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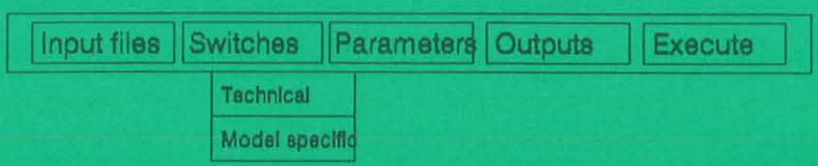
SOILN model

(ver 9.1)

User's manual

3rd edition



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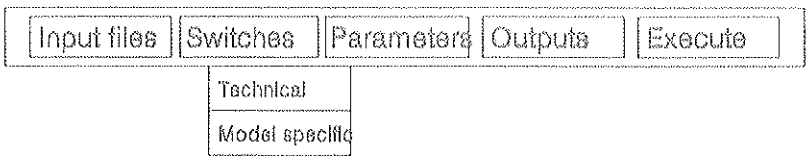

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Table of Contents

1 Background

Version 9.1; Uppsala 96-08-20

This manual is adapted to the SOILN model version 9.1 and is a development from Eckersten et al (1994). The model presentation is divided into one part which describes a basic and/or original part of the model and one part including special/new options which you can get access to by setting the SPECIAL switch ON. By this switch the model can be used as a tool for testing alternative theories selected by the user, and to get access to special options useful for application of the model. This report can not be used as a reference for the validity of those theories. The model is developed in close collaboration with several research scientists. The contribution of different persons is given in Acknowledgement.

1.1 Model description

The SOILN model simulates major C and N-flows in agricultural and forest soils and plants. The model has a daily time step and simulates flow and state variables on a field level. Input variables are daily data on air temperature and solar radiation, management data and variables on soil heat and water conditions which are simulated by an associated model named SOIL (Jansson & Halldin, 1979). The model can conceptually be divided into two submodels: the soil submodel and the plant submodel. The soil part is described in detail by Johnsson et al. (1987) (Figs. 1a and b) and the plant model description is divided into one part for the current year dynamics (Figs. 2a and b; Eckersten & Jansson, 1991) and one for the perennial part (Figs. 3a and b; Eckersten, 1994). Note that the flow schemes in Figs 1-3 describe possible flows whereas the flows used depend on the model application, i.e. the choice of switches and parameter values. Papers dealing with applications of the model are found in the reference list.

The soil is divided into layers. In each layer mineral N is represented by one pool for ammonium N and one for nitrate N. Ammonium is immobile whereas nitrate is transported with the water fluxes (a special option can make ammonium mobile). The ammonium pool is increased by nitrogen supplied from, manure application, mineralisation of organic material and by atmospheric deposition, and it is decreased by immobilization to organic material, nitrification to the nitrate pool, and plant uptake. The nitrate pool is increased through nitrification of the ammonium pool, fertilization, atmospheric deposition and by capillary rise of water from subsoil. It is decreased by leaching, denitrification and plant uptake. Water flows bringing nitrate between layers, is the process finally responsible for N leaching. The daily output of N from the mineral pools might in case of low mineral N contents be higher than available N plus input, especially as concerns nitrate. To reduce this problem the following priority of access to N was used. First immobilisation to microbes, then nitrification and root uptake.

The organic matter is normally represented by two pools, however, there are options to alter the number of pools used and to choose if microbe dynamics should be simulated or not. The rate of decomposition of organic matter depends on soil water and temperature conditions. Nitrogen dynamics of the organic matter is governed by those C flows and mineralisation or immobilisation depend on the C/N ratio of the decomposed material and availability of mineral N.

The plant biomass and N dynamics are based on a strong relationship between carbon and nitrogen as used by Eckersten & Slapokas (1990), Eckersten (1991a), Eckersten (1994) for willow and (Eckersten & Jansson, 1991) for wheat. The model concept has its origin in two basic model concepts; first that carbon input is strongly related to the energy input (de Wit 1965) and second, the nitrogen input is governing growth (Ingestad et al. 1981).

The plant is divided into one pool for biomass and one for nitrogen for each type of function simulated by the model. Leaves take up carbon from the atmosphere and roots take up nitrogen from the soil. Stem is used for storage. During grain development the grain pool is an additional storage organ supplied with assimilates from the stem. The maximum photosynthesis is related to the radiation intercepted by the canopy leaf area. The actual photosynthesis is then reduced by low air temperature, low leaf nitrogen concentrations and water deficit. N uptake is either limited by the sum of the demands by different plant tissues or the availability of N in soil. The demand depends on the plant growth and wanted N concentration of tissues. The available soil N is a fraction of the total mineral N in the root zone.

The partitioning of daily growth to root, leaf and stem is governed by two functions. The fraction partitioned to roots decreases as the total plant biomass increases or in case of nitrogen or water shortage. The partitioning between leaves and stems depends on the leaf area development which is determined by the leaf area to shoot biomass ratio. During grain development biomass and nitrogen are allocated from different plant tissues to grain. Litter formation occurs continuously and tissues may redraw some of their biomass and N before they die. There are different functions for governing the mortality of plant tissues. Dates of emergence, start and stop of grain filling and maturity are calculated as functions of temperature, daylength and a maximum harvest index.

In case of perennial plant there are additional pools for old plant biomass and a pool of easily available assimilates. The latter is added to the daily photosynthesis and re-allocated within the plant, and increases in proportion to the total biomass and temperature. The old tissues have a smaller influence on growth than the younger ones. They affect the C and N dynamics by consuming assimilates for the maintenance respiration, by increasing available assimilates for growth and by increasing root depth. They also affect the input to the litter pools by the contribution of material with relatively low nitrogen concentration. The biomass of the young pools are transferred to the old biomass pools at a certain age (normally one year) given by the user.

A more precise model description is given in the section on Parameters where the most essential equations for different processes are found. The parameters are given with their names whereas other variables are given by normal mathematic symbols, the explanation of which is found within the section on Outputs.

1.2 Model application

To enable a robust application procedure of the model, certain developments have been made. A special program SIMVB (see Appendix 2) allows the user a good overview when checking that all variables simulated by the model are reasonable. It also allows a handy way of comparison between simulations and measurements. In addition a special option is introduced (see BOUNDARY-switch) that enables simulated values to be replaced by measurements or values

calculated by another model. This option is meant to be used if only parts of the SOILN model is wanted to be studied, for instance when making step-wise calibration. It could also be used as an indicator of model performance (minimum correction corresponds to best performance).

The SOILN model includes a lot of parameters and there is no unique way of how to set those for a certain application. However, by following four calibration rules the number of possible solutions will strongly be reduced, depending on how many measurements there are available for the test of model outputs.

- Before start of calibration: Set input data according to independent data (measurements, literature etc) as far as possible and as correct as possible.

Four calibration rules:

- Change as few parameters as possible
- Change only to parameter values that are reasonable
- Make documentation: Which fit was improved by a certain change?
- Check that all variables simulated by the model are reasonable

Concerning the second rule (change only to reasonable parameter values) you should keep in mind that sometimes the interesting output of the model application is that model could fit measurements only if unreasonable parameter changes were made. In this case it reflects non validity of the model concept, if other input data are correct. Concerning the third rule (documentation) also document the interaction between parameter settings.

Normally, the model should be calibrated step-wise. In Appendix 2 an example of a procedure of how to calibrate the SOILN model is shown.

1.3 Flow schemes

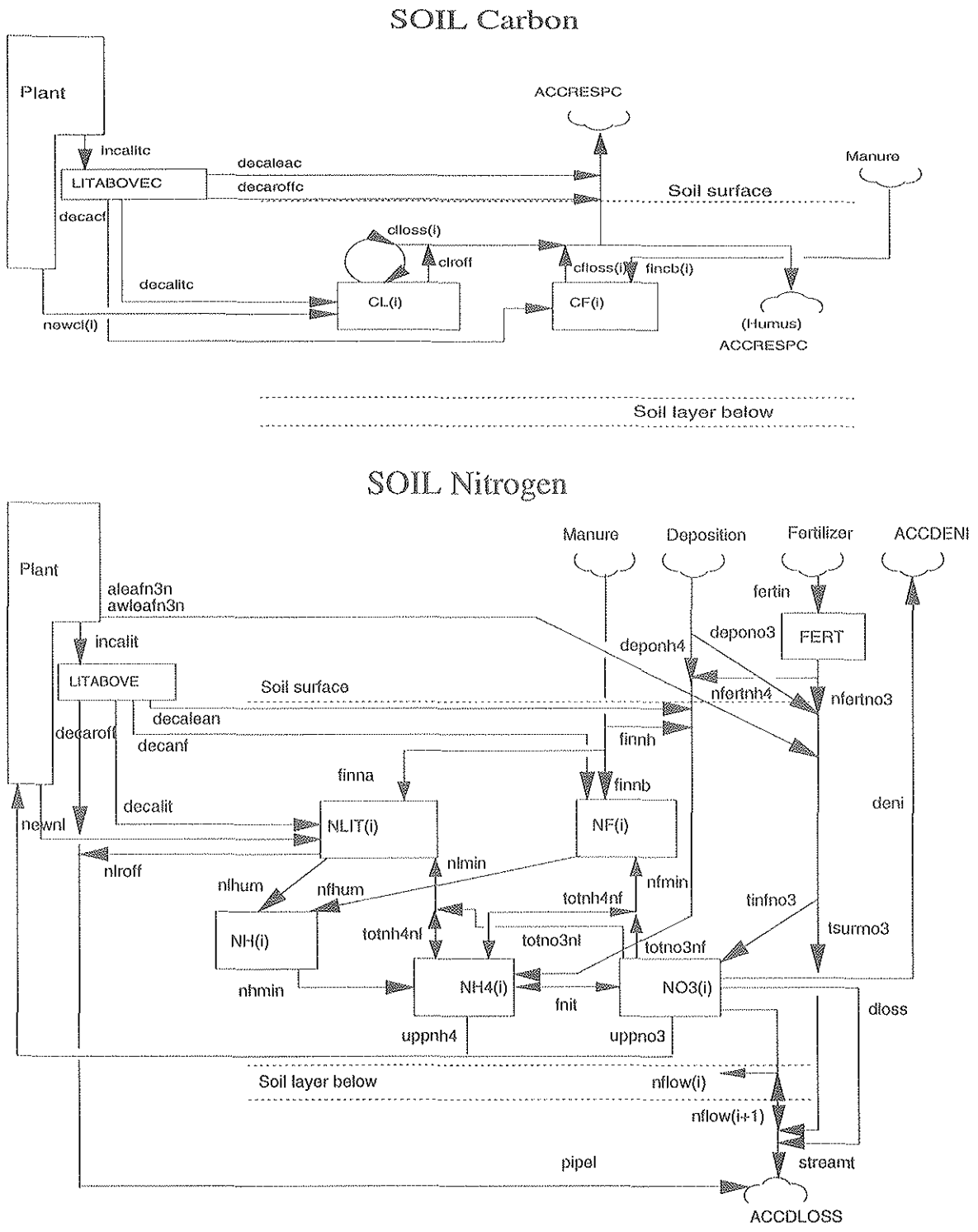
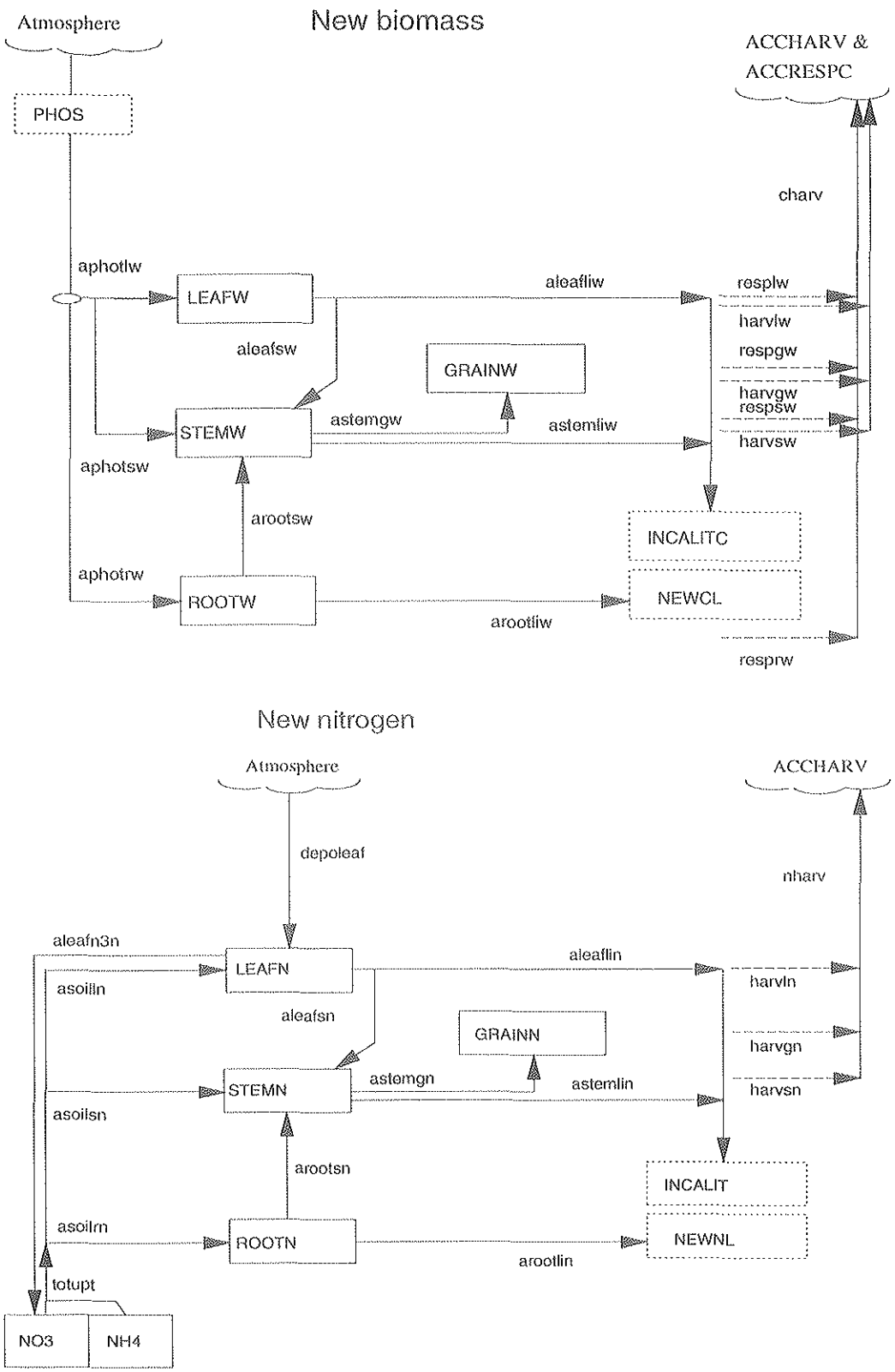
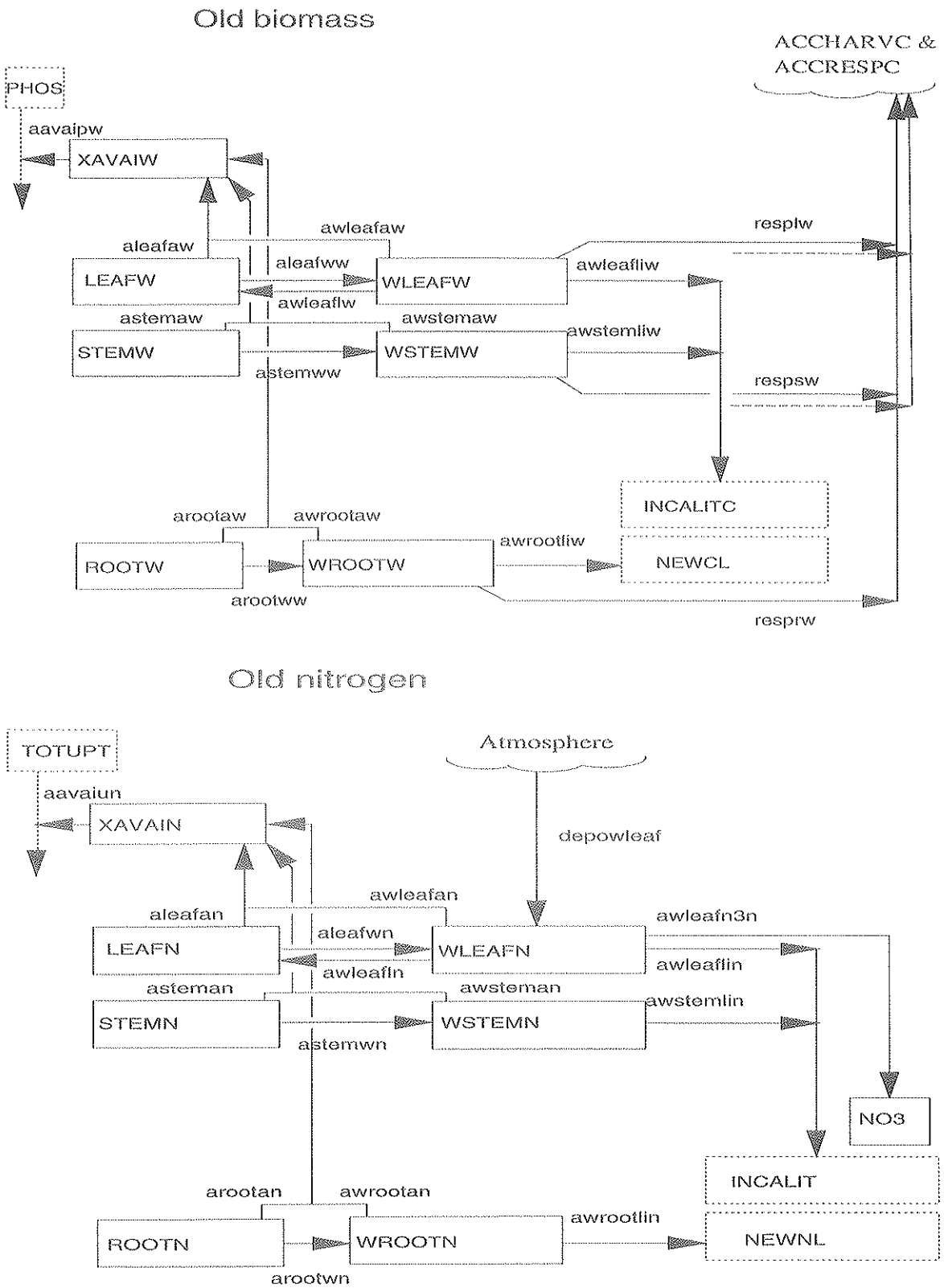


Figure 1a and b. A schematic description of carbon and nitrogen flows and states of the soil part of the SOILN model. Symbols are explained in the section of Output variables. Microbial biomass and extra litter pool are not included in the scheme.



Figures 2a and b. A schematic description of the biomass and nitrogen flows and states of the PLANT-submodel of SOILN model. The part concerning the current year growth. Symbols are explained in the section of Output variables.



Figures 3a and b. A schematic description of the biomass and nitrogen flows and states of the PLANT-submodel of SOILN model. The part concerning perennial growth. Symbols are explained in the section of Output variables.

2 Getting started

2.1 Installation

The model is normally distributed together with the SOIL model on a special floppy diskette for IBM/PC. Two different installation diskettes can be used depending on whether you are a previous user of the PGraph program or not.

Type the command: `A:INSTALL A: C: XXX`

This means that you have inserted the diskette into a floppy disk drive named A: and you want to install the model on your hard disk C: in the directory named XXX. Normally XXX is substituted by SIM or SIMVB. If you already have a directory with that name you should choose another name at the installation.

2.2 Files

The installation procedure will create one main directory (C:\SIMVB\) below which the program files are stored in different subdirectories. The excitable files are placed in the subdirectory named EXE and sample files in the subdirectory named DEMO.

Table 1: Description of files in the different directories.

Files	Description
Directory: C:\SIMVB\EXE	
SOILN.EXE	Execute file, SOILN model
SOILN.DEF	Definition file, SOILN model
SOILN.HLP	Help file, SOILN model
PREP.EXE	Execute file, PREP program
PG.EXE	Execute file, Pgraph program
PG.HLP	Help file, Pgraph program
PLOTPF.EXE	Execute file, PLOTPF program
PLOTPF.HLP	Help file, PLOTPF program
Directory: C:\SIMVB\DEMO\N	
DEMO.BAT	Demo file for running the SOILN model and using the PG program for visualizing some results on the screen.
AIN_INI.INI	Initial conditions for running the SOILN model
AIN_ONE.PAR	Parameter file for simulating nitrogen dynamics of an arable land with an agricultural crop during a growing season.
AIN_CLIM.BIN	PG-file with climatic driving variables for running the SOILN model.
AIN_SOIP.DAT	File with soil hydraulic properties.
SOILN.TRA	Translation files for variable names, SOILN
SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.

2.3 Running the model

Before running the model you must make sure that the model and utility programs are correctly installed on your computer. There must be a path to files store in directory C:\SIMVB\EXE (most conveniently in the AUTOEXEC.BAT file).

The DEMO.BAT file will be a good test of the installation and it will also show a number of results without any other efforts than running the DEMO.BAT file.

For running the program interactively use commands as specified in the section on Commands.

```
PREP SOILN AIN_ONE
```

Is an example of how you can make your own simulation based on information in the AIN_ONE.PAR file.

2.4 Evaluating your simulation

A successful simulation will result in two different output files numbered as nnn :

SOILNnnn.SUM Contains a summary of simulation results in ASCII.

SOILNnnn.BIN A binary file comprising output variables from the simulation. You start the Pgraph program by typing:

```
PG SOILNnnn
```

For details on how to use Pgraph see the Pgraph manual or use the help utility in the program (F1 key).

Another file created by the PREP program the first time you run the model in a certain directory is:

SOILN.STA which includes information about your run number. The numbering of a run within this file can be modified by the PREP program (see section 8 Run options)

3 Program structure

The preparation of the model prior to a run follows an interactive dialogue where the user has the possibility to design the run according to the present purpose.

The different menus can be reached in any order after moving the cursor to the subject using arrow keys and pressing "return" at the chosen subject. "Return" takes the cursor down in the menus and "Esc" moves the cursor up one level. Normally, a user will start with the subjects to the left in the main menu and move to the right. It is a good rule to modify the settings of switches and input files before moving to the other menus, since the content of the lower menus is influenced by the setting of those above.

4 Files

4.1 Input

Driving variable file

FILE(1) XXXXXX.BIN: A driving variable file is always a PG-file. The variables in the PG-file can be organized in different ways depending on how different parameters are specified. The driving variables for the SOILN model is generated by the SOIL model. The variables are identified by SOILN according to the names given below (see Driving variables to get the description). They can also be identified with the model description given by the SOIL model. Layers must be given in order, from the top to the bottom. In the output file SOILNxxx.SUM you can check that your driving variables were correctly identified.

Table 2: Variables in drivingvariable file (FILE(1)) to SOILN.

Name in the SOIL model	Number of variables	Optional	Unit
WFLOW	[N-1]	No	(mm/day)
INF	[1]	No	(mm/day)
INFBYPASS	[1]	Yes	(mm/day)
DFLOW	[N]	Yes	(mm/day)
SURR	[1]	No	(mm/day)
TEMP	[N]	No	(°C)
THETA	[N]	No	(vol %)
ETR	[1]	No	(-)
PERC	[1]	Yes	(mm/day)
TA	[1]	No	(°C)
RIS	[1]	No	(Jm2/day)
MEACONC	[1]	Yes	(mg/l)

N is the number of layers in your simulation and this number must correspond to the value of the NUMLAY parameter (See soil profile).

Parameter file

FILE(2) XXXXXX.PAR: The parameter file is an ordinary DOS-file with ASCII- characters. All parameters with actual numerical values should be included in the file. Parameters missing in the file receives the default value found in SOILN.DEF. New parameter files may be created prior the execution of the model using the WRITE command (see EXECUTION WRITE). Several parameter files could be used. The information from the last incorporated file gets the highest priority, it "overwrites information from earlier parameter files and the SOILN.DEF file.

Translation file

FILE(3) SOILN.TRA: A translation file (ASCII) has to exist in order that the variables in the output PG-file should get their correct identifications. Only when the OUTFORN switch is ON, this file is not necessary.

Initial states file

FILE(4) XXXXXX.INI: An ASCII file containing the initial values of all state variables that should start from a value > 0. The state variables denoted ACC... should normally be zero. Note that GROWINI-switch regulates if plant states should be read from this file.

Rules to write the file:
1. The most simple and safe way is to write only one variable name at each row followed by a space and the value, for instance: LITABOVE 1.2
2. Up to 3 variables could be put on each row with the following format: variable 1-3 should be in columns 2 to 27, 29 to 54 and 56 to 81, respectively. 3. Layers is denoted within brackets, for instance: NO3(3) 1.35
4. If different layers have the same value you could write for instance: NO3(1-3) 1.35
5. The name of the state variable file must be defined in the xxx.PAR-file or be given in PREP under Input files.

If INISTATE-switch = 0: All initial states are zero.

Output file

FILE(6) SOILNnnn.BIN: Only used if ADDSIM-switch = 1. The results of the current simulation are added to this file which contains output data from a previous simulation.

Validation file

FILE(7) XXXXXX.BIN: A file with variables (measured) that should be compared with simulated variables. The result of the comparison will be found in the SOILNnnn.SUM file. The first variable in the validation file will be compared with the first variable in the output PG-file, the second with the second and so on. If VALIDPG-switch = 0: Not used.

Soil physical properties

FILE(8) XXXXXX.DAT: An ASCII file containing soil physical properties of the soil profile which are used for the soil water and heat simulation with the SOIL model. The file is created by the PLOTPF program and must exist on the working directory. Only the porosity (PORO) and the water content at wilting point (WILT) are used in the nitrogen simulation. A complete description of the file is found in the SOIL manual (Jansson, 1991b).

In the SOIL model, the thickness given for each layer in the SOILP.DAT file can be adjusted in the simulation (Parameters in the SOIL model: UDEP and LDEP, in case UTHICK = 0, otherwise see UTHICK). Check your actual layer thickness used in the sum file of your SOIL simulation. If necessary adjust the layer thickness in the SOILP.DAT file used for the SOILN simulation. The result of these adjustments can be seen in the SOILNnnn.SUM file.

External inputs - driving variable file

FILE(9) XXXXXX.BIN: Depending on the value of the switch DRIVEXT different parameters concerning fertiliser application are expected to be find in this file (at time 12:00). Date of application is taken from the date record in the file. If the first variable (FERN) is missing for a date, no other variables are read. If it is -99 then the other variables are read. If a variable value is -99 then it is treated as missing in the calculations. All values are reset to zero for intermediate time points. Only used if DRIVEXT-switch>0.

Table 3: Variables in FILE(9) for different values on the DRIVEXT-switch.

DRIVEXT-switch	Variable (#)	Parameter name in model	Unit
1	1	FERN	gN m^{-2}
2	2	MANNH	gN m^{-2}
2	3	MANLN	gN m^{-2}
2	4	CNBED	(-)
2	5	MANFN	gN m^{-2}
2	6	CNFEC	(-)
2	7	MANDEPTH	(m)
3	8	DEPWC	(mgN l^{-1})
3	9	DEPDRY	(gN $m^{-2}day^{-1}$)

Crop - driving variable file

FILE(10) XXXXXX.BIN: Parameters related to plant N uptake. Same roles for reading values as for FILE(9) except that values are not reset for intermediate time points. The values are kept constant until a new value is read. Only used if the GROWTH-switch=0, BOUNDARY-switch=0 and DRIVCROP-switch>0.

Table 4: Variables in FILE(10) for different values on the DRIVCROP-switch.

DRIVCROP-switch	Variable (#)	Parameter name in model	Unit
1	1	ROOTDEP	(m)
2	2	UPA,UPB...	(gN $m^{-2}day^{-1}$)

Boundary - driving variable file

FILE(10) XXXXXX.BIN: Measured values of states, flows and auxiliaries to which the model should be fixed during simulation. Maximum 20 variables with their errors could be given. Variable that should be fixed to the value in the file is defined by parameter BOUNVNUM(nn). The parameter defines the number in X, T or G array of the model (see Appendix 2). Total number of variables in the files (including the error variables) is given by parameter BOUNFTOT. If the BOUNDARY-switch=3 the error variables should be omitted. The roles for reading values are the same as for FILE(10) in the previous section. Only used if BOUNDARY-switch>0.

Table 5: Variables in FILE(10) for different values on the BOUNDARY-switch.

BOUNDARY-switch	Variable (#)	Value	Unit
1	1	Mean value var1	(differ)
1	2	Relative error var1	(-)
1	3	Mean value var2	(differ)
1	4	Relative error var2	(-)
1	...	....	....

1	40	Relative error var20	(-)

Management - driving variable file
FILE(11) XXXXXX.BIN: Parameters related to harvest and ploughing can be given in this file. Same roles for reading values as for FILE(10). Only used if DRIVMANA-switch>0.

Table 6: Variables in FILE(10) for different values on the DRIVMANA-switch.

DRIVMANA-switch	Variable (#)	Parameter name in model	Unit
1	1	PLOUGHDEP	(m)
2	2	HARP	(-)
2	3	HARAR	(-)
2	4	HARLR	(-)
2	5	CNARES	(-)
2	6	CNROOT	(-)

4.2 Output

Simulated data
SOILNnnn.BIN: A binary file to be used by the Pgraph program for analysing results from the simulation. The file contains all the outputs that where selected in the PREP program.

Simulation summary
SOILNnnn.SUM: An ASCII file containing a summary of all instructions used for the simulation, a summary of simulated results and identification of model version used. The first part of this file corresponds with a parameter file. This means that you can always rename or copy this file to a file named with the extension .PAR, for example MYRUN.PAR, and use it as a parameter file in future simulations. If you have exactly the same input variables and initial states this file should exactly reproduce your old run.

Final states file
FILE(5) XXXXXX.FIN: Only used if OUTSTATE-switch = 1. An ASCII file containing the final values of all state variables. This file could be used as an initial states file.

5 SWITCHES

The purpose of switches is to choose the subroutines valid for you application. Switches can be OFF, ON or have a numerical value. You change value of a switch by putting the cursor at the switch and press the return key. Switches may be hidden if some other switches make them irrelevant. After you have modified a switch the modification is activated by escaping [ESC] the menu. By entering the menu again, immediately after the escape, you see whether some more switches have become visible because of the previous change. Note that also new parameter settings might appear. (Group names given within brackets (S, P, M or O) refer to Soil, Plant, Management and Others)

5.1 Technical

ADDSIM

OFF *Default*	The simulation results will be stored in a separate result file with a name according to the run number. (Group O)
ON	The simulation results are automatically added to the result file of a previous simulation, run for an earlier time period. Note that the selected output variables must be exactly the same for the current and the previous simulation. The name of the former result file is given by the user as the "output file" name (see FILE(6)). By default the start date of the present simulation is put identical to the terminate date of the previous simulation. The final values of state variables from the previous simulation must be selected as the initial values of state variables for the present run (see INSTATE and OUTSTATE switches). Note that the OUTSTATE switch must be ON for any simulation to which results of a later simulation will be added. No new result file ".BIN" will be created, but a separate summary file ".SUM" will be created just like for an ordinary simulation.

AVERAGED

OFF	All requested driving (=D) variables will be the current values at the end of each output interval. See also AVERAGEX-switch. (Group O)
ON *Default*	All requested driving (=D) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

AVERAGEG

OFF	All requested auxiliary (=G) variables will be the current simulated values at the end of each output interval. See also AVERAGEX-switch. (Group O)
ON *Default*	All requested auxiliary (=G) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

AVERAGET

OFF	All requested flow (=T) variables will be the current simulated values at the end of each output interval. See also AVERAGEX-switch. (Group O)
ON *Default*	All requested flow (=T) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

AVERAGEX

OFF	All requested state (=X) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-output file is also the date of the end of the interval. Otherwise the date is the middle of each output intervals. (Group O)
ON *Default*	All requested state (=X) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

CHAPAR

OFF *Default*	Parameter values are constants for the whole simulation period. (Group M)
ON	Parameter values may be changed at different dates during the simulation period. If you edit the parameter file then all parameter values given after a definition of a new time point will be activated when the simulation has reach that point in time. A maximum of 20 dates can be specified.

DRIVPG

0	No function (Group M)
1 *Default*	Driving variables will be read from a Pgraph file. The name of the file is specified by the user. See Driving Variable File for details.

INSTATE

OFF	All initial state values are zero (Group S)
ON *Default*	initial values of state variables will be read from a file. The name of the file is specified by the user, the format should be exactly the same as in the file for final values of state variables, created by the model when the OUTSTATE switch is ON.

LISALLV

OFF	only the subset of output variables selected by the user will be found in the summary file. (Group S)
ON *Default*	all output variables will be found in the summary file after the simulation.

OUTFORN

OFF *Default*	the variables will be named according to the information stored in the file SOILN.TRA. (Group O)
ON	all variables in the output Pgraph-file will be named according to their FORTRAN names.

OUTSTATE

OFF *Default*	no action. (Group O)
ON	final values of state variables will be written on a file at the end of a simulation. The name of the file is specified by the user and the format is the same as used in the file for initial state variables (see the INSTATE switch).

VALIDPG

OFF *Default*	No validation. (Group O)
ON	Validation variables will be read from a Pgraph file. The name of the file is specified by the user. The values in the validation file will be compared with variables from the output file.

5.2 Model specific

Switches denoted GROW.... are only used if GROWTH-switch = 1.

DENDIST

0 *Default*	Denitrification rate distribution from parameter values, separate fractions are given for each soil layer (see DFRAC) (Group S).
1	A linear decrease of denitrification rate from soil surface to the depth specified by the parameter DENDEPTH.
2	A constant denitrification rate from soil surface to the depth specified by the parameter DENDEPTH.
3	An exponential decrease of denitrification rate from soil surface to the depth specified by the parameter DENDEPTH.

DRIVCROP

0 *Default*	Plant development is simulated (i.e. the GROWTH-switch > 0) or specified by parameter values in parameter file. (Group S)
1	The root depth is read from a driving variable file (FILE(10)). Only used if BOUNDARY-switch=0.
2	As for 1 but also the potential N-uptake rate is read from the same file.

DRIVEXT

0 *Default*	Parameter values for external inputs of nitrogen to the model are specified in parameter files. (Group M)
1	N fertilization rate is taken from a driving variable file (FILE(9)).
2	As for 1 but also parameters for application of manure are taken from the same file.
3	As for 2 but also parameters for wet and dry deposition are taken from the same file.

DRIVMANA

0 *Default*	Parameters of management operations are taken from parameter file. (Group M)
1	Ploughing depth is read from a driving variable file (FILE(11)).
2	Also harvest and re-circulation of crop residues are taken from the same file.

GROWDECID

OFF *Default*	Current year old leaves are transferred (at the end of the year, normally) to old leaves according to leaf fall functions given by the user. Only used if GROWPREN-switch=1. (Group P)
ON	All remaining leaves are falling to the ground at the end of the year.

GROWGRAIN

0 *Default*	No grain development. (Group P)
1	Grain development may occur (see related parameters GRAINI, AGRAIN, AGRAINN). Only used if GROWPHEN-switch > 0.

GROWINI

OFF	Plant initial values (annual biomass pools only) are calculated from parameter (TOTW(1)). N plant values are set assuming maximum N concentrations. (Group P)
ON *Default*	Plant initial values for the first growing period are taken from initial file (FILE(4)). TOTW(1) is not used. For the second growing period TOTW(2) should be used.

GROWPEREN

0 *Default*	No perennial pools are used. (Group P)
1	Perennial (wood) pools are used. Perennial pools are pools older than DAYPEREN days. See related parameters APEREN, DAYPEREN. Nitrogen and assimilates can be stored in an available pool in plant (see related parameters AVA...).

GROWSTART

0 *Default*	Day for start of growth is given by parameter UPST and GROWPHEN switch. (Group P)
1	Day for start of growth is a function of temperature (see parameters DAYTAACC, TAACCG. Only used for GROWTH-switch = 1.

GROWTH

0	Potential N-uptake is given as a function of time and root depth is input (see parameter sections on Nitrogen uptake by roots). (Group P)
1 *Default*	Plant growth, N-uptake, allocation and litter fall are simulated by the SOILN/PLANT growth model (see the additional parameter sections denoted (P) and switches denoted GROW....).

GWFLOW

OFF	The PERC driving variable is considered as deep percolation to ground water. This means that the whole simulated soil profile is unsaturated and that the GWFLOW was OFF when running the SOIL model. This means that DFLOW driving variable is not needed. (Group S)
ON *Default*	The PERC driving variable is considered as a net horizontal ground water flow. This means that GWFLOW was ON when running the SOIL model.

MANURE

OFF *Default*	Application of manure and transformation of faeces is not considered. (Group M)
ON	Application of manure and transformation of faeces is considered.

ROOTDIST

0 *Default*	Root distribution from parameter values (ROOTF), separate fractions are given for each soil layer. (Group S)
1	A linear decrease of root density from soil surface to the root depth.
2	A constant root density from soil surface to the root depth.
3	An exponential decrease of the root density from soil surface to the root depth.

SPECIAL

OFF *Default*	No special functions are active. (Group M)
ON	Special functions are available. Gives access to the switches and parameters in the groups named SPECIAL. Note, that now the control of the special functions are made with these switches and parameters.

5.3 Special

These switches activates special options of the model and are only available if the SPECIAL-switch is ON (=1).

BOUNDARY

0 *Default*	No corrections of simulated values during simulation. (Group M)
1	Values in a driving variable file (see FILE(10)) are used for correction, during simulation, of simulated states, flows or auxiliaries (see parameter BOUNVNUM(nn) and Appendix 1). For each time point given in the file, correction is made to the given value, in case the simulated value is outside the error limits. States are corrected prior each timestep, flows immediately prior integration and other variables immediately after being set in the model. Errors given in the file are relative errors. Total number of variables in the file is set by parameter BOUNFTOT. Only used if DRIVCROP-switch=0.
2	The same as for 1 but errors given in the file are absolute values.
3	The same as for 1 but no error variables are given in the file. Relative error is given by parameter BOUNRERR.
4	The same as for 3 but no external file is used (i.e. FILE(10)). Instead the values to which variables should be corrected should be given in parameters BOUNVALU(1-20). The correction is made every timestep (day).

FERNCALC

0 *Default*	No action. (Group M)
1	Fertilisation is calculated by the model as the difference between the potential uptake and the actual uptake of the previous day. To this amount could be added a fraction given by the parameter AVAILN. The amount simulated by the model (FERNSIM) is added as ammonium and is incorporated in FERTNH4.
2	Fertilisation is calculated by the model as the difference between the wanted soil N mineral amount (given by parameter AVAILN) and the sum of the mineral pools, the deposition and fertilisation and a preliminary estimation of mineralisation from organic matter. The amount simulated (FERNSIM) is added as solid fertilisers and is incorporated in FERTNO3.

GROWAEQ

13250 *Default*	A combined switch selecting which type of allocation equations that will be used. (Note should be >10000) The first figure is the way different root allocation sub functions (b_{rw}, b_{rn}, b_{re}) should be combined. 1: $b_r = \max(b_{rw}, b_{rn}, b_{re})$ 2: $b_r = b_{rw}*b_{rn}*b_{re}$ and 3: $b_r = (b_{rw}+b_{rn}+b_{re})/3$. The second figure is leaf-stem allocation (b_l; parameter ALEAF). The third is the root allocation as function of total plant biomass (b_{rw}; parameter AROOTW). The forth is root allocation as function of leaf nitrogen (b_{rn}; parameter AROOTNI). The fifth is root allocation as function of transpiration ratio (b_{re}; parameters AROOTE and AROOTETR). The figures can range from 0 to 5 and means that different equations are used to estimate the function. 0: function is not active (not allowed for b_l), 1: y=a, 2: y=a+b*x, 3: y=a+b*ln(c*x), 4: y=a+b*exp(c*x), 5 y=other equation. Coefficients a, b and c are the indices 1, 2 and 3 of the parameter. Example: GROWAEQ=325 means b_l=ALEAF(1)+ALEAF(2)*ln(ALEAF(3)*W_{Ta}); b_{rw}=AROOTW(1)+AROOTW(2)*W_t; b_{rn}= special (see AROOTNI). As regards x and other equations (5), see the parameter name concerned. NOTE! When changing GROWAEQ, the meaning of the parameters changes (ALEAF, AROOTW, AROOTNI). (Group P)

GROWALLO

0	During grain development, reallocation of assimilates occur from leaf to grain (flows ALEAFGW and ALEAFGN), root to grain and stem to grain (flows AROOTGW and AROOTGN). (see parameters AGRAIN and AGRAINN). Flows AROOTSW and AROOTSN = 0 (Group P)
1 *Default*	During grain development, reallocation of assimilates occur from leaf to stem, root to stem and stem to grain (see parameters AGRAIN, AGRAINN, ADRAWLW, ADRAWLN).

GROWGEQ

Determining the calculation of the growth response function (f_{Tot}). If GROWPHOS = 1 then f_T is not included in the functions. (Group P)

0	$f_{Tot} = \text{Min}(f_T, f_N, f_W)$
1 *Default*	$f_{Tot} = f_T * f_N * f_W$
2	$f_{Tot} = (f_T + f_N + f_W)/3$

GROWPHEN

0	No phenologic functions are active. Day of emergency is given by parameter UPST and day of harvest is given by parameter UPET. (Group P)
1 *Default*	Start of grain development is an accumulated function of air temperature and daylength. Otherwise as for GROWPHEN = 0.
2	Day of emergency is a function of accumulated temperature since sowing. Day of sowing is given by the UPST parameter. Day of start of grain filling is calculated as for GROWPHEN = 1 except that accumulation of the index starts at day of emergency and not UPST. Day of end of grain filling is a function of accumulated temperature since start of grain filling. Day of harvest is a function of accumulated temperature since day for end of grain filling. The routine is taken from AFRCWHEAT model (Porter, 1984).

GROWPHOS

0 *Default*	Leaf assimilation is calculated using the radiation use efficiency concept. (Group P)
1	Leaf assimilation is calculated using a light response curve for photosynthesis taking account of growth respiration (France and Thornley, 1984) using the additional parameters PPMAX20, PTRANSM, and PGRESP.
2	The same as for (0) but the nitrogen response for photosynthesis is a linear function of total (annual) plant N concentration. This means that parameters NLEAFXG and NLEAFN are used to represent the total N concentration at which photosynthesis is at maximum and minimum.

LITTKCN

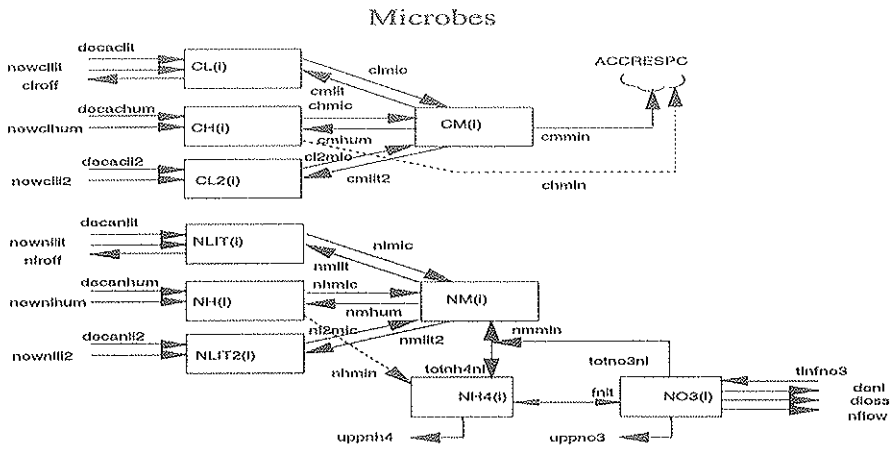
0 *Default*	The specific decomposition rate of litter (LITK) and faeces (FECK) are independent of C/N ratio. (Group S)
1	The specific decomposition rate of litter (LITK) can be set a linear function of the C/N ratio. If MICROB-switch>0 then MICK(1-3) is function of C/N ratio.
2	As for 1 but for faeces (FECK).
3	Both 1 and 2 above.

MICABIO

Only used if MICROB-switch>0

0	Neither microbial mortality rate or maintenance respiration are directly dependent on soil temperature and moisture conditions. (Group M)
1	Microbial mortality rate is dependent on soil temperature conditions.
2	Microbial mortality rate is dependent on soil moisture conditions.
3 *Default*	Microbial maintenance respiration is dependent on soil temperature conditions.
4	Microbial maintenance respiration is dependent on soil moisture conditions.
12,13,14,12 3,...etc	Combinations of the above alternatives. Note give figures in increasing order.

MICROB

0 *Default*	Microbial biomass is not explicitly simulated. Instead it is implicitly included in the litter (CL, NLIT) and faeces (CF, NF) pools (Group M)
1	Microbial biomass (CM, NM) dynamics are simulated. CM and NM receive mass from the litter pool (CL,NLIT) and looses mass to the same pool. The litter pool receives organic material from roots and above ground residues. Note that the meaning of variables related to normal pools are cancelled or modified: flows: NLHUM=NLMIN=NEWNL=NEWCL=NHMIN=0 auxiliaries: RATCNL= C/N meaning may differ, see parameter OUTRATCN Flow scheme is as follows: 
2	Same as for 1, except that an additional organic pool is included, humus (CH, NH). The microbial dynamics are in analogy with that of the litter pool. Specific coefficients for the humus pool should be given.
3	Same as for 2, except that one more organic pool is included, litter2 (CL2, NLIT2).

4	Same as for 2, except that the humus pool is included in the way it is used in the original model, i.e. mineralisation occurs directly from humus, proportional to the humus N and independent of the simulated microbial activity. In addition to the original model, respiration from humus (CH) is calculated. (The flows CHMIC=NHMIC=0, NHMIN>0, CHMIN>0)
91,92,93,94	Same as for 1-4, except that microbial gross consumption rate is proportional to substrate amount instead of microbial biomass.

NH4MOBIL

0 *Default*	Ammonium in soil profile is immobile. (Group M)
1	A fraction of ammonium is adsorbed to solid particles and the rest is in soil water and is mobile between layers, in analogy with nitrate flow.

OPTWATER

0 *Default*	Water response functions for soil biological activity and plant growth are active. (Group M)
1	Soil NH_4 mineralisation or immobilisation is not limited by soil water conditions.
2	Plant growth is not limited by plant water conditions. Only used for GROWTH-switch = 1.
3	Optimum water conditions are assumed for the allocation of assimilates to root function. Only used for GROWTH-switch = 1.
12,13,123,23	Combinations of the above alternatives.

TEMPREQ

0 *Default*	The temperature response function for soil biological processes is calculated from the Q_{10} expression in the whole range. (Group S)
1	The temperature response function is calculated from the Q_{10} expression when the temperature is above TEMLIN. Below that a linear decrease is assumed towards 0 °C where the response diminish.
2	The temperature response function is calculated from a quadratic response function (Ratkowsky function). Note that the TEMBAS parameter change meaning.
3	The temperature response function is calculated from a second order polynomial.
4	Separate parameters may be used for mineralisation, nitrification and denitrification.
14,24	Combinations of the above alternatives.

6 PARAMETERS

Parameters are grouped in accordance to the processes they belongs to. The most important equations are given in the top of each section. The basic ideas behind the equations are given as concerns soil by Johnsson et al. (1987) and as concerns plant Eckersten & Slapokas (1990) and Eckersten & Jansson (1991).

All parameter values may be modified in the PREP-program by pressing the return key when the cursor is located at a certain parameter. A new numerical value may then be specified and is loaded when you go back to the top menu again [Esc].

Beneath the unit in the parameter description a value is sometimes given. This is a default value given by SOILN.DEF file. In the head of each parameter group is given (S), (P) or (M) denoting Soil, Plant and Management, respectively.

6.1 External inputs (M)

Dry and wet deposition to the soil surface is determined by a dry deposition rate (DEPDRY) and the water supply rate (the driving variables infiltration and surface run off) multiplied by the concentration of total nitrogen in precipitation (DEPWC). The ammonium N fraction (DEPFNH4) enters the ammonium pool of the uppermost soil layer whereas the nitrate is separated between surface runoff and infiltration. Commercial fertilizer N (FERN) is applied at a certain day (FERDAY). The fertiliser is dissolved at a constant rate (FERK) and a certain fraction (FERNFNH4) enters the ammonium pool whereas the rest enters the nitrate pool. Under conditions of a water source flow to the soil, this flow can also be a source of nitrogen (see GWCONC). Dry deposition can also be directly taken up by leaves (DEPDRYA).

$N_{Dep\rightarrow NH4} = DEPDRY*DEPFNH4D + DEPWC*(q_{Inf}+q_{Surr})*DEPFNH4W$
$N_{Dep\rightarrow Inf+Surr} = DEPDRY*(1-DEPFNH4D) + DEPWC*(q_{Inf}+q_{Surr})*(1-DEPFNH4W)$

$N_{Dep\rightarrow I} = DEPDRYA*A_I$

$N_{Fert\rightarrow NH4} = FERNFNH4*FERK*N_{Fert}$
$N_{Fert\rightarrow Inf+Surr} = (1-FERNFNH4)*FERK*N_{Fert}$

$N_{I\rightarrow Inf}$ = *see N allocation*
$N_{Iw\rightarrow Inf}$ = *see N allocation*

$N_{Inf\rightarrow NO3} = x*q_{Inf}/(q_{Inf}+q_{Surr})$
$N_{Surr\rightarrow Stream} = x*q_{Surr}/(q_{Inf}+q_{Surr})$
where:
$x = N_{Dep\rightarrow Inf+Surr} + N_{Fert\rightarrow Inf+Surr} + N_{I\rightarrow Inf} + N_{Iw\rightarrow Inf}$

DEPDRY
Dry deposition of mineral N to soil nitrate and/or ammonium. (gN m^{-2} d^{-1})
A value of 0.001 correspond to 3.65 kg N/ha/year. Normal range for an open field in southern Sweden 0.0005 - 0.002 gN m^{-2} d^{-1}. *0.001*
If DRIVEXT-switch = 3:
Then DEPDRY is read from FILE(9)

DEPDRYA
Dry deposition of mineral N on canopy per unit of leaf area and which is taken up by leaves. (gN m^{-2} d^{-1})
Only used if GROWTH-switch = 1 *0*

DEPFNH4D
Fraction of ammonium N in DEPDRY. The rest is nitrate N (-)
0

DEPFNH4W
Fraction of ammonium N in wet deposition given by DEPWC. The rest is nitrate N (-)
0

DEPWC
Concentration of mineral N in infiltration and surface runoff. (mg l^{-1})
During a year with 800 mm infiltration a value of 0.8 corresponds to a wet deposition of 6.4 kg N/ha/year. Normal range for southern Sweden 0.8 - 1.8 mg/l and for central Sweden 0.4 - 1.0. *0.8*
If DRIVEXT-switch = 3:
Then DEPWC is read from FILE(9)

FERDAY
Fertilization date (commercial fertilizer). (day number)
140.

FERK
Specific dissolution rate of commercial fertilizer (not the ammonium N, if any). (d^{-1})
A value of 0.15 corresponds to half time of 5 days and that 90% of the fertilizer is dissolved within 15 days. A higher value results in faster dissolution. Dependent on fertilizer type and moisture conditions. Normal range 0.05 - 0.5. *0.15*

FERN
N-fertilization (commercial fertilizer) (gN m^{-2})
1 gN m^{-2} = 10 kgN/ha. Normal range 0 - 30 gN m^{-2}. *8*
If DRIVEXT-switch >= 1:
Then FERN is read from FILE(9)

FERNFNH4
Fraction of dissolved solid N fertiliser that is ammonium. The rest is nitrate N (-)
0

GWCONC
Concentration of nitrate in deeper groundwater. Input of N to profile from below is visible by DFLOW (driving variable) at the lower boundary being < 0. The negative value is added to the flow DLOSS. (mgN l^{-1})
Depends on the local conditions. Normal range 0.1 - 5. *0.3*

6.2 Manure application (M)

Manure can be applied during three different periods according to day numbers assigned to MANST and MANET. The manure-N is split up between inorganic forms as ammonia (MANNH), organic forms as faeces-N (MANFN) and litter-N (MANLN). The organic forms of manure are described by carbon-nitrogen ratios CNBED and CNFEC for litter and faeces respectively. Applied manure is mixed into the soil down to a depth given by the MANDEPTH parameter.

CNBED
C-N ratio of bedding in manure (-)
(index= application period 1, 2 or 3) *30.*
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range from 20 to 80. Default value 30.

CNFEC
C-N ratio of faeces in manure (-)
(index= application period 1, 2 or 3) *20.*
Only used when the MANURE switch is ON and DRIVEXT < 2
Depend on type of animals. Normal range 10 - 30. Default value 20.

MANDEPTH
Depth to which the applied manure is uniformly mixed into the soil (m)
(Index= application period 1, 2 or 3). *0.1*
Only used when the MANURE switch is ON and DRIVEXT < 2
Maximum depth = depth of layer 1+2. Normal range 0.5 - 0.25 m. Default value 0.10 m.

MANET
Last date of manure application (day number)
(index= application period 1, 2 or 3) *100.*
Only used when the MANURE switch is ON and DRIVEXT < 2
If MANET is given the same value as MANST the application of manure is made during one day.

MANFN
Nitrogen in faeces in manure ($gN\ m^{-2}$)
(index= application period 1, 2 or 3).
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range 0 - 30 $gN\ m^{-2}$.

MANLN
Nitrogen in bedding in manure ($gN\ m^{-2}$)
(index= application period 1, 2 or 3).
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range 0 - 5 $gN\ m^{-2}$.

MANNH
Nitrogen in ammonium in manure (gN m^{-2})
(index= application period 1, 2 or 3).
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range 0 - 30 gN m^{-2}.

MANST
First date of manure application (day number)
(Index= application period 1, 2 or 3) *100.*
Only used when the MANURE switch is ON and DRIVEXT < 2

6.3 Soil and Plant management (M)

At start of growth or simulation a certain amount of plant biomass exists on the field (TOTW(i); i=1-3 depending on which cultivation of the year is concerned).

Harvest of plant can take place at three different dates (UPET). At these dates a fraction of leaves (HARL) and a fraction of stems (HARS) are harvested. Another fraction remains alive: HARLL for leaves and HARLS for stems. The rest is included in the pool for above ground residuals (see output variables INCALIT and INCALITC). Concerning the roots a fraction remain alive (HARLR) and the rest is included in the litter pools in the horizon in accordance to the root depth distribution (see output variables NEWNL and NEWCL). At the day of ploughing (PLODAY) all remaining living leaves and stems, and roots down to a depth given by PLOUGHDEP, all above ground residues are evenly included in the litter pools down to a depth of PLOUGHDEP. The living roots below PLOUGHDEP are incorporated in the corresponding litter pools. Note, it is not possible to harvest at the same day as ploughing is made.

If GROWTH-switch = 0 then plant N is in focus. The plant is split into a harvested fraction (HARS), a fraction of plant residues above ground (HARLR) and a fraction of remaining living biomass-N (HARL). The residual (1-HARS-HARLR-HARL) is considered as dead root N. The dead root N is included into the litter-N pool and split between different soil horizons according to the depth distribution of roots (see parameter ROOT). The dead root C content is set according to a carbon-nitrogen ratio of roots (CNROOT).

CNARES
C-N ratio of above ground residues (-)
Normal range 20-100. Default value represents a grain crop. *50.*
If GROWTH-switch > 0: Not used. If DRIVMANA-switch = 2: Not used.

CNROOT
C-N ratio of roots (-)
Normal range 20-30. *25.*
If GROWTH-switch > 0: Not used. If DRIVMANA-switch = 2: Not used.

HARAR
Above ground residue fraction of plant N at harvest (-)
(index= growth period 1, 2 or 3) *0*
If GROWTH-switch > 0: Not used. If DRIVMANA-switch = 2: Not used.

HARG
The fraction of grains that is harvested. (-)
If GROWTH-switch = 0: Not used. If DRIVMANA-switch = 2: Not used. *0.*

HARL
The fraction of leaves that is harvested. (-)
(index= growth period 1, 2 or 3) *0.*
If GROWTH-switch = 0: Not used. If DRIVMANA-switch = 2: Not used.

HARLL
Fraction of leaves alive after harvest. (-)
(index= growth period 1, 2 or 3) *0*
If GROWTH-switch = 0: Not used

HARLR
Fraction of roots alive after harvest (-)
(index= growth period 1, 2 or 3) *0.*
If GROWTH-switch = 0: The fraction refers to plant N (PLANT)
If GROWTH-switch = 1: The fraction refers to root (ROOTN and ROOTW)
If DRIVMANA-switch = 2: Not used.

HARLS
Fraction of stems alive after harvest. (-)
(index= growth period 1, 2 or 3) *0*
If GROWTH-switch = 0: Not used.

HARP
Harvested fraction of plant N (-)
(index = growth period 1-3) *0.5*
If GROWTH-switch > 0: Not used. If DRIVMANA-switch = 2: Not used.

HARS
Fraction of stems that is harvested. (-)
(index = growth period 1-3) *0.5*
If GROWTH-switch = 0: Not used. If DRIVMANA-switch = 2: Not used.

PLOUGHDAY
Date of ploughing or soil cultivation. Note, must differ from harvest day (day number)
UPET.

PLOUGHDEP
Depth of ploughing or soil cultivation (m)
Normal range 0.05 - 0.30 m. *0.25*

TOTW
($W_t(t_o)$) Total plant biomass at start of growth. (gDW m^{-2})
(index= growth period 1, 2 or 3).
Maximum N-concentrations are assumed at the start.
GROWINI-switch=1 implies TOTW(1) is not used.

UPET
(t_e) End of plant uptake period and harvest date (day number)
(index= growth period 1, 2, or 3) *240.*

(CROP): If the GROWTH-switch is 1, 3, or 4:
UPET(i)=367 implies the current growth period is not ended until the simulation is ended.
UPET(i)>367 implies that the growing period (i) is stopped at day UPET(i)-365.
Should be: UPST(i)<UPET(i)<UPST(i+1)
If UPET is given a negative value then: t_e=-UPET and the root biomass remains unchanged.

UPST
(t_o) Start of plant uptake period (day number)
(index= growth period 1, 2 or 3) *120*
(CROP): If the GROWTH-switch is 1, 3 or 4: The parameter equals the earliest day for start of plant development. The temperature may delay the start of growth from this date.
Should be UPST(1)<UPST(2)<UPST(3)<366.
UPST(i)=0 implies the period (i) is cancelled (OBS! This parameter is related to UPET (this parameter group) and TOTW (Crop Biomass group)).

6.4 Soil Profile and Site Description (S)

The soil profile is divided into a number of layers (NUMLAY) with different thickness (THICK). The division of layers is strictly linked to which layers the driving variables represent. The driving variables are usually taken from the SOIL model. Then the borders of layers should coincide with those used in the SOIL simulations. However, number of layers may differ. For instance two layers in SOIL could be represented by one layer in SOILN. Then weighted means of outputs from SOIL should then be used as input to SOILN.

LATID
Latitude of the field. (°)

NUMLAY
Number of layers (maximum 22) in the soil profile used in the simulation

THICK
Thickness of soil layers (m)
Note that those should correspond to those used in the soil water and heat simulation.

UNUM
Replicate number of soil parameters in SOILP.DAT. The replicate number is also used in the PLOTPF program.

UPROF
Profile number as specified in SOILP.DAT. The profile number is also used in the PLOTPF program

6.5 Mineralisation and immobilisation (M)

The microbial activity determines the decomposition rate of litter. The microbial biomass is not explicitly represented but instead lumped into the litter pool. In this way it is assumed that the microbial biomass is constant. Rate coefficient for litter C decomposition is given by the parameter LITK. Efficiency constant (LITEFF) determines the fraction of organic C that after respiration remains as organic C. An assumed constant carbon-nitrogen ratio of microbes (CNORG) and a humification fraction (LITHF) determines the corresponding synthesis of N in litter and humus pools. Depending on the efficiency constants and the actual carbon-nitrogen ratios, litter may either demand nitrogen as ammonium or nitrate (= immobilization) or release nitrogen as ammonium (= mineralisation). The critical carbon-nitrogen ratio of litter for the shift from immobilization to mineralisation is determined by the ratio between CNORG and LITEFF.

The turnover of faeces and litter is treated in a similar way. What differs is the C/N ratio of the decomposing material. For faeces FECK corresponds to LITK, FECEFF to LITEFF and FECHF to LITHF.

Humus N mineralisation is given by the specific rate constant HUMK. Humus C is not represented.

Transformation of ammonium to nitrate (=nitrification) will occur if the ratio nitrate-ammonium is lower than NITR. The rate is controlled by NITK and response functions to temperature, soil water and pH.

If the MICROB-switch = 1 then dynamics of microbial biomass is simulated and C humus is represented explicitly. See section on Special parameters.

$C_{Li\rightarrow Decomp} = LITK*e_t e_m C_{Li}$
$C_{Li\rightarrow Atm} = (1\text{-}LITEFF)*C_{Li\rightarrow Decomp}$
$C_{Li\rightarrow h} = LITEFF*LITHF*C_{Li\rightarrow Decomp}$
$C_{Decomp\rightarrow Li} = LITEFF*(1\text{-}LITHF)*C_{Li\rightarrow Decomp}$

$N_{Li\rightarrow h} = C_{Li\rightarrow h}/CNORG$
$N_{Li\rightarrow Decomp} = C_{Li\rightarrow Decomp}N_{Li}/C_{Li}$
assumption: $C_{Decomp\rightarrow Li}/(N_{Li\rightarrow Decomp}\text{-}N_{Li\rightarrow h}\text{-}N_{Li\rightarrow NH4}) = CNORG$ *implies:*
$N_{Li\rightarrow NH4} = C_{Li\rightarrow Decomp}(N_{Li}/C_{Li} - LITEFF/CNORG)$

$N_{h\rightarrow NH4} = HUMK*e_t e_m N_h$

$N_{NH4\rightarrow NO3} = NITK*e_t e_m e_p(N_{NH4} - N_{NO3}/NITR)\ ;\ >=0$

CNORG
C-N ratio of microorganisms and humified products (-)
Increasing the value results in larger litter N mineralisation rates and increased C-N ratio of litter at which the shift between mineralisation and immobilization occur. Normal range from 5 to 15. *10.*
If MICROB-switch=1: C/N ratio of microbes.

CPLANT
C content of biomass when lost as litter. (gC gDW^{-1})
0.4

FECEFF
Efficiency of the internal synthesis of microbial biomass and metabolites in faeces (-)
0.5
Only used when the MANURE switch is on.
Normal range the same as for LITEFF (0.2 - 0.7).

FECHF
Faeces carbon humification fraction (-)
Only used when the MANURE switch is on. *0.2*
See LITHF for normal range.

FECK
Faeces specific decomposition rate (d^{-1})
Only used when the MANURE switch is on. *0.035*
Of the same order of magnitude as LITK. Dependent on the type of manure.

HUMK
Humus specific mineralisation rate (d^{-1})
A value of 5.0E-5 corresponds to a half time of 38 years under optimum water and temperature conditions. Thus, the effective half time is much longer. Values between 1.0E-5 and 20E-5 have been used. This parameter is also dependent on the definition of the turnover of litter and humus pools according to the assumed humification fraction (see LITHF). If a major part of the residues incorporated into the litter pool is assumed to be re-mineralised ("fast" litter N mineralisation), it is reasonable to assume a lower value than if the reverse ("slow" litter N mineralisation) is assumed (see LITHF). Only used if MICROB-switch=0. *5.0E-5*

LITEFF
Efficiency of the internal synthesis of microbial biomass and metabolites in litter. (-)
0.5
Normal range 0.2 - 0.7 based on literature values of microbial growth yield.
Increasing the value results in increased litter N mineralisation rates and a decreased C-N ratio at which the shift between litter mineralisation and immobilization occur.
Only used if MICROB-switch=0.

LITHF
Litter carbon humification fraction. (-)
Low values, 0.1 - 0.3 (Defining litter turnover as "fast"), results in that a major part of the residues incorporated into the litter-N pool is re-mineralised while a minor part is humified. High values 0.6 - 0.9 ("slow" litter turnover), results in the reverse. High values give the humus pool a more active role for the total mineralisation of nitrogen. A fast litter turnover has been assumed in most applications. *0.2*
Only used if MICROB-switch=0.

LITK
Litter specific decomposition rate. (d^{-1})
A value of 0.035 corresponds to a half time of 20 days under optimum water and temperature conditions. Thus, the effective half time is much longer. Increasing the value results in an increased litter decomposition rate. *0.035*

NITK
Specific nitrification rate. (d^{-1})
0.2

NITR
Nitrate-ammonium ratio in nitrification function. (-)
Normal range for agricultural soils 1 - 15. *8.*

6.6 Soil abiotic response (S)

A common soil temperature response function is used for mineralisation, immobilization and nitrification. The activity increases exponentially with temperature having the Q_{10}-value as a base. Different values of parameters in the response function for mineralisation, immobilization and nitrification, respectively, could be given, see the Special parameter group.

A common soil moisture response function is used for mineralisation, immobilization and nitrification. The activity is zero below the wilting point (defined in the SOILP.DAT file or by parameter WILT) and increases to unity in a soil moisture interval given by MOS(1). Near saturation, the activity decreases down to a saturation activity (MOSSA) in an interval given by MOS(2). Soil porosity (saturation water content) is defined in the SOILP.DAT file or by parameter PORO. The shape of the response curve in the intervals MOS(1) and MOS(2) can be varied according to the MOSM parameter.

The acidity of the soil (PH) affects the nitrifiers. A multiplicative response ranging between 0 at PHMIN and 1 at PHMAX affects nitrification.

Denitrification increases with increasing water content in an interval MOSDEN below saturation water content (PORO). The shape of the response curve may be varied according to DEND.

e_t = TEMQ10**((T_s-TEMBAS)/10)
e_m = MOSSA + (1-MOSSA)*x**MOSM ; *when* θ_s-MOS(1)<θ<θ_s
where
x = (θ_s - θ)/MOS(1)
e_m = ((θ - θ_w)/MOS(2))**MOSM ; *when* θ_w<θ<θ_w+MOS(2) , 0<= e_m <= 1

e_p = (PH(I) - PHMIN)/(PHMAX-PHMIN) , 0<= e_p <= 1

e_{md} = ((θ - (θ_s - MOSDEN))/MOSDEN)**DEND , 0<= e_{md} <= 1

DEND
Coefficient in function for soil moisture/aeration effect on denitrification. (-)
A linear response correspond to a value of 1 whereas higher values results *2*
in a concave non-linear response.

MOS
Water content intervals in the soil moisture response function defining ranges (%)
for increasing and decreasing biological activity.

MOS(1): Water content interval defining increasing activity from 0 (no *13*
activity) at wilting point to unity (optimum activity) at MOS(1) + wilting
point. Normal range 8 - 15 vol %, depending on soil type.

MOS(2): Water content interval defining decreasing activity from 1 *8*
(optimum activity) at porosity - MOS(2) to the activity given by parameter
MOSSA at porosity. Normal range 1 - 10 vol %, depending on soil type.

MOSDEN
Water content range in function for soil moisture/aeration effect on (vol %)
denitrification *17.*
Water content interval defining increasing activity from 0 (no activity) at
saturation water content - MOSDEN, to 1 (optimum activity) at saturation
water content.

MOSM
Coefficient in soil moisture function. (-)
A linear response correspond to the value 1.0. Values between 0 and 1 results *1*
in a convex response and values larger than 1 in a concave response.

MOSSA
Saturation activity in soil moisture response function. (-)
A value of 1 corresponds to optimum activity at saturation and 0 no activity. *0.6*
Normal range 0 - 1.

OUTLAY
(i) Layer. Only for presentation of outputs. For different soil response (-)
functions which are calculated for each layer but only have one output *1*
variable for presentation. OUTLAY is the soil layer for which the response
function will be stored. A value outside 1-10 will give you the average
response function for all layers.

PH
Acidity in terms of pH in each layer (-)
Index = soil layers (1-10) *0*
If PH(I) = 0 then the pH variable is not considered in any calculations of the layer concerned.

PHMAX
pH above which nitrification is not affected by acidity (-)
0

PHMIN
pH below which nitrification is zero (-)
0

TEMBAS
For the mineralisation-immobilisation process; Base temperature at which temperature effect = 1. (°C)
20

TEMQ10
For the mineralisation-immobilisation process. Response to a 10 °C soil temperature change. A value of 2 results in a doubled activity with a 10 °C increase in temperature. Normal range between 1.5 and 4. (-)
3

6.7 Denitrification (S)

Denitrification (=loss of nitrate from soil to the atmosphere) is calculated according to a potential rate (DENPOT), the nitrate concentration in soil solution and response functions for temperature and moisture. The temperature response is the same as for the other biological processes. The distribution of the potential rate of denitrification in the soil profile can be given separately for each layer (DFRAC) or according to distribution functions (see switch DENDIST). Denitrification is reduced when the nitrate concentration decreases in soil water solution according to a Micahelis-Menten type function (DENHS).

$N_{NO3\rightarrow atm} = f_r * DENPOT * e_t e_{md} x/(x + DENHS)$
where:
$x = N_{NO3}/\theta/\Delta z$
f_r = *fraction of total denitrification activity occurring in the layer concerned*

If DENDIST-switch=0:
$f_r(i) = DFRAC$
If DENDIST-switch=3:
$f_r(i) = (1 - \exp(-k_d z(i)/DENDEPTH))/(1 - DFRACLOW)$
where:
$k_d = -\ln(DFRACLOW)$

DENDEPTH
The depth where the denitrification capacity ceases. (m)
Only used when the DENDIST switch is set to 1,2 or 3.

DENHS
Half saturation constant in function for nitrate concentration effect on denitrification. Nitrate concentration at which the activity is half of the activity at optimum nitrate concentrations. Normal range 5 - 15. (mgN l^{-1}) *10*

DENPOT
Potential rate of denitrification. Dependent on type of cropping system and soil. Typical value for a barley crop on a loam soil 0.04 and for a grass ley 0.2. (gN m^{-2} d^{-1}) *0.04*

DFRAC
Fraction of potential denitrification in layers (-)
(Index= layer. 1 to minimum of 10 and NUMLAY)
Only used when the DENDIST switch is set to 0
A first assumption may be to assume similar distribution as the root distribution or the distribution of soil organic matter since the activity of denitrifiers is known to depend on carbon availability.

DFRACLOW
Fraction of the exponential function remaining below the depth where the denitrification activity ceases (DENDEPTH). The remaining fraction DFRACLOW is equally distributed among layers above the denitrification depth. (-) *0.05*
Normal range of k_d 2.5 - 4.5 corresponds to values from 0.08 to 0.01 of DFRACLOW.
Only used if DENDIST-switch = 3

6.8 Stream water (S)

Litter in uppermost layer and above ground residues is lost to stream by surface runoff.

Nitrate N is lost by consumption of nitrogen in a stream.

$N_{Li \rightarrow Stream} = LITTROFF * q_{Surr} N_{Li}$
$C_{Li \rightarrow Stream} = LITTROFF * q_{Surr} C_{Li}$

$N_{ab \rightarrow Stream} = ABOVROFF * q_{Surr} N_{ab}$
$C_{ab \rightarrow Stream} = ABOVROFF * q_{Surr} C_{ab}$

$N_{Surr \rightarrow Stream}$ = *see External inputs*

$N_{Stream \rightarrow Consum} = CONPOT * e_t N_{Stream} / (N_{Stream} + CONCRI)$; if $T_s > CONTEM$

ABOVROFF
Fraction of above ground residue lost per unit (mm) runoff. (mm^{-1})

CONCRI
Half saturation constant in calculation of nitrate consumption in stream water (-)

CONPOT
Potential rate of nitrate consumption in stream water. ($gN\ m^{-2}\ d^{-1}$)
Note that the area correspond to the total watershed area simulated. Value dependent on the total stream length in the watershed as well as on the biological factors in the stream. *0*

CONTEM
Lower temperature limit for nitrate consumption in stream water (°C)

LITTROFF
Fraction of litter in uppermost layer lost per unit (mm) runoff. (mm^{-1})

6.9 N root uptake (S)

Root depth: If GROWTH-switch = 1 then ROOTDINC and ROOTDMIN determine the root depth development. If GROWTH-switch = 0 then the development of the root depth is given by parameters ROOTT and ROOTDEP.

Distribution of plant N uptake capacity: Root biomass/area distribution in the soil profile can be given separately for each layer (ROOTF) or according to distribution functions (see switch ROOTDIST).

Plant N demand: If Growth-switch = 1: Plant demand for inorganic nitrogen from the soil (both nitrate and ammonium) is controlled by the growth of the plant (see the plant growth model: If the GROWTH-switch = 0 the plant demand is determined by a logistic uptake function defining the potential demand (UPA, UPB and UPC).

Soil N availability: The maximum amount of mineral N available for uptake from a soil layer is controlled by the UPMA parameter. In cases when actual uptake from one layer is below the potential uptake, re-allocation of the uptake demand to other layers occurs to a degree given by UPMOV.

$N_{Soil\rightarrow Plant}(i) = N_{Soil\rightarrow NO3}(i) + N_{Soil\rightarrow NH4}(i)$
$N_{Soil\rightarrow NO3}(i) = \min (UPMA*N_{NO3}(i), x_{fra}N_{PotUp}(i))$
$N_{Soil\rightarrow NO3}(i) = \min (UPMA*N_{NH4}(i), (1 - x_{fra})N_{PotUp}(i))$
where:
$N_{PotUp}(i) = a_r(i)N_{Demand} + N_{Deficit}$
$N_{Deficit} = \Sigma\ UPMOV*(N_{Potup}(i) - N_{Soil\rightarrow Plant}(i))$
$x_{fra} = N_{NO3}(i)/(N_{NO3}(i)+N_{NH4}(i))$

If GROWTH-switch=1:
$N_{Demand} = N_{lDemand} + N_{sDemand} + N_{rDemand}$; *see N allocation*
If GROWPEREN-switch=1:
$N_{Demand} = N_{Demand} - N_{a\rightarrow Upt}$

If ROOTDIST-switch=3:
The fraction of roots (ar) that are found above a depth z:
$a_r(i) = (1 - \exp(-k_r z(i)/z_r))/(1 - RFRACLOW)$
where:
$k_r = -\ln(RFRACLOW)$
If GROWTH-switch=1:
$z_r = ROOTDMIN*W_r/(W_r+ROOTDMIN/ROOTDINC)$; $z_r \geq ROOTDMIN$

RFRACLOW
Fraction of the exponential function remaining below the root depth. This fraction is distributed equally among layers above the root depth. Normal range of k_r 2.5 - 4.5 corresponds to values from 0.08 to 0.01 of RFRACLOW. Only Used when the ROOTDIST-switch=3. (-) *0.05*

ROOTDEP
(z_r) Root depth at days given of ROOTT(I) (m)
(Index= 1 to 5)
Only used when the DRIVCROP-switch = 0 and GROWTH-switch = 0.

ROOTDINC
Parameter determining root depth as function of root biomass; (OBS! <0). (m)

ROOTDMIN
Lowest level for roots (OBS! <0) (-largest root depth). (m)

ROOTF
(a_r) Fraction of roots in layers (when fully developed) (-)
(Index= layer 1 to min(10, NUMLAY))
Only used when the ROOTDIST switch is set to 0.

ROOTT
Day number for deepest root depth given of ROOTDEP(I) (day number)
(Index = 1 to 5)
Day number for deepest root depth given of ROOTDEP(1) (Index=6)
Only used when the DRIVCROP-switch = 0 and GROWTH-switch = 0.

UPA
Potential nitrogen uptake (u_c) (gN m^{-2} yr^{-1})
(index= growth period 1, 2 or 3) *20.*
Typical values may be around 20 gN m^{-2} yr^{-1} for a grain crop and 40 gN m^{-2} yr^{-1} for a grass ley in south and central Sweden.
If GROWTH-switch > 0: Not used.

UPB
Coefficient in plant uptake function (u_b) (-)
In case of an annual crop, UPB is the initial plant N content (gN m^{-2} yr^{-1}) at the start of the plant uptake period, i.e., the N-content of seed. A normal variation of UPB is 0.1 - 1.5. n.b! In older versions of the SOILN model the UPB parameter was defined slightly different, corresponding to (UPA-u_b)/u_b. Thus, a value of UPB of 0.95 and UPA of 20 in the present version of the model corresponds to a value of 20 in older simulations. *1.*
If GROWTH-switch > 0: Not used.

UPC
Coefficient in plant uptake function (u_c) (d^{-1})
Determines the plant development rate. Increasing UPC results in that the peek uptake occurs faster and at a higher rate. Typical values for rapid developing grain crops is around 0.12 and for slower developing crops like sugar-beets 0.04. Normal values 0.02 - 0.14. *0.12*
If GROWTH-switch > 0: Not used.

UPMA
Fraction of mineral N available for immobilization and plant uptake. For the lowest soil layer with roots, UPMA for roots is decreased in proportion to how large fraction of the layer that is not penetrated by roots. (d^{-1})
A value of 0.1 is equivalent to that 10% of the total mineral-N pool is available at one time-step. Normal range 0.05 - 0.12. *0.08*

UPMOV
Compensatory N uptake from layers with access of N. (-)
A value of 1 results in the most efficient compensation (i.e., all differences between potential and actual uptake occurring in layers with mineral N deficiency is added to the uptake demand in layers with no deficiency). A value of 0 represents a case where the uptake demand is strictly partitioned between different soil layers according to the soil root distribution. *1*

6.10 Leaf assimilation (P)

The potential total assimilation rate is basically proportional (PHOEFF) to the amount of solar radiation intercepted by the canopy (EXTCOEFF). The radiation use efficiency is decreased in case of grain development (PHOREDUC). The actual radiation use is finally determined by the reduction factors for low (or too high) temperature (PHOTEMP), low leaf nitrogen concentration (NLEAFN and NLEAFXG) or plant water stress.

If GROWPEREN-switch=1 then assimilates from the available pool in plant is added to the daily assimilation pool.

$W_{Atm\rightarrow p} = \alpha\, I_i\, f_T\, f_N\, f_W$
where:
α = PHOEFF-PHOREDUC*W_g
$I_i = I(1 - \exp(-EXTCOEFF * A_l))$
$f_T = (T_a - PHOTEMP(1))/(PHOTEMP(2)-PHOTEMP(1))$; $0<=f_T<=1$; $T<PHOTEMP(3)$
$f_T = 1 - (T_a-PHOTEMP(3))/(PHOTEMP(4)-PHOTEMP(3))$; $0<=f_T<=1$; $T>PHOTEMP(3)$
$f_N = (n_l - NLEAFN)/(NLEAFXG - NLEAFN)$
$f_W = E_t/E_{tp}$ *(input variable; see also special parameters)*

If GROWPEREN-switch=1:
$W_{Atm\rightarrow p} = W_{Atm\rightarrow p} + W_{a\rightarrow p}$

EXTCOEF
Radiation extinction coefficient for the canopy. (-)

NLEAFN
Leaf nitrogen concentration in leaf at which minimum growth occurs. (-)
If GROWPHOS-switch=2: Total plant N concentration at which minimum photosynthesis occurs.

NLEAFXG
Leaf nitrogen concentration in leaf at which maximum photosynthesis. (-)
If GROWPHOS-switch=2: Total plant N concentration at which maximum photosynthesis occurs.

PHOEFF
Radiation use efficiency at optimum temperature, water and nitrogen conditions. (gDW MJ^{-1})

PHOREDUC
Radiation use efficiency decreased due to grain development. Only used if GROWGRAIN-switch=1 (MJ^{-1})

PHOTEMP
Coefficients for the response of the growth (photosynthesis) to temperature.

PHOTEMP(1): Minimum daily mean air temperature for growth. (°C)

PHOTEMP(2): Minimum daily mean air temperature for optimum growth. (°C)

PHOTEMP(3): Maximum daily mean air temperature for optimum growth. (°C)

PHOTEMP(4): Maximum daily mean air temperature for growth. (°C)

6.11 Biomass allocation (P)

The plant biomass is divided into four compartments: root (W_r), stem (W_s), leaf (W_l) and grain (W_g). The daily new assimilates are partitioned between root, stem and leaf whereas grain receives assimilates from the other tissues. The root development is stimulated by low plant nitrogen (AROOTNI) or water status (AROOTE) but decreases with plant size (AROOTW). When grain development occurs allocation to roots is at a minimum (AROOTN). The allocation between stem and leaf depends on specific leaf area (WLAI) and the leaf area expansion. The latter in turn depends on above ground growth and biomass. The leaf area expansion increases with growth but decreases as the shoots become larger (ALEAF). When the above ground biomass has reached a high level no further development occurs. In this way the plant size strongly influences the partitioning between different organs. The grain development starts when a function of air temperature and day-length exceeds over a certain limit. Then a fraction of the assimilates in the stem tissues are translocated to grain (AGRAIN(2)). The stem receives assimilates from leaves (ADRAWLW) and roots (AGRAIN(3)). The vegetative growth goes on also after this time, although considerably reduced by the grain development. A certain fraction of the leaf biomass is withdrawn to stem (ADRAWLW) before abscission and a certain fraction of root litter is withdrawn to living roots (ADRAWRW).

In case of perennial plant accumulated current year growth is allocated to old biomass at a certain day (age) DAYPEREN. Assimilates can be released from biomass to an available pool both from young (AVACUR) and old (AVAWOOD) tissues. The available pool is then added to the daily total photosynthesis and allocated between leaf, stem and root.

$W_r' = W_{p\to r} - W_{r\to Li} - W_{r\to g} - W_{r\to Atm} - W_{r\to a}$

where:

$W_{p\to r} = b_r W_{Atm\to p}$

$W_{r\to Li}$ = *see Litter*

$W_{r\to g} = AGRAIN(3)*W_r$; = 0 if $i_g < 1$ *or GROWALLO-switch=1*

$W_{r\to s} = AGRAIN(3)*W_r$; = 0 if $i_g < 1$ *or GROWALLO-switch=0*

$W_{r\to Atm}$ = *see Respiration*

$W_{r\to a}$ = *see below*

where:

$b_r = \max(b_{rn}, b_{rw}, b_{re}, AROOTN)$; b_r= AROOTN if $i_g > 1$; b_r= 1 if $f_T <= 0$

$b_{rw} = AROOTW(1) + AROOTW(2)*W_t$ *(Note can differ, see Special parameters)*

$b_{rn} = AROOTNI(1) + AROOTNI(2)*(n_l' - NLEAFN)/(NLEAFXG - NLEAFN)$ *(Note can differ, see Special parameters)*

$b_{re} = AROOTE(1) + AROOTE(2)*(1 - AROOTETR*E_t/E_{tp})$ *(Note can differ, see Special parameters)*

$n_l' = N_{Soil\to l}/W_{p\to l}$

$A_l'(in) = W_{Ta}'(ALEAF(1) - ALEAF(2)*(1 + \ln(W_{Ta})))$; $A_l'(in) \geq 0$; $A_l'(in) \leq WLAI*W_{Ta}'$ *(Note can differ)*

where:

$W_{Ta} = W_l + W_s + W_g$

$W_l' = W_{p\to l} - W_{l\to Ab} - W_{l\to g} - W_{l\to Atm} - W_{l\to a}$

where:

$W_{p\to l} = A_l'(in)/WLAI$

$W_{l\to Ab}$ = *see Litter*

$W_{l\to g} = AGRAIN(1)*W_l$; = 0 if $i_g < 1$ *or GROWALLO-switch=1*

$W_{l\to Atm}$ = *see Respiration*

$W_{l\to a}$ = *see below*

$W_s' = W_{p\to s} + W_{l\to s} + W_{r\to s} - W_{s\to Ab} - W_{s\to g} - W_{s\to Atm} - W_{s\to a}$

where:

$W_{p\to s} = W_{Atm\to p} - W_{p\to r} - W_{p\to l}$

$W_{l\to s} = ADRAWLW*W_{l\to Ab}$

$W_{s\to Ab}$ = *see Litter*

$W_{s\to g} = AGRAIN(2)*W_s$; = 0 if $i_g < 1$

$W_{s\to Atm}$ = *see Respiration*

$W_{s\to a}$ = *see below*

$W_g' = W_{s\to g} + W_{l\to g} + W_{r\to g} - W_{g\to Atm}$
where:
$W_{g\to Atm}$ = *see Respiration*

If GROWPEREN-switch=1:
If t = DAYPEREN:
$W_{r\to a} = f_{Tas}$*AVACUR*W_r
$W_{rw\to a} = f_{Tas}$*AVAWOOD*W_{rw}
$W_{s\to a} = f_{Tap}$*AVACUR*W_s
$W_{sw\to a} = f_{Tap}$*AVAWOOD*W_{sw}
D:o for leaf: $W_{l\to a}$, $W_{lw\to a}$
where:
$f_{Tas} = (T_s$ - AVATEM(1))/(AVATEM(2)-AVATEM(1)); $0<=f_{Tas}<=1$; $T_s=\max(T_s(z))$
$f_{Tap} = (T_a$ - AVATEM(1))/(AVATEM(2)-AVATEM(1)); $0<=f_{Tap}<=1$

$W_{r\to rw} =$ APEREN*(W_r - $W_{r\to a}$)
$W_{s\to sw} =$ APEREN*(W_s - $W_{s\to a}$)
$W_{l\to lw} =$ APEREN*(W_l - $W_{l\to a}$) ; = 0 *If GROWDECID-switch=1*

$W_{rw}' = W_{r\to rw} - W_{rw\to a} - W_{rw\to Li} - W_{rw\to Atm}$
$W_{sw}' = W_{s\to sw} - W_{sw\to a} - W_{sw\to Li} - W_{sw\to Atm}$
$W_{lw}' = W_{l\to rw} - W_{lw\to a} - W_{lw\to Li} - W_{lw\to Atm} - W_{lw\to l}$
where:
$W_{rw\to Li} =$ (ALITTERR(1)-ADRAWRW)*$W_{p\to r}(t_1)$ + ALITTERR(2)*W_{rw}
$t_1 = t$-AROOTAGE *; in this case ALITTERR(2) is not used in* $W_{r\to Li}$
$W_{sw\to Li} =$ ALITTERS*W_{sw} ; then $W_{s\to Li} = 0$
$W_{lw\to L} =$ ADRAWLW*ALITTERL*W_{lw} ; = 0 *If GROWDECID-switch = 1*
$W_{lw\to Li} =$ (1-ADRAWLW)*ALITTERL*W_{lw} ; = 0 *If GROWDECID-switch = 1*
$W_{rw\to Atm} =$ *dito* $W_{r\to Atm}$ *but* W_r *replaced by* W_{rw} ; $W_{r\to Atm} = 0$; *see Respiration*
$W_{sw\to Atm} =$ *dito* $W_{s\to Atm}$ *but* W_s *replaced by* W_{sw} ; $W_{s\to Atm} = 0$; *see Respiration*
$W_{lw\to Atm} =$ *dito* $W_{l\to Atm}$ *but* W_r *replaced by* W_{lw} ; $W_{l\to Atm} = 0$; *see Respiration*

ADRAWLW
Fractional withdrawal of dry weight in leaf litter to stem before abscission. If GROWPEREN = 1 withdrawal is from old leaves to new leaves. (-)

ADRAWRW
Fractional withdrawal of dry weight in current year old root litter fall to the same pool before abscission. (-)

AGRAIN
Fraction of biomass in tissues re-allocated to other tissues during grain development.

AGRAIN(1): (d^{-1})
If GROWALLO-switch=0: From leaves to grain.
If GROWALLO-switch=1: Not used (see ADRAWLW)

AGRAIN(2): From stem to grain. (d^{-1})

AGRAIN(3): (d^{-1})
If GROWALLO-switch = 0: From roots to grain.
If GROWALLO-switch = 1: From roots to stem.

ALEAF
Coefficients for leaf area development as function of shoot biomass. NOTE! Depend on GROWAEQ-switch. For explanation of coefficients see GROWAEQ. Independent variable is above ground biomass ($x=W_{Ta}$). No "other equation" is available.

ALEAF(1): Coefficient a (m^2 gDW^{-1})

ALEAF(2): Coefficient b (differ)

ALEAF(3): Coefficient c (differ)

AROOTN
Minimum fraction of daily total growth allocated to roots. (-)

APEREN
() Fraction of annual growth allocated to woody pools. (-)

AVACUR
(w_a) Fraction of accumulated current year growth allocated to the available pool, daily. (d^{-1})

AVATEM
Coefficients for the response of the release of assimilates from biomass, to temperature.

AVATEM(1): Minimum daily mean soil temperature for release of assimilates. (°C)

AVATEM(2): Minimum daily mean soil temperature for maximum release of assimilates. (°C)

AVAWOOD
(w_{aw}) Fraction of old biomass allocated to the available pool, daily. (d^{-1})

WLAI
Specific leaf area. (m^2 gDW^{-1})

6.12 N allocation (P)

Allocation of the daily total nitrogen uptake to root, stem and leaf is based on the idea that the roots receive nitrogen first, until they reach their maximum concentrations (NROOTX). Then the stem (NSTEMX) and finally the leaf (NLEAFXD). Leaves can take up nitrogen from deposition (see parameter DEPDRYA).

The allocation of plant nitrogen as well as allocation to litter basically follows the allocation of biomass in accordance with the N concentrations. However parameters allow you to change those proportions.

The amount N leached from canopy is a fraction (ALEACHLN) of the amount N in leaves times the throughfall rate up to a certain value PRECLEAC.

N dynamics of perennial pools follows the dynamics of the corresponding biomass pools (see Biomass allocation parameters). Concerning the available assimilates N is released from structural biomass in proportion to the biomass flows, and delivered to the uptake flow of nitrogen, thereby allocated in relation to demand by different organs.

$N_{Soil\rightarrow r} = \min(N_{Soil\rightarrow Plant}, N_{rDemand})$; ≥ 0
$N_{Soil\rightarrow s} = \min(N_{Soil\rightarrow Plant}-N_{Soil\rightarrow r}, N_{sDemand})$; ≥ 0
$N_{Soil\rightarrow l} = \min(N_{Soil\rightarrow Plant}-N_{Soil\rightarrow r}-N_{Soil\rightarrow s}, N_{lDemand})$; ≥ 0
where:
$N_{rDemand} = NROOTX*W_{p\rightarrow r}$
$N_{sDemand} = NSTEMX*W_{p\rightarrow s}$
$N_{lDemand} = NLEAFXD*W_{p\rightarrow l}$

$N_r' = N_{Soil\rightarrow r} - N_{r\rightarrow Li} - x_1 - x_2$
$N_s' = N_{Soil\rightarrow s} + x_1 + x_3 - N_{s\rightarrow Ab} - n_s W_{s\rightarrow g}*AGRAINN(2)/AGRAIN(2)$
$N_l' = N_{Soil\rightarrow l} + N_{Dep\rightarrow l} - N_{l\rightarrow Ab} - x_3 - x_4 - + N_{l\rightarrow NO3}$
$N_g' = n_s W_{s\rightarrow g}*AGRAINN(2)/AGRAIN(2) + x_2 + x_4$
where:
$x_1 = n_r W_{r\rightarrow s}*AGRAINN(3)/AGRAIN(3)$ *if GROWALLO-switch=1*
$x_2 = n_r W_{r\rightarrow g}*AGRAINN(3)/AGRAIN(3)$ *if GROWALLO-switch=0*
$x_3 = n_l W_{l\rightarrow s}*AGRAINN(1)/AGRAIN(1)$ *if GROWALLO-switch=1*
$x_4 = n_l W_{l\rightarrow g}*AGRAINN(1)/AGRAIN(1)$ *if GROWALLO-switch=0*
$N_{r\rightarrow Li} = n_r W_{r\rightarrow Li}*ADRAWRN/ADRAWRW$
$N_{s\rightarrow Ab} = n_s W_{s\rightarrow Ab}$
$N_{l\rightarrow Ab} = n_l W_{l\rightarrow Ab}*ADRAWLN/ADRAWLW$
$N_{Dep\rightarrow l} =$ *see External inputs*
$N_{l\rightarrow Inf+Surr} = N_l*ALEACHLN*(q_{Inf}+q_{Surr})/PRECLEAC$

ADRAWLN
Fractional withdrawal of nitrogen in leaves before abscission. From leaf litter to stem. (-)

ADRAWRN
Fractional withdrawal of nitrogen in roots before abscission. From root litter to roots. (-)

AGRAINN
Fraction of N in tissues re-allocated to other tissues during grain development.

AGRAINN(1): (d^{-1})
If GROWALLO-switch = 0: From leaves to grain.
If GROWALLO-switch = 1: Not used (see ADRAWLN)

AGRAINN(2): From stem to grain. (d^{-1})

AGRAINN(3): (d^{-1})
If GROWALLO-switch = 0: From roots to grain.
If GROWALLO-switch = 1: From roots to stem.

ALEACHLN
Fraction of N in leaves and old leaves that are leached to soil nitrate each day in case of water throughfall more or equal to PRECLEAC mm. (d^{-1})

NLEAFXD
Leaf nitrogen concentration corresponding to maximum demand. (-)

NROOTX
Maximum nitrogen concentration of root biomass. (-)

NSTEMX
Maximum nitrogen concentration of stem biomass. (-)

PRECLEAC
Throughfall limit above which no further increasing of leaching from canopy occurs. (mm)

6.13 Respiration & Litter (P)

Maintenance respiration is a function of biomass content (WRESP) and temperature. The temperature response follows a Q_{10} function in a similar way as decomposition of organic matter, however with its own parameters (TEMQ10P and TEMBASP). Above ground respiration depends on air temperature whereas root respiration depends soil temperature.

Leaf litter fall is a fraction of leaf biomass (ALITTERL) and depends on leaf age (ALEAFAGE). Stem litter fall is a fraction of stem biomass (ALITTERS). Root litter fall is a fraction of root biomass (ALITTERR(2)) and depends on age of roots (AROOTAGE). All plant litter is assumed to have the same C/biomass ratio (CPLANT). In case of perennial plant maintenance respiration occurs only from old biomass.

Leaves and stems fall to a pool for above ground residues (LITABOVE and LITABOVEC). This pool is assumed to be inactive as regards microbial activity. The pool lose N and C either through leaching (ABOVELN and ABOVELC) or transfer of residues to the uppermost litter pool determined by a rate coefficient (ABOVEK) or to faeces (ABOVEFEC).

$W_{r\rightarrow Atm} = WRESP*e_{tr}*W_r$ *where:* $e_{tr} = TEMQ10P**((T_s-TEMBASP)/10)$ $W_{s\rightarrow Atm} = WRESP*e_{tp}*W_s$ $W_{l\rightarrow Atm} = WRESP*e_{tp}*W_l$ *where:* $e_{tp} = TEMQ10P**((T_a-TEMBASP)/10)$ *If GROWPEREN-switch=1:* $W_{r\rightarrow Atm} = W_{s\rightarrow Atm} = W_{l\rightarrow Atm} = 0$ $Q_{r\rightarrow Atm} = WRESP*e_{tr}*Q_r$ $Q_{s\rightarrow Atm} = WRESP*e_{tp}*Q_s$ $Q_{l\rightarrow Atm} = WRESP*e_{tp}*Q_l$
$W_{l\rightarrow Ab} = W_{p\rightarrow l}(t_1) + ALITTERL*W_l - W_{l\rightarrow s}$; $t_1 = t\text{-}ALEAFAGE$ $W_{s\rightarrow Ab} = ALITTERS*W_s$ $C_{Ab\rightarrow Out} = ABOVELC*C_{Ab}$; if $q_{Inf}>0$ $C_{Ab\rightarrow Li} = ABOVEK*C_{Ab}$; if $T_s(1)>0$ $W_{r\rightarrow Li}(i) = a_r(i)W_{r\rightarrow Li}$ *where:* $W_{r\rightarrow Li} = (ALITTERR(1)-ADRAWRW)*W_{p\rightarrow r}(t_1) + ALITTERR(2)*W_r$; $t_1 = t\text{-}AROOTAGE$ $W_{l\rightarrow Ab}$, $W_{s\rightarrow Ab}$ and $W_{r\rightarrow Li}$ *are converted to C with* CPLANT
If GROWDECID-switch = 1 and t = DAYPEREN $W_{l\rightarrow Ab} = W_l*APEREN$
$N_{Ab\rightarrow NH4} = ABOVELN*N_{Ab}$; if $q_{Inf}>0$ $N_{Ab\rightarrow Li} = ABOVEK*N_{Ab}$; if $T_s(1)>0$ $N_{r\rightarrow Li}$, $N_{s\rightarrow Ab}$, $N_{l\rightarrow Ab}$ *see N allocation*

ABOVEFEC
Fraction of N and C in above ground residues that are transformed to faeces. (d^{-1})
Only used if MANURE-switch=1. *1*

ABOVEK
Fraction of N and C in above ground residues that are transformed to the litter pool every day. (d^{-1}) *1*

ABOVELC
Fraction of C in above ground residues that are leached out every day. (d^{-1}) *0*

ABOVELN
Fraction of N in above ground residues that are leached out every day. (d^{-1}) *0*

ALEAFAGE
Lifetime of leaves (d)
(If GROWPEREN-switch=1: Only for leaves formed the current year)

ALITTERL
Fraction of leaf biomass (old biomass if GROWPEREN=1) lost to litter. (d^{-1})

ALITTERR
Parameters for root mortality.

ALITTERR(1): Fraction of daily root growth lost as litter. (-)

ALITTERR(2): Fraction of root biomass (woody biomass if GROWPEREN=1) lost as litter. (d^{-1})

ALITTERS
Fraction of stem biomass (woody biomass if GROWPEREN-switch=1) lost through litter. (d^{-1})

AROOTAGE
Lifetime of roots formed the current year. (d)

TEMBASP
For plant respiration; Base temperature at which temperature effect = 1. (°C)
20

TEMQ10P
For plant respiration. Response to a 10 °C soil temperature change (-)
3

WRESP
Coefficient to multiply the maintenance respiration of root, stem biomass and leaf biomass which is a Q_{10} function of temperature. The product of WRESP and the temperature is the fraction of biomass that is lost through respiration. (d^{-1})
If GROWPEREN-switch = 0: respiration acts on current year biomass.
If GROWPEREN-switch = 1: respiration acts on old biomass.

6.14 Growstage (P)

If GROWSTART-switch=1 then photosynthesis starts at a certain temperature sum (DAYTAACC, TAACC). Otherwise growth starts at day UPST (see Soil and plant management parameter group).

If GROWPHEN-switch>0 then the date for start of grain development is calculated as a function of temperature and daylength (GRAINI). Grain development starts when an index (i_g) becomes unity.

i_v = 11 if: t = UPST i_v = 2 if: UPST <= t <= UPET
If GROWSTART-switch=1: i_v = 10 if: t>=DAYTAACC t_f = t if: $\Sigma(T_a$-PHOTEMP(1); >0) = TAACC i_v = 12 if: t=t_f i_v = 2 if: t>t_f i_v = 13 if: t=DAYPEREN i_v = 0 if: W_l=0 & t>172
If GROWPHEN-switch>0: If i_v = 2 or i_v = 11: $i_g = \Sigma_{Acc}$ GRAINI(1)*(1 - exp(-x))(1 - exp(-y)) *where:* x = GRAINI(4)*(T(t) - GRAINI(5)) y = GRAINI(2)*(D(t) - GRAINI(3))

DAYTAACC
Day number at which the calculation of T_{aAcc} starts (d)

DAYPEREN
Day number at which the transformation of assimilates from young pools (current year) to old pools (wood) occur (d)

GRAINI
Coefficients for the index (i_g) which acts as a switch that starts the grain development.

GRAINI(1): The asymptote of the development rate curve. The inverse value gives the shortest possible duration of the phase in days and is therefore related to the basal vegetative period. (d^{-1})

GRAINI(2): Regulates the shape of the development-photoperiod (daylength) function. (h^{-1})

GRAINI(3): The critical photoperiod (threshold) for the development. (h)

GRAINI(4): Regulates the shape of the development - temperature function ($°C^{-1}$)

GRAINI(5): Threshold temperature (°C)

TAACC
Minimum value of the temperature sum (T_{aAcc}) at which growth starts. (°C)

6.15 Plotting on line

These parameters activates a display of outputs on the screen during the simulation.

PMAX
The expected maximum value among the variables selected by XTGD. (-)

XTGD
Numbers of output variables to be presented on the screen during the simulation. (-)
For instance, 4200 means 4 X-, 2 T-, zero G- and zero D variables. X= state, T= flow, G= auxiliary and D= driving variables. It is the first variables (of those selected as output) in each array that are plotted.

6.16 Special

These parameters are available only if the SPECIAL-switch is ON. They activates special routines not used, or kept fixed, in the original model.

Some of the parameters are used for sensitivity tests. The value for no test is the default value, given in italics. In case both the relative and the absolute value are possible to change a constant value of the variable concerned can be chosen by setting the relative change to 0.

TEMPREQ-switch: Alternative temperature response functions for microbial activity may be used. Also separate temperature response functions could be used for mineralisation-immobilization, denitrification and nitrification. The function is based on a Q_{10} relation (TEMQ10, TEMQ10D, TEMQ10N), with a temperature base (TEMBAS, TEMBASD, TEMBASN) at which the value of the function is one. Below a certain temperature (TEMLIN, TEMLIND, TEMLINN) the response is linear. This linear function equals the other function at temperature equal to TEMLIN, and is zero at 0°C.

LITTKCN-switch: CNLITN, CNLITX, CNFECN and CNFECX: The specific decomposition rate of litter (LITK) and faeces (FECK) can be set a linear function of the C-N ratio. If the MICROB-switch is on this option acts on the microbial gross consumption rate (MICK).

MICROB-switch: A special option of SOILN allows you to simulate microbe dynamics. In that case the microbes decompose dead organic material in proportion (MICK) to the amount of microbial biomass. The microbial gross consumption rate is decreased in case of substrate deficiency. At a certain amount of substrate (MICSUB) MICK is half of its maximum value. The microbes daily decomposition can not be more than a certain maximum fraction of the substrate (MICMAX). Some of the decomposed material is lost by growth respiration (1-MICEFF) whereas the remaining material increases the microbial biomass. The microbes die off in proportion (MICMORT) to their biomass. This is lost to the litter pool and mixed with dead plant material. The microbes also lose carbon due to maintenance respiration (MICMRESP). Both the mortality and the maintenance respiration rates can be set functions of abiotic conditions. The nitrogen dynamics follows the carbon dynamics. Nitrogen consumed by microbes is the N/C ratio of litter multiplied by the C amounts consumed. Then the C/N ratio of this material decreases due to respiration. The microbes lose N in proportion to their C/N ratio when they die. Depending on if the C/N ratio of microbes is lower or higher than MICCN, the microbes will mineralise N to soil or immobilise N from soil. In case mineral N is low in soil the microbes N uptake might be smaller than their demand and the microbes can get an increased C/N ratio. You can choose up to three different litter pools on which the microbes acts, litter, humus and an extra litter pool. The principals are the same for all pools. What differs are the microbial consumption rates (MICK(1-3) from the different pools, the respiration (1-MICEFF(1-3)) and the fraction of dead microbial biomass delivered to different pools (MICMORT(1-3)). The litter fall is separated into the different pools by parameters LITFRACA(1-3) (leaves and stems) and LITFRACR(1-3) (roots).

A certain fraction of N deposited and mineral N fertiliser could be directly allocated to the second layer (FERNLAY2).

The impact of water stress on growth can be modified by parameter PHOETR. CO_2 concentration of the air can be given as input affecting radiation use efficiency (CO2START, PHOCO2).

If GROWPHEN-switch=2 then dates for emergency, end of grain filling and harvest are calculated as function of temperature sum (TAPHENOL). If temperature sum is low, then date of harvest is determined by a maximum harvest index being achieved (HARINDEXX).

Special options for automatic fertilisation (FERNCALC-switch), an alternative function for calculating photosynthesis (GROWPHOS-switch), mobile ammonium (NH4MOBIL-switch) and automatic correction of certain simulated values (BOUNDARY-switch and parameters BOUN....) are activated by switches. For description of the options is referred to the description of switches.

If FERNCALC-switch=1:

$N_{Appl \rightarrow Fert} = N_{Appl \rightarrow Fert} + AVAILN*(N_{PotUp} - N_{Soil \rightarrow Plant} - x)/UPMA$

where:

$x = N_{Inf \rightarrow NO3} - N_{Dep \rightarrow NH4} - N_{Fert \rightarrow NH4}$

If FERNCALC-switch=2:

$N_{Appl \rightarrow Fert} = N_{Appl \rightarrow Fert} + AVAILN - x - y$

where:

$x = N_{Inf \rightarrow NO3} - N_{Dep \rightarrow NH4} - N_{Fert \rightarrow NH4}$

$y = 0.2*N_{Li} + 7.5*HUMK*N_h + 0.2*N_f + N_{NH4} + N_{NO3}$

	If MICROB-switch
If MICROB-switch>0:	
$C_{Ab \rightarrow Li} = LITFRACA(1)*C_{Ab \rightarrow LiTot}$	>=1
$C_{r \rightarrow Li} = LITFRACR(1)*C_{r \rightarrow LiTot}$	>=1
D:o for Nitrogen give: $N_{Ab \rightarrow Li}$, $N_{r \rightarrow Li}$	>=1
D:o for Humus give: $C_{Ab \rightarrow h}$, $C_{r \rightarrow h}$, $N_{Ab \rightarrow h}$, $N_{r \rightarrow h}$	=2 or 3
D:o for Litter2 give: $C_{Ab \rightarrow Li2}$, $C_{r \rightarrow Li2}$, $N_{Ab \rightarrow Li2}$, $N_{r \rightarrow Li2}$	=3
$C_{Li \rightarrow m} = MICK(1)*f_{Sub}*e_t e_m C_m$; <=$MICMAX*C_{Li}$	>=1
$C_{m \rightarrow Li} = x*MICMORT(1)*C_m$	>=1

where:

$f_{Sub} = C_{Li}/(C_{Li}+MICSUB(1))$

x = *abiotic factor, see below*

D:o for Humus give: $C_{h \rightarrow m}$, $C_{m \rightarrow h}$	
D:o for Litter2 give: $C_{Li2 \rightarrow m}$, $C_{m \rightarrow Li2}$	=2 or 3
	=3

$C_{m \rightarrow Atm} = (1-MICEFF(1))C_{Li \rightarrow m} + (1-MICEFF(2))C_{Li2 \rightarrow m} + (1-MICEFF(3))C_{h \rightarrow m} + y*MICMRESP*C_m$

where:

y = *abiotic factor, see below*

$N_{Li\rightarrow m} = C_{Li\rightarrow m}N_{Li}/C_{Li}$	>=1
$N_{m\rightarrow Li} = C_{m\rightarrow Li}N_{m}/C_{m}$	>=1
D:o for Humus give: $N_{h\rightarrow m}$, $N_{m\rightarrow h}$	=2 or 3
D:o for Litter2 give: $N_{Li2\rightarrow m}$, $N_{m\rightarrow Li2}$	=3
$N_m(new) = C_m(new)/MICCN$ *implies:*	
where:	
$C_m(new) = C_m + \Delta C_m$	
$\Delta C_m = C_{Li\rightarrow m}+C_{Li2\rightarrow m}+C_{h\rightarrow m}-(C_{m\rightarrow Li}+C_{m\rightarrow Li2}+C_{m\rightarrow h})-C_{m\rightarrow Atm}$	
$N_m(new) = N_m + \Delta N_{m1} - N_{m\rightarrow NH4}$	
$\Delta N_{m1} = N_{Li\rightarrow m}+N_{Li2\rightarrow m}+N_{h\rightarrow m}-(N_{m\rightarrow Li}+N_{m\rightarrow Li2}+N_{m\rightarrow h})$	
$N_{m\rightarrow NH4} = -((C_m+\Delta C_m)/MICCN - (N_m+\Delta N_{m1}))$; < $UPMA*(N_{NO3}+N_{NH4})$	
$N_{h\rightarrow NH4}$ = *see Mineralisation and immobilisation*	=4
$C_{h\rightarrow Atm} = CNORG*N_{h\rightarrow NH4}$	=4
If MICABIO-switch>0:	*If MICABIO-switch:*
mortality abiotic factor $x = e_t$	=1
mortality abiotic factor $x = e_m$	=2
maintenance respiration abiotic factor $y = e_t$	=3
maintenance respiration abiotic factor $y = e_m$	=4
combinations are multiplication of e_t *and* e_m, *f.i.* $x = e_t e_m$	>=12
If TEMPREQ-switch=1:	
$e_t = T_s/TEMLIN*TEMQ10**((TEMLIN-TEMBAS)/10)$; *if Ts<TEMLIN*	
If TEMPREQ-switch=2:	
$e_t = (T_s-TEMMIN)/(TEMBAS-TEMMIN)^2$	
If TEMPREQ-switch=3:	
$e_t = TEMPOL(1)+TEMPOL(2)*T_s+TEMPOL(3)*T_s^2+TEMPOL(4)*T_s^3+.....$	
If GROWPHOS-switch=1:	
$W_{Atm\rightarrow p} = PGRESP*\Sigma(\Delta A_i(xP_{Max}/(x+(1-PTRANSM)*P_{Max})$	
where:	
$x = PHOEFF*EXTCOEF*I*exp(-EXTCOEF*\Sigma\Delta A_i)$	
$P_{Max} = PMAX20(1)*(1-PMAX20(2)*(1-exp(-EXTCOEF*\Sigma\Delta A_i))*f_T*Daylength$	
If LITTKCN-switch =1 or 3:	
$LITK(new) = LITK*(1-(C_{Li}/N_{Li} - CNLITN)/(CNLITX - CNLITN))$	
and MICROB-switch >0:	
$MICK(new) = MICK(1)*(1-(C_{Li}/N_{Li} - CNLITN)/(CNLITX - CNLITN))$	
+D:o for Humus and Litter2 (MICK(2) and MICK(3))	
If LITTKCN-switch =2 or 3:	
$FECK(new) = FECK*(1-(C_f/N_f - CNFECN)/(CNFECX - CNFECN))$	
If GROWPHEN-switch=2:	
i_v = 1 if: $0 < i_g < 1$	
$i_g = (\Sigma(T_a-TAPHENOL(1);>0))/TAPHENOL(2)$	
i_v = 11 if: $i_g = 1$	
i_v = 2 if: $1 < i_g < 2$	
i_v = 21 if: $2 <= i_g < 3$	
$i_g = (\Sigma(T_a-TAPHENOL(3);>0))/TAPHENOL(4)+2$	
i_v = 22 if: $3 <= i_g < 4$	
$i_g = (\Sigma(T_a-TAPHENOL(5);>0))/TAPHENOL(6)+3$	
i_v = 3 if: $i_g = 4$ or $W_g/(W_g+W_l+W_s) > HARINDEXX$	
If ROOTDENS-parameter>0:	
$UPMA(new) = UPMA*(W_r(i)/\delta z(i)/ROOTDENS)**ROOTDENSE$	

If NH4MOBIL-switch=1:
$N_{NH4(i)} \rightarrow_{(i+1)} = q_{w(i)} n_{NH4(i)}/1000$ (i=layer)
where:
$n_{NH4(i)} = N_{NH4Sol(i)}/\theta/THICK(i)$; $\theta >= \theta_w$
where:
$N_{NH4Sol(i)} = N_{NH4(i)} - N_{NH4Ads(i)}$
where:
$N_{NH4Ads(i)} = x + y * N_{NH4(i)}$
where:
N_{NH4Ads}[gN/gSoil] = NH4ADSA + NH4ADSB*n_{NH4}[gN/m^3Water] *implies:*
x = NH4ADSA(i)/(1/BULKDENS(i)/THICK(i)+NH4ADSB(i)/θ/THICK(i))
y = 1/(θ/BULKDENS(i)/NH4ADSB(i)+1)

$f_W = PHOETR(1)+PHOETR(2)*E_t/E_{tp}$

if CO2START>0:
CO_{2Atm} = CO2START*(1+CO2INCY*(Year since simulation start))
PHOEFF(new) = x*PHOEFF; *where* x = 1+PHOCO2*(CO_{2Atm}-CO2REF)/CO2REF

AROOTE
Coefficients for root development as function of transpiration ratio.
NOTE! Depend on GROWAEQ-switch. For explanation of coefficients see GROWAEQ. Independent variable is: x = 1-AROOTETR*E_t/E_{tp}.

AROOTE(1): Coefficient a (-)

AROOTE(2): Coefficient b (differ)

AROOTE(3): Coefficient c (differ)

AROOTETR
Relative change of the transpiration ratio in the root allocation function. (-)
1

AROOTNI
Coefficients for root development as function of leaf N concentration.
NOTE! Depend on GROWAEQ-switch. For explanation of coefficients see GROWAEQ. Independent variable is relative leaf N concentration (x=(n_l-NLEAFN)/(NLEAFXG-NLEAFN)). "Other equation" is: 1+AROOTN-(1-((NLEAFXG-n_l)/(NLEAFXG-NLEAFN)^2)$^{0.5}$.
where n_l is N concentration of leaves (N_l/W_l). If GROWPEREN=1 then n_l is both current year and old leaves.
If SPECIAL-switch=1 then: If AROOTNI(1)<0 then n_l is replaced by N concentration of newly formed leaves (n_l'=N_l'/W_l'). If GROWPEREN=1 then n_l is now only the current year old leaves. (The absolute value of AROOTNI(1) is used)

AROOTNI(1): Coefficient a (-)

AROOTNI(2): Coefficient b (differ)

AROOTNI(3): Coefficient c (differ)

AROOTW
Coefficients for root development as function of total plant biomass.
NOTE! Depend on GROWAEQ-switch. For explanation of coefficients see GROWAEQ. Independent variable is total plant biomass ($x=W_t$).
No "other equation" is available.

AROOTW(1): Coefficient a	(-)
AROOTW(2): Coefficient b	(differ)
AROOTW(3): Coefficient c	(differ)

AVAILN
When simulating N fertilisation: (differs)
If FERNCALC-switch=1 then AVAILN is the fraction to multiply to the estimated supply (unit is -). *1*
If FERNCALC-switch=2 then AVAILN is the wanted soil mineral N (gN m^{-2}).

BOUNFTOT
Total number of variables (including error variables) in the file used for correction. Only used if BOUNDARY-switch = 1, 2 or 3 (-) *2*

BOUNRERR
Relative error of variables used for correction. If BOUNRERR<0 then equal to the absolute error. Only used if BOUNDARY-switch=3 (-) *2*

BOUNVALU
Value that simulated variable should be corrected to in each time step. Value = -99 is treated as missing. (differ) *-99*
Index 1-max20. Only used if BOUNDARY-switch=4

BOUNVNUM
Variable number of simulated variable that should be corrected during simulation. Numbers are listed in Appendix 1. (-) *0*
States variables (X-var): X(n) where n=BOUNVNUM
Flow variables (T-var): T(n) where n=BOUNVNUM-1000
Auxiliary variables (G-var): G(n) where n=BOUNVNUM-10000
Index 1-BOUNFTOT/2
Only used if BOUNDARY-switch > 0

BULKDENS
Bulkdensity of soil. Index 1-10: Soil layer. Below layer 10 the value of layer 10 is used. ($g\ m^{-3}$) *0.1e+6 1.0e+6*
Only used if NH4MOBIL-switch = 1.

CNFECN
Minimum C-N ratio of faeces at which no decomposition occurs. Only used i LITTKCN switch=2 or 3. (-) *0*

CNFECX
Maximum C-N ratio of faeces at which maximum decomposition occurs. Only used i LITTKCN switch=2 or 3. (-) *0*

CNLITN
Minimum C-N ratio of litter at which no decomposition occurs. Only used i LITTKCN switch=1 or 3. (-) *0*

CNLITX
Maximum C-N ratio of litter at which maximum decomposition occurs. Only used i LITTKCN switch=1 or 3. (-) *0*

CO2INCY
Annual relative increment of atmospheric CO_2 concentration. Not used if CO2START= 0 (y^{-1}) *0.01*

CO2REF
Atmospheric CO_2 concentration at which the radiation use efficiency equals the one given by parameter PHOEFF. (ppm) *350*

CO2START
Concentration of carbon dioxide in the atmosphere at start of simulation. = 0 implies option is cancelled. Normal value is about 350 (ppm) *0*

FERNLAY2
FERNLAY2(1): Fraction of dissolved ammonium N from solid fertiliser that is allocated directly to the second layer ($N_{Fert \rightarrow NH4}$) (-) *0*

FERNLAY2(2): Fraction of ammonium N deposition and ifiltrated nitrate that is allocated directly to the second layer ($N_{Dep \rightarrow NH4}$, $N_{Inf \rightarrow NO3}$) . (-) *0*

HARINDEXX
Maximum harvest index ((grain biomass)/(tot above ground biomass)). Only used if GROWPHEN-switch = 2. (-) *0.6*

LITFRACA
Fractions of leaf and stem litter delivered to (index 1-3) Litter, Humus and Litter2, respectively. Only used if MICROB-switch>0 (-) *1,0,0*

LITFRACR
Fractions of root litter delivered to (index 1-3) Litter, Humus and Litter2, respectively. Only used if MICROB-switch>0 (-) *1,0,0*

MICCN
C-N ratio of microbes. Only used i MICROB switch>0. (-)
5

MICEFF
Efficiency of the internal synthesis by microbial biomass of organic material from (index 1-3): Litter, Humus, Litter2 (-)
0,0,0
Only used if MICROB-switch>0

MICK
Microbial gross consumption rate per unit of microbial biomass, at a reference temperature and optimal soil water condition. The value differ depending of type of substrate. Index 1-3 refers to substrate: Litter, Humus, Litter2. (d^{-1})
0,0,0
Only used if MICROB-switch>0

MICMAX
Maximum fraction of substrate decomposed every day. Only used if MICROB-switch>0. (d^{-1})
0.1

MICMORT
Microbial relative mortality rate. (-)
Index 1-3: Litter, Humus, Litter2. Only used if MICROB-switch>0. *0,0,0*

MICMRESP
Fraction, at a reference temperature, of microbial biomass lost by maintenance respiration. Only used if MICROB-switch>0. (d^{-1})
0

MICSUB
Substrate amount at which MICK is half of its maximum value. Index 1-3: Litter, Humus, Litter2. (-)
If MICSUB(1)<0: $f_{Sub} = C_{Li}/(C_{Li}\text{-MICSUB}(1)*C_m)$; the same for index 2 and 3.
Only used if MICROB-switch>0.

NH4ADSA
Coefficient (a) in the relation between ammonium in soil solution and amount adsorbed on soil particles: (gN $gSoil^{-1}$)
0.5e-6
N_{NH4Ads} (gN/gSoil) = a + b * N_{NH4Sol} (gN/m^3Water). Index 1-10: Soil layer.
Below layer 10 the value of layer 10 is used.
Only used if NH4MOBIL-switch = 1.

NH4ADSB
Coefficient (b) in the relation between ammonium in soil solution and amount adsorbed on soil particles: (m^3Water $gSoil^{-1}$)
N_{NH4Ads} (gN/gSoil) = a + b * N_{NH4Sol} (gN/m3Water). Index 1-10: Soil layer. *2.0e-6*
Below layer 10 the value of layer 10 is used. *0.5e-6*
Only used if NH4MOBIL-switch = 1.

OUTLAY
(i) Layer. The abiotic response function is calculated for each layer but is stored as output only for this layer. A value outside 1-10 will give you the average response function for all layers as output. (-) *1*

OUTLITCN
Switch selecting for which pool the specific decomposition rate should be stored in the auxiliary variable LITKCN. 1/2/3: Litter, Humus, Litter2. Layer for which it should be stored is selected with parameter OUTLAY. (-) *1*

OUTRATCN
Switch selecting for which pool the C/N ratio should be stored in the auxiliary variable RATCNL. 1/2/3/4: Litter, Humus, Litter2, Microbes. (-) *1*

OUTSW
Switch selecting which internal model should be stored in the auxiliary variable SWITCHOUT. 1/2/3/4: Swflush, Swstart, Swplough, Swharv. (-) *1*

PHOCO2
Relative increase in radiation use efficiency due to doubled atmospheric CO_2 concentration. (ppm^{-1}) *0.4*

PHOETR
Coefficients modifying the effect of transpiration ratio on plant growth.

PHOETR(1): a in eq. $f_W=a+b*E_t/E_{tp}$ - *0*

PHOETR(2): b in eq. $f_W=a+b*E_t/E_{tp}$ - *1*

PPMAX20
Coefficients for maximum photosynthetic rate.
Only used if GROWPHOS-switch = 1.

PPMAX20(1): Maximum leaf photosynthesis rate at optimal temperature, water and nitrogen conditions (note area refers to leaf area). ($kgCO_2\ ha^{-1}\ h^{-1}$) *43.2*

PPMAX20(2): Rate of decline of maximum leaf photosynthesis with increased leaf area index. (-) *0.35*

PTRANSM
Leaf transmission coefficient. (-) *0.1*
Only used if GROWPHOS-switch = 1.

PGRESP
Growth conversion efficiency (reduction coefficient of canopy photosynthesis due to growth respiration). (-) *0.83*
Only used if GROWPHOS-switch = 1.

ROOTDENS
Parameter making root uptake (UPMA) equal a function of root density. Only used if ROOTDENS > 0. (gDW m^{-3}) *0*

ROOTDENSE
Parameter making root uptake (UPMA) equal a function of root density, see parameter ROOTDENS. (-) *1*

SLEAFND
Number of days before the current day of which the leaf N deficit should be added to the leaf N demand. (d) *0*

SROOTND
Fraction of the accumulated root N deficit during the current year that should be added to the root N demand. (-) *0*

SSTEMND
Fraction of the accumulated stem N deficit during the current year that should be added to the stem N demand. (-) *0*

TAPHENOL
Temperature limits for phenologic functions. differs
(index= 6)
TAPHENOL(1): Threshold temperature for calculating day of emergency. (°C)
TAPHENOL(2): Accumulated temperature sum since day of sowing to day for emergency. (day°C)
TAPHENOL(3): Threshold temperature for calculating day of end of grain filling. (°C)
TAPHENOL(4): Accumulated temperature sum since day for start of grain filling to day for stop of grain filling. (day°C)
TAPHENOL(5): Threshold temperature for calculating day of harvest. (°C)
TAPHENOL(6): Accumulated temperature sum since day for end of grain filling to harvest. (day°C)
Only used if GROWPHEN-switch = 2.

TEMBASD
For the denitrification process; Base temperature at which temperature effect = 1. Only used if TEMPREQ-switch=4, 14 or 24. (°C) *20*

TEMBASN
For the nitrification process; Base temperature at which temperature effect = 1. If TEMBASN = 0 then TEMBASN is set equal TEMBAS. Only used if TEMPREQ-switch=4, 14 or 24. (°C) *20*

TEMLIN
For the mineralisation-immobilisation process. Threshold temperature below which the temperature response is a linear function of temperature. Only used if TEMPREQ-switch=1. (°C) *5*

TEMLIND
For the denitrification process. Threshold temperature below which the temperature response is a linear function of temperature. Only used if TEMPREQ-switch=4 or 14. (°C) *5*

TEMLINN
For the nitrification process. Threshold temperature below which the temperature response is a linear function of temperature. Only used if TEMPREQ-switch=4 or 14. (°C) *5*

TEMMIN
Minimum temperature for microbial processes in the Ratkowsky function. Only used if TEMPREQ-switch=2 or 24 (°C) *-8*

TEMMIND
The same as for TEMMIN but for the denitrification process. Only used if TEMPREQ-switch=24 (°C) *-8*

TEMMINN
The same as for TEMMIN but for the nitrification process. Only used if TEMPREQ-switch=24 (°C) *-8*

TEMMPOL
Coefficients in a 6-degree polynomial temperature function. Index 1-7. Only used if TEMPREQ-switch=3 (differ)

TEMQ10D
For the denitrification process. Response to a 10 °C soil temperature change. Only used if TEMPREQ-switch=4 or 14. (-) *3*

TEMQ10N
For the nitrification process. Response to a 10 °C soil temperature change. Only used if TEMPREQ-switch=4 or 14. (-) *3*

7 OUTPUTS

Output variables are stored in a PG-structured file named SOILNnnn.BIN where nnn is the current run number. Also, a list of output variables are found in the summary file named SOILNnnn.SUM. The variables to be stored in the summary file can be selected by the switch LISALLV.

The output variables are divided into four categories:
states (=X), flows (=T), auxiliaries (=G) and drivings (=D).

Symbols given in brackets refer to Eckersten (1991a) and Eckersten & Jansson (1991).

7.1 States

All variables denoted ACC.... are used only to check output and not involved in the model calculations.

Variable	(Symbol) Explanation	Unit
ACCBAL	Nitrogen mass balance check of ACC...-variables (Input-Output-Store)	(gN m^{-2})
ACCBALC	Carbon mass balance check of ACC...C-variables (Input-Output-Store)	(gC m^{-2})
ACCDENI	Accumulated denitrification of NO3-N	(gN m^{-2})
ACCDEP	Accumulated N deposition	(gN m^{-2})
ACCDLOSS	Accumulated leaching of NO3-N	(gN m^{-2})
ACCFERT	Accumulated N fertilisation, other than manure and deposition	(gN m^{-2})
ACCHARV	Accumulated N harvested	(gN m^{-2})
ACCHARVC	Accumulated C harvested	(gC m^{-2})
ACCMAN	Accumulated N fertilisation through manure	(gN m^{-2})
ACCPHOSC	Accumulated C uptake by net photosynthesis	(gC m^{-2})
ACCPLANT	Accumulated change in total plant N	(gN m^{-2})
ACCPLANTC	Accumulated change in total plant C	(gC m^{-2})
ACCRESPC	Accumulated C lost by respiration from plant and litter	(gC m^{-2})
ACCSOIL	Accumulated change in soil N	(gN m^{-2})
ACCSOILC	Accumulated change in soil C	(gC m^{-2})
CF	(C_f) Faeces C-pool (Index= layer 1 to 2; two uppermost layers)	(gC m^{-2})

CH	(C_h) Humus C-pool (Index=layer 1 to min(NUMLAY,10))	(gC m^{-2})
CL	(C_{Li}) Litter C-pool (Index=layer 1 to min(NUMLAY,10))	(gC m^{-2})
CL2	(C_{Li2}) Intermediate litter C-pool (litter2) (Index=layer 1 to min(NUMLAY,10))	(gC m^{-2})
CM	(C_m) Microbial C-pool (Index=layer 1 to min(NUMLAY,10)) (if SPECIAL=1)	(gC m^{-2})
FERT	(N_{Fert}) Solid fertilizer N-pool (undissolved)	(gN m^{-2})
GRAINN	(N_g) Grain N-pool (PLANT)	(gN m^{-2})
GRAINW	(W_g) Grain dry weight (PLANT)	(gDW m^{-2})
LEAFN	(N_l) Leaf N-pool (PLANT)	(gN m^{-2})
LEAFW	(W_l) Leaf dry weight (PLANT)	(gDW m^{-2})
LITABOVE	(N_{Ab}) Plant residue N-pool, above ground	(gN m^{-2})
LITABOVEC	(C_{Ab}) Plant residue C-pool, above ground	(gC m^{-2})
NF	(N_f) Faeces N-pool (Index= layer 1 to 2)	(gN m^{-2})
NH	(N_h) Humus N-pool (Index=layer 1 to min(NUMLAY,10))	(gN m^{-2})
NH4	(N_{NH4}) Ammonium NH4-N pool (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2})
NLIT	(N_{Li}) Litter N-pool (Index=layer 1 to min(NUMLAY,10))	(gN m^{-2})
NLIT2	(N_{Li2}) Intermediate litter N-pool (litter2) (Index=layer 1 to min(NUMLAY,10))	(gN m^{-2})
NM	(N_m) Microbial N-pool (Index=layer 1 to min(NUMLAY,10)) (if SPECIAL=1)	(gN m^{-2})
NO3	(N_{NO3}) Nitrate NO3-N pool (Index= layer 1 to NUMLAY)	(gN m^{-2})
ROOTN	(N_r) Root-N (PLANT)	(gN m^{-2})
ROOTW	(W_r) Root dry weight (PLANT)	(gDW m^{-2})
STEMN	(N_s) Stem-N (PLANT)	(gN m^{-2})
STEMW	(W_s) Stem dry weight (PLANT)	(gDW m^{-2})
WLEAFN	(N_{lw}) N in old leaves (if GROWPEREN=1)	(gN m^{-2})

WLEAFW	(W_{lw}) Biomass in old leaves (older than one year, normally) (if GROWPEREN=1)	(gDW m^{-2})
WROOTN	(N_{rw}) N in old roots (if GROWPEREN=1)	(gN m^{-2})
WROOTW	(W_{rw}) Biomass in old roots (if GROWPEREN=1)	(gDW m^{-2})
WSTEMN	(N_{sw}) N in old stems (if GROWPEREN=1)	(gN m^{-2})
WSTEMW	(W_{sw}) Biomass in old stem (if GROWPEREN=1)	(gDW m^{-2})
XAVAIN	(N_a) N in plant available for re-translocation (if GROWPEREN=1)	(gN m^{-2})
XAVAIW	(W_a) Assimilates in plant available for growth (if GROWPEREN=1)	(gDW m^{-2})

7.2 Flows

Variable	(Symbol) Explanation	Unit
AAVAIPW	($W_{a\rightarrow p}$) Biomass flow: From available pool to growth (added to PHOS but not included) (PLANT)	(gDW m^{-2} d^{-1})
AAVAIUN	($N_{a\rightarrow Upt}$) N flow: From available pool to growth (added to TOTUPT but not included) (PLANT)	(gN m^{-2} d^{-1})
ALEAFAN	($N_{l\rightarrow a}$) N flow: From leaf to available pool (PLANT)	(gN m^{-2} d^{-1})
ALEAFAW	($W_{l\rightarrow a}$) Biomass flow: From leaf to available pool (PLANT)	(gDW m^{-2} d^{-1})
ALEAFGN	($N_{l\rightarrow g}$) N flow: From leaves to grains (PLANT)	(gN m^{-2} d^{-1})
ALEAFGW	($W_{l\rightarrow g}$) Biomass flow: From leaf to grain (PLANT)	(gDW m^{-2} d^{-1})
ALEAFN3N	($N_{l\rightarrow Inf+Surr}$) N flow: Leaches from leaf to nitrate infiltration (PLANT)	(gN m^{-2} d^{-1})
ALEAFLIN	($N_{l\rightarrow Ab}$) N flow: Leaf litter (PLANT)	(gN m^{-2} d^{-1})
ALEAFLIW	($W_{l\rightarrow Ab}$) Biomass flow: from leaves to above ground residues (PLANT)	(gDW m^{-2} d^{-1})
ALEAFSN	($N_{l\rightarrow s}$) N flow: From leaf to stem (PLANT)	(gN m^{-2} d^{-1})
ALEAFSW	($W_{l\rightarrow s}$) Biomass flow: From leaf to stem (PLANT)	(gDW m^{-2} d^{-1})
ALEAFWN	($N_{l\rightarrow lw}$) N flow: From leaf to old leaves (PLANT)	(gN m^{-2} d^{-1})
ASTEMWN	($N_{s\rightarrow sw}$) N flow: From stem to woody stems (PLANT)	(gN m^{-2} d^{-1})
ALEAFWW	($W_{l\rightarrow lw}$) Biomass flow from leaf to old leaves (PLANT)	(gDW m^{-2} d^{-1})
APHOTLW	($W_{p\rightarrow l}$) Daily gross leaf growth (PLANT)	(gDW m^{-2} d^{-1})

APHOTRW	($W_{p\rightarrow r}$) Daily gross root growth (PLANT)	(gDW m^{-2} d^{-1})
APHOTSW	($W_{p\rightarrow s}$) Daily gross stem growth (PLANT)	(gDW m^{-2} d^{-1})
AROOTAN	($N_{r\rightarrow a}$) N flow: From root to available pool (PLANT)	(gN m^{-2} d^{-1})
AROOTAW	($W_{r\rightarrow a}$) Biomass flow: From root to available pool (PLANT)	(gDW m^{-2} d^{-1})
AROOTGN	($N_{r\rightarrow g}$) N flow: from root to grain (PLANT)	(gN m^{-2} d^{-1})
AROOTGW	($W_{r\rightarrow g}$) Biomass flow: from root to grain (PLANT)	(gDW m^{-2} d^{-1})
AROOTLIN	($N_{r\rightarrow Li}$) N flow: Root litter (PLANT)	(gN m^{-2} d^{-1})
AROOTLIW	($W_{r\rightarrow Li}$) Biomass flow: from root to litter (PLANT)	(gDW m^{-2} d^{-1})
AROOTSN	($N_{r\rightarrow s}$) N flow: from root to stem (PLANT)	(gN m^{-2} d^{-1})
AROOTSW	($W_{r\rightarrow s}$) Biomass flow: from root to stem (PLANT)	(gDW m^{-2} d^{-1})
AROOTWN	($N_{r\rightarrow rw}$) N flow: From root to woody roots (PLANT)	(gN m^{-2} d^{-1})
AROOTWW	($W_{r\rightarrow rw}$) Biomass flow: From root to woody roots (PLANT)	(gDW m^{-2} d^{-1})
ASOILGN	($N_{Soil\rightarrow g}$) N flow: From soil to grain (PLANT)	(gN m^{-2} d^{-1})
ASOILLN	($N_{Soil\rightarrow l}$) N flow: From soil to leaves (PLANT)	(gN m^{-2} d^{-1})
ASOILRN	($N_{Soil\rightarrow r}$) N flow: From soil to root (PLANT)	(gN m^{-2} d^{-1})
ASOILSN	($N_{Soil\rightarrow s}$) N flow: From soil to stem (PLANT)	(gN m^{-2} d^{-1})
ASTEMAN	($N_{s\rightarrow a}$) N flow: From stem to available pool (PLANT)	(gN m^{-2} d^{-1})
ASTEMAW	($W_{s\rightarrow a}$) Biomass flow: From stem to available pool (PLANT)	(gDW m^{-2} d^{-1})
ASTEMGN	($N_{s\rightarrow g}$) Nitrogen flow: From stem to grain (PLANT)	(gN m^{-2} d^{-1})
ASTEMGW	($W_{g\rightarrow g}$) Biomass flow: From stem to grain (PLANT)	(gDW m^{-2} d^{-1})
ASTEMLIN	($N_{s\rightarrow Ab}$) N flow: (N_s'(ut)) Stem litter (PLANT)	(gN m^{-2} d^{-1})
ASTEMLIW	($W_{s\rightarrow Ab}$) Biomass flow: from stem to above ground residues (PLANT)	(gDW m^{-2} d^{-1})
ASTEMWW	($W_{s\rightarrow sw}$) Biomass flow: From stem to woody stems (PLANT)	(gDW m^{-2} d^{-1})
AWLEAFLIN	($N_{lw\rightarrow Li}$) N flow: From old leaf to litter (PLANT)	(gN m^{-2} d^{-1})
AWLEAFLN	($N_{lw\rightarrow l}$) N flow: From old leaf to young leaf (PLANT)	(gN m^{-2} d^{-1})
AWLEAFLIW	($W_{lw\rightarrow Li}$) Biomass flow: From old leaf to litter (PLANT)	(gDW m^{-2} d^{-1})
AWLEAFLW	($W_{lw\rightarrow l}$) Biomass flow: From old leaf to young leaf (PLANT)	(gDW m^{-2} d^{-1})

AWLEAFN3N	($N_{lw\rightarrow Inf+Surr}$) N flow: Leaches from old leaf to soil nitrate infiltration (PLANT)	(gN m^{-2} d^{-1})
AWLEAFAN	($N_{lw\rightarrow a}$) Nitrogen flow: From old leaf to available pool (PLANT) (Not amoung outputs yet)	(gN m^{-2} d^{-1})
AWLEAFAW	($W_{lw\rightarrow a}$) Biomass flow: From old leaf to available pool (PLANT)	(gDW m^{-2} d^{-1})
AWSTEMAN	($N_{sw\rightarrow a}$) Nitrogen flow: From old stem to available pool (PLANT)	(gN m^{-2} d^{-1})
AWSTEMAW	($W_{sw\rightarrow a}$) Biomass flow: From old stem to available pool (PLANT)	(gDW m^{-2} d^{-1})
AWROOTAN	($N_{rw\rightarrow a}$) Nitrogen flow: From old root to available pool (PLANT) (Not amoung outputs yet)	(gN m^{-2} d^{-1})
AWROOTAW	($W_{rw\rightarrow a}$) Biomass flow: From old root to available pool (PLANT)	(gDW m^{-2} d^{-1})
AWROOTLIN	($N_{rw\rightarrow Li}$) N flow: From woody root to litter (PLANT)	(gN m^{-2} d^{-1})
AWROOTLIW	($W_{rw\rightarrow Li}$) Biomass flow: From woody root to litter (PLANT)	(gDW m^{-2} d^{-1})
AWSTEMLIN	($N_{sw\rightarrow Ab}$) N flow: From woody stem to litter (PLANT)	(gN m^{-2} d^{-1})
AWSTEMLIW	($W_{sw\rightarrow Ab}$) Biomass flow: From woody stem to litter (PLANT)	(gDW m^{-2} d^{-1})
CFLOSS	C flow: Faeces mineralisation + humification (Index= layer 1 to 2)	(gC m^{-2} d^{-1})
CHARV	($C_{Plant\rightarrow Harv}$) C flow: Harvest export of plant-C (PLANT)	(gC m^{-2} d^{-1})
CLLOSS	C flow: Litter mineralisation + humification (CLMIN+CLHUM) (Index= layer 1 to min(NUMLAY,10))	(gC m^{-2} d^{-1})
CLMIC	($C_{Li\rightarrow m}$) C flow: Microbial gross consumption of litter (Index=layer)	(gC m^{-2} d^{-1})
CL2MIC	($C_{Li2\rightarrow m}$) C flow: Microbial gross consumption of litter2 (Index=layer)	(gC m^{-2} d^{-1})
CHMIC	($C_{h\rightarrow m}$) C flow: Microbial gross consumption of humus (Index=layer)	(gC m^{-2} d^{-1})
CHMIN	($C_{h\rightarrow Atm}$) C flow: Loss from humus by respiration (Index=layer). Only used if MICROB-switch=4	(gC m^{-2} d^{-1})
CLROFF	($C_{Li\rightarrow Stream}$) C flow: Loss of litter in uppermost layer to stream due to surface runoff (however included in ACCRESPC).	(gC m^{-2} d^{-1})
CMLIT	($C_{m\rightarrow Li}$) C flow: Microbial loss to litter (Index=layer)	(gC m^{-2} d^{-1})

CMLIT2	($C_{m\rightarrow Li2}$) C flow: Microbial loss to litter2 (Index=layer)	(gC m^{-2} d^{-1})
CMHUM	($C_{m\rightarrow h}$) C flow: Microbial loss to humus (Index=layer)	(gC m^{-2} d^{-1})
CMMIN	($C_{m\rightarrow Atm}$) C flow: Microbial loss due to growth and maintenance respiration (Index=layer)	(gC m^{-2} d^{-1})
DECACF	($C_{Ab\rightarrow f}$) C flow: Above-ground residue to faeces pool CF(1) if $T_s(1) > 0$. Only used if MANURE-switch=1.	(gC m^{-2} d^{-1})
DECACLIT	($C_{Ab\rightarrow Li}$) C flow: Above-ground residue to litter CL(1). Only used if MICROB-switch=1	(gC m^{-2} d^{-1})
DECACLI2	($C_{Ab\rightarrow Li2}$) C flow: Above-ground residue to litter2 CL2(1)	(gC m^{-2} d^{-1})
DECACHUM	($C_{Ab\rightarrow h}$) C flow: Above-ground residue to humus CH(1)	(gC m^{-2} d^{-1})
DECALEAC	($C_{Ab\rightarrow Out}$) C flow: Losses of above-ground residue to boundary through leaching	(gC m^{-2} d^{-1})
DECALEAN	($N_{Ab\rightarrow NH4}$) N flow: Leaching of above-ground residue to soil ammonium NH4(1)	(gN m^{-2} d^{-1})
DECALIT	($N_{Ab\rightarrow LiTot}$) N flow: Above-ground residue to litter NL(1). If MICROB-switch=1 then DECALIT is split up into flows to different pools.	(gN m^{-2} d^{-1})
DECALITC	($C_{Ab\rightarrow LiTot}$) C flow: Above-ground residue to litter CL(1). If MICROB-switch=1 then DECALITC is split up into flows to different pools.	(gC m^{-2} d^{-1})
DECANF	($N_{Ab\rightarrow f}$) N flow: Above-ground residue to faeces pool NF(1) if $T_s(1)>0$. Only used if MANURE-switch=1.	(gN m^{-2} d^{-1})
DECANLIT	($N_{Ab\rightarrow Li}$) N flow: Above-ground residue to litter NLIT(1). Only used if MICROB-switch=1	(gN m^{-2} d^{-1})
DECANLI2	($N_{Ab\rightarrow Li2}$) N flow: Above-ground residue to litter2 NLIT2(1)	(gN m^{-2} d^{-1})
DECANHUM	($N_{Ab\rightarrow h}$) N flow: Above-ground residue to humus NH(1)	(gN m^{-2} d^{-1})
DECAROFF	($N_{Ab\rightarrow Stream}$) N flow: Loss of above ground residue to stream due to surface runoff	(gN m^{-2} d^{-1})
DECAROFFC	($C_{Ab\rightarrow Out}$) C flow: Loss of above ground residue to stream due to surface runoff (however included in ACCRESPC).	(gC m^{-2} d^{-1})
DENI	($N_{NO3\rightarrow Atm}$) N flow: Denitrification of NO3 (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})
DEPOLEAF	($N_{Dep\rightarrow l}$) N flow: Dry deposition absorbed by leaves. (PLANT)	(gN m^{-2} d^{-1})
DEPONH4	($N_{Dep\rightarrow NH4}$) N flow: Deposition (wet and dry) to soil ammonium NH4(1)	(gN m^{-2} d^{-1})

DEPONO3	($N_{Dep\rightarrow Inf+Surf}$) N flow: Deposition of nitrate to soil (wet and dry)	(gN m^{-2} d^{-1})
DEPOWLEAF	($N_{Dep\rightarrow lw}$) N flow: Dry deposition absorbed by old leaves. (PLANT)	(gN m^{-2} d^{-1})
DLOSS	($N_{NO3\rightarrow Stream}$) N flow: NO3 leaching to tiles (Index= layer 1 to NUMLAY)	(gN m^{-2} d^{-1})
FERTIN	($N_{Appl\rightarrow Fert}$) N flow: Addition of solid fertilizer N	(gN m^{-2} d^{-1})
FINCB	($C_{Appl\rightarrow f}$) C flow: Carbon in faeces in manure to faeces (Index= layer 1 to 2)	(gC m^{-2} d^{-1})
FINNA	($N_{Appl\rightarrow Li}$) N flow: Nitrogen in bedding in manure to litter (Index= layer 1 to 2)	(gN m^{-2} d^{-1})
FINNB	($N_{Appl\rightarrow f}$) N flow: Nitrogen in faeces in manure to faeces-N (Index= layer 1 to 2)	(gN m^{-2} d^{-1})
FINNH	($N_{Appl\rightarrow NH4}$) N flow: Nitrogen in NH4 in manure to NH4() (Index= layer 1 to 2)	(gN m^{-2} d^{-1})
FNIT	($N_{NH4\rightarrow NO3}$) N flow: Nitrification of NH4 to NO3 (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})
HARVGN	($N_{g\rightarrow Harv}$) N flow: harvest of grain (PLANT)	(gN m^{-2} d^{-1})
HARVGW	($W_{g\rightarrow Harv}$) Biomass flow: harvest of grain (PLANT)	(gDW m^{-2} d^{-1})
HARVLN	($N_{l\rightarrow Harv}$) N flow: harvest of leaves (PLANT)	(gN m^{-2} d^{-1})
HARVLW	($W_{l\rightarrow Harv}$) Biomass flow: harvest of leaves (PLANT)	(gDW m^{-2} d^{-1})
HARVSN	($N_{s\rightarrow Harv}$) N flow: harvest of straw (PLANT)	(gN m^{-2} d^{-1})
HARVSW	($W_{s\rightarrow Harv}$) Biomass flow: harvest of straw (PLANT)	(gDW m^{-2} d^{-1})
INCALIT	($N_{Plant\rightarrow Ab}$) N flow: Plant to above-ground residue	(gN m^{-2} d^{-1})
INCALITC	($C_{Plant\rightarrow Ab}$) C flow: Plant to above-ground residue	(gC m^{-2} d^{-1})
NEWCL	($C_{r\rightarrow LiTot}$) C flow: Incorporation of root carbon or above-ground residues to litter-C. (Index=layer). If MICROB-switch=1 then NEWCL is split up into flows to different pools.	(gC m^{-2} d^{-1})
NEWCLLIT	($C_{r\rightarrow Li}$) C flow: Root to litter. (Index=layer). Only used if MICROB-switch=1.	(gC m^{-2} d^{-1})
NEWCLLI2	($C_{r\rightarrow Li2}$) C flow: Root to litter. (Index=layer)	(gC m^{-2} d^{-1})
NEWCLHUM	($C_{r\rightarrow Li}$) C flow: Root to litter. (Index=layer).	(gC m^{-2} d^{-1})

NEWNL	($N_{r\rightarrow LiTot}$) N flow: Root to litter (Index=layer). If MICROB-switch=1 then NEWNL is split up into flows to different pools.	(gN m^{-2} d^{-1})
NEWNLLIT	($N_{r\rightarrow Li}$) N flow: Root to litter (Index=layer). Only used if MICROB-switch=1.	(gN m^{-2} d^{-1})
NEWNLLI2	($N_{r\rightarrow Li2}$) N flow: Root to litter2 (Index=layer)	(gN m^{-2} d^{-1})
NEWNLHUM	($N_{r\rightarrow h}$) N flow: Root to humus (Index=layer)	(gN m^{-2} d^{-1})
NFERTNH4	($N_{Fert\rightarrow NH4}$) N flow: Solid fertilizer N dissolved to soil ammonium NH4(1)	(gN m^{-2} d^{-1})
NFERTNO3	($N_{Fert\rightarrow Inf+Surf}$) N flow: Solid fertilizer N dissolved	(gN m^{-2} d^{-1})
NFHUM	($N_{f\rightarrow h}$) N flow: Humification of faeces-N to humus-N (Index= layer 1 to 2)	(gN m^{-2} d^{-1})
NFLOW	($N_{NO3(i)\rightarrow NO3(i+1)}$) N flow: NO_3-N flow to the layer below (Index= layer 1 to NUMLAY-1)	(gN m^{-2} d^{-1})
NFMIN	($N_{f\rightarrow NH4}$) N flow: Mineralisation of faeces-N to NH_4-N (Index= layer 1 to 2)	(gN m^{-2} d^{-1})
NH4DLOSS	($N_{NH4\rightarrow Stream}$) N flow: NH_4 leaching to tiles (Index= layer 1 to NUMLAY)	(gN m^{-2} d^{-1})
NH4FLOW	($N_{NH4(i)\rightarrow NH4(i+1)}$) N flow: NH_4-N flow to the layer below (Index= layer 1 to NUMLAY-1)	(gN m^{-2} d^{-1})
NHARV	($N_{Plant\rightarrow Harv}$) N flow: Harvest export of plant-N (PLANT)	(gN m^{-2} d^{-1})
NHMIC	($N_{h\rightarrow m}$) N flow: Microbial gain from humus	(gN m^{-2} d^{-1})
NHMIN	($N_{h\rightarrow NH4}$) N flow: Mineralisation of humus-N to NH4-N (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})
NLHUM	($N_{Li\rightarrow h}$) N flow: Humification of litter-N to humus-N (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})
NLMIC	($N_{Li\rightarrow m}$) N flow: Microbial gain from litter	(gN m^{-2} d^{-1})
NL2MIC	($N_{Li2\rightarrow m}$) N flow: Microbial gain from litter2	(gN m^{-2} d^{-1})
NLMIN	($N_{Li\rightarrow NH4}$) N flow: Mineralisation(immobilisation) of litter-N to NH4 (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})
NLROFF	($N_{Li\rightarrow Stream}$) N flow: Loss of litter from uppermost layer to stream due to surface runoff	(gN m^{-2} d^{-1})
NMHUM	($N_{m\rightarrow h}$) N flow: Microbial-N to humus (Index=layer)	(gN m^{-2} d^{-1})
NMLIT	($N_{m\rightarrow Li}$) N flow: Microbial-N to litter (Index=layer)	(gN m^{-2} d^{-1})

NMLIT2	($N_{m\rightarrow Li2}$) N flow: Microbial-N to litter2 (Index=layer)	(gN m^{-2} d^{-1})
NMMIN	($N_{m\rightarrow NH4}$) N flow: Mineralisation(immobilisation) of microbial-N to NH4 (Index=layer)	(gN m^{-2} d^{-1})
PHOS	($W_{Atm\rightarrow Phos}$) Biomass flow: Assimilation rate (PLANT)	(gDW m^{-2} d^{-1})
RESPGW	($W_{g\rightarrow Atm}$) Biomass flow: Loss due to respiration of grains (PLANT)	(gDW m^{-2} d^{-1})
RESPLW	($W_{l\rightarrow Atm}$) Biomass flow: Loss due to respiration of old leaves. (PLANT)	(gDWm^{-2} d^{-1})
RESPRW	($W_{r\rightarrow Atm}$) Biomass flow: Loss due to respiration of woody root (PLANT)	(gDW m^{-2} d^{-1})
RESPSW	($W_{s\rightarrow Atm}$) Biomass flow: Loss due to respiration of woody stem (PLANT)	(gDWm^{-2} d^{-1})
UPPNH4	($N_{NH4\rightarrow Plant}$) N flow: Plant uptake of NH4-N (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})
UPPNO3	($N_{NO3\rightarrow Plant}$) N flow: Plant uptake of NO3-N (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2} d^{-1})

7.3 Auxiliaries

Variable	(Symbol) Explanation	Unit
AEFF	(e_m*e_t) For the mineralisation process. Combined effect of soil water content and soil temperature (concerning layer see OUTLAY parameter)	(-)
AEFFD	(e_m*e_{td})For the denitrification process. Combined effect of soil water content and soil temperature for a layer	(-)
AEFFN	(e_m*e_{tn})For the nitrification process. Combined effect of soil water content and soil temperature for a layer	(-)
ALI	(A_l) Total leaf area (index m^2/m^2) (PLANT)	(-)
ALINEW	(A_{lNew}) Leaf area (index m^2/m^2) of leaves formed the current year (PLANT)	(-)
ALIOLD	(A_{lw}) Leaf area (index m^2/m^2) of old leaves (if GROWPEREN=1) (PLANT)	(-)
ARESPP	(e_{tp}) Respiration function for above ground plant parts (PLANT)	(-)
ARESPR	(e_{tr}) Respiration function for roots, mean of all layers (PLANT)	(-)
ATEFF	(e_t) For the mineralisation process. Effect of soil temperature (concerning layer see OUTLAY parameter)	(-)

ATEFFD	(e_{td}) For the denitrification process. Effect of soil temperature for a layer	(-)
ATEFFN	(e_{tn}) For the nitrification process. Effect of soil temperature for a layer	(-)
AVTEMP	(f_{Tap}) Release of above ground available assimilates response function to temperature (PLANT)	(-)
AVTEMS	(f_{Tas}) Release of below ground available assimilates response function to temperature (PLANT)	(-)
BI	(b_i) Leaf area to shoot biomass ratio (tissues formed the current year) (PLANT)	(m^2 gDW^{-1})
BOUNCORR	() Accumulated correction (absolute values) of simulated value (Index=variable to be corrected). Only used if BOUNDARY-switch=1.	(differ)
BOUNVARN	() Variable used for correction of simulated value. Below this value correction is made. (Index=variable to be corrected). Only used if BOUNDARY-switch=1.	(differ)
BOUNVARX	() Variable used for correction of simulated value. Above this value correction is made (Index=variable to be corrected). Only used if BOUNDARY-switch=1.	(differ)
BR	(b_r) Root allocation function (PLANT)	(-)
BRE	(b_{re}) Root allocation, sub function dependent on plant water factor (PLANT)	(-)
BRN	(b_{rn}) Root allocation, sub function dependent on plant nitrogen factor (PLANT)	(-)
BRW	(b_{rw}) Root allocation, sub function dependent on plant biomass (PLANT)	(-)
CLMIN	($C_{Li\rightarrow Atm}$) C flow: C Mineralisation from litter (Index=layer 1 to min(NUMLAY,10))	($gC\ m^{-2}$)
CLHUM	($C_{Li\rightarrow h}$) C flow: C flow from litter to humus (Index=layer 1 to min(NUMLAY,10))	($gC\ m^{-2}$)
CLINT	($C_{Decomp\rightarrow Li}$) C flow: Internal circulation of C within litter (Index=layer 1 to min(NUMLAY,10))	($gC\ m^{-2}$)
CLTPROF	(ΣC_{Li}) Litter-C in whole profile	($gC\ m^{-2}$)
CO2CONC	(CO_{2Atm}) Atmospheric CO_2 concentration	(ppm)
DAYSTART	(t_f) Day number at which photosynthesis starts. (PLANT)	(d)
DEFICLN	Deficit in daily N uptake to leaves (PLANT)	($gN\ m^{-2}\ d^{-1}$)
DEPOWC	Total wet N deposition	($gN\ m^{-2}\ d^{-1}$)

FECKCN	(k_f) Faeces specific decomposition rate (parameter FECK). If SPECIAL-switch=1 it can be a function faeces C/N ratio.	(d^{-1})
FERNSIM	($N_{Appl \rightarrow NH4orNO3}$) N external supply simulated by the model. As NH_4 if FERNCALC-switch = 1 and as NO_3 if the switch = 2	(gN m^{-2} d^{-1})
GROWSTAG	(i_v) Index for stage of growth: sowing-emergence (i_v=1), accumulating temp. sum before growth (10), emergence (11), flushing (12), vegetative growth (2), grain filling (21), end grain filling-mature (22), harvest (3), annual-perennial (13), no photosynthesis (14) (PLANT)	()
LEAFDN	($N_{lDemand}$)N flow : leaves N demand (PLANT)	(gN m^{-2} d^{-1}
LEAFDNEX	N flow : extra leaf N demand (If SPECIAL-switch=1) (PLANT)	(gN m^{-2} d^{-1})
LITKCN	(k_l) Litter specific decomposition rate (parameter LITK). If SPECIAL-switch=1 it can be a function litter C/N ratio.	(d^{-1})
NAVAI	(n_a) The ratio between N and assimilates of the available pool (PLANT)	(-)
NCONC	(n_{NO3}) Concentration of NO_3-N in soil solution (Index= layer 1 to NUMLAY)	(mgN l^{-1})
NFTPROF	(ΣN_f) Faeces-N in whole profile	(gN m^{-2})
NGRAIN	(n_g) Actual N concentration of grain (PLANT)	(-)
NH4CONC	(n_{NH4}) Concentration of NH_4-N in soil solution (Index= layer 1 to NUMLAY)	(mgN l^{-1})
NH4T	(ΣN_{NH4}) NH4-N in whole profile	(gN m^{-2})
NHTPROF	(ΣN_h) Humus-N in whole profile	(gN m^{-2})
NLEAF	(n_l) Actual leaf N concentration (PLANT)	(-)
NLEAFNEW	(n_l') Actual N concentration of newly formed leaves (the ratio between daily uptake of nitrogen and growth of leaves) (PLANT)	(-)
NLTPROF	(ΣN_{Li}) Litter-N in whole profile	(gN m^{-2})
NO3T	(ΣN_{NO3}) NO3-N in whole profile	(gN m^{-2})
NROOT	(n_r) Actual root N concentration (PLANT)	(-)
NSTEM	(n_s) Actual stem N concentration (PLANT)	(-)
NWLEAF	(n_{lw}) Actual old leaf N concentration (PLANT)	(-)
NWROOT	(n_{rw}) Actual woody root N concentration (PLANT)	(-)

NWSTEM	(n_{sw}) Actual woody stem N concentration (PLANT)	(-)
ODNO3	"Partly measured" leaching of NO3-N to tile drainage system (from all layers) ,i.e., measured NO3 concentration multiplied by simulated water flows from drainage tile system.	(gN $m^{-2}d^{-1}$)
PHEFF	(e_p) Effect of soil acidity on nitrification (Index= layer 1 to min(NUMLAY,10))	(-)
PHOEFFC	(α) Potential radiation use efficiency only affected by atmospheric CO_2 and reduction due to radiation absorption by grains. (PLANT)	(gDW MJ^{-1})
PIPEL	($\Sigma N_{NO3\rightarrow Drain}$) Leaching of NO3-N to tile drainage system (from all layers)	(gN m^{-2} d^{-1})
PIPENO3C	(n_{Drain})Concentration of NO3-N in tile drainage	(mgN l^{-1})
PIPEQ	Water flow to drainage tiles (from total profile)	(mmH_2O d^{-1})
POTUPT	($N_{Soil\rightarrow PotUp}$) Potential plant uptake of NO3-N + NH4-N. If GROWPEREN-switch=1 then POTUPT includes the demand of release of available assimilates.	(gN m^{-2} d^{-1})
QNO3C1	(n_{Stream}) Concentration of NO3 in stream water.	(mgN l^{-1})
QNO3C2	(n_{Out}) Concentration of NO3 in stream water after N-consumption in stream.	(mgN l^{-1})
RATCNF	(c_f) C-N ratio of faeces (Index = layer 1 to min(NUMLAY,2))	(-)
RATCNL	(c_{Li}) C-N ratio of litter (Index=layer). If MICROB-switch=1 RATCNL can be C/N ratio of litter, litter2, humus or microbes depending on parameter OUTRATCN	(-)
RISGROUN	(I_g) Radiation reaching the soil surface. (PLANT)	(W m^{-2})
ROOTDENSI	Root biomass per soil volume (Index = layer 1 to min(NUMLAY,7)) (PLANT)	(gDW m^{-1})
ROOTDEPTH	(z_r) Root depth (PLANT)	(m)
ROOTDN	($N_{rDemand}$)N flow : roots nitrogen demand (PLANT)	(gN m^{-2} d^{-1})
ROOTDNEX	N flow : extra root nitrogen demand (if SPECIAL=1) (PLANT)	(gN m^{-2} d^{-1})
ROOTPROF	($W_r(i)$) Root biomass per soil layer. (Only current year old roots) (Index = layer 1 to min(NUMLAY,7)) (PLANT)	(gDW m^{-2})
RPMOS	(f_W) Plant growth response function to plant water factor (PLANT)	(-)

RPN	(f_N) Plant growth response function to plant nitrogen factor (PLANT)	(-)
RPTEM	(f_T) Plant growth response function to temperature (PLANT)	(-)
RPTOT	(f_{Tot}) Plant growth response function, combined effect of plant water factor (ETR), plant nitrogen factor (RPN) and temperature (RPTEM). (PLANT)	(-)
RROOT	(a_r): Root biomass in a layer as a fraction of total root biomass. (Index=layer 1 to min(NUMLAY,10))	(-)
RUSENO3	($N_{Stream \rightarrow Consum}$) NO3-N consumption in stream water	(gN m^{-2} d^{-1})
STEMDN	($N_{sDemand}$) N flow : stem nitrogen demand (PLANT)	(gN m^{-2} d^{-1})
STEMDNEX	N flow : extra stem nitrogen demand (if SPECIAL=1) (PLANT)	(gN m^{-2} d^{-1})
STREAMQ	Water flow in stream	(mmH_2O d^{-1})
STREAMT	($\Sigma(N_{NO3 \rightarrow Stream})$ Total leaching of NO3-N to stream flow (including tile drainage, surface runoff and ground water percolation)	(gN m^{-2} d^{-1})
SUMN	An estimated sum of N available for plant uptake. Only used if FERNCALC-switch = 2.	(gN m^{-2})
SWITCHOUT	Switch. Different internal model switches can be put into this variable, see parameter OUTSW.	()
TINFNO3	($N_{Inf \rightarrow NO3}$) N flow: Infiltration of NO3 to layer 1 (acts as a flow variable)	(gN m^{-2} d^{-1})
TOTDEN	($\Sigma N_{NO3 \rightarrow Atm}$) Actual denitrification (from total profile)	(gN m^{-2} d^{-1})
TOTFI	(N_{Stream}-$N_{Stream \rightarrow Consum}$) Total leaching of NO3-N to stream flow after N-consumption in stream	(gN m^{-2} d^{-1})
TOTMAE	($\Sigma N_{Appl \rightarrow f}$) Flow of nitrogen in faeces in manure to faeces-N (in total profile)	(gN m^{-2} d^{-1})
TOTMAL	($\Sigma N_{Appl \rightarrow Li}$) Flow of nitrogen in bedding in manure to litter-N (in total profile)	(gN m^{-2} d^{-1})
TOTMAN	($\Sigma N_{Appl \rightarrow NH4}$) Flow of nitrogen in NH4 in manure to NH4-N (in total profile)	(gN m^{-2} d^{-1})
TOTNFMIN	($\Sigma N_{f \rightarrow NH4}$) Mineralisation/immobilisation of faeces-N to NH4-N (in total profile)	(gN m^{-2} d^{-1})
TOTNHMIN	($\Sigma N_{h \rightarrow NH4}$) Mineralisation of humus-N to NH4-N (in total profile)	(gN m^{-2} d^{-1})

TOTNIT	($\Sigma N_{NH4\rightarrow NO3}$) Nitrification of NH4-N to NO3-N (in total profile)	(gN m^{-2} d^{-1})
TOTNLMIN	($\Sigma N_{Li\rightarrow NH4}$) Mineralisation/immobilisation of litter-N to NH4-N (in total profile). If MICROB-switch=1 then: mineralisation/immobilisation from microbes.	(gN m^{-2} d^{-1})
TOTNH4NF	($\Sigma N_{NH4\rightarrow f}$) N flow from NH4 to faeces (in total profile)	(gN m^{-2} d^{-1})
TOTNH4NL	($\Sigma N_{NH4\rightarrow Li}$) N flow from NH4 to litter (in total profile)	(gN m^{-2} d^{-1})
TOTNO3NF	($\Sigma N_{NO3\rightarrow f}$) N flow from NO3 to faeces (in total profile)	(gN m^{-2} d^{-1})
TOTNO3NL	($\Sigma N_{NO3\rightarrow Li}$) N flow from NO3 to litter (in total profile)	(gN m^{-2} d^{-1})
TOTUPT	($\Sigma N_{Soil\rightarrow Plant}$) Actual plant uptake of NO3-N + NH4-N, total profile.	(gN m^{-2} d^{-1})
TSURRNO3	($N_{Surr\rightarrow Stream}$) N flow: Surface runoff of NO3 to STREAMT (acts as a flow variable)	(gN m^{-2} d^{-1})
VDEV	(i_p) Index that determines the start of grain development (PLANT)	(-)

7.4 Drivings

Variable	Explanation	Unit
DFLOW	Driving variables: Water flow to drainage tiles, ground water flow and surface runoff because of limited hydraulic conductivity in the soil. (Index= layer 1 to NUMLAY). DFLOW in the SOIL model.	(mmH_2O d^{-1})
ETR	(E_t/E_{tp}) Transpiration ratio (actual/potential)	(-)
INF	(q_{Inf}) Infiltration of water into the soil surface (including infiltration from surface pool).	(mmH_2O d^{-1})
INFBYPASS	(q_{Inf2}) Infiltration of water directly to the second soil layer (Not used)	(mmH_2O d^{-1})
MEACONC	Measured concentration of NO3 in tile drainage.	(mgN l^{-1})
PERC	Driving variable: Ground water flow. PERC in the SOIL model.	(mmH_2O d^{-1})
RIS	(I) Solar radiation (300-3000 nm)	(MJm^{-2} d^{-1})
SURR	(q_{Surr})Driving variable: Runoff above surface because of limited infiltration capacity in the soil surface. SURR in the SOIL model.	(mmH_2O d^{-1})
TA	(T_a) Air temperature	(°C)

TEMP	(T_s) Driving variables: Soil temperature (Index= layer 1 to NUMLAY) TEMP in the SOIL model.	(°C)
THETA	(θ) Driving variables: Volumetric water content (Index= layer 1 to NUMLAY). THETA in the SOIL model.	(%)
WFLOW	Driving variables: Water flow between soil layers (Index= 1 to NUMLAY-1). WFLOW in the SOIL model.	($mmH_2O\ d^{-1}$)

8 Run options

Are used to specify the timestep, the temporal representation of output variables and the period for the simulation.

8.1 Run no.:

8.2 Start date:

8.3 End date:

8.4 Output interval:

The output interval determines how frequent the output variables will be written to the output file. The actual representation of the requested output variables can either be a mean value of the whole time interval or the actual value at time of output (see the switches, AVERAGEX, T.., G.., D..). You can specify the output interval as integers with units of days or minutes.

days:

minutes:

8.5 No of iterations:

The time step of the model is one day. No other values are allowed.

8.6 Run id:

Any string of characters may be specified to facilitates the identification of your simulation in addition to the run number. The identification given will be written in the variable identification field used by the Pgraph-program. Be careful when using long strings of characters since the default information for identification of a field may be overwritten in some cases.

8.7 Comment:

9 Execute

9.1 Exit

The exit command will terminate the interactive session and quit the program without starting a simulation. If a parameter file has been created the input will be saved otherwise all information entered will be lost.

9.2 Run

The run command will terminate the interactive session and start a simulation using the instructions entered. All the instructions are also written to the .SUM-file which may be used as a parameter file if you would like to reproduce the simulation.

9.3 Write parameter file

This will create a new parameter file which includes all the instructions which are specified when the command is given. The new parameter file can be used as an input file if you would like to run the model using instructions from the new parameter file.

10 Warnings and Errors

If you specify your input files or your parameter values in a strange way you may get informations about this before you start executing the model. There are two level: Warnings and Errors.

Normally you will be informed about warning or errors after you have modify a parameter value and moved to the new submenu. Some errors are the results of combinations of different parameters values and they may not occur before you try to run the model. In this situation a final check of all input files and all relevant parameter values are made. If the final check results in any messages you can always return to the PREP program and continue to modify your instructions so they will be within valid ranges of accepted intervals. If you do so the list of messages are found in an window under the execute menu.

In case of errors, the most severe level, there are no chance to run the model but in case of only warnings you may try to run the model without correcting your instructions.

11 Commands

You start the preparation of a simulation by pressing

```
PREP SOILN
```

on the command line of the DOS system. This will be the starting point for adding any type of new instructions for your simulation. If a parameter file named SOILN.PAR is present at the current directory default values from that file will be used otherwise original model default values will be used.

You can also start the interactive session with values taken from parameter file by entering the name of the parameter file name on the command line:

```
PREP SOILN AIN_ONE
```

will result in default values from the parameter file AIN_ONE.PAR.

You run the SOILN model in batch mode, which means that you will not make use of the interactive session at all. Instead you will run the model from default values.

```
PREP -b SOILN AIN_ONE
```

which will result in a simulation making use of information from the AIN_ONE.PAR file. If information is missing in the AIN_ONE.PAR file values from the original model definition file will be used. A parameter file does not need to be complete. It may be restricted to only instructions that need to be changed compared to what is found in the original model definition file. There are also a possibility to specify a number of parameter files on the command line:

```
PREP -b SOILN AIN_ONE AIN_TIME
```

This means that the PREP program will first read the instructions in the AIN_ONE.PAR file and then the AIN_TIME.PAR file. If information for one parameter is read several times the one read last will be used. Remember that the parameter files may not be complete. They can for instance be organized with only information about time periods as in the AIN_TIME.PAR file.

12 Additional information

12.1 Help

Just press the F1 key and you are transferred to the help utility.

In some situations you will get simultaneous help as you move between different items in the ordinary menus. In such a case you are fully transferred to the help by using the F2 key which may be necessary if the information from the help library is not fully within the size of the current size of the help window.

12.2 Acknowledgement

The SOILN model is the result of many years of work. A number of persons have contributed with ideas and suggestions. This could easily be seen from the reference list. Responsible for the present updating of the SOILN model from version 8.0 to 9.1 is Henrik Eckersten. This updating is based on discussions mainly with Karin Blombäck, Annemieke Gärdenäs, Per-Erik Jansson, Thomas Kätterer and Tryggve Persson, all at the Swedish University of Agricultural Sciences (Uppsala), Tor Arvid Breland at the Agricultural University of Norway (Ås, Norway) and also other participants of the NORN project (Jansson & Persson, 1992). Henrik Eckersten made the programming and Hans Johansson, SLU, Uppsala, contributed with help in programming the SIMVB-program. This work was done within the NORN project financed by Nordic authorities SNS/NKJ and national financial boards, mainly SJFR (Skogs- och jordbrukets forskningsråd, Sweden).

Specific contributions were as follows: The special option where the assimilation rate is a function of a light response curve for the single leaf integrated over the canopy (GROWPHOS-switch = 1) was implemented by Lianhai Wu, Beijing Agricultural University, China, currently working at the Soil Department, SAC, Edinburgh, Scotland. Lianhai Wu also contributed with some technical model developments. An option for calculating phenologic stages (GROWPHEN-switch = 2) was introduced from the AFRCWHEAT model (Porter, 1984). The software was delivered by Mikhail Semenov at Long Ashton Research Station, University of Bristol, UK. A special option on estimating N supply to cover deficiency in natural N supply (FERNCALC-switch = 2) was introduced by Peter Botterweg Jordforsk, Ås, Norway and Holger Johnsson SLU, Uppsala. The Ratkowsky temperature function and some other parts of the microbial activity was introduced after discussions with Tor Arvid Breland. The balance between adsorbed and dissolved ammonium was developed with help of Claus Beier, Risö National Laboratory, Roskilde, Denmark and Per Gundersen, Danish Forest and Landscape Research Institute, Lyngby, Denmark. The calibration procedure was developed and written together with Thomas Kätterer.

As concerns the responsibility of SOILN version 8.0, see Eckersten et al. (1994). Basic works for previous versions of the model have been made by the three authors of this manual. The PREP-program was made by Per-Erik Jansson and Jan Claréus. If you get problems, find bugs or just want to report an interesting phenomena please let us know about it (remember to send a copy of your input data files and summary-file when you get any problems). Write to:

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12.4 News

Important changes since SOILN v8.0 will be mentioned here. The best overview of new developments is given by the Model specific and special switches description.

February 95

The ZLEAF(2) parameter has got the opposite sign. The harvest routine for the forest growth model has been rebuild, but no changes in input has been made. The CROPPHEN-switch and TAPHENOL-parameters have been introduced.

Mars 95

Date of end of grain filling is also made a function of maximum possible harvest-index given the new parameter HARINDEXX. Additional options have been included for CROPALLO-switch = 2 (N demand by leaves).

August 95
Several changes have been made of which the following are most important: The FOREST submodel has been cancelled. Its options have been build into the CROP submodel which now is named PLANT submodel (the harvest routine remains to build in). Parameter, switch and variable names have been changed in many cases. Extensive error check has been made. The uppermost faeces pool can be used as an additional pool which litter has to path between LITABOVE and NLIT(1). Nitrate and ammonium are both immobilised by litter and faeces in proportion to its abundance. A microbial pool has been introduced in each layer. Deposition nitrogen can be taken up by leaves. Nitrogen can be leached from leaves in case of precipitation. Specific decomposition rate can be set a function of C/N ratio. A new option for calculating leaf assimilation with a photosynthesis response curve is activated with switch GROWPHOS.

July 96
Version 9.1 is ready. The main differences compare to August 95 are: The special option on microbial activity is further developed (MICROB-switch). The alternative use of the faeces pool, as mentioned for August 1995, is cancelled. Alternative temperature functions influencing soil biological processes are added (TEMPREQ-switch). The ammonium is made mobile in the profile (NH4MOBIL-switch). The response of plant biomass allocation to water conditions is included (AROOTE). The response of plant growth to water is given more alternatives (PHOETR) and the response to changing atmospheric CO_2 is included (PHOCO2). The utilisation of available pool in plant is changed (AVAWOOD). A special option on defining boundary conditions for the simulation is included (BOUNDARY-switch).

Appendix 1: Variable number list

Date: 1996-01-31

States (X-variables)
NO3 22 maxindex = 22
**This means that NO3(1-22)= variables 1-22
ACCPLANT 23
ACCDENI 24
ACCDLOSS 25
FERT 26
NLIT 36 maxindex = 10
NF 38 maxindex = 2
NH 48 maxindex = 10
CL 58 maxindex = 10
CF 60 maxindex = 2
NH4 70 maxindex = 10
LITABOVE 71
GRAINW 72
LEAFW 73
STEMW 74
ROOTW 75
GRAINN 76
LEAFN 77
STEMN 78
ROOTN 79
WROOTW 80
WSTEMW 81
WLEAFW 82
WROOTN 83
WSTEMN 84
WLEAFN 85
XAVAIN 90
XAVAIW 91
ACCFERT 98
ACCMAN 99
ACCDEP 100
ACCHARV 101
ACCSOIL 102
ACCBAL 103
ACCSOILC 104
ACCPHOSC 105
ACCHARVC 106
ACCRESPC 107
ACCPLANTC 108
ACCBALC 109
LITABOVEC 110
NM 120 maxindex = 10
CM 130 maxindex = 10
CH 140 maxindex = 10
CL2 150 maxindex = 10
NLIT2 160 maxindex = 10

Flows (T-variables)
UPPNO3 10 maxindex = 10 (change TOTUPT also)
DENI 20 maxindex = 10
DLOSS 42 maxindex = 22
DEPONO3 43
NFLOW 64 maxindex = 21
FERTIN 65
FINNB 67 maxindex = 2
NHARV 68
NEWNL 78 maxindex = 10
NLMIN 88 maxindex = 10
NLHUM 98 maxindex = 10
FINNA 100 maxindex = 2
NHMIN 110 maxindex = 10
NFHUM 112 maxindex = 2
FINNH 114 maxindex = 2
FNIT 124 maxindex = 10
CLLOSS 134 maxindex = 10
NEWCL 144 maxindex = 10
CFLOSS 146 maxindex = 2
FINCB 148 maxindex = 2
NFMIN 150 maxindex = 2
UPPNH4 160 maxindex = 10 (change TOTUPT also)
INCALIT 161
DECALIT 162
ASOILRN 163
ASOILSN 164
ASOILLN 165
PHOS 167
RESPLW 168
RESPSW 169
RESPRW 170
RESPGW 171
HARVGW 172
HARVLW 173
HARVSW 174
APHOTLW 175
ALEAFGW 176
ASTEMGW 177
APHOTSW 178
ALEAFSW 179
AROOTSW 180
ALEAFSN 181
AROOTSN 182
AROOTGN 183
APHOTRW 184
ASTEMGN 185
ALEAFGN 186

HARVGN 187
HARVLN 188
HARVSN 189
AWROOTLIN 190
AAVAIUN 191
AWSTEMAN 192
AWLEAFAW 193
AWSTEMAW 194
AWROOTAW 195
AROOTAW 196
ASTEMAW 197
AWROOTLIW 198
AWSTEMLIW 199
DECALEAC 200
AAVAIPW 201
ALEAFWN 202
AWLEAFLIW 203
DECALEAN 204
ALEAFWW 205
ASTEMWW 206
AROOTWW 207
ALEAFFAL 208
ASTEMWN 209
AROOTWN 210
ALEAFAN 211
ASTEMAN 212
AROOTLIN 213
ASTEMLIN 214
ALEAFLIN 215
CHARV 223
AWLEAFLW 224
AWLEAFLIN 225
AWSTEMLIN 226
ALEAFAW 227
INCALITC 228
DECALITC 229
DEPONH4 230
NFERTNO3 231
NFERTNH4 232
AROOTAN 233
ALEAFLIW 234
ASTEMLIW 235
AROOTLIW 236
AROOTGW 237
AWLEAFLN 238
TINFNO3 239
TSURRNO3 240
DECACF 241
DECANF 242
ALEAFN3N 243
DEPOLEAF 244
NLMIC 254 maxindex = 10
CMMIN 264 maxindex = 10
CMHUM 274 maxindex = 10
CLMIC 284 maxindex = 10
NMMIN 294 maxindex = 10
NMHUM 304 maxindex = 10
DEPOWLEAF 305
AWLEAFN3N 306
NLROFF 307
CLROFF 308
DECAROFF 309
DECAROFFC 310
CHMIC 325 maxindex = 10
CL2MIC 335 maxindex = 10
CMLIT 345 maxindex = 10
CHMIN 355 maxindex = 10
CMLIT2 365 maxindex = 10
NHMIC 375 maxindex = 10
NL2MIC 385 maxindex = 10
NMLIT 395 maxindex = 10
NMLIT2 405 maxindex = 10
NEWCLLIT 415 maxindex = 10
NEWCLLI2 425 maxindex = 10
NEWCLHUM 435 maxindex = 10
NEWNLLIT 445 maxindex = 10
NEWNLLI2 455 maxindex = 10
NEWNLHUM 465 maxindex = 10
DECACLIT 466
DECACLI2 467
DECACHUM 468
DECANLIT 469
DECANLI2 470
DECANHUM 471

Auxilaries (G-variabler)
NCONC 22 maxindex = 22
ROOTDEPTH 31 (depends on ROOTW)
POTUPT 32
TOTUPT 34 (change UPPNH4 and UPPNO3 also)
AEFF 60
ATEFF 63
ALI 65 (depends on LEAFW)
RPTEM 70
RPTOT 71
RPN 72
GROWSTAG 79
ALINEW 80
ALIOLD 81
AEFFD 122
AEFFN 123
ATEFFD 124
ATEFFN 125
PHEFF 135 maxindex = 10

Appendix 2: SIMVB; Run SOILN under the Windows program

The description below refers to the program SIMVB.EXE version 1.2 (dated 1996-07-01) made by H. Eckersten, Swedish University of Agricultural Sciences.

The objectives of the SIMVB program are to enable the user of the SOILN model to run the model technically in a simple way, to enable both a strict and flexible presentation of model output, and to enable a simple way of using the model as a tool for evaluation of possible changes in input, calibration, validation and to bring order to input and output files.

Normally, the SOILN model is used together with the SOIL model (Jansson 1991a), therefore the link to SOIL will mentioned below. The SIMVB program is also adapted to the SOIL model and the SPAC model (Eckersten, 1995).

How to run SOILN

Run under DOS

Firstly, we make a short summary of which programs and files that are involved when running SOILN program in an ordinary way under DOS.

The SOILN model is executed by the program file SOILN.EXE. There are some associated files to this program. A help-file with variable descriptions etc (SOILN.HLP), a file with standard parameter values and other informations needed by the model (SOILN.DEF) and a file including titles and units of the output variables (SOILN.TRA).

The model is run by using a program file named PREP.EXE. This program helps you to prepare and execute the simulation, i.e. you can select parameter values, input files, simulation period etc. The PREP program describes the in- and outputs of the model (type for instance, >prep soiln). All information needed for PREP can be stored in a parameter file (xxxx.PAR-file). You can give instructions to PREP to read the information directly from the PAR-file. PREP is the program that can activate SOILN.EXE, i.e. to start the simulation. Output from the simulation are stored in two files, SOILN001.BIN and SOILN001.SUM. The first file (.BIN) includes the values of the simulated variables. The second file (.SUM) includes both a summary of all outputs (averages, sums, etc.) and the prerequisites for the simulation (i.e. the inputs). The file can be used to repeat the simulation if it is renamed to xxxx.PAR.

You can look on the results and make further evaluations of the simulation outputs (SOILN001.BIN) with help of a special program, PG.EXE.

Run under WINDOWS (SIMVB)

The principal idea for this program (SIMVB.EXE) is to comfortably make use of already developed DOS programs and applications when running SOILN under WINDOWS. The program is restricted to the "administration" of the operative programs and routines. SIMVB.EXE is programmed in Windows-VisualBasic and used under WINDOWS. The VBRUN300.DLL file should be available.

You start SIMVB from the run option of WINDOWS, or by double clicking the icon (if installed) or by writing under DOS: >win simvb

In the program SIMVB you always start with the heading denoted *"Start here"*. Note, that in the SIMVB program you should always use only single click. First you select model to be used and second the application, which should be stored on disk. Thereafter you normally continue with *"Preparation of INput"*. (If you already have made a complete preparation, and want to have free access to any part of the program, you select *"Check off"*. The Check option checks the order in which you select options in the program from preparation to presentation of output during one run. If you leave the program the Check option is reseted.)

SIMVB enables a good overview of the principal way of using the model. If a complete run (*"Preparation of INput, Simulation"*, etc) has been made, the different options in the schedule can be chosen in any order at any time. However, for the first run, you have to choose them in the following order:

(i) PREPARATION of INPUT.
Copies input files to the working directory. Note, that the routines under this option overwrites files at the working directory, without warnings.

(ii) PRESENTATION of INPUT.
Variables in input files named AIN_CLIM.BIN, AIN_FERT.BIN etc are presented.

(iii) SIMULATION.
The results are stored in files named SOILNCUR.bin and SOILNCUR.sum (CUR denotes the current simulation).

(iv) PRESENTATION of OUTPUT.
Variables in SOILNCUR.bin are presented. Variables that are presented are grouped in accordance to subjects like litter N, plant N etc. You can also compare results with the previous run and/or simulations that have been stored, see below. You can view the summary file of the simulation as well.

(v) STORE FILES.
Here you can store the simulation results (SOILNCUR.*) under a different name. You can also recover a previous stored simulation to the name (SOILNCUR.*), thereby making it available for use in the presentation options etc.

(vi) SOIL-SOILN INTERACTION.
You should use this option if you want the current SOILN simulation to be input to the SOIL model, or vice versa.

(vii) EXIT the program.
You should exit the program by pressing the "EXIT" bottom on the main menu.

Alternative use of SIMVB

Documentation
You can read the SOILN-manual on screen by selecting *"Switches etc, Documentation*, Select item, SOILN users manual"*. In a similar way you can read this SIMVB documentation and the Fortran code of the SOILN model (the model specific code).

Type of User
You can select three type of users (Student, Teacher, Research) under *"Switches etc"*. Different users will get access to different parts of the SIMVB program. Some of the options below is only possible to use if *"Research ON"* is chosen.

Give comments
By putting the mouse arrow on space between boxes and by making a click on the right bottom you can give comments, on whatever you want. The comments should be stored or cancelled (MAIN MENU) immediately after the option is closed.

Edit files

You can change a single parameter value or initial state by selecting *"Switches etc., Edit files*"* or *"Preparation of INput, Changes*, Edit files*"*. Be aware of that you must spell the parameter/variable name correct. As concerns changes in parameter files: Note that changes of parameter values preferably are introduced in the AIN_MAN.PAR since values in this file have the highest priority (if you make a change in AIN_PLAN.PAR and the parameter name also appears in AIN_MAN.PAR the latter is the one used).

Make the simulation under DOS

The simulation made by SIMVB can be done from the DOS prompt as well: demo_vb sim ain_man. In case the SIMVB-program do not start the simulation properly, you can use this command to make the simulation and then go back to SIMVB for presentation of output.

Use PREP-program manually

The PREP-program can be run in a standard (interactive) way within SIMVB. If you have made *"Preparation of INput, Normal*...."* the prepared AIN_xxxx.PAR files are read by PREP. The files are read in the following order: AIN_SOIL.PAR, AIN_PLAN.PAR, AIN_OUT.PAR, AIN_TIME.PAR, AIN_MAN.PAR. Simulation results are stored in SOILNcur.BIN as in the normal simulation.

If you do not want to load the parameters files you have chosen with preparation, then select *"Switches etc, Check off"* before entering PREP. Note that output file now is named SOILNxxx.BIN (where xxx is a number between 001 and 999) and if you want to make use of presentation of output options it has to be restored to SOILNcur.BIN (use *"Store files*, xxx to Current")*.

Use PG-program manually

The PG-program can be used in a standard (interactive) way within SIMVB. Select *"Switches etc, PG ON"*.

Use Excel-program manually

The Excel-program can be used in a interactive way within SIMVB, in case Excel is loaded and there is a path to Excel. Select *"Switches etc, Excel ON"*. SIMVB converts the PG-binary-file concerned to dbf or lotus123 format and brings you automatically into Excel. With help of the presentation routines of SIMVB you can select variables to be exported to Excel.

Print files

Graphs plotted on screen can also be stored on TEK-files. Select *"Switches etc, Plot Tek-files, Make Tek-files"*. The files can be printed on screen or paper, or converted to meta files (.CGM-file) that can be imported to documents and graphical programs (*"Switches etc, Print files*"....)*. Under this option also ASCII files can be printed.

Using only one parameter file

To run SIMVB with only one parameter file, there are two possibilities:

(1) Really, using only one parameter file: In this case the simulation is completely governed with a single parameter. Store the file under name AIN_ONE.PAR and select *"Switches etc, one par-file"*.

(2) Actually, using two parameter files: In this case you make use of the parameter file AIN_OUT.PAR selecting proper outputs for the SIMVB presentation routines. The content of the other four parameter files are put together into the AIN_MAN.PAR file. Note that you should take away (i) the declaration of file names except for FILE(9), which should be named AIN_FERT.BIN if it is used, and (ii) the OUTFORN switch. The three other parameter files have to exist but should be empty except for a ";" (AIN_OUT.PAR is delivered by SIMVB automatically).

Making the five parameter files

Under the option *"Preparation of INputs, normal*"* the five parameter files AIN_SOIL.PAR, AIN_PLAN.PAR, AIN_OUT.PAR, AIN_TIME.PAR and AIN_MAN.PAR can be created automatically from the last simulation (i.e. from SOILNcur.SUM-file).

Multiple runs

Up to 6 multiple simulations can be done and plotted. (It is the presentation of output that limits the number of simulations.) (*"Preparation of INput, Multiple simulation, Simulation, Others*, Multiple simulation, Presentaion of OUTput*, Multiple simulation"*)

Initial states of previous run

Make a simulation using outputs of the previous simulation as initial states in the new simulation. (*"Simulation, Others*, Initial values..."*)

File list

In the *"Preparation of INput, Normal*..."* option of SIMVB files can be selected arbitrary by selecting *"file list*"* in the list menus. This is a compliment to the other preparation options.

Alternative applications under directory ... \XXXX\...

Often several versions of the same main application is wanted to be run by SIMVB. For the "Standard" application one way of storing them separately and to be able to run them under SIMVB is to do as follows:
1) Store the main application with a full set up of input files under ...\XXXX\N\NA, as usual.
2) Store the files changed due the specific version under a separate directory named f.i. VERSION1, i.e. ...\NA\VERSION1. Do not change the name of the files and remember to store the INFO.LIS file in which you give an identification of the application stored in the directory.
3) Copy files from VERSION1 directory to working directory by selecting *"Preparation of INput, normal*, Prep. from SubDir, Directory, Preparation"*

Change instruction files

The instruction files used by the PG-program are stored under the directory C:\SIMVB\xxxxx\N\NA\PG. If you want the drawing to be made in another way or other variables to be selected you can edit these. The address to the file to be edit you get by selecting *"Switches etc, File name"* immediately after making a plot or any other operation (this option is not available for all files).

Adaptation of application to SIMVB

The description below refers to a "Standard" application.

SOILN

If you would like to run the SOILN model under the SIMVB program, there are principally two different starting points. Either you have an own application already working under DOS or you have not yet parameterised SOILN for your site. Below will be described one procedure to follow in the latter case. In the former case, see the bottom of this section.

1) Install the SIM_96 application used for the simulation course on SOIL-SOILN held at SLU in Mars 1996. The application refers to the Kjettslinge site north of Uppsala (Andrén et al. 1990) can be delivered by Henrik Eckersten or Thomas Kätterer (Thomas.Katterer@emc.slu.se) at SLU.

2) Check that the application works in its original version, on your computer.

3) Replace the files denoted AIN_.... under C:\SIMVB\N\NA\KJETTSL-directory to those of your application. In INFO.LIS file you write the information that it is your directory now.

-a) Start by replacing AIN_CLIM.BIN (the driving variable file taken from the SOIL model) to that of yours.
-b) Change in AIN_SOIL.PAR the number of soil layers (NUMLAY) and the thickness of layers (THICK)
-c) Change in AIN_TIME.PAR the time period to be simulated.
-d) Run SIMVB and check that a simulation is done and that you receive results.

-e) Replace AIN_SOIP.DAT (soilp.dat-file) with yours.
-f) Change in AIN_SOIL.PAR the identification of your profile (UNUM, UPROF)
-g) Run SIMVB and check that a simulation is done and that you receive results.

-h) Change other parameters in the parameter files in accordance with your application
-g) Run SIMVB and check that a simulation is done and that you receive results.

4) Rename your application to standard format: After the two first points above your application set is technically ready, however, named SIM_96\S\SA\KJETTSL. Your results will not be affected by this. If you, however, want to put your application under standard format with a proper name (for instance Mellby) you do it this way:

-a) Create a directory C:\SIMVB\MELLBY\N\NA
-b) Copy the content of C:\SIMVB\SIM_96\N\NA\KJETTSL to that directory
-c) Create the following directories:
C:\SIMVB\MELLBY\N\NA\PG
C:\SIMVB\MELLBY\N\NA\START
-d) Copy the content of the corresponding directories for SIM_96 to those directories

5) Start SIMVB, choose SOILN model, Standard. Write MELLBY. Make preparation (*"Preparation of INput, Initial, Normal*, Full preparation"*) and simulation (*"Simulation, Normal"*) and presentation of output *"Presentation of OUTput*..."*.

Additional information: The description above does not handle the conversion of AIN_BOUN.BIN and MEAS.BIN. Those files are not necessarily needed. AIN_BOUN.BIN is needed if you choose the BOUNDARY-switch > 0, see manual above. MEAS.BIN is used for comparison between simulated and measured data (*"Presentation of OUTput*, Validation"*). You can not convert these two files straight forward to your application since you probably have measured other variables at other time points. However, you can use the principal structure of the files. As concerns MEAS.BIN you have to change in the PG-instruction files making the comparison. If you choose *"Switches etc, File name"* you get the address of the file used for the presentation. Replace that file(s) with the one(s) you want to apply for the comparison.

There are 4 parameter files. However, you do not necessarily need to have more than one, see the section above on Alternative use of SIMVB, using one parameter file together with an output parameter file. In case you already have an application working under DOS, you should follow the same procedure as above, except that you, in this way, replace the Kjettslinge parameter files with yours.

SOIL
The same procedure could be used for adaptation of a SOIL application to SIMVB as used for SOILN, above. Exceptions are:

Generally: All directories denoted \N\NA\ should be denoted \S\SA\ instead.

-3a) When changing AIN_CLIM.BIN: If you have another type of driving variable file than that of Kjettslinge then change in AIN_MAN.PAR: CNUMD.
-3b) Replace AIN_EXT.BIN so that it is in accordance with your plant and the time period of your application. Note that you can cancel the use of this file by setting DRIV_EXT=0 and choose plant properties with parameters. However, then it is difficult to link to simulations of LAI and ROOTDEPTH by SOILN, later on.

To make the driving variable file for SOILN "Link SOIL-SOILN" you need to change the PG-instruction which makes this file (C:\SIMVB\S\SA\PG\DEMODRIN.PG). Change in accordance with the number of layers used in SOILN. The boundary between layers should not differ between SOIL and SOILN. However, thickness of one SOILN-layer may be the same as for several SOIL-layers and you not necessarily need to represent as deep layers as in SOIL. If so, weighted averages of water contents, temperatures etc must be made to fit the SOILN profile structure and only the vertical water flows related to the boundaries between layers of SOILN should be included. Percolation should get the vertical flow at the bottom of the deepest layer of the SOILN application.

Calibration of SOIL-SOILN

Normally, the model should be calibrated step-wise. As an example, is shown a procedure of how to calibrate the SOIL-SOILN model to the Kjettslinge data set (Andrén et al. 1990), the same application as used in previous section when adapting your dataset to the SIMVB program. Since the calibration of the SOILN model is linked to the calibration of the SOIL model the description below includes SOIL, however, focusing SOILN and the link SOIL-SOILN. The SOILN model needs driving variables from SOIL, therefore the calibration starts with the SOIL model. (Also the SOIL model needs driving variables from SOILN, however, normally those are more easy to give reasonable preliminary estimates.) When doing the calibration you should keep in mind the rules given in the section on Model application, above.

Start SIMVB and, *"Start here, SOILN & SOIL, Sim-course, KJETTSL".*

Calibration procedure:

SOIL model:

1) Select input (driving) variables and a pre-parameterisation as a starting point for your SOIL calibration (*"Preparation of INput, SOIL, initial prep., Normal*, Soil..., Plant..., Weather..., Management..., Validation"; you can check your preparation under INFO).*

2) Set switches and parameters of SOIL, as far as possible, according to measurements at the site and general knowledge (literature) about this type of site. (*"Preparation of INput, SOIL, Changes*, Parameters etc*, Input, Select file, ain_soil.par, ain_plan.par, ain_man.par")*

3) Set initial values of state variables (ground water level, soil water potential and temperature (*"Preparation of INput, SOIL, Changes*, Parameters etc*, Input, Select file, ain_man.par")* according measurements. If no measurements are available reasonable estimates have to be done.

4) Calibrate SOIL against measured values. Make simulation with modified parameter values and compare with measurements (*"Simulation, Others*, Prep by hand, (make changes, Execute, Run), Presentation of OUTput*, Validation ....").*

5) When you are satisfied with the SOIL simulation, store the results (*"Store files*, Current to ...").*

SOILN model (plant):

6) Set switches and parameters of SOILN-plant, as far as possible, according to measurements at the site and general knowledge (literature) about this type of plant. *("Preparation of INput, SOILN, Changes*, Parameters etc*, Input, Select file, ain_plan.par")*

7) Select input (driving) variables and a pre-parameterisation as a starting point for your SOILN calibration *("Preparation of INput, SOILN, initial prep., Normal*, Soil..., Plant..., Weather..., Management..., Validation").*

8) Extract the driving variables of SOILN from your SOIL simulation *("Link SOIL-SOILN*, SOIL to ....").*

9) Set initial values of plant state variables *("Preparation of INput, SOILN, Changes*, Parameters etc*, Input, Select file, ain_ini.ini")*

10) Calibrate the plant N uptake process. Since plant N uptake usually is the largest N flow in the system, an appropriate calibration of this process is especially important. You should be aware of not introducing errors due to problems in simulating N availability in soil. That problem you intend to solve later. So you should use the measured values of soil mineral N, instead of the simulated N, as the source for N uptake. You do this by choosing "Auto correction" of both NO3 and NH4 values *("Preparation of INput, SOILN, Normal*, Management (Both NH4 and NO3 correction)")* (see BOUNDARY-switch).

The N uptake process could be separated into three different processes that we suggest that you consider in the following order.
a) The growth of plant is determining the potential demand for N. You calibrate this process against measurements on total above ground plant biomass.
b) The actual N uptake is then calibrated against measurements on total above ground plant N. This is done by the maximum N levels of the different tissues, which determines the ultimate demand, and the possibility to extract N from the mineral N pool.
c) The phenology or/and allocation to grain you calibrate against measurements on grain biomass and N. Note, that a), b) and c) are inter dependent and that a correction under b) might lead to that you have to modify the calibration under a).
The calibrations you do by making simulation with modified parameter values and compare with measurements *("Simulation, Others*, Prep by hand, (make changes, Execute, Run), Presentation of OUTput*, Validation ....")*. Note that the "Prep by hand" statement do not store the modified parameter setting in your parameter files, i.e. next time you start from the original parameter setting.

11) When you are satisfied with the SOILN plant simulation, store the results *("Store files*, Current to ...").*

12) Introduce the new parameter setting into the parameter files. *("Preparation of INput, SOILN, Changes*, Parameters etc*, Input, Select file, ain_soil.par, ain_plan.par")*. Note if you have made changes of parameters in ain_man.par you have to introduce these changes into ain_man.par each time after you have made a management preparation.

SOILN model (soil):

13) Set switches and parameters of SOILN-soil, as far as possible, according to measurements at the site and general knowledge (literature) about this type of site. *("Preparation of INput, SOILN, Changes*, Parameters etc*, Input, Select file, ain_soil.par")*

14) Calibrate the soil N processes against measured values on ammonium N and nitrate N. We suggest the following order for calibration:
a) First calibrate the nitrification and denitrification processes to fit the measured values of nitrate. You should use the measured values of ammonium instead of the simulated values *("Preparation of INput, SOILN, Normal*, Management (NH4 AutoCorrect)").*
b) Calibrate the mineralisation process to fit the measured values of ammonium. You should use the measured values of ammonium instead of the simulated values *("Preparation of INput, SOILN, Normal*, Management (NO3 AutoCorrect)").*

The calibrations you do by making simulation with modified parameter values and compare with measurements (*"Simulation, Others*, Prep by hand, (make changes, Execute, Run), Presentation of OUTput*, Validation ...."*).

15) When you are satisfied with the SOILN simulation, store the results (*"Store files*, Current to ..."*).

16) Take away the auto corrections (*"Preparation of INput, SOILN, Normal*, Management (Fertilis (B120))"*).

17) Introduce the new parameter setting into the parameter files. (*"Preparation of INput, SOILN, Changes*, Parameters etc*, Input, Select file, ain_soil.par, ain_plan.par"*)

18) Make a simulation, without auto corrections, and regressions between simulated and measured values, of all variables (plant biomass, plant N and so on...) (*"Simulation, Normal, (make changes, Execute, Run), Presentation of OUTput*, Validation ...."*).

Interactions:

19) Note, there is an inter dependency between 10) and 14) which might require changes of the plant N uptake calibration. You might have to do 10-12) and 14-18) again.

20) When you are satisfied with the SOILN simulation, store the results (*"Store files*, Current to ..."*).

21) Extract leaf area index and root depth to be used as inputs for a new SOIL simulation (*"Link SOIL-SOILN*, ... to SOIL"*).

22) Since the leaf area and root depth as simulated by SOILN probably differ from those used in the previous SOIL simulation you have to do the calibration procedure points 4-5), 8), 10-12) and 14-21) again.

File description of SIMVB

The description below refers to a "Standard" application.

Directory structure

The directory name given when choosing an application should be XXXX in: c:\sim\soilns\XXXX (c:\sim\soilns\ can be another address, if you specify it under "Switches etc." just after selected "Start here").

Under the application directory we find the "WORKING-directory" named ...\XXXX\N. In the "working-directory" all your preparations and simulation results are stored. The meaning is that it is up to the user to delete files within the directory. Original files can always be recovered from directories below this one. First time you run the program the directory is empty. When you run the program and make preparation, files are stored on the "working-directory". SIMVB writes files only on this directory (except for comment.txt under the application directory). (For the SOIL model the "working-directory" is named ...\XXXX\S.)

In the STORE-directory (...\XXXX\N\NA) below the "working-directory" program and data files are stored. Files in this directory as well as below this directory should not be deleted by the user.

Firstly an "initial preparation" is made. Then files are copied from ...\XXXX\N\NA\START. These are files related to programs and are common for all applications.

PG-instruction files used for presentations etc. are stored in ...\XXXX\N\NA\PG. Files are copied from this directory to the "working directory" as soon as PG is used. Some files are stored at the "working directory" to allow the user to make changes in the presentations. They are not overwritten until a new initial preparation is made.

When selecting an option within the "Preparation" option files are copied from the store directory ...\XXXX\N\NA. These are input files but also validation files for a certain application. Application information is given in the INFO.LIS file.

Other "sub-applications" can be stored below the store directory (...\XXXX\N\NA). Those applications can be stored on the "working directory" making use of the "preparation from sub-directories". Only the changes compare to the application stored under ...\XXXX\N\NA is needed to be given here.

Files

Directory ... *XXXX*; "Application directory"

COMMENT LIS	Comments given by the user while running SIMVB.

Directory ... *XXXX**N*; "Working directory"

AIN_CLIM BIN	Driving variables
*AIN_CLIM BPR	AIN_CLIM.BIN used in previous run
**AIN_FERT BIN	N input variables
*AIN_FERT BPR	Version of AIN_FERT.BIN used in previous run
**AIN_FERT DAT	N input variables as ASCII
**AIN_FERT DDE	Variable description for AIN_FERT.DAT
AIN_INI INI	Initial values of state variables
AIN_MAN PAR	Management parameters. Parameter Groups and Switches denoted (M) and file specification for files related to management (FILE(9) form SOILN). (Read by PREP as nr 5)
AIN_OUT PAR	Output variables. Parameter Groups and Switches denoted (O) and file specifications not related to management. Note, that OUTFORN must be ON otherwise none of the PG-instruction files will work, f.i. The "PRESENTATION" options. (Read by PREP as nr 3)
AIN_PLAN PAR	Plant parameters. Parameter Groups and Switches denoted (P). (Read by PREP as nr 2)
AIN_SOIL PAR	Soil parameters. All Parameter Groups and Switches denoted (S) or not found elsewhere. (Read by PREP as nr 1)
AIN_SOIP DAT	Soil physical data (from PLOTPF.EXE)
AIN_TIME PAR	Simulation period. (Read by PREP as nr 4)
DEMO_COP BAT	Program file that copies files from different directories to the working directory.
DEMO_VB BAT	Program file. Bat-file used to make simulations etc.
**DEMOCOMX PG	PG-instruction file
**DEMOPCAR PG	PG-instruction file in which variables for plotting can be selected *("Presentation of OUTput, Carbon, Other")*
**DEMOPCOM PG	PG-instruction file in which variables for comparison can be selected *("Presentation of OUTput, Comparison, ..., Other")*
**DEMOPNIT PG	PG-instruction file in which variables for plotting can be selected *("Presentation of OUTput, Nitrogen, Other")*
*DEMOZVAL BIN	Presentation data
INFO LIS	Information about the application loaded on the working directory
**MEAS BIN	Values to be compared with the simulation outputs *("Presentation of OUTput, Validation")*
**SOILN FIN	Output state variables in a form possible to be used as input
*SOILN STA	A counter used by SOILN
SOILN TRA	Data description for Output variables
*SOILNCUR BIN	Output variables from the current simulation
*SOILNCUR SUM	Data description for the bin-file
*SOILNPRE BIN	Output variables from the previous simulation

*SOILNPRE SUM
*SOILNXXX BIN Used by the comparison option
*SOILNXXX SUM
* = Files that can be deleted without needing new preparation
** = Files not always needed

Directory ... *XXXX**N**NA*; "Store directory", application specific
AIN_CLIM BIN see above
**AIN_FERT BIN see above
**AIN_FERT DAT see above
**AIN_FERT DDE see above
AIN_INIP INI Initial plant state variables
AIN_INI INI Initial soil state variables
AIN_MAN PAR see above
**AIN_MR CMD Multy Run instructions
**AIN_MR PAR Parameters that will be changed in the Multy Run
**AIN_ONE PAR Used when the one-parameter file option is used
**AIN_OUTM PAR Output variables for the Multy Run
AIN_PLAN PAR see above
AIN_SOIL PAR see above
AIN_SOIP DAT see above
AIN_TIME PAR see above
INFO LIS Information about the application stored in the directory
**MEAS BIN see above
** = Files not always needed

Directory ... *XXXX**N**NA**START*; "Store directory", common for all applications
AIN_OUT PAR see above
DEMO_COP BAT see above
DEMO_VB BAT see above
SOILN TRA see above
SOILN TXT SOILN User's manual (This report)
Directory ... *XXXX**N**NA**PG*; Directory with PG-instruction files
Directory ... *XXXX**N**NA**EXCEL*; Directory with EXCEL-instruction files

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