ANIMO 4.0

User's guide of the ANIMO 4.0 nutrient leaching model

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ABSTRACT

Renaud, L.V., Roelsma, J. and Groenendijk P., 2006. *User's guide of the ANIMO 4.0 nutrient leaching model.* Wageningen, Alterra, Alterra Report 224. 191 pp. 65 Fig.; 24 Tab.; 35 Ref.

This report presents a description of the use of the nutrient leaching model ANIMO (Agricultural Nutrient Model) version 4.0 with special emphasis on input instructions. Model input is described by its unit, range, data type and variable name in computer code. Program output and operational aspects of program execution are briefly given. Five examples are presented comprising values of input parameters and model results. A brief technical program description is presented focussing on the program structure, the nomenclature and structure of the source code.

Keywords: computer model, environmental protection, groundwater pollution, input instructions, nutrient leaching

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Preface

This report is part of the documentation on the simulation model ANIMO (Agricultural Nutrient Model). An extensive description of the theoretical background of the model ANIMO is given by Groenendijk and Kroes (1999), Rijtema et al. (1999) and Groenendijk et al., (2005).

The ANIMO model was originally developed in 1985 by the Institute for Land and Water management Research. The first version of the model was operational in 1985 and ever since its development has continued until the present version. Version 4.0 of the model ANIMO is integrated into the model instrument STONE (Samen Te Ontwikkelen Nutriënten Emissiemodel). STONE is a tool to analyse the impacts of fertilization scenarios on nutrient leaching to groundwater and surface water systems on the national scale for the Netherlands. For studying the nutrient leaching at field scale and at sub-catchment scale, the model ANIMO will be available as a stand-alone model or as a model to be integrated into other comprehensive modelling systems.

DWK- research programme 398-III takes the responsibility for the maintenance of the model and software implementation. For questions about the model formulations, the reader is referred to Mr. P. Groenendijk (piet.groenendijk@wur.nl). Information on the program code or availability of the ANIMO model is obtainable by contacting Mr. L.V. Renaud (leo.renaud@wur.nl) or Mr. H.P. Oosterom (henk.oosterom@wur.nl). More information is available through the Internet (http://www.alterra.wur.nl/NL/Producten/Modellen/).

Summary

The User's guide ANIMO 4.0 presents a description of the use of the nutrient leaching model ANIMO version 4.0 with special emphasis on input instructions. The model ANIMO can be used to derive cause-effect relationships between fertilizer strategy, cropping pattern and water management and the quantification of nutrient losses of the agricultural system.

A brief description of the theoretical background on the ANIMO model is given. A more extensive description is given in Groenendijk et al., (2005). An overview of the carbon, nitrogen and phosphorus cycle is presented as well as the hydrological schematization method and the transport and transformation processes in ANIMO.

Instructions to set up the input files are given. Each input parameter is characterized by its unit, range, data type and variable name in computer code. Operational aspects regarding program output and program execution are briefly presented.

Three examples including values of the input parameters and model results are provided. These examples are meant to give the reader a first impression of the input requirement and output options of the ANIMO model version 4.0.

Finally, for researchers who are interested in the technical aspects of the computer software information on the program structure and source code of the main program is provided.

1 Introduction

The aim of the ANIMO model is to derive cause-effect relationships between fertilizer strategy, cropping pattern and water management and the quantification of nutrients losses of the agricultural system. The model can be used at different spatial scales and temporal resolutions. User groups are mostly researchers who apply the model to analyse field experiments (local scale) or to analyse the consequences of policy scenarios on a regional scale.

An overview of the theoretical background of the model ANIMO is presented in Chapter 2. Inputs and outputs of the model are explained in Chapters 3. In this chapter also a data flow of the input and output data is presented as well as some information on the model execution. Execution of three simulations with the model is briefly discussed in Chapter 4. In this chapter all input and output data of the three cases are discussed.

For the more experienced users, the technical model description of ANIMO 4.0 is given in Annex 5. Some information on the model structure and the source code of the main program is given.

This technical document should be used in close connection to the report on model concepts of ANIMO by Groenendijk and Kroes (1999) and Groenendijk et al., (2005). Groenendijk and Kroes also present the model performance using results of different studies. Boogaard and Kroes (1997) give a description of pre- and post-processing of ANIMO 3.5 on a regional scale.

2 Theoretical background of the ANIMO model

A comprehensive model description is given in Groenendijk and Kroes (1999) and Groenendijk et al., (2005). A summarized description for the carbon, nitrogen and phosphorus cycles has been summarized in the subsequent section.

2.1 Carbon, nitrogen and phosphorus cycle

The transformation processes described are all part of the carbon, nitrogen or phosphorus cycle. These cycles have been modelled according to ***Figure 1*** and ***Figure 2***. These three figures show the interrelation between the cycles. The figures contain a horizontal line that indicates either the soil surface or the top boundary of the system described. Parameters mentioned above this line indicate actions concerning additions to and removal from the soil system. Below the horizontal line, the principal parameters of the soil system are shown with four kinds of organic matter in the centre of the soil system. These four kinds of organic matter are:

- a fresh organic matter pool: root and crop residues and organic parts of manure added to the soil;
- a dissolved organic matter pool: organic matter in solution from fresh organic matter or humus;
- an exudate pool: dead root cells and organic products excreted by living roots;
- humus/biomass: consists of dead organic matter and of living biomass and is formed from part of the fresh organic matter, root exudates and dissolved organic matter.

The organic material added to the soil may vary strongly from composition and quality. To express differences in quality, the fresh organic matter can be sub-divided into different fractions, each with its own decomposition rate, N-content and P-content. In this way, it is possible to distinguish between materials with their own specific characteristics.
In the ANIMO model, the rate variables for organic matter transformation are adjusted for the responses on temperature, moisture, pH and oxygen status; the nitrification rate is corrected for influences of temperature, moisture and pH.
The phosphorus cycle has been modelled according to ***Figure 3***. The organic transformation processes in phosphorus are very similar to the mineralization processes in the nitrogen cycle (***Figure 2***).

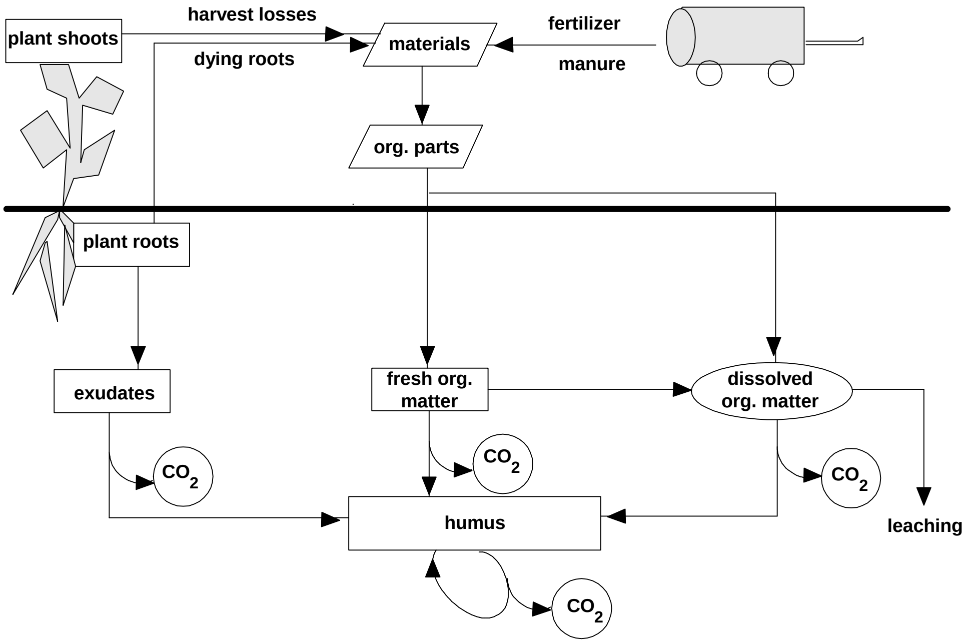

Figure 1 Representation of the Carbon cycle in ANIMO

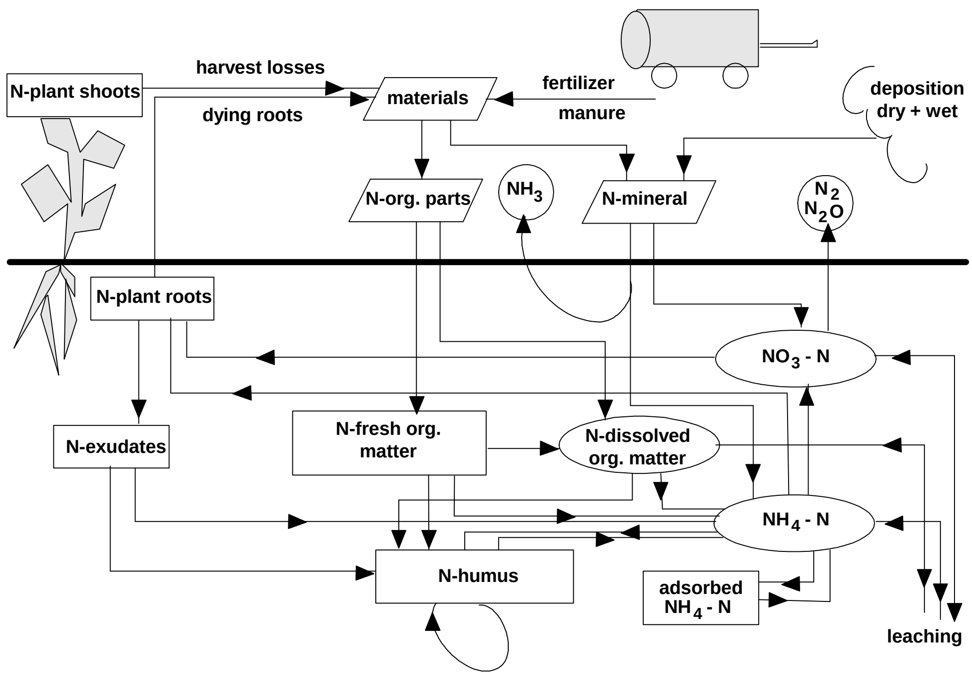

Figure 2 Representation of the Nitrogen cycle in ANIMO

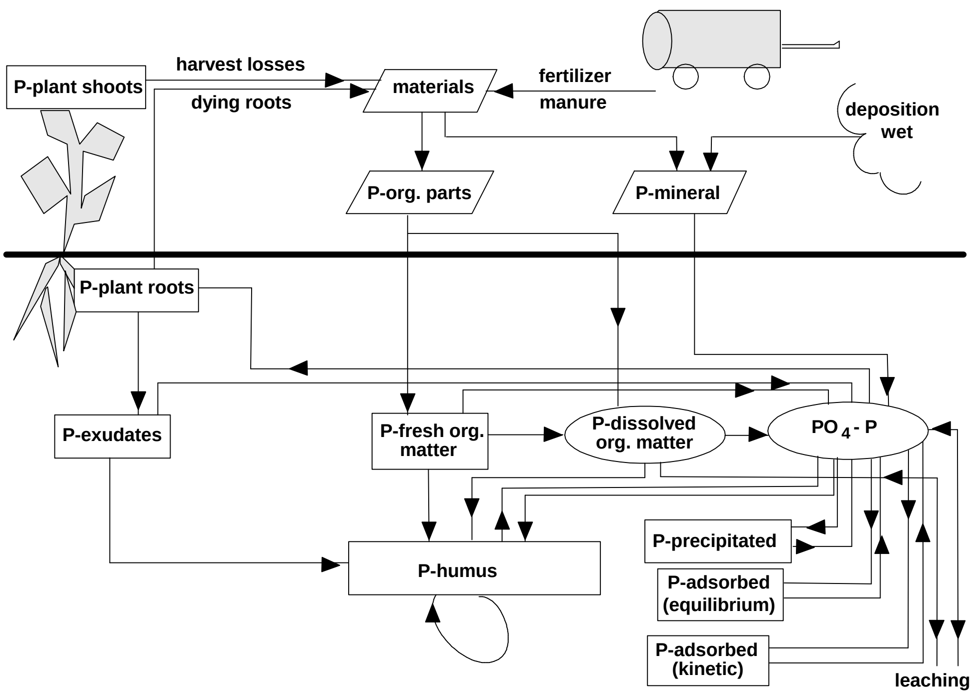

Figure 3 Representation of the Phosphorus cycle in ANIMO

2.2 Hydrological schematization

The ANIMO model requires data generated by a water quantity model (WATBAL (Berghuijs-Van Dijk, 1985) or SWAP (Kroes and Van Dam, 2003)). Depending on the scale of the information, one of the two water quantity-models must be applied in advance. Any other model producing output like WATBAL or SWAP can also be used. The output of one of these models must be used as input for ANIMO.

The WATBAL model produces water balances for two soil compartments: for the root zone and for the subsoil below the root zone. ANIMO is capable to convert this information into water balances for each soil -compartment in the ANIMO model. The SWAP model generates water balances for a freely chosen number of compartments; in ANIMO, the same compartments will then be used for water quality calculations. ***Figure 4*** gives a schematic representation of the water fluxes in the soil system of the model ANIMO for an arbitrary number of compartments.

A complete water balance for a soil-water-crop system should be formulated as:

$$\frac{\Delta V}{\Delta t} = q_p + q_s - \left(q_{e,s} + q_{e,p} + q_{e,i} + q_t + q_r + q_l + \sum_{i=1}^{3} q_{d,i} \right)$$

where:

- ΔV is the change of areic water volume during a time step ($m^3\ m^{-2}$)
- Δt is the length of the time step (d)
- q is a water flux ($m^3\ m^{-2}\ d^{-1}$) with:
    - q_p is
        - precipitation
        - irrigation
        - runon
        - melted snow
    - q_s is seepage
    - $q_{e,s}$ is the soil evaporation
    - $q_{e,p}$ is the ponding evaporation
    - $q_{e,I}$ is the interception evaporation
    - q_t is the transpiration
    - q_r is the surface runoff
    - q_l is the leaching across the bottom boundary
    - $q_{d,1}$, $q_{d,2}$, $q_{d,3}$ are drainage fluxes to or from (positive or negative) the first, second and third order drainage systems.

2.3 Transport and transformations

Substances transported by water flow are: dissolved organic matter, NH_4-N, NO_3-N, dissolved organic nitrogen, PO_4-P and dissolved organic phosphorus. The conservation and transport equation reads in general:

$$\frac{\partial(\theta c)}{\partial t} + \rho_d \frac{\partial X_e}{\partial t} + \rho_d \frac{\partial X_n}{\partial t} + \rho_d \frac{\partial X_p}{\partial t} = -\frac{\partial}{\partial z}\left(q c - \theta D_{dd} \frac{\partial c}{\partial z}\right) + R_p - R_d - R_u - R_x$$

where:

- θ is the volume fraction of liquid (m^3 m^{-3})
- c is the mass concentration in the liquid phase (kg m^{-3})
- t is time (d)
- ρ_d is the dry bulk density (kg m^{-3})
- X_e, X_n, X_p are contents (kg kg^{-1}) in the solid phase of the soil, i.e. the ratio of the mass of substance at the solid phase divided by the mass of dry soil
    - X_e is the content adsorbed to the solid phase in equilibrium with c
    - X_n is the content adsorbed to the solid phase in non-equilibrium with c
    - X_p is the precipitated content
- z is depth in the soil (m)
- q is the water flux (m^3 m^{-2} d^{-1}, or m d^{-1})
- D_{dd} is the apparent dispersion coefficient (m^2 d^{-1}), which is the sum of the coefficients for dispersion and diffusion of a solute in the liquid phase ($D_{dd} = D_{dis} + D_{dif}$)
- R is a sink or source term expressed as a volumic mass rate of the substance (kg m^{-3} d^{-1}):
    - R_p is a source for production
    - R_d is a sink for decomposition
    - R_u is a sink for crop uptake
    - R_x is a sink for lateral drainage or infiltration.

The soil is discretisized into a number of compartments. For each compartment the resulting conservation and transport equation can be solved analytically for a time step. The sequence of the compartments to be treated in the calculation procedure is determined according to the flow direction (***Figure 4***). For the first compartment, the boundary condition for the incoming downward flux is the precipitation with a user defined concentration. For the deepest compartment, the boundary condition is the upward seepage flux with a user-defined concentration.
The thickness of the model compartments and the length of the time step (mathematical dispersion) are used to simulate physical dispersion.
To implement manure and fertilizer additions to the soil system the model has an extra artificial reservoir on top of the compartment-division. The additions can be added to this reservoir and leach into the soil proportional to cumulated precipitation since the fertilization event.. Solute transport by surface runoff is simulated by a solute balance of the ponding-layer above the soil surface.

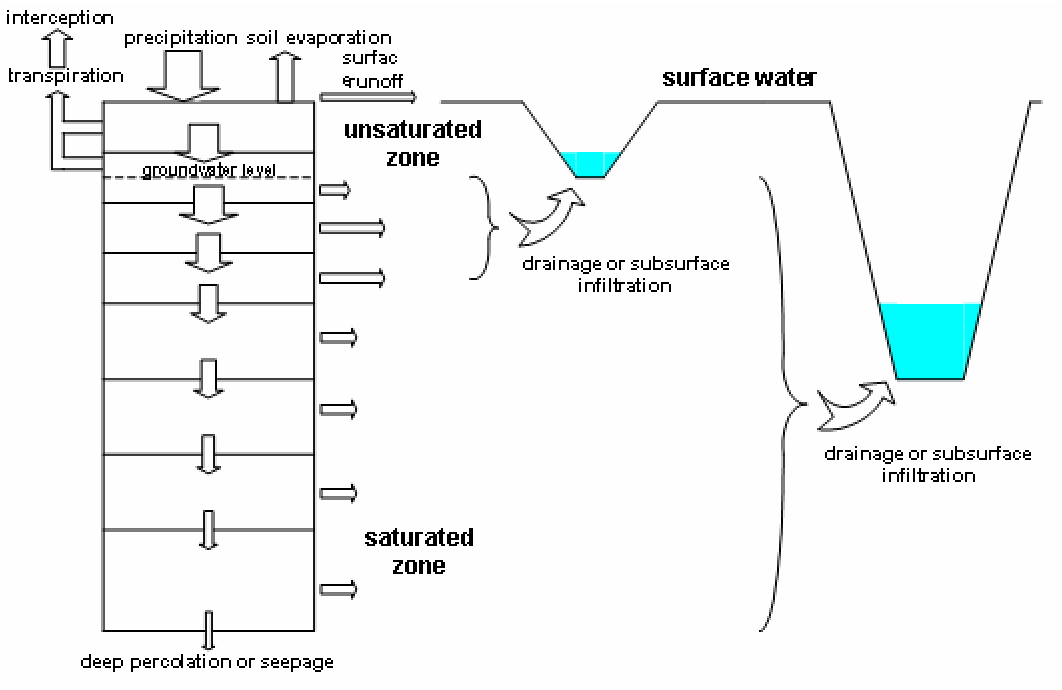

Figure 4 Definition of a soil profile and the main terms of the water balance

2.4 Crop uptake

The ANIMO 4.0 model comprises three different modules for the nutrient uptake by vegetation.

2.4.1 Annual arable crops

The nutrient uptake by arable crops has been described by a simple model. The nutrient demand has been defined by considering two phonological stages. During each period the concentration in the transpiration flux resulting in optimum growth is defined as:

$$c_{opt} = \frac{U^*}{\sum_{t_1}^{t_2} q_{tr}}$$

Where:

- c_{opt} is the optimal uptake concentration (M L^{-3})
- U^* is the reference cumulative uptake within the phonological stage (M L^{-2})
- Σq_{tr} is the expected cumulative transpiration flow (L)
- t_1, t_2 are the first date and last date of the stage considered.

The expected optimal cumulative uptake and cumulative transpiration flow are defined by the user in the model input files. For years with higher or lower transpiration rates, the total crop uptake will increase or decrease proportionally. Under optimal circumstances, the plant uptake parameters σ_{NO3}, σ_{NH4} and σ_{PO4} are defined as:

$$\sigma_{NO3} = \frac{c_{opt,NO3}}{c_{NO3}(t_0)} \quad and \quad \sigma_{NH4} = \frac{c_{opt,NH4}}{c_{NH4}(t_0)} \quad and \quad \sigma_{PO4} = \frac{c_{opt,PO4}}{c_{PO4}(t_0)}$$

Under non-optimal conditions (excessive supply or uptake deficit), the parameters are adjusted according to the hypothesis that actual crop uptake depends on both the soil availability and on crop requirement. The mineral nitrogen requirement during a simulation time interval is defined in three categories.

- Demand due to deficit in N-uptake during previous time steps
- Demand due to dry matter increase of the crop during the time interval
- Luxurious consumption, which occurs under excessive supply conditions in the soil.

A preference for nitrate uptake is assumed, based on the condition of electro-neutrality, and availability of nitrate and ammonium is considered separately. The uptake selectivity factor is bounded to a maximum value $\sigma_{N,max}$ or $\sigma_{P,max}$ in cases where the requirement exceeds a maximum level of the soil availability.

Crop damage due to an unfavourable mineral nitrogen status of the soil is assumed when the actual realized cumulative uptake is less than a certain fraction of the cumulative uptake for optimum growth. The admissible nitrogen deficit is bounded to a maximum value by adjusting the expected optimal cumulative uptake. This unrecoverable crop damage ratio is also applied to the optimal expected phosphate uptake curve. The plant uptake parameter σ_P is defined by the ratio between the demand and the availability. This parameter is bounded to a maximum value, expressing the limited delivery capability of the soil. Crop damage due to limited P-availability is estimated similar to the crop response to a shortage of mineral nitrogen in the root zone. If a certain threshold phosphorus deficit is exceeded, the expected optimal cumulative uptake is adjusted.

2.4.2 Permanent grassland

Nutrient uptake by grassland is described by considering a soil compartment and a plant compartment. The nutrient demand by the crop is derived from the dry matter production of grassland and both the potential and the actual nitrogen status within the plant. In order to have a time course of dry matter quantity values at one's disposal a simple grassland production module has been implemented. Dry matter production is simulated based on global radiation, light interception, partitioning between shoots and roots and herbage intake by grazing animals.

The nitrate concentration in the shoots liquid fraction can be considered as the internal concentration of the plant. Plant uptake is calculated by balancing the demand of the crop and the supply by the soil. The concept of the supply potential is based on the assumption where the total uptake is determined by the sum of passive flow with the transpiration stream and a diffusive flow. Most crops can develop an internal nitrate concentration in the plant liquid. The concentration gradient between the nitrate concentration in roots and the concentration in soil water is considered as a driving force for nitrate uptake.

The assessment of this total nitrogen fraction in shoots necessitates the simulation of the dry matter production and the nitrogen budget of the plant system.

The phosphate requirement for plant growth is defined as the gross dry matter production multiplied by the actual phosphorus content of shoots and roots. The P-fractions within the plant relate to the total N-fractions according to a constant P/N ratio.

2.4.3 External crop model

When the ANIMO model is used in combination with an external crop production model all the input data concerning nitrogen and phosphorous uptake and crop losses are read from an input file. The following data are required:

- Minimum and maximum nitrogen and phosphorous content values of crop losses as a constant value for the model run.
- Nitrogen and phosphorous uptake quantities as well as dry matter, nitrogen and phosphorous quantities of crop losses per time step

The time resolution (daily, weekly or per decade) depends on the specification in the hydrological input.

The forcing function for crop uptake is subdivided to values per soil compartment which show significant plant transpiration. If the nutrient availability in the soil is less compared to the nutrient demand the deficit is added to the demand of the next time step. Only when a deficit occurring at some day is not compensated by external sources (fertilization) or internal sources (mineralization), which can be expected during the remaining period of the growing season, the total realised uptake can stay under the total external forced uptake.

2.5 Responses to environmental factors

Transformation rate coefficients concerning transformation of fresh organic materials, dissolved organic matter, exudates and humus biomass and the nitrification rate coefficient are defined by a reference value k_{ref}. Environmental influences are taken into account by multiplication factors for reduced aeration at wet conditions f_{ae}, drought stress at dry conditions f_θ, temperature f_T and pH f_{pH}. For organic transformation processes:

$$k = f_{ae,OM}\ f_T\ f_\theta\ f_{pH}\ k_{ref}$$

and for the nitrification process:

$$k = f_{ae}\ f_T\ f_\theta\ f_{pH}\ k_{ref}$$

2.5.1 Aeration and drought stress

Aeration has a major influence on transformation rates of all micro-biological processes in agricultural eco-systems. Two options are available for taking soil moisture conditions into account.

2.5.1.1 Oxygen diffusion sub model

Since one of the model aims is to evaluate the environmental impacts of water management for a wide range of soil types and a wide range of hydrological conditions, a detailed sub model describing oxygen diffusion in the soil gas phase and in soil aggregates has been implemented. In this sub-model the aerated fraction per soil compartment depends on:

- oxygen demand, as a result of organic transformations and nitrification. Oxidations of other reduced components (e.g. sulphur) have been ignored.
- soil physics.
- hydrological conditions (partitioning between soil moisture and soil air).

The aeration factor f_{ae} has been formulated as a multiplicative factor setting $f_{ae} = 1$ at optimal conditions. For sub-optimal conditions ($f_{ae} < 1$), the diffusive capacity of the unsaturated zone is insufficient to fulfil the oxygen requirement. In situations where partial anaerobiosis occurs, the oxygen demand for the organic transformations is met by atmospheric oxygen as well as by nitrate-oxygen. The nitrification rate will be sub-optimal. Under these conditions, the available nitrate will be reduced partial or complete (denitrification). Under unfavourable wet conditions the upper compartment layers consume all oxygen which can enter the soil profile by diffusion and the atmospheric oxygen will not penetrate into the lower part of the unsaturated zone.

The partitioning between the aerobic soil fraction and the anaerobic soil fraction is determined by the equilibrium between oxygen demand for organic conversion processes plus nitrification and the oxygen supply capacity of the soil air and soil water system. Both the vertical diffusion in air filled pores and the lateral oxygen diffusion in the soil moisture phase are taken into consideration. In the anaerobic part of the soil, the oxygen demand for organic matter transformations is met by the utilisation of nitrate oxygen. It has been assumed that organic matter transformations proceeds slower when only nitrate oxygen is available. Therefore, a factor f_{hetero} has been introduced to account for the reduced process rates.

Drought stress of micro-organisms has been described by the multiplication factor f_θ. The *pF*-value has been used to describe the drought response of micro-organisms, based on the analogy of the root activity response to dry conditions. Below wilting point, the functioning of micro-organisms are disturbed.

Based on experimental data and model calibration it has been assumed that within the root zone between the values *pF* 3.2 and *pF* 4.2 the multiplication factor f_θ decreases linearly from 1.0 to 0.2. The influence of the moisture content is described by:

$$pF < 3.2 \rightarrow f_\theta = 1$$
$$3.2 < pF < 4.2 \rightarrow f_\theta = 1 - 0.8(pF - 3.2)$$
$$pF > 4.2 \rightarrow f_\theta = 0.2$$

Below the root zone, no adaptation for dry conditions is considered.

2.5.1.2 Water filled pore space driven sub model

A second more commonly used approach for accounting for the impact of soil moisture has been implemented. Water Filled Pore Space (WFPS) is defined as the ratio between the actual soil moisture content and the content at saturation. The WFPS-variable affects all the biological transformation processes:

- Mineralization
- Nitrification
- Denitrification

The SONICG-model (Bril et al., 1994) assumes a WFPS value of 58% for optimal mineralization conditions. At lower values the organic transformations will be reduced due to drought stress. Higher values of WFPS imply reduced aeration and therefore the transformation processes will be limited by unfavourable oxygen supply. Adjustments to the original SONICG-concepts have been made with respect to the mineralization rate under saturated conditions. In the ANIMO model the user should specify the expected relative mineralization rate at WFPS=1. For saturated conditions in wetland peat soils it is expected that the relative rate (rate at WFPS=1 divided by rate at WFPS=0.58) does not exceed 0.01.

For nitrification adjustments have been made to the original SONICG-concept. Bril et al., (1994) applied a WFPS-determined correction factor to the optimal process rates ignoring the differences between soil types. In the STONE-results (DeWilligen et al., 2003) it was found that this concept yielded unrealistic low nitrification rates in clay soils and peat soils. The WFPS-concept has been replaced by a response function which only depends on the soil air fraction (***Figure 5***). It is assumed that nitrification will not be affected by soil moisture conditions when the soil air fraction exceeds 8%.

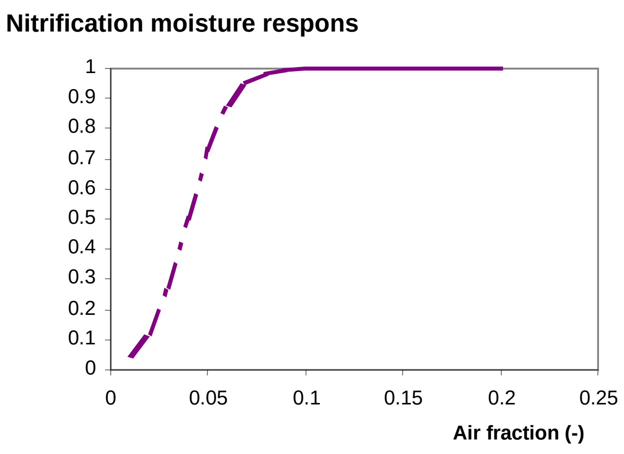

Figure 5 Nitrification response to soil air fraction

2.5.2 Temperature

The correction factor for temperature (f_T) is described by an Arrhenius equation:

$$f_T = \exp\left[-\frac{\mu}{R_{gas}} \left(\frac{1}{T + 273} - \frac{1}{T_{ref} + 273} \right) \right]$$

The molar activation energy μ is taken 74826 (J mol^{-1}). The gas constant R_{gas} equals 8.314 (J mol^{-1} K^{-1}). A reference temperature (T_{ref}) of 11 ^{o}C is applied in the model, being the average annual temperature for the Dutch climate.
Two options for obtaining soil temperature values per time step are available: a simple sine wave model and the capability to read soil temperature data per time step from the hydrological input file.

2.5.2.1 Simple sine wave temperature sub model

The soil temperature at a certain depth (z) from the soil surface and at a certain day of the year can be simulated using a sine wave sub model with a damping effect for depths below the soil surface:

$$T = T_a + A_0 \exp\left(-\frac{z}{\sqrt{\frac{2\lambda_h}{C_h \omega}}} \right) \cos\left(\omega t + \phi - \frac{z}{\sqrt{\frac{2\lambda_h}{C_h \omega}}} \right)$$

Due to the limited heat diffusivity of the soil, the amplitude of the heat wave decreases with soil depth.

2.5.2.2 Soil temperature generated by SWAP3.0

Some hydrological models (e.g. SWAP3.0) have the capability to calculate soil temperatures as a function for air temperature, soil physical properties and soil moisture content. When soil temperatures are specified in the so-called SWATRE.UNF input file, ANIMO recognizes these data and uses these data as inputs.

2.5.3 pH

For the effect of *pH* on reaction rates only one function for the organic transformation processes and the nitrification process has been formulated. The multiplication factor for the influence of *pH* f_{pH} is given as:

$$f_{pH} = \frac{1}{1 + e^{-2.5(pH - 5)}}$$

Time independent *pH*-values are defined by the user for each soil horizon. It has been assumed that under optimal agricultural practises, the *pH*-value will not change and the seasonal fluctuation has been ignored.

3 Program input and output data

3.1 General data flow

For each application, the model requires a set of input data files. The computer program is able to generate a set of output files during a ‘model-run’ (***Figure 6***).

The input data files can be divided into 3 groups:

1) General and default input data files. These files include a general file with model options. The model was developed for regional application and, for this purpose, default input data files are distinguished. These default data, in principal, need not to be changed. Default data are defined for materials and plants. Materials are substances with a predefined composition (e.g. different types of animal manure).
2) Field specific nutrient input data. These data files need to be changed when switching from one field application to another. These files include files with soil physical and soil chemical data, files with data on boundary and initial conditions and a file with data of management (inclusive additions and tillage).
3) Field specific hydrological input data files, which contain data that must be supplied by a hydrological model.

A detailed explanation of required input is given in Section 3.2.
The output data files can be divided into 4 groups: 1) standard output (error messages, echo of input), 2) mass balances, 3) state variables and 4) organic transformations.

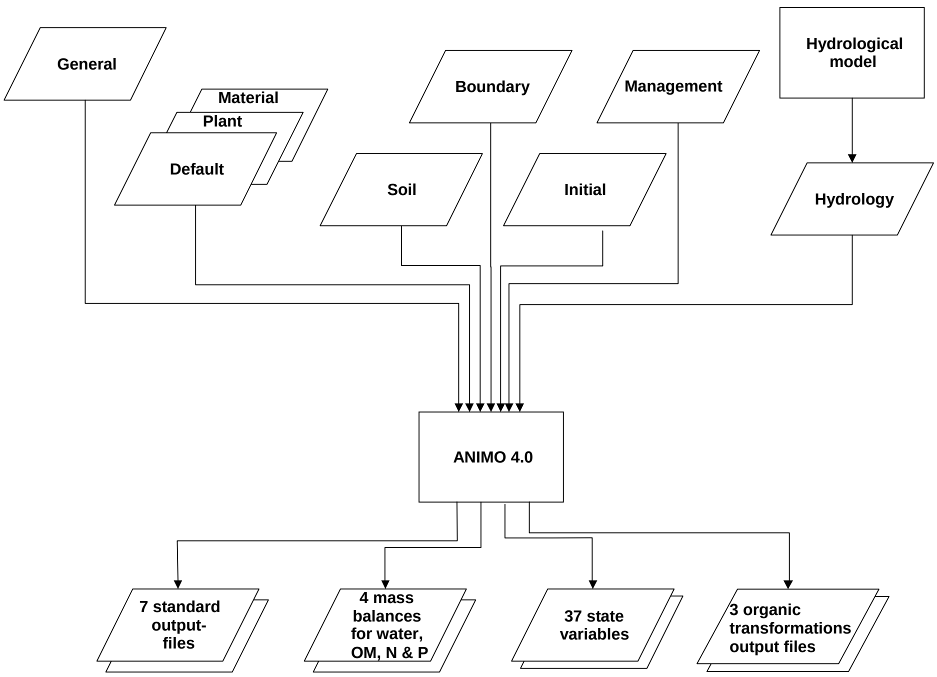

Figure 6 Flow chart of the input and output data of ANIMO 4.0

3.2 Description of the input files

The input for an application of ANIMO version 4.0 for a single field or sub region requires a minimum set of 8 files and a maximum of 12 files. A summary of input-files is given in ***Table 1***. A hydrological model must supply hydrological data prior to the simulation with the ANIMO-model. Two options are available, representing linkage with two types of hydrological models:

- A detailed multi-layer model (e.g. SWAP-model, Kroes and Van Dam, 2003).
- A two-layer model like WATBAL (Berghuys-van Dijk, 1985) or DEMGEN (Abrahamse et al., 1982)

If a multi-layer model is used to compute water quantity data then a file (SWATRE.UNF), including data on model-geometry, must have been created which contains all the required hydrological data. If a two-layer hydrological model has been used (file WATBAL.UNF) then more detailed hydrology-related input is required (file WATBAL.INP) to allow the conversion from a two-layer to the multi-layer system of the ANIMO-model.

Table 1 Summary of input-files for ANIMO version 4.0

Name of input-file	Content
ANIMO.INI	direct file of input files
GENERAL.INP	simulation- and output-options
MATERIAL.INP	default data on materials (composition, reaction rates)
PLANT.INP	default crop data (plant growth and uptake parameters)
SOIL.INP	soil chemical and soil physical data
BOUNDARY.INP	boundary conditions
INITIAL.INP	initial conditions
MANAGEMENT.INP	data concerning additions to and tillage of the soil system
SWATRE. UNF	water quantity data derived using a model like SWAP (SWATRE)
WATBAL.UNF and WATBAL.INP	water quantity data derived using a model like WATBAL
CHEMPAR.INP	soil chemical data for phosphorus
CROP_EXT.INP	extra crop file (necessary when ioptCU = 1)

Names of all input files are optional. In this table default names are used (see also section 3.4).

Nearly all input-files are ASCII text files, which can be produced with any text-editor. An exception is made for the files WATBAL.UNF and SWATRE.UNF, which are binary files. All ASCII input-files may have three types of lines (see also van den Broek et al., 1994):

- *Label lines*: The first 8 characters of a label line should contain the label as given in the column Range and indicate with the Mnemonic 'LABEL'. Characters to the right of the label are not significant and can be used as comment. The label indicates that the next line is a data line.
- *Data lines:* A data line always follows a label line. Data on one line must be separated by one or more blanks. Data lines must contain only data; labels or comments are not allowed on data lines. Data of the type character must be placed between apostrophes.
- *Comment lines:* These may be used before a label line or after a data line (or group of data lines). They are not significant to the program. Their only purpose is to make the input-file easier to read for the user.

In the subsequent tables the description of the input in each table is given in 6 columns:

- *column 1*: Description of the variable
- *column 2*: Unit of the variable
- *column 3*: Range of the variable with the following annotation:
  - [x ... y] range for integer values
  - [x.x ... y.y] range for real values
  - [... y] range with no minimum
  - [x ...] range with no maximum
  - >labeln: character string of 8 positions with name of label at position 2-7

  The given ranges have received values that should be regarded as estimates introduced to give users an indication for average situations. Range checking in the computer code is in most cases performed with a wider range to allow executions under more extreme circumstances.

  Some boundaries of ranges are defined by parameters values, which always have a name that starts with MA (e.g. MANL, MANH, etc.). These values are defined in the Fortran source file PARAM.INC. A listing of this file is given in annex 1
- *column 4:* Indicator for position of variable at new record:
  - * write at new record;
  - \- write with separation sign (space, comma, or new line);
- *column 5:* Indicator for kind of data type of variable:
  - Cx character-string of x positions,
  - I Integer*2,
  - R Real*4
- *column 6* The Mnemonic of the variable used in the computer program

Table 2 The input file Animo.ini [1] for assigning input file names.

Description of variable	Unit	Range	R	DT	Mnemonic
Label for checking the compliance of the input file with the ANIMO version. Should be specified as **Animo40**	-	-	*	*C7*	LABEL
List of input files specified. List should be ended by END label. File names can be chosen freely with a maximum of 80 characters. If not specified, the default names, as shown below, are assumed. GEN="General.inp" MAT="Material.inp" PLA="Plant.inp" SOI="Soil.inp" BOU="Boundary.inp" INI="Initial.inp" MAN="Management.inp" SWU="Swatre.unf" [2] WAI="Watbal.inp" [2] WAU="Watbal.unf" [2] CHE="Chempar.inp" [3] INO="Initial.out" CRU="Crop_ext.inp" [4] MES="Message.out" END	-	-	*	*C80*	

[1]) The use of an ***Animo.ini*** file is optional. If used, it should be declared in combination with the run-command. E.g.: `c:\models\Animo40\work\Animo40 Animo.ini`. The name of the ini-file can be chosen freely.

[2]) If a 2-layer hydrological model is used: WAI and WAU should be specified;
If a multiple layer model is used: SWU should be specified

[3]) Must be given if soil chemical data for phosphorus are required

[4]) Must be given if input data generated by an external crop model are used

Table 3 The input file GENERAL.INP: simulation and output options

Description of variable	**Unit**	**Range**	**R**	**DT**	**Mnemonic**
Label for section with simulation options	-	**>simopt:**	*	C8	LABEL
Switch for type of hydrological model which has been run prior to ANIMO IWA = 1: data from two layer model (e.g. WATBAL) IWA = 2: data from detailed model (e.g. SWAP)	-	[1 ... 2]	*	I	IWA
Switch for optional simulation of P-cycle IPO = 0: only carbon and nitrogen cycle IPO = 1: carbon, nitrogen and phosphorus cycle	-	[0 ... 1]	-	I	IPO
Switch for aeration option to be used ioptAE = 0: original aeration module (ANIMO3.5) ioptAE = 1: moisture respons accordging to SONICG	-	[0 ... 1]	-	I	ioptAE
Switch for crop uptake ioptCU = 0: crop uptake simulated by ANIMO ioptCU = 1: crop uptake read from file (generated by external crop model)	-	[0 ... 1]	-	I	ioptCU
Switch for transport simulation through macro pores ioptMP = 0: simulation without macro pores ioptMP = 1: simulation with macro pores **Should be set to 0, since this option is not fully operational in ANIMO version 4.0**		[0 ... 1]	-	I	ioptMP
Label for section with time options	-	**>simtim:**	*	C8	LABEL
Start year of simulation	-	[0 ... YRMAAN]	*	I	YRMIAN
Start time of simulation	-	[0.0 ... 365.0]	-	R	TIMIAN
End year of simulation	-	[YRMIAN ... 3000]	-	I	YRMAAN
End time of simulation	-	[1.0 ... 366.0]	-	R	TIMAAN
Label for section type of output to screen	-	**>outscr:**	*	C8	LABEL
Output of simulation-stage to screen OUTSC = 0: no output to screen OUTSC = 1: output of years and daynrs OUTSC = 2: output of percentage-bar OUTSC = 3: output of percentages	-	[0 ... 3]	-	I	OUTSC

Table 3 The input file GENERAL.INP: simulation and output options

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for section describing output of balances	-	**>outbal:**	*	C8	LABEL	
Number of balance sets; a balance set is characterized by the number of compartments of balance profile (maximum number of balance profiles is 10)	-	[0 ... MABA]	*	I	NUBASE	
Identifier of balance set. A character string of 2 positions between quotes must be given. The character string CHBA will added to the filename given below at the position //	-	-	*	C2	CHBA	**Should be repeated NUBASE times**
Array with selections of kind of balances (1 = output) OUTBA(1) = waterbalance BAWA//.OUT OUTBA(2) = organic matter balance BAOM//.OUT OUTBA(3) = N balance BAN//.OUT OUTBA(4) = P balance BAP//.OUT	-	[0 … 1]	*	I	OUTBA(i) i=1..4	
Compartment number of upper boundary of balance	-	[0 ... BALNMA]	*	I	BALNMI	
Compartment number of lower boundary of balance [1]	-	[BALNMI... NL]	-	I	BALNMA	
Number of time periods per year the balance should be written to file and updated afterwards NUBATI = -1 at each time-interval NUBATI = [1 ... 100]: at time-intervals of array TIBA(i), i=1… NUBATI	-	[-1]; [1 ... 100]	*	I	NUBATI	
Array with last day per time period for which the balance should be written and updated	-	[1.0 ... 365.0]	*	R	TIBA(i), i=1… NUBATI	**Only if NUBATI ≠ -1**

[1]) NL is the maximum number of compartments simulated by the hydrological model and defined in the file SWATRE.UNF

Table 3 The input file GENERAL.INP: simulation and output options

Description of variable	Unit	Range	R	DT	Mnemonic
Label for selection of results (state and rate variables per compartment) to be written every timestep	-	**>outsel:**	*	C8	LABEL
Array with switches for selection of output-files to be writen for each time interval and for each model compartment OUTSE(i) =0: no output OUTSE(i) =1: output to file [1] OUTSE(1) : NO_3-N (NITRATE.OUT) OUTSE(2) : NH_4-N (AMMONIUM.OUT) OUTSE(3) : dissolved organic N (SOLU-NOR.OUT) OUTSE(4) : PO_4-P (PHOSPHAT.OUT) OUTSE(5) : dissolved organic P (SOLU-POR.OUT) OUTSE(6) : moisture content (MOISTURE.OUT) OUTSE(7) : adsorbed NH_4-N (SORBED-N.OUT) OUTSE(8) : mineral N (MINER-N.OUT) OUTSE(9) : organic N in solid matter (SOLID-N.OUT) OUTSE(10) : total N (TOTAL-N.OUT) OUTSE(11) : adsorbed P (SORBED-P.OUT) OUTSE(12) : mineral P (MINER-P.OUT) OUTSE(13) : precipitated P (PRECIP-P.OUT) OUTSE(14) : organic P in solid matter (SOLID-P.OUT) OUTSE(15) : total P (TOTAL-P.OUT) OUTSE(16) : Pw (PW-P.OUT) OUTSE(17) : P-Al (PAL-P.OUT) OUTSE(18) : C/N organic matter (ORQCN-P.OUT) OUTSE(19) : C/P organic matter (ORQCP-P.OUT) OUTSE(20) : oxalaat extractable (OX-P.OUT) OUTSE(21) : sorbed P1 fast (CXF1-P.OUT) OUTSE(22) : sorbed P2 fast (CXF2-P.OUT) OUTSE(23) : sorbed P3 fast (CXF3-P.OUT) OUTSE(24) : sorbed P1 slow (CXS1-P.OUT) OUTSE(25) : sorbed P2 slow (CXS2-P.OUT) OUTSE(26) : sorbed P3 slow (CXS3-P.OUT) OUTSE(27) : sorbed P3 total (CXST-P.OUT) OUTSE(28) : P-discharge 3_{rd} drain (COMP-G-P.OUT) OUTSE(29) : P-discharge 2_{nd} drain (COMP-S-P.OUT) OUTSE(30) : P-discharge 1_{st} drain (COMP-K-P.OUT) OUTSE(31) : water disch. 3_{rd} drain (COMP-G-F.OUT) OUTSE(32) : water disch. 2_{nd} drain (COMP-S-F.OUT) OUTSE(33) : water disch. 1_{st} drain (COMP-K-F.OUT) OUTSE(34) : oxygen concentration (OXYGEN.OUT) OUTSE(35) : aerated fraction (AERAT_FR.OUT) OUTSE(36) : denitrification (DENITRIF.OUT) OUTSE(37) : time series of water and solute discharge to surface water per hydrological pathway (Discharge.OUT)	-	[0 ... 1]	*	I	OUTSE(i), i=1..37

[1]) Data by OUTSE(1:5) in kg N of P per m^3 water
Data by OUTSE(6) in m^3 water per m^3 soil
Data by OUTSE(7:15) in kg N of P per m^2 soil
Data by OUTSE(16) in mg P_2O_5 per liter soil solution
Data by OUTSE(17) in mg P_2O_5 per 100 g soil
Data by OUTSE(18:19) in kg C per kg N or P
Data by OUTSE(20:30) in kg P per m^2 soil
Data by OUTSE(31:33) in m^3 water per m^2 soil per day
Data by OUTSE(34) in $m^3.m^{-3}$
Data by OUTSE(35) (-)
Data by OUTSE(36) in $kg.m^{-3}.d^{-1}$
Data by OUTSE(37) in mm and kg per ha

Table 3 The input file GENERAL.INP: simulation and output options

Description of variable	Unit	Range	R	DT	Mnemonic
Switch for shoot-, root-development, harvest-, grazing- and root-losses. OUTGR =0: no output; OUTGR =1: output to file. (*only relevant for grassland applications)*	-	[0 ... 1]	*	I	OUTGR
Switch for detailed output of organic transformations OUTTRANSFOM=0: no output; OUTTRANSFOM=1: output to file	-	[0 ... 1]	-	I	OUTTRANSFOM
Label for specifying echo of input and detailled intermediate output of subroutines to the files AnimoInputs.out and AnimoIntermediate.out	-	**>outtot:**	*	C8	LABEL
Option-parameter for output per time step OUTTO = 0: time steps indicated by NUOUT, OUT(..) OUTTO = 1: each time step	-	[0 ... 1]	*	I	OUTTO
Number of time-intervals for which output is asked for (specify dummy when OUTTO=1)	-	[1 ... 52]	-	I	NUOUT
Array with time-interval(s) (daynumber) with detailled output, with length NUOUT. Daynumbers are cumulative from start of simulation and should correspond with daynumbers generated by hydrological model; maximum is also defined by hydrological model: max=amount of years to simulate*number of days in years to simulate. (The value must be exactly a day number which is being sumalated)	d	[1 ... max]	-	I	OUT(I), I=1..NUOUT

Table 4 The input file MATERIAL.INP: standard definitions of materials: reaction rates, substance contents

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of materials	-	**>defmat:**	*	C8	LABEL	
Total number of materials defined	-	[1 ... MANM]	*	I	NM	
Array specifying the organic matter contents per material	kg kg^{-1}	[0.0 ... 1.0]	-	R	FROR(NM)	
Array specifying the NH_4-N contents per material	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRNH(NM)	
Array specifying the NO_3-N contents per material	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRNI(NM)	
Label for specification of mineral-P contents	-	**>minpho:**	*	C8	LABEL	**This label only if IPO=1**
Array specifying the PO_4-P contents per material	kg kg^{-1}	[0.0 ... 1.0]	*	R	FRPO(NM)	
Label for specification of organic classes	-	**>orgmat:**	*	C8	LABEL	
Total number of classes used for sub-division of all materials	-	[1 ... MANF]	*	I	NF	
Array specifying the solid organic mass fraction per class (columns) in each material (records)	kg kg^{-1}	[0.0 ... 1.0]	*	R	FR(NM,NF)	**Should be repeated NM times**
Array specifying the dissolved org. mass fraction per class (columns) in each material (records); each array-element is defined as a mass fraction of the solid organic part of a material	kg kg^{-1}	[0.0 ... FR(NM,NF)]	*	R	FRCA(NM,NF)	**Should be repeated NM times**
Mass fraction of decomposed fresh organic material transformed directly into humus/biomass	kg kg^{-1}	[0.0 ... 1.0]	*	R	HUFROS	
Label for specification of decomposition rates under reference conditions (average temperature of 11 ^{o}C)	-	**>orgdec:**	*	C8	LABEL	
Array specifying the assimilation efficiency per organic class	-	[0.0 ... 1.0]	*	R	ASFA(NF)	
Assimilation efficiency of dissolved organic matter	-	[0.0 ... 1.0]	*	R	ASFACA	
Assimilation efficiency of humus/biomass	-	[0.0 ... 1.0]	-	R	ASFAHU	
Assimilation efficiency of root exudates	-	[0.0 ... 1.0]	-	R	ASFAEX	
Relative decomposition rate constant for nitrate driven organic transformations (if air-oxygen concentration → 0)	-	[0.0 ... 1.0]	*	R	FRHETERO	
Array specifying the decomposition rate constants of the organic classes	a^{-1}	[0.0005 ... 365.0]	*	R	RECFAV(NF)	
Decomposition rate constant of dissolved organic matter	a^{-1}	[0.1 ... 100.0]	-	R	RECFCAAV	
Decomposition rate constant of humus/biomass	a^{-1}	[0.0 ... 0.1]	-	R	RECFHUAV	
Decomposition rate constant of root exudates	a^{-1}	[10.0 ... 365.0]	-	R	RECFEXAV	
Nitrification rate constant	a^{-1}	[1.0 ... 500.0]	-	R	RECFNTAV	
Denitrification rate (holds only for nitrate limited conditions)	d^{-1}	[0.001 ... 1.0]	*	R	RECFDEAV	
Label for specification of N-contents per organic pool	-	**>orgnit:**	*	C8	LABEL	
Array specifying nitrogen contents per organic class	kg kg^{-1}	[0.0 ... 1.0]	*	R	NIFR(NF)	
Nitrogen content of humus biomass	kg kg^{-1}	[0.0 ... 1.0]	-	R	NIFRHUMA	
Nitrogen content of exudates	kg kg^{-1}	[0.0 ... 1.0]	-	R	NIFREX	
Label for specification of P-contents per organic pool	-	**>orgpho:**	*	C8	LABEL	**This label only if IPO=1**
Array specifying phosphorus contents per organic class	kg kg^{-1}	[0.0 ... 1.0]	*	R	POFR(NF)	
Phosphorus content of humus biomass	kg kg^{-1}	[0.0 ... 1.0]	-	R	POFRHUMA	
Phosphorus content of exudates	kg kg^{-1}	[0.0 ... 1.0]	-	R	POFREX	

Table 4 The input file MATERIAL.INP: standard definitions of materials: reaction rates, substance contents

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of SONICG-related parameters	-	**>sonicg:**	*	C8	LABEL	**This label only if ioptAE=1**
NO3-N concentration for which the MichaelisMenten-function takes a value half of the optimal value	$m^3\ kg^{-1}$	[0.0 ... 1.0]	*	R	HALFDENITR	
Relative process rate constant for organic transformations at complete anaerobic conditions	-	[0.0 ... 1.0]	-	R	RECFANAER	
Critical value of water filled pore space at near saturation conditions for adjustment of original water response on organic transformation to lower values	-	[0.0 ... 1.0]	-	R	WFPSCRIT	
Label for specification of SONICG-related parameters	-	**>sonic2:**	*	C8	LABEL	**This label only if ioptAE=1**
Critical value of water filled pore space for sandy soils at near saturation conditions for adjustment of original water response on nitrification to lower values	-	[0.0 ... 1.0]	-	R	WFPSCRIT2	

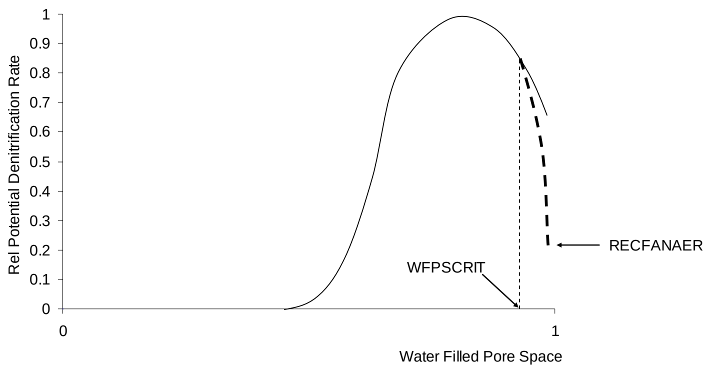

Figure 7 Label >sonicg: parameters depicted

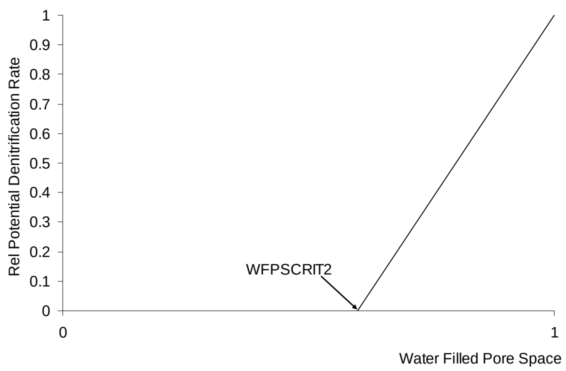

Figure 8 Label >sonic2: parameter depicted, only used for sandy soils

Table 5 The input file PLANT.INP: standard parameters for crop growth and crop uptake

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of number of crops	-	**>cropdt:**	*	C8	LABEL	
Total number of crops for which data are given	-	[1 ... MAKC]	*	I	NK	
Label for definition of default crop data for crop number KC = [1 ... NK]	-	**>cropKC:**	*	C8	LABEL	**This label should be repeated NK times**
Crop number If kind of crop is grassland the value 6 must be assigned to CN.	-	[1 ... MAKC]	*	I	CN	
Plant residues (shoots) are assigned to material number SM	-	[1 ... NM]	*	I	SM	
Plant residues (roots) are assigned to material number RM	-	[1 ... NM]	-	I	RM	
Day number of first day of growing season	d	[0.0 ... 366.0]	*	R	TIGRBEG	**Only if CN=6 (grassland data)**
Day number of last day of growing season	d	[0.0 ... 366.0]	-	R	TIGREND	
Latest day the grazing will start if it has not been triggered before by an exceedance of the amount of shoots by AMSHMI_GRSTART	d	[0.0 ... 366.0]	-	R	TIGRT0	
Amount of grass shoots that triggers the start of grazing	kg m^{-2}	[0.0 ... 1.0]	*	R	AMSHMI_ GRSTART	
Amount of shoots to be exceeded that triggers a harvest event in a combined system of cutting and grazing	kg m^{-2}	[0.0 ... 1.0]	-	R	AMSHHA_ COMB	
Amount of shoots to be exceeded that triggers a harvest event in a system of cutting only	kg m^{-2}	[0.0 ... 1.0]	-	R	AMSHHA_ CUTT	
Amount of shoots remaining after a cutting event in a combined system of cutting and grazing	kg m^{-2}	[0.0 ... 1.0]	-	R	AMSHMI_ COMB	
Amount of shoots remaining after a cutting event in a system of cutting only	kg m^{-2}	[0.0 ... 1.0]	-	R	AMSHMI_ CUTT	
Relative duration of sunshine (long term seasonal average)	-	[0.0 ... 1.0]	*	R	RESU	
Maximum amount of grass shoots produced when grazing and cutting are abandoned	kg m^{-2}	[0.0 ... 1.0]	-	R	AMSHMA	
Shoot production rate constant	-	[0.0 ... 10.0]	-	R	SHPDRA	
Efficiency factor for gross dry matter production relative to optimal standard production	-	[0.0 ... 1.0]	-	R	EFFA	
Fraction of dry matter produced allocated to grass shoots	-	[0.0 ... 1.0]	-	R	SHFR	
Day number where the maximum gross dry matter production is expected (related to light interception)	d	[0.0 ... 366.0]	-	R	TMAX	
Mass fraction of shoots lost by grazing	kg kg^{-1}	[0.0 ... 1.0]	*	R	FROSGR	
Mass fraction of shoots lost by harvesting	kg kg^{-1}	[0.0 ... 1.0]	-	R	FROSHA	
Reduction factor for grass production due to grazing by cattle	kg kg^{-1}	[0.0 ... 1.0]	-	R	RDFAGRAZING	
Minimum nitrogen content of grass shoots	kg kg^{-1}	[0.0 ... NIFRSHMA]	*	R	NIFRSHMI	
Maximum nitrogen content of grass shoots	kg kg^{-1}	[NIFRSHMI ... 0.1]	-	R	NIFRSHMA	
Minimum nitrogen content of grass roots	kg kg^{-1}	[0.0 ... NIFRROMA]	-	R	NIFRROMI	
Maximum nitrogen content of grass roots	kg kg^{-1}	[NIFRROMI ... 0.1]	-	R	NIFRROMA	
Number of data on depth of addition to soil of died roots	-	[1 ... 20]	*	I	NULNRO	
Array with Julian day numbers for which the addition depth of died roots (LNROTI) have been specified	d	[0.0 ... 366.0]	*	R	TILNRO (NULNRO)	

Table 5 The input file PLANT.INP: standard parameters for crop growth and crop uptake

Description of variable	Unit	Range	R	DT	Mnemonic	
Array with addition depth of died roots	m	[0.0 ... 2.0]	-	R	LNROTI (NULNRO)	
Turnover rate for dying of roots	d^{-1}	[0.0 ... 1.0]	*	R	TURA	
Ammonium transpiration stream concentration factor of grassland	-	[0.0 ... 2.0]	*	R	SEFANHGR	
Nitrate transpiration stream concentration factor of grassland (convective uptake)	-	[0.0 ... 2.0]	-	R	SEFANIGRCV	
Nitrate transpiration stream concentration factor of grassland (diffusive uptake)	d^{-1}	[0.0 ... 10.0]	-	R	DFCFUPNIGR	
Nitrate transpiration stream concentration factor (grassland) for diffusive counter flow	d^{-1}	[0.0 ... 10.0]	-	R	DFCFUPNIGRBW	
Minimum phosphorus content of grass shoots	-	[0.0 ... POFRSHMA]	*	R	POFRSHMI	**Only if IPO=1**
Maximum phosphorus content of grass shoots	-	[POFRSHMI ... 0.01]	-	R	POFRSHMA	
Minimum phosphorus content of grass roots	-	[0.0 ... POFRROMA]	-	R	POFRROMI	
Maximum phosphorus content of grass roots	-	[POFRROMI ... 0.01]	-	R	POFRROMA	
Phosphate transpiration stream concentration factor of grassland	-	[0.1 ... 5.0]	*	R	SEFAPOGR	
Switch for type of reduction relation with transpiration is applied. 1. (Actual evapotranspiration flux and soil evaporation flux) divided by (Potential transpiration flux and Potential soil evaporation flux) 2. (Actual evapotranspiration flux) divided by (Potential transpiration flux) 3. (Actual evapotranspiration flux) divided by (Potential transpiration flux and Potential soil evaporation flux)	-	[1 ... 3]	*	I	ioptGrEv	
Number of data on root mass development	-	[1 ... 20]	*	I	NUAMRO	**Only if CN≠6 (no grassland data)**
Array with Julian day numbers for which the root mass data (AMROTI) have been specified	-	[0.0 ... 366.0]	*	R	TIAMRO (NUAMRO)	
Array with root mass data	kg ha^{-1}	[0.0 ...]	-	R	AMROTI (NUAMRO)	
Number of data on depth of addition to soil of died roots	-	[1 ... 20]	*	I	NULNRO	
Array with Julian day numbers for which the addition depth of died roots (LNROTI) have been specified	-	[0.0 ... 366.0]	*	R	TILNRO (NULNRO)	
Array with addition depth of died roots	m	[0.0 ... 2.0]	-	R	LNROTI (NULNRO)	
Sowing date (Julian day number)	-	[0.0 ... TIHA]	*	R	TISO	
Harvesting date (Julian day number)	-	[TISO ... 366.0]	-	R	TIHA	
Areic mass of tubers harvested	kg ha^{-1}	[0.0 ...]	-	R	TUTO	
Expected cumulative N-uptake by crop KC in first period	kg ha^{-1}	[0.0 ...]	-	R	UPNIMA1	
Expected cumulative N-uptake by crop KC in second period	kg ha^{-1}	[0.0 ...]	-	R	UPNIMA2	
Cumulative transpiration in first period	m	[0.0 ... 1.0]	-	R	SUEVMA1	
Cumulative transpiration in second period	m	[0.0 ... 1.0]	-	R	SUEVMA2	
Transition date between first and second uptake period (Julian day)	-	[0.0 ... 366.0]	-	R	TIUP1	
Maximum nitrogen transpiration stream concentration factor	-	[0.0 ... 50.0]	-	R	SEFAMA	

Table 5 The input file PLANT.INP: standard parameters for crop growth and crop uptake

Description of variable	Unit	Range	R	DT	Mnemonic	
Factor to express the dependence of assumed potential uptake rates either on the defined cumulative transpiration (SUEVMA1; SUEVMA2) or on the actual transpiration rates as generated by the hydrological model calculation (Note: If Watbal as hydrological model is used this parameter should have a lower value, because the transpiration flux from Watbal is the actual evapotranspiration flux and is interpreted the same in Animo as the actual transpiration flux from Swap.)	-	[0.0 ... 1.0]	-	R	FAACTRUPCR	
Expected cumulative P-uptake by crop KC in first period	kg ha^{-1}	[0.0 ... 100.0]	*	R	UPPOMA1	**Only if IPO=1**
Expected cumulative P-uptake by crop KC in second period	kg ha^{-1}	[0.0 ... 100.0]	-	R	UPPOMA2	**Only if IPO=1**

Table 6 The input file SOIL.INP: soil chemical and soil physical data

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of geometry data	-	**>profil:**	*	C8	LABEL	
Number of soil horizons for which data are provided (should correspond with file SWATRE.UNF or WATBAL.UNF)	-	[1 ... MANH]	*	I	NUHO	
Thickness of the virtual reservoir where fertilizer additions are leached from proportional to the cumulative precipitation since the fertilization event	m	[0.0 ... 0.2]	*	R	HETOP	
Thickness of compartment on top of the soil surface (in case of ponding)	m	[0.0 ... 10.0]	-	R	HE(0)	
Fraction of surface runoff passing the surface reservoir and flowing either to surface waters or to the first soil layer	-	[0.0 ... 1.0]	*	R	LEFRRV	
Fraction of runoff passed through the surface reservoir that passes the first soil layer	-	[0.0 ... 1.0]	-	R	LEFRSO	
Depth of the initial root zone	m	[0.0 ...]	*	R	RODP	
Label for specification of temperature data	-	**>tempar:**	*	C8	LABEL	**This label only if soil temperatures are not provided by the result of the hydrological model**
Frequency of annual temperature wave	rad d^{-1}	[0.015 ... 0.02]	*	R	FQTE	
Thermal diffusivity	m^2 d^{-1}	[0.01 ... 0.1]	-	R	TESMCF	
Amplitude of annual sine wave	^oC	[0.0 ... 30.0]	*	R	APTE	
Average annual temperature at soil surface	^oC	[-30.0 ... 30.0]	-	R	AVTE	
Phase shift of temperature wave	rad	[0.0 ... 6.28]	-	R	PHSH	
Label for first specification of diffusion and soil physical data	-	**>sophy1:**	*	C8	LABEL	
Array with constant in oxygen diffusion relation per horizon in air filled part of the soil according to: $\frac{D_{soil}}{D_{air}} = p_1\ (gas\ \ fraction)^{p_2}$	-	[0.0 ... 10.0]	*	R	PMDF1HN, PMDF2HN (NUHO)	
Array with saturated conductivity per horizon	m d^{-1}	[0.0 ... 10.0]	*	R	CDSAHN (NUHO)	
Array with dry bulk density per horizon	kg m^{-3}	[0.001 ... 2700.0]	*	R	RHBDHO (NUHO)	
Array with C/N-ratio per horizon	-	[5.0 ... 60.0]	*	R	CNRATIOHO (NUHO)	
Array with temp. response coefficient for organic transformations and nitrification per horizon	J mol^{-1}	[0.0 ... 100000.0]	*	R	ACRDTEHO (NUHO)	
Array with temp. response coefficient for transformation of dissolved organic matter (Arrhenius) per horizon	J mol^{-1}	[0.0 ... 100000.0]	-	R	ACRDTEDISHO (NUHO)	
Label for second specification of soil physical data	-	**>sophy2:**	*	C8	LABEL	**This label only if IWA=1**
Switch to select distribution of evapotranspiration flux	-	[0 ... 1]	*	I	EVROSE	
EVROSE=0: uniform root extraction EVROSE=1: root extraction decreases linear with depth						
Switch to select kind of input of soil physical variables NUPF-SCPF	-	[0 ... 1]	*	I	OPTPFHN	
OPTPFHN=0: values are provided for two zones (root zone and subsoil) OPTPFHN=1: values are provided for each soil horizon (only relevant for regional SIMGRO applications)						

Table 6 The input file SOIL.INP: soil chemical and soil physical data

Description of variable	Unit	Range	R	DT	Mnemonic	
If OPTPFHN = 0: K = 2 If OPTPFHN = 1: K = NUHO						
Array with number of data-pairs the moisture retention curve is described with of horizon HN for every K	-	[3 ... 100]	*	I	NUPF(K)	
Array with volume moisture fractions of horizon HN for every NUPF(K)	$m^3\ m^{-3}$	[0.0 ... 1.0]	*	R	MOFRPF (NUPF(K))	
Array with suction values of pF-curve of horizon HN for every NUPF(K)	cm	[0.0 ... 1.0E+7]	*	R	SCPF(NUPF(K))	
Capillary height: distance between root zone and groundwater level if capillary rise flux equals 0.1 $mm\ d^{-1}$ under steady state conditions	m	[0.1 ... 3.0]	*	R	HECZ	**Only if OPTPFHN ≠1**
Label for specification of soil chemical data	-	**>sochem:**	*	C8	LABEL	
Array with pH-H_2O per horizon	-	[3.0 ... 9.0]	*	R	PHHO(NUHO)	
Array with NH_4-N sorption coefficient per horizon	$m^3\ kg^{-1}$	[0.0 ... 0.05]	*	R	SOCFNHHO (NUHO)	
Label for specification of soil chemical data for phosphorus	-	**>soalfe:**	*	C8	LABEL	**This label only if IPO=1**
Switch for type of input concerning Al and Fe input OTPALFE = 0 no values for Al and Fe are given in Soil.Inp file (Values should be specified in the file Chempar.inp) (**Not optional)** OTPALFE = 1 Sum of Al and Fe per horizon is specified OTPALFE = 2 Both Al and Fe per horizon are specified	-	[0 ... 2]	*	I	OPTALFE	
Array with Al+Fe-content of horizons 1-NUHO	$mmol\ kg^{-1}$	[5.0 ... 1000.0]	-	R	ALFEHO (NUHO)	**Only if OPTALFE=1**
Array with Al-content of horizons 1-NUHO	$mmol\ kg^{-1}$	[5.0 ... 500.0]	-	R	ALHO (NUHO)	**Only if OPTALFE=2**
Array with Fe-content of horizons 1-NUHO	$mmol\ kg^{-1}$	[5.0 ... 500.0]	-	R	FEHO(NUHO)	
Label for specification of macro pore data	-	**>MPdscf:**	*	C8	LABEL	**This label only if ioptMP=1**
(Not operational in ANIMO version 4.0!)						
Diffusion coefficient for NH_4-N	$m^2\ d^{-1}$	[0.0 ... 0.1]	*	R	DSCFNH	
Diffusion coefficient for NO_3-N	$m^2\ d^{-1}$	[0.0 ... 0.1]	-	R	DSCFNI	
Diffusion coefficient for dissolved organic matter	$m^2\ d^{-1}$	[0.0 ... 0.1]	-	R	DSCFDIOR	
Diffusion coefficient for PO_4-P	$m^2\ d^{-1}$	[0.0 ... 0.1]	-	R	DSCFPO	**Only if IPO=1**
Label for specification of sandy soil	-	**>nisand:**	*	C8	LABEL	**This label only if ioptAE=1**
Array with switch for indicator of sand per horizon 0: no sandy soil horizon 1: sandy soil horizon Use this label if distinction has to be made between sandy and not sandy soils concerning critical value of the moisture response of denitrification. See label '>sonic2:' in MATERIAL.INP. Only to be used in the framework of a STONE model application.	-	[0 ... 1]	*	I	Flsand(NUHO)	

Table 7 The input file BOUNDARY.INP: boundary conditions

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of boundary condition options	-	**>optibc:**	*	C8	LABEL	
Switch for specifying the Runon concentrations as a function of time IoptDTI=0: time independent values are specified at label **>topbou:** IoptDTI=1: values per time step are specified at label **>runoti:**	-	[0 ... 1]	*	I	ioptIDTI	
Switch for specifying the Irrigation concentrations as a function of time IoptRTI=0: time independent values are specified at label **>topbou:** IoptRTI=1: values per time step are specified at label **>irriti:**	-	[0 ... 1]	*	I	ioptIRTI	
Label for specification of top boundary condition	-	**>topbou:**	*	C8	LABEL	
Array with NH4-N concentration in precipitation water per year	kg m^{-3}	[0.0 ... 1.0]	*	R	COPRNH(NUYR)	
Array with NO3-N concentration in precipitation water per year	kg m^{-3}	[0.0 ... 1.0]	*	R	COPRNI(NUYR)	
Array with PO4-P concentration in precipitation water per year	kg m^{-3}	[0.0 ... 0.1]	*	R	COPRPO(NUYR)	**Only if IPO=1**
Array with annual areic mass of dry deposition of NH_4-N per year	kg ha^{-1} a^{-1}	[0.0 ... 100.0]	*	R	DRDEPNH(NUYR)	
Array with annual areic mass of dry deposition of NO_3-N per year	kg ha^{-1} a^{-1}	[0.0 ... 100.0]	*	R	DRDEPNI (NUYR)	
NH_4-N concentration in runon water	kg m^{-3}	[0.0 ...]	*	R	CRUNONH	**Only if ioptIDTI≠1**
NO_3-N concentration in runon water	kg m^{-3}	[0.0 ...]	-	R	CRUNONI	
PO_4-P concentration in runon water	kg m^{-3}	[0.0 ...]	*	R	CRUNOPO	**Only if IPO=1**
Dissolved organic matter concentration in runon water	kg m^{-3}	[0.0 ... 10.0]	*	R	CORMARUNO	
Dissolved organic nitrogen concentration in runon water	kg m^{-3}	[0.0 ... 10.0]	-	R	CORNIRUNO	
Dissolved organic phosphor concentration in runon water	kg m^{-3}	[0.0 ... 10.0]	*	R	CORPORUNO	**Only if IPO=1**
NH_4-N concentration in irrigation water	kg m^{-3}	[0.0 ...]	*	R	CIRRNH	**Only if ioptIRTI≠1**
NO_3-N concentration in irrigation water	kg m^{-3}	[0.0 ...]	-	R	CIRRNI	
PO_4-P concentration in irrigation water	kg m^{-3}	[0.0 ...]	*	R	CIRRPO	**Only if IPO=1**
Dissolved organic matter concentration in irrigation water	kg m^{-3}	[0.0 ... 10.0]	*	R	CORMAIRR	
Dissolved organic nitrogen concentration in irrigation water	kg m^{-3}	[0.0 ... 10.0]	-	R	CORNIIRR	
Dissolved organic phosphor concentration in irrigation water	kg m^{-3}	[0.0 ... 10.0]	*	R	CORPOIRR	**Only if IPO=1**
Label for specification of lateral boundary condition	-	**>latbou:**	*	C8	LABEL	
NH_4-N concentration in infiltration water	kg m^{-3}	[0.0 ... 1.0]	*	R	COIDNH	
NO_3-N concentration in infiltration water	kg m^{-3}	[0.0 ... 1.0]	-	R	COIDNI	
PO_4-P concentration in infiltration water	kg m^{-3}	[0.0 ... 0.1]	*	R	COIDPO	**Only if IPO=1**

Table 7 The input file BOUNDARY.INP: boundary conditions

Description of variable	Unit	Range	R	DT	Mnemonic	
Dissolved organic matter concentration in infiltration water	kg m^{-3}	[0.0 ... 10.0]	*	R	CODIORMAID	
Dissolved organic nitrogen concentration in infiltration water	kg m^{-3}	[0.0 ... 1.0]	-	R	CODIORNIID	
Dissolved organic phosphorus concentration in infiltration water	kg m^{-3}	[0.0 ... 0.1]	*	R	CODIORPOID	**Only if IPO=1**
Label for specification of bottom boundary conditions	-	**>botbou:**	*	C8	LABEL	
NH_4-N concentration in upward seepage water	kg m^{-3}	[0.0 ... 0.1]	*	R	COAQNH	
NO_3-N concentration in upward seepage water	kg m^{-3}	[0.0 ... 0.1]	-	R	COAQNI	
PO_4-P concentration in upward seepage water	kg m^{-3}	[0.0 ... 0.02]	*	R	COAQPO	**Only if IPO=1**
Dissolved organic matter concentration in upward seepage water	kg m^{-3}	[0.0 ... 1.0]	*	R	CODIORMAAQ	
Dissolved organic nitrogen concentration in upward seepage water	kg m^{-3}	[0.0 ... 1.0]	-	R	CODIORNIAQ	
Dissolved organic phosphorus concentration in upward seepage water	kg m^{-3}	[0.0 ... 0.1]	*	R	CODIORPOAQ	**Only if IPO=1**
Label for specification of boundary concentration of runon	-	**>runoti:**	*	C8	LABEL	**This label only if ioptIDTI=1**
These variables should be given sequentially and repeated for every time step (T) in the simulation period						
NH_4-N concentration in runon water for every time step	kg m^{-3}	[0.0 ...]	*	R	CORUNONNH (T)	**Should be repeated for every time step**
NO_3-N concentration in runon water for every time step	kg m^{-3}	[0.0 ...]	-	R	CORUNONNI (T)	
PO_4-P concentration in runon water for every time step	kg m^{-3}	[0.0 ...]	-	R	CORUNONPO (T)	**Only if IPO=1**
Dissolved organic matter concentration in runon water for every time step	kg m^{-3}	[0.0 ... 10.0]	-	R	CODIORMARUNON (T)	
Dissolved organic nitrogen concentration of in runon water for every time step	kg m^{-3}	[0.0 ... 1.0]	-	R	CODIORNIRUNON (T)	
Dissolved organic phosphor concentration in runon water for every time step	kg m^{-3}	[0.0 ... 0.1]	-	R	CODIORPORUNON (T)	**Only if IPO=1**
Label for specification of boundary concentration of irrigation	-	**>irriti:**	*	C8	LABEL	**This label only if ioptIRTI=1**
These variables should be given sequentially and repeated for every time step (T) in the simulation period						
NH_4-N concentration in irrigation water for every time step	kg m^{-3}	[0.0 ...]	*	R	COIRRNH(T)	**Should be repeated for every time step**
NO_3-N concentration in irrigation water for every time step	kg m^{-3}	[0.0 ...]	-	R	COIRRNI(T)	
PO_4-P concentration in irrigation water for every time step	kg m^{-3}	[0.0 ...]	-	R	COIRRPO(T)	**Only if IPO=1**
Dissolved organic matter concentration in irrigation water for every time step	kg m^{-3}	[0.0 ... 10.0]	-	R	CODIORMAIRR(T)	
Dissolved organic nitrogen concentration in irrigation water for every time step	kg m^{-3}	[0.0 ... 1.0]	-	R	CODIORNIIRR(T)	
Dissolved organic phosphor concentration in irrigation water for every time step	kg m^{-3}	[0.0 ... 0.1]	-	R	CODIORPOIRR(T)	**Only if IPO=1**

Table 8 The input file INITIAL.INP: initial conditions

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of volume moisture fractions	-	**>moistf:**	*	C8	LABEL	
Array with volume moisture fractions in compartments 1-NL	$m^3\ m^{-3}$	[0.0 ... 1.0]	*	R	MOFRO(NL)	**Only if IWA=1 and INMO≠1**
Array with Dummy values in compartments 1-NL	-	[0.0 ... 1.0]	*	R	DUMMY(NL)	**Only if IWA≠1 or IWA=1 and INMO=1**
Label for specification of concentration of NH_4-N	-	**>ammoni:**	*	C8	LABEL	
NH_4-N concentration in virtual top layer used for additions.	kg m^{-3}	[0.0 ... 10.0]	*	R	CONHTOP	
Array with NH_4-N concentration in soil moisture of compartments 0-NL	kg m^{-3}	[0.0 ... 10.0]	-	R	CONH(NL)	
Label for specification of concentration of NO_3-N	-	**>nitrat:**	*	C8	LABEL	
NO_3-N concentration in virtual top layer used for additions	kg m^{-3}	[0.0 ... 10.0]	*	R	CONITOP	
Array with NO_3-N concentration in soil moisture of compartments 0-NL	kg m^{-3}	[0.0 ... 10.0]	-	R	CONI(NL)	
Label for specification of amount of exudates	-	**>orgexu:**	*	C8	LABEL	
Array with areic mass of organic exudates in compartments 1-NL	kg m^{-2}	[0.0 ... 10.0*He(NL)]	*	R	EX(NL)	
Label for specification of humus from exudates (lumped with humus originating from other organic sources)	-	**>humexu:**	*	C8	LABEL	
Array with areic mass of humus from exudates in compartments 1-NL	kg m^{-2}	[0.0 ... 1000.0*He(NL)]	*	R	HUEX(NL)	
Label for specification of amount of fresh organic matter	-	**>orgfsh:**	*	C8	LABEL	
Array with areic mass of fresh organic matter in the organic fractions (columns) in compartments 1-NL (records)	kg m^{-2}	[0.0 ... Rhbdho(Lnhn(Ln))*He(ln)]	*	R	OS(NL,NF)	**Should be repeated NL times**
Label for specification of amount of humus from fresh organic matter	-	**>humorg:**	*	C8	LABEL	
Array with areic mass of humus from fresh organic matter in compartments 1-NL	kg m^{-2}	[0.0 ... 1000.0*He(NL)]	*	R	HUOS(NL)	
Label for specification of concentration of dissolved organic matter	-	**>orgsol:**	*	C8	LABEL	
Dissolved organic matter concentration in virtual top layer used for additions.	kg m^{-3}	[0.0 ... 10.0]	*	R	CODIORMATOP	
Array with Dissolved organic matter concentration in soil moisture of compartments 0-NL	kg m^{-3}	[0.0 ... 10.0]	-	R	CODIORMA(NL)	
Dissolved organic nitrogen concentration in virtual top layer used for additions.	kg m^{-3}	[0.0 ... 1.0]	*	R	CODIORNITOP	
Array with Dissolved organic nitrogen concentration in soil moisture of compartments 0-NL	kg m^{-3}	[0.0 ... 10.0]	-	R	CODIORNI(NL)	
Label for specification of amount of fresh organic matter and plant uptake	-	**>orgpla:**	*	C8	LABEL	
Areic mass of roots (dry matter)	kg m^{-2}	[0.0 ... 20.0]	*	R	AMPLRO	
Areic mass of shoots (dry matter)	kg m^{-2}	[0.0 ... 20.0]	-	R	AMPLSH	
Areic mass of nitrogen present in crop (initial uptake)	kg m^{-2}	[0.0 ... 800.0]	-	R	AMPLNI_ACT	

Table 8 The input file INITIAL.INP: initial conditions

Description of variable	Unit	Range	R	DT	Mnemonic	
Areic mass of phosphorus present in crop (initial uptake)	kg m^{-2}	[0.0 ... 80.0]	*	R	AMPLPO_ACT	**Only if IPO=1**
Label for specification of initial conditions of phosphorus	-	**>inipho:**	*	C8	LABEL	**This label only if IPO=1**
Switch for kind of variables given for each model compartment INPO = 1: variables COPO, AMCXFA, AMCXSL, AMPOPR are given INPO = 2: variables AMPOTO, COPOEB are given INPO = 3: variables COPO, AMPOTO, COPOEB are given	-	[1 ... 3]	*	I	INPO	
PO_4-P concentration in virtual top layer used for additions.	kg m^{-3}	[0.0 ... 1.0]	*	R	COPOTOP	**Only if INPO = 1**
Array with PO_4-P concentration of soil moisture in compartments 0-NL	kg m^{-3}	[0.0 ... 0.1]	-	R	COPO(NL)	
Array with adsorbed equilibrium mass concentration of phosphorus in the soil system; specified for compartments 0-NL (columns) and equilibrium sites 1-NCXFA (records) In ANIMO4.0, only 1 site is operational	kg m^{-3}	[0.0 ...]	*	R	AMCXFA (NCXFA,NL)	**Should be repeated NCXFA times**
Array with adsorbed non equilibrium mass concentration of phosphorus in the soil system; specified for compartments 0-NL (columns) and non equilibrium sites 1-NCXSL (records)	kg m^{-3}	[0.0 ...]	*	R	AMCXSL (NCXSL,NL)	**Should be repeated NCXSL times**
Array with precipitated mass concentration of phosphorus in the soil system; specified for model compartments 0-NL	kg m^{-3}	[0.0 ...]	*	R	AMPOPR(NL)	
Array with total mass concentration of phosphorus in the soil system; specified for model compartments 0-NL	kg m^{-3}	[0.0 ...]	*	R	AMPOTO(NL)	**Only if INPO=2**
Environmental background values of phosphorus soil moisture concentration	kg m^{-3}	[0.0 ... 0.1]	-	R	COPOEB	
Phosphorus concentration in virtual top layer used for additions.	kg m^{-3}	[0.0 ... 1.0]	*	R	COPOTOP	**Only if INPO=3**
Array with phosphorus concentration in soil moisture of compartments 0-NL	kg m^{-3}	[0.0 ... 0.1]	-	R	COPO(NL)	
Array with total mass concentration of phosphorus in the soil system; specified for model compartments 0-NL	kg m^{-3}	[0.0 ...]	*	R	AMPOTO(NL)	
Environmental background value of phosphorus soil moisture concentration	kg m^{-3}	[0.0 ... 0.1]	-	R	COPOEB	
Dissolved organic phosphorus concentration in virtual top layer used for additions.	kg m^{-3}	[0.0 ... 0.1]	*	R	CODIORPOTOP	
Array with dissolved organic phosphorus concentration in soil moisture for compartments 0-NL	kg m^{-3}	[0.0 ... 0.1]	-	R	CODIORPO(NL)	
Label for specification of initial data of nitrogen concentrations in macropores ***(Not operational in ANIMO version 4.0!)***	-	**>MPnitr:**	*	C8	LABEL	
Macro pore NH_4-N concentration domain 1 (Main Bypass Flow domain)	kg m^{-3}	[0.0 ... 10.0]	*	R	COMPNH(1)	**This label only if ioptMP=1**
Macro pore NH_4-N concentration domain 2 (Internal Catchment domain)	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPNH(2)	
Macro pore NO_3-N concentration domain 1	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPNI(1)	
Macro pore NO_3-N concentration domain 2	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPNI(2)	

Table 8 The input file INITIAL.INP: initial conditions

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of initial data of soluble organic concentrations in macropores **_(Not operational in ANIMO version 4.0!)_**	-	**>MPorgs:**	*	C8	LABEL	
Macro pore soluble organic matter concentration domain 1	kg m^{-3}	[0.0 ... 10.0]	*	R	COMPDIORMA (1)	**This label only if ioptMP=1**
Macro pore soluble organic matter concentration domain 2	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPDIORMA (2)	
Macro pore soluble organic nitrogen concentration domain 1	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPDIORNI (1)	
Macro pore soluble organic nitrogen concentration domain 2	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPDIORNI (2)	
Label for specification of initial data of phosphate concentrations in macropores **_(Not operational in ANIMO version 4.0!)_**	-	**>MPphos:**	*	C8	LABEL	
Macro pore PO_4-P concentration domain 1	kg m^{-3}	[0.0 ... 1.0]	*	R	COMPPO(1)	**This label only if ioptMP=1 and IPO=1**
Macro pore PO_4-P concentration domain 2	kg m^{-3}	[0.0 ... 1.0]	-	R	COMPPO(2)	
Macro pore soluble organic phosphorus concentration domain 1	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPDIORPO (1)	
Macro pore soluble organic phosphorus concentration domain2	kg m^{-3}	[0.0 ... 10.0]	-	R	COMPDIORPO (2)	

Table 9 The input file MANAGEMENT.INP: data concerning additions and tillage to the soil system

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of crop rotation definition	-	**>kicrop:**	*	C8	LABEL	
Array with kind of crop grown for every year	-	[1 ... NK]	*	I	KICR(NUYR)	
Label for specification of livestock unit definition	-	**>lsunit:**	*	C8	LABEL	
Array with annual average number of lifestock-units (lsu) grazing on grassland for every year (dummy values must be given for years with other crops than grassland)	lsu ha^{-1} a^{-1}	[0.0 ... 100.0]	*	R	NRGR(NUYR)	
Label for specification of (variable) material composition	-	**>matvar:**	*	C8	LABEL	
Switch for variable composition of materials added	-	[0 ... 2]	*	I	OPTMF	
OPTMF = 0: fixed composition given in file MATERIAL.INP; no other variables need to be given at this label OPTMF = 1: composition varies in time and based on given details (see e.g. label for first event **>add001:**) OPTMF = 2: composition varies in time and is based on given N-total, P-total, organic matter fraction. N-mineral is divided over NO_3-N and NH_4-N according to default values given in MATERIAL.INP						
If OPTMF=1 or OPTMF=2 then the default composition of materials (given in file MATERIAL.INP) will be adjusted according to the composition given in this file. This option is intended for animal manure materials 1 to NMVA. It is assumed that organic fractions are defined (in MATERIAL.INP) starting from 1 and continuing till NFVA.						
Number of materials with variable compositions	-	[1 ... NM]	*	I	NMVA	**Only if OPTMF=1 or 2**
Number of organic fractions with variable compositions	-	[1 ... NF]	-	I	NFVA	
Label for specification of first event period	-	**>add001:**	*	C8	LABEL	
Time of first event period	d	[0.0 ...]	*	R	TINEAD	
Number of events in the first period (additions, fertilization, ploughing)	-	[1 ... MAAD]	*	I	NUAD	
Number of material added	-	[1 ... NM]	*	I	MTNU(1)	
Areic mass of material added	kg ha^{-1}	[0.0 ...]	-	R	QUMT(1)	
Number of model compartments over which the addition is distributed	-	[0 ... NL]	-	I	WYAD(1)	
WYAD(i) = 0: addition to an additional top compartment (artificial resevoir). Anorganic parts of material are added to the top compartment, organic parts are added to compartment 1 WYAD(i) = n: addition of all parts to compartments 1 to n						
Number of model compartments to be ploughed (redistributed). Compartment 0 is always emptyed when PL(1) is greater than 0	-	[0 ... NL]	-	I	PL(1)	
Fraction of volatilization of NH_4-N	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRVO(1)	
Organic matter content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	*	R	FROR(m)	**Only if OPTMF=1 and should be repeated m=MTNU(1) times**
Mineral NH_4-N content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRNH(m)	
Mineral NO_3-N content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRNI(m)	
Mineral P content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRPO(m)	
Array with mass fractions of organic classes (FN = 1 to NFVA) as part of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	*	R	FR(m,FN)	
Array with mass fractions of dissolved part of organic classes as part of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... FR(m,FN)]	*	R	FRCA(m,FN)	

Table 9 The input file MANAGEMENT.INP: data concerning additions and tillage to the soil system

Description of variable	Unit	Range	R	DT	Mnemonic	
Organic matter content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	*	R	FROR(m)	**Only if OPTMF=2 and should be repeated m=MTNU(1) times**
Total-N content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRNT(m)	
Total-P content of material m (=MTNU(1))	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRPT(m)	
Daynumber of next addition event	d	[0.0 ...]	*	R	TINEAD	
Label for specification of event number x (002≤x≤999)	-	**>addx:**	*	C8	LABEL	**This label should be repeated x=each planned time of event period**
Number of events (additions, fertilization, ploughing)	-	[0 ... MAAD]	*	I	NUAD	
Number of material added	-	[1 ... NM]	*	I	MTNU(x)	
Areic mass of material added	kg ha^{-1}	[0.0 ...]	-	R	QUMT(x)	
Number of model compartments over which the addition is distributed (see label **>add001:**)	-	[0 ... NL]	-	I	WYAD(x)	
Number of model compartments to be ploughed (redistributed). Compartment 0 is always emptyed when PL(x) > 0	-	[0 ... NL]	-	I	PL(x)	
Fraction of volatilization of NH4-N of the addition	kg kg^{-1}	[0.0 ... 1.0]	-	R	FRVO(x)	
If OPTMF=1 then the variables (FROR, FRNH, FRNI, FRPO, FR and FRCA) should be specified for materials m=MTNU(x) (see label >add001:)						
If OPTMF=2 then the following variables (FROR, FRNT and FRPT) should be specified for materials m=MTNU(x) (see label >add001:)						
Time of addition event x+1	d	[0.0 ...]	*	R	TINEAD	

Table 10 The input file SWATRE.UNF: water quantity data from a model like SWAP						**This file only if IWA=2**
Description of variable	**Unit**	**Range**	**R**	**DT**	**Mnemonic**	
Switch to enable the pass through of macro pore simulation results by the Swap model (1: no data of macropore flow; 2: data of macropore flow)	-	[1 ... 2]	*	I	HLPIMP	
Time domain						
Start year of hydrological simulation	-	[1 ...]	*	I	YRMIHY	
End year of hydrological simulation	-	[YRMIHY ...]	-	I	YRMAHY	
Start time (Julian daynumber) of hydrological simulation (minimum); should be 0.0 when simulation started at 1st of January, 00:00 hour	-	[0.0 ... 366.0]	-	R	TIMIHY	
End time (Julian daynumber) of hydrological simulation (maximum)	-	[0.0 ... 366.0]	-	R	TIMAHY	
Geometry of model system						
Number of model compartments	-	[1 ... MANL]	*	I	NL	
Number of horizons	-	[1 ... MANH]	-	I	NH	
Number of drainage systems	-	[0 ... 5]	-	I	NUDR	
Array with compartment number of the deepest compartment (bottom) of each soil horizon	-	[1 ... NL]	*	I	LNBOHO(NH)	
Array with volume moisture fraction at saturation of each soil horizon	m^3 m^{-3}	[0.0 ... 1.0]	*	R	MOFRSAHO(NH)	
Array with volume moisture fraction at field capacity of each soil horizon	m^3 m^{-3}	[0.0 ... 1.0]	*	R	MOFRFCHO(NH)	
Array with volume moisture fraction at wilting point of each soil horizon	m^3 m^{-3}	[0.0 ... 1.0]	*	R	MOFRWIHO(NH)	
Array with thickness of each compartment (=layer)	m	[0.0 ... 100.0]	*	R	HE(NL)	
(Not operational in ANIMO version 4.0!)						
Geometry of macropore system						
Areic volume of static macro pores in domain 1: Main Bypass Flow domain (must be given for the compartments (=layer) 1-NL)	m^3 m^{-2}	[0.0 …]	*	R	VLMPST1(NL)	**Only if ioptMP =1**
Areic volume of static macro pores in domain 2: Internal Catchment domain (must be given for the compartments (=layer) 1-NL)	m^3 m^{-2}	[0.0 ...]	*	R	VLMPST2(NL)	
Array with diameter of soil matrix polygons (must be given for the compartments (=layer) 1-NL)	m	[0.001 ... 10.0]	*	R	AGDIAM(NL)	
Initial conditions						
Array with volume moisture fraction initially present (must be given for the compartments (=layer) 1-NL)	m^3 m^{-3}	[0.0 ... 1.0]	*	R	MOFRO(NL)	
Initial groundwater level (m-surface)	m	[0.0 ...]	*	R	WALE	
Storage by initial ponding (m+surface)	m	[0.0 ...]	-	R	PN	
Storage by snow	m	[0.0 ...]	*	R	SNLA	
Array with soil temperature of compartments must be given for the compartments (=layer) 1-NL)	°C	[0.0 ...]	*	R	LATE(NL)	
(Not operational in ANIMO version 4.0!)						
Initial conditions for macropores, domain 1 (Main Bypass Flow domain)						
Water level	m-surf	[0.0 ...]	*	R	Dummy	**Only if ioptMP =1**
Areic volume	m^3 m^{-2}	[0.0 ...]	-	R	VLMP(1)	
Areic volume of water stored	m^3 m^{-2}	[0.0 ...]	-	R	SRWAMP(1)	

Table 10 The input file SWATRE.UNF: water quantity data from a model like SWAP

This file only if IWA=2

Description of variable	Unit	Range	R	DT	Mnemonic	
Initial conditions for macropores, domain 2 (Internal Catchment domain)						
Areic volume	$m^3\ m^{-2}$	[0.0 ...]	-	R	VLMP(2)	**Only if ioptMP =1**
Areic volume of water stored	$m^3\ m^{-2}$	[0.0 ...]	-	R	SRWAMP(2)	
Dynamic part						
Time (Julian daynumber) in hydrological model. (TIWA=1.0 has the meaning: 1st of January, 24:00 hour)	-	[0.0 ...]	*	R	TIWA	
Step size of time-interval with dynamic hydrological data	d	[1.0 ... 30.0]	-	R	ST	
Precipitation flux	$m\ d^{-1}$	[0.0 ...]	-	R	PRR	
Snowfall (water equivalents) flux	$m\ d^{-1}$	[0.0 ...]	-	R	PRSN	
Irrigation flux	$m\ d^{-1}$	[0.0 ...]	-	R	PRIRR	
Interception evaporation flux of precipitation	$m\ d^{-1}$	[0.0 ...]	-	R	EVICPR	
Interception evaporation flux of irrigation	$m\ d^{-1}$	[0.0 ...]	-	R	EVICIRR	
Sublimation of snow	$m\ d^{-1}$	[0.0 ...]	-	R	EVSN	
Actual evaporation of bare soil	$m\ d^{-1}$	[0.0 ...]	-	R	EVSO	
Evaporation flux of ponded water layer	$m\ d^{-1}$	[0.0 ...]	-	R	EVPN	
Potential soil evaporation flux	$m\ d^{-1}$	[0.0 ...]	-	R	EVSOMA	
Potential transpiration flux	$m\ d^{-1}$	[0.0 ...]	-	R	EVTRMA	
Surface runon flux (inflow from adjacent fields)	$m\ d^{-1}$	[0.0 ...]	-	R	RUNON	
Surface runoff flux (negative values means inundation)	$m\ d^{-1}$	[...]	-	R	RU	
Groundwater level at end of time-interval (m-surface)	m	[0.0 ...]	-	R	WALET	
Water level in ponding layer at end of time-interval (m+surface)	m	[0.0 ...]	-	R	PNT	
Snow thickness (water equivalents) at end of time-interval	m	[0.0 ...]	-	R	SNT	
Water balance error	m	[...]	-	R	WABAER	
Array with soil moisture pressure head (negative when unsaturated) of compartment (=layer) 1-NL	cm	[...]	*	R	SC(NL)	
Array with volume moisture fraction at end of time-interval of compartment (=layer) 1-NL	$m^3\ m^{-3}$	[0.0 ... 1.0]	*	R	MOFRT(NL)	
Array with actual transpiration flux of compartment (=layer) 1-NL	$m\ d^{-1}$	[0.0 ...]	*	R	FLEV(NL)	
Array with downward flux through top of compartment (=layer) 1-NL+1 (downward = positive)	$m\ d^{-1}$	[...]	*	R	FLAB(NL+1)	
The presence of values for variables FLK to FLD2 is determined by the variable NUDR. The value of NUDR determines the number of drainage systems for which flux densities must be given.						
Array with drainage flux of 1st order system (canal) of compartment (=layer) 1-NL	$m\ d^{-1}$	[0.0 ...]	*	R	FLK(NL)	
Array with drainage flux of 2nd order system (ditch) of compartment (=layer) 1-NL	$m\ d^{-1}$	[0.0 ...]	*	R	FLS(NL)	
Array with drainage flux of 3rd order system (trench) of compartment (=layer) 1-NL	$m\ d^{-1}$	[0.0 ...]	*	R	FLG(NL)	
Array with drainage flux of 4th order system (tube drain) of compartment (=layer) 1-NL	$m\ d^{-1}$	[0.0 ...]	*	R	FLD(NL)	
Array with drainage flux of 5th order system (rapid drainage) of compartment (=layer) 1-NL	$m\ d^{-1}$	[0.0 ...]	*	R	FLD2(NL)	
Soil cover fraction	$m^2\ m^{-2}$	[0.0 ... 1.0]	*	R	SOCO	

Table 10 The input file SWATRE.UNF: water quantity data from a model like SWAP						**This file only if IWA=2**
Description of variable	**Unit**	**Range**	**R**	**DT**	**Mnemonic**	
Leaf Area Index	$m^2\ m^{-2}$	[0.0 ... 10.0]	-	R	LAI	
Maximum depth for root water extraction	m	[0.0 ...]	-	R	DPRO	
Crop factor (or crop height)	- or cm	[0.0 ...]	-	R	HECR	
Average daily air temperature	^oC	[-50.0 ... 50.0]	*	R	AVDATE	
Array with average daily soil temperature of layers 1-NL	^oC	[-50.0 ... 50.0]	*	R	TE(NL)	
(Not operational in ANIMO version 4.0!) **Dynamic part for macropores, domain 1 (Main Bypass Flow domain)**						
Water level at end of time-interval (m-surf)	m	[0.0 ...]	*	R	Dummy	
Areic volume of macro pores at end of time-interval	$m^3\ m^{-2}$	[0.0 ...]	-	R	VLMP(1)	
Areic volume of water stored in macro pores at end of time-interval	$m^3\ m^{-2}$	[0.0 ...]	-	R	SRWAMP(1)	
Water infiltration flux at soil surface directly by precipitation	$m\ d^{-1}$	[0.0 ...]	-	R	FLMPINPR(1)	
Water infiltration flux at soil surface indirectly by lateral overland flow (runoff)	$m\ d^{-1}$	[0.0 ...]	-	R	FLMPINRU(1)	
Array with water exchange flux with soil matrix per layer (1-NL) (positive: from macropores into matrix)	$m\ d^{-1}$	[...]	*	R	FLMPOUIF(1,NL)	
Array with water rapid drainage flux towards drain (tube) per layer (1-NL) overland flow (runoff)	$m\ d^{-1}$	[0.0 ...]	*	R	FLMPOUDR(NL)	
Array with average fraction of macropore wall in contact with macropore water during time step per layer (1-NL)	$m\ d^{-1}$	[0.0 ...1.0]	*	R	FRWEMPWL(1,NL)	**Only if ioptMP =1**
Dynamic part for macropores, domain 2 (Internal Catchment domain)						
Areic volume of macro pores at end of time-interval	$m^3\ m^{-2}$	[0.0 ...]	*	R	VLMP(2)	
Areic volume of water stored in macro pores at end of time-interval	$m^3\ m^{-2}$	[0.0 ...]	-	R	SRWAMP(2)	
Water infiltration flux at soil surface directly by precipitation	$m\ d^{-1}$	[0.0 ...]	-	R	FLMPINPR(2)	
Water infiltration flux at soil surface indirectly by lateral overland flow (runoff)	$m\ d^{-1}$	[0.0 ...]	-	R	FLMPINRU(2)	
Array with water exchange flux with soil matrix per layer (1-NL) (positive: from macropores into matrix)	$m\ d^{-1}$	[...]	*	R	FLMPOUIF(2,NL)	
Array with average fraction of macrop[ore wall in contact with macropore water during time step per layer (1-NL)	$m\ d^{-1}$	[0.0 ...]	*	R	FRWEMPWL(2,NL)	

Table 11 The input file WATBAL.INP: data related to a model like WATBAL

This file only if IWA=1

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of simulation period and length of time-interval	-	**>simper:**	*	C8	LABEL	
Start year of hydrological simulation	-	[1 ... YRMAHY]	*	I	YRMIHY	
End year of hydrological simulation	-	[YRMIHY ... 3000]	-	I	YRMAHY	
Start time (Julian daynumber) of hydrological simulation	-	[0.0 ... 366.0]	-	R	TIMIHY	
End time (Julian daynumber) of hydrological simulation	-	[0.0 ... 366.0]	-	R	TIMAHY	
Switch for input of stepsize of time-interval with dynamic hydrological data OPTST = 1: stepsize is fixed and given in this file OPTST = 2: stepsize is given in WATBAL.UNF	-	[1 ... 2]	-	I	OPTST	
Indicator for initial moisture volume fractions INMO = 0: values specified in the input-file INITIAL.INP should be used INMO = 1: values to be calculated in ANIMO	-	[0 ... 1]	-	I	INMO	
Length of time-interval (time step)	d	[1.0 ...]	-	I	ST	**Only if OPTST =1 otherwise give a dummy value**
Label for specification of geometry of model system	-	**>geomet:**	*	C8	LABEL	
Number of model compartments	-	[1 ... MANL]	*	I	NL	
Number of soil horizons	-	[NUHO]	*	I	NH	
Number of compartments with roots	-	[1 ... NL]	*	I	NUROUP	
Array with compartment (=layer) number of the deepest compartment (bottom) of each horizon 1-NUHO	-	[1 ... NL]	*	I	LNBOHO(NUHO)	
Array with thickness of compartments(=layers) 1-NL	m	[0.03 ... 10.0]	*	R	HE(NL)	
Label for specification of drainage parameters	-	**>drains:**	*	C8	LABEL	
Average drain distance of 1st order drains (canals) (AK=1/DK; DK is density of canals in m^{-1})	m	[0.0 ...]	*	R	AK	
Average drain distance of 2nd order drains (ditches) (AS=1/(DK+DS); DS is density of ditches in m^{-1})	m	[0.0 ...]	-	R	AS	
Average drain distance of 3rd order drains (trenches) (AG=1/(DK+DS+DG); DG is density of trenches in m^{-1})	m	[0.0 ...]	-	R	AG	
Drainage level of first order system relative to soil surface (m-surface)	m	[0.0 ...]	-	R	HDK	
Drainage level of second order system relative to soil surface (m-surface)	m	[0.0 ...]	-	R	HDS	
Drainage level of third order system relative to soil surface (m-surface)	m	[0.0 ...]	-	R	HDG	

Table 12 The input file WATBAL.UNF: water quantity data from a model like WATBAL

This file only if IWA=1

Description of variable	Unit	Range	R	DT	Mnemonic	
Initial part						
Areic moisture volume of rootzone	$m^3 m^{-2}$	[0.0 ...]	*	R	MOCORO	
Initial groundwaterlevel (m-surface)	m	[0.0 ...]	-	R	WALE	
Areic moisture deficit of subsoil below the rootzone	$m^3 m^{-2}$	[0.0 ...]	-	R	MODEUN	
Dynamic part						
Time in waterquantity model	d	[0.0 ...]	*	R	TIWA	
Length of time-interval (time step)	d	[1.0 ...]	-	R	ST	**Only if IOPTST=2**
Potential evapotranspiration flux	$m d^{-1}$	[0.0 ...]	-	R	ETMA	
Precipitation flux	$m d^{-1}$	[0.0 ...]	-	R	PR	
Actual evapotranspiration flux	$m d^{-1}$	[0.0 ...]	-	R	EV	
Surface runoff flux	$m d^{-1}$	[0.0 ...]	-	R	RU	
Drainage flux of 3rd order system (trench)	$m d^{-1}$	[0.0 ...]	-	R	FG	
Drainage flux of 2nd order system (ditch)	$m d^{-1}$	[0.0 ...]	-	R	FS	
Drainage flux of 1st order system (canal)	$m d^{-1}$	[0.0 ...]	-	R	FK	
Leaching/seepage flux across lower boundary (downward flux is defined positive)	$m d^{-1}$	[0.0 ...]	-	R	LEAK	
Areic moisture volume of rootzone at end of time-interval	m	[0.0 ...]	-	R	MOCOROT	
Groundwater level at end of time-interval	m	[0.0 ...]	-	R	WALET	

Table 13 The input file CHEMPAR.INP: chemical parameters for phosphorus

This file only if IPO=1

Description of variable	Unit	Range	R	DT	Mnemonic		
Label for specification of definition of chemical system	-	**>chedef:**	*	C8	LABEL		
Switch (option) for equilibrium sorption OPTCXFA = 1: Linear OPTCXFA = 2: Langmuir OPTCXFA = 3: Freundlich **(ANIMO 4.0 version allows only OPTCXFA=2)**	-	[2]	*	I	OPTCXFA		
Number of sites for equilibrium sorption (ANIMO4.0 version allows only 1 equilibrium sorption site: NCXFA=1)	-	[1 ... 3]	*	I	NCXFA		
Switch (option) for non equilibrium sorption OPTCXSL = 1: linear OPTCXSL = 2: Langmuir OPTCXSL = 3: Freundlich	-	[1 ... 3]	*	I	OPTCXSL		
Number of sites for non equilibrium sorption	-	[1 ... 3]	*	I	NCXSL		
Switch for type of precipitation process OPTPR = 0: instantaneous OPTPR = 1: first order (ANIMO4.0 version allows only OPTPR=0)	-	[0 ... 1]	*	I	OPTPR		
Label for specification of sorption variables	-	**>chesor:**	*	C8	LABEL		
Switch for input of sorption parameters (from PACXFAHO to RECFDESHO) either for whole profile or per soil horizon OPTCXHO = 1: Input for whole profile (HN=1) OPTCXHO = 2: Input per horizon (HN=NUHO)	-	[1 ... 2]	*	I	OPTCXHO		
(ANIMO 4.0 version must receive dummy values for PACXFAHO(1), PACXFAHO(4) and PACXFAHO(5))							
Dummy variable	-	[0.0 ...]	*	R	PACXFAHO (1,I,HN)	**Should be repeated (I = 1 to NCXFA times**	**Should be repeated NH times**
Langmuir max. sorption amount	kg m^3	[0.0 ...]	-	R	PACXFAHO (2, I,HN)		
Langmuir sorption coefficient	m^3 kg^{-1}	[0.0 ...]	-	R	PACXFAHO (3, I,HN)		
Dummy variable	-	[0.0 ...]	-	R	PACXFAHO (4, I,HN)		
Dummy variable	-	[0.0 ...]	-	R	PACXFAHO (5, I,HN)		
Langmuir desorption coefficient	d^{-1}	[0.0 ... 1.0]	*	R	PARKD(HN)		
Linear sorption coefficient	m^3 .m^{-3}	[0.0 ...]	*	R	PACXSLHO (1,I,HN)	**Should be repeated (I = 1 to NCXSL times**	
Langmuir maximum sorption amount	kg.m^{-3}	[0.0 ...]	-	R	PACXSLHO (2,I,HN)		
Langmuir sorption coefficient	m^3 kg^{-1}	[0.0 ...]	-	R	PACXSLHO (3,I,HN)		
Freundlich sorption constant	-	[0.0 ...]	-	R	PACXSLHO (4,I,HN)		
Freundlich sorption exponent	-	[0.0 ... 1.0]	-	R	PACXSLHO (5,I,HN)		
First order adsorption rate constant	d^{-1}	[0.0 ... 0.01]	*	R	RECFADSHO (I,HN)		
First order desorption rate constant	d^{-1}	[0.0 ... 1.0E-4]	-	R	RECFDESHO (I,HN)		

Table 13 The input file CHEMPAR.INP: chemical parameters for phosphorus

This file only if IPO=1

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for specification of kinetic precipitation variables	-	**>chepre:**	*	C8	LABEL	
First order kinetic precipitation rate constant	d^{-1}	[0.0 ... 0.5]	*	R	RECFPR	
Label for specification of PO_4-P threshold concentration (precipitation occurs when the threshold level is exceeded)	-	**>chebuf:**	*	C8	LABEL	
Switch for input method of equilibrium (buffer) concentration OPTCOBU = 0: variable COBUHO is calculated in ANIMO using a pH/c_{eq} relation OPTCOBU = 1: COBUHO is specified in this file	-	[0 ... 1]	*	I	OPTCOBU	
Threshold concentration (PO_4-P) for P-precipitation	kg m^{-3}	[0.0 ... 0.2]	*	R	COBUHO	**Only if OPTCOBU=1**

Table 14 The input file CROP_EXT.INP: external crop data file.						**This file only if ioptCU=1**
Description of variable	**Unit**	**Range**	**R**	**DT**	**Mnemonic**	
If the option ioptCU is set to 1, the MATERIAL.INP file should comprise 4 organic fractions to be used for the aboveground plant parts (shoots) and the subterranean plant parts (roots). Also an adaptation in the INITIAL.INP file must be made, since the fresh organic matter (label >orgfsh:) is given per fraction.						
Header with variable names	-	-	*	CH	Header	
Minimum nitrogen fraction in shoots	-	[0.0 ... NISHMA]	*	R	NISHMI	
Maximum nitrogen fraction in shoots	-	[NISHMI ... 1.0]	-	R	NISHMA	
Minimum nitrogen fraction in roots	-	[0.0 ... NIROMA]	-	R	NIROMI	
Maximum nitrogen fraction in roots	-	[NIROMI ... 1.0]	-	R	NIROMA	
Minimum phosphorus fraction in shoots	-	[0.0 ... POSHMA]	-	R	POSHMI	
Maximum phosphorus fraction in shoots	-	[POSHMI ... 1.0]	-	R	POSHMA	
Minimum phosphorus fraction in roots	-	[0.0 ... POROMA]	-	R	POROMI	
Maximum phosphorus fraction in roots	-	[POROMI ... 1.0]	-	R	POROMA	
Header with variable names	-	-	*	CH	Variable names	
These variables should be given sequentially and repeated for every time step (T) in the simulation period						
Year Month Day	-	[YRMI+TIMI ... YRMA+TIMA]	*	I - I - I	YR-MO-DA	**Should be repeated for every T=time step**
Gross nitrogen-N uptake	$kg.ha^{-1}$	[0.0 ... 500.0]	-	R	NIUP(T)	
Gross phosphor-P uptake	$kg.ha^{-1}$	[0.0 ... 50.0]	-	R	POUP(T)	
Crop losses of organic matter in aboveground parts (shoots)	$kg.ha^{-1}$	[0.0 ... 30000.0]	-	R	OMCRSH(T)	
Crop losses of nitrogen in aboveground parts (shoots)	$kg.ha^{-1}$	[0.0 ... 300.0]	-	R	NICRSH(T)	
Crop losses of phosphor in aboveground parts (shoots)	$kg.ha^{-1}$	[0.0 ... 30.0]	-	R	POCRSH(T)	
Crop losses of organic matter in subterranean parts (roots)	$kg.ha^{-1}$	[0.0 ... 30000.0]	-	R	OMCRRO(T)	
Crop losses of nitrogen in subterranean parts (roots)	$kg.ha^{-1}$	[0.0 ... 300.0]	-	R	NICRRO(T)	
Crop losses of phosphorus in subterranean parts (roots)	$kg.ha^{-1}$	[0.0 ... 30.0]	-	R	POCRRO(T)	

3.3 Program output data

The model always writes output to the following files::

- AnimoInputs.out,
- AnimoIntermediate.out,
- INITIAL.out and
- MESSAGE.out.

Other output-files are optional. The AnimoInputs.out file echoes output of input and the file AnimoIntermediate.out provides optional output for each time step from each subroutine. The output-files AnimoInputs.out and AnimoIntermediate.out can be used to verify part of the input. The INITIAL.out file contains the same type of data concerning state-variables for the model profile (mineral N and P, organic matter contents) in the same sequence as the input-file INITIAL.INP and can be used to initialize another simulation run. The MESSAGE.out file contains all warning- and error-messages. Most subroutines can create error messages, which all refer to the subroutine that generates the message.

Optional output can be directed by means of one of the options given at the end of the input-file GENERAL.INP (see Section 3.2). By means of these options, one can create balances for a freely chosen number of model compartment layers and a freely chosen time-interval. These balances can be generated for water, nitrogen, phosphate and organic matter. An explanation of the mass balance-terms is given in Annex 2. Subsequent to balances, the model can also produce output regarding quite a number of items for each time step for each model compartment.
Output can also be generated for detailed organic transformations for organic matter, nitrogen and/or phosphorus in dissolved and/or in solid phase (variables OUTSE(1-37)). A description is given with the input-file GENERAL.INP (see Section 3.2).

3.4 Model execution

Once the input files are prepared, an execution of a simulation is performed by entering the path and name of the executable from the command line that can be followed by the path and name of a direct file with the names of the input files to be used, e.g. "..\..\Executable\Animo40.exe Animo.ini". See ***Figure 9*** for an example of the content of a direct file with names of input files.

```
Animo40
GEN=".\Input\general.inp"
MAT=".\Input\material.inp"
PLA=".\Input\plant.inp"
SOI=".\Input\soil.inp"
BOU=".\Input\boundary.inp"
INI=".\Input\initial.inp"
MAN=".\Input\management.inp"
SWU=".\Input\swatre.unf"
WAI=".\Input\watbal.inp"
WAU=".\Input\watbal.unf"
CHE=".\Input\chempar.inp"
INO=".\Output\initial.out"
CRU=".\Input\crop_ext.inp"
MES=".\Input\message.out"
END
```

Figure 9 Example of a direct file named Animo.ini.

If the direct file is not used the input-files must be located at the same directory as the working directory. With the direct file, it is possible to add the path to the file name. Output-files produced by the model will be directed to the same directory as the executable.

The program may direct error messages to the screen. All error-messages of the program also will be written to the output-file MESSAGE.out.

The program is only protected against extreme incorrect input of parameter-values. On each input-parameter a check is performed. Labels are checked on their presence and input-parameters are checked on minimum and maximum values. The upper bound of dimensions of input-parameters is checked.

These checks are not executed for the unformatted (binary) files 'SWATRE.UNF' and 'WATBAL.UNF' because these values are results from other simulation-models. The ANIMO model will generate warning or error messages and may be interrupted if these binary files do not contain sound and accurate water balances. When a simulation is completed without fatal errors, the model produces the following message to the screen: ‘Successful completion of simulation'.

After execution, the model results can be analysed.

4 Case studies

The program is released with five cases. This chapter briefly discusses the input-files and presents the results and balances of these examples.

In the first case, the model ANIMO 4.0 is applied using data from a field experiment on non-grazed grassland on a sandy soil (Ruurlo) for only the carbon and nitrogen cycle. In the second case, the ANIMO model is applied using data from a field experiment on grazed grassland on a sandy soil (Cranendonck grassland) for the carbon, nitrogen and phosphorus cycle. In the third case, the ANIMO model is applied using data from a field experiment on forage maize on a sandy soil (Cranendonck maize) for only the carbon and nitrogen cycle. In the fourth case, the ANIMO model is applied using data from a STONE application. Grazed grassland on a dry sandy soil is taken for the nitrogen and phosphorus cycle. And in the fifth case, the ANIMO model is applied using data from a STONE application on grassland on a peat soil for the carbon, nitrogen and phosphorus cycle.

4.1 Ruurlo: non-grazed grassland on a sandy soil

Between 1980 and 1985, field research at an experimental farm in Ruurlo (field 16) aimed to quantify the influence of different application techniques on soil fertility, crop yields and nitrate leaching. The data sets have been utilized by Jansen (1991) to evaluate the performance of the ANIMO model within the framework of a comparison of six nitrate-leaching models. The main characteristics of the Ruurlo field plots are:

- soils are classified as loamy sand soils;
- different fertilization levels and application techniques (both injection and surface applications of manure);
- land use is grassland without grazing;
- high water holding capacity.

Manure-additions were given as 80 tons of cattle slurry per hectare per year and 400 kg artificial fertilizer per hectare per year.

In section 4.1.2 some results of the ANIMO model for this case are presented. In section 4.1.3 the water and mass balances are given as they should be produced by the model ANIMO 4.0.

8 input-files are required for a single application of the model (9 input-files are required when also the P-cycle is simulated). A summary of these input-files for which data are given in this chapter is given below:

1. input-file GENERAL.INP: simulation and output options (***Figure 10***),
2. input-file MATERIAL.INP: standard definitions of materials: reaction rates, substance contents (***Figure 11***),
3. input-file PLANT.INP: standard parameters for crop growth and crop uptake (***Figure 12***),
4. input-file SOIL.INP: Soil chemical and soil physical data (***Figure 13***),
5. input-file BOUNDARY.INP: boundary conditions (***Figure 14***),
6. input-file INITIAL.INP: initial conditions (***Figure 15***),
7. input-file MANAGEMENT.INP: data concerning additions and tillage to the soil system (***Figure 16***),
8. input-file SWATRE.UNF: water quantity input-data resulting from simulations with the SWAP model.

4.1.1 Input files

GENERAL.INP

```
Filename:  General.inp
Content:Input for Animo-version 4.0 (case Ruurlo Grass field 16)
------------------------------------------------------------------------
>simopt: -------------- simulation options -----------------------------
 2 0 0 0 0
        - Hydrological parameters were simulated with the model SWAP.
        - Only carbon and nitrogen cycle are simulated.
        - Aeration calculation in ANIMO
        - Crop uptake simulated by ANIMO
        - Simulation without macro pores
>simtim: -------------- simulation time --------------------------------
  1980   1.0 1985 120.0
        - 6 years are simulated: the period 1 1 1980 through 30 04 1985
>outscr: -------------- output to screen -------------------------------
 1      - Simulation-stage is written to screen as year and day number
>outbal: -------------- output of balances -----------------------------
 3      - 3 balance series
 RP     - The character string 'RP' is given
 1 1 1 0- Output of balances written to files BAWARP.OUT, BAOMRP.OUT,
 0  3     BANHRP.OUT, BANIRP.OUT and BANORP.OUT
 1      - Compartment 0 is the addition-reservoir on top of the model
 365.     soil system. The bottom of compartment 3 is at 0.25 meter
 GP       below the soil surface (root zone). The balances are made
 1 1 1 0  up for 0-0.25 meter below the soil surface.
 0 12   - Each simulated year one reset at the last day number of the
 -1       year (365 or 366 for a leap year); this reset includes
 TP       writing of balance-terms to files and initializing all
 1 1 1 0  balance terms at zero.
 0 16   - The character string 'GP' is given
 1      - Output of balances written to files BAWAGP.OUT, BAOMGP.OUT,
 365.     BANHGP.OUT, BANIGP.OUT and BANOGP.OUT.
        - Compartment 0 is the addition-reservoir on top of the model
          soil system. The bottom of compartment 12 is at 1.40 meter
          below the soil surface. The balances are made up for 0-1.40
          meter below the soil surface.
        - Each simulated time step balance terms are written
        - The character string 'TP' is given.
        - Output of balances written to files BAWATP.OUT, BAOMTP.OUT,
          BANHTP.OUT, BANITP.OUT and BANOTP.OUT.
        - Compartment 0 is the addition-reservoir on top of the model
          soil system. The bottom of compartment 16 is at 3.0 meter below
          the soil surface (defined by hydrological simulations)
          The balances are made up for 0-3.0 meter below the soil surface.
        - Each simulated year 1 reset at day number 365; this reset
          includes writing of balance-terms to files and initializing
          all balance terms at zero.
>outsel: -------------- output-selection -------------------------------
 1 1 0 0 0     0 0 1 0 0     0 0 0 0 0
 0 0 0 0 0     0 0 0 0 0     0 0 0 0 0     0 0 0 0 0     0 0
 1 1
        - The files Nitrate.out, Ammonium.out, Miner-n.out and Discharge.out
          are created and filled with simulation results.
        - The files Grass.out and Grass-yr.out are created and filled
          with simulation results. The detailed organic transformation files
          are created and filled with simulation results.
 >outtot: ------------ output of input, and output per time step ----
 0 3
 10 151 365
        - At the time steps 10, 151 and 365 detailed output is written
          to output-file AnimoIntermediate.OUT.
```

Figure 10 The input-file GENERAL.INP: data for example Ruurlo

MATERIAL.INP

For the composition of some materials in this case the following brief explanation is given.

Table 15 gives the relation between N-mineral, N-organic and N-total of the first 5 materials.

Table 15 Nitrogen composition of materials 1-5

Material nr.	N-content							
	N-mineral		N-organic			Org. matter		N-total
	(FRNH)		(NIFR*FR)	(NIFR*FR)	(NIFR*FR)	(FROR)		
1	0.00192	+	(0.07*0.116	+0.05*0.5	+0.01*0.384)	* 0.078	=	0.00480
2	0.002	+	(0.07*0.088	+0.05*0.5	+0.01*0.412)	* 0.085	=	0.00500
3	0.0024	+	(0.07*0.056	+0.05*0.5	+0.01*0.444)	* 0.084	=	0.00520
4	0.0018	+	(0.07*0.174	+0.05*0.5	+0.01*0.326)	* 0.089	=	0.00540
5	0.0013	+	(0.07*0.084	+0.05*0.5	+0.01*0.416)	* 0.077	=	0.00400

```
Filename:  MATERIAL.INP
Content:Input for ANIMO-version 4.0 (example Ruurlo)
-----------------------------------------------------------------------------

>defmat: ----------------- definition of materials -----------------------
 11
 0.078    0.085  0.084   0.089   0.077   0.0  1.0  1.0    1.0  1.0  1.0
 0.00192  0.002  0.0024  0.0018  0.0013  0.5  0.0  0.0    0.0  0.0  0.0
 0.0      0.0    0.0     0.0     0.0     0.5  0.0  0.001  0.0  0.0  0.002

- 11 materials are defined (5 different types of animal manure, 1 inorganic
  fertilizer, 2 different types of root material, 1 type of organic matter
  and 2 different type of shoot material.
- Fraction of organic matter in the materials 1 to NM (FROR):
   - Material 1-5: Lammers (1983) gives organic matter contents.
   - Material 6: Inorganic fertilizer is 100% inorganic.
   - Material 7-11: The material for roots and shoots should have a FROR
     to 1.0 (100% organic) because AMROTI is expressed as dry matter.
- Fraction of NH4-N in the materials 1 to NM (FRNH).
   - Material 1-5: Mineral nitrogen of manure is assumed to be 100% NH4-N.
     FRNH can be determined as: NH4-N = N-total - N-organic.
     The animal manure materials are divided into 3 organic fractions (FR)
     with each fraction having its own nitrogen content (NIFR).
     N-total and N-mineral have been based on data from Cranendonck and
     Lammers et al. (1983).
   - Material 6-11: See parameter FRNI.
- Fraction of NO3-N in the materials 1 to NM (FRNI).
   - Material 1-5: Animal manure contains no NO3-N
   - Material 6: Inorganic fertilizer, half NO3-N, half NH4-N.
   - Material 7-11: root material, organic matter in the subsoil and
     shoot materials are 100% organic.
  material nr 1  = cattle slurry 1st year
  material nr 2  = cattle slurry 2nd year
  material nr 3  = cattle slurry 3rd year
  material nr 4  = cattle slurry 4th year
  material nr 5  = cattle slurry 5th year
  material nr 6  = fertilizer
  material nr 7  = roots of non-grassland
  material nr 8  = roots of grassland
  material nr 9  = organic matter in the subsoil
  material nr 10 = shoots of non-grassland
  material nr 11 = shoots of grassland
```

```
>orgmat: ----------------- definition of organic fractions ---------------
 14
 0.116  0.5   0.384  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.088  0.5   0.412  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.056  0.5   0.444  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.174  0.5   0.326  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.084  0.5   0.416  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.9  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.9  0.1  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.8  0.2  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.8  0.2
 0.116  0.05  0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.088  0.05  0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.056  0.05  0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.174  0.05  0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.084  0.05  0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0   0.0    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.75

- The organic part of each material consists of fractions; each fraction
  has it own decomposition rate and its own nitrogen content.
- Based on a different decomposition rate one can distinguish different
  fractions in each material, each fraction having its specific decomposition
  rate and nitrogen content.
   - Material 1-5: Decomposition rates and nitrogen contents of three
     fractions were calibrated with measured lysimeter-data
     (Berghuijs-van Dijk et al., 1985).
   - Material 6: Inorganic fertilizer: 100% mineral.
   - Material 7-8: Calibrated with measured lysimeter-data
     (Berghuijs-van Dijk et al., 1985).
   - Material 9: No further division into fractions.
- Part of the fractions of the organic part of the materials that goes into
  solution.
   - Material 1-5:
      - Fraction 1: 100% dissolved organic matter.
      - Fraction 2: One part (0.5-0.05=0.45) is defined as fresh
        organic matter (OS) the rest (0.05) is defined as dissolved
        organic matter.
      - Fraction 3: 100% fresh organic matter.
   - Material 6-11: No dissolved parts.

The meaning of the organic fractions can be summarized as followed:
    organic fraction nr 1 = soluble, rapidly decomposing part of slurry
    organic fraction nr 2 = partly soluble, rapidly decomposing part of
    organic fraction nr 3 = solid, slowly decomposing part of slurry
    organic fraction nr 4 = rapidly decomposing part of non-grassland roots
    organic fraction nr 5 = slowly decomposing part of non-grassland roots
    organic fraction nr 6 = very slowly decomposing organic matter
    organic fraction nr 7 = not used
    organic fraction nr 8 = not used
    organic fraction nr 9 = rapidly decomposing part of grassland roots
    organic fraction nr 10= slowly decomposing part of grassland roots
    organic fraction nr 11= rapidly decomposing part of shoots non-grassland
    organic fraction nr 12= slowly decomposing part of shoots non-grassland
    organic fraction nr 13= rapidly decomposing part of grassland shoots
    organic fraction nr 14= slowly decomposing part of grassland shoots

- Humus fraction of the fresh organic matter does not pass the dissolved stage,
  but decomposes directly to humus. This value resulted from simulating
  lysimeter-experiments in which the behaviour of organic matter in solution
  was observed over a certain period of time.

>orgdec: ----------------- definition of rates --------------------------
 0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25
 0.25  0.25  0.25
 0.50
 1.0  0.60  0.12  2.0  0.22  0.00141 0.0005 0.0005 2.0  0.22  2.0  0.22  2.0  0.22
 30.0 0.02 365.0 100.0
 0.01
```

```
- Assimilation factor of 0.25 for all fractions (Berghuijs-van Dijk et al., 1985).
  This parameter indicates the fraction of the decomposable fresh organic matter
  or exudates that can be converted to humus/biomass.
- Assimilation efficiency of dissolved organic matter, humus/biomass and exudates
  all of 0.25.
- Reduction factor of 50% for microbiological transformations under oxygen limited
  situations.
- First order average decomposition rate for the organic fractions.
   - Fractions 1-3: Fractions used for material nr 1-5 (animal manure).
     Model-verification resulted in a calibration of the decomposition-rates
     for fraction 2 and 3 (fraction 1 has a dummy value since this fraction
     goes fully into solution).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6: Fraction used for organic material in subsoil.
     Decomposition rate was derived from rates given by Jenkinson and Rayne (1977)
     and calibrated with simulations of a region in the southern part of
     the Netherlands (Drent et al., 1988).
   - Fraction 7-8: Not used in this study.
   - Fraction 11-14: Fractions used for materials nr 10 and 11 (shoots).
- First order average decomposition rate for dissolved organic matter.
  Berghuijs-van Dijk et al. (1985) gives the value of 30, which was derived from
  lysimeter-experiments.
- First order average decomposition rate for humus.
  Berghuijs-van Dijk et al. (1985): a low rate for humus of 1.5-2.0% per year for
  net humus-decomposition in the long term.
- First order average decomposition rate for exudates.
  Berghuijs-van Dijk et al. (1985): a high rate of 365, because of rapid
  decomposition.
- First order average nitrification rate. Van Huet (1983) gives some values
  derived on a literature research. For sandy-loam column experiments resulted
  in a value of 365. Literature research (Hendriks, 1992) and application of
  the ANIMO model resulted in better results with a lower value of 100.
- First order average denitrification rate. A value of 0.01 is based on the
  following assumption: in 10 days no more than 50% of the present nitrate can
  be denitrified.

>orgnit: ----------------- definition of N-contents ----------------------
 0.07 0.05 0.01 0.01 0.01 0.01 0.0  0.0  0.02  0.01 0.025 0.015 0.01 0.005
 0.048  0.025

- Nitrogen fractions in organic matter.
   - Fraction 1-3: Fractions used for material nr 1-5 (animal manure).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
     An average value was used of nitrogen content of crop residues above
     soil surface and root material below soil surface.
   - Fraction 6: Fraction used for organic material in subsoil; nitrogen
     content derived from data given by Berghuijs-van Dijk et al. (1985).
     Berghuijs-van Dijk gives nitrogen fractions in various materials,
     division over fractions has to be estimated or calibrated.
     It seems likely that the large fractions have the highest nitrogen content.
   - Fraction 11-14: Fractions used for material nr 10 and 11 (shoots).
- Maximal nitrogen fraction in humus.
  Value as given by Berghuijs-van Dijk et al. (1985).
  It corresponds to a C/N ratio of 14 (the carbon content of the material has
  been assumed to 0.58). This value 0.048 is added to the nitrogen fraction in
  the root zone layers. Below the root zone the nitrogen fraction is calculated
  from the given C/N ratio * 0.58 (See Soil.inp).
- Nitrogen fraction in exudates.
  Value as given by Berghuijs-van Dijk et al. (1985).

Optional if aeration option Ioptae = 1 (See General.inp).

>sonicg: ----------------- definition of SONICG-concept variables --------
  0.3  0.01  0.9

- The nitrate-N concentration for which the MM-function takes a value half of
  the optimal value is 0.3
- Multiplication factor for org. transformations at complete anaerobic conditions
  is set to 0.01
- The critical value of water filled pore space for adjustment of original water
  response on organic transformation to lower values is set to 0.9
```
Figure 11 The input-file MATERIAL.INP: data for example Ruurlo

PLANT.INP

```
Filename:  PLANT.INP
Content:   Input for ANIMO-version 4.0 (example Ruurlo)
-----------------------------------------------------------------------------
>cropdt:---------- number of crops for which data are given --------------
 1

- One crop is defined in this file.

>crop01: --------------- crop nr 1: grassland ----------------------------
 6
 11  8
 100.  321.  130.0
 0.175 0.375 0.375 0.165 0.075
 0.321 0.35  2.30  0.65  0.60  182.00
 0.2   0.0   1.0
 0.019  0.05 0.0076  0.02
 2
 0. 366.
 0.3  0.3
 0.0055
 1.0  1.0  0.03  0.0028
 2

Data originate from literature and calibration on grassland data (Ruurlo).
- Crop number 6 (simulation with grassland requires crop number 6).
- Shoot material is 11 and root material is 8 for grassland
  (See input-file MATERIAL.INP).
- Number of data given for time of first day of growing season (e.g. 100.0),
  time of last day of growing season (e.g. 321.0) and time of start of
  grazing season, when AMSHMI_GRSTART has not been exceeded (e.g. 130.0).
- Minimum quantity of grass shoots required for grazing within the period
  (e.g. 0.175). Amount of shoots to be exceeded when harvesting will occur in
  a combined system of cutting and grazing (e.g. 0.375). Amount of shoots to be
  exceeded when harvesting will occur in a system of cutting only (e.g. 0.375).
  Amount of remaining shoots after a cutting event in a combined system of cutting
  and grazing (e.g. 0.165). Amount of remaining shoots after a cutting event in a
  combined system of cutting only (e.g. 0.075).
- Relative duration of sunshine (e.g. 0.321).
  Maximum shoot production is 0.35 kg m-2.
  Shoot production rate (e.g. 2.3).
  Efficiency factor for gross dry matter production in shoot system of grassland
  (e.g. 0.65).
  Weight fraction of grass shoots dry matter is 0.6.
  Day number where the maximum gross dry matter production is expected
  (related to light interception) is 182.0.
- Mass fraction of shoots lost by grazing (e.g. 0.2)
  and by harvesting (e.g. 0.0: no harvesting losses assumed).
  Reduction factor for grass production due to grazing by cattle (e.g. 1.0).
- Minimum and maximum nitrogen content of grass shoots (e.g. 0.019, 0.05).
  Minimum and maximum nitrogen content of grass roots (e.g. 0.0076, 0.02).
- Number of data given for the root length (NULNRO).
- Array with Julian day numbers versus length of roots.
- Turnover rate for dying of roots (e.g. 0.0055 d-1).
- Transpiration stream concentration factor for ammonium in grassland (e.g. 1.0),
  transpiration stream concentration factor for nitrate in grassland
  (convective: 1.0 and diffusive: 0.03) and transpiration stream concentration
  factor (nitrate in grassland) for diffusive counter flow (e.g. 0.0028).
- Switch for type of reduction relation with transpiration is applied is 2
  (Actual evapotranspiration flux) divided by (Potential transpiration flux)
```

Figure 12 The input-file PLANT.INP: data for example Ruurlo

SOIL.INP

```
Filename:  SOIL.INP
Content:Input for ANIMO-version 4.0 (example Ruurlo)
---------------------------------------------------------------------------

>profil: ----------------- horizons -------------------------------------
 6
 0.02 0.2
 0.2  0.25
 0.25

- Six soil horizons were distinguished.
- The thickness of the top of the soil compartment is set to 0.02 m;
  The thickness of the reservoir for additions to the soil system is set to 0.2 m.
- The fraction of runoff passing the surface reservoir is set to 0.2
  and for passing the first soil layer is set to 0.25.
- The depth of the initial root zone is 0.25 m.

>tempar: ----------------- temperature parameters-------------------------
 0.01726 0.05184
 9.5   9.0   3.7721

- Frequency of the early temperature wave; used in sine and Fourier model.
  Used in sine model: 2.0*3.14/365 = 0.01726.
  Thermal diffusivity; used in sine and Fourier model.
  Huet (1982) gives this value (0.05184 m2 d-1 = 0.006 cm2 sec-1).
- Amplitude of yearly temperature wave (9.5 oC).
  Average yearly temperature (9 oC) at soil surface. Used in sine model.
  Phase shift (3.7721 rad) of sine wave.

>sophy1: ----------------- soil physical parameters ----------------------
 2.0   2.5
 2.0   2.5
 2.0   2.5
 2.0   2.5
 2.0   2.5
 2.0   2.5
     0.18     0.18     0.18     0.18     0.18     0.18
  1250.0   1320.0   1660.0   1720.0   1720.0   1720.0
    14.0     14.0     35.0     60.0     60.0     60.0
 74826.0  74826.0  74826.0  74826.0  74826.0  74826.0
 74826.0  74826.0  74826.0  74826.0  74826.0  74826.0

- Parameters in calculation of diffusion coefficient for oxygen in the air filled
  part of soil for each horizon. Empirical constants dependent on the soil type.
  Some values are given by Hoeks (1983). More values can be found in Bakker et al.
  (1987). Data for the 'Staringreeks' soil schematisation are given in Groenendijk
  and Kroes (1999).
- Saturated conductivity of the root zone, for horizons 1 to 6 a value of
  0.18 m d-1. Same values as used in hydrological model SWAP.
- Dry bulk density for each horizon.
- C/N-ratio for each horizon. (C/N-ratio for the root zone are dummy’s,
  because the nitrogen fraction of humus for the root zone are set to the
  maximum nitrogen fraction of humus.)
- Coefficient temperature response for organic and dissolved organic
  transformations by Arrhenius per horizon.

>sochem: ----------------- soil chemical parameters ----------------------
  5.60      5.50      5.50      6.00      6.60      6.60
  0.000613  0.000454  0.000292  0.000291  0.000043  0.000004

- pH-H2O for each horizon.
  Values originate from PAGV (1985) where values were presented as measured pH-KCL.
  Conversion to pH-H2O was made with a conversion table (TNO, 1956).
- Values for the distribution coefficient for ammonium. The ratio between
  the amounts of NH4-N in the soil solution. Values are given for each horizon.
  Estimated values derived from Kroes et al. (1990).
```

Figure 13 The input-file SOIL.INP: data for example Ruurlo

BOUNDARY.INP

```
Filename:  BOUNDARY.INP
Content:Input for ANIMO-version 4.0 (example Ruurlo)
--------------------------------------------------------------------------

>optibc: ----------------- boundary options ------------------------------
 0  0

- Runon and irrigation concentration data are not given per time step

>topbou: ------------- top boundary conditions Nitrogen and Carbon -------
  0.002534  0.002534  0.002534  0.002534  0.002534   0.002534
  0.00084   0.00084   0.00084   0.00084   0.00084    0.00084
 18.0      18.0      18.0      18.0      18.0       18.0
 16.4      16.4      16.4      16.4      16.4       16.4
 0.0  0.0
 0.0  0.0
 0.0  0.0
 0.0  0.0

- For each year concentrations of NH4-N and NO3-N in the precipitation must be
  given. NH4-N: 0.002534 kg m-3 for each year; NO3-N: 0.00084 kg m-3 for each year.
- Atmospheric dry deposition of NH4-N of 18.0 kg ha-1 N for each year.
- Atmospheric dry deposition of NO3-N of 16.4 kg ha-1 N for each year.
- Concentrations of NH4-N and NO3-N in runon are set to 0.0.
- Concentration of dissolved organic matter and dissolved organic nitrogen
  in runon are set to 0.0. Not relevant for this field because runon does not
  occur in this example.
- Concentration of NH4-N and NO3-N in irrigation is set to 0.0.
- Concentration of dissolved organic matter and dissolved organic nitrogen in
  irrigation are set to 0.0.

>latbou: ----------------- lateral boundary conditions -------------------
 0.0  0.0
 0.0  0.0

- Concentration of NH4-N, NO3-N, dissolved organic matter and dissolved organic
  nitrogen in infiltrating drain water are set to 0.0.
  Not relevant for this field because infiltration does not occur in this case.

>botbou: ----------------- bottom boundary conditions --------------------
 0.0  0.0
 0.0  0.0

- Concentration of NH4-N, NO3-N, dissolved organic matter and dissolved organic
  nitrogen below model profile are assumed to be 0.0.
  Not relevant for this field, because seepage does not occur in this example.
```

Figure 14 The input-file BOUNDARY.INP: data for example Ruurlo

INITIAL.INP

```
Filename:  INITIAL.INP
Content:Input for ANIMO-version 4.0 (example Ruurlo)
--------------------------------------------------------------------------

>moistf: -------------------- moisture content ---------------------------
  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0

- Moisture fractions of the compartments 1 to NL at the beginning of a time step.
  In this case, dummy values of 0.0 have been used, because hydrology is
  simulated by Swap.

>ammoni: ------------------- ammonium concentration ----------------------
 0.0  0.0
 3.0E-03  1.8E-03  1.3E-03  8.0E-04  8.0E-04
 3.0E-04  3.0E-04  3.0E-04  3.0E-04  3.0E-04
 3.0E-04  3.0E-04  3.0E-04  3.0E-04  3.0E-04
 3.0E-04  3.0E-04  3.0E-04  3.0E-04  3.0E-04

- Concentrations of NH4-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>nitrat: ------------------- nitrate concentration -----------------------
 0.0  0.0
 1.0E-02  1.0E-02  1.0E-02  1.0E-02  2.0E-02
 2.0E-02  2.0E-02  2.0E-02  2.0E-02  2.0E-02
 5.0E-03  5.0E-03  1.0E-03  1.0E-03  1.0E-04
 1.0E-04  1.0E-04  1.0E-04  1.0E-04  1.0E-04

- Concentrations of NO3-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>orgexu: ------------------- exudates ------------------------------------
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

- Exudate content of compartments 1 to NL. The amount of exudates present has been
  estimated as 0.0 kg m-2. Low amounts of exudates and high decomposition rates
  make this acceptable.

>humexu: ------------------- humus from exudates -------------------------
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

- Amount of humus from exudates present in compartments 1 to NL. HUEX, HUOS and OS
  are the main organic components in the model ANIMO.
  OS is the fresh organic matter; HUEX and HUOS together form humus.
  OS decomposes with rates RECFAV (1-NF),
  HUEX and HUOS both decompose with the rate RECFHUAV.

>orgfsh:-------------------- fresh organic matter ------------------------
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.25 0.25 0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  0.5  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.35 0.35 0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

```
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

- Amount of fresh organic matter present in compartments 1 to NL for
  fractions 1 to NF.

>humorg: ------------------- humus from fresh organic matter -------------
  4.5    9.0    6.3   2.988  2.988   3.096  3.096  3.096  3.096   4.644
  6.192  3.784  3.784 3.784  3.784  18.92  18.92  18.92  18.92  397.32

- Amount of humus from fresh organic matter and dissolved organic matter
  present in compartments 1 to NL (see parameter HUEX).

>orgsol:-------------------- dissolved organic matter --------------------
  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

- Concentration of dissolved organic matter (including addition reservoir
  and LN=0).
  Concentration of dissolved organic nitrogen (including addition reservoir
  and LN=0).
  Dissolved organic matter was estimated to be nil. Therefore zeros are given
  for dissolved organic matter and dissolved organic nitrogen.

>orgpla: ----------- fresh organic matter and uptake by grassland --------
  2.5E-02  7.5E-02  2.0E-03

- Amount of roots, shoots and uptake are taken from Dutch field experiments.
```

Figure 15 The input-file INITIAL.INP: data for example Ruurlo

MANAGEMENT.INP

```
Filename:  MANAGEMENT.INP
Content:   Input for ANIMO-version 4.0
           Ruurlo, field 16 (80 ton/ha injection + 400kg/ha N)
-----------------------------------------------------------------------

>kicrop: ------------------- crop definitions ---------------------------
 6 6 6 6 6   6

- Kind of crop grown each year is grassland.
  Crops have been defined in the input-file PLANT.INP.

>lsunit: ------------------- number of livestock ------------------------
   0.0  0.0  0.0  0.0  0.0  0.0

- Number of livestock units per hectare per year.
  In this example the livestock unit is 0.0 (non-grazed grassland).

>matvar: ------------------- definition of materials ---------------------
 0

- Material composition is fixed and defined in the input-file MATERIAL.INP.

>add001:
  78.
 1
  1  80535.0  2  0 0.05
  84.

- At day number 78 (18-Mar-1980) the first addition takes place.
- One addition event at this day
- Number of the added material is 1. One of the materials (MN) defined in the file
  MATERIAL.INP. In this case, material 1 is cattle slurry first year.
  Quantity of material added is 80 535 kg ha-1.
  The cattle slurry is added to the first 2 compartments of the soil profile.
  No ploughing.
  In this case, 5% of the mineral part of the cattle slurry volatilizes.
- Time of next addition is day number 84 (24-Mar-1980).

>add002:
 1
  6    100.0  0  0 0.0
 128.

- One addition event at this day
- Number of the added material is 6 (inorganic N-fertilizer).
  Quantity of material added is 100 kg ha-1.
  The fertilizer is added to the reservoir on top of compartment 1.
  No ploughing.
  No volatilization of inorganic fertilizer is assumed.
- Time of next addition is day number 128 (07-May-1980).

>add003:
 1
  6     80.0  0  0 0.0
 150.

- and so on...

>add034:
1
6     40.  0  0  0.0
4000.
```

Figure 16 The input-file MANAGEMENT.INP: data for example Ruurlo

For each year, additions are made with a sequentially rising label number at the following years and day numbers:

1980				
1:	78	18-Mar	80 535 kg ha^{-1}	cattle slurry
2:	84	24-Mar	100 kg ha^{-1}	fertilizer
3:	128	7-May	80 kg ha^{-1}	fertilizer
4:	150	29-May	80 kg ha^{-1}	fertilizer
5:	177	25-Jun	60 kg ha^{-1}	fertilizer
6:	211	29-Jul	40 kg ha^{-1}	fertilizer
7:	232	19-Aug	40 kg ha^{-1}	fertilizer
8:	261	17-Sep	40 kg ha^{-1}	fertilizer
1981				
9:	471	15-Apr	77 854 kg ha^{-1}	cattle slurry
10:	472	16-Apr	100 kg ha^{-1}	fertilizer
11:	508	22-May	80 kg ha^{-1}	fertilizer
12:	536	19-Jun	80 kg ha^{-1}	fertilizer
13:	561	14-Jul	60 kg ha^{-1}	fertilizer
14:	583	5-Aug	40 kg ha^{-1}	fertilizer
15:	617	8-Sep	40 kg ha^{-1}	fertilizer
1982				
16:	822	1-Apr	78 027 kg ha^{-1}	cattle slurry
17:	827	6-Apr	100 kg ha^{-1}	fertilizer
18:	865	14-May	80 kg ha^{-1}	fertilizer
19:	884	2-Jun	80 kg ha^{-1}	fertilizer
20:	921	9-Jul	30 kg ha^{-1}	fertilizer
21:	954	11-Aug	40 kg ha^{-1}	fertilizer
1983				
22:	1206	20-Apr	81 780 kg ha^{-1}	cattle slurry
23:	1208	22-Apr	100 kg ha^{-1}	fertilizer
24:	1247	31-May	80 kg ha^{-1}	fertilizer
25:	1268	21-Jun	80 kg ha^{-1}	fertilizer
26:	1292	15-Jul	60 kg ha^{-1}	fertilizer
27:	1345	6-Sep	40 kg ha^{-1}	fertilizer
1984				
28:	1551	30-Mar	75 520 kg ha^{-1}	cattle slurry
29:	1554	2-Apr	100 kg ha^{-1}	fertilizer
30:	1605	23-May	80 kg ha^{-1}	fertilizer
31:	1627	14-Jun	80 kg ha^{-1}	fertilizer
32:	1654	11-Jul	60 kg ha^{-1}	fertilizer
33:	1683	9-Aug	40 kg ha^{-1}	fertilizer
34:	1723	18-Sep	40 kg ha^{-1}	fertilizer
---	4000	--------	----------	----------

(Last value for TINEAD (e.g. 4000) contains a dummy value which should be higher than the last simulated time step (e.g. 1947)).

4.1.2 Results

Case Ruurlo Field 16: non-grazed grassland on a sandy soil

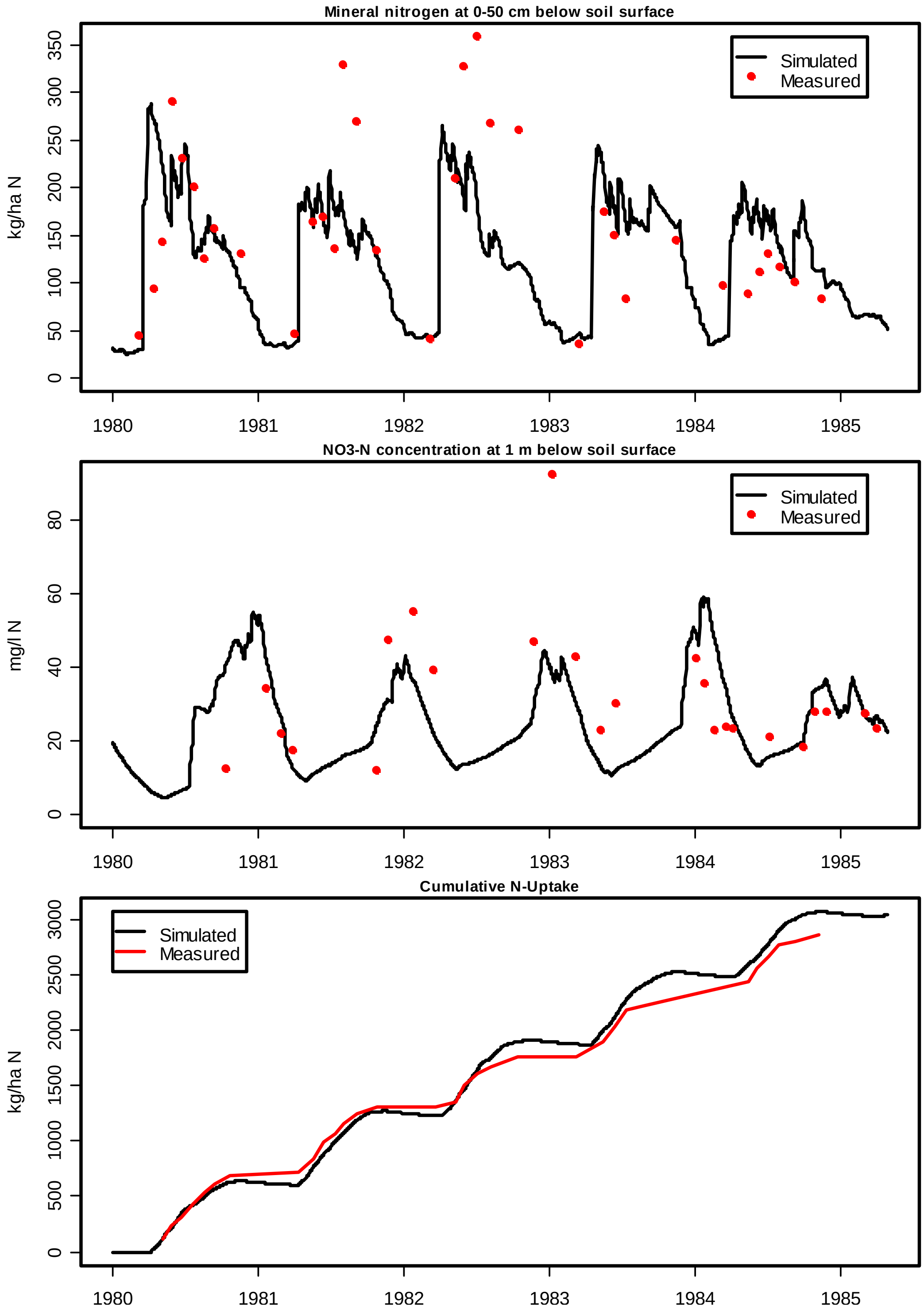

Figure 17 Measured and simulated mineral nitrogen content (a), NO_3-N concentration (b) and cumulative uptake of nitrogen by crop for permanent grassland (c)

4.1.3 Balances

This section presents the content of water, organic matter and nitrogen balances and detailed organic transformations of the Ruurlo case. The presentation of these balances is achieved with the following procedure:

- With output options in the input file GENERAL.INP the output files BAWA//.OUT, BAOM//.OUT, BANH//.OUT, BANI//.OUT and BANO//.OUT are created.
- Besides the BA* files, balance table files are created. With the output options in the input file GENERAL.INP, the balance table files Ani_wa//.out, Ani_om//.out and Ani_n//.out are created.
- Also with the output options in GENERAL.INP the output files transfom//.out and transfon//.out are created and de files grass.out and grass-yr.out.

At the position // a character string of 2 positions must be given to identify the set of the output files with mass balances, balance tables and organic transformations (see Chapter 3: input file GENERAL.INP).

Balances are created for each balance period.
This section gives only some balance table files and detailed organic transformations for the period 1-1-1984 to 31-12-1984.

Water, organic matter and nitrogen balances of the non-grazed grassland case (Case Ruurlo Field 16)

Soil profile RP: 0.00 - 0.25 m below soil surface

Output file Ani_waRP.bal:

```
Water balance (mm);   profile  top - 0.25m-ss;  period  365-1983/ 366-1984
==============================================================================
Input:                                   | Output:
==============================================================================
Rainfall                           743.9 | Interception                   30.7
Snowfall                             0.0 | Snow sublimation                0.0
Irrigation                           0.0 | Pond evaporation                0.0
                                         | Soil evaporation               25.1
                                         | Plant evaporation             406.8
Runon                                0.0 | Runoff_Pr                       4.0
Inundation                           0.0 | Runoff_L0                       0.7
                                         | Runoff_L1                       0.2
Infiltration from:                       | Drainage to:
- 3rd order                          0.0 | - 3rd order                     0.0
- 2nd order                          0.0 | - 2nd order                     0.0
- 1st order                          0.0 | - 1st order                     0.1
Bottom upw flux                    151.2 | Bottom downw flux             410.2
-----------------------------------------+------------------------------------
Total input                        895.1 | Total output                  877.9
==============================================================================
Storage change snow layer (+ = increase)                                   0.0
Storage change ponding layer (+ = increase)                                0.0
Storage change soil moisture (+ = increase)                               17.3
Balance deviation                                                          0.0
==============================================================================
```

Output file Ani_omRP.bal:

```
Org.matter (kg/ha);   profile  top - 0.25m-ss;  period  365-1983/ 366-1984
==============================================================================
Input:          Fresh    Hu/bio   Diss. | Output:     Fresh    Hu/bio    Diss.
==============================================================================
Additions      5035.8       0.0   779.2 |
Redistrib         0.0       0.0     0.0 | Redistrib      0.0       0.0     0.0
Crop res.     10070.0                   |
Exudates          0.0                   |
Formation                3857.4  2717.2 | Dissoc.    10868.8    4141.6  3136.5
Irrigation                          0.0 |
Runon                               0.0 | Runoff_L0                        0.0
Inundation                          0.0 |
                                        | Runoff_L1                        0.3
Infiltration from:                      | Discharge to:
- 3rd order                         0.0 | - 3rd order                      0.0
- 2nd order                         0.0 | - 2nd order                      0.0
- 1st order                         0.0 | - 1st order                      0.0
Bottom upw flux                    42.0 | Bottom downw flux              365.2
----------------------------------------+-------------------------------------
Total input   15105.8    3857.4  3538.4 | Tot outp   10868.8    4141.6  3502.1
==============================================================================
Dissimilated                                         6113.7    3106.2  2352.4
==============================================================================
Final.present                                       44503.5  196317.9    87.1
Init.present                                        40266.4  196602.1    50.7
                                                    --------------------------
Storage change                                       4237.0    -284.2    36.3
Input-Output                                         4237.0    -284.2    36.3
Balance deviation                                       0.0       0.0     0.0
==============================================================================
```

Output file Ani_nRP.bal:

```
Nitrogen   (kg/ha);   profile  top - 0.25m-ss;  period  365-1983/ 366-1984
==============================================================================
Input:           Org-N    Nh4-N   No3-N | Output:        Org-N   Nh4-N   No3-N
==============================================================================
Deposition dry             18.0    16.4 |
Deposition wet             18.9     6.2 |
Additions        203.8    298.2   200.0 | Volatilization           4.9
Redistrib          0.0      0.0     0.0 | Redistrib        0.0     0.0     0.0
Crop residues    112.0      0.0    36.2 | Crop uptake             89.8   605.1
Exudates           0.0                  |
Incorporation    185.2                  | Gross mineral.  465.8
Nett mineral.             280.6         | Immobilization           0.0
Nitrification                     508.8 | Nitrification          508.8
                                        | Denitrification                  9.1
Irrigation         0.0      0.0     0.0 | Runoff_Pr        0.0     0.1     0.0
Runon              0.0      0.0     0.0 | Runoff_L0        0.0     0.5     0.5
Inundation         0.0      0.0     0.0 |
                                        | Runoff_L1        0.0     0.1     0.4
Infiltration from:                      | Discharge to:
- 3rd order        0.0      0.0     0.0 | - 3rd order      0.0     0.0     0.0
- 2nd order        0.0      0.0     0.0 | - 2nd order      0.0     0.0     0.0
- 1st order        0.0      0.0     0.0 | - 1st order      0.0     0.0     0.0
Bottom upw flux    1.4      1.8    90.0 | Bot downw flux  10.6    13.6   232.3
--------------------------------------+---------------------------------------
Total input      502.3    617.5   857.6 | Total output   476.4   617.8   847.4
==============================================================================
Final.present solid/complex                                9993.4     5.5
Init.present solid/complex                                 9968.1     6.1
                                                         ---------------------
Storage change solid/complex (+ = increase)                  25.3    -0.6
==============================================================================
Final.present solution                                        1.7     4.0    36.6
Init.present solution                                         1.1     3.9    26.4
                                                         ---------------------
Storage change solution (+ = increase)                        0.7     0.2    10.2
==============================================================================
Input-Output                                                 26.0    -0.4    10.2
Balance deviation                                             0.0     0.0     0.0
==============================================================================
```

Soil profile TP: 0.00 - 3.00 m below soil surface

Output file Ani_waTP.bal:

```
Water balance (mm);   profile  top - 3.00m-ss;  period  365-1983/ 366-1984
==============================================================================
Input:                                   | Output:
==============================================================================
Rainfall                           743.9 | Interception                    30.7
Snowfall                             0.0 | Snow sublimation                 0.0
Irrigation                           0.0 | Pond evaporation                 0.0
                                         | Soil evaporation                25.1
                                         | Plant evaporation              406.8
Runon                                0.0 | Runoff_Pr                        4.0
Inundation                           0.0 | Runoff_L0                        0.7
                                         | Runoff_L1                        0.2
Infiltration from:                       | Drainage to:
- 3rd order                          0.0 | - 3rd order                      0.0
- 2nd order                          0.0 | - 2nd order                      0.0
- 1st order                          0.0 | - 1st order                     20.6
Bottom upw flux                      0.0 | Bottom downw flux              204.0
-----------------------------------------+------------------------------------
Total input                        743.9 | Total output                   692.2
==============================================================================
Storage change snow layer (+ = increase)                                    0.0
Storage change ponding layer (+ = increase)                                 0.0
Storage change soil moisture (+ = increase)                                51.7
Balance deviation                                                           0.0
==============================================================================
```

Output file Ani_omTP.bal:

```
Org.matter (kg/ha);   profile  top - 3.00m-ss;  period  365-1983/ 366-1984
==============================================================================
Input:          Fresh    Hu/bio   Diss. | Output:     Fresh    Hu/bio    Diss.
==============================================================================
Additions      5035.8       0.0   779.2 |
Redistrib         0.0       0.0     0.0 | Redistrib      0.0       0.0     0.0
Crop res.     10357.7                   |
Exudates          0.0                   |
Formation              5255.6  2760.5 | Dissoc.    11042.0    9223.2  3517.8
Irrigation                          0.0 |
Runon                               0.0 | Runoff_L0                        0.0
Inundation                          0.0 |
                                        | Runoff_L1                        0.3
Infiltration from:                      | Discharge to:
- 3rd order                         0.0 | - 3rd order                      0.0
- 2nd order                         0.0 | - 2nd order                      0.0
- 1st order                         0.0 | - 1st order                      1.1
Bottom upw flux                     0.0 | Bottom downw flux                1.3
----------------------------------------+-------------------------------------
Total input   15393.5    5255.6  3539.7 | Tot outp   11042.0    9223.2  3520.6
==============================================================================
Dissimilated                                           6211.1    6917.4  2638.4
==============================================================================
Final.present                                         45262.7  809028.5   115.7
Init.present                                          40911.2  812996.0    96.5
                                                     -------------------------
Storage change                                         4351.5   -3967.5    19.1
Input-Output                                           4351.5   -3967.6    19.1
Balance deviation                                         0.0      -0.1     0.0
==============================================================================
```

Output file Ani_nTP.bal:

```
Nitrogen   (kg/ha);   profile  top - 3.00m-ss;  period  365-1983/ 366-1984
=============================================================================
Input:           Org-N   Nh4-N   No3-N | Output:        Org-N   Nh4-N   No3-N
=============================================================================
Deposition dry            18.0    16.4 |
Deposition wet            18.9     6.2 |
Additions        203.8   298.2   200.0 | Volatilization           4.9
Redistrib          0.0     0.0     0.0 | Redistrib        0.0     0.0     0.0
Crop residues    115.2     0.0    37.2 | Crop uptake             89.8   605.1
Exudates           0.0                 |
Incorporation    201.1                 | Gross mineral.  533.9
Nett mineral.            332.8         | Immobilization           0.0
Nitrification                    571.9 | Nitrification          571.9
                                       | Denitrification                235.6
Irrigation         0.0     0.0     0.0 | Runoff_Pr        0.0     0.1     0.0
Runon              0.0     0.0     0.0 | Runoff_L0        0.0     0.5     0.5
Inundation         0.0     0.0     0.0 |
                                       | Runoff_L1        0.0     0.1     0.4
Infiltration from:                     | Discharge to:
- 3rd order        0.0     0.0     0.0 | - 3rd order      0.0     0.0     0.0
- 2nd order        0.0     0.0     0.0 | - 2nd order      0.0     0.0     0.0
- 1st order        0.0     0.0     0.0 | - 1st order      0.0     0.1     3.0
Bottom upw flux    0.0     0.0     0.0 | Bot downw flux   0.0     1.1     1.1
---------------------------------------+-------------------------------------
Total input      520.1   667.8   831.8 | Total output   534.0   668.6   845.7
=============================================================================
Final.present solid/complex                           16310.6     8.2
Init.present solid/complex                            16324.7     9.4
                                                     -----------------------
Storage change solid/complex (+ = increase)             -14.1    -1.2
=============================================================================
Final.present solution                                    2.2     8.7   200.5
Init.present solution                                     1.9     8.1   214.3
                                                     -----------------------
Storage change solution (+ = increase)                    0.3     0.5   -13.9
=============================================================================
Input-Output                                            -13.8    -0.7   -13.9
Balance deviation                                         0.0     0.0     0.0
=============================================================================
```

The output of transfomTP.out can be reflected as transformations between the different pools as shown in the picture underneath.

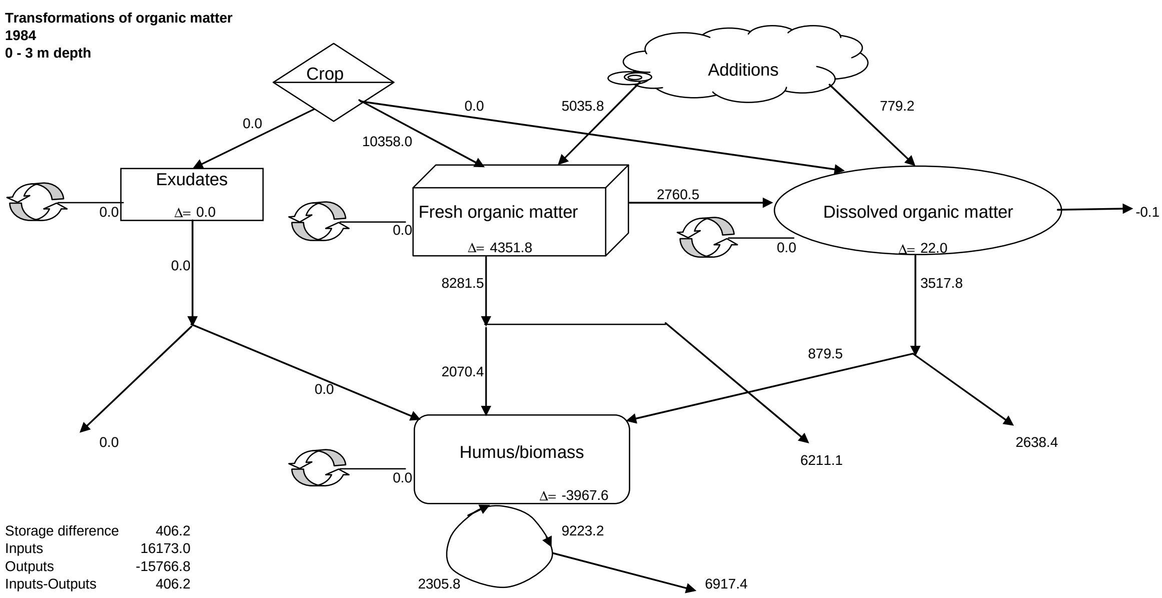

Figure 18 Reflection of the detailed organic transformations between the different organic pools.

In the files grass.out and grass-yr.out output of grass values are presented.
Below the output of the two files are described.

Output file Grass.out
For the first two time steps on overview is given.

```
*   Yr Tiyr  Tito    Amplsh  Rsamplsh    Amplro  Rsamplro    Frosgr    Frosha    Icroto      Icsh      Pdst
*            Tito      Upgr     Yield      Osgr      Osha   Osroto  Cum_icro  Cum_icsh Cum_yield  Cum_upgr
*            Tito  Cum_osha  Cum_osgr    Ni_act    Po_act    Conipl   Ev/etma  Cum_upni  Cum_uppo  Lightint
1 1980  1.0   1.0  7.50E-02  7.50E-02  2.50E-02  2.49E-02  2.00E-01  0.00E+00  0.00E+00  0.00E+00  0.00E+00
2             1.0  0.00E+00  0.00E+00  0.00E+00  0.00E+00  1.37E-04  0.00E+00  0.00E+00  0.00E+00  0.00E+00
3             1.0  0.00E+00  0.00E+00  2.00E-03  0.00E+00  1.33E-03  0.00E+00  0.00E+00  0.00E+00  3.89E-01
1 1980  2.0   2.0  7.50E-02  7.50E-02  2.49E-02  2.47E-02  2.00E-01  0.00E+00  0.00E+00  0.00E+00  0.00E+00
2             2.0  0.00E+00  0.00E+00  0.00E+00  0.00E+00  1.36E-04  0.00E+00  0.00E+00  0.00E+00  0.00E+00
3             2.0  0.00E+00  0.00E+00  2.00E-03  0.00E+00  1.33E-03  0.00E+00  0.00E+00  0.00E+00  3.89E-01
etc .... etc ....

where:
Yr        =  Year number
Tiyr      =  Time of end of timestep within the current year
Tito      =  Totalized time of end of the timestep
Amplsh    =  Amount of shoots at start of time step
Rsamplsh =  Amount of shoots at end of time step
Amplro    =  Amount of roots at start of time step
Rsamplro =  Amount of roots at end of time step
Frosgr    =  Mass fraction of shoots lost by grazing
Frosha    =  Mass fraction of shoots lost by harvesting
Icroto    =  Increase in amount of total living roots during timestep
Icsh      =  Increase in amount of shoots during a timestep
Pdst      =  Average standard crop production
Upgr      =  Amount of shoots being grazed
Yield     =  Yield
Osgr      =  Grazing losses to be added to layer 1
Osha      =  Harvest losses to be added to layer 1
Osroto    =  Root material available for decomposition to be added to organic matter pools
Cum_icro =  Cumulative increase of roots relative to day 1 of each year
Cum_icsh =  Cumulative increase of shoots relative to day 1 of each year
Cum_yield=  Cumulative yield relative to day 1 of each year
Cum_upgr =  Cumulative amount of shoots being grazed relative to day 1 of each year
Cum_osha =  Cumulative harvest losses relative to day 1 of each year
Cum_osgr =  Cumulative grazing losses relative to day 1 of each year
Ni_act    =  Actual amount of nitrogen in plant
Po_act    =  Actual amount of phosphate in plant
Conipl    =  NO3-N concentration in grass shoots
Ev/etma   =  Potential evapotranspiration flux devided by the actual evapotranspiration flux
Cum_upni =  Cumulative uptake of NO3-N relative to day 1 of each year
Cum_uppo =  Cumulative uptake of PO4-P relative to day 1 of each year
Lightint =  Relative light intensity
```

Output file Grass-yr.out

```
*   Yr  Cum_icsh  Cum_icro Cum_yield  Cum_osha  Cum_upgr  Cum_osgr  Cum_upni  Cum_uppo
1 1980  1.64E+00  1.09E+00  1.64E+00  0.00E+00  0.00E+00  0.00E+00  7.13E-02  0.00E+00
1 1981  1.64E+00  1.09E+00  1.64E+00  0.00E+00  0.00E+00  0.00E+00  7.77E-02  0.00E+00
1 1982  1.54E+00  1.03E+00  1.54E+00  0.00E+00  0.00E+00  0.00E+00  8.10E-02  0.00E+00
1 1983  1.49E+00  9.93E-01  1.49E+00  0.00E+00  0.00E+00  0.00E+00  7.80E-02  0.00E+00
1 1984  1.58E+00  1.05E+00  1.58E+00  0.00E+00  0.00E+00  0.00E+00  6.95E-02  0.00E+00
1 1985  1.12E-01  7.45E-02  0.00E+00  0.00E+00  0.00E+00  0.00E+00  2.04E-03  0.00E+00
where:
Cum_icsh =  Cumulative increase of shoots per year
Cum_icro =  Cumulative increase of roots per year
Cum_yield=  Cumulative yield per year
Cum_osha =  Cumulative harvest losses per year
Cum_upgr =  Cumulative amount of shoots being grazed per year
Cum_osgr =  Cumulative grazing losses per year
Cum_upni =  Cumulative uptake of NO3-N per year
Cum_uppo =  Cumulative uptake of PO4-P per year
```

4.2 Grazed grassland on a sandy soil

To obtain information on the effects of reduction in nitrogen and phosphate application to grassland soils used for dairy farming, experiments have been started in autumn 1996 on four experimental farms in the Netherlands. This section describes the input of the ANIMO model for one case of these experiments (Cranendonck Field 6; in the southern part of the Netherlands).
The experimental farm in Cranendonck is located on well-drained sandy soils. Six plots were established receiving different amounts of nitrogen and phosphate. The main characteristics of the Cranendonck plots are:

- soils are classified as sandy soils;
- different combination of fertilization levels for nitrogen and phosphorus;
- land use is grassland with grazing;
- medium water holding capacity.

The applied phosphate surplus of this case is amounted to 10 kg ha^{-1} a^{-1} P. This phosphate level is combined with a nitrogen surplus of 180 kg ha^{-1} a^{-1} N.

In section 4.2.2 some results of the ANIMO model for this example are presented.
In section 4.2.3 the water and mass balances are given as they should be produced by the model ANIMO 4.0.
For more detailed information about the model input see also section 4.1.

4.2.1 Input files

GENERAL.INP

```
Filename:  GENERAL.INP
Content:Input for ANIMO-version 4.0 (Case Cranendonck Grass Field 6)
---------------------------------------------------------------------------

>simopt: --------------- simulation options ------------------------------
 2 1 0 0 0

        - Hydrological parameters were simulated with the model SWAP.
        - The carbon, nitrogen and phosphorus cycle are simulated.
        - Aeration calculation in ANIMO
        - Crop uptake simulated by ANIMO
        - Simulation without macro pores


>simtim: --------------- simulation time ---------------------------------
 1992   0.0 1999 365.0

        - 8 years are simulated: the period 1 1 1992 through 31 12 1999.

>outscr: --------------- output to screen --------------------------------
 1      - Simulation-stage is written to screen as year and day number.

>outbal: --------------- output of balances ------------------------------
 2      - 2 balance series
 RP     - The character string 'RP' is given
 1 1 1 1- Output of balances written to files BAWARP.OUT, BAOMRP.OUT,
 0  6     BANHRP.OUT, BANIRP.OUT, BANORP.OUT, BAPPRP.OUT and BAPORP.OUT.
 1      - Compartment 0 is the addition-reservoir on top of the model soil
 365.     system. The bottom of compartment 6 is at 0.30 meter below the
 TP       soil surface (root zone). The balances are made up for
 1 1 1 1  0-0.30 meter below the soil surface.
 0 22   - Each simulated year one reset at the last day number of the
 1        year (365 or 366 for a leap year); this reset includes
 365.     writing of balance-terms to files and initializing all
          balance terms at zero.
        - The character string 'TP' is given.
        - Output of balances written to files BAWATP.OUT, BAOMTP.OUT,
          BANHTP.OUT, BANITP.OUT, BANOTP.OUT, BAPPTP.OUT and BAPOTP.OUT.
        - Compartment 0 is the addition-reservoir on top of the model soil
          system. The bottom of compartment 22 is at 3.60 meter below the
          soil surface (defined by hydrological simulations).
          The balances are made up for 0-3.60 meter below the soil surface.
        - Each simulated year 1 reset at the last day number of the year;
           this reset includes writing of balance-terms to files and initializing
           all balance terms at zero.
>outsel: --------------- output-selection --------------------------------
 1 1 0 1 1   0 0 0 0 0   0 0 0 0 0
 1 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 1
 0 1
        - The files NITRATE.OUT, AMMONIUM.OUT, PHOSPHAT.OUT, SOLU-POR.OUT
          and PW-P.OUT are created and filled with simulation results.
        - No output for grassland. The detailed organic transformation files
          are created an filed with simulation results.

>outtot: --------------- output of input, and output per time step -------
 0  1
 1000
        - At the time step 1000 detailed output is written to output-file
          AnimoIntermediate.out.
```

Figure 19 The input-file GENERAL.INP: data for example Cranendonck grass

MATERIAL.INP

```
Filename:   MATERIAL.INP
Content: Input for ANIMO-version 4.0 (Case Cranendonck Grass Field 6)
--------------------------------------------------------------------------

>defmat: --------------- definition of materials -------------------------
 14
 0.05   0.015  0.063   0.095  0.37   0.0  1.0  0.99  1.0  1.0  0.0  1.0  0.0  0.0
 0.0023 0.0021 0.00218 0.0063 0.0095 0.5  0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0
 0.0    0.0    0.0     0.0    0.0    0.5  0.0  0.01  0.0  0.0  0.0  0.0  0.0  0.0

- 14 materials are defined (5 different types of animal manure, 2 different types
  of inorganic fertilizers, 3 different types of root material, 1 type of organic
  matter and 3 types of shoot material).
- Fraction of organic matter in the materials 1 to NM (FROR).
   - Material 1-5: Lammers (1983) gives organic matter contents.
   - Material 6: Inorganic N-fertilizer is 100% inorganic.
   - Material 7: Roots of non-grassland contain no mineral part.
   - Material 8: A small part of grassland roots (1%) is added as mineral
     NO3-N. (reserved for dynamic simulations)
   - Material 9: Organic matter in the subsoil contains no mineral part.
   - Material 10: Shoots of grassland contain no mineral part.
     (reserved for dynamic simulations)
   - Material 11: Inorganic P-fertilizer is 100% inorganic.
   - Material 12: Shoots of grassland (input in management.inp)
   - Material 13: Shoots external crop
   - Material 14: Roots external crop
- Fraction of NH4-N in the materials 1 to NM (FRNH).
   - Material 1-5: Mineral nitrogen of manure is assumed to be 100% NH4-N.
   - Material 6-14: See parameter FRNI.
- Fraction of NO3-N in the materials 1 to NM (FRNI).
   - Material 1-5: Animal manure contains no NO3-N
   - Material 6: Inorganic fertilizer, half NO3-N, half NH4-N.
   - Material 7, 9, 10 and 12: root material of non-grassland, organic matter
     in the subsoil and shoot material of grassland are 100% organic.
   - Material 8: root material grassland contains 1% NO3-N.
   - Material 11: Inorganic fertilizer contains no NO3-N.
   - Material 13 and 14: Roots and shoots of external crops.
     Dummy values must be given.

  material nr  1 = cattle slurry;
  material nr  2 = calve slurry;
  material nr  3 = pig slurry;
  material nr  4 = poultry slurry;
  material nr  5 = dry poultry manure;
  material nr  6 = N-fertilizer;
  material nr  7 = roots of non-grassland;
  material nr  8 = roots of grassland (reserved for dynamic simulations)
  material nr  9 = organic matter in the subsoil
  material nr 10 = shoots of grassland  (reserved for dynamic simulations)
  material nr 11 = P-fertilizer
  material nr 12 = shoots of grassland (input in management.inp)
  material nr 13 = shoots external crop
  material nr 14 = roots external crop


>minpho: --------------- definition of mineral P -------------------------
0.000467 0.0005 0.00106 0.00304 0.00973 0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0

- Material nr 1-5: mineral phosphorus in cattle slurry.
- Material 6-10 and 12-14: contains no mineral phosphorus.
- Material 11: inorganic P-fertilizer contains 100% mineral phosphorus.

>orgmat: --------------- definition of organic fractions -----------------
 18
 0.1  0.7  0.2  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.8  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.8  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.8  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.4  0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.9  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.9  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.9  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.9  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.25 0.25 0.25 0.25 0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.25 0.25 0.25 0.25
 0.1  0.05 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.05 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.05 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.05 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.1  0.05 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

```
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.9

- The organic part of each material consists of fractions; each fraction has it own
  decomposition rate and its own nitrogen content.
- Based on a different decomposition rate one can distinguish different fraction in each
  material, each fraction having its specific decomposition rate and nitrogen content.
   - Material 1-5: Decomposition rates and nitrogen contents of three fractions were
     calibrated with measured lysimeter-data (Berghuijs-van Dijk et al., 1985).
   - Material 6: Inorganic N-fertilizer: 100% mineral.
   - Material 7, 8, 10 and 12: Calibrated with measured lysimeter-data
     (Berghuijs-van Dijk et al., 1985).
   - Material 9: No further division into fractions.
   - Material 11: Inorganic P-fertilizer: 100% mineral.
   - Material 13 and 14: Dummy values must be given to indicate which fraction decomposes
     where. In the subroutine Root_extern, the fractions will be determined dynamically.
- Part of the fractions of the organic part of the materials that goes into solution.
   - Material 1-5:
      - Fraction 1: 100% dissolved organic matter.
      - Fraction 2: One part (material nr 1: 0.7-0.05=0.65; material nr 2: 0.8-0.05=0.75;
        material nr 3=0.8-0.05=0.75; material nr 4=0.8-0.05=0.75; material nr 5=0.4-0.05=0.35)
        is defined as fresh organic matter (OS) the rest (0.05) is defined as dissolved
        organic matter.
      - Fraction 3: 100% fresh organic matter.
   - Material 6-14: No dissolved parts.

The meaning of the organic fractions can be summarized as followed:

  Org. fraction nr.  1 = soluble, rapidly decomposing part of slurry
  Org. fraction nr.  2 = partly soluble, rapidly decomposing part of slurry
  Org. fraction nr.  3 = solid, slowly decomposing part of slurry
  Org. fraction nr.  4 = rapidly decomposing part of non-grassland roots
  Org. fraction nr.  5 = slowly decomposing part of non-grassland roots
  Org. fraction nr.  6 = very slowly decomposing org. matter
  Org. fraction nr.  7 = rapidly decomposing part of grassland shoots
  Org. fraction nr.  8 = slowly decomposing part of grassland shoots
  Org. fraction nr.  9 = rapidly decomposing part of grassland roots
  Org. fraction nr. 10 = slowly decomposing part of grassland roots
  Org. fraction nr. 11 = dummy value for part of shoots external crop
  Org. fraction nr. 12 = dummy value for part of shoots external crop
  Org. fraction nr. 13 = dummy value for part of shoots external crop
  Org. fraction nr. 14 = dummy value for part of shoots external crop
  Org. fraction nr. 15 = dummy value for part of roots external crop
  Org. fraction nr. 16 = dummy value for part of roots external crop
  Org. fraction nr. 17 = dummy value for part of roots external crop
  Org. fraction nr. 18 = dummy value for part of roots external crop

- Humus fraction of the fresh organic matter does not pass the dissolved stage,
  but decomposes directly into humus.

>orgdec: --------------- definition of rates ----------------------------
 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
 0.25  0.25  0.25
 0.5
 1.0 0.6 0.12 2.0 0.22 0.00141 2.0 0.22 2.0 0.22 2.0 0.22 2.0 0.22  2.0 0.22 2.0 0.22
 30.0 0.02 365.0 365.0
 0.06

- Assimilation factor of 0.25 for all fractions (Berghuijs-van Dijk et al., 1985).
  This parameter indicates the fraction of the decomposable fresh organic matter or
  exudates that can be converted to humus/biomass.
- Assimilation efficiency of dissolved organic matter, humus/biomass and exudates
  all of 0.25.
- Reduction factor of 50% for microbiological transformations under oxygen limited
  situations.
- First order average decomposition rate for the organic fractions.
   - Fractions 1-3: Fractions used for material nr 1-5 (animal manure).
     Model-verification resulted in a calibration of the decomposition-rates for
     fraction 2 and 3 (fraction 1 has a dummy value since this fraction goes fully
     into solution).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6: Fraction used for organic material in subsoil. Decomposition rate
     was derived from rates given by Jenkinson and Rayne (1977) and calibrated with
     simulations of a region in the southern part of the Netherlands (Drent et al., 1988).
   - Fraction 7-8: Fractions used for material nr 10 and 12 (grassland shoots).
   - Fraction 11-18: Fractions used for material nr 13 and 14, external crop.
  First order average decomposition rate for dissolved organic matter.
  Berghuijs-van Dijk et al. (1985) gives the value of 30, which was derived from
  lysimeter-experiments.
```

```
  First order average decomposition rate for humus. Berghuijs-van Dijk et al. (1985):
  a low rate for humus of 1.5-2.0% per year for net humus-decomposition in the long term.
  First order average decomposition rate for exudates. Berghuijs-van Dijk et al. (1985):
  a high rate of 365, because of rapid decomposition.
  First order average nitrification rate. In this example, an average nitrification rate
  of 365 a-1 has been used.
- First order average denitrification rate. A value of 0.06 is based on the following
  assumption: in 10 days no more than 50% of the present nitrate can be denitrified.

>orgnit: --------------- definition of N-contents ------------------------
 0.07 0.05 0.01 0.01 0.01 0.015 0.01 0.005 0.05 0.019 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.048 0.025

- Nitrogen fractions in organic matter.
   - Fraction 1-3: Fractions used for material nr 1-5 (animal manure).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
     An average value was used of nitrogen content of crop residues above soil surface
     and root material below soil surface.
   - Fraction 6: Fraction used for organic material in subsoil. Nitrogen content derived
     from data given by Berghuijs-van Dijk et al. (1985). Berghuijs-van Dijk gives nitrogen
     fractions in various materials, division over fractions has to be estimated or
     calibrated. It seems likely that the large fractions have the highest nitrogen content.
   - Fraction 7-8: Fractions used for material nr 10 and 12 (shoots grassland).
   - Fraction 11-18: Fractions used for material nr 13 and 14, external crop.
- Maximal nitrogen fraction in humus. Value as given by Berghuijs-van Dijk et al. (1985).
  It corresponds to a C/N ratio of 14 (the carbon content of the material has been assumed
  to 0.58). This value 0.048 is added to the nitrogen fraction in the root zone layers.
  Below the root zone the nitrogen fraction is calculated from the given C/N ratio * 0.58
  (See Soil.inp).
- Nitrogen fraction in exudates. Value as given by Berghuijs-van Dijk et al. (1985).

>orgpho: --------------- definition of organic P fractions ---------------
 0.007 0.005 0.001 0.001 0.001 0.0015 0.004 0.002 0.005 0.0019 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.006 0.0025

- Phosphorus fractions in organic matter. Derived from literature.
  Related to nitrogen fractions (1:10).
- Maximal phosphorus fraction in humus. Derived from literature. Related to NIFRHUMA (1:8).
- Phosphorus fraction in exudates; like POFR related to organic-N (1:10).

>sonicg: --------------- definition of SONICG-concept variables ----------
 0.3  0.01  0.90

- The nitrate-N concentration for which the MM-function takes a value half of
  the optimal value is 0.3
- Multiplication factor for org. transformations at complete anaerobic conditions
  is set to 0.01
- The critical value of water filled pore space for adjustment of original water
  response on organic transformation to lower values is set to 0.9
```

Figure 20 The input-file MATERIAL.INP: data for example Cranendonck grass

PLANT.INP

```
Filename:  PLANT.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck grass)
---------------------------------------------------------------------------

>cropdt:---------- number of crops for which data are given --------------
 1

- One crop is defined in this file.

>crop01: ----------------- crop nr 1: grassland ---------------------------
 6
 10  8
 100.  321.  130.0
 0.175 0.375 0.375 0.165 0.075
 0.321 0.35  2.30  0.65  0.60  182.00
 0.2   0.05  1.0
 0.019  0.05 0.0076  0.02
 2
 0. 366.
 0.3  0.3
 0.0055
 1.0  1.0  0.028  0.0028
 0.003068 0.00543 0.001786 0.003163
 5.0
 2

Data originate from literature and calibration on grassland data (Ruurlo).
- Crop number 6 (simulation with grassland requires crop number 6).
- Shoot material is 10 and root material is 8 for grassland
  (see input-file MATERIAL.INP).
- Number of data given for time of first day of growing season (e.g. 100.0),
  time of last day of growing season (e.g. 321.0) and time of start of
  grazing season, when AMSHMI_GRSTART has not been exceeded (e.g. 130.0).
- Minimum quantity of grass shoots required for grazing within the period
  (e.g. 0.175). Amount of shoots to be exceeded when harvesting will occur in
  a combined system of cutting and grazing (e.g. 0.375). Amount of shoots to be
  exceeded when harvesting will occur in a system of cutting only (e.g. 0.375).
  Amount of remaining shoots after a cutting event in a combined system of cutting
  and grazing (e.g. 0.165). Amount of remaining shoots after a cutting event in a
  combined system of cutting only (e.g. 0.075).
- Relative duration of sunshine (e.g. 0.321).
  Maximum shoot production is 0.35 kg m-2.
  Shoot production rate (e.g. 2.3).
  Efficiency factor for gross dry matter production in shoot system of grassland
  (e.g. 0.65).
  Weight fraction of grass shoots dry matter is 0.6.
  Day number where the maximum gross dry matter production is expected
  (related to light interception) is 182.0.
- Mass fraction of shoots lost by grazing (e.g. 0.2) and by harvesting (e.g. 0.05).
  Reduction factor for grass production due to grazing by cattle (e.g. 1.0).
- Minimum and maximum nitrogen content of grass shoots (e.g. 0.019, 0.05).
  Minimum and maximum nitrogen content of grass roots (e.g. 0.0076, 0.02).
- Number of data given for the root length (NULNRO).
- Array with Julian day numbers versus length of roots.
- Turnover rate for dying of roots (e.g. 0.0055 d-1).
- Transpiration stream concentration factor for ammonium in grassland (e.g. 1.0),
  transpiration stream concentration factor for nitrate in grassland
  (convective: 1.0 and diffusive: 0.028) and transpiration stream concentration
  factor (nitrate in grassland) for diffusive counter flow (e.g. 0.0028).
- Minimum and maximum phosphorus content of grass shoots
  (e.g. 0.003068 and 0.00542)
- Minimum and maximum phosphorus content of grass roots
  (e.g. 0.001786 and 0.003163)
- Transpiration stream concentration factor for phosphate in grassland (e.g. 5.0).
- Switch for type of reduction relation with transpiration is applied is 2
  (Actual evapotranspiration flux) divided by (Potential transpiration flux)
```

Figure 21 The input-file PLANT.INP: data for example Cranendonck grass

SOIL.INP

```
Filename:  SOIL.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck grass)
--------------------------------------------------------------------------

>profil: ----------------- horizons -------------------------------------
 5
 0.02 0.2
 0.2  0.25
 0.30

- Five soil horizons were distinguished.
- The thickness of the top of the soil compartment is set to 0.02 m;
  the thickness of the reservoir for additions to the soil system is set to 0.2 m.
- The fraction of runoff passing the surface reservoir is set to 0.2
  and for passing the first soil layer is set to 0.25.
- The depth of the initial root zone is 0.30 m.

>tempar: ----------------- temperature parameters-------------------------
 0.01726 0.05184
 10.0  11.0  3.7721

- Frequency of the early temperature wave; used in sine and Fourier model.
  Used in sine model: 2.0*3.14/365 = 0.01726.
  Thermal diffusivity; used in sine and Fourier model.
  Huet (1982) gives this value (0.05184 m2 d-1 = 0.006 cm2 sec-1).
- Amplitude of yearly temperature wave (10 oC).
  Average yearly temperature (11 oC) at soil surface. Used in sine model.
  Phase shift (3.7721 rad) of sine wave.

>sophy1: ----------------- soil physical parameters ----------------------
 2.5   3.0
 2.5   3.0
 2.5   3.0
 2.5   3.0
 2.5   3.0
     0.322    0.322    0.322    0.322    0.531
  1281.0   1448.0   1399.0   1500.0   1600.0
    12.0     12.0     12.0     15.0     20.0
 74826.0  74826.0  74826.0  74826.0  74826.0
 74826.0  74826.0  74826.0  74826.0  74826.0

- Parameters in calculation of diffusion coefficient for oxygen in the air filled
  part of soil for each horizon. Empirical constants dependent on the soil type.
  Some values are given by Hoeks (1983). More values can be found in Bakker et al.
  (1987). Data for the 'Staringreeks' soil schematisation are given in Groenendijk
  and Kroes (1999).
- Saturated conductivity of the root zone, for horizons 1 to 5.
- Dry bulk density for each horizon.
- C/N-ratio for each horizon. (C/N-ratio for the root zone are dummy’s,
  because the nitrogen fraction of humus for the root zone are set to the
  maximum nitrogen fraction of humus.)
- Coefficient temperature response for organic and dissolved organic
  transformations by Arrhenius per horizon.

>sochem: ----------------- soil chemical parameters ----------------------
  5.90    5.90    5.90    5.90    5.90
  0.0003  0.0002  0.0002  0.0002  0.0002

- pH-H2O for each horizon.
  Values originate from PAGV (1985) where values were presented as measured pH-KCL.
  Conversion to pH-H2O was made with a conversion table (TNO, 1956).
- Values for the distribution coefficient for ammonium. The ratio between the
  amounts of NH4-N in the soil solution. Values are given for each horizon.
  Estimated values derived from Kroes et al. (1990).

>soalfe: ----------------- soil chemical parameters for phosphorus -------
  2
  46.0  40.0  48.0  38.0  17.0
  32.2  30.6  35.3  34.0  15.0

- Al and Fe are given separate per horizon.
- For each horizon an estimate for the Al-content is given.
- For each horizon an estimate for the Fe-content is given.
```

Figure 22 The input-file SOIL.INP: data for example Cranendonck grass

CHEMPAR.INP

```
Filename:  CHEMPAR.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck grass)
-------------------------------------------------------------------------

>chedef: ----------------- definition of chemical system -----------------
 2   ! optcxfa: langmuir
 1   ! ncxfa:   1 equilibrium sorption site
 3   ! optcxsl: freundlich
 3   ! ncxsl:   3 non equilibrium sorption sites
 0   ! optpr:   instantaneous

- Option of equilibrium sorption: Langmuir.
- Number of sites for equilibrium sorption: 1.
- Option for non equilibrium sorption: Freundlich.
- Number of sites for non equilibrium sorption: 3.
- Option for precipitation model: Instantaneous.

>chesor: ----------------- sorption variables ---------------------------
  1                                 ! optcxho: sorption parameters for whole pofile
 0.0  2.9078e-6  768.38  0.0  0.0   ! pacxfaho (1-5,1,1)
 0.30                               ! parkd(1)
 0.0     0.0  0.0 11.874e-6  0.5357 ! pacxslho (1-5,1,1)
 1.1755  0.0                        ! recfadsho(1,1),recfdesho(1,1)
 0.0     0.0  0.0  4.667e-6  0.1995 ! pacxslho (1-5,2,1)
 0.0334  0.0                        ! recfadsho(2,1),recfdesho(2,1)
 0.0     0.0  0.0  9.711e-6  0.2604 ! pacxslho (1-5,3,1)
 0.00144 0.0                        ! recfadsho(3,1),recfdesho(3,1)

- Option for input of sorption parameters per horizon:
  the parameters PACXFAHO - RECFDESHO are given for whole soil profile.
- In this example the following parameters for each equilibrium sorption site
  were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]: dummy value
     Langmuir maximum sorption amount   = 2.9078E-6 [kg m-3]
     Langmuir sorption coefficient = 768.38 [m3 kg-1]
     Freundlich sorption constant     = 0.0 [-]: dummy value
     Freundlich sorption exponent     = 0.0 [-]: dummy value
- Langmuir desorption coefficient     = 0.30 [d-1]
- In this example the following parameters for the first non equilibrium sorption
  site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount   = 0.0 [kg m-3]
     Langmuir sorption coefficient = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 11.874E-6 [-]
     Freundlich sorption exponent     = 0.5357 [-]
   - First order rate constant of adsorption for the first
     non equilibrium sorption site = 1.1755 [d-1]
     First order rate constant of desorption for the first
     non equilibrium sorption site = 0.0 [d-1]
- In this example the following parameters for the second non equilibrium sorption
  site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount   = 0.0 [kg m-3]
     Langmuir sorption coefficient = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 4.667E-6 [-]
     Freundlich sorption exponent     = 0.1995 [-]
   - First order rate constant of adsorption for the second
     non equilibrium sorption site = 0.0334 [d-1]
     First order rate constant of desorption for the second
     non equilibrium sorption site = 0.0 [d-1]
- In this example the following parameters for the third non equilibrium sorption
  site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount   = 0.0 [kg m-3]
     Langmuir sorption coefficient = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 9.711E-6 [-]
     Freundlich sorption exponent     = 0.2604 [-]
   - First order rate constant of adsorption for the third
     non equilibrium sorption site = 0.00144 [d-1]
     First order rate constant of desorption for the third
     non equilibrium sorption site = 0.0 [d-1]
```

```
>chepre: ----------------- precipitation variables -----------------------
 0.01                               ! recfpr

- First order rate constant for kinetic precipitation: 0.01 [d-1]

>chebuf: ----------------- precipitation variables for phosphate ---------
 1                                  ! optcobuho: cobuho for whole profile
 0.05                               ! cobuho(1)

- Option for input of buffer concentration:
  variable COBUHO is given for whole soil profile.
- Buffer concentration for phosphorus in solution: 0.05 [kg m-3]

Data were derived by Schoumans (1995).
```

Figure 23 The input-file CHEMPAR.INP: data for example Cranendonck grass

BOUNDARY.INP

```
Filename:  BOUNDARY.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck grass)
--------------------------------------------------------------------------

>optibc: ----------------- boundary options ------------------------------
 0  0

- Runon and irrigation concentration data are not given per time step

>topbou: ------ top boundary conditions Nitrogen,Phosphorus and Carbon ---
  0.00127   0.00127   0.00127   0.00127   0.00127   0.00127   0.001270  0.00127
  0.00078   0.00078   0.00078   0.00078   0.00078   0.00078   0.000780  0.00078
  0.000122  0.000122  0.000122  0.000122  0.000122  0.000122  0.000122  0.000122
 12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0
  8.0       8.0       8.0       8.0       8.0       8.0       8.0       8.0
 0.0  0.0
 0.0
 0.0  0.0
 0.0
 0.0  0.0
 0.0
 0.0  0.0
 0.0

- Concentrations of precipitation of NH4-N: 0.00127 kg m-3 for each year
- Concentrations of precipitation of NO3-N: 0.00078 kg m-3 for each year
- Concentrations of precipitation of PO4-P: 0.000122 kg m-3 for each year.
- Atmospheric dry deposition of NH4-N: 12.0 kg ha-1 N for each year.
- Atmospheric dry deposition of NO3-N: 8.0 kg ha-1 N for each year.
- Concentrations of NH4-N, NO3-N and PO4-P in runon are set to 0.0.
- Concentration of dissolved organic matter, dissolved organic nitrogen
  and dissolved organic phosphorus in runon are set to 0.0.
  Not relevant for this field because runon does not occur in this case.
- Concentration of NH4-N, NO3-N and PO4-P in irrigation is set to 0.0.
- Concentration of dissolved organic matter, dissolved organic nitrogen
  and dissolved organic phosphorus in irrigation are set to 0.0.

>latbou: ----------------- lateral boundary conditions -------------------
 5.0e-4  1.0e-5
 5.0e-7
 5.0e-5  1.0e-6
 5.0e-7

- Concentration of infiltrating drain water:
   - NH4-N: 0.5    mg.l-1
     NO3-N: 0.01   mg.l-1
   - PO4-P: 0.0005 mg.l-1
   - DOM  : 0.05   mg.l-1
     DON  : 0.001  mg.l-1
   - DOP  : 0.0005 mg.l-1

>botbou: ----------------- bottom boundary conditions --------------------
 2.5e-4  5.0e-6
 1.0e-5
 2.5e-5  5.0e-7
 5.0e-7

- Concentration of incoming seepage water across lower boundary:
   - NH4-N: 0.25   mg.l-1
     NO3-N: 0.005  mg.l-1
   - PO4-P: 0.01   mg.l-1
   - DOM  : 0.025  mg.l-1
     DON  : 0.0005 mg.l-1
   - DOP  : 0.0005 mg.l-1
```

Figure 24 The input-file BOUNDARY.INP: data for example Cranendonck grass

INITIAL.INP

```
Filename:  INITIAL.INP
Content:Input for ANIMO-version 4.0 (case Cranendonck grass)
--------------------------------------------------------------------------

>moistf: ------------------- moisture content ----------------------------
 0.305 0.305 0.308 0.308 0.316     0.316 0.327 0.344 0.364 0.386
 0.410 0.358 0.360 0.360 0.360     0.360 0.360 0.360 0.360 0.360
 0.360 0.360

- Moisture fractions of the compartments 1 to NL at the beginning of a time step.
  In this case, dummy values of 0.0 have been used, because hydrology is
  simulated by Swap.

>ammoni: ------------------- ammonium concentration ----------------------
 0.0 0.0
 3.0836998E-03  3.0836998E-03  1.4595365E-03  1.4595365E-03  7.4032356E-04
 7.4032356E-04  2.3822261E-04  1.2175296E-04  1.0375012E-04  9.5985095E-05
 9.0205722E-05  1.7915890E-04  2.8267442E-04  3.0E-04        3.0E-04
 2.0E-03        6.0E-03        9.0E-03        6.0E-03        1.5E-03
 3.0E-04        3.0E-04

- Concentrations of NH4-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>nitrat: ------------------- nitrate concentration -----------------------
 0.0 0.0
 1.9892645E-03  1.9892645E-03  1.0710537E-02  1.0710537E-02  2.1456176E-02
 2.1456176E-02  4.7881104E-02  9.1812938E-02  0.1362179      0.1579066
 0.1488567      0.1200135      9.4767593E-02  8.0E-02        7.0E-02
 6.0E-02        3.0E-02        4.0E-03        1.0E-04        4.0E-07
 3.0E-07        3.0E-07

- Concentrations of NO3-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>orgexu: ------------------- exudates ------------------------------------
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Exudate content of compartments 1 to NL. The amount of exudates present has been
  estimated as 0.0 kg m-2. Low amounts of exudates and high decomposition rates
  make this acceptable.

>humexu: ------------------- humus from exudates -------------------------
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Amount of humus from exudates present in compartments 1 to NL. HUEX, HUOS and OS
  are the main organic components in the model ANIMO.
  OS is the fresh organic matter; HUEX and HUOS together form humus.
  OS decomposes with rates RECFAV (1-NF),
  HUEX and HUOS both decompose with the rate RECFHUAV.

>orgfsh:-------------------- fresh organic matter ------------------------
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 1.4550E-01 1.4550E-01   0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 1.4550E-01 1.4550E-01   0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 1.4800E-01 1.4800E-01   0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 1.4800E-01 1.4800E-01   0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 1.0575E-01 1.0575E-01   0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 1.0575E-01 1.0575E-01   0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0        0.0          0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
```

```
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0       0.0         0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0       0.0         0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0       0.0         0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0 0.0       0.0         0.0 0.0 0.0 0.0 0.0   0.0 0.0 0.0

- Amount of fresh organic matter present in compartments 1 to NL for
  fractions 1 to NF.

>humorg: ------------------- humus from fresh organic matter -------------
 2.619 2.619 2.664 2.664 1.9035     1.9035 1.31  1.30  1.30 1.31
 1.33  0.29  0.29  0.58  0.65       0.815  1.425 1.425 3.25 3.25
 3.25  3.25

- Amount of humus from fresh organic matter and dissolved organic matter
  present in compartments 1 to NL (see parameter HUEX).

>orgsol:-------------------- dissolved organic matter --------------------
 0.0 0.0
 6.1087189E-09  2.7264485E-02  2.7264485E-02  3.4121379E-02  3.4121379E-02
 1.8927777E-02  9.6078617E-03  4.8159165E-03  2.2455119E-03  8.8303263E-04
 2.7986223E-04  8.1390965E-05  2.0E-05        4.0E-06        4.0E-07
 2.0E-07        1.5E-05        2.0E-04        6.0E-05        3.0E-05
 3.0E-05        3.0E-05
 0.0 0.0
 1.0221617E-10  4.5442651E-04  4.5442651E-04  6.1559869E-04  6.1559869E-04
 3.4538159E-04  1.7672553E-04  8.9544876E-05  4.2257045E-05  1.6800877E-05
 5.3737508E-06  1.5741523E-06  4.0E-07        7.0E-08        7.0E-09
 2.0E-09        1.0E-07        2.0E-06        7.0E-07        5.0E-07
 5.0E-07        5.0E-07

- Concentration of dissolved organic matter (including addition reservoir
  and LN=0).
  Concentration of dissolved organic nitrogen (including addition reservoir
  and LN=0).

>orgpla: ----------- fresh organic matter and uptake by grassland --------
 0.3800902  7.5E-02  4.2645028E-03
 7.5E-04

- Amount of shoots, roots, initial nitrogen uptake and
  initial phosphorus uptake are taken from Dutch field experiments.

>inipho:
 1
 0.0 0.0
 1.25E-03 1.25E-03 7.28E-04 7.28E-04 3.88E-04
 3.88E-04 3.18E-04 6.99E-05 6.99E-05 9.45E-05
 9.45E-05 1.77E-04 1.77E-04 1.77E-04 1.77E-04
 1.77E-04 1.77E-04 1.77E-04 1.77E-04 1.77E-04
 1.77E-04 1.77E-04
 0.0
 0.142707 0.142707 0.106633 0.121558 7.78E-02
 0.072124 6.17E-02 1.60E-02 1.60E-02 2.12E-02
 0.010079 1.78E-02 1.78E-02 1.78E-02 1.78E-02
 1.78E-02 1.78E-02 1.78E-02 1.78E-02 1.78E-02
 1.78E-02 1.78E-02
 0.0
 0.033126 0.033126 0.025305 0.028847 0.020592
 0.019083 0.017154 0.007619 0.007619 0.008955
 0.004245 0.005942 0.005942 0.005942 0.005942
 0.005942 0.005942 0.005942 0.005942 0.005942
 0.005942 0.005942
 0.0
 0.123205 0.123205 0.112877 0.128675 0.113494
 0.105180 0.101087 0.074720 0.074720 0.079352
 0.037619 0.042636 0.042636 0.042636 0.042636
 0.042636 0.042636 0.042636 0.042636 0.042636
 0.042636 0.042636
 0.0
 0.170630 0.170630 0.151264 0.172435 0.146372
 0.135650 0.128801 0.086814 0.086814 0.093905
 0.044518 0.052421 0.052421 0.052421 0.052421
 0.052421 0.052421 0.052421 0.052421 0.052421
 0.052421 0.052421
 0.0
 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0
```

```
 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 1.5507276E-11  0.0
 6.9092785E-05  6.9092785E-05  8.9312154E-05  8.9312154E-05  4.9801449E-05
 4.9801449E-05  2.5396716E-05  1.2810544E-05  6.0132456E-06  2.3787638E-06
 7.5758993E-07  2.2117194E-07  5.3536674E-08  1.0435065E-08  8.8052182E-10
 8.7356913E-11  5.8018262E-10  1.2189669E-07  4.3295591E-07  4.9606183E-07
 5.0E-07        5.0E-07

- INPO = 1: variables COPO, AMCXFA, AMCXSL and AMPOPR are given.
- Concentration of phosphorus in liquid phase in the top layer and
  compartments 0 to NL.
- Adsorbed equilibrium mass concentration of phosphorus in the soil system;
  given for equilibrium sites 1-NCXFA (1) and compartments 0-NL.
- Adsorbed non equilibrium mass concentration of phosphorus in the soil system;
  given for non equilibrium sites 1-NCXSL (3) and compartments 0-NL.
- Precipitated mass concentration of phosphorus in the soil system;
  given for model compartments 0-NL.
- Concentration of dissolved organic phosphorus in liquid phase in the top layer
  and compartments 0 to NL.
```
Figure 25 The input-file INITIAL.INP: data for example Cranendonck grass

MANAGEMENT.INP

```
Filename:  MANAGEMENT.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck grass)
----------------------------------------------------------------------

>kicrop: ----------------- crop definitions -----------------------------
 6 6 6 6 6   6 6 6

- Kind of crop grown each year is grassland.
  Crops have been defined in the input-file PLANT.INP.

>lsunit:
   1.8  1.8  1.8  1.8  1.8  1.8  1.4  1.4

- Number of livestock units per hectare per year. In this case the
  livestock unit for the first 6 years is 1.8 and 1.4 for the last 2 years.

>matvar:
 0

- Material composition is fixed and defined in the input-file MATERIAL.INP.

>add001:
  71.
 1
  1  18750.00   2   0 0.00
  76.

- At day number 71 (11-Mar-1992) the first addition takes place.
- Number of the added material is 1. One of the materials (MN) defined in
  the file MATERIAL.INP. In this case, material 1 is cattle slurry.
- Quantity of material added is 18750 kg ha-1.
  The cattle slurry is added to the first 2 compartments of the soil profile.
  No ploughing.
  In this case, 0% of the mineral part of the cattle slurry volatilizes.
- Time of next addition is day number 76 (15-Mar-1992).

>add002:
 2
  6     57.00   0   0 0.00
 11      7.85   0   0 0.00
 136.

- Number of events is 2.
- Numbers of the added materials are 6 (inorganic N-fertilizer)
  and 11 (inorganic P-fertilizer).
- Quantity of material nr 6 added is 57 kg.ha-1
  The fertilizer is added to the reservoir on top of compartment 1.
  No ploughing.
  No volatilization of inorganic N-fertilizer is assumed.
- Quantity of material nr 11 added is 7.85 kg.ha-1
  The fertilizer is added to the reservoir on top of compartment 1.
  No ploughing.
  No volatilization of inorganic P-fertilizer is assumed.
- Time of next addition is day number 136 (15-May-1992).

>add003:
 1
  6     24.00   0   0 0.00
 156.

- and so on...

>add145:
  1
  1   416.50  0  0 0.50
  9999.
```

Figure 26 The input-file MANAGEMENT.INP: data for example Cranendonck grass

(Last value for TINEAD (e.g. 9999) contains a dummy value, which should be higher than the last simulated time step).

4.2.2 Results

Case Cranendonck Field 6: grazed grassland on a sandy soil

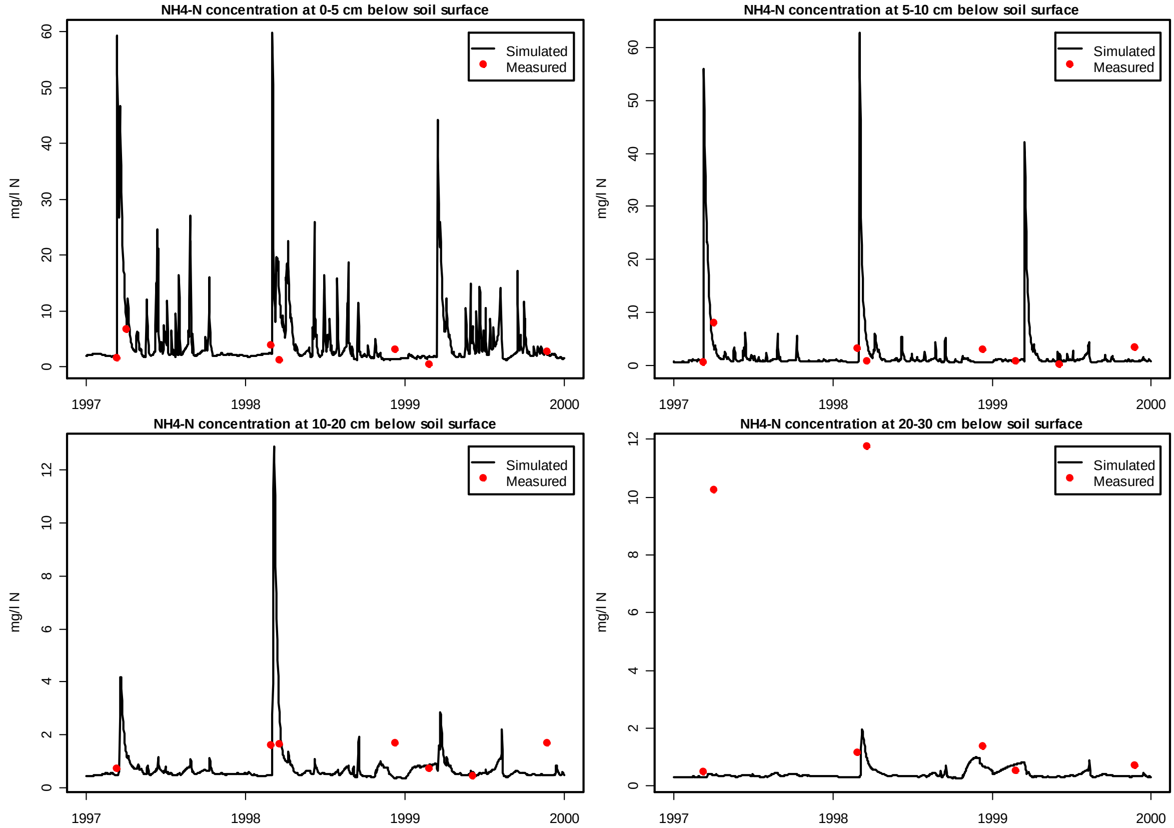

Figure 27 Measured and simulated NH_4-N concentrations at 4 different soil layers for permanent grassland

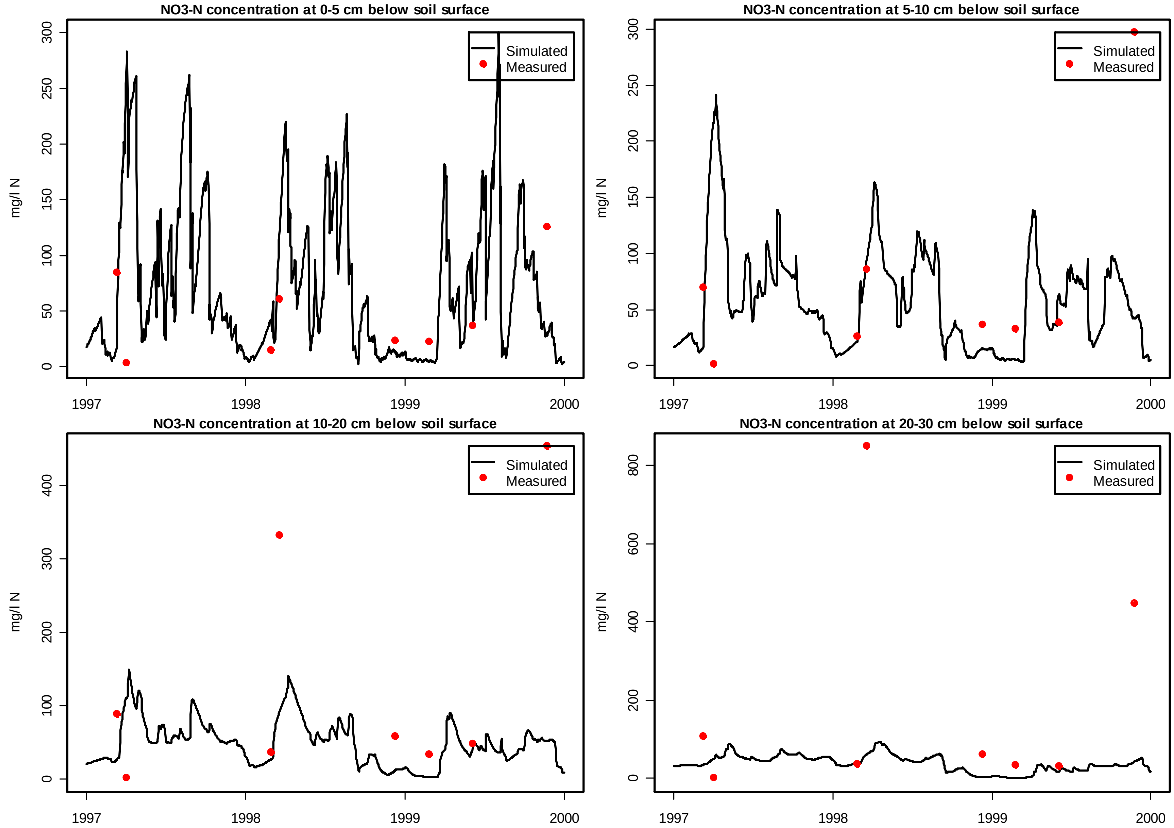

Figure 28 Measured and simulated NO_3-N concentrations at 4 different soil layers for permanent grassland

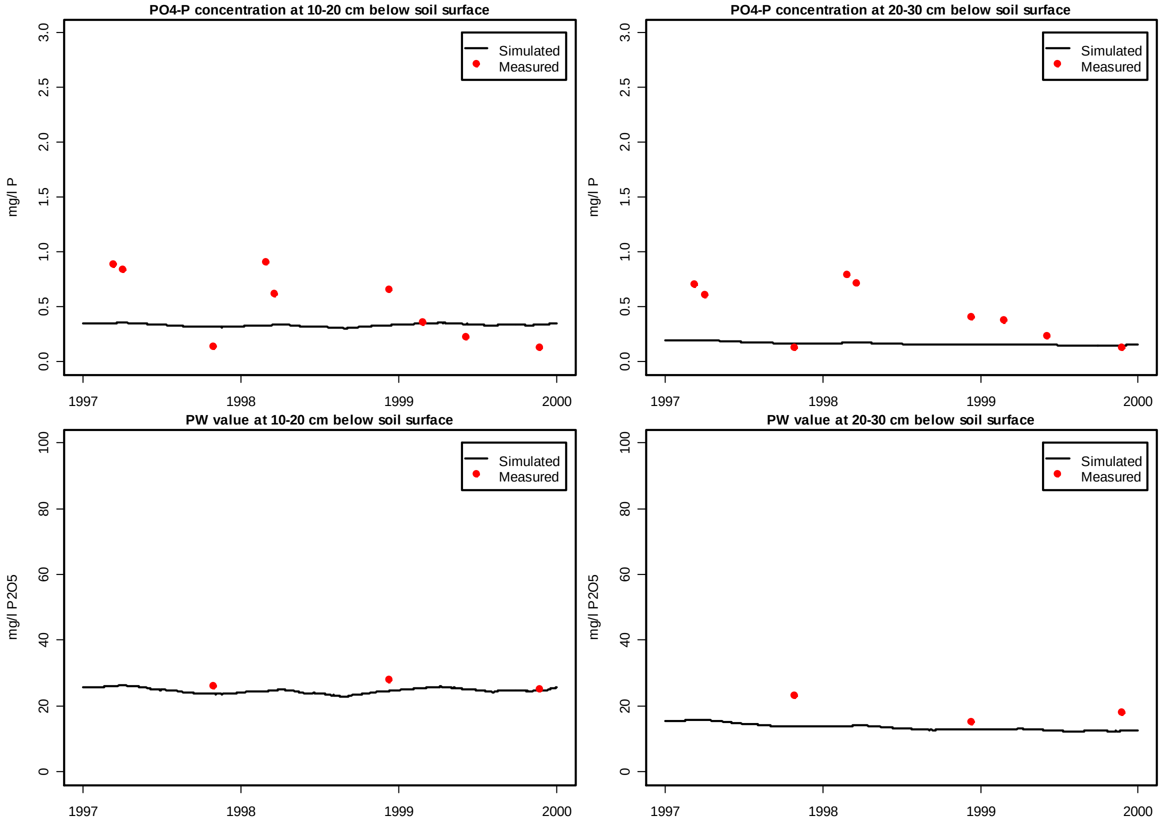

Figure 29 Measured and simulated PO_4-P concentrations and Pw-values at 2 different soil layers for permanent grassland

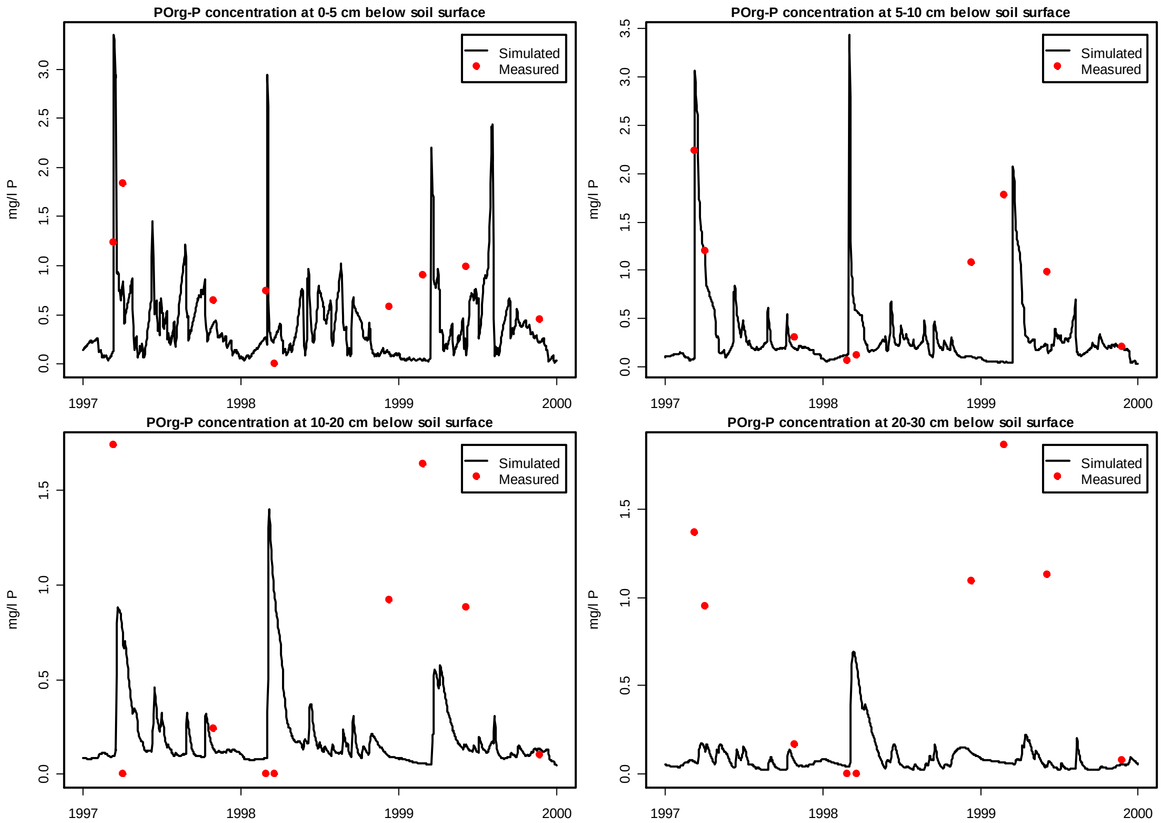

Figure 30 Measured and simulated organic-P concentrations at 4 different soil layers for permanent grassland

4.2.3 Balances

This section presents the content of water, organic matter, nitrogen and phosphorus balances and detailed organic transformations of the Cranendonck case. The presentation of these balances is achieved with the following procedure:

- With output options in the input file GENERAL.INP the output files BAWA//.OUT, BAOM//.OUT, BANH//.OUT, BANI//.OUT, BANO//.OUT, BAPP//.OUT and BAPO//.OUT are created.
- Besides the BA* files, balance table files are created. With the output options in the input file GENERAL.INP, the balance table files Ani_wa//.out, Ani_om//.out, Ani_n//.out and Ani_p//.out are created.
- Also with the output options in GENERAL.INP the output files transfom//.out and transfon//.out are created

At the position // a character string of 2 positions must be given to identify the set of the output files with mass balances, balance tables and organic transformations (see Chapter 3: input file GENERAL.INP).

Balances are created for each balance period.
This section gives only some balance table files and detailed organic transformations for the period 1-1-1999 to 31-12-1999.

Water, organic matter, nitrogen and phosphate balances of grazed grassland case (Case Cranendonck Field 6)

Soil profile RP: 0.00 - 0.30 m below soil surface

Output file Ani_waRP.bal:

```
Water balance (mm);   profile  top - 0.30m-ss;  period  365-1998/ 365-1999
==============================================================================
Input:                                   | Output:
==============================================================================
Rainfall                           811.0 | Interception                   99.6
Snowfall                             0.0 | Snow sublimation                0.0
Irrigation                           0.0 | Pond evaporation                0.0
                                         | Soil evaporation               96.4
                                         | Plant evaporation             399.8
Runon                                0.0 | Runoff_Pr                      23.5
Inundation                           0.0 | Runoff_L0                       4.4
                                         | Runoff_L1                       1.5
Infiltration from:                       | Drainage to:
- 3rd order                          0.0 | - 3rd order                     0.0
- 2nd order                          0.0 | - 2nd order                     0.0
- 1st order                          0.0 | - 1st order                     0.0
Bottom upw flux                    155.3 | Bottom downw flux             350.6
-----------------------------------------+------------------------------------
Total input                        966.3 | Total output                  975.8
==============================================================================
Storage change snow layer (+ = increase)                                   0.0
Storage change ponding layer (+ = increase)                                0.0
Storage change soil moisture (+ = increase)                               -9.5
Balance deviation                                                          0.0
==============================================================================
```

Output file Ani_omRP.bal:

```
Org.matter (kg/ha);   profile  top - 0.30m-ss;  period  365-1998/ 365-1999
==============================================================================
Input:          Fresh    Hu/bio   Diss. | Output:     Fresh    Hu/bio    Diss.
==============================================================================
Additions      1287.8       0.0   227.3 |
Redistrib         0.0       0.0     0.0 | Redistrib      0.0       0.0     0.0
Crop res.     10624.4                   |
Exudates          0.0                   |
Formation                4042.1  1189.8 | Dissoc.    11897.5    4114.0  1346.8
Irrigation                          0.0 |
Runon                               0.0 | Runoff_L0                        0.0
Inundation                          0.0 |
                                        | Runoff_L1                        0.2
Infiltration from:                      | Discharge to:
- 3rd order                         0.0 | - 3rd order                      0.0
- 2nd order                         0.0 | - 2nd order                      0.0
- 1st order                         0.0 | - 1st order                      0.0
Bottom upw flux                     2.9 | Bottom downw flux               90.6
----------------------------------------+-------------------------------------
Total input   11912.2    4042.1  1419.9 | Tot outp   11897.5    4114.0  1437.6
==============================================================================
Dissimilated                                          8030.8    3085.5  1010.1
==============================================================================
Final.present                                        39690.5  141410.9    18.6
Init.present                                         39675.8  141482.8    36.3
                                                    --------------------------
Storage change                                          14.7     -71.9   -17.7
Input-Output                                            14.7     -71.9   -17.7
Balance deviation                                        0.0       0.0     0.0
==============================================================================
```

Output file Ani_nRP.bal:

```
Nitrogen   (kg/ha);   profile  top - 0.30m-ss;  period  365-1998/ 365-1999
==============================================================================
Input:           Org-N   Nh4-N   No3-N | Output:        Org-N   Nh4-N   No3-N
==============================================================================
Deposition dry            12.0     8.0 |
Deposition wet            10.3     6.3 |
Additions         66.7   152.0    82.4 | Volatilization          16.3
Redistrib          0.0     0.0     0.0 | Redistrib        0.0     0.0     0.0
Crop residues    116.6     0.0     0.7 | Crop uptake             12.6   379.1
Exudates           0.0                 |
Incorporation    194.0                 | Gross mineral.  400.4
Nett mineral.            206.4         | Immobilization           0.0
Nitrification                    350.0 | Nitrification          350.0
                                       | Denitrification                 27.7
Irrigation         0.0     0.0     0.0 | Runoff_Pr        0.0     0.3     0.2
Runon              0.0     0.0     0.0 | Runoff_L0        0.0     0.1     0.1
Inundation         0.0     0.0     0.0 |
                                       | Runoff_L1        0.0     0.0     0.1
Infiltration from:                     | Discharge to:
- 3rd order        0.0     0.0     0.0 | - 3rd order      0.0     0.0     0.0
- 2nd order        0.0     0.0     0.0 | - 2nd order      0.0     0.0     0.0
- 1st order        0.0     0.0     0.0 | - 1st order      0.0     0.0     0.0
Bottom upw flux    0.1     0.2    27.0 | Bot downw flux   1.8     1.6    68.6
---------------------------------------+--------------------------------------
Total input      377.4   380.9   474.4 | Total output   402.2   381.0   475.8
==============================================================================
Final.present solid/complex                               7228.7     0.7
Init.present solid/complex                                7253.2     0.7
                                                        ------------------------
Storage change solid/complex (+ = increase)                -24.4     0.0
==============================================================================
Final.present solution                                       0.3     1.0    11.2
Init.present solution                                        0.7     1.0    12.6
                                                        ------------------------
Storage change solution (+ = increase)                      -0.4    -0.1    -1.4
==============================================================================
Input-Output                                               -24.8    -0.1    -1.4
Balance deviation                                            0.0     0.0     0.0
==============================================================================
```

Output file Ani_pRP.bal:

```
Phosphorus (kg/ha);   profile  top - 0.30m-ss;  period  365-1998/ 365-1999
==============================================================================
INPUT:                   ORG-P   PO4-P | OUTPUT:                ORG-P   PO4-P
==============================================================================
Deposition wet                    0.99 |
Additions                 6.67   41.19 |
Redistrib                 0.00    0.00 | Redistrib               0.00    0.00
Crop residues            22.83         | Crop uptake                    63.27
Exudates                  0.00         |
Incorporation            24.25         | Gross mineral.         55.62
Net mineral.                     31.37 | Immobilization                  0.00
Irrigation                0.00    0.00 | Runoff_Pr               0.00    0.03
Runon                     0.00    0.00 | Runoff_L0               0.00    0.01
Inundation                0.00    0.00 |
                                       | Runoff_L1               0.00    0.05
Infiltration from:                     | Discharge to:
- 3rd order               0.00    0.00 | - 3rd order             0.00    0.00
- 2nd order               0.00    0.00 | - 2nd order             0.00    0.00
- 1st order               0.00    0.00 | - 1st order             0.00    0.00
Bottom Upw flux           0.01    0.52 | Bottom downw flux       0.26    0.53
---------------------------------------+--------------------------------------
Total input              53.76   74.07 | Total output           55.88   63.89
==============================================================================
Final.present solid/complex                                    930.0  1275.0
              precipitated                                               0.0
Init.present solid/complex                                     932.1  1264.9
              precipitated                                               0.0
                                                              ----------------
Storage change solid/complex/precipitated                      -2.07   10.17
------------------------------------------------------------------------------
Final.present solution                                          0.05    1.15
Init.present solution                                           0.10    1.13
                                                              ----------------
Storage change solution                                        -0.05    0.01
------------------------------------------------------------------------------
Input-Output                                                   -2.12   10.18
Balance deviation                                               0.00    0.00
==============================================================================
```

Soil profile TP: 0.00 - 3.60 m below soil surface

Output file Ani_waTP.bal:

```
Water balance (mm);   profile  top - 3.60m-ss;  period  365-1998/ 365-1999
==============================================================================
Input:                                  | Output:
==============================================================================
Rainfall                          811.0 | Interception                   99.6
Snowfall                            0.0 | Snow sublimation                0.0
Irrigation                          0.0 | Pond evaporation                0.0
                                        | Soil evaporation               96.4
                                        | Plant evaporation             399.8
Runon                               0.0 | Runoff_Pr                      23.5
Inundation                          0.0 | Runoff_L0                       4.4
                                        | Runoff_L1                       1.5
Infiltration from:                      | Drainage to:
- 3rd order                         0.0 | - 3rd order                     0.0
- 2nd order                         0.0 | - 2nd order                     0.0
- 1st order                         0.0 | - 1st order                     0.0
Bottom upw flux                    20.4 | Bottom downw flux             221.8
----------------------------------------+-------------------------------------
Total input                       831.4 | Total output                  846.9
==============================================================================
Storage change snow layer (+ = increase)                                  0.0
Storage change ponding layer (+ = increase)                               0.0
Storage change soil moisture (+ = increase)                             -15.5
Balance deviation                                                         0.0
==============================================================================
```

Output file Ani_omTP.bal:

```
Org.matter (kg/ha);   profile  top - 3.60m-ss;  period  365-1998/ 365-1999
==============================================================================
Input:          Fresh    Hu/bio   Diss. | Output:     Fresh    Hu/bio    Diss.
==============================================================================
Additions      1287.8       0.0   227.3 |
Redistrib         0.0       0.0     0.0 | Redistrib      0.0       0.0     0.0
Crop res.     10624.4                   |
Exudates          0.0                   |
Formation                4529.6  1189.8 | Dissoc.    11897.5    5970.1  1440.7
Irrigation                          0.0 |
Runon                               0.0 | Runoff_L0                        0.0
Inundation                          0.0 |
                                        | Runoff_L1                        0.2
Infiltration from:                      | Discharge to:
- 3rd order                         0.0 | - 3rd order                      0.0
- 2nd order                         0.0 | - 2nd order                      0.0
- 1st order                         0.0 | - 1st order                      0.0
Bottom upw flux                     0.0 | Bottom downw flux                0.0
----------------------------------------+-------------------------------------
Total input   11912.2    4529.6  1417.0 | Tot outp   11897.5    5970.1  1440.9
==============================================================================
Dissimilated                                          8030.8    4477.5  1080.5
==============================================================================
Final.present                                        39690.5  378838.0    34.9
Init.present                                         39675.8  380278.4    58.8
                                                    --------------------------
Storage change                                          14.7   -1440.4   -23.9
Input-Output                                            14.7   -1440.4   -23.9
Balance deviation                                        0.0       0.0     0.0
==============================================================================
```

Output file Ani_nTP.bal:

```
Nitrogen   (kg/ha);   profile  top - 3.60m-ss;  period  365-1998/ 365-1999
==============================================================================
Input:           Org-N   Nh4-N   No3-N | Output:         Org-N   Nh4-N   No3-N
==============================================================================
Deposition dry            12.0     8.0 |
Deposition wet            10.3     6.3 |
Additions         66.7   152.0    82.4 | Volatilization          16.3
Redistrib          0.0     0.0     0.0 | Redistrib         0.0     0.0     0.0
Crop residues    116.6     0.0     0.7 | Crop uptake              12.6   379.1
Exudates           0.0                 |
Incorporation    211.1                 | Gross mineral.  467.4
Nett mineral.            256.3         | Immobilization           0.0
Nitrification                    403.2 | Nitrification          403.2
                                       | Denitrification                 124.8
Irrigation         0.0     0.0     0.0 | Runoff_Pr         0.0     0.3     0.2
Runon              0.0     0.0     0.0 | Runoff_L0         0.0     0.1     0.1
Inundation         0.0     0.0     0.0 |
                                       | Runoff_L1         0.0     0.0     0.1
Infiltration from:                     | Discharge to:
- 3rd order        0.0     0.0     0.0 | - 3rd order       0.0     0.0     0.0
- 2nd order        0.0     0.0     0.0 | - 2nd order       0.0     0.0     0.0
- 1st order        0.0     0.0     0.0 | - 1st order       0.0     0.0     0.0
Bottom upw flux    0.0     0.1     0.0 | Bot downw flux    0.0     8.3     0.0
---------------------------------------+--------------------------------------
Total input      394.4   430.7   500.6 | Total output    467.4   440.9   504.2
==============================================================================
Final.present solid/complex                            14543.4    18.9
Init.present solid/complex                             14615.6    23.5
                                                      ------------------------
Storage change solid/complex (+ = increase)              -72.3    -4.6
==============================================================================
Final.present solution                                     0.6    21.5    91.3
Init.present solution                                      1.4    27.1    94.9
                                                      ------------------------
Storage change solution (+ = increase)                    -0.8    -5.6    -3.6
==============================================================================
Input-Output                                             -73.0   -10.2    -3.6
Balance deviation                                          0.0     0.0     0.0
==============================================================================
```

Output file Ani_pTP.bal:

```
Phosphorus (kg/ha);   profile  top - 3.60m-ss;  period  365-1998/ 365-1999
==============================================================================
INPUT:                   ORG-P   PO4-P | OUTPUT:                 ORG-P   PO4-P
==============================================================================
Deposition wet                    0.99 |
Additions                 6.67   41.19 |
Redistrib                 0.00    0.00 | Redistrib                0.00    0.00
Crop residues            22.83         | Crop uptake                     63.27
Exudates                  0.00         |
Incorporation            26.39         | Gross mineral.          64.02
Net mineral.                     37.63 | Immobilization                   0.00
Irrigation                0.00    0.00 | Runoff_Pr                0.00    0.03
Runon                     0.00    0.00 | Runoff_L0                0.00    0.01
Inundation                0.00    0.00 |
                                       | Runoff_L1                0.00    0.05
Infiltration from:                     | Discharge to:
- 3rd order               0.00    0.00 | - 3rd order              0.00    0.00
- 2nd order               0.00    0.00 | - 2nd order              0.00    0.00
- 1st order               0.00    0.00 | - 1st order              0.00    0.00
Bottom Upw flux           0.00    0.00 | Bottom downw flux        0.00    0.39
---------------------------------------+--------------------------------------
Total input              55.89   79.82 | Total output            64.02   63.75
==============================================================================
Final.present solid/complex                                    1844.4  5637.5
              precipitated                                                0.0
Init.present solid/complex                                     1852.4  5621.4
              precipitated                                                0.0
                                                               ----------------
Storage change solid/complex/precipitated                        -8.05   16.07
------------------------------------------------------------------------------
Final.present solution                                            0.09    3.24
Init.present solution                                             0.18    3.24
                                                               ----------------
Storage change solution                                          -0.09    0.00
------------------------------------------------------------------------------
Input-Output                                                     -8.14   16.07
Balance deviation                                                 0.00    0.00
==============================================================================
```

The output of transfopTP.out can be reflected as transformations between the different pools as shown in the picture underneath.

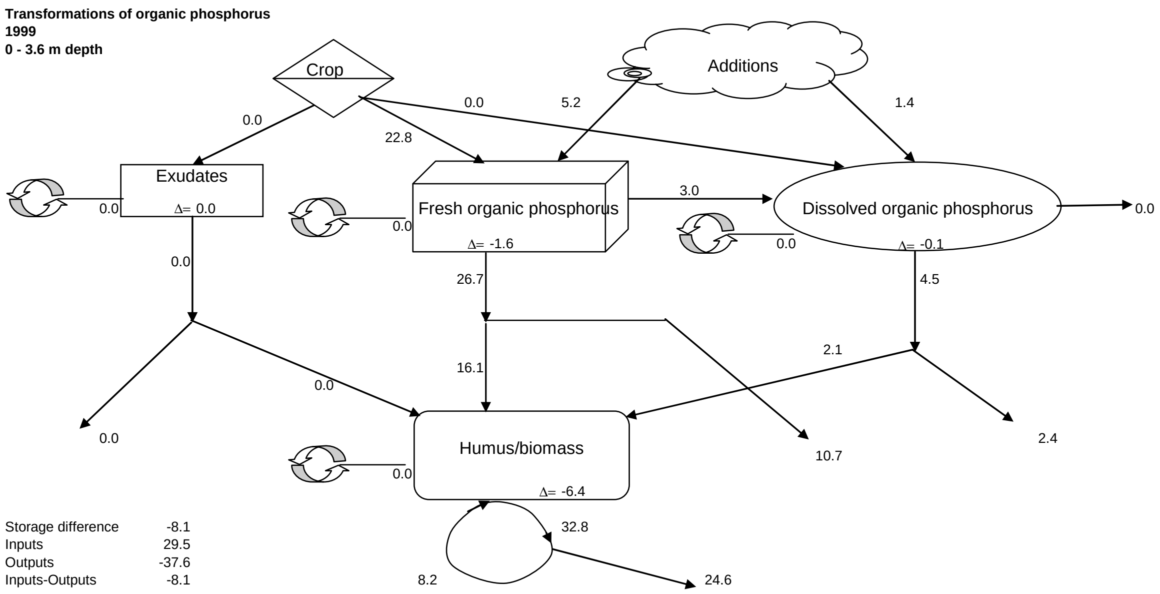

Figure 31 Reflection of the detailed organic transformations between the different organic pools.

4.3 Maize on a sandy soil

This experiment was carried out on a maize field which received applications of 50 tons of cattle slurry per ha per year. Data were taken from experiments on a field of a regional investigation centre (Regionaal Onderzoekscentrum Cranendonck Field 18; in the southern part of the Netherlands). Oosterom and Steenvoorden (1984) conducted leaching investigations. Van Geelen and Kroes (1995) give more information on simulations with data from the same experiment.
The main characteristics of the Cranendonck plots are:

- soils are classified as sandy soils;
- different combination of fertilization levels for nitrogen;
- land use is maize;
- medium water holding capacity.

In section 4.3.2 some results of the ANIMO model for this case are presented.
In section 4.3.3 the water and mass balances are given as they should be produced by the model ANIMO 4.0.
For more detailed information about the model input see also section 4.1.

4.3.1 Input files

GENERAL.INP

```
Filename:  GENERAL.INP
Content:   Input for ANIMO-version 4.0  (example Cranendonck maize)
---------------------------------------------------------------------------

>simopt: -------------- simulation options -------------------------------
 2 0 0 0 0

        - Hydrological parameters were simulated with the model SWAP.
        - The carbon and nitrogen cycle are simulated.
        - Aeration calculation in ANIMO
        - Crop uptake simulated by ANIMO
        - Simulation without macro pores

>simtim:
  1974   0.0 1982 365.0

        - 9 years are simulated: the period 1 1 1974 t/m 31 12 1982.

>outscr:
 1      - Simulation-stage is written to screen as year and day number.

>outbal: --------------- output of balances ------------------------------
 2      - 2 balance series
 MP     - The character string 'MP' is given
 1 1 1 0- Output of balances written to files BAWARP.OUT, BAOMRP.OUT,
 0 13     BANHRP.OUT, BANIRP.OUT and BANORP.OUT.
 1      - Compartment 0 is the addition-reservoir on top of the model soil
 365.     system. The bottom of compartment 13 is at 1.0 meter below the
 TP       soil surface. The balances are made up for 0-1.0 meter below
 1 1 1 0  the soil surface.
 0 22   - Each simulated year one reset at the last day number of the
 1        year (365 or 366 for a leap year); this reset includes
 365.     writing of balance-terms to files and initializing all
          balance terms at zero.
        - The character string 'TP' is given.
        - Output of balances written to files BAWATP.OUT, BAOMTP.OUT,
          BANHTP.OUT, BANITP.OUT and BANOTP.OUT.
        - Compartment 0 is the addition-reservoir on top of the model soil
          system. The bottom of compartment 22 is at 3.60 meter below the
          soil surface (defined by hydrological simulations).
          The balances are made up for 0-3.60 meter below the soil surface.
        - Each simulated year 1 reset at the last day number of the year;
          this reset includes writing of balance-terms to files and initializing
          all balance terms at zero.

>outsel: --------------- output-selection --------------------------------
 1 0 0 0 0   0 0 1 0 0   0 0 0 0 0
 0 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 0
 0 0

        - The files NITRATE.OUT and MINER-N.OUT are created and filled
          with simulation results.
        - No output for grassland and detailed organic transformations.

>outtot: --------------- output of input, and output per time step -------
 0  1
 1000
        - At the time step 1000 detailed output is written to output-file
          AnimoIntermediate.out.
```

Figure 32 The input-file GENERAL.INP: data for example Cranendonck maize

MATERIAL.INP

```
Filename:   MATERIAL.INP
Content:    Input for ANIMO-version 4.0  (example Cranendonck maize)
--------------------------------------------------------------------------

>defmat: --------------- definitions of materials ------------------------
 11
 0.05    0.015   0.063    0.095   0.37    0.0  1.0  0.99  1.0  1.0  1.0
 0.0022  0.0021  0.00275  0.0063  0.0095  0.5  0.0  0.0   0.0  0.0  0.0
 0.0     0.0     0.0      0.0     0.0     0.5  0.0  0.01  0.0  0.0  0.0

- 11 materials are defined (5 different types of animal manure, 1 inorganic
  fertilizer, 2 different types of root material and 3 different types of
  organic matter in the soil).
- Fraction of organic matter in the materials 1 to NM (FROR):
   - Material 1-5: Lammers (1983) gives organic matter contents.
   - Material 6: Inorganic N-fertilizer is 100% inorganic.
   - Material 7: Roots of non-grassland contain no mineral part.
   - Material 8: A small part of grassland roots (1%) is added as mineral NO3-N.
   - Material 9-11: Organic matter in the soil contains no mineral part.
- Fraction of NH4-N in the materials 1 to NM (FRNH):
   - Material 1-5: Mineral nitrogen of manure is assumed 100% NH4-N.
   - Material 6-11: See parameter FRNI.
- Fraction of NO3-N in the materials 1 to NM (FRNI):
   - Material 1-5: Animal manure contains no NO3-N
   - Material 6: Inorganic fertilizer, half NO3-N, half NH4-N.
   - Material 7, 9-11: Root material of non-grassland and organic matter in the soil are 100%
organic.
   - Material 8: Root material of grassland contains 1% NO3-N.

   material nr  1 = cattle slurry;
   material nr  2 = calve slurry;
   material nr  3 = pig slurry;
   material nr  4 = poultry slurry;
   material nr  5 = dry poultry manure;
   material nr  6 = fertilizer;
   material nr  7 = roots of non-grassland;
   material nr  8 = roots of grassland;
   material nr  9 = organic matter in the subsoil;
   material nr 10 = organic matter in eutrophic peat;
   material nr 11 = organic matter in mesotrophic peat;

>orgmat: ----------------- definition of organic fractions ---------------
 14
 0.1  0.7   0.2  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.8   0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.8   0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.8   0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.4   0.5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.9  0.1  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.9  0.1  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  1.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.33  0.67  0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.33  0.67
 0.1  0.05  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.05  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.05  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.05  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.1  0.05  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.0  0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0   0.0   0.0
 0.75

- The organic part of each material consists of fractions; each fraction has it own
  decomposition rate and its own nitrogen content.
- Based on a different decomposition rate one can distinguish different fraction in each
  material, each fraction having its specific decomposition rate and nitrogen content.
   - Material 1-5: Decomposition rates and nitrogen contents of three fractions were
     calibrated with measured lysimeter-data (Berghuijs-van Dijk et al., 1985).
   - Material 6: Inorganic N-fertilizer: 100% mineral.
   - Material 7, 8, 10 and 11: Calibrated with measured lysimeter-data
     (Berghuijs-van Dijk et al., 1985).
   - Material 9: No further division into fractions.
- Part of the fractions of the organic part of the materials that goes into solution.
   - Material 1-5:
      - Fraction 1: 100% dissolved organic matter.
      - Fraction 2: One part (material nr 1: 0.7-0.05=0.65; material nr 2: 0.8-0.05=0.75;
        material nr 3=0.8-0.05=0.75; material nr 4=0.8-0.05=0.75; material nr 5=0.4-0.05=0.35)
        is defined as fresh organic matter (OS) the rest (0.05) is defined as dissolved
```

```
        organic matter.
      - Fraction 3: 100% fresh organic matter.
   - Material 6-11: No dissolved parts.

The meaning of the organic fractions can be summarized as followed:

  organic fraction nr 1 = soluble, rapidly decomposing part of slurry
  organic fraction nr 2 = partly diss., rapidly decomposing part of slurry
  organic fraction nr 3 = solid, slowly decomposing part of slurry
  organic fraction nr 4 = rapidly decomposing part of non-grassland roots
  organic fraction nr 5 = slowly decomposing part of non-grassland roots
  organic fraction nr 6 = very slowly decomposing organic matter
  organic fraction nr 7 = not used
  organic fraction nr 8 = not used
  organic fraction nr 9 = rapidly decomposing part of grassland roots
  organic fraction nr 10= slowly decomposing part of grassland roots
  organic fraction nr 11= slowly decomposing, high N-content,eutrophic peat
  organic fraction nr 12= rapidly decomposing, low N-content,eutrophic peat
  organic fraction nr 13= slowly decomposing, mesotrophic peat
  organic fraction nr 14= rapidly decomposing, mesotrophic peat

- Humus fraction of the fresh organic matter does not pass the dissolved stage,
  but decomposes directly into humus.

>orgdec: --------------- definition of rates ----------------------------
 0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25
 0.25  0.25  0.25
 0.5
 1.0 0.6 0.12 2.0 0.22 0.00141 0.0005 0.0005 2.0 0.22 0.001 0.0383 0.001 0.024
 30.0 0.02 365.0 100.0
 0.06

- Assimilation factor of 0.25 for all fractions (Berghuijs-van Dijk et al., 1985).
  This parameter indicates the fraction of the decomposable fresh organic matter or
  exudates that can be converted to humus/biomass.
- Assimilation efficiency of dissolved organic matter, humus/biomass and exudates
  all of 0.25.
- Reduction factor of 50% for microbiological transformations under oxygen limited
  situations.
- First order average decomposition rate for the organic fractions.
   - Fractions 1-3: Fractions used for material nr 1-5 (animal manure).
     Model-verification resulted in a calibration of the decomposition-rates for
     fraction 2 and 3 (fraction 1 has a dummy value since this fraction goes fully
     into solution).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6: Fraction used for organic material in subsoil. Decomposition rate
     was derived from rates given by Jenkinson and Rayne (1977) and calibrated with
     simulations of a region in the southern part of the Netherlands (Drent et al., 1988).
   - Fraction 11-12: Fractions used for eutrophic peat (not used in this case).
   - Fraction 13-14: Fractions used for mesotrophic peat (not used in this case).
- First order average decomposition rate for dissolved organic matter.
  Berghuijs-van Dijk et al. (1985) gives the value of 30, which was derived from
  lysimeter-experiments.
  First order average decomposition rate for humus. Berghuijs-van Dijk et al. (1985):
  a low rate for humus of 1.5-2.0% per year for net humus-decomposition in the long term.
  First order average decomposition rate for exudates. Berghuijs-van Dijk et al. (1985):
  a high rate of 365, because of rapid decomposition.
  First order average nitrification rate. Van Huet (1983) gives some values derived on a
  literature research. For sandy-loam column experiments resulted in a value of 365.
  Literature research (Hendriks, 1992) and application of the ANIMO model resulted in better
  results with a lower value of 100.
- First order average denitrification rate. A value of 0.06 is based on the following
  assumption: in 10 days, no more than 50% of the present nitrate can be denitrified.

>orgnit: --------------- definition of N-contents ------------------------
 0.025 0.015 0.01 0.008 0.008 0.01 0.0 0.0 0.01 0.01 0.043 0.028 0.02 0.019
 0.048 0.02

- Nitrogen fractions in organic matter.
   - Fraction 1-3: Fractions used for material nr 1-5 (animal manure).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
     An average value was used of nitrogen content of crop residues above soil surface
     and root material below soil surface.
   - Fraction 6: Fraction used for organic material in subsoil. Nitrogen content derived
     from data given by Berghuijs-van Dijk et al. (1985). Berghuijs-van Dijk gives nitrogen
     fractions in various materials, division over fractions has to be estimated or
     calibrated. It seems likely that the large fractions have the highest nitrogen content.
   - Fraction 7-8: Not used in this example.
   - Fraction 11-12: Fractions used for eutrophic peat.
   - Fraction 13-14: Fractions used for mesotrophic peat.
- Maximal nitrogen fraction in humus. Value as given by Berghuijs-van Dijk et al. (1985).
  It corresponds to a C/N ratio of 14 (the carbon content of the material has been assumed
  to 0.58). This value 0.048 is added to the nitrogen fraction in the root zone layers.
  Below the root zone the nitrogen fraction is calculated from the given C/N ratio * 0.58
  (See Soil.inp).
- Nitrogen fraction in exudates. Value as given by Berghuijs-van Dijk et al. (1985).
```

```
>sonicg: --------------- definition of SONICG-concept variables ----------
  0.3 0.01 0.90

- The nitrate-N concentration for which the MM-function takes a value half of
  the optimal value is 0.3
- Multiplication factor for org. transformations at complete anaerobic conditions
  is set to 0.01
- The critical value of water filled pore space for adjustment of original water
  response on organic transformation to lower values is set to 0.9
```

Figure 33 The input-file MATERIAL.INP: data for example Cranendonck maize

PLANT.INP

```
Filename:  PLANT.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck maize)
---------------------------------------------------------------------------

>cropdt:---------- number of crops for which data are given --------------
 1

- One crop is defined in this file.

>crop01: ----------------- crop nr 1: maize ------------------------------
 2
 7  7
 10
 115.   130.   151.   166.   181.   196.   212.   232.   275.   295.
   0.    80.   120.   400.  2000.  2000.  2000.  2000.  2000.     0.
 10
 115.   130.   151.   166.   181.   196.   212.   232.   275.   295.
 0.00   0.05   0.20   0.35   0.57   0.60   0.60   0.60   0.60   0.00
 115.   275.    0.0  147.0   20.0   0.2700   0.0500  285.0    5.0    1.0

Plant parameters for maize:
- Crop number 2 is defined as maize.
- Root material is 7 for non-grassland (see input-file MATERIAL.INP).
  In this case, the shoot material is taken the same as for root material number 7.
- Number of data given for the amount of roots (NUAMRO).
  These data are used to simulate the decomposition of root material.
  For a realistic simulation the values should correspond to the values
  applied in the hydrological model.
- Array with Julian day numbers versus amount of roots.
- Number of data given for the root length (NULNRO)
- Array with Julian day numbers versus length of roots.
- Average sowing and harvesting times over the period 1974-1982 as given
  in PAGV (1985).
  Areic mass of tubers harvested.
  UPNIMA1 and UPNIMA2 describe the cumulative gross root uptake over two periods.
  This is different from many measured values because it includes uptake by plant
  parts above and below the soil surface (e.g. roots). Part of this gross uptake
  returns and/or remains in the soil. Care should be taken when trying to use
  measured values because most measurements only refer to the harvested crop.
  Given values are estimations based on data given by PAGV (1985),
  Steenvoorden and Oosterom (1984). The final values were achieved by calibrating
  on field measurements.
  The cumulative transpiration in first and second period.
  Day number when max. N-uptake rate alters.
  Maximum selectivity factor for N-uptake.
  Factor for actual transpiration in crop uptake calculation.
```

Figure 34 The input-file PLANT.INP: data for example Cranendonck maize

SOIL.INP

```
Filename:  SOIL.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck maize)
--------------------------------------------------------------------------

>profil: ----------------- horizons ------------------------------------
 5
 0.02 0.2
 0.2  0.25
 0.60

- Five soil horizons were distinguished.
- The thickness of the top of the soil compartment is set to 0.02 m;
  the thickness of the reservoir for additions to the soil system is set to 0.2 m.
- The fraction of runoff passing the surface reservoir is set to 0.2
  and for passing the first soil layer is set to 0.25.
- The depth of the initial root zone is 0.60 m.

>tempar: ----------------- temperature parameters-------------------------
 0.01726 0.05184
 10.0  11.0  3.7721

- Frequency of the early temperature wave; used in sine and Fourier model.
  Used in sine model: 2.0*3.14/365 = 0.01726.
  Thermal diffusivity; used in sine and Fourier model.
  Huet (1982) gives this value (0.05184 m2 d-1 = 0.006 cm2 sec-1).
- Amplitude of yearly temperature wave (10 oC).
  Average yearly temperature (11 oC) at soil surface. Used in sine model.
  Phase shift (3.7721 rad) of sine wave.

>sophy1: ----------------- soil physical parameters ----------------------
 2.5   3.5
 2.5   3.5
 2.5   3.5
 2.5   3.5
 2.5   3.5
    0.3221    0.3221    0.3221    0.5310    0.5310
 1418.     1470.     1470.     1470.     1550.
   14.       17.       17.       24.       30.
 74826.0  74826.0   74826.0   74826.0   74826.0
 74826.0  74826.0   74826.0   74826.0   74826.0

- Parameters in calculation of diffusion coefficient for oxygen in the air filled
  part of soil for each horizon. Empirical constants dependent on the soil type.
  Some values are given by Hoeks (1983). More values can be found in Bakker et al.
  (1987). Data for the 'Staringreeks' soil schematisation are given in Groenendijk
  and Kroes (1999).
- Saturated conductivity of the root zone, for horizons 1 to 5.
- Dry bulk density for each horizon.
- C/N-ratio for each horizon. (C/N-ratio for the root zone are dummy’s,
  because the nitrogen fraction of humus for the root zone are set to the
  maximum nitrogen fraction of humus.)
- Coefficient temperature response for organic and dissolved organic
  transformations by Arrhenius per horizon.

>sochem: ----------------- soil chemical parameters ----------------------
  5.63    5.63    5.63    5.70    5.70
  0.0003  0.0003  0.0003  0.0003  0.0003

- pH-H2O for each horizon.
  Values originate from PAGV (1985) where values were presented as measured pH-KCL.
  Conversion to pH-H2O was made with a conversion table (TNO, 1956).
- Values for the distribution coefficient for ammonium. The ratio between the
  amounts of NH4-N in the soil solution. Values are given for each horizon.
  Estimated values derived from Kroes et al. (1990).
```

Figure 35 The input-file SOIL.INP: data for example Cranendonck maize

BOUNDARY.INP

```
Filename:  BOUNDARY.INP
Content:Input for ANIMO-version 4.0 (example Cranendonck maize)
--------------------------------------------------------------------------

>optibc: ----------------- boundary options ------------------------------
 0  0

- Runon and irrigation concentration data are not given per time step

>topbou: ------ top boundary conditions Nitrogen,Phosphorus and Carbon ---
  0.00127  0.00127  0.00127  0.00127  0.00127  0.00127  0.00127  0.00127  0.00127
  0.00078  0.00078  0.00078  0.00078  0.00078  0.00078  0.00078  0.00078  0.00078
 12.0     12.0     12.0     12.0     12.0     12.0     12.0     12.0     12.0
  8.00     8.00     8.00     8.00     8.00     8.00     8.00     8.00     8.00
 0.0  0.0
 0.0  0.0
 0.0  0.0
 0.0  0.0

- Concentrations of precipitation of NH4-N: 0.00127 kg m-3 for each year
- Concentrations of precipitation of NO3-N: 0.00078 kg m-3 for each year
- Atmospheric dry deposition of NH4-N: 12.0 kg ha-1 N for each year.
- Atmospheric dry deposition of NO3-N: 8.0 kg ha-1 N for each year.
- Concentrations of NH4-N and NO3-N in runon are set to 0.0.
- Concentration of dissolved organic matter and dissolved organic nitrogen
  are set to 0.0.
  Not relevant for this field because runon does not occur in this case.
- Concentration of NH4-N and NO3-N in irrigation is set to 0.0.
- Concentration of dissolved organic matter and dissolved organic nitrogen
  are set to 0.0.

>latbou: ----------------- lateral boundary conditions -------------------
 0.0  0.0
 0.0  0.0

- Concentration of NH4-N, NO3-N, dissolved organic matter and dissolved organic
  nitrogen in infiltrating drain water are set to 0.0.
  Not relevant for this field because infiltration does not occur in this case.

>botbou: ----------------- bottom boundary conditions --------------------
 0.0  0.0
 0.0  0.0

- Concentration of NH4-N, NO3-N, dissolved organic matter and dissolved organic
  nitrogen below model profile are assumed to be 0.0.
  Not relevant for this field, because seepage does not occur in this case.
```

Figure 36 The input-file BOUNDARY.INP: data for example Cranendonck maize

INITIAL.INP

```
Filename:     INITIAL.INP
Content:      Input for ANIMO-version 4.0  (case Cranendonck maize)
---------------------------------------------------------------------------

>moistf: ------------------- moisture content ----------------------------
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Moisture fractions of the compartments 1 to NL at the beginning of a time step.
  In this case, dummy values of 0.0 have been used, because hydrology is
  simulated by Swap.

>ammoni: ------------------- ammonium concentration ----------------------
 0.0 0.0
 1.3E-3 1.3E-3 1.3E-3 1.3E-3 1.3E-3    1.3E-3 1.3E-3 1.3E-3 1.3E-3 1.3E-3
 1.3E-3 1.3E-3 1.3E-3 1.3E-3 1.3E-3    1.3E-3 1.3E-3 1.3E-3 1.3E-3 1.3E-3
 1.3E-3 1.3E-3

- Concentrations of NH4-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>nitrat: ------------------- nitrate concentration -----------------------
 0.0 0.0
 7.8E-4 7.8E-4 7.8E-4 7.8E-4 7.8E-4    7.8E-4 7.8E-4 7.8E-4 7.8E-4 7.8E-4
 7.8E-4 7.8E-4 7.8E-4 7.8E-4 7.8E-4    7.8E-4 7.8E-4 7.8E-4 7.8E-4 7.8E-4
 7.8E-4 7.8E-4

- Concentrations of NO3-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>orgexu: ------------------- exudates -----------------------------------
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Exudate content of compartments 1 to NL. The amount of exudates present has been
  estimated as 0.0 kg m-2. Low amounts of exudates and high decomposition rates
  make this acceptable.

>humexu: ------------------- humus from exudates ------------------------
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0     0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Amount of humus from exudates present in compartments 1 to NL. HUEX, HUOS and OS
  are the main organic components in the model ANIMO.
  OS is the fresh organic matter; HUEX and HUOS together form humus.
  OS decomposes with rates RECFAV (1-NF),
  HUEX and HUOS both decompose with the rate RECFHUAV.

>orgfsh:-------------------- fresh organic matter -----------------------
 0.0 0.0 0.0 0.09926  0.09926    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.09926  0.09926    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.09926  0.09926    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.09926  0.09926    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.077175 0.077175   0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.077175 0.077175   0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.15435  0.15435    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.15435  0.15435    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.15435  0.15435    0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
```

```
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0

 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0      0.0        0.0 0.0 0.0 0.0 0.0    0.0 0.0 0.0 0.0

- Amount of fresh organic matter present in compartments 1 to NL for
  fractions 1 to NF.

>humorg: ------------------- humus from fresh organic matter -------------
 1.7867 1.7867 1.7867 1.7867     1.3891 1.3891 2.7783 2.7783 2.7783 3.2340
 3.2340 1.0850 1.0850 2.1700     2.1700 2.1700 2.1700 2.1700 2.1700 2.1700
 2.1700 2.1700

- Amount of humus from fresh organic matter and dissolved organic matter
  present in compartments 1 to NL (see parameter HUEX).

>orgsol:-------------------- dissolved organic matter --------------------
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0      0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0      0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0      0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0      0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Concentration of dissolved organic matter (including addition reservoir
  and LN=0).
  Concentration of dissolved organic nitrogen (including addition reservoir
  and LN=0).
  Dissolved organic matter was estimated to be nil. Therefore zero's are given
  for dissolved organic matter and dissolved organic nitrogen.

>orgpla: ----------- fresh organic matter and uptake by grassland --------
 0.0000000E+00  0.0000000E+00  0.0000000E+00

- Amount of roots, shoots and uptake are taken from Dutch field experiments.
```

Figure 37 The input-file INITIAL.INP: data for example Cranendonck maize

MANAGEMENT.INP

```
Filename:     MANAGEMENT.INP
Content:      Input for ANIMO-version 4.0  (example Cranendonck maize)
--------------------------------------------------------------------------

>kicrop: ------------------- crop definitions ---------------------------
 2 2 2 2 2   2 2 2 2

- Kind of crop grown each year is maize.
  Crops have been defined in the input-file PLANT.INP.

>lsunit: ------------------- number of livestock ------------------------
   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

- Number of livestock units per hectare per year if the kind of crop is grassland.
  For this example there is no grassland, so dummy values should be given for
  9 years.

>matvar: ------------------- definition of materials ---------------------
 2
 1  3

- The composition of material nr 1 varies in time and is based on given N-total,
  P-total and organic matter fraction. N-mineral is divided over NO3-N and NH4-N
  according to default values given in Material.inp.
- Only the first material (cattle slurry, see Material.inp) is divided into
  three organic fractions with variable compositions in time.

>add001:-------------------- first addition -----------------------------
 102.
 1
  6    100.00   0   0 0.00
 112.

- At day number 102 (12-Apr-1974) the first addition takes place.
- Number of the added material is 6. One of the materials (MN) defined in the file
  MATERIAL.INP. In this case material 6 is inorganic N-fertilizer.
  Quantity of material added is 100 kg ha-1.
  The fertilizer is added to the reservoir on top of compartment 1.
  No ploughing.
  No volatilization of inorganic N-fertilizer is assumed.
- Time of next addition is day number 112 (22-Apr-1974).

>add002:-------------------- second addition ----------------------------
 1
  1  50000.00   0   0 0.50
 0.0430  0.0042  0.0023
 115.

- Number of the added materials is 1 (cattle slurry).
  Quantity of material added is 50000 kg ha-1.
  The cattle slurry is added to the reservoir on top of compartment 1.
  No ploughing.
  In this case 50% of the mineral part of the cattle slurry volatilizes.
- The content of organic matter in material nr 1 is 0.043 kg kg-1
  The content of N-total is 0.0042 kg kg-1
  The content of P-total is 0.0023 kg kg-1
- Time of next addition is day number 115 (25-Apr-1974).

>add003:-------------------- third addition -----------------------------
 1
  1      0.00   0   2 0.00
 0.0000  0.0000  0.0000
 469.

- Number of the added materials is 1 (cattle slurry).
- Quantity of material added is 0 kg ha-1. A dummy value has been given because
  the option of ploughing is used.
  The cattle slurry is added to the reservoir on top of compartment 1
  (dummy value).
  Ploughing of the first 2 compartments.
  In this case 0% of the mineral part of the cattle slurry volatilizes
  (dummy value).
```

```
- The contents of organic matter, N-total and P-total in material nr 1 is
  0.0 kg kg-1, 0.0 kg kg-1, 0.0 kg kg-1 respectively (dummy values).
- Time of next addition is day number 469 (14-Apr-1975).

>add004:

etc.... etc.....


>add023:
 1
 1 50000. 0 0  0.50
 0.079 0.0050 0.0019
 3037.
>add024:
 1
 1 0.0 0 2 0.0
 0.0 0.0 0.0
 9999.
```

Figure 38 The input-file MANAGEMENT.INP: data for example Cranendonck maize

(Last value for TINEAD (e.g. 9999) contains a dummy value which should be higher than the last simulated time step).

4.3.2 Results

Case Cranendonck Field 18: maize on a sandy soil

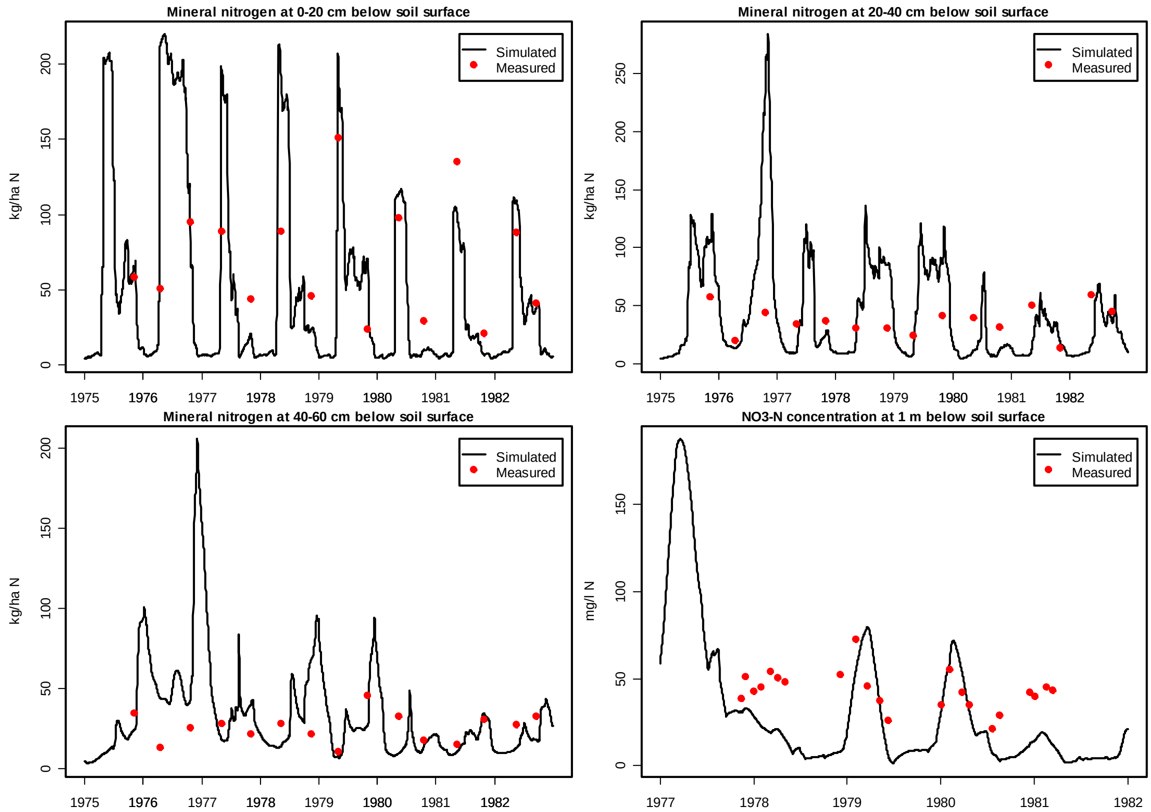

Figure 39 Measured and simulated NO_3-N concentrations at 1 m below soil surface and mineral nitrogen content at 3 different soil layers for maize

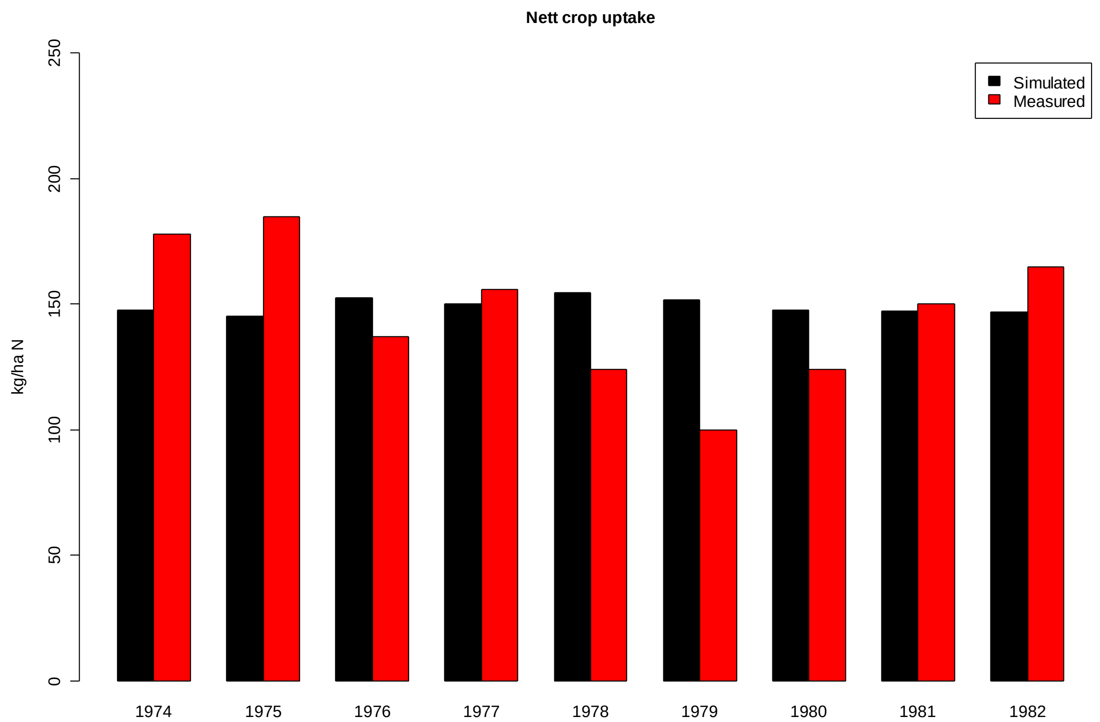

Figure 40 Measured and simulated nett crop uptake for maize

4.3.3 Balances

This section presents the content of water, organic matter and nitrogen balances and detailed organic transformations of the Cranendonck case. The presentation of these balances is achieved with the following procedure:

- With output options in the input file GENERAL.INP the output files BAWA//.OUT, BAOM//.OUT, BANH//.OUT, BANI//.OUT and BANO//.OUT are created.
- Besides the BA* files, balance table files are created. With the output options in the input file GENERAL.INP, the balance table files Ani_wa//.out, Ani_om//.out and Ani_n//.out are created.

At the position // a character string of 2 positions must be given to identify the set of the output files with mass balances, balance tables and organic transformations (see Chapter 3: input file GENERAL.INP).

Balances are created for each balance period.
This section gives only some balance table files and detailed organic transformations for the period 1-1-1982 to 31-12-1982.

Water, organic matter and nitrogen balance of the maize case (Case Cranendonck Field 18)

Soil profile MP: 0.00 - 1.00 m below soil surface

Output file Ani_waMP.bal:

```
Water balance (mm);   profile  top - 1.00m-ss;  period  365-1981/ 365-1982
==============================================================================
Input:                                   | Output:
==============================================================================
Rainfall                           644.9 | Interception                   46.0
Snowfall                             0.0 | Snow sublimation                0.0
Irrigation                           0.0 | Pond evaporation                0.0
                                         | Soil evaporation              162.0
                                         | Plant evaporation             286.7
Runon                                0.0 | Runoff_Pr                       0.0
Inundation                           0.0 | Runoff_L0                       0.0
                                         | Runoff_L1                       0.0
Infiltration from:                       | Drainage to:
- 3rd order                          0.0 | - 3rd order                     0.0
- 2nd order                          0.0 | - 2nd order                     0.0
- 1st order                          0.0 | - 1st order                     0.0
Bottom upw flux                    109.4 | Bottom downw flux             284.7
-----------------------------------------+------------------------------------
Total input                        754.3 | Total output                  779.4
==============================================================================
Storage change snow layer (+ = increase)                                   0.0
Storage change ponding layer (+ = increase)                                0.0
Storage change soil moisture (+ = increase)                              -25.0
Balance deviation                                                          0.0
==============================================================================
```

Output file Ani_omMP.bal:

```
Org.matter (kg/ha);   profile  top - 1.00m-ss;  period  365-1981/ 365-1982
==============================================================================
Input:          Fresh    Hu/bio   Diss. | Output:     Fresh    Hu/bio    Diss.
==============================================================================
Additions      3357.5       0.0   592.5 |
Redistrib         0.0       0.0     0.0 | Redistrib      0.0       0.0     0.0
Crop res.      1763.9                   |
Exudates        723.2                   |
Formation                3268.4  1339.2 | Dissoc.     6080.2    6401.3  1931.2
Irrigation                          0.0 |
Runon                               0.0 | Runoff_L0                        0.0
Inundation                          0.0 |
                                        | Runoff_L1                        0.0
Infiltration from:                      | Discharge to:
- 3rd order                         0.0 | - 3rd order                      0.0
- 2nd order                         0.0 | - 2nd order                      0.0
- 1st order                         0.0 | - 1st order                      0.0
Bottom upw flux                     0.0 | Bottom downw flux                2.5
----------------------------------------+-------------------------------------
Total input    5844.6    3268.4  1931.8 | Tot outp    6080.2    6401.3  1933.6
==============================================================================
Dissimilated                                        3555.7    4801.0  1448.4
==============================================================================
Final.present                                      10930.5  242036.8    43.2
Init.present                                       11166.1  245169.8    45.1
                                                   ---------------------------
Storage change                                      -235.6   -3133.0    -1.9
Input-Output                                        -235.6   -3133.0    -1.9
Balance deviation                                      0.0       0.0     0.0
==============================================================================
```

Output file Ani_nMP.bal:

```
Nitrogen   (kg/ha);   profile  top - 1.00m-ss;  period  365-1981/ 365-1982
==============================================================================
Input:           Org-N   Nh4-N   No3-N | Output:         Org-N   Nh4-N   No3-N
==============================================================================
Deposition dry            12.0     8.0 |
Deposition wet             8.2     5.0 |
Additions         59.3   190.8     0.0 | Volatilization           95.4
Redistrib          0.0     0.0     0.0 | Redistrib         0.0     0.0     0.0
Crop residues     14.1     0.0     0.0 | Crop uptake               0.0   175.5
Exudates          14.5                 |
Incorporation    144.9                 | Gross mineral.  351.0
Nett mineral.            206.1         | Immobilization            0.0
Nitrification                    322.0 | Nitrification           322.0
                                       | Denitrification                  84.6
Irrigation         0.0     0.0     0.0 | Runoff_Pr         0.0     0.0     0.0
Runon              0.0     0.0     0.0 | Runoff_L0         0.0     0.0     0.0
Inundation         0.0     0.0     0.0 |
                                       | Runoff_L1         0.0     0.0     0.0
Infiltration from:                     | Discharge to:
- 3rd order        0.0     0.0     0.0 | - 3rd order       0.0     0.0     0.0
- 2nd order        0.0     0.0     0.0 | - 2nd order       0.0     0.0     0.0
- 1st order        0.0     0.0     0.0 | - 1st order       0.0     0.0     0.0
Bottom upw flux    0.0     0.2     3.7 | Bot downw flux    0.0     1.4    29.6
---------------------------------------+--------------------------------------
Total input      232.7   417.3   338.7 | Total output    351.0   418.7   289.7
==============================================================================
Final.present solid/complex                             9728.5     3.6
Init.present solid/complex                              9846.8     4.2
                                                      ------------------------
Storage change solid/complex (+ = increase)             -118.3    -0.6
==============================================================================
Final.present solution                                     0.5     2.8    96.8
Init.present solution                                      0.5     3.6    47.8
                                                      ------------------------
Storage change solution (+ = increase)                     0.0    -0.8    49.0
==============================================================================
Input-Output                                            -118.3    -1.4    49.0
Balance deviation                                          0.0     0.0     0.0
==============================================================================
```

Soil profile TP: 0.00 - 3.60 m below soil surface

Output file Ani_waTP.bal:

```
Water balance (mm);   profile  top - 3.60m-ss;  period  365-1981/ 365-1982
==============================================================================
Input:                                   | Output:
==============================================================================
Rainfall                          644.9 | Interception                   46.0
Snowfall                            0.0 | Snow sublimation                0.0
Irrigation                          0.0 | Pond evaporation                0.0
                                        | Soil evaporation              162.0
                                        | Plant evaporation             286.7
Runon                               0.0 | Runoff_Pr                       0.0
Inundation                          0.0 | Runoff_L0                       0.0
                                        | Runoff_L1                       0.0
Infiltration from:                      | Drainage to:
- 3rd order                         0.0 | - 3rd order                     0.0
- 2nd order                         0.0 | - 2nd order                     0.0
- 1st order                         0.0 | - 1st order                     0.0
Bottom upw flux                    82.7 | Bottom downw flux             258.0
----------------------------------------+-------------------------------------
Total input                       727.6 | Total output                  752.6
==============================================================================
Storage change snow layer (+ = increase)                                  0.0
Storage change ponding layer (+ = increase)                               0.0
Storage change soil moisture (+ = increase)                             -25.0
Balance deviation                                                         0.0
==============================================================================
```

Output file Ani_omTP.bal:

```
Org.matter (kg/ha);   profile  top - 3.60m-ss;  period  365-1981/ 365-1982
==============================================================================
Input:          Fresh    Hu/bio   Diss. | Output:     Fresh    Hu/bio    Diss.
==============================================================================
Additions      3357.5       0.0   592.5 |
Redistrib         0.0       0.0     0.0 | Redistrib      0.0       0.0     0.0
Crop res.      1763.9                   |
Exudates        723.2                   |
Formation                3377.4  1339.2 | Dissoc.     6080.2    6835.3  1933.3
Irrigation                          0.0 |
Runon                               0.0 | Runoff_L0                        0.0
Inundation                          0.0 |
                                        | Runoff_L1                        0.0
Infiltration from:                      | Discharge to:
- 3rd order                         0.0 | - 3rd order                      0.0
- 2nd order                         0.0 | - 2nd order                      0.0
- 1st order                         0.0 | - 1st order                      0.0
Bottom upw flux                     0.0 | Bottom downw flux                0.4
----------------------------------------+-------------------------------------
Total input    5844.6    3377.4  1931.7 | Tot outp    6080.2    6835.3  1933.6
==============================================================================
Dissimilated                                        3555.7    5126.5  1450.0
==============================================================================
Final.present                                      10930.5  433864.8    45.1
Init.present                                       11166.1  437322.8    47.0
                                                   --------------------------
Storage change                                      -235.6   -3457.9    -1.9
Input-Output                                        -235.6   -3458.0    -1.9
Balance deviation                                      0.0       0.0     0.0
==============================================================================
```

Output file Ani_nTP.bal:

```
Nitrogen   (kg/ha);   profile  top - 3.60m-ss;  period  365-1981/ 365-1982
==============================================================================
Input:           Org-N   Nh4-N   No3-N | Output:         Org-N   Nh4-N   No3-N
==============================================================================
Deposition dry           12.0     8.0 |
Deposition wet            8.2     5.0 |
Additions         59.3  190.8     0.0 | Volatilization          95.4
Redistrib          0.0    0.0     0.0 | Redistrib        0.0     0.0     0.0
Crop residues     14.1    0.0     0.0 | Crop uptake              0.0   175.5
Exudates          14.5                |
Incorporation    147.0                | Gross mineral.  359.4
Nett mineral.           212.4         | Immobilization           0.0
Nitrification                   328.9 | Nitrification          328.9
                                      | Denitrification                119.3
Irrigation         0.0    0.0     0.0 | Runoff_Pr        0.0     0.0     0.0
Runon              0.0    0.0     0.0 | Runoff_L0        0.0     0.0     0.0
Inundation         0.0    0.0     0.0 |
                                      | Runoff_L1        0.0     0.0     0.0
Infiltration from:                    | Discharge to:
- 3rd order        0.0    0.0     0.0 | - 3rd order      0.0     0.0     0.0
- 2nd order        0.0    0.0     0.0 | - 2nd order      0.0     0.0     0.0
- 1st order        0.0    0.0     0.0 | - 1st order      0.0     0.0     0.0
Bottom upw flux    0.0    0.0     0.0 | Bot downw flux   0.0     3.1     0.0
--------------------------------------+---------------------------------------
Total input      234.8  423.4   341.9 | Total output   359.4   427.4   294.8
==============================================================================
Final.present solid/complex                          13437.2    15.3
Init.present solid/complex                           13561.8    17.4
                                                    -----------------------
Storage change solid/complex (+ = increase)           -124.6    -2.1
==============================================================================
Final.present solution                                   0.5    11.8   101.2
Init.present solution                                    0.5    13.8    54.0
                                                    -----------------------
Storage change solution (+ = increase)                   0.0    -1.9    47.2
==============================================================================
Input-Output                                          -124.6    -4.0    47.2
Balance deviation                                        0.0     0.0     0.0
==============================================================================
```

4.4 STONE: grazed grassland on a dry sandy soil

The stone model was developed for evaluating the effects of changes in the agricultural sector (e.g. changes in fertilizer recommendations and cropping patterns) and in policy measures that restrict fertilization levels on the leaching of N and P to ground water and surface waters. The system was in particular developed for evaluations at the national scale, and may also be applied at the regional scale.
N and P uptake by crops and input to the soil by crop residues is calculated using the QUAD-MOD model (ten Berge et al., 2000). The animo model is used for calculating the organic matter and nutrient cycling in the soil and the N and P transport to the groundwater and surface water systems. Within this system the results can be presented as maps of, for example, crop uptake rates, N and P accumulation in soils, nitrate concentrations in groundwater, phosphate contents of top soils and the N and P transport to surface waters.
In this example one single field of grassland on a dry sandy soil of the STONE plots from the southern part of the Netherlands is picked out.

The main characteristics of this field plot are:

- soil is classified as Podzolic, medium textured sandy soil;
- different fertilization levels with a temperate decrease in the course of time;
- land use is grazing grassland;
- a low groundwater level.

Manure-additions were given as different kinds of slurry with for every addition its own nitrogen and phosphorus fraction and artificial fertilizer.

In section 4.4.2 some results of the ANIMO model for this case are presented.
In section 4.4.3 the water and mass balances are given as they should be produced by the model ANIMO 4.0.
For more detailed information about the model input see also section 4.1.

4.4.1 Input files

GENERAL.INP

```
Filename:  GENERAL.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
----------------------------------------------------------------------------

>simopt:
 2 1 1 1 0

   - Hydrological parameters were simulated with the model SWAP.
   - The carbon, nitrogen and phosphorus cycle are simulated.
   - Aeration calculation by SONICG concept
   - Crop uptake simulated by QUAD-MOD (external crop module)
   - Simulation without macro pores

 >simtim:
 1986 0.0 2000 366.0

   - 15 years are simulated: the period 1 1 1986 through 31 12 2000.

>outscr:
 0 - Simulation-stage is not written to screen.

>outbal:
 3       - 3 balance series
'TP'     - The character string ‘TP’ is given (total profile)
 1 0 1 1 - Output of balances written to files BAWARP.OUT, BANHRP.OUT,
 0 22      BANIRP.OUT, BANORP.OUT, BAPPRP.OUT and BAPORP.OUT.
 -1      - Compartment 0 is the addition-reservoir on top of the model soil
'GP'       system. The bottom of compartment 22 is at 13 meter below the
 1 0 1 1   soil surface (defined by hydrological simulations).
 0 22      The balances are made up for 0-13 meter below the soil surface.
 1       - Each simulated time step balance terms are written.
 365.0   - The character string ‘GP’ is given
'RP'     - Output of balances written to files BAWAGP.OUT, BANHGP.OUT,
 1 0 1 1   BANIGP.OUT and BANOGP.OUT.
 0 6     - Compartment 0 is the addition-reservoir on top of the model
 1         soil system. The bottom of compartment 22 is at 13 meter
 365.0     below the soil surface. The balances are made up for 0-13
           meter below the soil surface.
         - Each simulated year one reset at the last day number of the
           year (365 or 366 for a leap year); this reset includes
           writing of balance-terms to files and initializing all
           balance terms at zero.
         - The character string ‘RP’ is given (root zone)
         - Output of balances written to files BAWARP.OUT, BANHRP.OUT,
           BANIRP.OUT and BANORP.OUT
         - Compartment 0 is the addition-reservoir on top of the model
           soil system. The bottom of compartment 6 is at 0.50 meter
           below the soil surface (root zone). The balances are made
           up for 0-0.50 meter below the soil surface.
         - Each simulated year 1 reset at day number 365; this reset
           includes writing of balance-terms to files and initializing
           all balance terms at zero.

>outsel:
 1 0 0 0 0  0 0 0 0 0  0 0 0 0 0
 0 0 0 0 0  0 0 0 0 0  0 0 0 0 0  0 0 0 0 0  0 1
 0 0
   - The files Nitrate.out and Discharge.out are created and filled
     with simulation results.

>outtot:
 0 1 10
   - At the time step 10 detailed output is written to output-file
     AnimoIntermediate.OUT.
```

Figure 41 The input-file GENERAL.INP: data for example grass on dry sand

MATERIAL.INP

```
Filename:   GENERAL.INP
Content: Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
------------------------------------------------------------------------

>defmat: ----------------- definition of materials ---------------------
 14
 0.0  0.0  0.0  0.0   0.0  0.0   1.0   1.0  1.0  1.0  1.0  1.0 1.0 1.0
 0.0  0.0  0.0  0.0   0.5  0.0   0.0   0.0  0.0  0.0  0.0  0.0 0.0 0.0
 0.0  0.0  0.0  0.0   0.5  0.0   0.0   0.0  0.0  0.0  0.0  0.0 0.0 0.0

- 14 materials are defined (4 different types of animal manure, 2 inorganic
  fertilizer, 2 different types of root material, 3 type of organic matter,
  1 type of grassland shoot material, 1 type of shoots of external crop and
  1 type of roots of external crop.) The animal manure materials are defined
  in the management.inp file
- Fractions of organic matter, NH4-N and NO3-N are given in the management.inp file.

 material nr 1 = cattle slurry;
 material nr 2 = pig slurry;
 material nr 3 = poultry slurry;
 material nr 4 = meadow manure;
 material nr 5 = N-fertilizer;
 material nr 6 = P-fertilizer;
 material nr 7 = roots of non-grassland;
 material nr 8 = roots of grassland;
 material nr 9 = organic matter in the subsoil;
 material nr 10 = organic matter in eutrophic peat;
 material nr 11 = organic matter in mesotrophic peat.
 material nr 12 = shoots of grassland;
 material nr 13 = shoots of external crop
 material nr 14 = roots of external crop

>orgmat: ----------------- definition of organic fractions -------------
 22
 0.00 0.82 0.18 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.09 0.91 0.00 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.06 0.52 0.42 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.00 0.74 0.26 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.5 0.5  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.5 0.5  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  1.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.33 0.67 0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.33 0.67 0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.8 0.2 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.25  0.25 0.25 0.25 0.0
0.0  0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.25
0.25  0.25 0.25
 0.00 0.41 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.09 0.45 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.06 0.26 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.00 0.37 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.50

- The organic part of each material consists of fractions; each fraction has it own
  decomposition rate and its own nitrogen content.
- Based on a different decomposition rate one can distinguish different fraction in each
  material, each fraction having its specific decomposition rate and nitrogen content.
```

```
   - Material 1-4: Decomposition rates and nitrogen contents of three fractions.
   - Material 5: Inorganic N-fertilizer: 100% mineral.
   - Material 6: Inorganic P-fertilizer: 100% mineral.
   - Material 7 and 8: 50% of the roots are slowly decomposing and 50% are fastly decomposing
   - Material 9: No further division into fractions.
   - Material 10 and 11: Calibrated with measured lysimeter-data (Berghuijs-van Dijk et al.,
1985).
   - Material 13 and 14: Dummy values must be given to indicate which fraction decomposes
     where. In the subroutine Root_extern, the fractions will be determined dynamically.
- Part of the fractions of the organic part of the materials that goes into solution.
   - Material 1-4:
      - Fraction 1: 100% dissolved organic matter.
      - Fraction 2: Half is defined as fresh organic matter (OS) the other half
        is defined as dissolved organic matter.
      - Fraction 3: 100% fresh organic matter.
   - Material 5-14: No dissolved parts.

The meaning of the organic fractions can be summarized as followed:

   organic fraction nr 1 = soluble, rapidly decomposing part of slurry
   organic fraction nr 2 = partly soluble, rapidly decomposing part of slurry
   organic fraction nr 3 = solid, slowly decomposing part of slurry
   organic fraction nr 4 = rapidly decomposing part of non-grassland roots
   organic fraction nr 5 = slowly decomposing part of non-grassland roots
   organic fraction nr 6 = very slowly decomposing organic matter
   organic fraction nr 7 = rapidly decomposing part of grassland shoots
   organic fraction nr 8 = slowly decomposing part of grassland shoots
   organic fraction nr 9 = rapidly decomposing part of grassland roots
   organic fraction nr 10= slowly decomposing part of grassland roots
   organic fraction nr 11= slowly decomposing, high N-content,eutrophic peat
   organic fraction nr 12= rapidly decomposing, low N-content,eutrophic peat
   organic fraction nr 13= slowly decomposing, mesotrophic peat
   organic fraction nr 14= rapidly decomposing, mesotrophic peat
   organic fraction nr 15= dummy value for part of shoots external crop
   organic fraction nr 16= dummy value for part of shoots external crop
   organic fraction nr 17= dummy value for part of shoots external crop
   organic fraction nr 18= dummy value for part of shoots external crop
   organic fraction nr 19= dummy value for part of roots external crop
   organic fraction nr 20= dummy value for part of roots external crop
   organic fraction nr 21= dummy value for part of roots external crop
   organic fraction nr 22= dummy value for part of roots external crop

- Humus fraction of the fresh organic matter does not pass the dissolved stage,
  but decomposes directly into humus.

>orgdec: ----------------- definition of rates ------------------------
 0.10 0.10 0.10 0.25 0.25  0.25 0.25 0.25 0.25 0.25  0.25 0.25 0.25 0.25 0.10
 0.10 0.10 0.10 0.10 0.10  0.10 0.10
 0.10 0.25  0.25
 0.5
 1.0 0.6 0.12 2.0 0.22 0.00553 2.0 0.22 2.0 0.22  0.001 0.0383 0.001 0.024
 100.0 6.00 100.0 6.00 100.0 6.00 100.0 6.00
 30.0 0.01 365.0 365.0
 0.06

- Assimilation factor of 0.10 for the manure fractions and crop residues of grassland
  (Groenendijk et al., 2004) and 0.25 for the fractions (Berghuijs-van Dijk et al., 1985).
  This parameter indicates the fraction of the decomposable fresh organic matter
  or exudates that can be converted to humus/biomass.
- Assimilation efficiency of dissolved organic matter is 0.10 (Groenendijk et al., 2004)
  and of humus/biomass and exudates all of 0.25.
- Reduction factor of 50% for microbiological transformations under oxygen limited
  situations.
- First order average decomposition rate for the organic fractions.
   - Fractions 1-3: Fractions used for material nr 1-4 (animal manure).
     Model-verification resulted in a calibration of the decomposition-rates
     for fraction 2 and 3 (fraction 1 has a dummy value since this fraction
     goes fully into solution).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6,11-14: Fraction used for organic material in subsoil.
   - Fraction 7-8: Fraction used for shoots of grassland (material nr 12).
   - Fraction 15-22: Fractions used for material nr 13 and 14, external crop.
- First order average decomposition rate for dissolved organic matter.
  Berghuijs-van Dijk et al. (1985) gives the value of 30, which was derived from
  lysimeter-experiments.
  First order average decomposition rate for humus of 0.01.
  First order average decomposition rate for exudates.
  Berghuijs-van Dijk et al. (1985): a high rate of 365, because of rapid
  decomposition.
  First order average nitrification rate. (Groenendijk et al., 2004)
- First order average denitrification rate. A value of 0.06 is based on the following
  assumption: in 10 days no more than 50% of the present nitrate can be denitrified.
```

```
>orgnit: ----------------- definition of N-contents --------------------
 0.12 0.07 0.02 0.008 0.008  0.01 0.05 0.019 0.02 0.0076  0.043 0.028 0.020 0.019
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.048   0.02

- Nitrogen fractions in organic matter.
   - Fraction 1-3: Fractions used for material nr 1-4 (animal manure).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6,11-14: Fraction used for organic material in subsoil.
   - Fraction 7-8: Fractions used for material 12 (shoots grassland).
   - Fraction 15-22: Dummy fractions used for material nr 13 and 14 (external crop).
- Maximal nitrogen fraction in humus. Value as given by Berghuijs-van Dijk et al. (1985).
  It corresponds to a C/N ratio of 14 (the carbon content of the material has been assumed
  to 0.58). This value 0.048 is added to the nitrogen fraction in the root zone layers.
  Below the root zone the nitrogen fraction is calculated from the given C/N ratio * 0.58
  (See Soil.inp).
- Nitrogen fraction in exudates. Value as given by Berghuijs-van Dijk et al. (1985).

>minpho: ----------------- definition of mineral P ---------------------
 0.0 0.0 0.0 0.0 0.0  1.0 0.0 0.0 0.0 0.0  0.0 0.0  0.0 0.0

- Material nr 1-4: mineral phosphorus is defined in the management.inp file.
- Material 5 and 7-14: contains no mineral phosphorus.
- Material 6: inorganic P-fertilizer contains 100% mineral phosphorus.


>orgpho: ----------------- definition of organic P fractions -----------
 0.012 0.007 0.002 0.001 0.001  0.00125 4.430E-03 3.068E-03 3.163E-03 1.786E-03
 0.0001 0.0006 0.0001 0.0006  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.006   0.0025

- Phosphorus fractions in organic matter. Derived from literature.
  Related to nitrogen fractions (1:10).
- Maximal phosphorus fraction in humus. Derived from literature. Related to NIFRHUMA (1:8).
- Phosphorus fraction in exudates; like POFR related to organic-N (1:8).

>sonicg:
  0.3 0.001 0.90

- The nitrate-N concentration for which the MM-function takes a value half of
  the optimal value is 0.3
- Multiplication factor for org. transformations at complete anaerobic conditions
  is set to 0.001 (Groenendijk et al., 2004).
- The critical value of water filled pore space for adjustment of original water
  response on organic transformation to lower values is set to 0.9

>sonic2:
  0.6

- The critical value of water filled pore space in sandy soils for adjustment of
  original water response on organic transformation to lower values is set to 0.6
```
Figure 42 The input-file MATERIAL.INP: data for example grass on dry sand

PLANT.INP

```
Filename:  PLANT.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
--------------------------------------------------------------------------

>cropdt:
 1

- One crop is defined in this file.

>crop01:
 5
 13 14
 2
   1.     1.
   1.     1.
 2
   0.     366.
   0.50   0.50
   0.     366.    0.0  260.0   30.0   0.1300   0.1250  200.0    5.0    1.0
 38.0 4.0

Plant parameters for grass with use of an external cropmodule (QUAD-MOD):
- Crop number 5 is defined as external crop (grass).
- Shoot material is 13 and root material is 14 for external crop
  (see input-file MATERIAL.INP).
- Number of data given for the amount of roots (NUAMRO).
  These data are used to simulate the decomposition of root material.
  For a realistic simulation the values should correspond to the values
  applied in the hydrological model.
- Array with Julian day numbers versus amount of roots.
- Number of data given for the root length (NULNRO)
- Array with Julian day numbers versus length of roots.
- Growing period during whole year.
  Areic mass of tubers harvested.
  Dummy values for the rest of the parameters. These parameters are not used
  because crop growth is determined in the external crop module QUAD-MOD.
```

Figure 43 The input-file PLANT.INP: data for example grass on dry sand

SOIL.INP

```
Filename:  SOIL.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
-------------------------------------------------------------------------

>profil:
12
0.02 0.2
0.2 0.25
0.5000

- Twelve soil horizons were distinguished.
- The thickness of the top of the soil compartment is set to 0.02 m;
  the thickness of the reservoir for additions to the soil system is set to 0.2 m.
- The fraction of runoff passing the surface reservoir is set to 0.2
  and for passing the first soil layer is set to 0.25.
- The depth of the initial root zone is 0.50 m.

>tempar:
 0.01726 0.05184
  9.0   9.0   3.7721

- Frequency of the early temperature wave; used in sinus and Fourier model.
  Used in sinus model: 2.0*3.14/365 = 0.01726.
  Thermal diffusivity; used in sinus and Fourier model.
  Huet (1982) gives this value (0.05184 m2 d-1 = 0.006 cm2 sec-1).
- Amplitude of yearly temperature wave (9 oC).
  Average yearly temperature (9 oC) at soil surface. Used in sinus model.
  Phase shift (3.7721 rad) of sinus wave.

>sophy1:
 2.5   3.0
 2.5   3.0
 2.5   3.0
 2.5   3.0
 2.5   3.0
 2.5   3.0
 7.5   4.0
 7.5   4.0
 7.5   4.0
 7.5   4.0
 7.5   4.0
 7.5   4.0
 0.1252  0.1252  0.1252  0.1252  0.1252  0.1252  0.1268  0.1268  0.1268  0.1268  0.1268
0.1268
 1346.0  1350.0  1353.0  1370.0  1469.0  1508.0  1540.0  1558.0  1585.0  1700.0  1700.0
1700.0
 17.0   17.0   17.0   24.0   24.0   24.0   24.0   24.0   20.0   30.0   30.0   30.0
 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0
74826.0 74826.0
 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0 74826.0
74826.0 74826.0

- Dummy values should be given, because aeration is calculated by the SONICG-
concept.
- Saturated conductivity of the root zone, for horizons 1 to 12.
- Dry bulk density for each horizon.
- C/N-ratio for each horizon. (C/N-ratio for the root zone are dummy's,
  because the nitrogen fraction of humus for the root zone are set to the
  maximum nitrogen fraction of humus.)
- Coefficient temperature response for organic and dissolved organic
  transformations by Arrhenius per horizon.

>sochem:
 5.46 5.38 5.38 5.38 5.38 5.38 5.38 5.46 5.46 5.46 5.46 5.46
 6.6169E-04  6.5058E-04  6.3947E-04  5.8824E-04  4.7084E-04  3.7073E-04  2.8400E-04
2.3946E-04
 1.9505E-04 5.0589E-05 5.0589E-05 5.0589E-05

- pH-H2O for each horizon.
- Values for the distribution coefficient for ammonium. The ratio between the
  amounts of NH4-N in the soil solution. Values are given for each horizon.
```

```
>soalfe:
1
 69.0 69.0 70.0 70.0 68.0 62.0 56.0 49.0 41.0 129.0 128.0 129.0

- Sum of Al and Fe per horizon is specified.

>nisand:
 1 1 1 1 1 1 1 1 1 1 1 1

- Whole profile is sandy
```

Figure 44 The input-file SOIL.INP: data for example grass on dry sand

CHEMPAR.INP

```
Filename:  CHEMPAR.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
--------------------------------------------------------------------------

>chedef: ----------------- definition of chemical system ---------------
 2       ! optcxfa: langmuir
 1       ! ncxfa:   1 equilibrium sorption site
 3       ! optcxsl: freundlich
 3       ! ncxsl:   3 non equilibrium sorption site
 0       ! optpr:   non equilibrium precipitation

- Option of equilibrium sorption: Langmuir.
- Number of sites for equilibrium sorption: 1.
- Option for non equilibrium sorption: Freundlich.
- Number of sites for non equilibrium sorption: 3.
- Option for precipitation model: Instantaneous.

>chesor: ----------------- sorption variables -------------------------
 1                                 ! optcxho: sorption parameters for w
 0.0  5.167E-6   300.0  0.0  0.0   ! pacxfaho(1-5,1)
 0.300                             ! parkd(1)
 0.0  0.0  0.0  11.870E-6  0.5357  ! pacxslho(1-5,1)
 1.17550  0.011755                 ! recfads(1), recfdes(1)
 0.0  0.0  0.0   4.667E-6  0.1995  ! pacxslho(1-5,2)
 0.03340  0.000334                 ! recfads(2), recfdes(2)
 0.0  0.0  0.0   9.711E-6  0.2604  ! pacxslho(1-5,3)
 0.00144  0.0000144                ! recfads(3), recfdes(3)

- Option for input of sorption parameters per horizon:
  the parameters PACXFAHO - RECFDESHO are given for whole soil profile.
- In this example the following parameters for each equilibrium sorption site
  were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]: dummy value
     Langmuir maximum sorption amount = 5.167E-6 [kg m-3]
     Langmuir sorption coefficient    = 300.0 [m3 kg-1]
     Freundlich sorption constant     = 0.0 [-]: dummy value
     Freundlich sorption exponent     = 0.0 [-]: dummy value
- Langmuir desorption coefficient     = 0.30 [d-1]
- In this example the following parameters for the first non equilibrium sorption
  site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount = 0.0 [kg m-3]
     Langmuir sorption coefficient    = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 11.870E-6 [-]
     Freundlich sorption exponent     = 0.5357 [-]
   - First order rate constant of adsorption for the first
     non equilibrium sorption site    = 1.1755 [d-1]
     First order rate constant of desorption for the first
     non equilibrium sorption site    = 0.011755 [d-1]
```

```
- In this example the following parameters for the second non equilibrium sorption
  site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount = 0.0 [kg m-3]
     Langmuir sorption coefficient    = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 4.667E-6 [-]
     Freundlich sorption exponent     = 0.1995 [-]
   - First order rate constant of adsorption for the second
     non equilibrium sorption site    = 0.0334 [d-1]
     First order rate constant of desorption for the second
     non equilibrium sorption site    = 0.000334 [d-1]

- In this example the following parameters for the third non equilibrium sorption
  site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount = 0.0 [kg m-3]
     Langmuir sorption coefficient    = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 9.711E-6 [-]
     Freundlich sorption exponent     = 0.2604 [-]
   - First order rate constant of adsorption for the third
     non equilibrium sorption site    = 0.00144 [d-1]
     First order rate constant of desorption for the third
     non equilibrium sorption site    = 0.0000144 [d-1]

>chepre: ----------------- precipitation variables ---------------------
 0.01     ! recfpr

- First order rate constant for kinetic precipitation: 0.01 [d-1]

>chebuf: ----------------- buffer concentration ------------------------
 0        ! optcobu : cobuho calculated in subr. INICALC_P with given pH
 0.05     ! cobuho(1)

- Option for input of buffer concentration:
  variable COBUHO is determined with pH\Ceq relation.
- Buffer concentration for phosphorus in solution: 0.05 [kg m-3]

Data were derived by Schoumans (1995).
```
Figure 45 The input-file CHEMPAR.INP: data for example grass on dry sand

BOUNDARY.INP

```
Filename:  BOUNDARY.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
--------------------------------------------------------------------------

>optibc:
     0     0

- Runon and irrigation concentration data are not given per time step

>topbou:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0

 53.704201 54.190201 53.625702 51.967400 54.494202
 52.712002 50.212799 49.475899 44.903900 41.842300
 40.801601 39.877899 39.574001 37.735600 35.389999

 13.078400 15.278400 13.798200 13.325000 12.128800
 13.065600 11.944300 11.910400 11.768000 11.232700
 10.655800 10.185600 10.869700 11.375100 10.083000

    0.0 0.0
    0.0
    0.0 0.0
    0.0
    0.0 0.0
    0.0
    0.0 0.0
    0.0

- Concentrations of precipitation of NH4-N,NO3-N and PO4-P are all set to
  0.0 kg m-3 for each year.
  In the STONE project the N precipitation is added to the dry deposition.
  The P deposition is assumed zero
- Atmospheric dry deposition of NH4-N
- Atmospheric dry deposition of NO3-N
- Concentrations of NH4-N, NO3-N and PO4-P in runon are set to 0.0.
- Concentration of dissolved organic matter, dissolved organic nitrogen
  and dissolved organic phosphorus in runon are set to 0.0.
  Not relevant for this field because runon does not occur in this case.
- Concentration of NH4-N, NO3-N and PO4-P in irrigation is set to 0.0.
- Concentration of dissolved organic matter, dissolved organic nitrogen
  and dissolved organic phosphorus in irrigation are set to 0.0.

>latbou:
    2.0E-04    9.0E-03
    0.0
    0.0 0.0
    0.0

- Concentration of infiltrating drain water:
   - NH4-N: 2.0E-04 mg.l-1
     NO3-N: 9.0E-03 mg.l-1
   - PO4-P: 0.0     mg.l-1
   - DOM  : 0.0     mg.l-1
     DON  : 0.0     mg.l-1
   - DOP  : 0.0     mg.l-1

>botbou:
    2.01E-03    1.00E-04
    3.20E-04
    4.90E-04    5.00E-05
    1.30E-04

- Concentration of incoming seepage water across lower boundary:
   - NH4-N: 2.01E-03 mg.l-1
     NO3-N: 1.00E-04 mg.l-1
   - PO4-P: 3.20E-04 mg.l-1
   - DOM  : 4.90E-04 mg.l-1
     DON  : 5.00E-05 mg.l-1
   - DOP  : 1.30E-04 mg.l-1
```

Figure 46 The input-file BOUNDARY.INP: data for example grass on dry sand

INITIAL.INP

```
Filename:   INITIAL.INP
Content: Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
--------------------------------------------------------------------------

>moistf:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0

- Moisture fractions of the compartments 1 to NL at the beginning of a time step.
  In this case, dummy values have been used, because hydrology is simulated by Swap.

>ammoni:
 1.913780E-03 0.0
 4.077826E-03 4.186617E-03 4.015842E-03 3.078037E-03 2.050338E-03
 1.346492E-03 8.781241E-04 4.054563E-04 9.127618E-05 1.125775E-05
 8.527628E-06 4.038795E-05 3.873700E-05 3.108114E-05 2.722103E-05
 2.570811E-05 2.659096E-05 2.889878E-05 2.974590E-05 2.843840E-05
 3.367369E-05 6.640128E-05

-  Concentrations  of  NH4-N  in  the  top  layer  and  compartments  0  to  NL  (where  the  top
   layer is the addition reservoir and layer 0 the layer reserved for ponding).

>nitrat:
 6.050786E-04 0.0
 4.712529E-03 2.699141E-02 4.351960E-02 5.843322E-02 8.295610E-02
 9.674020E-02 9.614293E-02 7.854205E-02 4.395880E-02 2.374819E-02
 1.432275E-02 1.171905E-02 1.553989E-02 2.007706E-02 2.268844E-02
 2.311376E-02 2.093454E-02 1.776071E-02 1.571320E-02 1.848977E-02
 1.634177E-02 7.724794E-03

-  Concentrations  of  NO3-N  in  the  top  layer  and  compartments  0  to  NL  (where  the  top
   layer is the addition reservoir and layer 0 the layer reserved for ponding).

>orgexu:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0

- Exudate content of compartments 1 to NL. The amount of exudates present has been estimated
as 0.0 kg m-2. Low amounts of exudates and high decomposition rates make this acceptable.

>humexu:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0

- Amount of humus from exudates present in compartments 1 to NL. HUEX, HUOS and OS
  are the main organic components in the model ANIMO.
  OS is the fresh organic matter; HUEX and HUOS together form humus.
  OS decomposes with rates RECFAV (1-NF), HUEX and HUOS both decompose with the rate RECFHUAV.

>orgfsh:
 0.0 2.273597E-01 6.760752E-01 0.0 0.0 0.0 0.0 0.0 0.0 9.993884E-05
 0.0 0.0 0.0 0.0 1.417068E-06 4.761470E-04 2.404906E-03 7.964306E-02 2.398658E-07 7.189233E-05
 3.607206E-04 1.194561E-02
 0.0 1.050985E-01 3.297904E-01 0.0 0.0 0.0 0.0 0.0 0.0 3.039262E-04
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 4.353453E-07 1.870932E-04
 6.558648E-04 2.444376E-02
 0.0 5.289007E-02 1.664120E-01 0.0 0.0 0.0 0.0 0.0 0.0 1.652941E-04
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.692085E-07 9.724223E-05
 2.559989E-04 1.197962E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.568110E-04
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.459452E-07 1.008043E-04
 2.213729E-04 1.184937E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 2.751088E-04
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 2.393780E-07 2.177266E-04
 3.643647E-04 2.340859E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3.399731E-04
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 2.678647E-07 3.983178E-04
 4.100915E-04 3.477851E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
```

```
- Amount of fresh organic matter present in compartments 1 to NL for
  fractions 1 to NF.

>humorg:
  4.028112 5.305423 2.576244 2.274299 3.799537
  4.324667 1.871970 2.035145 1.583405 2.614442E-01
  2.615069E-01 4.037206E-01 4.252166E-01 4.490052E-01 4.589171E-01
  6.118910E-01 7.648602E-01 7.648568E-01 1.529709 3.059373
  3.059349  6.118546

- Amount of humus from fresh organic matter and dissolved organic matter
  present in compartments 1 to NL (see parameter HUEX).

>orgsol:
 4.500471E-04 0.0
 8.566487E-02 3.016644E-01 4.024669E-01 4.525610E-01 4.520594E-01
 3.883454E-01 3.052644E-01 1.686199E-01 4.658310E-02 8.560599E-03
 7.438120E-03 3.306386E-02 3.165982E-02 2.261519E-02 1.627992E-02
 1.230996E-02 1.011027E-02 9.231618E-03 8.347221E-03 5.837438E-03
 4.573976E-03 4.402461E-03

 3.150329E-05 0.0
 2.791058E-03 1.147351E-02 1.623531E-02 1.874647E-02 1.798950E-02
 1.411627E-02 1.055368E-02 5.533607E-03 1.441769E-03 2.516047E-04
 2.131549E-04 9.328811E-04 8.938797E-04 6.550463E-04 4.943704E-04
 3.898016E-04 3.204215E-04 2.854772E-04 2.492066E-04 1.654044E-04
 1.172992E-04 9.952265E-05

- Concentration of dissolved organic matter (including addition reservoir
  and LN=0).
  Concentration of dissolved organic nitrogen (including addition reservoir
  and LN=0).

>orgpla:
 0.0 0.0 7.789475E-02
 7.752563E-03

- Amount of shoots, roots, initial nitrogen uptake and initial phosphorus uptake.

>inipho:
     1
 9.316226E-05 0.0
 5.316515E-03 3.370383E-03 2.457369E-03 8.927803E-04 3.514737E-04
 6.682907E-04 2.116918E-04 1.047376E-04 7.527688E-05 5.217563E-05
 5.104463E-05 5.051320E-05 5.020099E-05 5.005639E-05 5.000020E-05
 5.000006E-05 5.000005E-05 5.000003E-05 5.000008E-05 5.000005E-05
 5.000002E-05 5.000002E-05
 0.0
 2.949519E-01 2.419830E-01 2.076699E-01 1.046792E-01 4.923197E-02
 8.067902E-02 2.660921E-02 1.201683E-02 7.415422E-03 1.746308E-02
 1.709024E-02 1.691497E-02 1.681197E-02 1.663431E-02 1.661591E-02
 1.661587E-02 1.661587E-02 1.661586E-02 1.674569E-02 1.674568E-02
 1.674567E-02 1.674567E-02
 0.0
 6.816266E-02 5.236152E-02 4.495618E-02 2.640714E-02 1.672202E-02
 2.210152E-02 1.099921E-02 6.682823E-03 4.767804E-03 1.322318E-02
 1.306953E-02 1.299586E-02 1.295271E-02 1.283246E-02 1.282474E-02
 1.282472E-02 1.282472E-02 1.282472E-02 1.292492E-02 1.292492E-02
 1.292491E-02 1.292491E-02
 0.0
 1.556269E-01 1.392143E-01 1.328550E-01 1.098856E-01 9.522010E-02
 1.014649E-01 7.431408E-02 5.721311E-02 4.561953E-02 1.431225E-01
 1.424998E-01 1.422060E-01 1.420282E-01 1.408453E-01 1.408126E-01
 1.408125E-01 1.408125E-01 1.408125E-01 1.419126E-01 1.419126E-01
 1.419126E-01 1.419126E-01
 0.0
 2.266673E-01 1.956284E-01 1.831197E-01 1.434874E-01 1.190923E-01
 1.332639E-01 9.070075E-02 6.753276E-02 5.302756E-02 1.632636E-01
 1.623847E-01 1.619779E-01 1.617202E-01 1.603466E-01 1.603004E-01
 1.603004E-01 1.603004E-01 1.603004E-01 1.615528E-01 1.615528E-01
 1.615528E-01 1.615528E-01
 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 3.150330E-06 0.0
 2.835821E-04 1.137443E-03 1.603593E-03 1.849774E-03 1.773220E-03
 1.392401E-03 1.036619E-03 5.409959E-04 1.404658E-04 2.447276E-05
 2.187343E-05 9.647953E-05 9.223593E-05 6.722599E-05 5.037028E-05
 3.950463E-05 3.254917E-05 2.925985E-05 2.600533E-05 1.773651E-05
 1.310658E-05 1.173645E-05

- INPO = 1: variables COPO, AMCXFA, AMCXSL and AMPOPR are given.
- Concentration of phosphorus in liquid phase in the top layer and
  compartments 0 to NL.
- Adsorbed equilibrium mass concentration of phosphorus in the soil system;
  given for equilibrium sites 1-NCXFA (1) and compartments 0-NL.
- Adsorbed non equilibrium mass concentration of phosphorus in the soil system;
```

```
  given for non equilibrium sites 1-NCXSL (3) and compartments 0-NL.
- Precipitated mass concentration of phosphorus in the soil system;
  given for model compartments 0-NL.
- Concentration of dissolved organic phosphorus in liquid phase in the top layer
  and compartments 0 to NL.
```

Figure 47 The input-file INITIAL.INP: data for example grass on dry sand

MANAGMENT.INP

```
Filename:   MANAGEMENT.INP
Content: Input for ANIMO-version 4.0 (Case STONE plot 5617 grassland on dry sand)
------------------------------------------------------------------------

>kicrop:
 5 5 5 5 5  5 5 5 5 5  5 5 5 5 5

- Kind of crop grown each year is external crop (grass).
  Crop has been defined in the input-file PLANT.INP.

>lsunit:
 3.39 3.25 3.06 3.11 3.29  3.36 3.25 3.15 4.28  3.05 2.98 2.65 2.84 2.49 2.37

- Number of livestock units per hectare per year.

>matvar:
 1
 4 3

- Material composition varies in time and is based on given OM, N and P fractions.
- 4 materials with variable compositions
  3 organic fractions with variable compositions

>add001:
 5.0
 3
 1 1833.794 3 0 0.0
 0.06250 0.0012898 0.0 0.0005170
 0.0 0.4182595 0.5817405
 0.0 0.2091297 0.0
 2 811.761 3 0 0.0
 0.06250 0.0019670 0.0 0.0016381
 0.0 0.8588688 0.1411311
 0.0 0.4294344 0.0
 3 564.983 3 0 0.0
 0.06250 0.0014858 0.0 0.0015704
 0.0 0.6903281 0.3096719
 0.0 0.3451641 0.0
 15.0

- At day number 5 (05-Jan-1986) the first addition takes place.
- 3 materials are added this time step
   - Number of the first added material 1 is cattle slurry.
     (defined in the file MATERIAL.INP.)
     Quantity of material added is 1833.794 kg ha-1.
     The cattle slurry is added to the first 3 compartments of the soil profile.
     No ploughing.
     In this case, 0% of the mineral part of the cattle slurry volatilizes.
   - The organic matter content is 0.06250
     The mineral NH4-N content is 0.0012898
     The mineral NO3-N content is 0.0
     The mineral P content is 0.0005170
   - The mass fractions in the solid organic part of the cattle slurry are:
     0.0 0.4182595 0.5817405
     The dissolved mass fractions in the solid organic part of the cattle slurry are:
     0.0 0.2091297 0.0
   - Number of the second added material 2 is pig slurry.
     Quantity of material added is 811.761 kg ha-1.
     The pig slurry is added to the first 3 compartments of the soil profile.
     No ploughing.
     In this case, 0% of the mineral part of the pig slurry volatilizes.
   - The organic matter content is 0.06250
     The mineral NH4-N content is 0.0019670
     The mineral NO3-N content is 0.0
     The mineral P content is 0.0016381
   - The mass fractions in the solid organic part of the pig slurry are:
     0.0 0.8588688 0.1411311
     The dissolved mass fractions in the solid organic part of the pig slurry are:
     0.0 0.4294344 0.0
   - Number of the third added material 3 is poultry slurry.
     Quantity of material added is 564.983 kg ha-1.
     The poultry slurry is added to the first 3 compartments of the soil profile.
```

```
     No ploughing.
     In this case, 0% of the mineral part of the poultry slurry volatilizes.
   - The organic matter content is 0.06250
     The mineral NH4-N content is 0.0014858
     The mineral NO3-N content is 0.0
     The mineral P content is 0.0015704
   - The mass fractions in the solid organic part of the poultry slurry are:
     0.0 0.6903281 0.3096719
     The dissolved mass fractions in the solid organic part of the poultry slurry are:
     0.0 0.3451641 0.0
- Time of next addition is day number 15 (15-Jan-1986).

>add002:
 3
 1 1833.794 3 0 0.0
 0.06250 0.0012898 0.0 0.0005170
 0.0 0.4182595 0.5817405
 0.0 0.2091297 0.0
 2 811.761 3 0 0.0
 0.06250 0.0019670 0.0 0.0016381
 0.0 0.8588688 0.1411311
 0.0 0.4294344 0.0
 3 564.983 3 0 0.0
 0.06250 0.0014858 0.0 0.0015704
 0.0 0.6903281 0.3096719
 0.0 0.3451641 0.0
 25.0

- and so on...

>add003:
etc.... etc....
>add405:
 1
 4 1265.743 0 0 0.0
 0.06250 0.0036045 0.0 0.0005695
 0.0 0.3689562 0.6310437
 0.0 0.1844781 0.0
 9999.9
```

Figure 48 The input-file MANAGEMENT.INP: data for example grass on dry sand

CROP_EXT.INP

```
    nishmi     nishma     niromi     niroma     poshmi     poshma     poromi     poroma
0.2181E-01 0.2352E-01 0.2181E-01 0.2352E-01 0.2270E-02 0.2270E-02 0.2270E-02 0.2270E-02
year-mo-da,Ntotuptake,Ptotuptake,DMcressurf,N-cressurf,P-cressurf,DMcresbott,N-cresbott,P-cresbott
1986-01-01,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-01-02,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-01-03,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-02-01,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-02-02,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-02-03,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-03-01,0.0000E+00,0.0000E+00,5.2589E+01,1.2314E+00,1.1939E-01,7.8883E+01,1.8471E+00,1.7909E-01
1986-03-02,0.0000E+00,0.0000E+00,1.1505E+02,2.6939E+00,2.6120E-01,1.7258E+02,4.0409E+00,3.9179E-01
1986-03-03,0.0000E+00,0.0000E+00,1.4275E+02,3.3425E+00,3.2408E-01,2.1412E+02,5.0138E+00,4.8612E-01
1986-04-01,7.5519E+00,7.3459E-01,1.4546E+02,3.4061E+00,3.3024E-01,2.1820E+02,5.1091E+00,4.9536E-01
etc.... etc....
2000-10-01,2.0218E+01,2.0505E+00,2.4841E+02,5.5791E+00,5.6397E-01,3.7262E+02,8.3687E+00,8.4595E-01
2000-10-02,1.1284E+01,1.1444E+00,2.3407E+02,5.2569E+00,5.3140E-01,3.5110E+02,7.8854E+00,7.9710E-01
2000-10-03,0.0000E+00,0.0000E+00,2.3998E+02,5.3897E+00,5.4482E-01,3.5997E+02,8.0846E+00,8.1723E-01
2000-11-01,0.0000E+00,0.0000E+00,2.0183E+02,4.5328E+00,4.5821E-01,3.0274E+02,6.7993E+00,6.8731E-01
2000-11-02,0.0000E+00,0.0000E+00,1.8621E+02,4.1820E+00,4.2274E-01,2.7931E+02,6.2730E+00,6.3411E-01
2000-11-03,0.0000E+00,0.0000E+00,1.7081E+02,3.8362E+00,3.8778E-01,2.5621E+02,5.7543E+00,5.8167E-01
2000-12-01,0.0000E+00,0.0000E+00,1.5482E+02,3.4770E+00,3.5148E-01,2.3223E+02,5.2155E+00,5.2722E-01
2000-12-02,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
2000-12-03,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00

- Minimum nitrogen fraction in shoots is 0.2181E-01
  Maximum nitrogen fraction in shoots is 0.2352E-01
  Minimum nitrogen fraction in roots is 0.2181E-01
  Maximum nitrogen fraction in roots is 0.2352E-01
  Minimum phosphor fraction in shoots is 0.2270E-02
  Maximum phosphor fraction in shoots is 0.2270E-02
  Minimum phosphor fraction in roots is 0.2270E-02
  Maximum phosphor fraction in roots is 0.2270E-02

Dynamic part of the input file
- Date is given in Year Month and decade number (1-3) The first 6 decades no N or P uptake
  and no Crop losses take place. From the seventh decade there are crop losses of organic
  matter, nitrogen and phosphorus of shoots and roots until the 34th decade.
  From the tenth decade there is some nitrogen and phosphorus uptake until the 29th decade.
- This applies to every year.
```

Figure 49 The input-file CROP_EXT.INP: data for example grass on dry sand

4.4.2 Results

Case grass on dry sand Plot 5617: grass on a sandy soil

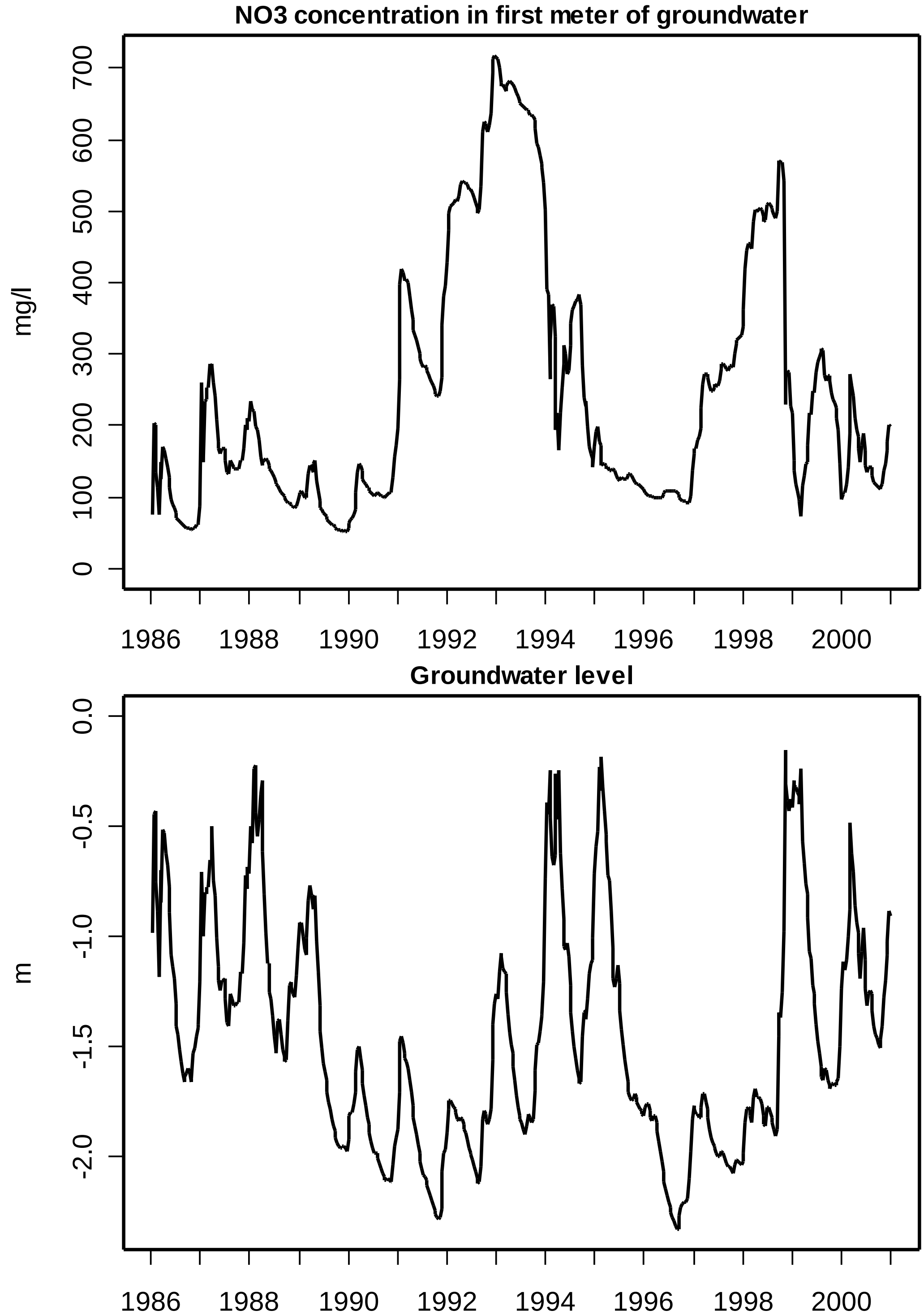

Figure 50 Simulated groundwater level and NO_3 concentrations at first meter of groundwater level for grass on dry sand

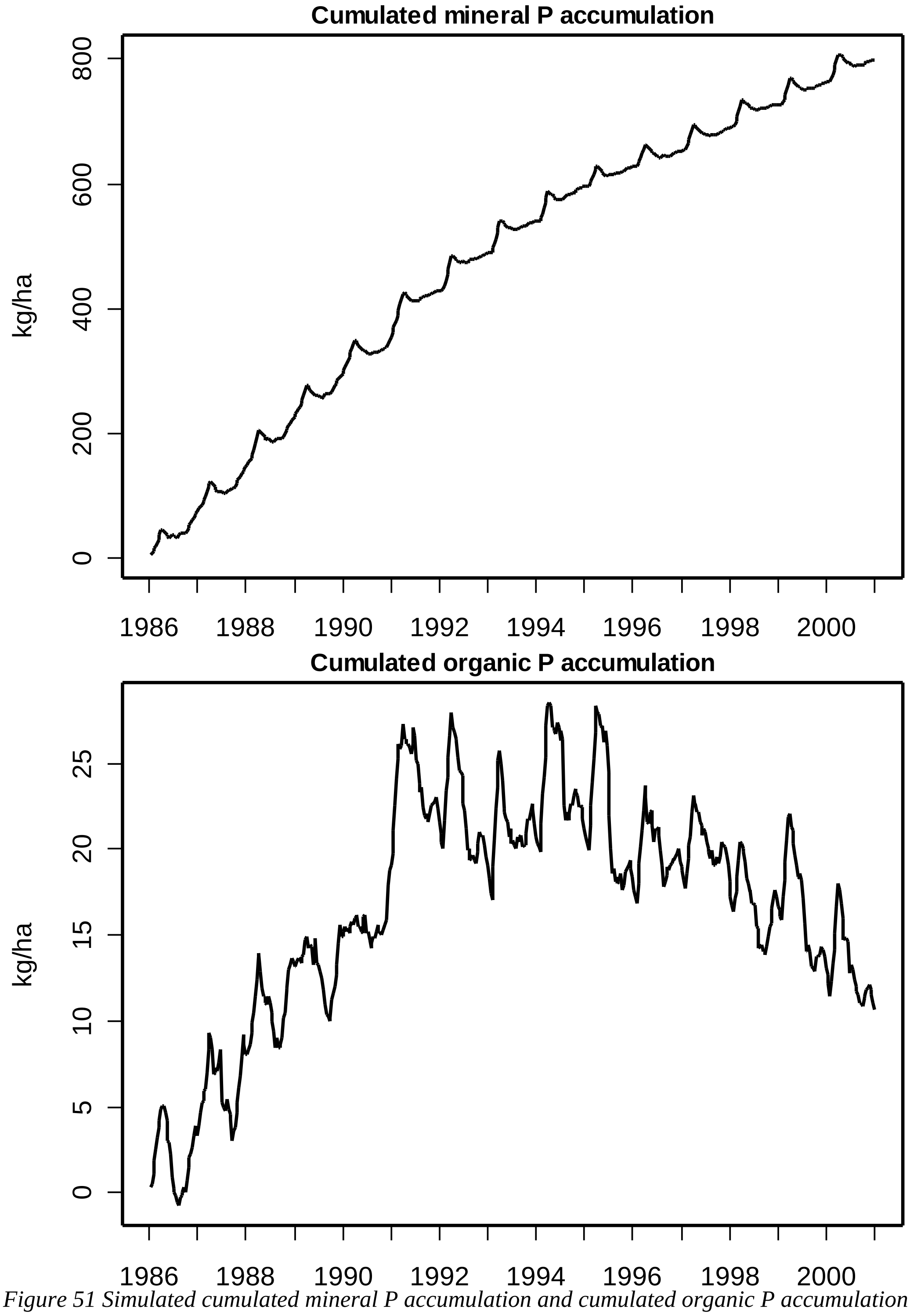

Figure 51 Simulated cumulated mineral P accumulation and cumulated organic P accumulation from the start of the simulation period (01-01-1986) for grass on dry sand

4.4.3 Balances

This section presents the content of water, organic matter, nitrogen and phosphorus of the grass on dry sand case. The presentation of these balances is achieved with the following procedure:

- With output options in the input file GENERAL.INP the output files BAWA//.OUT, BANH//.OUT, BANI//.OUT, BANO//.OUT, BAPO//.OUT and BAPP//.OUT are created.
- Besides the BA* files, balance table files are created. With the output options in the input file GENERAL.INP, the balance table files Ani_wa//.out, Ani_n//.out and Ani_p//.out are created.

At the position // a character string of 2 positions must be given to identify the set of the output files with mass balances, balance tables and organic transformations (see Chapter 3: input file GENERAL.INP).

Balances are created for each balance period.
This section gives only some balance table for the period 1-1-2000 to 31-12-2000.

Water, nitrogen and phosphorus balance of the grass on dry sand case (Case STONE plot 5617)

Soil profile GP: 0.00 - 13.00 m below soil surface

Output file Ani_waGP.bal:

```
Water balance (mm);   profile  top -13.00m-ss;  period  365-1999/ 366-2000
==============================================================================
Input:                                  | Output:
==============================================================================
Rainfall                          905.6 | Interception                   105.5
Snowfall                           10.7 | Snow sublimation                 0.3
Irrigation                          0.0 | Pond evaporation                 0.0
                                        | Soil evaporation               103.8
                                        | Plant evaporation              387.5
Runon                               0.0 | Runoff_Pr                        0.0
Inundation                          0.0 | Runoff_L0                        0.0
                                        | Runoff_L1                        0.0
Infiltration from:                      | Drainage to:
- 3rd order                         0.0 | - 3rd order                      8.5
- 2nd order                         0.0 | - 2nd order                      4.6
- 1st order                         0.1 | - 1st order                      6.2
Bottom upw flux                     0.0 | Bottom downw flux              256.2
----------------------------------------+-------------------------------------
Total input                       916.4 | Total output                   872.6
==============================================================================
Storage change snow layer (+ = increase)                                   2.7
Storage change ponding layer (+ = increase)                                0.0
Storage change soil moisture (+ = increase)                               41.1
Balance deviation                                                          0.0
==============================================================================
```

Output file Ani_nGP.bal:

```
Nitrogen   (kg/ha);   profile  top -13.00m-ss;  period  365-1999/ 366-2000
=============================================================================
Input:            Org-N   Nh4-N   No3-N | Output:        Org-N   Nh4-N   No3-N
=============================================================================
Deposition dry             35.5    10.1 |
Deposition wet              0.0     0.0 |
Additions         174.8   350.4   164.8 | Volatilization           0.0
Redistrib           0.0     0.0     0.0 | Redistrib        0.0     0.0     0.0
Crop residues     354.8     0.0     0.0 | Crop uptake            310.1   435.4
Exudates            0.0                 |
Incorporation     128.3                 | Gross mineral.  680.2
Nett mineral.             551.9         | Immobilization           0.0
Nitrification                     628.9 | Nitrification          628.9
                                        | Denitrification                528.9
Irrigation          0.0     0.0     0.0 | Runoff_Pr        0.0     0.0     0.0
Runon               0.0     0.0     0.0 | Runoff_L0        0.0     0.0     0.0
Inundation          0.0     0.0     0.0 |
                                        | Runoff_L1        0.0     0.0     0.0
Infiltration from:                      | Discharge to:
- 3rd order         0.0     0.0     0.0 | - 3rd order      0.1     0.0     4.2
- 2nd order         0.0     0.0     0.0 | - 2nd order      0.0     0.0     2.0
- 1st order         0.0     0.0     0.0 | - 1st order      0.0     0.0     1.4
Bottom upw flux     0.0     0.0     0.0 | Bot downw flux   0.7     0.3    10.9
----------------------------------------+------------------------------------
Total input       657.9   937.8   803.8 | Total output   681.0   939.2   982.8
=============================================================================
Final.present solid/complex                            16271.5     5.0
Init.present solid/complex                             16293.2     6.0
                                                      -----------------------
Storage change solid/complex (+ = increase)              -21.7    -1.0
=============================================================================
Final.present solution                                    23.1     4.8  1113.1
Init.present solution                                     24.5     5.2  1292.0
                                                      -----------------------
Storage change solution (+ = increase)                    -1.4    -0.4  -179.0
=============================================================================
Input-Output                                             -23.1    -1.5  -179.0
Balance deviation                                          0.0     0.0     0.0
=============================================================================
```

Output file Ani_pGP.bal:

```
Phosphorus (kg/ha);   profile  top -13.00m-ss;  period  365-1999/ 366-2000
==============================================================================
INPUT:                    ORG-P   PO4-P | OUTPUT:                   ORG-P   PO4-P
==============================================================================
Deposition wet                     0.00 |
Additions                  17.48  56.77 |
Redistrib                   0.00   0.00 | Redistrib                  0.00    0.00
Crop residues              35.87        | Crop uptake                       75.18
Exudates                    0.00        |
Incorporation              16.03        | Gross mineral.            71.74
Net mineral.                      55.70 | Immobilization                     0.00
Irrigation                  0.00   0.00 | Runoff_Pr                  0.00    0.00
Runon                       0.00   0.00 | Runoff_L0                  0.00    0.00
Inundation                  0.00   0.00 |
                                        | Runoff_L1                  0.00    0.00
Infiltration from:                      | Discharge to:
- 3rd order                 0.00   0.00 | - 3rd order                0.01    0.01
- 2nd order                 0.00   0.00 | - 2nd order                0.00    0.00
- 1st order                 0.00   0.00 | - 1st order                0.00    0.00
Bottom Upw flux             0.00   0.00 | Bottom downw flux          0.07    0.13
----------------------------------------+-------------------------------------
Total input                69.38  112.47 | Total output             71.82   75.32
==============================================================================
Final.present solid/complex                                      2021.3 43698.0
              precipitated                                                  0.0
Init.present solid/complex                                       2023.6 43661.2
              precipitated                                                  0.0
                                                               ----------------
Storage change solid/complex/precipitated                          -2.33   36.84
------------------------------------------------------------------------------
Final.present solution                                              2.32    7.55
Init.present solution                                               2.43    7.27
                                                               ----------------
Storage change solution                                            -0.11    0.28
------------------------------------------------------------------------------
Input-Output                                                       -2.44   37.15
Balance deviation                                                   0.00    0.02
==============================================================================
```

4.5 STONE: grassland on a peat soil

A short description of the STONE model is described in section 4.4.

In this example a field with grassland on peat in the Krimpenerwaard in the Netherland is picked out.

The main characteristics of this field plot are:

- soil is classified as Koopveen soil;
- different fertilization levels;
- land use is grazing grassland;
- a high groundwater level.

Manure-additions were given as different kinds of slurry with for every addition its own nitrogen and phosphorus fraction and artificial fertilizer.

In section 4.5.2 some results of the ANIMO model for this case are presented.
In section 4.5.3 the water and mass balances are given as they should be produced by the model ANIMO 4.0.
For more detailed information about the model input see also section 4.1.

4.5.1 Input files

GENERAL.INP

```
Filename:  GENERAL.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
--------------------------------------------------------------------------

>simopt:
 2 1 1 1 0

   - Hydrological parameters were simulated with the model SWAP.
   - The carbon, nitrogen and phosphorus cycle are simulated.
   - Aeration calculation by SONICG concept
   - Crop uptake simulated by QUAD-MOD (external crop module)
   - Simulation without macro pores

>simtim:
 1986 0.0 2000 366.0

   - 15 years are simulated: the period 1 1 1986 through 31 12 2000.

>outscr:
 0   - Simulation-stage is not written to screen.

>outbal:
 3       - 3 balance series
'TP'     - The character string ‘TP’ is given (total profile)
 1 0 1 1 - Output of balances written to files BAWARP.OUT, BANHRP.OUT,
 0 22      BANIRP.OUT, BANORP.OUT, BAPPRP.OUT and BAPORP.OUT.
 -1      - Compartment 0 is the addition-reservoir on top of the model soil
'GP'       system. The bottom of compartment 22 is at 13 meter below the
 1 0 1 1   soil surface (defined by hydrological simulations).
 0 22      The balances are made up for 0-13 meter below the soil surface.
 1       - Each simulated time step balance terms are written.
 365.0   - The character string ‘GP’ is given
'RP'     - Output of balances written to files BAWAGP.OUT, BANHGP.OUT,
 1 0 1 1   BANIGP.OUT and BANOGP.OUT.
 0 6     - Compartment 0 is the addition-reservoir on top of the model
 1         soil system. The bottom of compartment 22 is at 13 meter
 365.0     below the soil surface. The balances are made up for 0-22
           meter below the soil surface.
         - Each simulated year one reset at the last day number of the
           year (365 or 366 for a leap year); this reset includes
           writing of balance-terms to files and initializing all
           balance terms at zero.
         - The character string ‘RP’ is given (root zone)
         - Output of balances written to files BAWARP.OUT, BANHRP.OUT,
           BANIRP.OUT and BANORP.OUT
         - Compartment 0 is the addition-reservoir on top of the model
           soil system. The bottom of compartment 6 is at 0.50 meter
           below the soil surface (root zone). The balances are made
           up for 0-0.50 meter below the soil surface.
         - Each simulated year 1 reset at day number 365; this reset
           includes writing of balance-terms to files and initializing
           all balance terms at zero.

>outsel:
 1 0 0 1 1  0 0 0 0 0  0 0 0 0 0
 1 0 0 0 0  0 0 0 0 0  0 0 0 0 0  0 0 0 0 0  0 1
 0 0
   - The files Nitrate.out, Phosphat.out, Solu-Por.out, Pw-P.out and Discharge.out
     are created and filled with simulation results.

>outtot:
 0 1 10
   - At the time step 10 detailed output is written to output-file
     AnimoIntermediate.OUT.
```

Figure 52 The input-file GENERAL.INP: data for example grass on peat

MATERIAL.INP

```
Filename:   GENERAL.INP
Content: Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
--------------------------------------------------------------------------

>defmat: ----------------- definition of materials ---------------------
 14
 0.0  0.0  0.0  0.0   0.0  0.0   1.0   1.0  1.0  1.0  1.0  1.0 1.0 1.0
 0.0  0.0  0.0  0.0   0.5  0.0   0.0   0.0  0.0  0.0  0.0  0.0 0.0 0.0
 0.0  0.0  0.0  0.0   0.5  0.0   0.0   0.0  0.0  0.0  0.0  0.0 0.0 0.0

- 14 materials are defined (4 different types of animal manure, 2 inorganic
  fertilizer, 2 different types of root material, 3 type of organic matter,
  1 type of grassland shoot material, 1 type of shoots of external crop and
  1 type of roots of external crop.) The animal manure materials are defined
  in the management.inp file
- Fractions of organic matter, NH4-N and NO3-N are given in the management.inp file.

 material nr 1 = cattle slurry;
 material nr 2 = pig slurry;
 material nr 3 = poultry slurry;
 material nr 4 = meadow manure;
 material nr 5 = N-fertilizer;
 material nr 6 = P-fertilizer;
 material nr 7 = roots of non-grassland;
 material nr 8 = roots of grassland;
 material nr 9 = organic matter in the subsoil;
 material nr 10 = organic matter in eutrophic peat;
 material nr 11 = organic matter in mesotrophic peat.
 material nr 12 = shoots of grassland;
 material nr 13 = shoots of external crop
 material nr 14 = roots of external crop

>orgmat: ----------------- definition of organic fractions -------------
 22
 0.00 0.82 0.18 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.09 0.91 0.00 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.06 0.52 0.42 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.00 0.74 0.26 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.5 0.5  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.5 0.5  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  1.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.33 0.67 0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.33 0.67 0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.8 0.2 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.25  0.25 0.25 0.25 0.0
0.0   0.0  0.0
 0.0  0.0  0.0  0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0  0.0  0.0  0.0  0.0   0.0  0.0  0.0  0.25
0.25  0.25 0.25
 0.00 0.41 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.09 0.45 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.06 0.26 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.00 0.37 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.0  0.0  0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0
 0.50

- The organic part of each material consists of fractions; each fraction has it own
  decomposition rate and its own nitrogen content.
- Based on a different decomposition rate one can distinguish different fraction in each
  material, each fraction having its specific decomposition rate and nitrogen content.
```

```
   - Material 1-4: Decomposition rates and nitrogen contents of three fractions.
   - Material 5: Inorganic N-fertilizer: 100% mineral.
   - Material 6: Inorganic P-fertilizer: 100% mineral.
   - Material 7 and 8: 50% of the roots are slowly decomposing and 50% are fastly decomposing
   - Material 9: No further division into fractions.
   - Material 10 and 11: Calibrated with measured lysimeter-data (Berghuijs-van Dijk et al.,
1985).
   - Material 13 and 14: Dummy values must be given to indicate which fraction decomposes
     where. In the subroutine Root_extern, the fractions will be determined dynamically.
- Part of the fractions of the organic part of the materials that goes into solution.
   - Material 1-4:
      - Fraction 1: 100% dissolved organic matter.
      - Fraction 2: Half is defined as fresh organic matter (OS) the other half
        is defined as dissolved organic matter.
      - Fraction 3: 100% fresh organic matter.
   - Material 5-14: No dissolved parts.

The meaning of the organic fractions can be summarized as followed:

   organic fraction nr 1 = soluble, rapidly decomposing part of slurry
   organic fraction nr 2 = partly soluble, rapidly decomposing part of slurry
   organic fraction nr 3 = solid, slowly decomposing part of slurry
   organic fraction nr 4 = rapidly decomposing part of non-grassland roots
   organic fraction nr 5 = slowly decomposing part of non-grassland roots
   organic fraction nr 6 = very slowly decomposing organic matter
   organic fraction nr 7 = rapidly decomposing part of grassland shoots
   organic fraction nr 8 = slowly decomposing part of grassland shoots
   organic fraction nr 9 = rapidly decomposing part of grassland roots
   organic fraction nr 10= slowly decomposing part of grassland roots
   organic fraction nr 11= slowly decomposing, high N-content,eutrophic peat
   organic fraction nr 12= rapidly decomposing, low N-content,eutrophic peat
   organic fraction nr 13= slowly decomposing, mesotrophic peat
   organic fraction nr 14= rapidly decomposing, mesotrophic peat
   organic fraction nr 15= dummy value for part of shoots external crop
   organic fraction nr 16= dummy value for part of shoots external crop
   organic fraction nr 17= dummy value for part of shoots external crop
   organic fraction nr 18= dummy value for part of shoots external crop
   organic fraction nr 19= dummy value for part of roots external crop
   organic fraction nr 20= dummy value for part of roots external crop
   organic fraction nr 21= dummy value for part of roots external crop
   organic fraction nr 22= dummy value for part of roots external crop

- Humus fraction of the fresh organic matter does not pass the dissolved stage,
  but decomposes directly into humus.

>orgdec: ----------------- definition of rates ------------------------
 0.10 0.10 0.10 0.25 0.25  0.25 0.25 0.25 0.25 0.25  0.25 0.25 0.25 0.25 0.10
 0.10 0.10 0.10 0.10 0.10  0.10 0.10
 0.10 0.25  0.25
 0.5
 1.0 0.6 0.12 2.0 0.22 0.00553 2.0 0.22 2.0 0.22  0.001 0.0383 0.001 0.024
 100.0 6.00 100.0 6.00 100.0 6.00 100.0 6.00
 30.0 0.01 365.0 365.0
 0.06

- Assimilation factor of 0.10 for the manure fractions and crop residues of grassland
  (Groenendijk et al., 2004) and 0.25 for the fractions (Berghuijs-van Dijk et al., 1985).
  This parameter indicates the fraction of the decomposable fresh organic matter
  or exudates that can be converted to humus/biomass.
- Assimilation efficiency of dissolved organic matter is 0.10 (Groenendijk et al., 2004)
  and of humus/biomass and exudates all of 0.25.
- Reduction factor of 50% for microbiological transformations under oxygen limited
  situations.
- First order average decomposition rate for the organic fractions.
   - Fractions 1-3: Fractions used for material nr 1-4 (animal manure).
     Model-verification resulted in a calibration of the decomposition-rates
     for fraction 2 and 3 (fraction 1 has a dummy value since this fraction
     goes fully into solution).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6,11-14: Fraction used for organic material in subsoil.
   - Fraction 7-8: Fraction used for shoots of grassland (material nr 12).
   - Fraction 15-22: Fractions used for material nr 13 and 14, external crop.
- First order average decomposition rate for dissolved organic matter.
  Berghuijs-van Dijk et al. (1985) gives the value of 30, which was derived from
  lysimeter-experiments.
  First order average decomposition rate for humus of 0.01.
  First order average decomposition rate for exudates.
  Berghuijs-van Dijk et al. (1985): a high rate of 365, because of rapid
  decomposition.
  First order average nitrification rate. (Groenendijk et al., 2004)
- First order average denitrification rate. A value of 0.06 is based on the following
  assumption: in 10 days no more than 50% of the present nitrate can be denitrified.
```

```
>orgnit: ----------------- definition of N-contents --------------------
 0.12 0.07 0.02 0.008 0.008  0.01 0.05 0.019 0.02 0.0076  0.043 0.028 0.020 0.019
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.048   0.02

- Nitrogen fractions in organic matter.
   - Fraction 1-3: Fractions used for material nr 1-4 (animal manure).
   - Fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
   - Fraction 6,11-14: Fraction used for organic material in subsoil.
   - Fraction 7-8: Fractions used for material 12 (shoots grassland).
   - Fraction 15-22: Dummy fractions used for material nr 13 and 14 (external crop).
- Maximal nitrogen fraction in humus. Value as given by Berghuijs-van Dijk et al. (1985).
  It corresponds to a C/N ratio of 14 (the carbon content of the material has been assumed
  to 0.58). This value 0.048 is added to the nitrogen fraction in the root zone layers.
  Below the root zone the nitrogen fraction is calculated from the given C/N ratio * 0.58
  (See Soil.inp).
- Nitrogen fraction in exudates. Value as given by Berghuijs-van Dijk et al. (1985).

>minpho: ----------------- definition of mineral P ---------------------
 0.0 0.0 0.0 0.0 0.0  1.0 0.0 0.0 0.0 0.0  0.0 0.0  0.0 0.0

- Material nr 1-4: mineral phosphorus is defined in the management.inp file.
- Material 5 and 7-14: contains no mineral phosphorus.
- Material 6: inorganic P-fertilizer contains 100% mineral phosphorus.


>orgpho: ----------------- definition of organic P fractions -----------
 0.012 0.007 0.002 0.001 0.001  0.00125 4.430E-03 3.068E-03 3.163E-03 1.786E-03
 0.0001 0.0006 0.0001 0.0006  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.006   0.0025

- Phosphorus fractions in organic matter. Derived from literature.
  Related to nitrogen fractions (1:10).
- Maximal phosphorus fraction in humus. Derived from literature. Related to NIFRHUMA (1:8).
- Phosphorus fraction in exudates; like POFR related to organic-N (1:8).

>sonicg:
  0.3 0.001 0.90

- The nitrate-N concentration for which the MM-function takes a value half of
  the optimal value is 0.3
- Multiplication factor for org. transformations at complete anaerobic conditions
  is set to 0.001 (Groenendijk et al., 2004).
- The critical value of water filled pore space for adjustment of original water
  response on organic transformation to lower values is set to 0.9

>sonic2:
  0.6

- The critical value of water filled pore space in sandy soils for adjustment of
  original water response on organic transformation to lower values is set to 0.6
```

Figure 53 The input-file MATERIAL.INP: data for example grass on peat

PLANT.INP

```
Filename:  PLANT.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
--------------------------------------------------------------------------

>cropdt:
 1

- One crop is defined in this file.

>crop01:
 5
 13 14
 2
   1.     1.
   1.     1.
 2
   0.     366.
   0.50   0.50
   0.     366.    0.0  260.0   30.0   0.1300   0.1250  200.0    5.0    1.0
 38.0 4.0

Plant parameters for grass with use of an external cropmodule (QUAD-MOD):
- Crop number 5 is defined as external crop (grass).
- Shoot material is 13 and root material is 14 for external crop
  (see input-file MATERIAL.INP).
- Number of data given for the amount of roots (NUAMRO).
  These data are used to simulate the decomposition of root material.
  For a realistic simulation the values should correspond to the values
  applied in the hydrological model.
- Array with Julian day numbers versus amount of roots.
- Number of data given for the root length (NULNRO)
- Array with Julian day numbers versus length of roots.
- Growing period during whole year.
  Areic mass of tubers harvested.
  Dummy values for the rest of the parameters. These parameters are not used
  because crop growth is determined in the external crop module QUAD-MOD.
```

Figure 54 The input-file PLANT.INP: data for example grass on peat

SOIL.INP

```
Filename:  SOIL.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
-------------------------------------------------------------------------

>profil:
12
0.02 0.2
0.2 0.25
0.5000

- Twelve soil horizons were distinguished.
- The thickness of the top of the soil compartment is set to 0.02 m;
  the thickness of the reservoir for additions to the soil system is set to 0.2 m.
- The fraction of runoff passing the surface reservoir is set to 0.2
  and for passing the first soil layer is set to 0.25.
- The depth of the initial root zone is 0.50 m.

>tempar:
 0.01726 0.05184
  9.0   9.0   3.7721

- Frequency of the early temperature wave; used in sinus and Fourier model.
  Used in sinus model: 2.0*3.14/365 = 0.01726.
  Thermal diffusivity; used in sinus and Fourier model.
  Huet (1982) gives this value (0.05184 m2 d-1 = 0.006 cm2 sec-1).
- Amplitude of yearly temperature wave (9 oC).
  Average yearly temperature (9 oC) at soil surface. Used in sinus model.
  Phase shift (3.7721 rad) of sinus wave.

>sophy1:
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.3   1.5
 0.0667  0.0667  0.0667  0.0667  0.0293  0.0293  0.0293  0.0293  0.0293  0.0293
0.0293  0.0293
  588.0   593.0   580.0   454.0   243.0   229.0   221.0   224.0   222.0   400.0
1100.0  1000.0
 12.0  12.0  12.0  12.0  12.0  15.0  15.0  15.0  15.0  30.0  30.0  30.0
 74826.0  74826.0  74826.0  74826.0  74826.0  74826.0  74826.0  74826.0  74826.0
74826.0  74826.0  74826.0
 74826.0  74826.0  74826.0  74826.0  74826.0  74826.0  74826.0  74826.0  74826.0
74826.0  74826.0  74826.0

- Dummy values should be given, because aeration is calculated by the SONICG-
concept.
- Saturated conductivity of the root zone, for horizons 1 to 12.
- Dry bulk density for each horizon.
- C/N-ratio for each horizon. (C/N-ratio for the root zone are dummy’s,
  because the nitrogen fraction of humus for the root zone are set to the
  maximum nitrogen fraction of humus.)
- Coefficient temperature response for organic and dissolved organic
  transformations by Arrhenius per horizon.

>sochem:
  5.47  5.47  5.47  5.38  5.38  5.21  5.13  5.21  5.21  5.21  5.21  5.21
 2.5693E-03 2.5607E-03 2.7542E-03 3.1043E-03 3.5443E-03 1.9345E-03 2.0786E-03
1.9996E-03
 1.9700E-03 2.6747E-03 2.0025E-03 4.5225E-03

- pH-H2O for each horizon.
- Values for the distribution coefficient for ammonium. The ratio between the
  amounts of NH4-N in the soil solution. Values are given for each horizon.
```

```
>soalfe:
1
   453.0   446.0   391.0   387.0   328.0   276.0   237.0   194.0   113.0    78.0
290.0   177.0

- Sum of Al and Fe per horizon is specified.

>nisand:
 0 0 0 0 0 0 0 0 0 0 0 0

- Whole profile is not sandy
```

Figure 55 The input-file SOIL.INP: data for example grass on peat

CHEMPAR.INP

```
Filename:  CHEMPAR.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
--------------------------------------------------------------------------

>chedef: ----------------- definition of chemical system ---------------
 2       ! optcxfa: langmuir
 1       ! ncxfa:   1 equilibrium sorption site
 3       ! optcxsl: freundlich
 3       ! ncxsl:   3 non equilibrium sorption site
 0       ! optpr:   non equilibrium precipitation

- Option of equilibrium sorption: Langmuir.
- Number of sites for equilibrium sorption: 1.
- Option for non equilibrium sorption: Freundlich.
- Number of sites for non equilibrium sorption: 3.
- Option for precipitation model: Instantaneous.

>chesor: ----------------- sorption variables -------------------------
 2                                 ! optcxho: sorption parameters for w
 0.0  4.743E-6   300.0  0.0  0.0   ! pacxfaho(1-5,1,1)
 0.300                             ! parkd(1)
 0.0  0.0  0.0  11.353E-6  0.5357  ! pacxslho(1-5,1,1)
 1.17550  0.011755                 ! recfads(1,1), recfdes(1,1)
 0.0  0.0  0.0   4.463E-6  0.1995  ! pacxslho(1-5,2,1)
 0.03340  0.000334                 ! recfads(2,1), recfdes(2,1)
 0.0  0.0  0.0   9.287E-6  0.2604  ! pacxslho(1-5,3,1)
 0.00144  0.0000144                ! recfads(3,1), recfdes(3,1)

 ...


- Option for input of sorption parameters per horizon:
  the parameters PACXFAHO - RECFDESHO are given per soil profile.
- In this example the following parameters for the first soil profile
  for each equilibrium sorption site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]: dummy value
     Langmuir maximum sorption amount    = 4.743E-6 [kg m-3]
     Langmuir sorption coefficient = 300.0 [m3 kg-1]
     Freundlich sorption constant     = 0.0 [-]: dummy value
     Freundlich sorption exponent     = 0.0 [-]: dummy value
- Langmuir desorption coefficient    = 0.30 [d-1]
- In this example the following parameters for the first soil profile
  for the first non equilibrium sorption site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount    = 0.0 [kg m-3]
     Langmuir sorption coefficient = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 11.353E-6 [-]
     Freundlich sorption exponent     = 0.5357 [-]
   - First order rate constant of adsorption for the first
     non equilibrium sorption site = 1.1755 [d-1]
     First order rate constant of desorption for the first
     non equilibrium sorption site = 0.011755 [d-1]
- In this example the following parameters for the first soil profile
  for the second non equilibrium sorption site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount    = 0.0 [kg m-3]
     Langmuir sorption coefficient = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 4.463E-6 [-]
```

```
     Freundlich sorption exponent     = 0.1995 [-]
   - First order rate constant of adsorption for the second
     non equilibrium sorption site = 0.0334 [d-1]
     First order rate constant of desorption for the second
     non equilibrium sorption site = 0.000334 [d-1]
- In this example the following parameters for the first soil profile
  for the third non equilibrium sorption site were used:
   - Linear sorption coefficient      = 0.0 [m3 m-3]
     Langmuir maximum sorption amount   = 0.0 [kg m-3]
     Langmuir sorption coefficient = 0.0 [m3 kg-1]
     Freundlich sorption constant     = 9.287E-6 [-]
     Freundlich sorption exponent     = 0.2604 [-]
   - First order rate constant of adsorption for the third
     non equilibrium sorption site = 0.00144 [d-1]
     First order rate constant of desorption for the third
     non equilibrium sorption site = 0.0000144 [d-1]

>chepre: ----------------- precipitation variables ---------------------
 0.01     ! recfpr

- First order rate constant for kinetic precipitation: 0.01 [d-1]

>chebuf: ----------------- buffer concentration ------------------------
 0        ! optcobu : cobuho calculated in subr. INICALC_P with given pH
 0.05     ! cobuho(1)

- Option for input of buffer concentration:
  variable COBUHO is determined with pH\Ceq relation.
- Buffer concentration for phosphorus in solution: 0.05 [kg m-3]

Data were derived by Schoumans (1995).
```
Figure 56 The input-file CHEMPAR.INP: data for example grass on peat

BOUNDARY.INP

```
Filename:  BOUNDARY.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
--------------------------------------------------------------------------

>optibc:
     0     0

- Runon and irrigation concentration data are not given per time step

>topbou:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0

 31.080200 30.709101 29.990200 27.513300 27.977100
 27.723400 27.342899 28.341499 24.726000 22.245300
 21.379900 21.466101 23.251200 20.671400 19.179001

 13.638500 15.564500 14.241800 13.651800 12.654200
 13.319800 12.721400 12.518500 12.268600 11.607800
 11.232300 10.891400 11.708500 12.486600 10.967700

 0.0 0.0
 0.0
 0.0 0.0
 0.0
 0.0 0.0
 0.0
 0.0 0.0
 0.0

- Concentrations of precipitation of NH4-N,NO3-N and PO4-P are all set to
  0.0 kg m-3 for each year.
  In the STONE project the N precipitation is added to the dry deposition.
  The P deposition is assumed zero
- Atmospheric dry deposition of NH4-N
- Atmospheric dry deposition of NO3-N
- Concentrations of NH4-N, NO3-N and PO4-P in runon are set to 0.0.
- Concentration of dissolved organic matter, dissolved organic nitrogen
  and dissolved organic phosphorus in runon are set to 0.0.
  Not relevant for this field because runon does not occur in this case.
- Concentration of NH4-N, NO3-N and PO4-P in irrigation is set to 0.0.
- Concentration of dissolved organic matter, dissolved organic nitrogen
  and dissolved organic phosphorus in irrigation are set to 0.0.

>latbou:
 2.0E-04 1.0E-03
 0.0
 0.0 0.0
 0.0

- Concentration of infiltrating drain water:
   - NH4-N: 2.0E-04 mg.l-1
     NO3-N: 1.0E-03 mg.l-1
   - PO4-P: 0.0     mg.l-1
   - DOM  : 0.0     mg.l-1
     DON  : 0.0     mg.l-1
   - DOP  : 0.0     mg.l-1

>botbou:
 2.100E-03 1.100E-04
 1.450E-03
 1.529E-02 1.530E-03
 5.800E-04

- Concentration of incoming seepage water across lower boundary:
   - NH4-N: 2.100E-03 mg.l-1
     NO3-N: 1.100E-04 mg.l-1
   - PO4-P: 1.450E-03 mg.l-1
   - DOM  : 1.529E-02 mg.l-1
     DON  : 1.530E-03 mg.l-1
   - DOP  : 5.800E-04 mg.l-1
```

Figure 57 The input-file BOUNDARY.INP: data for example grass on peat

INITIAL.INP

```
Filename:   INITIAL.INP
Content: Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
-------------------------------------------------------------------------

>moistf:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0

- Moisture fractions of the compartments 1 to NL at the beginning of a time step.
  In this case, dummy values have been used, because hydrology is simulated by Swap.

>ammoni:
 0.0 5.547087E-04
 1.100803E-05 1.275490E-05 1.411693E-05 8.339303E-06 1.517577E-06
 5.478376E-04 4.844239E-04 4.086554E-04 4.103297E-04 4.693786E-04
 5.821328E-04 8.000684E-04 9.541871E-04 1.062197E-03 1.099092E-03
 1.102189E-03 1.081200E-03 9.772346E-04 6.564818E-04 5.968120E-04
 5.784747E-04 5.721172E-04

- Concentrations of NH4-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>nitrat:
 0.0 3.349183E-04
 2.766365E-06 1.323477E-06 1.085585E-06 3.304929E-07 1.795678E-07
 1.071404E-08 1.117167E-05 1.045890E-05 1.733300E-05 8.874953E-06
 3.996995E-06 7.472140E-07 4.284232E-07 1.404357E-07 1.294495E-07
 1.365374E-07 1.507923E-07 1.713475E-07 6.131649E-07 7.162676E-07
 5.547704E-07 5.744288E-07

- Concentrations of NO3-N in the top layer and compartments 0 to NL
  (where the top layer is the addition reservoir and layer 0 the layer reserved
  for ponding).

>orgexu:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0

- Exudate content of compartments 1 to NL. The amount of exudates present has been
  estimated as 0.0 kg m-2. Low amounts of exudates and high decomposition rates
  make this acceptable.

>humexu:
 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0  0.0 0.0

- Amount of humus from exudates present in compartments 1 to NL. HUEX, HUOS and OS
  are the main organic components in the model ANIMO.
  OS is the fresh organic matter; HUEX and HUOS together form humus.
  OS decomposes with rates RECFAV (1-NF), HUEX and HUOS both decompose with the rate RECFHUAV.

>orgfsh:
 0.0 2.358716E-01 6.592316E-01 0.0 0.0 0.0 0.0 0.0 9.550825E-17 5.976113E-03
 0.0 0.0 0.0 0.0 1.290127E-06 8.067369E-03 1.096491E-02 1.297903E-01 2.211260E-07 1.210185E-03
 1.644801E-03 1.946784E-02
 0.0 1.230810E-01 3.872746E-01 0.0 0.0 0.0 0.0 0.0 1.781211E-12 2.786353E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5.573918E-07 4.191435E-03
 4.123782E-03 4.610532E-02
 0.0 7.010307E-02 1.918872E-01 0.0 0.0 0.0 0.0 0.0 8.626724E-09 3.518486E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 4.627064E-07 4.139078E-03
 3.354919E-03 2.861882E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.039497E-05 7.657097E-02
 0.0 0.0 5.412370E-03 1.035805E-02 0.0 0.0 0.0 0.0 3.358440E-06 9.262479E-03
 6.516229E-03 3.828691E-02
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.654891E-03 2.148169E-01
 0.0 0.0 1.431167E-01 2.785644E-01 0.0 0.0 0.0 0.0 6.455237E-04 4.924422E-02
 2.775421E-02 1.026912E-01
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3.707870E-02 5.700932E-01
 0.0 0.0 1.763525 3.514352 0.0 0.0 0.0 0.0 1.495818E-02 3.261035E-01
 1.201296E-01 3.056787E-01
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 5.080425 10.294492 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 7.453300 15.123678 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 12.622924 25.613863 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 25.087919 50.908108 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 25.087751 50.908421 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
```

```
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 37.631554 76.362762 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 37.631409 76.362946 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 76.252693 154.736542 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 76.251884 154.737442 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 101.668602 206.317398 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 127.085037 257.897858 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 127.083633 257.899811 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 115.530136 234.454712 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 231.057877 468.913971 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 231.053726 468.919739 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 462.000000 937.635437 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0

- Amount of fresh organic matter present in compartments 1 to NL for
  fractions 1 to NF.

>humorg:
  9.733728     18.205458     9.874711     9.591879     11.963309
 15.022933      6.680018E-03 2.221097E-03 2.714380E-03  3.971666E-03
  3.827426E-03  5.694905E-03 5.653525E-03 1.077113E-02  1.067009E-02
  1.401236E-02  1.710976E-02 1.658407E-02 1.514545E-02  2.819960E-02
  2.652076E-02  5.053340E-02

- Amount of humus from fresh organic matter and dissolved organic matter
  present in compartments 1 to NL (see parameter HUEX).

>orgsol:
 0.0 2.434567E-04
 1.885666E-01 3.181480E-01 3.809234E-01 4.088758E-01 4.551322E-01
 5.111651E-01 3.681957E-01 1.876476E-01 8.346540E-02 4.869701E-02
 4.170250E-02 5.049011E-02 6.136516E-02 7.616466E-02 8.523354E-02
 9.006719E-02 8.968873E-02 8.180702E-02 5.936896E-02 4.623097E-02
 4.171501E-02 3.949091E-02
 0.0 1.704197E-05
 5.797061E-03 1.183298E-02 1.487627E-02 1.514261E-02 1.325852E-02
 1.214511E-02 8.226237E-03 4.008864E-03 1.736316E-03 9.905960E-04
 8.212425E-04 9.683089E-04 1.167204E-03 1.446370E-03 1.618781E-03
 1.711385E-03 1.704942E-03 1.555543E-03 1.129085E-03 8.793021E-04
 7.934225E-04 7.511225E-04

- Concentration of dissolved organic matter (including addition reservoir
  and LN=0).
  Concentration of dissolved organic nitrogen (including addition reservoir
  and LN=0).

>orgpla:
 0.0 0.0 5.794437E-02
 6.161097E-03

- Amount of shoots, roots, initial nitrogen uptake and
  initial phosphorus uptake.

>inipho:
     1
 0.0 6.880528E-05
 4.136029E-04 9.284689E-05 8.342874E-05 2.963357E-05 2.131307E-05
 5.457216E-04 3.011331E-04 2.775160E-04 2.697496E-04 2.749723E-04
 2.852537E-04 2.987433E-04 2.993987E-04 2.999428E-04 2.999410E-04
 2.999397E-04 2.999436E-04 2.999392E-04 2.998801E-04 2.998772E-04
 2.998829E-04 2.998845E-04
 0.0
 1.394556E-01 3.399381E-02 2.626388E-02 7.343132E-03 2.276192E-03
 5.816128E-02 3.309446E-02 2.546978E-02 1.879975E-02 2.379985E-02
 2.461960E-02 2.568809E-02 2.573980E-02 2.636117E-01 2.636103E-01
 2.636092E-01 2.636124E-01 2.636089E-01 1.462393E-01 1.462380E-01
 1.462405E-01 1.462412E-01
```

```
 0.0
 4.660360E-02 2.080502E-02 1.683531E-02 7.476289E-03 2.841016E-03
 1.027308E-02 3.311371E-03 2.630110E-03 4.971510E-04 6.247171E-04
 6.371085E-04 6.530654E-04 6.538233E-04 6.691425E-03 6.691405E-03
 6.691389E-03 6.691435E-03 6.691383E-03 3.712381E-03 3.712362E-03
 3.712401E-03 3.712412E-03
 0.0
 2.564558E-01 1.847766E-01 1.553478E-01 9.784879E-02 4.347984E-02
 5.049469E-02 1.987207E-02 1.626173E-02 3.112228E-03 3.883461E-03
 3.907317E-03 3.937258E-03 3.938508E-03 4.028191E-02 4.028186E-02
 4.028181E-02 4.028191E-02 4.028181E-02 2.234977E-02 2.234969E-02
 2.234980E-02 2.234984E-02
 0.0
 3.100234E-01 2.167820E-01 1.845370E-01 1.390441E-01 6.213863E-02
 6.592380E-02 2.518860E-02 2.087096E-02 4.011097E-03 4.991652E-03
 4.997035E-03 5.003857E-03 5.004238E-03 5.116542E-02 5.116542E-02
 5.116542E-02 5.116542E-02 5.116542E-02 2.838959E-02 2.838959E-02
 2.838959E-02 2.838959E-02
 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
 0.0 0.0
 0.0 1.704197E-06
 5.512535E-04 1.147312E-03 1.452475E-03 1.479045E-03 1.287532E-03
 1.212011E-03 8.481737E-04 4.257934E-04 1.788589E-04 8.772911E-05
 5.629019E-05 4.944213E-05 4.890591E-05 5.299804E-05 5.515905E-05
 5.571078E-05 5.408380E-05 4.873614E-05 3.514114E-05 2.728798E-05
 2.461084E-05 2.329745E-05

- INPO = 1: variables COPO, AMCXFA, AMCXSL and AMPOPR are given.
- Concentration of phosphorus in liquid phase in the top layer and
  compartments 0 to NL.
- Adsorbed equilibrium mass concentration of phosphorus in the soil system;
  given for equilibrium sites 1-NCXFA (1) and compartments 0-NL.
- Adsorbed non equilibrium mass concentration of phosphorus in the soil system;
  given for non equilibrium sites 1-NCXSL (3) and compartments 0-NL.
- Precipitated mass concentration of phosphorus in the soil system;
  given for model compartments 0-NL.
- Concentration of dissolved organic phosphorus in liquid phase in the top layer
  and compartments 0 to NL.
```

Figure 58 The input-file INITIAL.INP: data for example grass on peat

MANAGMENT.INP

```
Filename:  MANAGEMENT.INP
Content:Input for ANIMO-version 4.0 (Case STONE plot 3320 grassland on peat)
--------------------------------------------------------------------------

>kicrop:
 5 5 5 5 5  5 5 5 5 5  5 5 5 5 5

- Kind of crop grown each year is external crop (grass).
  Crop has been defined in the input-file PLANT.INP.

>lsunit:
 1.89 1.76 1.70 1.66 1.67 1.67 1.64 1.63 2.02 1.55 1.51 1.42 1.50 1.41 1.38

- Number of livestock units per hectare per year.

>matvar:
 1
 4 3

- Material composition varies in time and is based on given OM, N and P fractions.
- 4 materials with variable compositions
  3 organic fractions with variable compositions

>add001:
    56.0
    2
 1   4663.803  3  0    0.000000
   0.0625000   0.0012839   0.0000000   0.0005210
   0.0000000   0.4114043   0.5885956
   0.0000000   0.2057022   0.0000000
 6      1.637  0  0    0.000000
    66.0

- At day number 56 (25-Feb-1986) the first addition takes place.
- 3 materials are added this time step
```

```
   - Number of the first added material 1 is cattle slurry.
     (defined in the file MATERIAL.INP.)
     Quantity of material added is 4663.803 kg ha-1.
     The cattle slurry is added to the first 3 compartments of the soil profile.
     No ploughing.
     In this case, 0% of the mineral part of the cattle slurry volatilizes.
   - The organic matter content is 0.0625000
     The mineral NH4-N content is 0.0012898
     The mineral NO3-N content is 0.0000000
     The mineral P content is 0.0005170
   - The mass fractions in the solid organic part of the cattle slurry are:
     0.0000000   0.4114043   0.5885956
     The dissolved mass fractions in the solid organic part of the cattle slurry
     are:
     0.0000000   0.2057022   0.0000000
   - Number of the second added material 6 is P-fertilizer.
     Quantity of material added is 1.637 kg ha-1.
     The P-fertilizer is added to the top compartments of the soil profile.
     No ploughing.
     0% of the mineral part of the P-fertilizer volatilizes.
- Time of next addition is day number 66 (7-Mar-1986).

>add002:
    3
 1   4663.803  3  0    0.000000
   0.0625000   0.0012839   0.0000000   0.0005210
   0.0000000   0.4114043   0.5885956
   0.0000000   0.2057022   0.0000000
 5     29.282  0  0    0.000000
 6      1.637  0  0    0.000000
    76.0

 - and so on

>add003:
 etc... etc...
>add372:
    1
 4    676.932  0  0    0.000000
   0.0625000   0.0048572   0.0000000   0.0006725
   0.0000000   0.6362010   0.3637990
   0.0000000   0.3181005   0.0000000
  9999.9
```
Figure 59 The input-file MANAGEMENT.INP: data for example grass on peat

CROP_EXT.INP

```
    nishmi     nishma     niromi     niroma     poshmi     poshma     poromi     poroma
0.1845E-01 0.2362E-01 0.1845E-01 0.2362E-01 0.2270E-02 0.2270E-02 0.2270E-02 0.2270E-02
year-mo-da,Ntotuptake,Ptotuptake,DMcressurf,N-cressurf,P-cressurf,DMcresbott,N-cresbott,P-cresbott
1986-01-01,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-01-02,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-01-03,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-02-01,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-02-02,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-02-03,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
1986-03-01,0.0000E+00,0.0000E+00,4.4452E+01,1.0333E+00,1.0092E-01,6.6677E+01,1.5500E+00,1.5138E-01
1986-03-02,0.0000E+00,0.0000E+00,9.7249E+01,2.2607E+00,2.2078E-01,1.4587E+02,3.3910E+00,3.3117E-01
1986-03-03,0.0000E+00,0.0000E+00,1.2066E+02,2.8049E+00,2.7393E-01,1.8099E+02,4.2074E+00,4.1090E-01
1986-04-01,6.3371E+00,6.2093E-01,1.2296E+02,2.8583E+00,2.7914E-01,1.8443E+02,4.2874E+00,4.1872E-01
etc.... etc....
2000-10-01,1.8737E+01,2.2860E+00,2.7694E+02,5.1710E+00,6.2873E-01,4.1540E+02,7.7566E+00,9.4309E-01
2000-10-02,1.0458E+01,1.2759E+00,2.6094E+02,4.8724E+00,5.9242E-01,3.9142E+02,7.3086E+00,8.8863E-01
2000-10-03,0.0000E+00,0.0000E+00,2.6753E+02,4.9955E+00,6.0738E-01,4.0130E+02,7.4932E+00,9.1108E-01
2000-11-01,0.0000E+00,0.0000E+00,2.2500E+02,4.2013E+00,5.1082E-01,3.3750E+02,6.3019E+00,7.6623E-01
2000-11-02,0.0000E+00,0.0000E+00,2.0759E+02,3.8761E+00,4.7128E-01,3.1138E+02,5.8142E+00,7.0692E-01
2000-11-03,0.0000E+00,0.0000E+00,1.9042E+02,3.5556E+00,4.3231E-01,2.8563E+02,5.3334E+00,6.4847E-01
2000-12-01,0.0000E+00,0.0000E+00,1.7259E+02,3.2227E+00,3.9184E-01,2.5889E+02,4.8341E+00,5.8776E-01
2000-12-02,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00
2000-12-03,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00,0.0000E+00

- Minimum nitrogen fraction in shoots is 0.1845E-01
  Maximum nitrogen fraction in shoots is 0.2362E-01
  Minimum nitrogen fraction in roots is 0.1845E-01
  Maximum nitrogen fraction in roots is 0.2362E-01
  Minimum phosphor fraction in shoots is 0.2270E-02
  Maximum phosphor fraction in shoots is 0.2270E-02
  Minimum phosphor fraction in roots is 0.2270E-02
  Maximum phosphor fraction in roots is 0.2270E-02

Dynamic part of the input file
- Date is given in Year Month and decade number (1-3)
  The first 6 decades no N or P uptake and no Crop losses take place.
  From the seventh decade there are crop losses of organic matter, nitrogen and phosphorus
  of shoots and roots until the 34th decade.
  From the tenth decade there is some nitrogen and phosphorus uptake until the 29th decade.
- This applies to every year.
```

Figure 60 The input-file CROP_EXT.INP: data for example grass on peat

4.5.2 Results

Case grass on peat Plot 3320: grass on a peat soil

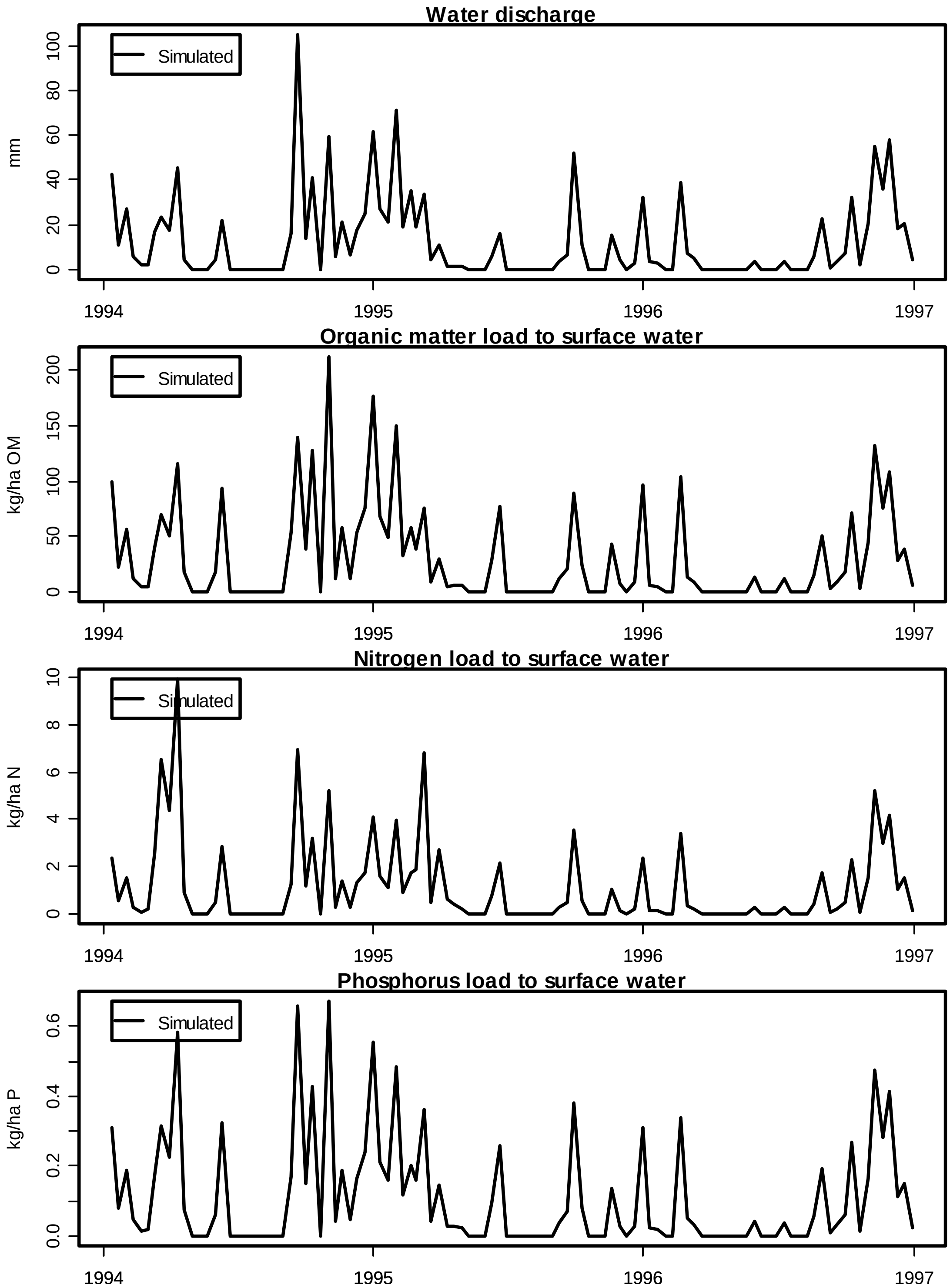

Figure 61 Simulated water discharge to surface water and organic matter, nitrogen and phosphorus loads to surface water in a wet and dry period of the simulation for grass on peat

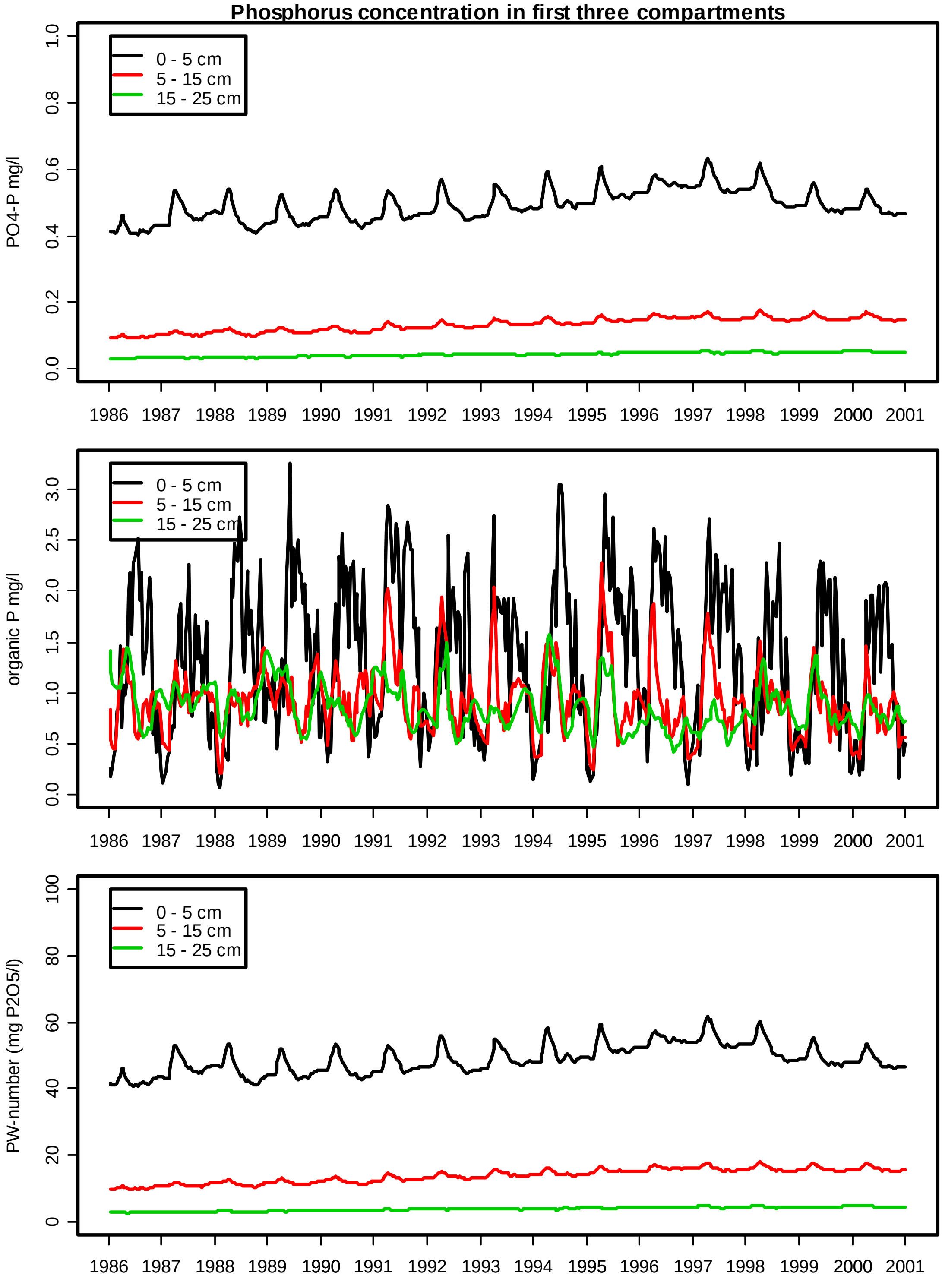

Figure 62 Simulated phosphate concentration, organic-P concentration and PW-number in the first three compartments of the field for grass on dry sand

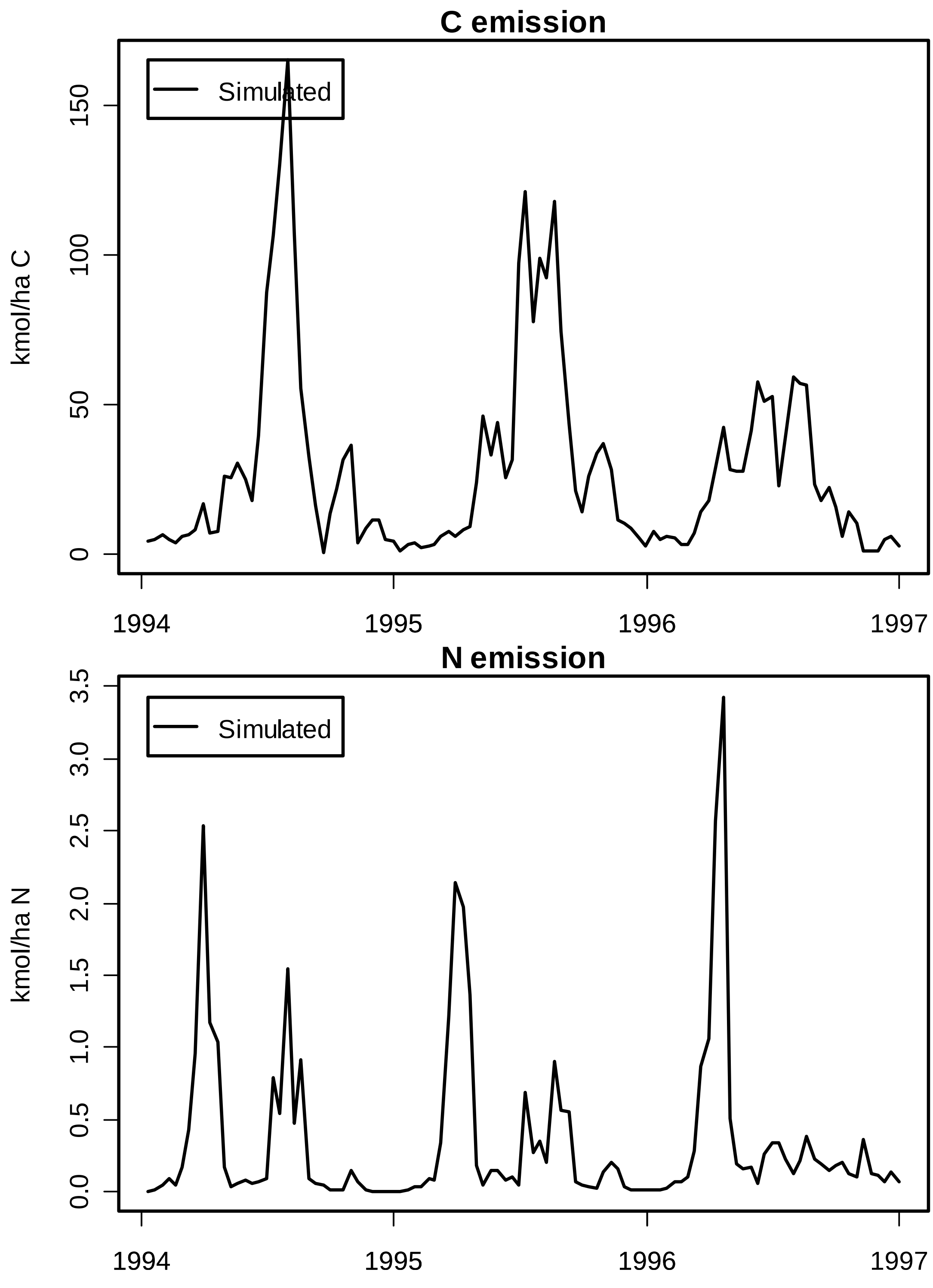

Figure 63 Simulated carbondioxyde and nitrogen emission to the air in a wet and dry period of the simulation for grass on peat

4.5.3 Balances

This section presents the content of water, organic matter, nitrogen and phosphorus of the grass on dry sand case. The presentation of these balances is achieved with the following procedure:

- With output options in the input file GENERAL.INP the output files BAWA//.OUT, BANH//.OUT, BANI//.OUT, BANO//.OUT, BAPO//.OUT and BAPP//.OUT are created.
- Besides the BA* files, balance table files are created. With the output options in the input file GENERAL.INP, the balance table files Ani_wa//.out, Ani_n//.out and Ani_p//.out are created.

At the position // a character string of 2 positions must be given to identify the set of the output files with mass balances, balance tables and organic transformations (see Chapter 3: input file GENERAL.INP).

Balances are created for each balance period.
This section gives only some balance table for the period 1-1-1995 to 31-12-1995.

Water, nitrogen and phosphorus balance of the grass on peat case (Case STONE plot 3320)

Soil profile GP: 0.00 - 13.00 m below soil surface

Output file Ani_waGP.bal:

```
Water balance (mm);   profile  top -13.00m-ss;  period  365-1994/ 365-1995
==============================================================================
Input:                                  | Output:
==============================================================================
Rainfall                          740.1 | Interception                    83.7
Snowfall                           26.8 | Snow sublimation                 0.5
Irrigation                          0.0 | Pond evaporation                 0.0
                                        | Soil evaporation               103.2
                                        | Plant evaporation              393.3
Runon                               0.0 | Runoff_Pr                       19.7
Inundation                          0.0 | Runoff_L0                        3.7
                                        | Runoff_L1                        1.2
Infiltration from:                      | Drainage to:
- 3rd order                         1.0 | - 3rd order                    246.3
- 2nd order                       165.5 | - 2nd order                     91.7
- 1st order                        61.8 | - 1st order                     32.4
Bottom upw flux                     0.0 | Bottom downw flux               24.1
----------------------------------------+-------------------------------------
Total input                       995.2 | Total output                   999.8
==============================================================================
Storage change snow layer (+ = increase)                                   1.1
Storage change ponding layer (+ = increase)                                0.0
Storage change soil moisture (+ = increase)                               -5.7
Balance deviation                                                          0.0
==============================================================================
```

Output file Ani_nGP.bal:

```
Nitrogen   (kg/ha);   profile  top -13.00m-ss;  period  365-1994/ 365-1995
==============================================================================
Input:           Org-N   Nh4-N   No3-N | Output:         Org-N   Nh4-N   No3-N
==============================================================================
Deposition dry            22.2    11.6 |
Deposition wet             0.0     0.0 |
Additions        175.8   279.1    92.1 | Volatilization           0.0
Redistrib          0.0     0.0     0.0 | Redistrib         0.0     0.0     0.0
Crop residues    401.4     0.0     0.0 | Crop uptake             658.5   169.9
Exudates           0.0                 |
Incorporation    158.6                 | Gross mineral.  766.8
Nett mineral.            608.3         | Immobilization           0.0
Nitrification                    244.4 | Nitrification          244.4
                                       | Denitrification                 173.4
Irrigation         0.0     0.0     0.0 | Runoff_Pr         0.0     0.0     0.0
Runon              0.0     0.0     0.0 | Runoff_L0         0.2     0.8     0.3
Inundation         0.0     0.0     0.0 |
                                       | Runoff_L1         0.2     0.0     0.0
Infiltration from:                     | Discharge to:
- 3rd order        0.0     0.0     0.0 | - 3rd order      18.6     1.4     6.0
- 2nd order        0.0     0.3     1.7 | - 2nd order       5.1     0.3     0.5
- 1st order        0.0     0.1     0.6 | - 1st order       0.5     0.2     0.0
Bottom upw flux    0.0     0.0     0.0 | Bot downw flux    0.2     0.1     0.0
---------------------------------------+--------------------------------------
Total input      735.8   910.0   350.5 | Total output    791.6   905.9   350.1
==============================================================================
Final.present solid/complex                                1032379.9   325.2
Init.present solid/complex                                 1032437.1   322.0
                                                            ------------------------
Storage change solid/complex (+ = increase)                    -57.2     3.2
==============================================================================
Final.present solution                                         165.2    80.2     0.4
Init.present solution                                          163.9    79.2     0.3
                                                            ------------------------
Storage change solution (+ = increase)                           1.4     1.0     0.1
==============================================================================
Input-Output                                                   -55.8     4.2     0.4
Balance deviation                                                0.1     0.0     0.2
==============================================================================
```

Output file Ani_pGP.bal:

```
Phosphorus (kg/ha);   profile  top -13.00m-ss;  period  365-1994/ 365-1995
==============================================================================
INPUT:                   ORG-P   PO4-P | OUTPUT:                  ORG-P   PO4-P
==============================================================================
Deposition wet                    0.00 |
Additions                17.58   53.67 |
Redistrib                 0.00    0.00 | Redistrib                 0.00    0.00
Crop residues            44.10         | Crop uptake                      92.44
Exudates                  0.00         |
Incorporation            19.82         | Gross mineral.           85.77
Net mineral.                     65.95 | Immobilization                    0.00
Irrigation                0.00    0.00 | Runoff_Pr                 0.00    0.00
Runon                     0.00    0.00 | Runoff_L0                 0.02    0.06
Inundation                0.00    0.00 |
                                       | Runoff_L1                 0.02    0.01
Infiltration from:                     | Discharge to:
- 3rd order               0.00    0.00 | - 3rd order               1.97    0.38
- 2nd order               0.00    0.00 | - 2nd order               0.56    0.26
- 1st order               0.00    0.00 | - 1st order               0.03    0.10
Bottom Upw flux           0.00    0.00 | Bottom downw flux         0.01    0.07
---------------------------------------+--------------------------------------
Total input              81.50  119.62 | Total output             88.37   93.32
==============================================================================
Final.present solid/complex                                    26982.5 27613.5
              precipitated                                                 0.0
Init.present solid/complex                                     26989.3 27587.3
              precipitated                                                 0.0
                                                              ----------------
Storage change solid/complex/precipitated                        -6.84   26.25
------------------------------------------------------------------------------
Final.present solution                                            9.19   33.38
Init.present solution                                             9.22   33.32
                                                              ----------------
Storage change solution                                          -0.03    0.06
------------------------------------------------------------------------------
Input-Output                                                     -6.86   26.30
Balance deviation                                                 0.00   -0.01
==============================================================================
```

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Annex 1 The file PARAM.INC: maximum dimensions of variables

The file PARAM.INC is part of the FORTRAN external dependencies of the source code of ANIMO 4.0. The content of this file defines the upper boundaries of the size of array variables.

```
!  Param.inc
!
      Integer ::    Maad, Makc, Manf, Manh, Manl, Manm, Many, Mapf,     &
     &           Macx, Masp, Maba, Mase
!                           maximum number of additions within one tstep
      Parameter (Maad = 10)
!                           maximum kind of crops (see function RINT !)
      Parameter (Makc = 15)
!                           maximum number of organic fractions
      Parameter (Manf = 22)
!                           maximum number of horizons
      Parameter (Manh = 15)
!                           maximum number of layers
      Parameter (Manl = 50)
!                           maximum number of materials
      Parameter (Manm = 20)
!                           maximum number of years
      Parameter (Many = 20)
!                           maximum number of data in pF-tables per
!                           soil building blocks/units (according to Staringreeks,
                            Wosten, 1987)
      Parameter (Mapf = 100)
!                           maximum number of fractions of complexes
!                           (fast or slow)
      Parameter (Macx=3)
!                           maximum number of sorption parameters of
!                           all sorption formulations
      Parameter (Masp=5)
!                           maximum number of balance profiles
      Parameter (Maba=10)
!                           maximum number of time series for output
      Parameter (Mase=37)
```

Annex 2 Description of the mass balances

ANIMO 4.0 has the ability to generate mass balances. In ***Table 16*** to ***22*** a description of the mass balances generated as output files by ANIMO 4.0 is given. The output files are optional (see also Chapter 3: input file GENERAL.INP).

On the next pages, a description will be given of the content of the following seven output files:

- ***Table 16***: water balance BAWA//.OUT
- ***Table 17***: organic matter balance BAOM//.OUT
- ***Table 18***: ammonium balance BANH//.OUT
- ***Table 19***: nitrate balance BANI//.OUT
- ***Table 20***: organic nitrogen balance BANO//.OUT
- ***Table 21***: phosphate balance BAPP//.OUT
- ***Table 22***: organic phosphorus balance BAPO//.OUT

At the position // a character string of 2 positions must be given to identify the set of 7 output files with mass balances (see Chapter 3: input file GENERAL.INP)

Table 16 Output from ANIMO: ---------- water balance ----------

Balance terms : in mm accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
WALET	= groundwater level (m below the soil surface) at the end of the time step (If the groundwater level exceeds the bottom of the profile this value is set to the depth of the bottom of the profile.)
WALEAV	= groundwater level (m below the soil surface)
BAWAST	= storage (mm) in the soil profile at the beginning of the balance period
BAWASTT	= storage (mm) in the soil profile at the end of the balance period
BAWAPN	= ponding (mm) on top of the soil profile at the beginning of the balance period
BAWAPNT	= ponding (mm) on top of the soil profile at the end of the balance period
BAWADV	= deviation (mm) of water balance for the balance period and the balance profile
BAWADVCU	= deviation (mm) of water balance; cumulative from the start of the simulation

Record 2 (balance input terms in mm):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BAWATD	= downward flux across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BAWAINFG	= infiltration from 3rd order drainage system (trenches, drain-pipes)
BAWAINFS	= infiltration from 2nd order drainage system (ditches, small rivers)
BAWAINFK	= infiltration from 1st order drainage system (canals, large rivers)
BAWASE	= upward flux across the lower boundary (dependent on balance profile: seepage or capillary rise)

Record 3 (balance output terms in mm):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BAWATU	= upward flux across the top boundary (dependent on balance profile: seepage or capillary rise)
BAWAEI	= interception-evaporation
BAWAES	= soil-evaporation
BAWAET	= transpiration
BAWARU	= surface runoff
BAWADRFG	= drainage towards 3rd order drainage system (trenches, drain-pipes)
BAWADRFS	= drainage towards 2nd order drainage system (ditches, small rivers)
BAWADRFK	= drainage towards 1st order drainage system (canals, large rivers)
BAWALE	= downward flux across the lower boundary (dependent on balance profile: percolation or leakage)
BAWAESMA	= potential soil evaporation
BAWAETMA	= potential plant evaporation

Table 17 Output from ANIMO: ---------- Mass balance of organic matter ----------

Balance terms : in kg ha^{-1} organic matter accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
BAOMSD	= storage (kg ha^{-1}) of solid organic matter at the beginning of the time step
BAOMSDT	= storage (kg ha^{-1}) of solid organic matter at the end of the time step
BAHUSD	= storage (kg ha^{-1}) of solid humus at the beginning of the time step
BAHUSDT	= storage (kg ha^{-1}) of solid humus at the end of the time step
BADOST	= storage (kg ha^{-1}) of dissolved organic matter at the beginning of the time step
BADOSTT	= storage (kg ha^{-1}) of dissolved organic matter at the end of the time step
BAOMDV	= deviation (kg ha^{-1}) of org mat balance for the balance period and the balance profile
BAOMDVCU	= deviation (kg ha^{-1}) of org mat balance; cumulative from the start of the simulation
BAHUDV	= deviation (kg ha^{-1}) of humus balance for the balance period and the balance profile
BAHUDVCU	= deviation (kg ha^{-1}) of humus balance; cumulative from the start of the simulation
BADODV	= deviation (kg ha^{-1}) of dissolved organic matter balance for the balance period and the balance profile
BADODVCU	= deviation (kg ha^{-1}) of dissolved organic matter balance; cumulative from the start of the simulation

Record 2 (balance input terms in kg ha^{-1}):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BADOTD	= downward flux of dissolved organic matter across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BAOMAD	= additions of organic matter
BAHUAD	= additions of humus
BADOAD	= additions of dissolved organic matter
BAOMCR	= crop residues of organic matter
BAOMEX	= exudates of organic matter
BAHUFM	= formation of humus
BADOFM	= formation of dissolved organic matter
BADOINFG	= infiltration of dissolved organic matter from 3rd order drainage system (trenches, drain-pipes)
BADOINFS	= infiltration of dissolved organic matter from 2nd order drainage system (ditches, small rivers)
BADOINFK	= infiltration of dissolved organic matter from 1st order drainage system (canals, large rivers)
BADOSE	= upward flux of dissolved organic matter across the lower boundary

Record 3 (balance output terms in kg ha^{-1}):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BADOTU	= upward flux of dissolved organic matter across the top boundary (dependent on balance profile: seepage or capillary rise)
BADORU	= surface runoff of dissolved organic matter
BAOMDI	= dissociation of organic matter
BAHUDI	= dissociation of humus
BADODI	= dissociation of dissolved organic matter
BADODRFG	= drainage of dissolved organic matter towards 3rd order drainage system (trenches, drain-pipes)
BADODRFS	= drainage of dissolved organic matter towards 2nd order drainage system (ditches, small rivers)
BADODRFK	= drainage of dissolved organic matter towards 1st order drainage system (canals, large rivers)
BADOLE	= downward flux of dissolved organic matter across the lower boundary (dependent on balance-profile: percolation or leakage)
BAOMCO2	= dissimilation of organic matter
BAHUCO2	= dissimilation of humus
BADOCO2	= dissimilation of dissolved organic matter

Table 18 Output from ANIMO: ---------- Mass balance of NH4-N ----------

Balance terms : in kg ha^{-1} NH_4-N accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
BANHST	= storage (kg ha^{-1} NH_4-N) in the soil solution at the beginning of the balance period
BANHSTT	= storage (kg ha^{-1} NH_4-N) in the soil solution at the end of the balance period
BANHCX	= storage (kg ha^{-1} NH_4-N) at the soil complex at the beginning of the balance period
BANHCXT	= storage (kg ha^{-1} NH_4-N) at the soil complex at the end of the balance period
BANHDV	= deviation (kg ha^{-1} NH_4-N) of NH_4-N balance for the balance period and the balance profile
BANHDVCU	= deviation (kg ha^{-1} NH_4-N) of NH_4-N-balance; cumulative from the start of the simulation

Record 2 (balance input terms in kg ha^{-1} NH_4-N):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BANHTD	= downward flux across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BANHINFG	= infiltration from 3rd order drainage system (trenches, drain-pipes)
BANHINFS	= infiltration from 2nd order drainage system (ditches, small rivers)
BANHINFK	= infiltration from 1st order drainage system (canals, large rivers)
BANHSE	= upward flux across the lower boundary (dependent on balance-profile: seepage or capillary rise)
BANHMI	= mineralization
BANHAD	= additions
BANHCR	= crop residues
BANHDD	= dry deposition

Record 3 (balance output terms in kg ha^{-1} NH_4-N):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BANHTU	= upward flux across the top boundary (dependent on balance profile: seepage or capillary rise)
BANHUP	= gross crop uptake
BANHRU	= surface runoff
BANHDRFG	= drainage towards 3rd order drainage system (trenches, drain-pipes)
BANHDRFS	= drainage towards 2nd order drainage system (ditches, small rivers)
BANHDRFK	= drainage towards 1st order drainage system (canals, large rivers)
BANHLE	= downward flux across the lower boundary (dependent on balance profile: percolation or leakage)
BANHIM	= immobilisation
BANHNT	= nitrification
BANHVO	= volatilisation

Table 19 Output from ANIMO: ---------- Mass balance of NO3-N ----------

Balance terms : in kg ha^{-1} NO_3-N accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
BANIST	= storage (kg ha^{-1} NO_3-N) in the soil profile at the beginning of the balance period
BANISTT	= storage (kg ha^{-1} NO_3-N) in the soil profile at the end of the balance period
BANIDV	= deviation (kg ha^{-1} NO_3-N) of nitrate balance for the balance period and the balance profile
BANIDVCU	= deviation (kg ha^{-1} NO_3-N) of nitrate balance; cumulative from the start of the simulation

Record 2 (balance input terms in kg ha^{-1} NO_3-N):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BANITD	= downward flux across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BANIINFG	= infiltration from 3rd order drainage system (trenches, drain-pipes)
BANIINFS	= infiltration from 2nd order drainage system (ditches, small rivers)
BANIINFK	= infiltration from 1st order drainage system (canals, large rivers)
BANISE	= upward flux across the lower boundary (dependent on balance profile: seepage or capillary rise)
BANINT	= nitrification
BANIAD	= additions
BANICR	= crop residues
BANIDD	= dry deposition

Record 3 (balance output terms in kg ha^{-1} NO_3-N):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BANITU	= upward flux across the top boundary (dependent on balance profile: seepage or capillary rise)
BANIUPCV	= gross crop uptake by convection
BANIUPDF	= gross crop uptake by diffusion
BANIRU	= surface runoff
BANIDRFG	= drainage towards 3rd order drainage system (trenches, drain-pipes)
BANIDRFS	= drainage towards 2nd order drainage system (ditches, small rivers)
BANIDRFK	= drainage towards 1st order drainage system (canals, large rivers)
BANILE	= downward flux across the lower boundary (dependent on balance profile: percolation or leakage)
BANIDE	= denitrification

Table 20 Output from ANIMO: ---------- Mass balance of organic nitrogen ----------

Balance terms : in kg ha^{-1} N accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
BANOST	= storage (kg ha^{-1} N) of dissolved organic matter at the beginning of the balance period
BANOSTT	= storage (kg ha^{-1} N) of dissolved organic matter at the end of the balance period
BANOSD	= storage (kg ha^{-1} N) of solid organic matter at the beginning of the balance period
BANOSDT	= storage (kg ha^{-1} N) of solid organic matter at the end of the balance period
BANODV	= deviation (kg ha^{-1} N) of org.-N balance for the balance period and the balance profile
BANODVCU	= deviation (kg ha^{-1} N) of organic-N balance; cumulative from the start of the simulation

Record 2 (balance input terms in kg ha^{-1} N):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BANOTD	= downward flux across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BANOINFG	= infiltration from 3rd order drainage system (trenches, drain-pipes)
BANOINFS	= infiltration from 2nd order drainage system (ditches, small rivers)
BANOINFK	= infiltration from 1st order drainage system (canals, large rivers)
BANOSE	= upward flux across the lower boundary (dependent on balance profile: seepage or capillary rise)
BANOIM	= immobilisation
BANOAD	= additions
BANOCR	= crop residues
BANOEX	= exudates

Record 3 (balance output terms in kg ha^{-1} N):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BANOTU	= upward flux across the top boundary (dependent on balance profile: seepage or capillary rise)
BANORU	= surface runoff
BANODRFG	= drainage towards 3rd order drainage system (trenches, drain-pipes)
BANODRFS	= drainage towards 2nd order drainage system (ditches, small rivers)
BANODRFK	= drainage towards 1st order drainage system (canals, large rivers)
BANOLE	= downward flux across the lower boundary (dependent on balance profile: percolation or leakage)
BANOMI	= mineralization

Table 21 Output from ANIMO: ---------- Mass balance of PO4-P ----------

Balance terms : in kg ha^{-1} PO_4-P accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
BAPPST	= storage (kg ha^{-1} PO_4-P) in the soil solution at the beginning of the balance period
BAPPSTT	= storage (kg ha^{-1} PO_4-P) in the soil solution at the end of the balance period
BAPPCX	= storage (kg ha^{-1} PO_4-P) at the soil complex at the beginning of the balance period
BAPPCXT	= storage (kg ha^{-1} PO_4-P) at the soil complex at the end of the balance period
BAPPPR	= storage (kg ha^{-1} PO_4-P) of precipitated P at the beginning of the balance period
BAPPPRT	= storage (kg ha^{-1} PO_4-P) of precipitated P at the end of the balance period
BAPPDV	= deviation (kg ha^{-1} PO_4-P) of PO^4-P balance for the balance period and the balance profile
BAPPDVCU	= deviation (kg ha^{-1} PO_4-P) of PO_4-P balance; cumulative from the start of the simulation

Record 2 (balance input terms in kg ha^{-1} PO_4-P):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BAPPTD	= downward flux across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BAPPINFG	= infiltration from 3rd order drainage system (trenches, drain-pipes)
BAPPINFS	= infiltration from 2nd order drainage system (ditches, small rivers)
BAPPINFK	= infiltration from 1st order drainage system (canals, large rivers)
BAPPSE	= upward flux across the lower boundary (dependent on balance profile: seepage or capillary rise)
BAPPMI	= mineralization
BAPPAD	= additions
BAPPCR	= crop residues

Record 3 (balance output terms in kg ha^{-1} PO_4-P):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BAPPTU	= upward flux across the top boundary (dependent on balance profile: seepage or capillary rise)
BAPPUP	= gross crop uptake
BAPPRU	= surface runoff
BAPPDRFG	= drainage towards 3rd order drainage system (trenches, drain-pipes)
BAPPDRFS	= drainage towards 2nd order drainage system (ditches, small rivers)
BAPPDRFK	= drainage towards 1st order drainage system (canals, large rivers)
BAPPLE	= downward flux across the lower boundary (dependent on balance profile: percolation or leakage)
BAPPIM	= immobilisation

Table 22 Output from ANIMO: ---------- Mass balance of organic phosphorus -------

Balance terms : in kg ha^{-1} P accumulated for the balance period
For each balance period three records are given:

Explanation of names of variables:
Record 1 (time-variables, and balance-terms for storage and deviation):

R1	= number (identifier) of first record
YR	= year of simulation
TITO	= Julian day number accumulated from the start of the simulation
TIYR	= Julian day number from the year of simulation
BAPOST	= storage (kg ha^{-1} P) of dissolved organic-P at the beginning of the balance period
BAPOSTT	= storage (kg ha^{-1} P) of dissolved organic-P at the end of the balance period
BAPOSD	= storage (kg ha^{-1} P) of solid organic phosphorus at the beginning of the balance period
BAPOSDT	= storage (kg ha^{-1} P) of solid organic phosphorus at the end of the balance period
BAPODV	= deviation (kg ha^{-1} P) of organic-P balance for the balance period and the balance profile
BAPODVCU	= deviation (kg ha^{-1} P) of organic-P balance; cumulative from the start of the simulation

Record 2 (balance input terms in kg ha^{-1}):

R2	= number (identifier) of second record
TITO	= Julian day number accumulated from the start of the simulation
BAPOTD	= downward flux across the top boundary (dependent on balance profile: precipitation, percolation or leakage)
BAPOINFG	= infiltration from 3rd order drainage system (trenches, drain-pipes)
BAPOINFS	= infiltration from 2nd order drainage system (ditches, small rivers)
BAPOINFK	= infiltration from 1st order drainage system (canals, large rivers)
BAPOSE	= upward flux across the lower boundary (dependent on balance profile: seepage or capillary rise)
BAPOIC	= incorporation
BAPOAD	= additions
BAPOCR	= crop residues
BAPOEX	= exudates

Record 3 (balance output terms in kg ha^{-1}):

R3	= number (identifier) of third record
TITO	= Julian day number accumulated from the start of the simulation
BAPOTU	= upward flux across the top boundary (dependent on balance profile: seepage or capillary rise)
BAPORU	= surface runoff
BAPODRFG	= drainage towards 3rd order drainage system (trenches, drain-pipes)
BAPODRFS	= drainage towards 2nd order drainage system (ditches, small rivers)
BAPODRFK	= drainage towards 1st order drainage system (canals, large rivers)
BAPOLE	= downward flux across the lower boundary (dependent on balance profile: percolation or leakage)
BAPOMI	= mineralization

Annex 3 Composition of some materials

Table 23 presents the organic and inorganic/mineral composition of some materials. Data in these tables originate from regional studies of which the reference is given with numbers in the last column of both tables. These numbers refer to the following regional studies:
1. Kroes et al., 1990, Boers et al;, 1997, Boogaard and Kroes, 1997.
2. Bolt et al., 1996.
3. Groenendijk and Kroes, 1999.

Table 23 The organic and inorganic composition of some materials

Mat nr.	Description	Mass fractions ($kg\ kg^{-1}$ material)				Ref.
		organic matter	inorganic (mineral) N and P			
			NH_4-N	NO_3-N	PO_4-P	
1	cattle slurry	0.06	0.0022	0	0.0008	1
2	calve slurry	0.015	0.0021	0	0.0015	1
3	pig slurry	0.063	0.00275	0	0.004	1
4	poultry slurry	0.095	0.0063	0	0.008	1
5	dry poultry manure	0.37	0.0095	0	0.0028	1
6	grazing slurry losses	0.063	0.0023	0	0.00057	2
7	dry stable manure	0.15	0.0011	0	0.00122	3
8	N-fertilizer	0	0.5	0.5	0	1
9	kalkammonsalpeter	0	0.29	0.29	0	3
10	kalksalpeter	0	0.012	0.143	0	3
11	P-fertilizer	0	0	0	1	2
12	triplefosfaat	0	0	0	0.1965	3
13	compost	0.183	0	0	0	3
14	straw	0.8	0	0	0	3
15	roots of non-grassland	1	0	0	0	1
16	roots of grassland	1	0	0	0	1
17	organic matter subsoil	1	0	0	0	1
18	organic matter mesotrophic peat	1	0	0	0	1
19	organic matter eutrophic peat	1	0	0	0	1

Annex 4 Description of the external crop module PRICrop

A4.1 Description of the program PRICrop

The PRICrop model is based on the special version of the QUADMOD model for STONE applications (ten Berge et al., 2000). This module is a static model expressing the relations between the rate of nitrogen applications, crop N-yield and crop dry matter yield. An extension has been made on the occasion of the STONE integration with respect to the partitioning of biomass, nitrogen and phosphorous over plant parts, the timing of the N- and P-uptake and the release of crop residues.

While linked to the ANIMO model, the uptake of nutrients simulated by PRICrop is not assessed in response to the instantaneous availability of the nutrients in the root zone, but the annual total uptake is first calculated in response to the annual nutrient supply and other factors. Subsequently, the annually values are translated into an a priori time pattern: the course of uptake and the crop residue release over the growing season. This result in daily uptake rates presented as input to ANIMO.

The response of total seasonal nitrogen yield U to the applied nitrogen dose A is determined by crop characteristics, weather, crop management and nutrient management (ten Berge et al., 2000). The N-yield in the QUADMOD is described by the sum of uptake from the soil-stored N-pool and the uptake from applied fertilizer. The final relations for the N-uptake contain seven independent parameters. Six of them could be calibrated on series of field trials. The remaining parameter expresses the N-yield on non-fertilised field plots and should be set as an input parameter to the model. The total uptake is distributed over time utilising a generalised logistic function.

A4.2 Description of the input file.

The program needs one input file. The input file is an ASCII text file, which can be produced, with any text-editor. The ASCII input-file may have three types of lines (see also van den Broek et al., 1994):

- *Label lines*: The first 8 characters of a label line should contain the label as given in the column Range and indicate with the Mnemonic 'LABEL'. Characters to the right of the label are not significant and can be used as comment. The label indicates that the next line is a data line.
- *Data lines:* A data line always follows a label line. Data on one line must be separated by one or more blanks. Data lines must contain only data; labels or comments are not allowed on data lines. Data of the type character must be placed between apostrophes.
- *Comment lines:* These may be used before a label line or after a data line (or group of data lines). They are not significant to the program. Their only purpose is to make the input-file easier to read for the user.

The description of the variables in ***Table 24*** is given in 6 columns:

- *column 1*: Description of the variable
- *column 2*: Unit of the variable
- *column 3*: Range of the variable with the following annotation:
  [x ... y] range for integer values
  [x.x ... y.y] range for real values
  [... y] range with no minimum
  [x ...] range with no maximum
  >labeln: character string of 8 positions with name of label at position 2-7
  The given ranges have received values that should be regarded as estimates introduced to give users an indication for average situations. Range checking in the computer code is in most cases performed with a wider range to allow executions under more extreme circumstances.
  Some boundaries of ranges are defined by parameters values, which always have a name that starts with m (e.g. mcrop, msoil, etc.). These values are defined in the Fortran source file Dims.inc. Some initial parameters of crops are defined in a data file, gg2params.inc. A listing of these file are given in annex 7.
- *column 4:* Indicator for position of variable at new record:
  * write at new record;
  \- write with separation sign (space, comma, or new line);
- *column 5:* Indicator for kind of data type of variable:
  Cx character-string of x positions positioned between quotes ('),
  I Integer*2,
  R Real*4
- *column 6* The Mnemonic of the variable used in the computer program

Table 24 The input file GG2.inp: simulation options

This file only if ioptCU=1

Description of variable	Unit	Range	R	DT	Mnemonic	
Label for section with simulationtime options	-	**>timcnt:**	*	C8	LABEL	
Year simulation starts	-	[1941 ... YRMA]	*	I	YRMI	
Year simulation ends	-	[YRMI ... 2040]	-	I	YRMA	
Time step Only 1 day or a decade is possible [10]. If chosen for a decade the model determines the decay length to complete a whole year.	-	[1],[10]	*	I	STEP	
Label for soiltype and region number	-	**>lnduse:**	*	C8	LABEL	
Region number (Detremined by PAWN-district) 1 = Sea clay 2 = River clay 3 = Southern sand area 4 = Sandy soils with a peat cover	-	[1 ... 4]	*	I	REGION	
Soiltype (Detremined by PAWN Soil-unit) 1 = Peat 2 = Clay 3 = Wet sandy soils (mean highest water-table (MHW) 0-0.40m) 4 = Intermediate sandy soils (MHW 0.40-0.80m) 5 = Dry sandy soils (MHW >0.80m)	-	[1 ... 5]	-	I	SOILTYPE	
Label for crop loses due to aboveground parts (shoots)	-	**>frcrls:**	*	C8	LABEL	
Fraction of crop losses due to aboveground parts (shoots)	-	[0 ... 1]	*	R	FRSH	
Label for kind of crop and landuse	-	**>kicrop:**	*	C8	LABEL	
Year with data	-	[YRMI ... YRMA]	*	I	YEARLP(YR)	**Should be repeated for every year**
Array with the fraction of the area used with the predifined crops (1 .. 6) 1 = grass_cut 2 = grass_grazed 3 = maize 4 = weat 5 = sugar beet 6 = potato	-	[0 ... 1]	-	R	AREALP(YR,I)	
N-delivery of the soil	-	[0.0 ... 1000.0]	-	R	NETNSOILLP(YR)	
N-available for the crop: NH4-part + Ne-part org. manure (exclusive pasture manure!!) + N-fertilizer	-	[0.0 ... 1000.0]	-	R	NWDOSELP(YR)	

A4.3 Description of the output file.

The output of the program PRICrop can be used as input for the program ANIMO.
The detailed description of the variables in the output file Crop_ext.inp can be found in section 3.2 Description of the input files.

The output is divided into a crop uptake and a crop losses part.
The relation between the development of the uptake and losses against the time for every kind of crop is given in the following figures.
The uptake and losses of the both grasses show the same dynamics, only the values of crop uptake of the grazed grassland are higher and the values of crop losses lower. But the ratio is the same, so for grass only one graph will be given.
For maize, sugar beet and potatoes only the crop uptake show the same dynamics. Generally sugar beet gives higher crop uptake values than maize and maize higher than potatoes.

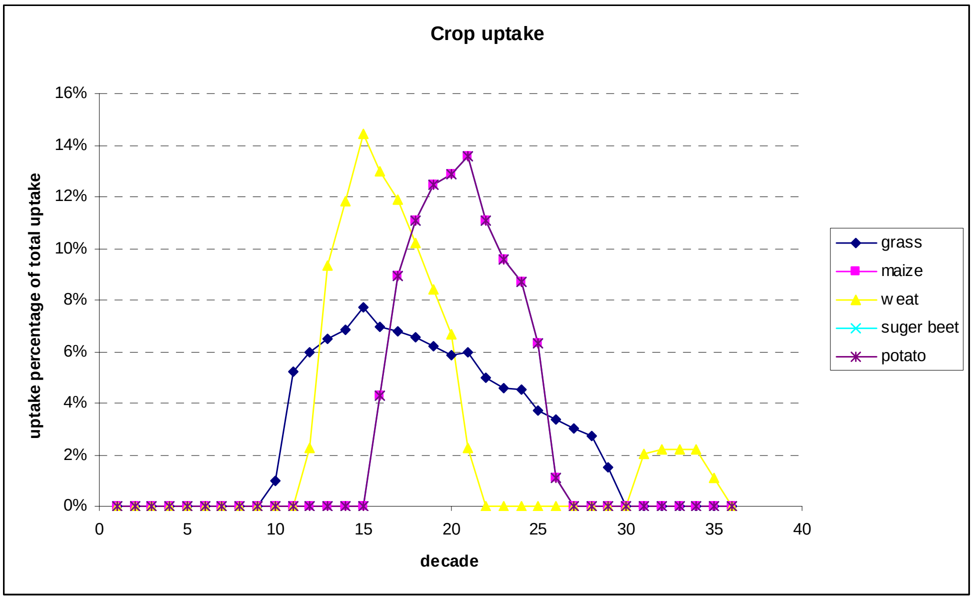

Figure 64 Crop uptake percentage of total uptake for the five kinds of crops in PRICrop

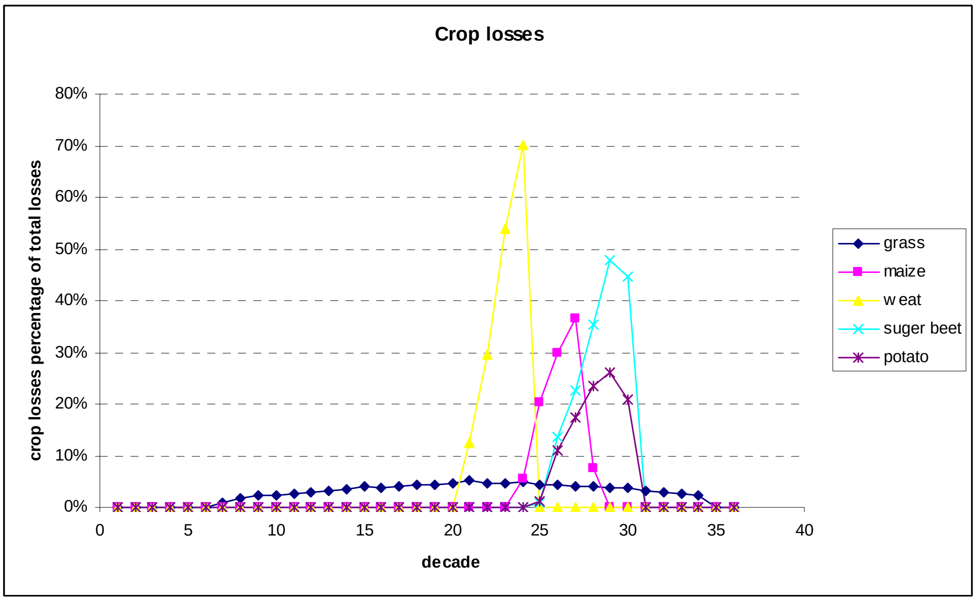

Figure 65 Crop losses percentage of total losses for the five kind of crops in PRICrop

Annex 5 Technical model description of ANIMO 4.0

A5.1 Model structure

The flow chart (***Figure 66***) presents simulation core and the model structure. Initialisation is the first step in the ANIMO model. It results to an initial distribution of organic matter and mineral N and P over the model compartments. The simulation then enters a loop with time-intervals. The length of a time step is defined by the results of the hydrological model. Results of the hydrological model are read as terms of a complete water balance for the soil-water-plant system. If the user has chosen the original crop uptake module for arable crops the procedure proceeds with a simulation of shoot and root development by the ANIMO model. Soil temperatures are simulated with a sinus wave sub-model or read from an input file. Additions and tillage are introduced as pulses at the beginning of the time step. The nitrogen and phosphorus uptake rates are determined as sink terms for the mass conservation and transport equation (CTE). Reaction rates (sink and source terms) are corrected for the environmental influences of temperature, moisture and pH. In principal, the CTE for soluble substances can be solved now. However, oxygen is required for the transformation of organic matter and for nitrification. Therefore, an estimate is of the oxygen profile. By attuning the oxygen demand to the diffusive capabilities of the soil an aerated fraction of each soil compartment is calculated. Once the decomposition of dissolved organic matter is known, the CTE can be solved for each soluble organic fraction. From the results of the dissolved organic matter compounds and the transformation rates of solid organic matter mineralization can be calculated. When the conservation and transport equation for ammonium is considered nitrification is a sink term depending on the ammonium concentration and on the aeration fraction of the soil. While solving the CTE for nitrate, the denitrification is considered as a zero order or as a first order sink term, depending on whether the organic matter respiration or the nitrate concentration is rate limiting. At the end of each time interval the nutrient uptake rates are integrated and compared to the potential uptake rates as defined by the user in the input files. An uptake surplus or a deficit will be accounted for during the next time step.

Mass balances are verified and results are written to output-files.

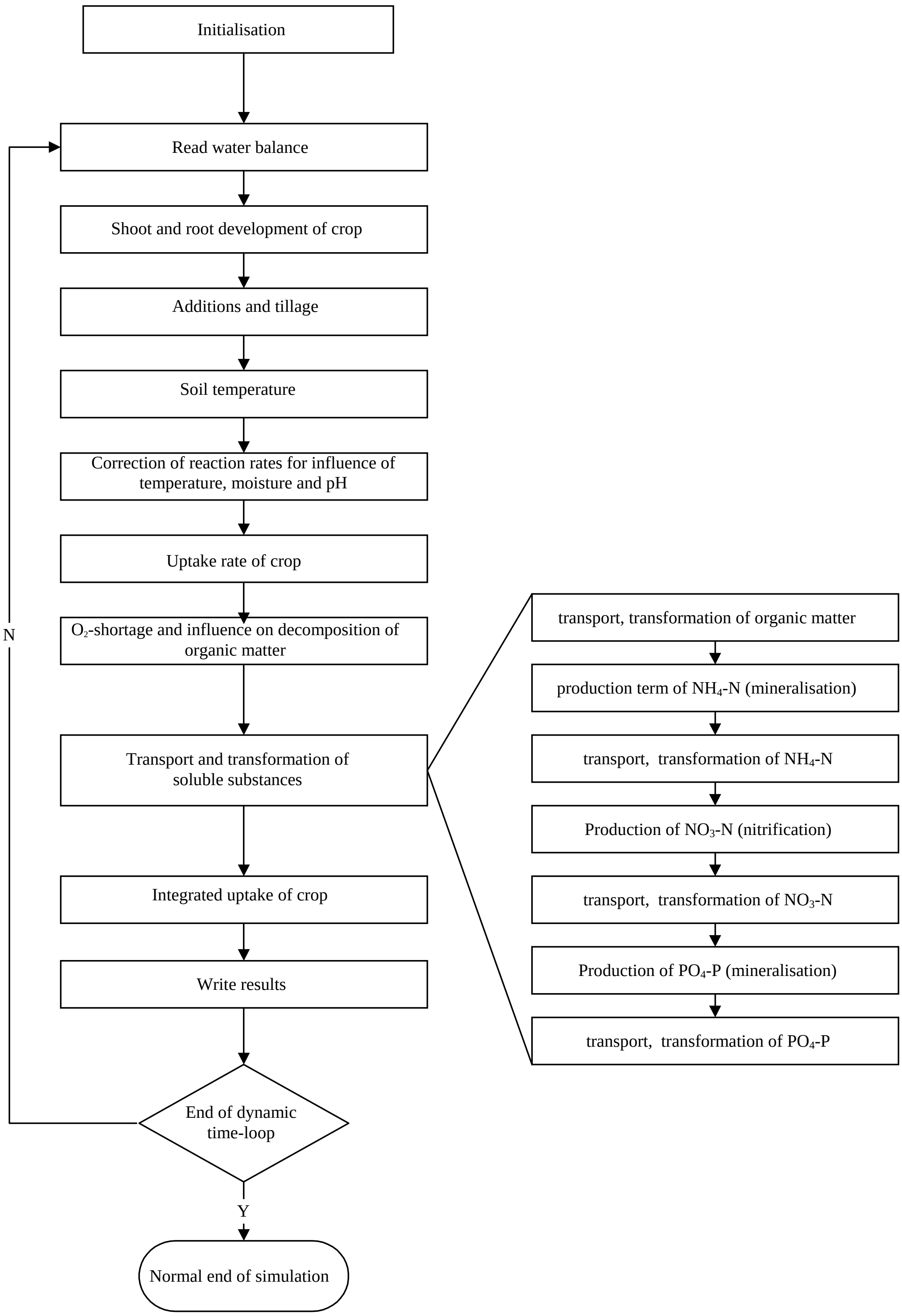

Figure 66 Flow chart of main module of ANIMO 4.0

A5.2 Source Code

The computer program has been coded in FORTRAN on the operation system MS-DOS. It can be compiled either with FORTRAN77 or with FORTRAN90 compilers and it has been checked for syntax using FORCHECK (Leiden, 1993).
The source code of the model ANIMO 4.0 consists of the following modules:
- the main program;
- a number of subroutines;
- a number of functions;
- three include-files:
  - `Param.inc`: parameter-statements for the dimensions of arrays;
  - `Animo.inc`: formal variables in the main program Animo
  - `Outbal.inc`: declaration of the output balance array variables

A description of the main program and a brief summary of the subroutines are given in the subsequent paragraphs.

A5.2.1 Main program

Structure of the source code of the main program ANIMO is presented in ***Figure 67*** and will be discussed in this section. All reading of input-data is performed by the subroutines **`Input1`**, **`Input_addit`**, **`Input_cropext`** and **`Input_hydro`**. These subroutines also perform range checking on minimum and maximum values of all input-parameters. Initial calculations (conversions of and processing of extensions from input-variables) are executed in the subroutine **`INICALC`**. If a 2-layer (root zone/subsoil) hydrological model (e.g. WATBAL) has been applied for the hydrological calculation then the initial moisture contents for the ANIMO compartments are calculated, otherwise initial moisture contents are given as input. For grassland initial uptake and root-development is calculated.
The subroutine **`Input_Echo`** writes output from input to the file AnimoInputs.OUT and the subroutine OUTPUT writes intermediate results, at times defined in the input file General.inp, to the file AnimoIntermediate.OUT. The subroutine **`Outbal_write`** opens the selected output files assigned in General.inp.
Two loops control the dynamic part of the model: a year-loop and a time step loop. At the start of each year the subroutine **`Init_yr`** is called. This subroutine makes single values of year array variables read from the input files. For grassland, the subroutine **`Grass_init`** is executed which opens the output files Grass.out and Grass-yr.out if selected in General.inp. The next part of the main program is executed during each simulated time step.
The subroutine Init updates all state variables. Reading of the dynamic part of the hydrological data is done in the subroutine **`Input_hydro`**.
The subroutine **`Hydro_Aggregated`** converts hydrological data generated by a two-layer water quantity model (e.g. WATBAL) to fluxes and moisture contents per compartment. If the hydrological data originate from a detailed water quantity model (e.g. SWAP), fluxes and moisture fractions are taken as input and the subroutine **`Hydro_detailed`** only modifies flux-terms of the water balance for use in the transport equation (all fluxes must be greater than or equal to zero).
Development of root mass and rooting-depth is calculated in the subroutine **`GRASSPRD`** and **`Root_grass`** for grassland, in **`Root_plant`** for non-grassland and in **`Root_extern`** for crop uptake by an external crop module.

In the subroutines **Input_addit** and **ADDIT** the additions to the model system are read and executed. The subroutine **UBoundconc** calculates the upper boundary concentration for the top layer (used for additions) and either layer number ln=0 (top of soil compartment allocated to ponding) or layer number ln=1 (first compartment layer), dependent on the hydrological situation. Crop uptake variables (selectivity factors) are determined in the subroutine **Uptpar_Grass** for grassland, in **Uptpar_Plant** for non-grassland and **Uptpar_Extern** for crop uptake by external crop module. If a detailed water quantity model (e.g. SWAP) calculates the temperature, ANIMO can read these temperatures. If such a water quantity model does not the subroutine **TEMPER** uses a sine wave model to calculate the soil temperatures. The subroutine **FRACPOINT** determines the number of existing organic fractions. Potential reaction rates are corrected for environmental influences of moisture, temperature and pH in the subroutine **RATES1**. Potential transport and transformation of soluble organic matter is computed in the subroutine **Transca**.
In the subroutine **Respirate** the respiration terms and oxygen demand of organic matter transformation are calculated. An oxygen profile is determined, for (partial and temporary) anaerobe conditions. If the potential oxygen consumption is higher than the availability of oxygen, the decomposition of organic matter is reduced. The first estimate of average ammonium concentration to calculate the oxygen requirement of the nitrification process is calculated in **Transport**. Influences of reduction factors of aeration on transformation rates are calculated in **Aeration_original** when aeration is calculated in the oxygen diffusion sub model and in **Aeration_sonicg** when aeration is calculated in the water filled pore space driven sub model. Actual reaction rates are corrected for environmental influences of moisture, temperature and pH in the subroutine **RATES2**.
The subroutine **TRANSCA** then determines the actual transport and conservation of organic matter in solution and the mineralization takes place in the subroutine **MINER**. The mineral ammonium can now be transported and nitrified in the subroutine **TRANSPORT**. The zero-order production rate for the net production of nitrate is determined in the subroutine **DENITR**. For grassland, the subroutine **Grassup3** calculates crop uptake by diffusion.
Nitrate is transported and produced/consumed in the subroutine **TRANSPORT**. The subroutine **TRANS-GEN** calculates transformation and transport of phosphorus.
Calculation of the parameters of crop uptake is summarized in the subroutines Upting_plant for non-grassland, in **Upting_grass** for grassland and in **Upting_extern** for crop uptake by an external crop module.
The subroutine **Outbal_calc** creates mass balances for water, organic matter, nitrate-N, ammonium-N, organic-N, ortho-phosphate-P and organic-P, and the results of these mass balances are written by the subroutine **Outbal_write**. During each simulated time step, results (concentrations and amounts) are written to the files defined in the file General.inp. After the time step loop, if the output option for grass is turned on, the subroutine **Outputgr_yr** writes results to the file Grass_yr.out. At the end of the simulation, the subroutine **Outbal_write** writes the concentrations and amounts to the mass balances and the balance files. The subroutine **Output_Init** writes the final results to the file INITIAL.OUT, a file which can be used as input for a next simulation period.

```
      Program Animo
!.... Declarations
      Implicit none
      Include  'Param.inc'
      Include  'Animo.inc'
      Data IDum, RDum, Uosc /0 , 0.0 , 6/
!                                                 Version identification:
      Rcstemp='$Name: Animo_4_0_18 $'
      Rcsname=RcsTemp(8:Len_trim(Rcstemp)-2)
!                                               general and initial input
      Call Input1                                                       &
        If(Errornumber.ne.0) Goto 9999
!....       crop uptake and crop residues data from external crop module
      If (Ioptcu.eq.1) Call Input_cropext                               &
        If(Errornumber.ne.0) Goto 9999
!                                                    initial calculations
      Call Inicalc                                                      &
        If(Errornumber.ne.0) Goto 9999
!........................... macro pore begin ........................
!... Initial calculations for macro pore
      If (Ioptmp.eq.1) call Mapoinicalc                                 &
!........................... macro pore End ..........................
!                                     output of general and initial input
      Call Input_Echo                                                   &
      Itask = 1
      Call Outbal_write                                                 &
!.... Simulation
!                                                               year loop
      Sttot = 0
      tito  = 0.0
      Tiyr  = Timi
      DO Yr = Yrmi, Yrma
         Yn = Yr - Yrmi + 1
         Call Init_yr                                                   &
         If(Ioptcu.eq.1) Then
           Ioptplant = 3
         Else
           If(Kicryn.eq.6) Then
             Ioptplant = 2
             Fiyrgr=0
             If (Yn.eq.1 .or. Yn.gt.1.and.Kicrold.ne.6) Fiyrgr=Yr
           Else
             Ioptplant = 1
           End If
         End If
         If(Ioptplant.eq.2) Then
            Call Grass_init                                             &
            If(Errornumber.ne.0) Goto 9999
         End If

         If(Yr.eq.Yrmi) Call Outbal_Init                                &
!                                                           Timestep loop
         Stnu = 0
         If(Iwa.Eq.1) Latist = 365.0+0.9*St
         If(Iwa.Eq.2) Latist = Nudayr(Yr)
         If(Yr.Eq.Yrma) Then
           If(Iwa.Eq.1) Last = Tima+0.9*St
           If(Iwa.Eq.2) Last = Tima
         End If
         Do While ( Yr.lt.Yrma .and. Tiyr+St.le.Latist .or.             &
     &              Yr.eq.Yrma .and. Tiyr+St.le.Last)
!             T I M E   V A R I A B L E S
            Sttot = Sttot + 1
            Stnu  = Stnu  + 1
            If(Optst.Eq.3) St=Stlen(Tiyr+1,Yr)
!                                       Read next timestep to update Tiyr
            If (Iopthyvs.Eq.1) Then
              Read(Uiun) Tiwa,St
              Backspace(Uiun)
            End If
            Tiyr  = Tiyr  + St
            Tito  = Tito  + St
!                                                         Write to screen
            If (Outsc.ne.0) Call Comstage                               &
     &      (Outsc,Stnu,Uosc,Yr,Yrma,Yrmi,Tima,Timi,Tito,Tiyr)

            Toutout = .false.
            If(Outto.eq.1.or.Nint(Tito).eq.Out(Iout)) Then
              Toutout = .true.
              Iout = Iout+1
            End If
!                U P D A T E   S T A T E   V A R I A B L E S
!                                            (RESULT FROM PREVIOUS STEP)
            Call Init                                                   &
!........................... macro pore begin ........................
!... Initial calculations for macro pore
            If(Ioptmp.eq.1) Call Mapoinit                               &
!........................... macro pore End ..........................
!                H Y D R O L O G Y
!                   moisture contents and fluxes from hydrological model
            Call Input_hydro                                            &
            If(Errornumber.ne.0) Goto 9999
!                                       waterbalance calculations WATBAL
            If (Iwa.eq.1) Call Hydro_Aggregated                         &
            If(Errornumber.ne.0) Goto 9999
!                                         waterbalance calculations SWAP
            If (Iwa.eq.2) Call Hydro_detailed                           &
```

```
          If(Errornumber.ne.0) Goto 9999
!                                 Write to file AnimoIntermediate.OUT
          If(Toutout) Call Output6                                     &
!              C R O P   R E S I D U E S
          If(Ioptplant.eq.1) Then
            Call Root_plant                                            &
!                                           echo intermediate results
            If(Toutout .and. Nuroom.Gt.0) Call Output9                 &
          End If
!              grassland:  production, root and shoot development, and
!           production-reduction in case of N-shortage, N-content of roots
          If(Ioptplant.eq.2) Then
            Call Grassprd                                              &
            Call Root_grass                                            &
            If(Toutout) Call Output22                                  &
          End If
          If(Ioptplant .eq.3) Then
            Call Root_extern                                           &
          End If
!              F E R T I L I Z A T I O N
!                                            additions to soil system
          If(Tito.ge.Tinead .and. (Tito-St).lt.Tinead) Then
            Call Input_addit                                           &
          End If
          Call Addit                                                   &
          If(Errornumber.ne.0) Goto 9999
          If(Toutout) Call Output10                                    &
!              U P P E R   B O U N D A R Y
!                                      set top boundary concentrations
          Call Uboundconc                                              &
          If(Errornumber.Ne.0) Goto 9999
!              U P T A K E   P A R A M E T E R S
!                                           sel.factor for crop uptake
          If(Ioptplant.eq.1) Then
            Call Uptpar_Plant                                          &
          End If
          If(Ioptplant.eq.2) Then
            Call Uptpar_Grass                                          &
          End If
          If(Ioptplant.eq.3) Then
            Call Uptpar_extern                                         &
          End if
!              T E M P E R A T U R E   O F   S O I L   L A Y E R S
!                                    temperature behaviour in the soil
          If(Ioptte.ne.1) Call Temper                                  &
!                                           pointer array of fractions
          Call Fracpoint(Ipafr,Nf,Nl,Nufr,Os)
!              P O T E N T I A L   R A T E S
!                                 oxygen status NOT taken into account
          Call Rates1                                                  &
          If(Toutout) Call Output11                                    &
          If(Toutout) Call Output12                                    &
!             potential transport and transform. of soluble org.matter
          Call Transca                                                 &
          If(Errornumber.ne.0) Goto 9999
!                                 respiration terms and oxygen demand of
!                                         organic matter transformation
          Call Respirate                                               &
!                      first estimate of average ammonium concentration
!                            to calculate the oxygen requirement of the
!                                                 nitrification process
          Call Transport                                               &
          If(Errornumber.ne.0) Goto 9999
!        reduction factors influence of aeration on transformation rates
          If(Ioptae.ne.1) Then
            Call Aeration_original                                     &
            If(Toutout) Call Output13                                  &
          Else If(Ioptae.eq.1) Then
            Call Aeration_sonicg                                       &
            If(Toutout) Call Output14(Nl,Uoto,Yr,Mofr,Mofrsa,Tiyr)
          End If
!              A C T U A L   R A T E S
!                                     oxygen status taken into account
          Call Rates2                                                  &
!              D I S S O L V E D   O R G A N I C   M A T T E R
!                                transport, production and decomposition
          Call Transca                                                 &
          If(Errornumber.ne.0) Goto 9999
!              transformation of organic matter and production rate of
!              CO2, NH4 and PO4
          Call Miner                                                   &
          If(Errornumber.ne.0) Goto 9999
          If(Toutout) Call Output17                                    &
!          C O N S E R V A T I O N  AND  T R A N S P O R T  OF  N H 4 N
          CAll Transport                                               &
          If(Errornumber.ne.0) Goto 9999
!          D E N I T R I F I C A T I O N
!                                                        denitrification
          Call Denitr                                                  &
!          A C C O U N T I N G   FOR   D I F F U S I V E   U P T A K E
!                                 uptake by diffusion (adjustment of k0)
          If(Nuroup.ge.1 .and. Ioptplant.eq.2) Then
            Call grassup3                                              &
          End If
!                        transport, production and decomposition of NO3
!                           call correction of rekoni & rekonide part 1
          Call Correction(1,Nl,Rekoni,Rekoni_org,Rekonide)
```

```
!         C O N S E R V A T I O N  AND  T R A N S P O R T  OF  N O 3 N
           Call Transport                                              &
           If(Errornumber.ne.0) Goto 9999
!                            call correction of rekoni & rekonide part 2
           Call Correction(2,Nl,Rekoni,Rekoni_org,Rekonide)
!         C O N S E R V A T I O N  AND  T R A N S P O R T  OF  Pmineral
!       transport, production, decomposition, precipitation of phosphor
           If(Ipo.eq.1) Then
             Call Transgen                                             &
             If(Errornumber.ne.0) Goto 9999
           End if
!               I N T E G R A T I O N   O F   U P T A K E
           If(Nuroup.ge.1) Then
             If(Ioptplant.eq.1) Then
               Call Upintg_Plant                                       &
               If(Toutout) Call Output19                               &
             End If
             If(Ioptplant.eq.2 .and. Tiyr.ge.Tigrbeg .and. Tiyr.lt.    &
    &        (Tigrend+St)) Then
               Call Upintg_Grass                                       &
               If(Toutout) Call Output20                               &
             End If
             If(Ioptplant.eq.3) Then
               Call Upintg_Extern                                      &
               If(Toutout) Call Output21                               &
             End If
           End If
!                                                        output-options
           If(Ioptplant.eq.2 .and. Outgr.eq.1) Call Outputgr           &
           Call Outbal_calc                                            &
           Itask = 2
           Call Outbal_write                                           &
!............................ macro pore begin .........................
           If(Ioptmp.eq.1) Call Mapooutbal                             &
!............................ macro pore End ...........................
           Call Outsel                                                 &
!                                                            time steps
        End Do
        If(Ioptplant.eq.2 .and. Outgr.eq.1) Call Outputgr_yr           &
        If(Iwa.eq.1) Tiyr = 0
        If(Iwa.eq.2) Tiyr=Tiyr-Nudayr(Yr)
!                                                                years
     End do
!.... Final results
!                                 Write final concentrations and amounts
     Itask = 3
     Call Outbal_write                                                 &
     Call Output_Init                                                  &
       If(Errornumber.ne.0) Goto 9999
     Write (Uoer,44)
     Call date_and_time(Dmy,Hms)
     Write (Uoer,45)Dmy(1:4),Dmy(5:6),Dmy(7:8),Hms(1:2),Hms(3:4),      &
    &              Hms(5:10)
     Close(Unit=Uoer)
     Write (Uosc,44)
  44 Format(/' Successful completion of simulation')
  45 Format(/' ANIMO run End  : ',a4,'-',a2,'-',a2,2x,a2,':',a2,':',a6)
     Stop 100
9999 Call Stoponerror(Errornumber)
     End
```

Figure 67 Listing of the FORTRAN source code of the main program ANIMO

A5.2.2 Subroutines

A number of subroutines and functions is called from the main program. A short description will be given of each subroutine.

SUBROUTINE ADDIT
Additions are introduced as pulse-wise inputs to the soil system. Additions are instantaneously introduced by adding them to the relevant state variables at the start of a time step. The following additions are considered: dry deposition, dead root material, harvest losses, grazing losses, manure additions and fertilizer additions. Root-material is added during the growing season at the start of each time step and harvest- and grazing-losses are added when they occur. Root-, harvest- and grazing-losses of grassland are simulated in the subroutine **GRASSPRD**. The input of data concerning additions is specified in the input-file MANAGEMENT.INP.

SUBROUTINE AERATION_ORIGINAL
This subroutine is called when the user has indicated the application of the original aeration concept of the ANIMO model, the oxygen diffusion sub model. The subroutine determines whether there is enough oxygen present for the organic transformation processes and the nitrification process. In case of atmospheric-oxygen shortage, the decomposition rates for the organic materials are reduced and nitrate will be reduced in order to meet the oxygen requirement. In case of nitrate shortage, the denitrification is not longer driven by the organic transformation rate but limited by the nitrate concentration and is then simulated as a first order process.

SUBROUTINE AERATION_SONICG
This subroutine is called when the user has indicated the application of the SONICG concept to account for the moisture response. The subroutine calculates the Water Filled Pore Space Values for each compartment and then applies the relations to compute the reduction factors for mineralization, nitrification and denitrification.

SUBROUTINE CORRECTION
When denitrification is limited by the organic transformation rate, it will be considered as a zero order sink term in the conservation and transport equation. The sink term may be reduced during the conservation and transport-simulation to prevent for negative nitrate concentrations. This subroutine takes care for the book-keeping of the sink-term adjustment.

SUBROUTINE DENITR
Computation of the formation of nitrate as a result of nitrification and the reduction of nitrate as a consequence denitrification

SUBROUTINE FRACPOINT
At the start of each time step, a pointer array is determined indicating the presence of a certain organic fraction. 'Empty' organic fractions without organic material are ignored in the organic transformation simulations to optimize the computer program for speed.

SUBROUTINE **COMSTAGE**	
	Prints the computation stage to screen according to a user defined format. Four options are available.

SUBROUTINE **GRASS_INIT**	
	Initializes crop uptake parameters if the kind of crop grown is grassland, and opens the output files Grass.out and Grass-yr.out (not in subroutine **OUTSEL** because **OUTSEL** is called for the first time at the end of the first time-step)

SUBROUTINE **GRASSPRD**; **GRASSINC**	
	GRASSPRD calculates dry mater production of grassland and the accompanying root mass. The dry matter root mass is sub divided over compartments in the root zone. The availability of mineral nitrogen may reduce shoot growth. Harvest losses and grazing losses are calculated if the shoot mass exceeds given maxima. The live stock density is taken into account.

SUBROUTINE **GRASSUP3**	
	Nitrate uptake by grassland is simulated as a combination of first-order and zero-order uptake. The zero order term represents the 'backward' diffusive mass flow of nitrate. **GRASSUP3** calculates this zero order term as part of the conservation transport equation.

SUBROUTINE **HYDRO_AGGREGATED**	
	This subroutine handles the post-processing of the output generated by a two-layer hydrological model: - Moisture contents for each compartment (**MOISTURE**). - Lateral fluxes to/from drainage systems (**LATFLX**). - Fluxes per compartment (evapotranspiration and fluxes to/from other compartments and drainage systems) (**MODFLUX**). For assigning the evapotranspiration flux (EV) to the root zone compartments there are two options (indicated by the input parameter EVROSE): - Fluxes decreasing linear to the depth of the root zone layer. - Fluxes equally sub-divided over the compartments of the root zone.

SUBROUTINE **MOISTURE**	
	Part of the post-processing of a two-layered hydrological model output: In the root zone, the moisture fractions are evenly distributed over the compartment layers. The moisture content of the compartment layers below the root zone can be distributed according to one of the following schematizations: a) linear relation, b) non-linear relation with one bend-point, c) non-linear relation with two bend-points. Which schematization is used depends on the actual moisture content and the fixed moisture contents (e.g. wilting point, saturation) and the height for capillary rise.

SUBROUTINE **LATFLX**	
	Simulation of 1st, 2nd and 3rd order lateral water fluxes in the saturated zone. In two steps: 1. top- and bottom-boundary of 1st, 2nd and 3rd order model_discharge_layer; 2. subdivide 1st, 2nd and 3rd order discharge-flux over each model_discharge_layer.

SUBROUTINE LATFLDEV

Assigns drain fluxes to compartments within a so-called model_discharge_layer.

SUBROUTINE CORRWBAL

Within certain limits, water balance deviations in output generated by a two-layered hydrological model can be corrected. This subroutine modifies the drainage/seepage fluxes to correct the in the water-balance deviation.

SUBROUTINE HYDRO_DETAILED

This subroutine reads hydrological data generated by a detailed water quantity model (e.g. SWAP). These data are processed for the use in the ANIMO-simulations by the subroutine **MODFLUX**. Two checks are executed on the water balance: for the whole model profile and for each model compartment separately.

SUBROUTINE INICALC; INICALC_P

Pre-processing of soil and crop related input to initialise state variables per compartment and determine the internally used crop uptake parameters.

SUBROUTINE INIT_YR; INIT

Sets initial values for state variables per year / time based on the results of the previous year/time step.

SUBROUTINE INPUT1, INPUT_ADDIT, INPUT_CROPEXT, INPUT_HYDRO, CHECKINT, CHECKREA, FINDADR, FINDADRFIX

These subroutines open input-files and reads values of input variables. Each variable is checked on boundary values using the subroutines **CHECKINT** (checks the boundaries of integers) and **CHECKREA** (checks the boundaries of reals). The subroutines **FINDADR** and **FINDADRFIX** make sure that an input file is read from the first record until the last record until a given label has been found. If the label is not encountered then an error-message is written to the screen and a message file and the execution of the program is interrupted.

SUBROUTINE INPUT_ECHO

The output-file AnimoInputs.OUT is opened at the start of the simulation. Output of initial input is written to the file AnimoInputs.OUT

SUBROUTINE MINER

This subroutine computes the transformation of the organic matter pools. The resulting quantities remaining at the end of the time step are calculated. These calculations result in a net release of NH_4-N (REKONH); a positive release means mineralization, a negative release means immobilization of ammonium. If the calculated immobilization exceeds the amount of ammonium present at the beginning of a time step, the simulation is repeated with a reduced assimilation factor to avoid negative NH_4-N contents.

SUBROUTINE MODFLUX

Downward and upward water fluxes are assigned on the basis of the hydrological input. The sequence of conservation and transport computation per compartment is determined

SUBROUTINE OUTBAL_INIT
Accumulation variables for the water, organic matter, nitrogen and phosphor balances are initialized.

SUBROUTINE OUTBAL_CALC and OUTBAL_WRITE
Mass balances are compiled for water, organic matter, nitrate-N, ammonium-N, organic-N, mineral-P and organic-P. These balances are created for the soil compartments defined by the input parameters BALNMI-BALNMA. The balance period is defined by the input parameters TIBASE(1-NUBASE). Series of mass balances may be created, where each series has its own time and spatial dimensions. The number of balance series is defined by NUBASE; the maximum is 10. Subroutine **OUTBAL_CALC** accumulates mass balance terms for respectively the balance series. The subroutine **OUTBAL_WRITE** writes the balance terms to the output files.

SUBROUTINE's concerning presentation of intermediate and final results: **INPUT_ECHO**, **OUTPUT6**, **OUTPUT9, OUTPUT10, OUTPUT11, OUTPUT12, OUTPUT13, OUTPUT14, OUTPUT17, OUTPUT19, OUTPUT20, OUTPUT21** and **OUTPUT22, OUPUT_INIT, OUTSEL, OUTPUTGR**

The output file AnimoIntermediate.out is opened in the subroutine INPUT_ECHO.

During each simulation period, results of most subroutines are written to the file AnimoIntermediate.out. Option parameter OUT(1 ... NUOUT) arranges the number of time steps with this complete output.

OUTPUT6: Output of Hydro_Aggregated (hydrology from a 2-layer system)
Output of Hydro_Detailed (hydrology from a multi-layer system)

OUTPUT9: Output of ROOTS

OUTPUT10: Output of ADDIT

OUTPUT11: Output of TEMPERATURE

OUTPUT12: Output of RATES

OUTPUT13: Output of Aeration_original

OUTPUT14: Output of Aeration_sonicg

OUTPUT17: Output of MINER

OUTPUT19: Output of PLANT

OUTPUT20: Output of Uptpar_grass

OUTPUT21: Output of Uptpar_Extern

OUTPUT22: Output of GRASS

OUPUT_INIT: The final results for the model profile are written to the file INITIAL.OUT. All the output files are closed at the end of the simulation.

OUTSEL: The output files are opened at the start of the simulation. During each simulated time step results are written to the opened files. Option parameter OUTSE(1-37) arranges the number of files with this output.

OUTPUTGR: The output-file Grass.out is opened by the subroutine **GRASS_INIT**. During each simulation time step results concerning dry matter quantities, nitrogen and phosphorous status of the crop are written to this file.

SUBROUTINE PW6
PW6 calculates the Pw-value of the first compartment, the PAL-value of layer 1, and the mean phosphate saturation degree for the whole profile.

SUBROUTINE OXYDEM

An oxygen-profile (m3 m-3) is calculated as a function of oxygen demand by nitrification and organic transformations. Temporal anaerobiosis is approximated on the basis of precipitation surplus and the saturated conductivity of the top compartment layer. Partial anaerobiosis is approximated on the basis of vertical oxygen diffusion in air-filled pores and lateral-radial diffusion in saturated soil aggregates. The aerated fraction (AEVO) per compartment layer is determined

SUBROUTINE RATES1 and **RATES2**

Actual transformation rate coefficients are calculated for the response on: pH, temperature, moisture. The decomposition rate and the N-content of the humus/biomass pool are reduced for layers below the root zone.
RATES1 considers the rates for the "non-limited by aeration" case and RATES2 calculates the rate coefficients taking the limitation by oxygen status into account.

SUBROUTINE ROOT_PLANT

For annual arable crops, the rooting depth as well as the distribution of roots over the compartments is determined. Exudate production is calculated as a function of the root development. Amounts and lengths of roots are derived by linear interpolation between the input-data. The distribution of roots decreases linear with depth.

SUBROUTINE ROOT_GRASS

Root_Grass calculates:

1) the depth in soil to which the crop residues are added (interpolation based on a time series defined in the input file PLANT.INP)
2) the sub-division of the living roots and the root losses with depth
3) when the hydrology is simulated with a detailed model (SWAP), the transpiration flux is given for each soil compartment. Subroutine **Root_Extern** determines the number of soil compartments for which the transpiration flux has a significant value.

SUBROUTINE ROOT_EXTERN

Root_extern is called by the AMINO main program when the External Crop Uptake option is used. The daily nitrogen and phosphorus uptake are then defined in an input file. Within this file, also the daily crop residues are defined: dry matter, nitrogen and phosphorus.
Subroutine **Root_extern** calculates:

1) the depth in soil to which the crop residues are added (interpolation based on a time series defined in the input file PLANT.INP)
2) the sub-division of the crop residues over the fresh organic matter fractions (4 fractions)
3) when the hydrology is simulated with a detailed model (SWAP), the transpiration flux is given for each soil compartment. The subroutine determines the number of soil compartments for which the transpiration flux has a significant value.

SUBROUTINE TEMPER

TEMPER calculates the temperature at the centre of each compartment using a simple sine wave model. The increasing effect of damping and time lag with increasing soil depth is taken into account.

SUBROUTINE TRANSCA	
	Calls the subroutine **TRANSPORT** to determine transformation and transport of the 3 dissolved organic compounds: organic matter, organic-N and organic-P.

SUBROUTINE TRANSGEN	
	Calls the subroutine **TRANSORP** to determine accumulation, transformation and transport of phosphorous. The concentration liquid at the end of the time step (CO), the average concentration during the time step (AVCO) and the total inflow (TOIN) and outflow (TOOU) are determined.

SUBROUTINE TRANSORP	
	Calculates the P concentration per compartment at the end of time step and the average concentration during the time step. It also calculates the quantities in time-dependent sorption phase, the quantities in the instantaneous sorption phase and the quantity in the precipitation phase.

SUBROUTINE CONC_UNL, C_UNL, CONC_TIM and CTIMPRE	
	These subroutines are called by TRANSORP and perform parts of the total computation algorithm in the determination of soluble mineral P in relation to the solid pools.

SUBROUTINE DETCOEF	
	Determines the coefficients A1, A2, B1 and B2 used in the analytical solution of the conservation and transport equation.

SUBROUTINE COEFDC	
	Determines the derivates to C of the coefficients A1, A2, B1 and B2 used in the analytical solution to the conservation and transport equation.

SUBROUTINE COEFDT	
	determines the derivates to time of the coefficients A1, A2, B1 and B2 used in the analytical solution of the conservation and transport equation

SUBROUTINE SORPFAST	
	Calculates the quantity in the instantaneous sorption phase RSAMPOCXFA, the av. adsorption coefficient AVADCO and the derivate to C (AVADCODC).

SUBROUTINE SORPSLOW	
	Calculates the quantity in the slow sorption phase EQCXSL under steady state conditions and the derivate to the average conc. EQCXSLDC.

SUBROUTINE TRANSPORT	
	Calculates for the whole soil profile the average concentration during the time step (AVCO), the concentration at the end of the time step (CO), the adsorbed amount at the end of the time step (CX) and the total inflow (TOIN) and outflow (TOOU).

SUBROUTINE TRANSSUB

Calculates both the resulting concentration RSC in a compartment as well as the average concentration AVC at the end of time step ST. The differential equation to solve:

$$\frac{dc(t)}{dt}+\frac{HV_1}{\theta_0+\rho_d k_a+\Delta\theta/\Delta t\, t}c(t)=\frac{HV_2}{\theta_0+\rho_d k_a+\Delta\theta/\Delta t\, t}$$

where HV_1 and HV_2 are help variables, θ_0 is the initial moisture fraction $\rho_d k_a$ is the dimensionless sorption coefficient and $\Delta\theta/\Delta t$ is the change of moisture fraction with time

SUBROUTINE UBOUNDCONC

UBoundconc calculates the upper boundary concentration for either the compartment layer ln=0 or the first compartment layer ln=1, dependent on whether ponding occurs or not. Dry deposition is added to the first soil compartment (ln=1) in the case of no-ponding.

SUBROUTINE UPTPAR_PLANT and PLANTPO

For annual arable crops the selectivity factor for nutrient uptake in the conservation and transport equation is determined on the basis of the realised summarized uptake during previous time steps and the expected summarized uptake. The uptake is reduced if a certain maximum is reached. In the subroutine **PLANTPO** the selectivity-factor for P-uptake is determined based on the summarized uptake during previous time steps. The uptake is related to N-uptake.

SUBROUTINE UPTPAR_GRASS

Calculates parameters for crop-uptake if the kind of crop grown is grassland. The main program uses the subroutine at various times:
- Selectivity factor and initialisation of diffusion-uptake
FANHCOCX, FAPOCOCX = soil specific factors (calculated in **INICALC**)
SEFANHGR, SEFAPOGR = crop specific factors (=input)

SUBROUTINE UPTPAR_EXTERN

In the conservation/transport equation solved by the ANIMO model, the crop uptake rate for a time step is described as $\frac{\sigma\, q_{tr}\, \bar{c}}{\Delta z}$ where q_{tr} is the transpiration flux, $\bar{c}$ is the time weighted average concentration, Δz is the thickness of the soil compartment and σ is the Concentration Transpiration Stream factor. This subroutine calculates a value for σ preceding to the solution of the Conservation and Transport equation

SUBROUTINE UPTING_PLANT

Called by the AMINO main program when the option for annual arable crops is used. Cumulated actual uptake amounts are calculated from the results of conservation/transport equation. Accumulated potential crop uptake amounts are calculated from the ratio between expected uptake and expected transpiration. The potential uptake is reduced when the actual uptake lags behind the potential uptake to a certain degree. (Miup=0.9, the minimum uptake as a fraction of the demand below which no crop damage occurs)

SUBROUTINE UPTING_GRASS	
	Calculates parameters for nutrient uptake by grassland. Accumulated quantities concerning crop uptake are calculated: the integrated gross-uptake

SUBROUTINE UPTING_EXTERN	
	Called when the external crop uptake option is used. The daily nitrogen and phosphorus uptake are then defined in an input file. Within this file, also the daily crop residues are defined: dry matter, nitrogen and phosphorus. This subroutine calculates the accumulated actual crop uptake, potential crop uptake and uptake deficit. During the subsequent time step, an eventual deficit is accounted for with the uptake demand as specified in the input file.