*Appendix I: DAMM-MCNiP model parameters, default and initial values, and equations.*

**Model parameters and their default values.**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Units | Default Value | Description |
| rootDOC | mg cm-3 | input | Root exudates |
| T | K | input | temperature in Kelvin |
| θ | cm3 H2O cm-3 soil | input | volumetric water content |
| BD | g cm-3 | 0.8 | bulk density |
| PD | g cm-3 | 2.52 | particle density |
| O2frac | L O2/ L air | 0.209 | volume fraction of O2 air |
| Cfrac | g C cm-3/ g C cm-3 | 0.000414 | fraction of unprotected SOM, using soluble substrate estimated from Magill et al., 2000 |
| dLiq | - | 3.17 | diffusion coefficient for unprotected SOM and DOM in liquid |
| dGas | - | 1.67 | diffusion coefficient for O2 in air |
| kmO2 | cm3 O2 cm-3 air | 0.121 | Michaelis constant for O2 |
| R | kJ K-1 mol-1 | 0.0083145 | universal gas constant |
| filePath | - |  | file path to temperature data |
| endTime | h | 2000000 | number of hours simulated in model run |
| p | - | 0.5 | proportion of assimilated C allocated to enzyme production |
| q | - | 0.5 | proportion of assimilated N allocated to enzyme production |
| a | - | 0.5 | proportion of enzyme pool acting on SOC pool (1-a = proportion acting on SON pool) |
| initSOC | mg cm-3 | 144.5986 | initial SOC pool |
| initSON | mg cm-3 | 5.4413 | initial SON pool |
| initDOC | mg cm-3 | 0.00091631 | initial DOC pool |
| initDON | mg cm-3 | 0.00049421 | initial DON pool |
| initBiomassC | mg cm-3 | 1.1957 | initial microbial biomass C |
| initBiomassN | mg cm-3 | 0.1196 | initial microbial biomass N |
| litterC | mg cm-3 hr-1 | 0.0005 | litter input to SOC pool |
| initEnz | mg cm-3 | 0.0381 | initial enzyme pool |
| inputDOC | mg cm-3 hr-1 | 0.0005 | litter input to DOC pool |
| death | hr-1 | 0.00015 | microbial turnover rate |
| enzLoss | hr-1 | 0.001 | enzyme turnover rate |
| micToSom | mg mg-1 | 0.5 | fraction of dead microbial biomass |
| aDep | mg SOM cm-3 (mg Enz cm-3)-1 h-1 | 1.0815\*1011 | Vmax intercept for SOM depolymerization |
| aUpt | mg DOC cm-3 (mg biomass cm-3)-1 h-1 | 1.0815\*1011 | Vmax intercept for DOC uptake |
| kmDep | mg cm-3 | 0.0025 | Km for SOM depolymerization |
| kmUpt | mg cm-3 | 0.3 | Km for DOC uptake |
| CUE | mg mg-1 | 0.31 | Carbon use efficiency |
| eaDep | kJ mol-1 | 61.77 | Ea for SOM depolymerization |
| eaUpt | kJ mol-1 | 61.77 | Ea for DOC uptake |
| cns | - | 27.6 | C:N of soil |
| cnl | - | 27.6 | C:N of litter |
| cnm | - | 10 | C:N of microbial biomass |
| cne | - | 3 | C:N of enzymes |
| cnex | - | 27.6 | C:N of root inputs |
|  |  |  |  |

**Initial parameters**

Most parameters listed in Table S7 are from Allison et al. (2010). One exception is the C:N of soil, taken from Schimel and Weintraub (2003). Default initial pool sizes were determined after model spin up for 2000 years using spin up parameters from Allison et al. (2010) for the C pool. The N pool was parameterized using the following principles, SON = SOC/27.6 [C:N ratio of soil], DON = DOC/15 [mid-range of DOC:DON from Hopkinson et al. (1997) and Neff & Hooper (2002)], microbial biomass N = microbial biomass C/10 [C:N ratio of microbes]. For the default model, we assume that litter and root inputs have C:N of 27.6.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Abbreviation | Units | Spin Up | Default |
| SOC pool | initSOC | mg cm-3 | 100 | 144.5986 |
| SON pool | initSON | mg cm-3 | 3.6232 | 5.4413 |
| DOC pool | initDOC | mg cm-3 | 0.5 | 0.00091631 |
| DON pool | initDON | mg cm-3 | 0.0333 | 0.00049421 |
| microbial biomass C | initBiomassC | mg cm-3 | 0.5 | 1.1957 |
| microbial biomass N | initBiomassN | mg cm-3 | 0.05 | 0.1196 |
| enzyme pool | initEnz | mg cm-3 | 0.01 | 0.0325 |

**Model equations**

Soluble C & N Pool

Change in the soluble C & N pool depends on inputs to the pool, depolymerization of SOM, turnover of microbial biomass and enzymes, and microbial uptake [1,2]. Litter DOM is added to the bulk [1] and rhizosphere [2] soil at each timestep, but root inputs (rootDOC\_N) are only added to rhizosphere [2] soil. Depolymerization depends on (1) amount of available SOC that can diffuse through soil pores to the reaction site [3], (2) Michaelis-Menton dynamics [4,5] and (3) temperature according to Arrhenius dynamics [6].

*dDOC/dt = DOCmult\*inputDOC + DEPOLYC + DEATH \* (1 – MICC toSOMC ) + (CNe/(1+CNe)) + ELOSSC – UPTC [1a]*

*dDON/dt = DOCmult\*inputDON + DEPOLYN + DEATH \* (1 – MICN toSOMN ) + (1/CNe) + ELOSSN – UPTN  [1b]*

*dDOC/dt = DOCmult\*(inputDOC + rootDOC) + DEPOLYC + DEATH \* (1 – MICCtoSOMC) + (CNe/(1+CNe)) + ELOSSC – UPTC [2a]*

*dDON/dt = DOCmult\*(inputDON + rootDON) + DEPOLYN + DEATH \* (1 – MICNtoSOMN) + (1/CNe) + ELOSSN – UPTN [2b]*

*avail\_SOM=SOM\*frac\*Dliq\*soilM^3 [3]*

*DEPOLYC* = *VmaxC \* a\*Enz \*avail\_ SOC/(KmC +avail\_ SOC) [4]*

*DEPOLYN* = *VmaxN \* (1-a)\*Enz \* avail\_SON/(KmN +avail\_ SON) [5]*

*VmaxC\_N = AC\_N* \* exp (*-EaC\_N / RT*)  *[6]*

Microbial Biomass

Change in microbial biomass is determined by uptake of C and N, C and N use efficiency, growth and death of microbes, and production of extracellular enzymes [7,8]. Uptake is limited by oxygen availability in soil pore spaces [9,10]. Similar to depolymerization, uptake of C and N depend on Michaelis-Menton and Arrhenius equations [11,12]. Maintenance respiration [13] depends on the carbon use efficiency. Enzyme production can be C or N limited, depending on the stoichiometry of the C and N after allocation to maintenance respiration [14,15]. Growth occurs after allocation to both maintenance respiration and enzyme production. Like enzyme production, either C or N can be limiting [16,17]. After enzyme production and growth, excess C and N are mineralized [18,19]. Death is a first order processes with a pre-defined rate constant [20].

***dMICC/ dt =CNm\*GROWTH – DEATHC*** *[7]*

***dMICN/ dt =GROWTH – DEATHN*** *[8]*

*porosity = 1 – BD/PD [9]*

*O2 = Dgas\*O2airfrac\*[(porosity –soilM)4/3] [10]*

*UPTC\_N = MicC\_N \* VmaxuptC\_N \* DOC\_N / (KmuptC\_N + DOC\_N)\*O2/(KmO2 + O2)[11]*

*VmaxuptC\_N = AuptC\_N* \* exp (*-EauptC\_N / RT*) *[12]*

*CMIN = UPTc \* (1 – CUE) [13]*

*EPROD = q\*UPTN [N limited] [14]*

*EPROD=p\*(CUE\*UPTC)/CNe [C limited] [15]*

*GROWTH= ((1-p)\*UPTC\*CUE + EnzC – CNe\*EPROD) /CNm [C limited] [16]*

*GROWTH = (1-q)\*UPTN\*EnzN – EPROD [N limited] [17]*

*OverflowC = GrowthC – CNm\*Growth [18]*

*NMIN = GrowthN - Growth [19]*

*DEATH = rdeath \* MicC\_N [20]*

Enzyme Pool & Turnover

The enzyme pool is a balance between production and turnover, defined as a first order process [21,22].

***dEnz/dt = EPROD – ELOSS*** *[21]*

*ELOSS = renzloss\*Enz[22]*

SOM Dynamics

The SOM pool is fed by litter inputs and turnover of microbial biomass. Depolymerization transfers SOC and SON to the DOC and DON pools, respectively [23].

***dSOMC\_N/dt = LitterC\_N + DEATH\*MICC\_NtoSOMC\_N – DEPOLYC\_N*** *[23]*