Appendix 9.1

The BIOMOD model and clay dependency

1 Introduction

BIOMOD refers to a project, where differently structured organic matter models were tested against each other. This option in Daisy refers to a model described in Petersen et al. (2005a), (2005b) and (2007). It is recommended that these articles are consulted before the clay option is selected, as it requires re-definition of the organic matter model. In the following only the basics of the required descriptions are outlined.

2 The organic matter model

The BIOMOD organic matter model is shown in Figure 1. Note, that the connections between pools differ from the ones in Daisy, and application of this model thus requires a thorough revision of the *fractions*, describing the connections. Similarly, a revision of efficiencies and turn-over rates to fit the findings in the mentioned articles will be necessary.

Turnover of the pools depends on abiotic factors, just as in Daisy. The temperature function used is shown in Eq. (9.1.1). This function has a value of 1 and 10°C.

$$F_T(T) = 7.24\, exp\left[-3.432 + 0.168 \cdot T\left(1 - 0.5 \cdot \frac{T}{36.9}\right)\right] \qquad (9.1.1)$$

The dependency of soil water content is quite similar to the one used in Daisy from saturation till pF 2.5. However, the value drops linearly from 1 to 0 between pF 2.5 and 5.5, while the function used in Daisy reaches 0 at pF 6.5. The dependency on clay content is, however, somewhat different from what is used in the standard organic matter model.

3 The BIOMOD clay factor

It is assumed that the clay content has two effects: First, it modifies both the decay and respiration rates of the soil microbial biomass, by the equation:

$$g(X) = 1 - 2 \cdot min(0.25, X) \qquad (9.1.2)$$

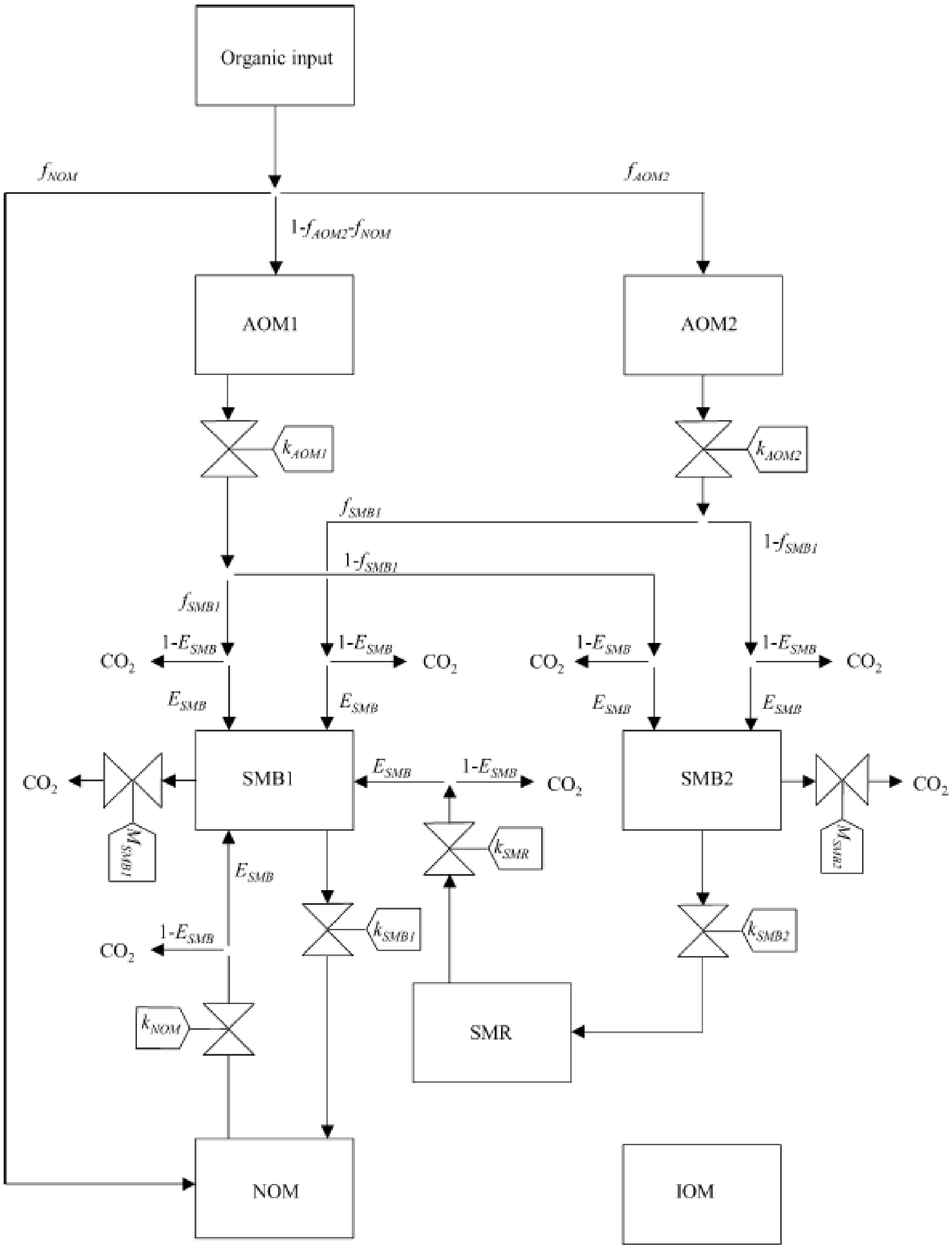

Figure 1. Model structure, AOM1 and AOM 2 is added organic matter, SMB1 and SMB2 is soil microbial biomass, SMR and NOM are soil organic matter pools and IOM represents intert organic matter. Boxes represent carbon pools and valves represent turnover rates. From Petersen et al. (2005a), Fig.1.

Eq. (9.1.2) is similar to the standard clay function in Daisy. For the microbial pools, both the turnover rate and the maintenance rates are multiplied with $g(X)$. It mimics the reduced protection of the soil microbial biomass when the clay content is low.

The second clay response, which affects the "humification coefficient", h, is based on (Coleman and Jenkinson, 1996). They found that the ratio (R, [(C lost as CO_2)/(C directed to NOM)]) depends on the clay content (X, [kg kg^{-1}]) as follows:

$$R = 1.67 \cdot (1.85 + 1.6 \cdot \exp(-7.86 \cdot X) \quad (9.1.3)$$

Humification is given as

$$h = 1/(R + 1) \tag{9.1.4}$$

and ranges from 0.15 at zero clay content [kg kg^{-1}] to 0.24 at one.

From the model structure (Figure 1) it is noted that added C can enter the NOM pool either by passing only SMB1 or passing through first SMB2 and then SMB1. Thus, the fraction that at some stage will enter the NOM-pool can be calculated as:

$$h = f_{SMB1} \cdot q_1 + (1 - f_{SMB1}) \cdot q_1 . q_2 \tag{9.1.5}$$

where q1 and q2 are the fractions of C not lost after passing through, respectively, SMB1 and SMB2. As $q_i = E_{SMB} k_{SMBi}/(k_{SMB1} + M_{SMBi})$, Eq. (9.1.5) can be expanded to eq. (9.1.6):

$$h = \frac{E_{SMB} k_{SMB1}}{(k_{SMB1} + M_{SMB1})} \left(f_{SMB1} + \frac{(1 - f_{SMB1}) \cdot E_{SMB} k_{SMB2}}{(k_{SMB2} + M_{SMB2})} \right) \tag{9.1.6}$$

where the first term represents the C going to NOM after passing through SMB1, and the second term is the fraction going to NOM after passing through both SMB1 and SMB2. The effect of clay on this relationship is modelled by introducing a clay function, *l(X)*, which is multiplied onto the ratio $r_{SMBi} = k_{SMBi}/(k_{SMBi} + M_{SMBi})$, while leaving the total turnover of the microbial pool, $t_{SMBi} = k_{SMBi} + M_{SMBi}$, unchanged. The higher the ratio (r_{SMBi}), the more C will be lost as CO_2 and less C is finally incorporated into the NOM pool.

Thus, the effect of clay from Eq. (9.1.6) can be written as:

$$h(X) = E_{SMB} \cdot r_{SMB1} \cdot l(X)(f_{SMB1} + (1 - f_{SMB1}) \cdot E_{SMB} \cdot r_{SMB2} \cdot l(X)) \tag{9.1.7}$$

Solving this equation for *l(X)* gives a 2nd order equation, where the relevant solution is:

$$l(X) = \frac{-r_{SMB1} \cdot f_{SMB1} + \sqrt{(r_{SMB1} \cdot f_{SMB1})^2 + 4 \cdot h \cdot r_{SMB1} r_{SMB2} (1 - f_{SMB1})}}{2 \cdot E_{SMB} \cdot r_{SMB1} r_{SMB2} (1 - f_{SMB1})} \tag{9.1.8}$$

This function is scaled by a constant, so that it is one at zero clay content. Using eq. (9.1.3) and (9.1.4) for calculating *h*, it is possible to calculate *l(X)*.

From Eq. (9.1.7) r_{SMB1} can be estimated at zero clay content as:

$$r_{SMB1} = \frac{h(0)}{E_{SMB} \cdot (f_{SMB1} + (1 - f_{SMB1}) \cdot E_{SMB} \cdot r_{SMB2})} \tag{9.1.9}$$

So, in short: all the SMB-pools are affected by the clay factor, but not the SOM-pools. Additionally, the ratio between maintenance and turnover is clay dependent.

4 Parameters in the <biomod> submodel

The use of the <biomod> clay function allows specification of four parameters. These are:

factor = a plf-function describing the function given in Eq. (9.1.2), which is also used in Daisy. Default values are identical with the Daisy clay function.

a = a maintenance ratio parameter, which is the “1.67” in Eq. (9.1.3). It can be used for calibration.

E_SMB = The efficiency with which the SMB-pools process organic matter. In BIOMOD, the efficiency parameter for all OM pools must be equal to this value for the BIOMOD clay response model to work correctly.

f_SMB1 = Fraction of AOM pools going to SMB1. Only the fraction of AOM going to a SMB pool counts, so it is really a fraction of the fraction going to the SMB-pools. Note, that the “fraction” parameter of all AOM pools must be set to reflect this for the BIOMOD clay response model to work correctly.