and 4, and a list of all parameters is found in Table 5.

0.1.2.1 Reverse Michaelis Menten Kinetics (Y. P. Wang et al., 2016),(G. Wang et al., 2013),(German et al., 2012),(Moorhead & Weintraub, 2018),(Y. P. Wang et al., 2014)

0.1.2.2 Moisture function Some of the flows are modified by a moisture function, the same that is used for MIMICS in the testbed (KILDE):

$$r_{moist} = \left(0.05, P \cdot \left(\frac{\Theta_{liq}}{\Theta_{sat}}\right)^3 \cdot \left(1 - \frac{\Theta_{liq}}{\Theta_{sat}} - \frac{\Theta_{frozen}}{\Theta_{sat}}\right)^{gas\_diff}\right) \tag{12}$$

Where Θ_{liq} and Θ_{frozen} are respectivley, the liquid and frozen soil water content. Θ_{sat} is volumetric soil moisture at saturation, $P = 44.247$ is a scalar that normalizes the function so that its maximum value is 1.0 and the gas diffusion is $gas\_diff = 2.5$. [setning om hva funksjonen representerer]

0.1.2.3 Input modifier To ensure that the most efficient mining happens when the influx of C to mycorrhiza is largest, and to avoid that ectomycorrhiza provides "free" N to the plant during winter when $I_{veg,Myc} = 0$ we introduced a function that modifies the mining rates.

$$r_{input} = \frac{I_{veg,Myc}(t)}{max(I_{veg,Myc})} \tag{13}$$

Here, $I_{veg,Myc}(t)$ (units $gCm^{-2}hr{-}1$) is the amount of C the vegetation will use on mycorrhizal N uptake in that timestep, and $max(I_{veg,Myc})$ is the maximum value of $I_{veg,Myc}$ in the current year.

0.1.2.4 Sorption-desorption algorithm After the "flux sequence" for inorganic N is calculated, the new total $NH4$ value is

$$NH4_{tot} = NH4_{sorp} + NH4_{sol} \tag{14}$$

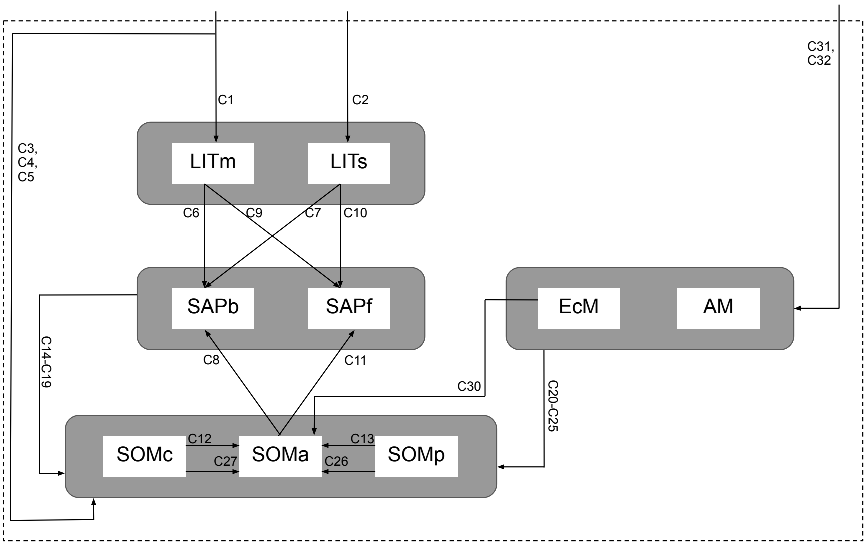
By solving Eq. 14 together with the Langmuir isotherm equation, we find the equilibrium partition between $NH4_{sol}$ and $NH4_{sorp}$ given the total amount $NH4_{tot}$. The Langmuir isotherm equation is given by

$$NH4_{sorp,eq} = \frac{NH4_{sorp,max} \cdot K'_L \cdot NH4_{sol,eq}}{1 + K'_L \cdot NH4_{sol,eq}} \tag{15}$$

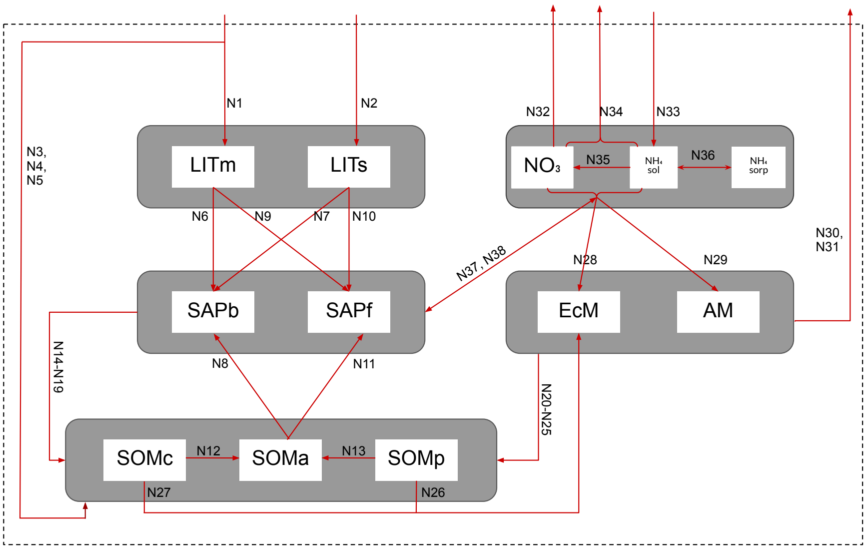
where K'_L is a Langmuir constant related to adsorption energy, and a function of water content [How to describe this, it cant be a constant and a function of water content at the same time..], and $NH4_{sorp,max}$ is the maximum adsorption capacity. We assume that the system moves towards the equilibrium value during the timestep, via the following mechanism:

$$NH4_{sorp} = \begin{cases} NH4_{sorp,eq} - \frac{1}{\frac{1}{NH4_{sorp,eq} - NH4_{sorp,prev.}} + k \cdot dt} & \text{if } NH4_{sorp,eq} > NH4_{sorp,prev.}, \\ NH4_{sorp,eq} + \frac{1}{\frac{1}{NH4_{sorp,prev.} - NH4_{sorp,eq}} + k \cdot dt} & \text{if } NH4_{sorp,eq} < NH4_{sorp,prev.}, \\ NH4_{sorp,prev.} & \text{if } NH4_{sorp,eq} = NH4_{sorp,prev.} \end{cases} \tag{16}$$

Here k is a rate constant and dt is the size of the timestep. The top option corresponds to absorption, the middle option to desorption and the third if equilibrium is already reached.



(a) Schematic of carbon pools and flows for each layer in the model. The numbers indicated correspond to the expressions in Table 3.



(b) Schematic of nitrogen pools and flows for each layer in the model. The numbers indicated correspond to the expressions in Table 4 in the Appendix.

Figure 2: Illustration of the total system of pools and fluxes in the system, 2a shows the C flows while 2b show the N flows.

Table 3: Details about C fluxes in the model. The flux numbers corresponds to the arrows in Fig. 2a. The equation letters in the last column ma with those given in Table 1. All $FC_{donor,reciver}$ has units $gCm^{-3}h^{-1}$. Parameters are described in Table 5.

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
C1	LITm production	$FC_{Veg,LITm} =$	$f_{met} \cdot I_C \cdot (1 - f_{met,SOM})$	(a)	
C2	LITs production	$FC_{Veg,LITs} =$	$(1 - f_{met})I_C + CWD_C$	(b)	
C3	Met. Lit to SOMp	$FC_{Veg,SOMp} =$	$f_{met} \cdot I_C \cdot f_{met,SOM} \cdot f_{SOMp}$	(g)	
C4	Met. Lit to SOMc	$FC_{Veg,SOMc} =$	$f_{met} \cdot I_C \cdot f_{met,SOM} \cdot f_{SOMc}$	(h)	
C5	Met. Lit to SOMa	$FC_{Veg,SOMa} =$	$f_{met} \cdot I_C \cdot f_{met,SOM} \cdot f_{SOMa}$	(i)	
	SAPb decomposition of:				
C6	LITm to SAPb	$FC_{LITm,SAPb} =$	$C_{SAPb} \cdot V_{max1} \frac{C_{LITm}}{K_{m1}+C_{LIT_m}}$	(a)(c)	Forward MMK
C7	LITs to SAPb	$FC_{LITs,SAPb} =$	$C_{SAPb} \cdot V_{max2} \frac{C_{LITs}}{K_{m2}+C_{LIT_s}}$	(b)(c)	Forward MMK
C8	SOMa to SAPb	$FC_{SOMa,SAPb} =$	$C_{SAPb} \cdot V_{max3} \frac{C_{SOMa}}{K_{m3}+C_{SOM_a}}$	(i)(c)	Forward MMK
	SAPf decomposition of:				
C9	LITm to SAPf	$FC_{LITm,SAPf} =$	$C_{SAPf} \cdot V_{max4} \frac{C_{LITm}}{K_{m4}+C_{LIT_m}}$	(a)(d)	Forward MMK
C10	LITs to SAPf	$FC_{LITs,SAPf} =$	$C_{SAPf} \cdot V_{max5} \frac{C_{LITs}}{K_{m5}+C_{LIT_s}}$	(b)(d)	Forward MMK
C11	SOMa to SAPf	$FC_{SOMa,SAPf} =$	$C_{SAPf} \cdot V_{max6} \frac{C_{SOMa}}{K_{m6}+C_{SOMa}}$	(i)(d)	Forward MMK
	Desorption and oxidation:				
C12	Oxidation from SOMc to SOMa	$FC_{SOMc,SOMa} =$	$\frac{C_{SAPf} \cdot V_{max2} \cdot C_{SOMc}}{KO \cdot K_{m2}+C_{SOMc}} + \frac{C_{SAPb} \cdot V_{max5} \cdot C_{SOMc}}{KO \cdot K_{m5}+C_{SOMc}}$	(h)(i)	As in MIMICS

Table 3 – Continued from previous page

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
C13	Desorption from SOMp to SOMa	$FC_{SOMp,SOMa} =$	$C_{SOMp} \cdot desorb$	(g)(i)	As in MIMICS
	Saprotrophic bacteria necromass to:				
C14	SOMp	$FC_{SAPb,SOMp} =$	$C_{SAPb} \cdot k_{SAPb,som} \cdot f_{SAPb,SOMp}$	(c)(g)	
C15	SOMc	$FC_{SAPb,SOMc} =$	$C_{SAPb} \cdot k_{SAPb,som} \cdot f_{SAPb,SOMc}$	(c)(h)	
C16	SOMa	$FC_{SAPb,SOMa} =$	$C_{SAPb} \cdot k_{SAPb,som} \cdot f_{SAPb,SOMa}$	(c)(i)	
	Saprotrophic fungi necromass to:				
C17	SOMp	$FC_{SAPf,SOMp} =$	$C_{SAPf} \cdot k_{SAPf,som} \cdot f_{SAPf,SOMp}$	(d)(g)	
C18	SOMc	$FC_{SAPf,SOMc} =$	$C_{SAPf} \cdot k_{SAPf,som} \cdot f_{SAPf,SOMc}$	(d)(h)	
C19	SOMa	$FC_{SAPf,SOMa} =$	$C_{SAPf} \cdot k_{SAPf,som} \cdot f_{SAPf,SOMa}$	(d)(i)	
	Ectomycorrizal necromass to:				
C20	SOMp	$FC_{EcM,SOMp} =$	$C_{EcM} \cdot k_{EcM,som} \cdot f_{EcM,SOMp}$	(e)(g)	
C21	SOMc	$FC_{EcM,SOMc} =$	$C_{EcM} \cdot k_{EcM,som} \cdot f_{EcM,SOMc}$	(e)(h)	
C22	SOMa	$FC_{EcM,SOMa} =$	$C_{EcM} \cdot k_{EcM,som} \cdot f_{EcM,SOMa}$	(e)(i)	
	Arbuscular mycorrizal necromass to:				
C23	SOMp	$FC_{AM,SOMp} =$	$C_{AM} \cdot k_{AM,som} \cdot f_{AM,SOMp}$	(f)(g)	
C24	SOMc	$FC_{AM,SOMc} =$	$C_{AM} \cdot k_{AM,som} \cdot f_{AM,SOMc}$	(f)(h)	
C25	SOMa	$FC_{AM,SOMa} =$	$C_{AM} \cdot k_{AM,som} \cdot f_{AM,SOMa}$	(f)(i)	

Table 3 – Continued from previous page

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
	<u>Mycorrhiza related fluxes:</u>				
C26	C made available by mining	$FC_{EcMdecompSOMp} =$	$K_{MO} \cdot H \cdot C_{EcM} \cdot C_{SOMp} \cdot r_{input}$	(g)(i)	Baskaran + mining term
C27	C made available by mining	$FC_{EcMdecompSOMc} =$	$K_{MO} \cdot H \cdot C_{EcM} \cdot C_{SOMc} \cdot r_{input}$	(h)(i)	Baskaran + mining term
C28	EcM enzyme production	$FC_{enzEcM,SOMa} =$	$f_{enz} \cdot CUE_m \cdot FC_{Veg,EcM}$	(e)(i)	Fraction of input goes directly to enzyn
C29	EcM	$FC_{Veg,EcM} =$	$f_{EcM} \cdot I_{veg,Myc}$	(e)	
C30	AM	$FC_{Veg,AM} =$	$(1 - f_{EcM}) \cdot I_{veg,Myc}$	(f)	

Table 4: Details about N fluxes in the model. The flux numbers corresponds to the arrows in Fig. 2b. The equations in the last column matches with those given in Table 2. Parameters are described in Table 5.

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
	Litter input				
N1	LITm production	$FN_{Veg,LITm} =$	$f_{met} \cdot I_N$	(j)	
N2	LITs production	$FN_{Veg,LITm} =$	$(1 - f_{met}) \cdot I_N + CWD_N$	(k)	
N3	Met. Lit to SOMp	$FN_{Veg,SOMp} =$	$f_{met} \cdot I_N \cdot f_{met,SOM} \cdot f_{SOMp}$	(g)	
N4	Met. Lit to SOMc	$FN_{Veg,SOMc} =$	$f_{met} \cdot I_N \cdot f_{met,SOM} \cdot f_{SOMc}$	(h)	
N5	Met. Lit to SOMa	$FN_{Veg,SOMa} =$	$f_{met} \cdot I_N \cdot f_{met,SOM} \cdot f_{SOMa}$	(i)	
	SAPb decomposition of:				
N6	LITm	$FN_{LITm,SAPb} =$	$FC_{LITm,SAPb} \cdot \left(\frac{N_{LITm}}{C_{LITm}}\right)$	(j)(l)	as in MIMICS
N7	LITs	$FN_{LITs,SAPb} =$	$FC_{LITs,SAPb} \cdot \left(\frac{N_{LITs}}{C_{LITs}}\right)$	(k)(l)	as in MIMICS
N8	SOMa	$FN_{SOMa,SAPb} =$	$FC_{SOMa,SAPb} \cdot \left(\frac{N_{SOMa}}{C_{SOMa}}\right)$	(r)(l)	as in MIMICS
	SAPf decomposition of:				
N9	LITm	$FN_{LITm,SAPf} =$	$FC_{LITm,SAPf} \cdot \left(\frac{N_{LITm}}{C_{LITm}}\right)$	(j)(m)	as in MIMICS
N10	LITs	$FN_{LITs,SAPf} =$	$FC_{LITs,SAPf} \cdot \left(\frac{N_{LITs}}{C_{LITs}}\right)$	(k)(m)	as in MIMICS
N11	SOMa	$FN_{SOMa,SAPf} =$	$FC_{SOMa,SAPf} \cdot \left(\frac{N_{SOMa}}{C_{SOMa}}\right)$	(r)(m)	as in MIMICS

Continued o

Table 4 – Continued from previous page

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
	Desorption and oxidation:				
N12	Oxidation	$FN_{SOMc,SOMa} =$	$FC_{SOMc,SOMa} \cdot \left(\frac{N_{SOMc}}{C_{SOMc}}\right)$	(q)(r)	
N13	Desorption	$FN_{SOMp,SOMa} =$	$FC_{SOMp,SOMa} \cdot \left(\frac{N_{SOMp}}{C_{SOMp}}\right)$	(p)(r)	
	Saprotrophic bacteria necromass to:				
N14	SOMp	$FN_{SAPb,SOMp} =$	$FC_{SAPb,SOMp} \cdot \left(\frac{N_{SAPb}}{C_{SAPb}}\right)$	(l)(p)	
N15	SOMc	$FN_{SAPb,SOMc} =$	$FC_{SAPb,SOMc} \cdot \left(\frac{N_{SAPb}}{C_{SAPb}}\right)$	(l)(q)	
N16	SOMa	$FN_{SAPb,SOMa} =$	$FC_{SAPb,SOMa} \cdot \left(\frac{N_{SAPb}}{C_{SAPb}}\right)$	(l)(r)	
	Saprotrophic fungi necromass to:				
N17	SOMp	$FN_{SAPf,SOMp} =$	$FC_{SAPf,SOMp} \cdot \left(\frac{N_{SAPf}}{C_{SAPf}}\right)$	(m)(p)	
N18	SOMc	$FN_{SAPf,SOMc} =$	$FC_{SAPf,SOMc} \cdot \left(\frac{N_{SAPf}}{C_{SAPf}}\right)$	(m)(q)	
N19	SOMa	$FN_{SAPf,SOMa} =$	$FC_{SAPf,SOMa} \cdot \left(\frac{N_{SAPf}}{C_{SAPf}}\right)$	(m)(r)	
	Ectomycorrhizal necromass to:				
N20	SOMp	$FN_{EcM,SOMp} =$	$FC_{EcM,SOMp} \cdot \left(\frac{N_{EcM}}{C_{EcM}}\right)$	(n)(p)	
N21	SOMc	$FN_{EcM,SOMc} =$	$FC_{EcM,SOMc} \cdot \left(\frac{N_{EcM}}{C_{EcM}}\right)$	(n)(q)	
N22	SOMa	$FN_{EcM,SOMa} =$	$FC_{EcM,SOMa} \cdot \left(\frac{N_{EcM}}{C_{EcM}}\right)$	(n)(r)	
	Arbuscular mycorrhizal necromass to:				
N23	SOMp	$FN_{AM,SOMp} =$	$FC_{AM,SOMp} \cdot \left(\frac{N_{AM}}{C_{AM}}\right)$	(o)(p)	

Continued o

Table 4 – Continued from previous page

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
N24	SOMc	$FN_{AM,SOMc} =$	$FC_{AM,SOMc} \cdot \left(\frac{N_{AM}}{C_{AM}}\right)$	(o)(q)	
N25	SOMa	$FN_{AM,SOMa} =$	$FC_{AM,SOMa} \cdot \left(\frac{N_{AM}}{C_{AM}}\right)$	(o)(r)	
	Mycorrhiza related fluxes:				
N26	N aquired from SOMp	$FN_{SOMp,EcM} =$	$FC_{EcMdecompSOMp} \cdot \left(\frac{N_{SOMp}}{C_{SOMp}}\right)$	(g)(e)	
N27	N aquired from SOMc	$FN_{SOMc,EcM} =$	$FC_{EcMdecompSOMc} \cdot \left(\frac{N_{SOMc}}{C_{SOMc}}\right)$	(h)(e)	
N28	N from inorganic to EcM	$FN_{IN,EcM} =$	$V_{max,EcM} \cdot N_{IN} \cdot \left(\frac{C_{EcM}}{(C_{EcM}+K_{m,EcM}/H)}\right)$	(s)(u)(n)	Based on Baskaran
N29	N from inorganic to AM	$FN_{IN,AM} =$	$V_{max,AM} \cdot N_{IN} \cdot \left(\frac{C_{AM}}{(C_{AM}+K_{m,AM}/H)}\right)$	(s)(u)(o)	
	N from myc. fungi to plant:				
N30	EcM	$FN_{EcM,Veg} =$	$FN_{IN,EcM} + FN_{SOMc,EcM} + FN_{SOMp,EcM}$	(n)	
			$-CUE_m \cdot FC_{Veg,EcM}/CN_m$		
			If positive, otherwise zero.		
N31	AM	$FN_{AM,Veg} =$	$FN_{IN,AM} - CUE_m \cdot FC_{Veg,AM} \cdot \left(\frac{N_{AM}}{C_{AM}}\right)$	(o)	
			If positive, otherwise zero.		
	Inorganic N related:				
N32	Leaching	$LEACH =$	$N_{NO3} \cdot \frac{QDRAI}{H_2O_{tot}}$	(u)	Based on CTSM doc. ch
N32	Deposition	$DEP =$	$NDEP\_TO\_SMINN \cdot NDEP\_PROF_j$	(s)	
N34	Direct plant uptake	$FN_{Inorg,Veg} =$	$(N_{NH4} + N_{NO3})k_{uptake}$	(s)(u)	

Continued o

Table 4 – Continued from previous page

Eq.	Description	Flux Name	Rate functions	Used in eqn	Notes
N35	Nitrification	$FN_{NH4,NO3} =$	$NH4 \cdot k_{nitr}$	(s)(u)	based on CTSM doc. cha
N36	Equil. kinetics NH4	$FN_{sol,sorp} =$			
Exchange of N between saprotrophic pools and inorg. N[c0]:					
	Here $U_{S*} = FC_{LITm,SAP*} + FC_{LITs,SAP*} + FC_{SOMa,SAP*}$, * is B or F.				
N36	SAPb	$FN_{IN,SAPb} =$	$(1 - NUE) \cdot (FN_{LITm,SAPb} + FN_{LITs,SAPb} + FN_{SOMa,SAPb})$		
			$-CUE_b \cdot U_{SB}/CN_b$	(l)(u)(s)	
		or =	$f_b \cdot N_{for\_sap}$ if limited N		
N37	SAPf	$FN_{IN,SAPf} =$	$(1 - NUE) \cdot (FN_{LITm,SAPf} + FN_{LITs,SAPf} + FN_{SOMa,SAPf})$		
			$-CUE_f \cdot U_{SF}/CN_f$	(m)(u)(s)	
		or =	$(1 - f_b) \cdot N_{for\_sap}$ if limited N		

[2]See text for details of the N exchange between saprotrophs and the inorganic pool.

[for mycorrizal turnover rates, Baskaran refers to Edblad 2013, which gives 0.1/year?]

Table 5: Description of parameters and other relevant sizes used in the model.

Parameter	Description	Value	Units	Notes
f_{MET}	Metabolic fraction of plant litter	0.0-1.0	-	(Wieder et al.
f_{CLAY}	Clay fraction in soil	0.0-1.0	-	
T	Soil temperature	-	$^{\circ}C$	Constant or v
r_{moist}	Moisture function	0.05-1.0	-	As in MIMICS
Michaelis Menten kinetics parameters for saprotrophs:				(Wieder et al.
V_{max}	Max reaction velocity	$exp(V_{slope} \cdot T + V_{int}) \cdot a_V \cdot V_{mod} \cdot r_{moist}$	$mg(mg)^{-1}h^{-1}$	
K_m	Half saturation constant	$exp(K_{slope} \cdot T + K_{int}) \cdot a_K \cdot K_{mod}$	$mgCcm^{-3}$	
K_{slope}	Regression coefficient	0.017	$ln(mgCcm^{-3})^{\circ}C^{-1}$	For all 6 fluxe
V_{slope}	Regression coefficient	0.63	$ln(mg(mg)^{-1}h^{-1})^{\circ}C^{-1}$	For all 6 fluxe
K_{int}	Regression intercept	3.19	$ln(mgCcm^{-3})$	Directly (Wie
V_{int}	Regression intercept	5.47	$ln(mg(mg)^{-1}h^{-1})$	Directly (Wie
a_K	Tuning coefficient	10^4	-	
a_V	Tuning coefficient	$8 \cdot 10^{-6}$	-	
P_{scalar}	Physical protection scalar used in K_{mod}	$1/(2.0 \cdot exp(-2\sqrt{f_{CLAY}}))$	-	range: 0.5-3.7
K_{mod}	Modifies K_m	$0.125, 0.5, 0.25 \cdot P_{scalar}, 0.5, 0.25, 0.167 \cdot P_{scalar}$	-	for LITm, LIT

Table 5 – Continued from previous page

Parameter	Description	Value	Units	Notes
V_{mod}	Modifies V_{max}	$10.0, 2.0, 10.0, 3.0, 3.0, 2.0$	-	for LITm, LIT
KO	Increase Km in eq. C19	4	-	Directly (Wie
$k_{myc,som}$	Turnover rate	$1.14 \cdot 10^{-4}$	h^{-1}	1/year as (Sul
$k_{SAPb,som}$	Turnover rate of SAPb	$5 \cdot 10^{-4} \cdot exp(0.3 \cdot f_{MET}) \cdot r_{moist}$	h^{-1}	Equiv. of τ in
$k_{SAPf,som}$	Turnover rate of SAPf	$5 \cdot 10^{-4} \cdot exp(0.1 \cdot f_{MET}) \cdot r_{moist}$	h^{-1}	Equiv. of τ in
$desorb$	desorption rate	$1.5 \cdot 10^{-5} \cdot exp(-1.5 \cdot f_{clay})$	h^{-1}	(Wieder et al.
K_{MO}	Mycorrhizal decay rate constant for oxidizable store	$3.42 \cdot 10^{-7}$ or $3.42 \cdot 10^{-8}$	$m^2/(gC \cdot hr)$	(Baskaran et a
$V_{max,myc}$	Max. ectomycorrhizal uptake of inorg N	$2.05 \cdot 10^{-4}$	$g/(g \cdot hr)$	(Baskaran et a
$K_{m,myc}$	Half saturation constant of ectomycorrhizal uptake of inorg N	0.08	gN/m^2	(Baskaran et a
CUE_{EcM}	Growth efficiency of mycorrhiza	0.25	-	(Baskaran et a
CUE_{AM}	Growth efficiency of mycorrhiza	0.25	-	(Baskaran et a
CUE_b	Growth efficiency of sap. bacteria	0.0-0.5	-	Determined by
CUE_f	Growth efficiency of sap. fungi	0.0-0.5	-	Determined by
NUE	Nitrogen use efficiency of saprotrophs	0.7	-	Elin: [Need justif
f_{SOMp}	Fraction of sap. or input into SOMp	$0.3 \cdot exp(fCLAY)$	-	SAPb, input
		$0.2 \cdot exp(0.8 \cdot fCLAY)$	-	SAPf

Table 5 – Continued from previous page

Parameter	Description	Value	Units	Notes
f_{SOMc}	Fraction of sap. or input into SOMc	$0.1 \cdot exp(-3 \cdot fCLAY)$	-	SAPb, input
		$0.3 \cdot exp(-3 \cdot fCLAY)$	-	SAPf
f_{SOMa}	Fraction of sap. or input into SOMa	$1-(f_{SOMp}+f_{SOMc})$	-	
$f_{m,s}$	Fraction of mycorrhizal pool m to SOM pool s	0.2-0.4	-	Assumed
f_{enz}	Fraction of EcM C uptake used for enzyme prod.	0.10	-	Assumed
f_{use}	Fraction C released by mining taken up by EcM.	0.10	-	Assumed
$f_{met,SOM}$	Fraction of metabolic litter prod. going directly to SOM	0.05	-	As in (Wieder
H	Soil depth (column height)		m	Depth of activ
I_C, I_N	Litter and fine root C and N input	$FROOT*\_TO\_LIT \cdot froot\_prof+$		
		$LEAF*\_TO\_LIT \cdot litter\_prof$	$g*/m3h$	*: C or N
CWD_C,	Coarse woody debris C and N input	CWD*_TO_LITR2, CWD*_TO_LITR3	$g*/m3h$	*: C or N
CWD_N				
D	Diffusion coefficient	$1.14e^{-8}$	$m2/h$	1cm2/yr, (Ko
CN_b	Optimal CN ratio for bacteria	5	-	(Tang et al., 2
CN_f	Optimal CN ratio for sap. fungi	8	-	(Tang et al., 2
CN_m	Optimal CN ratio for mycorrhizal fungi	20	-	(Baskaran et a

Table 6

CLM-BGC variable	Units	Long name	Notes
LEAFC_TO_LITTER	$gCm^{-2}s^{-1}$	leaf C litterfall	Partitioned between the two litter pools based on f_{MET}.
FROOTC_TO_LITTER	$gCm^{-2}s^{-1}$	fine root C litterfall	Partitioned between the two litter pools based on f_{MET}
CWDC_TO_LITR2C_vr	$gCm^{-3}s^{-1}$	decomp. of coarse woody debris C to litter 2 C	Input to structural litter (LITs)
CWDC_TO_LITR3C_vr	$gCm^{-3}s^{-1}$	decomp. of coarse woody debris C to litter 3 C	Input to structural litter (LITs)
LEAFN_TO_LITTER	$gNm^{-2}s^{-1}$	leaf N litterfall	Partitioned between the two litter pools based on f_{MET}
FROOTN_TO_LITTER	$gNm^{-2}s^{-1}$	fine root N litterfall	Partitioned between the two litter pools based on f_{MET}
CWDN_TO_LITR2N_vr	$gNm^{-3}s^{-1}$	decomp. of coarse woody debris N to litter 2 N	Input to structural litter (LITs)
CWDN_TO_LITR3N_vr	$gNm^{-3}s^{-1}$	decomp. of coarse woody debris N to litter 3 N	Input to structural litter (LITs)
NPP_NACTIVE	$gCm^{-2}s^{-1}$	Mycorrhizal N uptake used C (WRONG??)	First subtract NPP_NNONMYC,
			then partition between EcM and AM based on f_{EcM}
NPP_NNONMYC	$gCm^{-2}s^{-1}$	Non-mycorrhizal N uptake used C	Subtracted from NPP_NACTIVE
NDEP_TO_SMINN	$gNm^{-2}s^{-1}$	atmospheric N deposition to soil mineral N	N deposition to NH4 pool
LEAF_PROF	m^{-1}	profile for litter C and N inputs from leaves	Multiplied with LEAF_TO_LITTER to get rates for each dept
FROOT_PROF	m^{-1}	profile for litter C and N inputs from fine roots	Multiplied with FROOT_TO_LITTER to get rates for each de
NDEP_PROF	m^{-1}	profile for atmospheric N deposition	Multiplied with NDEP_TO_SMINN to get deposition for each
Environmental variables:			
TSOI	K	soil temperature	Converted to $^{\circ}C$

WATSAT	$mm^3 mm^{-3}$	saturated soil water content (porosity)	Used for calculating r_{moist}, see 0.1.2.2
SOILLIQ	kgm^{-2}	soil liquid water	Used for calculating r_{moist}, see 0.1.2.2 and leaching.
SOILICE	kgm^{-2}	soil ice water	Used for calculating r_{moist}, see 0.1.2.2
W_SCALAR	-	Moisture (dryness) inhibition of decomposition	Used in nitrification algorithm
T_SCALAR	-	temperature inhibition of decomposition	Used in nitrification algorithm
QDRAI	mms^{-1}	sub-surface drainage	Used for calculating leaching
nbedrock	$mm^3 mm^{-3}$	index of shallowest bedrock layer	for determining how many layers to use in the simulations
Read from surface data file:			
PCT_CLAY	-	percent CLAY	
PCT_NAT_PFT	-	percent plant functional type on the natural veg landunit	

Table 7 gives the mycorrhizal assiciation of each PFT according to the CLM parameter file[Elin:] [Sett inn kilde her.]. So for example, if a site has 50% needleleaf evergreen boreal tree, 20% broadleaf evergreen shrub and 30% c4 grass, 70% of the incoming carbon is directed to EcM, while 30% is directed to AM.

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Table 7: List over the possible Plant Functional Types (PFTs) and their mycorrhizal associations according to CLM parameter file.

PFT	Mycorrhizal associations	Notes
not vegetated	EcM	
needleleaf evergreen temperate tree	EcM	
needleleaf evergreen boreal tree	EcM	
needleleaf deciduous boreal tree	EcM	
broadleaf evergreen tropical tree	AM	
broadleaf evergreen temperate tree	AM	
broadleaf deciduous tropical tree	AM	
broadleaf deciduous temperate tree	50% EcM 50% AM	
broadleaf deciduous boreal tree	EcM	
broadleaf evergreen shrub	EcM	
broadleaf deciduous temperate shrub	EcM	
broadleaf deciduous boreal shrub	EcM	
c3 arctic grass	EcM	
c3 non-arctic grass	AM	
c4 grass	AM	

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