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ANIMO Version 2

User's guide

ing. J.G. Kroes

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Table of contents

1. INTRODUCTION

The groundwaterquality-model ANIMO (Agricultural NItrogen MOdel) is a model which describes the nitrogen and carbon cycle and its interrelation with as main purpose the prediction of nitrate leaching to ground- and surface-waters.
The model was developed for agricultural areas, but various modifications have made it also suitable for applications on areas with another kind of landuse (nature, forest).
ANIMO is a dynamic computer simulation model which is operational for field- and regional applications. Calculations are performed on a soil profile with a m2 soil surface as unit, which is divided into different horizontal layers. In principal it calculates for a one-dimensional soil profile, but with lateral fluxes to/from the soil profile the calculation can be called two-dimensional and with the regional fluxes in the lowest part of the profile it becomes a three-dimensional calculation.
A waterquantity model (like: WATBAL, SWATRE, SIMGRO) should give information about moisture contents and waterfluxes.
Vertical fluxes across the lower boundary of the profile result in a leakage/seepage. Lateral fluxes to/from different layers lead to infiltration/drainage from/to surface waters.
This guide gives information about:

- the way in which the transformation- and transport-processes of the carbon and nitrogen cycles are implied in the model (par.2.1 and 2.2).
- the places in the various subroutines where one can find a specific process (par. 2.3 and 2.4)
- input and output (chapter 3 and 4)
- how the model was verified (par. 5.1)
- examples of applications (par. 5.1 and 5.2)
- sensivity of the model for a number of parameter-changes (chaper 6).

In this guide the abbreviations that have been used to describe variables are in most cases similar to those used in the computerprogram; the vocabulary of the program-variables is enclosed as appendix A.
The computerprogram is written in FORTRAN-77. For one timestep a VAX3600 uses about 0.3 cpusec.

The most important change since ANIMO version 1 is the implementation of the P-cycle. The model is also made operational for 5 optional ways of connections with hydrological models. Other changes were made on the input and output.
VAX-FORTRAN was translated into Microsoft-FORTRAN, so the model can now also be executed on personal computers with an MS-DOS operating system (main restriction is that it should be compiled with "NOTRUNCATE", because of the long variable names)

2. MODEL APPROACH

2.1 transformation processes

The simulated transformation processes are all part of the carbon and nitrogen cycle. The phosphor cycle can also be simulated. These three cycles have been modelled according to figures 2.1, 2.2 and 2.3. These three figures were designed in such a way that the interrelation between the three cycles can easily be recognized. All three figures have a horizontal interrupted line which stands for both the soil surface and the model-interior. 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 system. These four kinds of organic matter are:

- fresh organic matter: root and crop residues and organic parts of manure added to the soil
- soluble organic matter: organic matter in solution from fresh organic matter or humus; in the model and in this guide named as COCA (concentration of carbon in solution)
- exudates: dead root cells and organic products excreted by living roots.
- humus: consists of dead organic matter and of living biomass and is formed from part of the fresh organic matter, root exudates and soluble organic matter.

The organic material added to the soil profile varies strongly from composition. In the model fresh organic matter can be divided into different fractions, each with their own decomposition rate and N-content. In this way it is possible to create materials with their own specific characteristics. The way this division can be made and the way decomposition takes place has been schematized in figure 2.0 for 4 materials and 3 fractions. In this figure material 1 consists of fractions 1 and 2, which partly are transformed into soluble organic matter and humus.

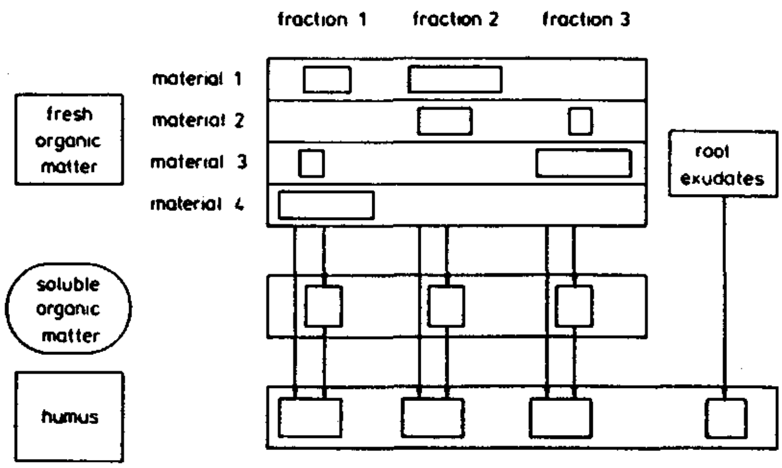


Figure 2.0 The organic matter transformations

Figure 2.1 The CARBON cycle in ANIMO

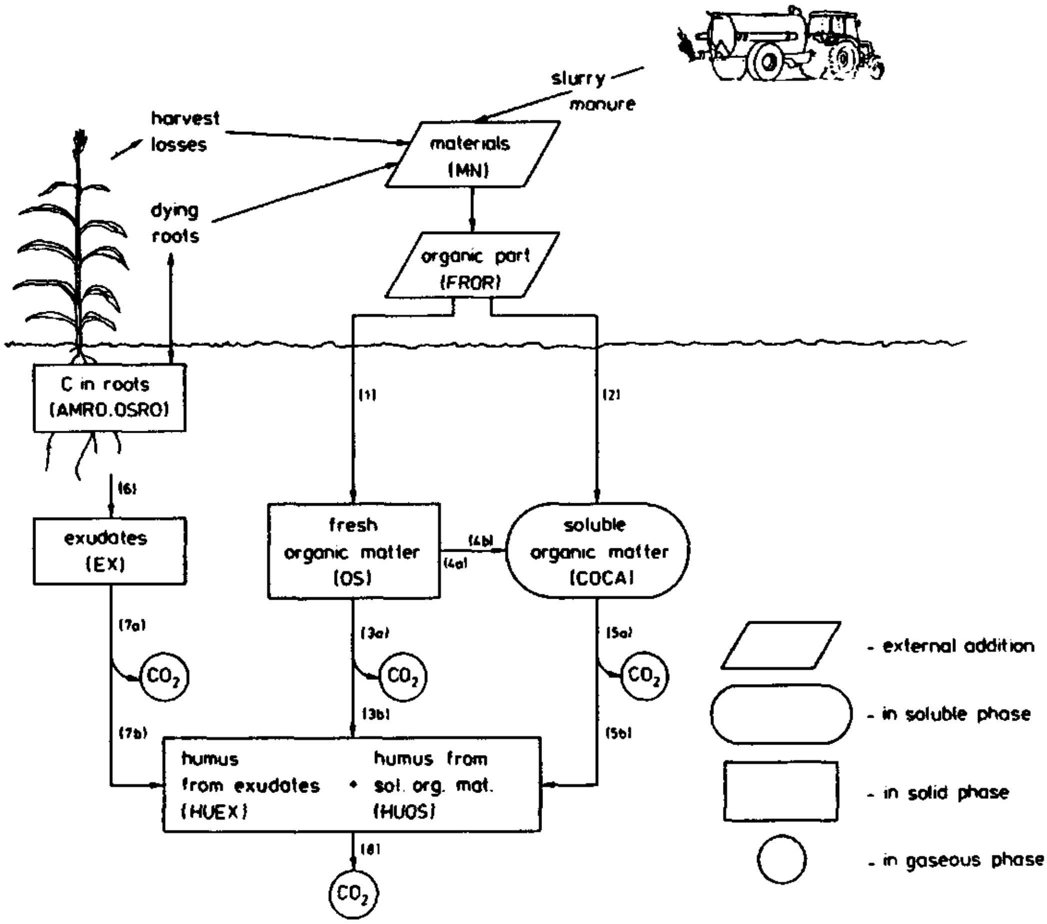


Figure 2.2 The NITROGEN cycle in ANIMO

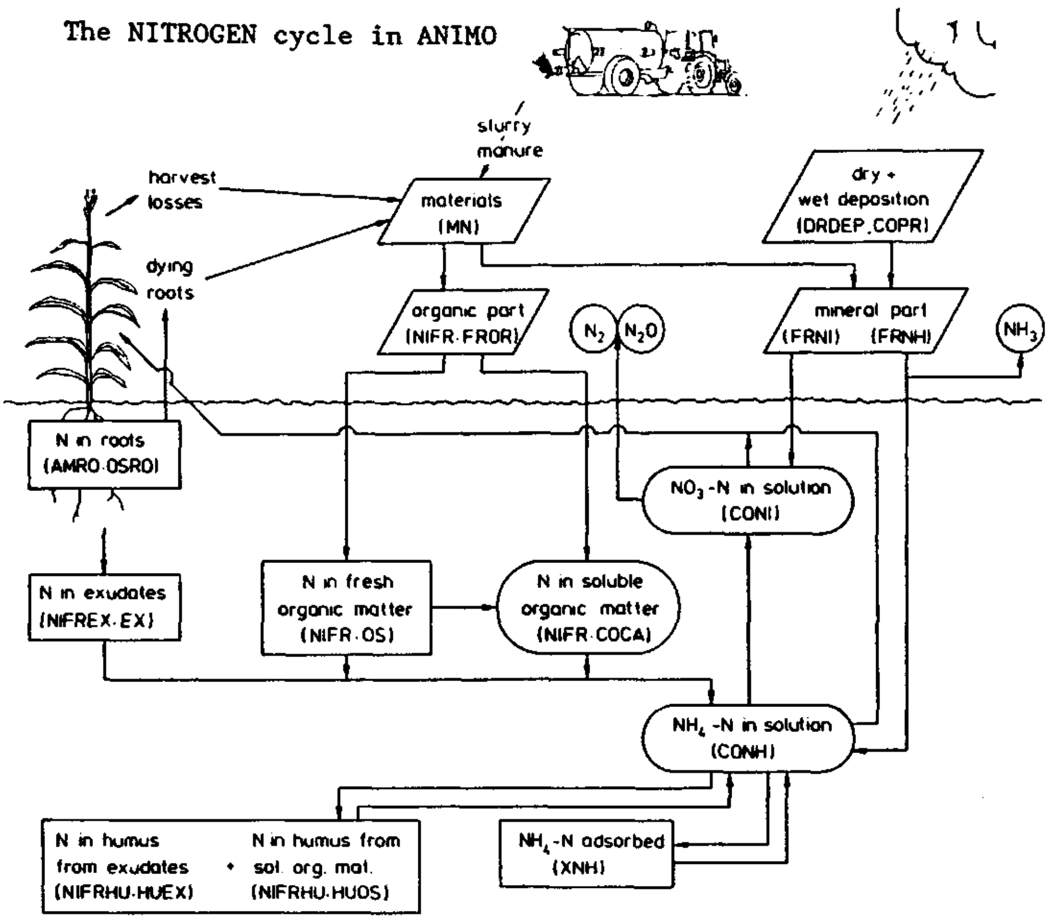
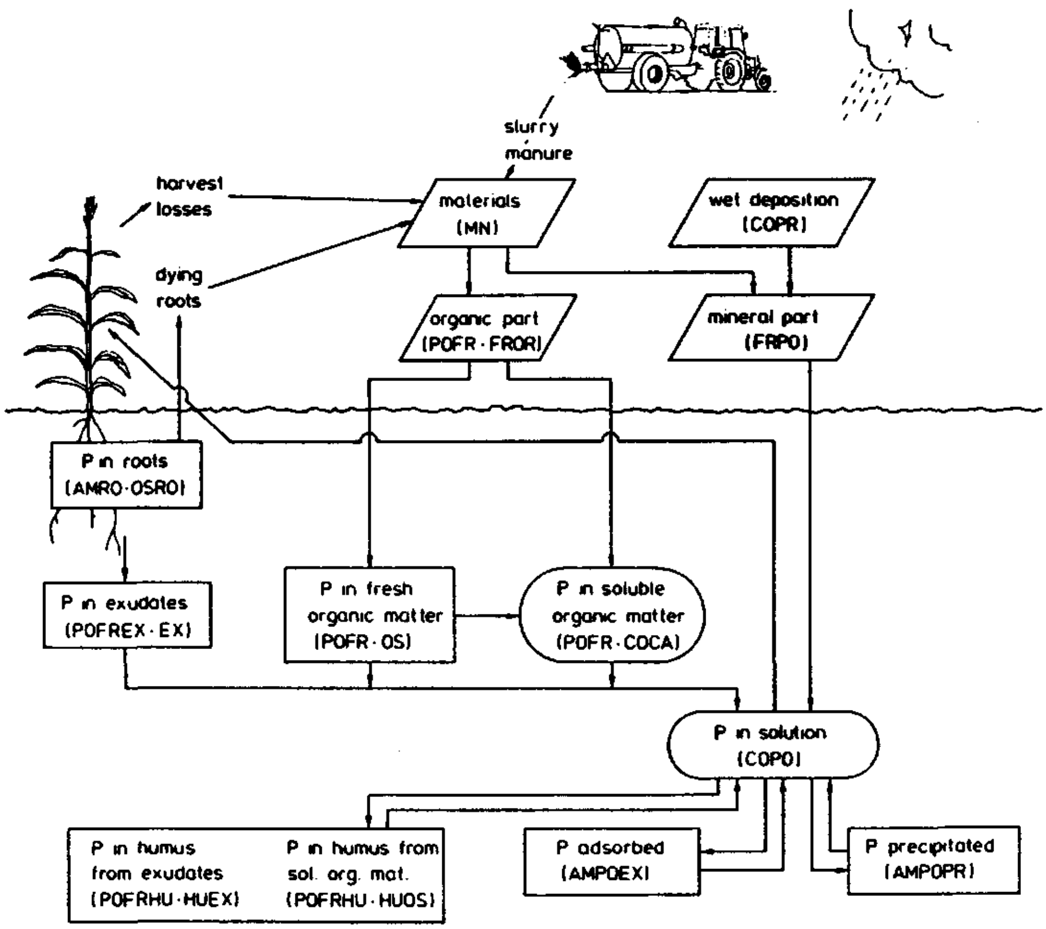


Figure 2.2 The PHOSPHOR cycle in ANIMO



A summary of the most important transformation-formulations used in the model ANIMO is given for carbon in table 1.1, for nitrogen in table 1.2 and for phosphor in table 1.3.

The most important transformation processes of the carbon and nitrogen cycles will be described briefly.

Decomposition:
Decomposition of humus, fresh and soluble organic matter means that part of the organic matter oxidizes to CO_2 and H_2O and another part is transformed into humus. The ratio "produced humus / decomposed organic matter" is called the assimilation factor.

Mineralization/immobilization:
Decomposition of organic matter may result in formation or disappearance of NH_4. This is described as a 0-order process with a rate of k0(NH4)

Denitrification:
The denitrification is dependent on the amount of decomposable organic matter and the presence of oxygen. It is described with a 0-order production rate: K0(NO3).

Nitrification:
Transformation from NH_4 into NO_3 is described with a 1-order production rate for NH_4: K1(NH4) and a 0-order rate for NO_3: K0(NO3)

Ad-/desorption:
Linear sorption to/from soil complex.

Volatilization:
A given fraction of the mineral N in slurry added to the soil system volatilizes as NH_3.

In the model ANIMO the rate variabels for organic matter transformation are corrected for the following influences: temperature, moisture, pH and oxygen demand. This correction is done as for the following rate variabels:

* recf(fn) = f(temperature, moisture, pH, oxygen demand)
* recfca = f(temperature, moisture, pH, oxygen demand)
* recfex = f(temperature, moisture, pH, oxygen demand)
* recfhu = f(temperature, moisture, pH, oxygen demand)
* recfnt = f(temperature, moisture, pH)

Table 1.1. Formulation of organic matter transformation-processes in ANIMO.

organic matter	process	formulation	process (fig. 2.2)
fresh organic matter	supply =	(fr(fn)-frca(fn))*fror*dQ/dt	[1]
	decomposition =	- hufros*recf(fn)*O(t) - (1-hufros)*recf(fn)*O(t)	[3a,4a]
	total: $\frac{dO(t)}{dt}$ =	(fr(fn)-frca(fn))*fror*dQ/dt - recf(fn)*O(t)	
soluble organic matter	supply =	frca(fn)*fror*dQ/dt	[2]
	production =	$1/\Delta t * \int_{t}^{t+\Delta t}$ (1-hufros)*recf(fn)*O(t)*dt	[4b]
	decomposition =	- recfca*S(t)	[5a]
	transport =	flin*Sin - flou*S(t)	
	total: $\frac{dS(t)}{dt}$ =	frca(fn)*fror*dQ/dt + flin*Sin-flou*S(t) + $1/\Delta t * \int_{t}^{t+\Delta t}$ (1-hufros)*recf(fn)*O(t)*dt - recfca*S(t)	
exudates	production =	Epd	[6]
	decomposition =	- recfex*E(t)	[7a]
	total: $\frac{dE(t)}{dt}$ =	Epd - recfex*E(t)	
humus	production =	asfa*hufros*recf(fn)*O(t) + asfa*recfca*S(t) + asfa*recfex*E(t)	[3b,5b,7b]
	decomposition =	- recfhu*H(t)	[8]
	total: $\frac{dH(t)}{dt}$ =	asfa*hufros*recf(fn)*O(t) + asfa*recfca*S(t) + asfa*recfex*E(t) - recfhu*H(t)	

Table 1.2. Formulation of nitrogen transformation-processes in ANIMO.

component	process	formulation
ammonium	supply	$\frac{d[NH4]}{dt} = frnh * dQ/dt$
	mineralization/ immobilization	$\frac{he*mofr*d[NH4]}{dt} = \sum_{fn=1}^{nf} (nifr(fn) * (dS/dt + dO/dt)) + nifrhu*(dH/dt) + nifrex*(dE/dt)$
	nitrification	$\frac{d[NH4]}{dt} = - recfnt * aevo * [NH4]$
	crop uptake	$\frac{d[NH4]}{dt} = - rd * flev * [NH4]$
	volatilization	$\frac{d[NH4]}{dt} = - frvo * frnh * d[Q]/dt$
	sorption (ad-/de-)	$\frac{d[NH4ads]}{dt} = drad * d[NH4]/dt$
	transport	$\frac{d[NH4]}{dt} = flin*[NH4]in - flou*[NH4]$
nitrate	supply	$\frac{d[NO3]}{dt} = frni * dQ/dt$
	nitrification	$\frac{d[NO3]}{dt} = recfnt * aevo * [NH4]$
	denitrification	$\frac{d[NO3]}{dt} = - aevo * oxdd * rdfade$
	crop uptake	$\frac{d[NO3]}{dt} = - rd * flev * [NO3]$
	transport	$\frac{d[NO3]}{dt} = flin*[NO3]in - flou*[NO3]$

Table 1.3. **Formulation of phosphor transformation-processes in ANIMO.**

component	process	formulation
phosphor	supply	$\frac{d[P]}{dt} = frpo * dQ/dt$
	mineralization/ immobilization	$\frac{he*mofr*d[P]}{dt} = \sum_{fn=1}^{nf} (pofr(fn) * (dS/dt + dO/dt)) + pofrhu*(dH/dt) + pofrex*(dE/dt)$
	crop uptake	$\frac{d[P]}{dt} = - rd * flev * [P]$
	fast sorption (ad-/de-)	$\frac{d\{Psof\}}{dt} = dradpo * d[P]/dt$
	slow sorption (ad-/de-)	$\frac{d\{Psos\}}{dt} = recfso * (Pmax/[Pmax])*(Pads/Pmax)**(1-adcf) * ([P]-[Peq])$
	total sorption (ad-/de-)	$\frac{d\{Pads\}}{dt} = d\{Psof\}/dt + d\{Psos\}/dt$
	precipitation	$\frac{d[Ppre]}{dt} = ([P] - [Pbuf]) * mofrt/dt$
	transport	$\frac{d[P]}{dt} = flin*[P]in - flou*[P]$

variables used in tables 1.1, 1.2 and 1.3

State variables:

E	- quantity of exudates	[kg m-2]
he	- layer-thickness	[m]
H	- quantity of humus	[kg m-2]
NH4	- quantity of ammonium present	[kg m-2]
[NH4]	- concentration of ammonium	[kg m-3]
(NH4ads)	- quantity of ammonium at soil complex	[kg m-2]
[NH4]in	- concentration of ammonium flowing into a layer	[kg m-3]
[NO3]	- concentration of nitrate	[kg m-3]
[NO3]in	- concentration of nitrate flowing into a layer	[kg m-3]
O	- quantity of fresh organic matter	[kg m-2]
P	- quantity of phosphor	[kg m-2]
Ppre	- quantity of phosphor precipitated	[kg m-2]
(Psof)	- quantity of phosphor at fast soil complex	[kg m-2]
(Psos)	- quantity of phosphor at slow soil complex	[kg m-2]
[P]	- concentration of phosphor	[kg m-2]
[Pbuf]	- maximum concentration of phosphor in solution	[kg m-2]
[Peq]	- equilibrium concentration of phosphor ([Peq]=[Pmax]*((Pads)/(Pmax))**adcf)	[kg m-2]
Q	- quantity of added material (manure,fertilizer,etc.)	[kg m-2]
S	- quantity of soluble organic matter	[kg m-3]
Sin	- concentration of soluble organic matter flowing into a layer	[kg m-3]
dt	- time difference	[d]

Rate variables (transformation):

Epd	- exudate production	[kg m-2 d-1]
oxdd	- oxygen demand	[kg m3 d-1]
recf(fn)	- decompositition rate of fresh organic matter-fraction	[d-1]
recfca	- decompositition rate of soluble organic matter	[d-1]
recfex	- decompositition rate of exudates	[d-1]
recfhu	- decompositition rate of humus	[d-1]
recfnt	- nitrification rate	[d-1]
recfso	- desorption rate	[d-1]

Rate variables (transport):

flev	- evapotranspiration flux	[m d-1]
flin	- flux into a layer	[m d-1]
flou	- flux out of a layer	[m d-1]

Fractions and factors:

adcf	- ad-/desorption-exponent for phosphor	[-]
aevo	- aerated soil fraction	[-]
asfa	- assimilation factor	[-]
drad	- distribution ratio for ammonium	[-]
dradpo	- distribution ratio for phosphor	[-]
fn,nf	- fraction number and number of organic fractions	[-]
frvo	- fraction of added NH4-N that volatilizes	[-]
fr(fn)	- fraction of organic part in added material	[-]
frca(fn)	- soluble fraction of organic part in added material	[-]
fror	- organic part of added material	[-]
frnh	- fraction of NH4-N in added material	[-]
frni	- fraction of NO3-N in added material	[-]
hufros	- fraction of fresh organic matter trasnformed to humus	[-]
mofr	- moisture fraction	[-]
nifr(fn)	- N-fraction of the corresponding organic fraction	[-]
nifrhu	- N-fraction of humus	[-]
nifrex	- N-fraction of exudates	[-]
rd	- selectivity factor for crop uptake	[-]
rdfade	- reduction factor for denitrification	[-]

2.2 transport processes

With data delivered by a waterquantity model, the model ANIMO calculates moisture fractions at the end of a timestep and water-fluxes per layer. Average moisture fractions are calculated assuming a linear change with time. There can be four levels of drainage:

1. flux to or from trenches (surface runoff, interflow)
2. flux to or from ditches/drains
3. flux to or from canals
4. flux to or from lower boundary of model-profile (seepage or leakage)

For each layer a water balance is formulated with the general form:

$$(flin - flou - flev) * t - (mofrt-mofro)*he = 0.0$$

in which:

flin	= incoming flux	[m3 solution m-2 surface d-1]
flou	= outgoing flux	["]
flev	= evapotranspiration flux	["]
he	= layer thickness	[m]
mofro	= inital moisture fraction	[m3 solution m-3 soil system]
mofrt	= moisture fraction at end of tstep	["]
t	= time	[d]

Incoming fluxes may include: precipitation, infiltration, seepage. Outgoing fluxes may include: drainage, evapotranspiration, leakage.
Figure 2.4 indicates some of the fluxes in a soil system with a few layers.

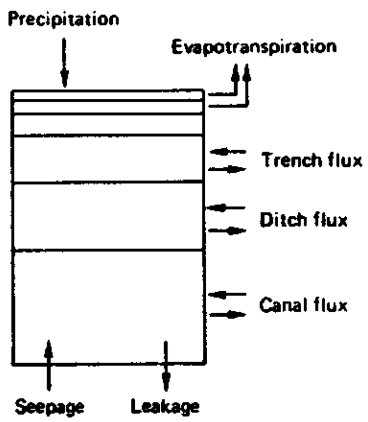


Figure 2.4 Schematization of fluxes in a model soil system with a few layers.

Soluble organic matter and mineral N (NO3 and NH4) can be transported with water-fluxes to and from different layers. For this transport combined with production or consumption a transport- and conservation-equation is being used (per layer) with the general form:

$$\frac{d(\,mofrt*he * co\,)}{dt} = flin * coin - flou * co - flev * rd * co + K0 * he + K1 * mofr*he * co - \frac{drad * d(\,mofrt*he * co\,)}{dt}$$

in which:

co	= concentration in a layer	[kg N or C m-3 sol. m-2 surface]
coin	= concentration of incoming flux	["]
drad	= distribution ratio of adsorption	[-]
K0	= 0-order production rate	[kg N or C m-3 soil d-1]
K1	= 1-order production rate	[d-1]
mofr	= average moisture fraction	[m3 solution m-3 soil system]
rd	= reduction factor for crop uptake	[-]
t	= time	[d]

This equation is solved analytically every timestep for every layer for NH4-N, NO3-N and for every soluble organic matter-fraction. For the first layer the boundary condition for the incoming flux from above is the precipitation with a concentration of the precipitation. For the last layer the boundary condition of the incoming flux is the seepage flux with a concentration of the soil solution below the described profile.
The reduction factor for crop-uptake (rd) is determined on base of the summarized crop uptake during previous timesteps. Only for grass the uptake is unlimited.
K0 and K1 are 0-order and 1-order production rates. In the model production is always positive and consumption is negative.
K0(COCA) is calculated from the decomposition of fresh organic matter; K1(COCA) is an input-parameter.
K0(NH4) results from mineralization/immobilization calculations; K1(NH4) is an input-parameter which is reduced for (partial) anaerobic conditions.
K0(NO3) results from nitrification/denitrification calculations. K1(NO3) is not used.
For Phosphor this transport- and conservation equation is slightly adjusted; more information about the P-cycle will be given by Roest (1989). In the P-cycle the K0(Phosphor) results from mineralization/immobilization calculations; K1(Phosphor) is not used.

2.3 main program

The next page gives the structure-diagram of the main program ANIMO for carbon and nitrogen.
In the description of main program and subroutines the same sequence has been followed as in the computerprogram itself.
All the reading of input-data is executed by a subroutine INPUT.
For progam-adjustments the use of unit-nrs and the openening of files is given as appendix F; 'local' in this appendix means that the file is closed directly after reading, which enables further use of this unit-nr.

After reading of general data the program executes calulations for subsequently: every year, area, timestep, and technology.
For field-applications there is only one area and one technology.
The most important calculations are performed in the innermost part of the technology-loop.

Hydrological data coming from the waterquantity model are converted in the subroutine BALANCE to fluxes and moisture fractions per layer. If hydrological data come from a detailed waterquantity model (e.g.SWATRE) the subroutine BALANCE is not used and fluxes and moisture fractions are given as input.
At the beginning of the timestep in the subroutine RESPI the potential oxygen consumption for decomposition of organic matter and for nitrification is calculated. An oxygen profile is determined and for (partial or temporary) anaerob conditions the oxygen from NO3 can be used and denitrification will take place.
If the potential oxygen consumption is higher than the availability of oxygen, the decomposition of organic matter is reduced.
The subroutine TRANSPORT then determines the transport and conservation of organic matter in solution and the mineralisation can take place in the subroutine MINER2. The mineral ammonium can now be transported and nitrified in the subroutine TRANSPORT. The zero-order production rate constant for the net production of nitrate is determined in the subroutine DENITR, after which nitrate is transported and produced/consumed in the subroutine TRANSPORT.
Finally concentration and loads to and from drainage systems are calculated with the subroutine CONCDRAIN.
For regional applications an imaginary boundary in the aquifer is introduced (see par. 3.3); above this boundary vertical fluxes are dominant and below this boundary horizontal fluxes dominate. Above this boundary calculations are performed per timestep and below this boundary a mixing takes place after each simulated year.

For the Phosphor-cycle two subroutines were added: PLANTP and TRANSPHOS. PLANTP calculates P-uptake by the crop and is called from the subroutine PLANT; TRANSPHOS is called from the subroutine TRANSPORT after the calulations for transport and conservation of nitrate.

Structure diagram of the main program ANIMO

```
READ  GENERAL.DAT                                        ! read general input
DO  YR - 1,NYR                                           ! for every year
    DO  AN - 1,NA                                        ! for every subregion
        READ  AREA.DAT                                   ! read subregion-input
        IF  (YR-1)  ->  READ INI.DAT                     ! read initial data
        DO  ST - 1,NST                                   ! for every tstep
            READ  WATBAL.DAT                             ! read waterquantity-data
            DO  TN - 1,NT                                ! for each technology
                IF  (YR-1,ST-1)  ->  CALL INIMO          ! initial moisture
                CALL BALANCE     ->  CALL FLUX           ! moisture + fluxes
                IF  (KC-/-6)     ->  CALL ROOT           ! root-development
                CALL ADDIT       ->  READ ADDIT.DAT      ! additions per tstep
                CALL TEMPER                              ! temperature profile
                CALL MINER1                              ! reduction factors,K0(COCA)
                CALL RESPI       ->  CALL OXYDEM         ! O2-profile,rates,K1(NH4)
                DO  FN - 1,NF                            ! for each organic fraction
                    CALL TRANSPORT ->  CALL TRANSSUB     ! transp.+conserv. of COCA
                CALL MINER2                              ! K0(NH4),K0(P)
                CALL PLANT       ->  CALL PLANTP         ! crop uptake factors
                CALL TRANSPORT   ->  CALL TRANSSUB       ! transp.+conserv. of NH4-N
                CALL DENITR                              ! K0(NO3)
                CALL TRANSPORT   ->  CALL TRANSSUB       ! transp.+conserv. of NO3-N
                CALL TRANSPORT   ->  CALL TRANSPHOS      ! transp.+conserv. of P
                CALL CONCDRAIN                           ! mass-flux to drains
                CALL MASSBAL              ! mass-control, N-uptake, initialization
                IF  (KC-6)       ->  CALL GRASS          ! root-development
                CALL SELECT                              ! output-selection
    IF  (IWA-1)  ->  CALL AQUIFER                        ! NO3-N mixing aquifer
```

2.4 subroutines

The program consists of various subroutines, which are for field and regional applications:
INPUT, OUTPUT, OUTPUT1, OUTPUT2, HYDRO, INIMO, BALANCE, FLUX, ROOT, ADDIT, TEMPER, MINER1, RESPI, OXYDEM, TRANSPORT, TRANSSUB, MINER2, PLANT, PLANTP, DENITR, TRANSPHOS, CONVR4R8, CONVR8R4, CONCDRAIN, MASSBAL, GRASS, SELECT
extra for regional applications:
READFEM, MANURE, TRANSFER, TRANSFERT, AQUIFER, CDSYS

Of each subroutine a short description will be given.

SUBROUTINE INPUT
This subroutine arranges all input of parameter-values.
In two cases this subroutine executes another subroutine:
- for regional applications the hydrological data are read with subroutine READFEM.
- for field applications the hydrological data may come from a waterquantity model like SWATRE; in that case the subroutine HYDRO executes the reading of parameter-values.

SUBROUTINES OUTPUT, OUTPUT1, OUTPUT2
These subroutines arrange a detailed output of parameter-values to the file TOUT.DAT. OUTPUT1 gives output of input; OUTPUT2 gives output of each subroutine for a selected amount of timesteps.

SUBROUTINE HYDRO
This subroutine reads hydrological data delivered by a detailed waterquantity model (e.g. SWATRE). These data are modified for use in the transport-equation.

SUBROUTINE INIMO
Initial moisture fractions are calculated in the same way as in the subroutine BALANCE (see subr.BALANCE). This subroutine receives the following input-parameters from the waterquantity model:
- moisture content rootzone (MOCORO)
- groundwaterlevel (WALE)
- moisture deficit under the rootzone (MODEUN)

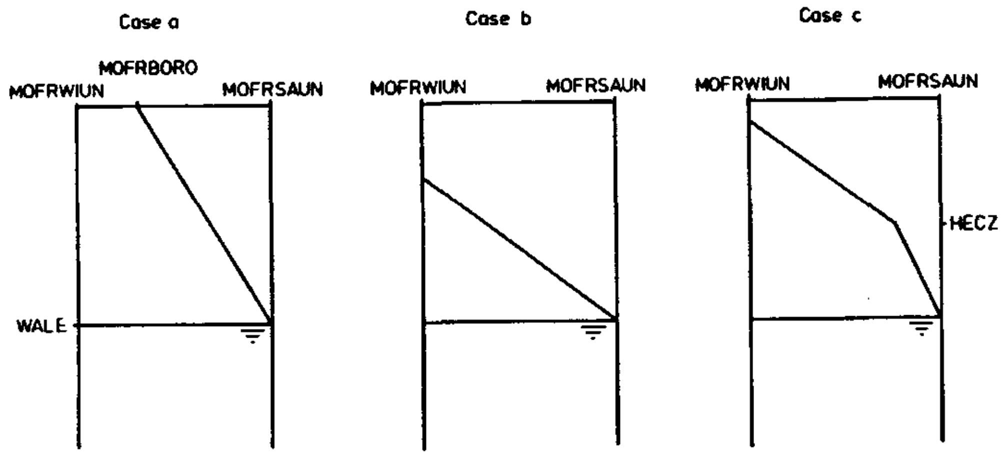
SUBROUTINE BALANCE
This subroutine calculates:
- moisture fractions (end of tstep and average) for each layer
- number of layers discharging to the drainage systems
- fluxes per layer (evapotranspiration and fluxes to/from other layers and drainage systems)

For the distribution of the evapotranspiration flux (EV) over the layers of the rootzone there are two options (indicated by the input-parameter EVROSE):
- fluxes decreasing linear to the depth of the rootzone-layer.
- fluxes equally distributed over the layers of the rootzone.

The moisture-fractions of layers below the rootzone can be distributed according to the folowing schematization:
case a. linear relation.

case b. non-linear relation with one bend-point.
case c. non-linear relation with two bend-points.

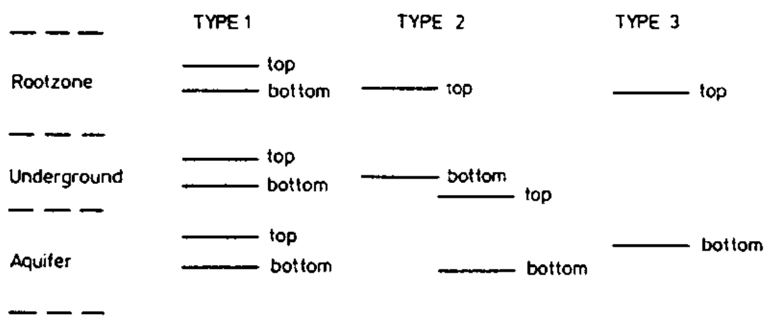
Figure 2.5 Schematic relationship of moisture fraction below rootzone.



SUBROUTINE FLUX
This subroutine is used in the subroutine BALANCE to determine for each drainage system the discharge/infiltration fluxes per layer.
Subroutine BALANCE has calculated thickness and number of layers discharging to the drainage system, which results in a discharge zone. The position of top and bottom of this zone lead to 3 types of solutions to determine the discharge-flux for each layer. Figure 2.6 gives these three types of solutions with the profile divided into three parts on base of different conductivities.

- rootzone
- underground (=layers between rootzone and aquifer)
- aquifer

Figure 2.6. three types of solutions to determine discharge



SUBROUTINE ROOT

For non-grassland applications this subroutine determines amount and lenght of roots as well as the distribution of roots over the layers. Exudate productions is also determined as a function of the root development. For amount and lenght of roots an interpolation is executed between input-data. The distribution of roots decreases linear with depth.

SUBROUTINE ADDIT
In this subroutine the additions take place that can be regarded as additions to the top of the soil system; they are added to the soil and can be mixed through one or more layers. The following additions can take place:
- dry deposition
- death root material
- harvest losses
- grazing losses
- manure additions
- fertilizer additions

Dry deposition is an input-parameter which is added every timestep to the reservoir on top of the layers.
For grassland root-, harvest- and grazing-losses are determined in the subroutine GRASS; root-material is added continuously and harvest- and grazing-losses are added when they are calculated by the subroutine GRASS.
For field-applications the input-data concerning additions can be delivered by means of an input-file (ADDIT.DAT); for regional applications data concerning manure-additions are delivered by the subroutine MANURE.
This subroutine uses an artificial reservoir for the additions of mineral nitrogen and soluble organic matter. Out of this reservoir mineral nitrogen and soluble organic matter may leave the system with surface runoff or go to the first layer.

SUBROUTINE TEMPER
This subroutine calculates the temperature of each layer with either a Fourier analysis model (if temperatures are given as input) or with a sinus model. The temperature is calculated for the middle of a timestep and for the middle of a layer. A demping towards depth is calculated in both the sinus and the Fourier model.

SUBROUTINE MINER1
In this subroutine reduction factors and reaction rates per layer are calculated. Reduction factors are determined for pH, temperature and moisture. The N-fraction of humus is decreased by a factor 0.2 for the layers with a reduced decomposition (indicated by the input-parameters LR and RDFADCHU)
The first-order rate constants are calculated for:
- decomposition of fresh organic matter (each fraction)
- decomposition of organic matter in solution
- decomposition of humus
- decomposition of exudates
- nitrification

The zero-order rate constant is calculated for the production of organic matter in solution (k0(COCA)).

SUBROUTINE RESPI
Calculation of nitrification (REKINH) and denitrification (decomposition part of REKONI).
This subroutine starts with the calculation of diffusion coefficients for oxygen in air pores; the number of aerated layers is then also determined.
For every layer the potential oxygen demand is calculated as the sum of oxygen demand for:
- decomposition of organic matter (fresh, in solution and humus)
- decomposition of exudates
- nitrification of the decomposed organic matter
- nitrification of the present ammonium

With this potential oxygen demand and the determined diffusion coefficients the subroutine OXYDEM then calculates an oxygen profile resulting in a (partial) aerobiosis per layer (aerated fraction AEVO).
On base of precipitation excess and hydraulic conductivity of the rootzone a temporary anaerobiosis (TIAN) is calculated which has been introduced to simulated denitrification in top-layers due to have rainfall.
Then per layer the following calculations:
1. potential denitrification
2. reduction factor for denitrification
3. denitrification
4. reduction factor for oxygen deficit

ad 1. In case of outgoing fluxes potential denitrification is determined with a transport-and conservation equation; if there are no outgoing fluxes then 60% of the present nitrate-N can be denitrified.

ad 2. For (partial) anaerob conditions this reduction factor is:

$$\text{rdfade} = \frac{\text{potential denitrif.} + \text{incoming nitrate}}{\text{oxdd}} \qquad [-]$$

in which:
oxdd = potential oxgen demand for decomposition of organic matter [kg O m-3 d-1]
rdfade = reduction factor for denitrification [-]

ad 3. Final denitrification determined as:

$$\text{deni} = \text{aevoan} * \text{oxdd} * \text{rdfade}$$

in which:
deni = denitrification [kg O m-3 d-1]
aevoan = anaerob fraction [m3 m-3]

ad 4. In case of an oxygen deficit the decomposition of organic matter during the timestep is reduced with the following factor:

$$\text{rdfaox} = \frac{\text{deni} - \text{aevoar*oxpdra}}{\text{aevoan*oxdd} - \text{aevoar*oxpdra}}$$

in which:
aevoar = aerob fraction [m3 m-3]
oxpdra = total potential oxygen demand (incl. nitrification) [kg O m-3 d-1]

The decomposition rates for organic matter are calculated and the nitrification rate is determined.

SUBROUTINE OXYDEM
In this subroutine oxygen-demand calculations are performed resulting in an oxygen-profile. A vertical oxygen profile is determined in no more than 3 iterations. Per iteration a reduced oxygen demand (RDOXPDRA,OXDDRA) per layer is calculated as a result of partial anaerobiosis. This reduced oxygen demand results in an oxygen concentration per layer (OXCO1,OXCO2). An aerated radius (RIAE) is calculated to determine vertical oxygen distribution. This radius is calculated with a Newton-Raphson iteration. Finally the aerated fraction (AEVO) per layer is determined.

SUBROUTINE TRANSPORT
This subroutine is used to determine transport and production/consumption of organic matter in solution, ammonium and nitrate.
For every layer the transport- and conservation-equation is solved analytically in the subroutine TRANSSUB (for phospor in the subroutine TRANSPHOS) The sequence of calculations is determined on base of the flow direction.

SUBROUTINE TRANSSUB
For every layer the functions FCONIT and FAVCO calculate the concentrations at the end of a timestep and the average concentration during a timestep.

SUBROUTINE TRANSPHOS
Like TRANSSUB but then for phosphor.

SUBROUTINES CONVR4R8, CONVR8R4 Used in the subrountei TRANSPHOS to convert from real data type to double precision or vice versa.

SUBROUTINE MINER2
In this subroutine the amount of each of the four kinds of organic matter, remaining at the end of the timestep, is calculated. These calculations result in a net release of NH4-N (REKONH); a positive release means mineralization, a negative release means immobilization of ammonium. If the calculated immobilization is greater than the amount of ammonium present at the beginning of a timestep, the present ammonium is immobilized and the net release of NH4-N is calculated once again with a reduced assimilation-factor.

SUBROUTINE PLANT
In this subroutine the selectivity-factor (RDFAUP) is calculated which can reduce the crop-uptake.
For grassland-applications this selectivity-factor only limits uptake if there is not enough growth to keep up with the rising N-content of the root-material.
For non-grassland applications the selectivity-factor is determined on base of the summarized uptake during previous timesteps. The uptake is reduced if a certain maximum, based on input-data, is reached. Reduction may also occur if the nitrogen concentration at the beginning of the timestep is too high.

SUBROUTINE DENITR
This subroutine determines the 0-order production term for NO3 (REKONI), which describes nitrification/denitrification. For nitrification the average ammonium concentration is used, which is a result of the subroutine TRANSPORT. Denitrification is determined in the subroutine RESPI.

SUBROUTINE CONCDRAIN
This subroutine calculates for organic matter in solution, ammonium and nitrate the concentration of the drainage/infiltration water of the four systems (trenches, ditches, canals, deeper layers)

SUBROUTINE MASSBAL
Performs massbalance calculations to verify previous calculations. Furthermore the summarized uptake is determined and initialization of organic matters and mineral nitrogen for the next timestep takes place.

SUBROUTINE GRASS
This subroutine calculates root-mass distribution over the layers of the rootzone. The amount is calculated as a function of the amount of shoots. The amount of shoots is a function of a standard crop production. The availability of mineral nitrogen may reduce shoot growth.
Harvest-losses are calculated if the shoot-mass exceeds 0.4 kg.m-2. Grazing-losses may occur before 15 May if the amount of shoots exceeds 0.25 kg.ha-1 and after 15 May if the amount of shoots exceeds 0.075 kg.m-2.

SUBROUTINE SELECT
This subroutine arranges the output to different files. A selection in the output must have been made in the input-file GENERAL.DAT.

For regional applications the following subroutines are also being used:

SUBROUTINE READFEM
This subroutine reads hydrological data calculated by the model SIMGRO

SUBROUTINE MANURE
Determines the values of variables concerning manure-additions for this timestep. These variables are:
- time for next addition (TINEAD)
- number of additions (NUAD)
- material number of the added material (MTNU)
- quantity of material to be added (QUMT)
- the way the addition has to take place (WYAD)
- ploughing or not (PL)

1 Kind of fertilizer and 5 kinds of manure are distinguished and the input-file ADDIT.DAT should contain the quantities of the additions. For the four kinds of manure two data should be

given, one standing for a spring-application and another-one as a winter-application.
The division of the additions is the following:
Fertilizer:

- 1 application on arable land and maize: on 1 April
- 4 appl. on grassland: 1 April, 25 May, 30 Juin, 23 August

5 Kinds of manure:

- 6 spring-applications on arable land: between daynrs 46 and 91
- 15 winter-applications on arable land: between daynrs 305 and 46
- 11 spring-applications on maize land: between daynrs 46 and 121
- 15 winter-applications on maize land: between daynrs 305 and 46
- 37 spring-applications on grassland: between daynrs 46 and 305 (incl. 10 ton per ha per livestock unit)
- 15 winter-applications on grassland: between daynrs 305 and 46

The high intensity of spring-applications on grassland is caused by the continuous excreting of cattle.
.BR
Fertilizer and manure on grass are added to the reservoir (WYAD=0) and not ploughed (PL=0).
.BR
Manure on arable and maize land is added to the reservoir (WYAD=0) and ploughed through the first three layers (PL=3).

SUBROUTINE TRANSFER
Transfers data that are time and technology dependent. This subroutine collects them at the beginning of a timestep (except the first timestep).

SUBROUTINE TRANSFERT
Transfers data that are time and technology dependent. This subroutine writes them into arrays at the end of a timestep.

SUBROUTINE CDSYS Arranges writing to a file CDS....DAT which can directly be used by the Interactive Comparative Display System (Walsum,1986)

SUBROUTINE AQUIFER
This subroutine executes a mixing in the lowest part of the aquifer at the end of a simulated year. An imaginary boundary (see par. 3.3) is the upper limit for this part of the aquifer. Above this boundary vertical flow is dominant and below this boundary horizontal flow dominates.
Figure 2.7 gives an impression of the various fluxes to/from this part of the aquifer below one subregion.

The following formulation is applied to determine the concentration at the end of each simulated year.

$$rsconiaq = (1-mifa) * coniaq + mifa * \frac{co(i) * fl(i)}{fl(i)}$$

in which:

rsconiaq	= concentration NO3-N in the aquifer at the end of a year	[kg.m-3]
coniaq	= concentration NO3-N in the aquifer at the beginning of a year	[kg.m-3]
mifa	= mixing factor	[-]
i	= side of polygone	[-]
co	= average concentration of flux through side i	[kg.m-3]
fl	= flux through side i	[m3.yr-1]

Since mixing is done on a year base, the mixing factor is the inverse of the residence time; the mixing factor should be less then 1.0. The residence time is determined as:

$$resti = he * ar * por / flin$$

in which:

resti	= residence time in years	[yr]
he	= layer thickness	[m]
ar	= area	[m2]
por	= porosity	[-]
flin	= incoming flux	[m3.yr-1]

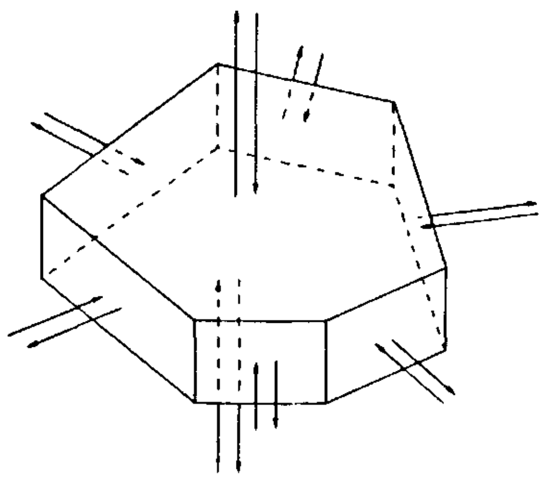


Figure 2.7. Fluxes to/from the aquifer below one subregion

3. INPUT

3.1 general

For field- and regional applications the file GENERAL.DAT has to be created. This file contains data that are valid for more than one field or subregion (incase of regional applications). In appendix B one can find a summary of the data required in this file. In the appendices C and D extensive informations is given about field- and regional applications.

3.2 field application

For field-applications the following files have to be created:
- GENERAL.DAT (general data)
- AREA.DAT (general data valid for a specific field)
- INI.DAT (initial data about mineral N and organic matter)
- ADDIT.DAT (data concerning additions to the soil system)
- WATBAL.DAT, SWATRE.DAT or DEMGEN.DAT (waterquantity data)

Appendix B gives a summary of the input-parameters needed for field-applications. Appendix C gives an extensive description of the required input-data for a field applications.
Dependent on the applied kind of waterquantity model (like WATBAL, SWATRE or DEMGEN) the waterquantity data-file should be either WATBAL.DAT, SWATRE.DAT or DEMGEN.

3.3 regional application

For regional applications a region is divided into a number of subregions or areas (NA). Each subregion is divided into a number of technologies. Subregion-division is based on differences in soil physical and hydrologal properties; subregions are geographically fixed. Technology-division is based on differences in land-use; technologies are fractions of a subregion and geographically not fixed.
The following input-files have to be created:
- GENERAL.DAT (general data)
- AREA(1-NA).DAT (general data valid for a specific subregion)
- INI(1-NA).DAT (initial data valid for a specific subregion)
- SIMGROQ.DAT (waterquantity data)
- SIMGRO.FLW (yearly-fluxes to/from first aquifer)
- CAPSEVPF.DAT (pF-relations per soil physical unit)
- ADDIT.DAT (manure-quantities)

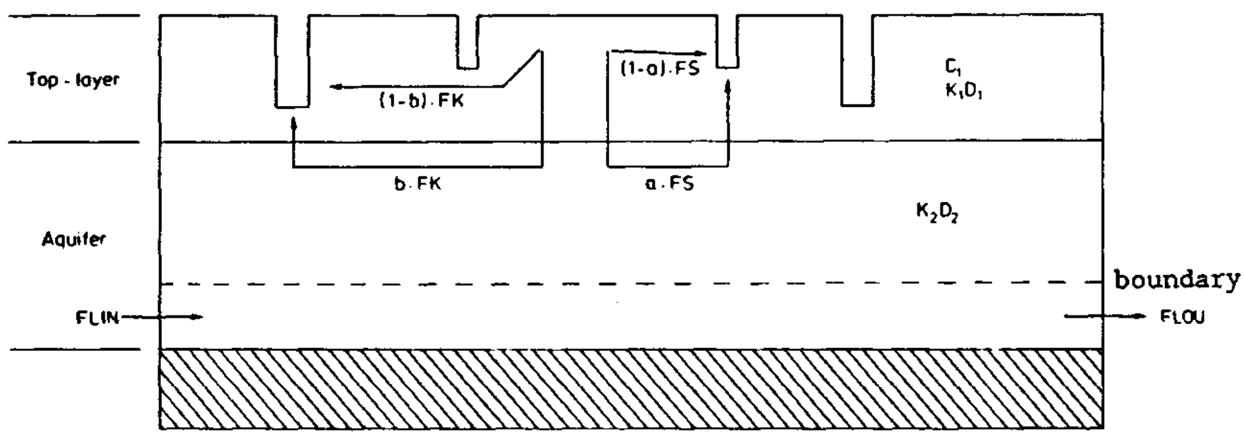
The summarized description given in Appendix B and the extensive file-descriptions in appendix D can be used for the files GENERAL.DAT, AREA(1-NA).DAT and INI(1-NA).DAT.
The files SIMGROQ.DAT and SIMGRO.FLW are output-files of the regional waterquantity model SIMGRO and are also discussed in appendix D.
The file CAPSEFPF.DAT contains for every soil physical unit a relation between groundwaterlevel and moisture-content. These

relations have been determined with the ICW-model CAPSEV and served as input for the model SIMGRO. These data are also used in ANIMO in the subroutine READFEM to determine initial moisture deficits of layers under the rootzone.
The file ADDIT.DAT is a file which can be created with the model SLAPP (Walsum,1988). The file ADDIT.DAT contains manure-quantities that have to be added to the soil system at fixed timesteps in the model ANIMO.

An important input-value is the position of the imaginary boundary in the aquifer; above this boundary local flow is dominant and below this boundary horizontal (regional) flow dominates. This boundary must be determined in calculations performed beforehand.
In the following allineas an explanation will be given of a determination of the position of this boundary.
The regional model SIMGRO calculates:
- fluxes to ditches (FS) and canals (FK) per subregion
- lateral fluxes (FL) across the boundaries of each subregion

It's assumed that the position of this boundary is determined by the ratio between the local groundwaterflow (FS and FK) through the aquifer and the regional groundwaterflow (FL). For both terms year-averages are used. Figure 3.1 gives the applied schematization in which Y stands for the distance between boundary and bottom of toplayer. FLIN and FLOU stand for the summarized incoming, resp. outgoing fluxes. (see also figure 2.7).

Figure 3.1 Schematization to determine position of imaginary boundary in aquifer.



About local groundwater-flow:
A part of FS and FK passes through the aquifer. This part is inversely proportional to the relation between the resistances that the waterflow find on its way through respectively the top-layer and the aquifer. In formulas:

For ditches:

$$RES1 = \frac{Ls*Ls}{8*K1*D1} + Ls*RESs$$

$$RES2 = 2*C + \frac{Ls*Ls}{8*K2*D2} + Ls*RESs$$

$$a = RES1 / (RES1 + RES2)$$

For canals:

$$RES3 = \frac{Lk*Lk}{8*K1*D1} + Lk*RESk$$

$$RES4 = 2*C + \frac{Lk*Lk}{8*K2*D2} + Lk*RESk$$

$$b = RES3 / (RES3 + RES4)$$

in which:

a	= part of FS that dicharges through the aquifer	[-]
b	= part of FK that dicharges through the aquifer	[-]
RES1	= resistance for flow through top-layer to ditches	[d]
RES2	= resistance for flow through aquifer to ditches	[d]
RES3	= resistance for flow through top-layer to canal s	[d]
RES4	= resistance for flow through aquifer to canals	[d]
Ls	= ditch-distance	[m]
Lk	= canal-distance	[m]
K1	= horizontal conductivity of top-layer	[m.d-1]
D1	= thickness of top-layer	[d]
RESs	= radial and entrance flow resistance to ditches	[d.m-1]
RESk	= radial and entrance flow resistance to canals	[d.m-1]
K2*D2	= transmissivity of (first) aquifer	[m2.d-1]
C	= vertical flow resistance of top-layer	[d]

The summarized average local groundwater-flow through the aquifer is now: $a * ABS(FSav) + b * ABS(FKav)$
Absolute values of year-averages (FSav and FKav) are used because in this case it doesn't matter whether water flows to or from ditches and canals.

About regional groundwater-flow:
The regional model SIMGRO calculates for every subregion incoming and outgoing fluxes of the first aquifer. From these data an average regional groundwaterflow (FL) can be determined by taking the average of the summarized incoming (FLIN) and outgoing (FLOU) amounts.

In formula: $FL = (FLIN + FLOU) / 2$

The position of the boundary (distance Y to bottom of toplayer) is now the following:

$$Y = \frac{a * ABS(FSav) + b * ABS(FKav)}{a * ABS(FSav) + FL + b * ABS(FKav)} * D2 \qquad [m]$$

Once the position of this boundary is determined for each subregion the layer-division per subregion can take place.

4. OUTPUT

4.1 general

There are two standard output-files. The file TOUT.DAT will be created for every run, output will be given for as many timesteps as indicated with the input-parameters OUTTO-OUTTN. The other file that will be created is the file INIT.DAT. For field applications this is a file with the same data in the same sequence as the input-file INI.DAT. For regional applications INIT.DAT-files are unformatted files.
Another way of getting output is by means of one of the options given at the end the input-file GENERAL.DAT (see appendix B).
A summary of these options will be given:

output-file	contents
TOUT.DAT	detailed output per timestep of all subroutines
NITRATE.DAT	NO3-N per timestep per layer in kg N m-3 solution
AMMONIUM.DAT	NH4-N per timestep per layer in kg N m-3 solution
OMS.DAT	organic matter in solution per timestep per layer in kg dry matter m-3 solution
UPTAKE.DAT	crop uptake per timestep per layer in kg N m-3 sol.
MINERAL-N.DAT	mineral-N per timestep per layer in kg N m-2 soil
TOTAL-N.DAT	total N present at the end of tstep per layer in kg N m-2 soil
TOMNNITO.DAT	total mineralization per timestep per layer in kg N m-2 soil
RDFA.DAT	reduction factors per timestep per layer for oxygen (RDFAOX) and total (RDFAOX*RDFATE*RDFAPH*RDFAMO)
MASSBAL.OUT	massbalance per selected timestep
BANIYR.DAT	NO3-N massbalance per year for a given amount of layers and updated (total values set to 0) at a given daynr.
BANHYR.DAT	NH4-N massbalance per year (like BANIYR.DAT)
BAWAYR.DAT	waterbalance per year
BANIST.DAT	NO3-N massbalance per timestep for a given amount of layers.
BANHST.DAT	NH4-N massbalance per timestep (like BANIST.DAT)
ADDITNH.OUT	water-and massbalance for NH4-N in the addition-reservoir
ADDITNI.OUT	water-and massbalance for NO3-N in the addition-reservoir
BANHYR.DAT	Phosphor massbalance per year (like BAPOYR.DAT)
BANHST.DAT	Phosphor massbalance per timestep (like BAPOST.DAT)
GRASS1.OUT	shoot and root development per timestep in kg dry matter per ha
GRASS2.OUT	per timestep information about several variables related to production-reduction due to N-shortage

The files GRASS1.OUT and GRASS2.OUT can only be created for grassland applications.

Furthermore extra output can be obtained by compiling the following subroutines with the D_line compile option.

subroutine	output-file	contents
AQUIFER	AQUIFER.OUT	per year variable-information about regional and local fluxes in (first) aquifer.
BALANCE	BALANCE.OUT	per timestep a waterbalance
HYDRO	HYDRO.OUT	per timestep a waterbalance
READFEM	READFEM.OUT	per technology per timestep a waterbalance

4.2 regional

The output as explained in par. 4.1 can be given for a specific technology (indicated with input-parameters OUTAN and OUTTN). Apart from that there is a special option for regional applications. The input-parameters OUTCDS-CDSYR arrange output for all subregions, technologies, years and layers. This is done in such a way that the following output is written to one file:

- NO3-N (in mg.l-1) at daynr 32 (1 February) of each year of all layers for each technology and each subregion.

This outputfile can be created for a maximum period of 30 years. It's a file that is especially suitable for a graphical representation of the data with the interactive Comparative Display System developed by P.E.V. van Walsum. (Walsum, 1986).

4.3 error messages

The program is not protected against incorrect input of parameter-values.
The output-file TOUT.DAT can be used to verify the input.

Most subroutines can create error messages, which all refer to the subroutine that creates the message. Two examples of error messages will be discussed.

1.

```
  subr.BALANCE\mess3: mofr. below rootz. > saturated
    LN=          10 MOFRT(LN)=  0.3600001    MOFRSAUN=  0.3600000
    subregion           1   technology          1   timestep   1095.746
    MOFRT(LN) set to saturation, program continues..
```

2.

```
  subr. TRANSPORT: BAPD and BATR differ more then 5%
    BAPD=  2.3582299E-05 TI=   192.7702      LN=          8 NTR=        2
    BATR=  2.6751050E-05 (BAPD=processes, BATR=transp.+storage)
```

ad 1. error message from the subroutine BALANCE, which indicates over-saturation, explanation of variables is given in appendix A. A more detailed verification can take place be compiling subr. BALANCE with the D_option. This error is created by calculation (accuracy) errors.

ad 2. error messsage from the subroutine TRANSPORT, which indicates a deviation in the solution of the transport- and conservation-equation for nitrate-N (NTR=2), layernr 8 (LN=8). A massbalance-cheque is performed with processes (BAPD) on one side of the balance and transport and storage (BATR) on the other side of the balance. A further verification can take place by means of on output-file MASSBAL.OUT for the timesteps with error messages.

5. VERIFICATION AND APPLICATION

The model ANIMO is applied on a field- and on a regional scale. Of the field-applications a maize- and a grassland-applications will be explained in this chapter, both served as a model-verification.
The application of ANIMO on a regional scale took place in the south-eastern part of the province of N-Brabant.

5.1 verification with field-experiments

The two field applications that are described in this paragraph are maize and grassland treated with different kinds of manure-applications.
These applications also served as a verification of the model. For this verification special attention has been paid to the following output:
- mineral-N
- total-N
- crop uptake
- leakage

The model was adjusted in such a way that this verification can take place with the aid of output-files and measured field data.

5.1.1 maize

The application of the model on maize concerned maize-fields of a regional investigation centre (Regionaal Onderzoeks-Centrum Cranendonck; in Maarheze, south-eastern part of N-Brabant). During 9 years high doses of cattle slurry were added to maize fields. For the ANIMO-application two fields were selected. One field received gifts of 250 ton cattle slurry per ha per year and had an optimal yield, a high leakage and no fertilizer-applications. The other field received 100 ton cattle slurry per ha per year, had a high leakage and no fertilizer applications (PAGV verslag nr.31, 1985).
Appendix C gives an extensive explanation of the input-parameters used for the maize application of 250 tons per ha per year. In this guide attention will only be paid to the 250 ton object. Manure-additions were given as: 100 ton in autumn, 100 ton in winter and 50 ton per ha in spring.

The waterquantity input-data were simulated with the model WATBAL. The groundwaterlevel is an important parameter since most transformation processes are related to the aeration of the soil profile. Figure 5.1 shows the simulated and measured groundwaterlevel.
For the verification of the model the massbalances on a year-base for nitrate and ammonium (files BANIYR.DAT,BANHYR.DAT) are very useful. Table 5.1 gives the year-balance of nitrate for the simulated period.

Table 5.1

Mass-balance of NO3-N for layers 1 to 8 written and updated at daynr 91.
(balance terms in KG.HA-1)

balance period	nitrification	additions	deposition wet	deposition dry	crop uptake	denitrification	leakage	drainage	storage pos=increase
Ø-1974 / 91-1974	29Ø.	Ø.	1.	2.	Ø.	139.	15.	Ø.	138.
91-1974 / 91-1975	838.	Ø.	6.	8.	266.	279.	372.	4.	-68.
91-1975 / 91-1976	898.	Ø.	4.	8.	278.	111.	182.	Ø.	34Ø.
91-1976 / 91-1977	85Ø.	Ø.	4.	8.	198.	75.	686.	Ø.	-98.
91-1977 / 91-1978	994.	Ø.	6.	8.	269.	543.	274.	Ø.	-78.
91-1978 / 91-1979	789.	Ø.	5.	8.	264.	25Ø.	4Ø5.	1.	-117.
91-1979 / 91-198Ø	1Ø25.	Ø.	5.	8.	227.	451.	291.	Ø.	68.
91-198Ø / 91-1981	961.	Ø.	6.	8.	266.	446.	312.	Ø.	-49.
91-1981 / 91-1982	886.	Ø.	5.	8.	274.	99.	494.	Ø.	32.
91-1982 / 365-1982	616.	Ø.	4.	6.	267.	7.	255.	Ø.	98.

The leakage investigations (Oosterom, 1984) on the maize fields were executed by measuring NO3-N concentrations at an average level of 1.0-1.2 m below soil surface. Verification of leakage took place with these data. Figure 5.2 gives measured and simulated data.

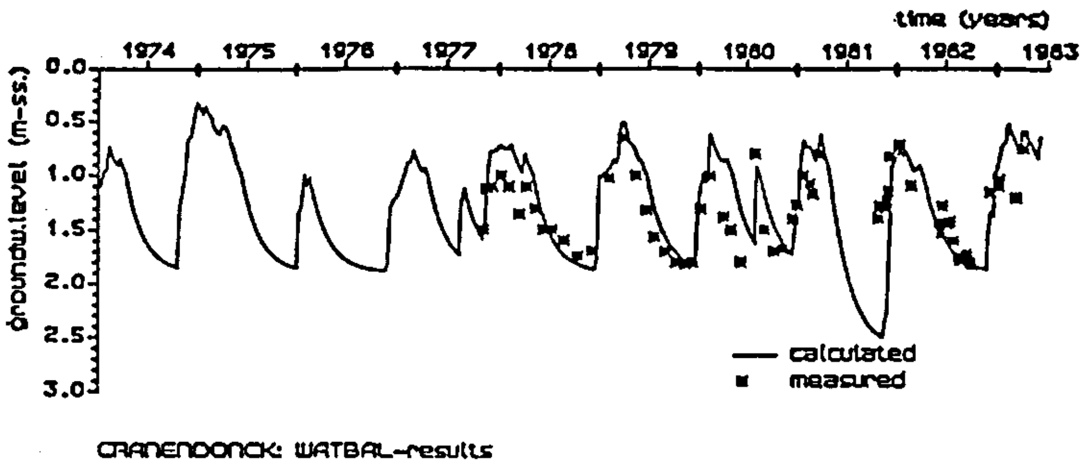


Figure 5.1

Mineral-N was measured and accumulated for the layers of the rootzone. Figure 5.3 gives measured and simulated data for the rootzone
The same goes for total-N, only here there was only measured on three data. Figure 5.4 gives measured and simulated data for the rootzone.
Crop uptake in the year-balance is the uptake by the whole

plant. Field measurements relate to the uptake by the harvested part of the plant. Figure 5.5 gives measured and simulated uptake. Simulated uptake is higher (about 28%) because a lot of nitrogen remains in the soil.

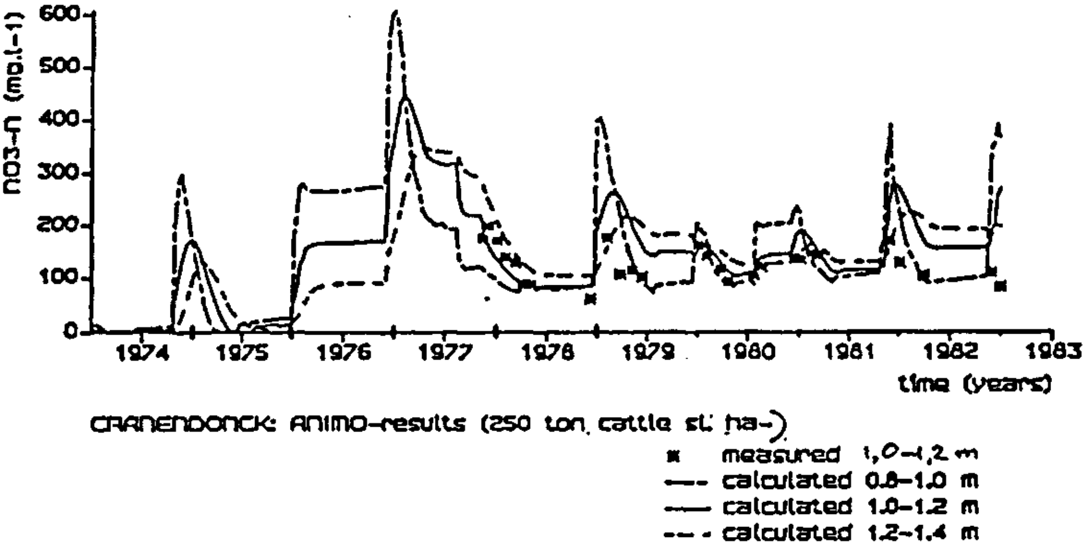


Figure 5.2

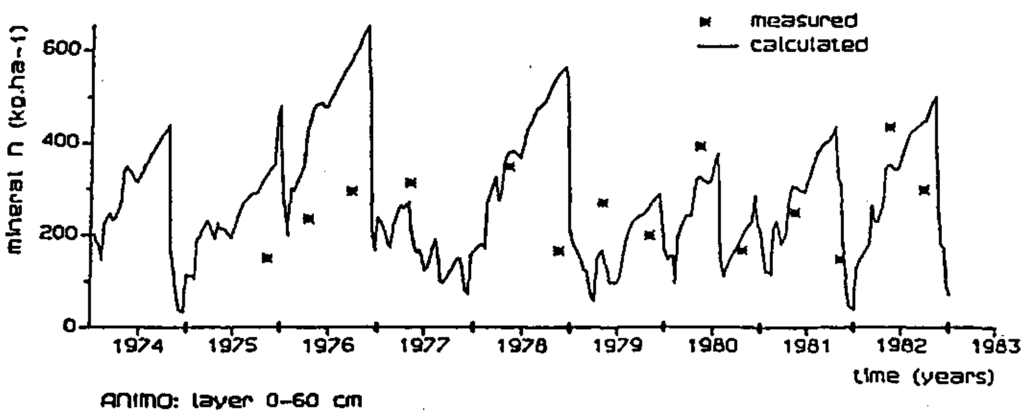


Figure 5.3

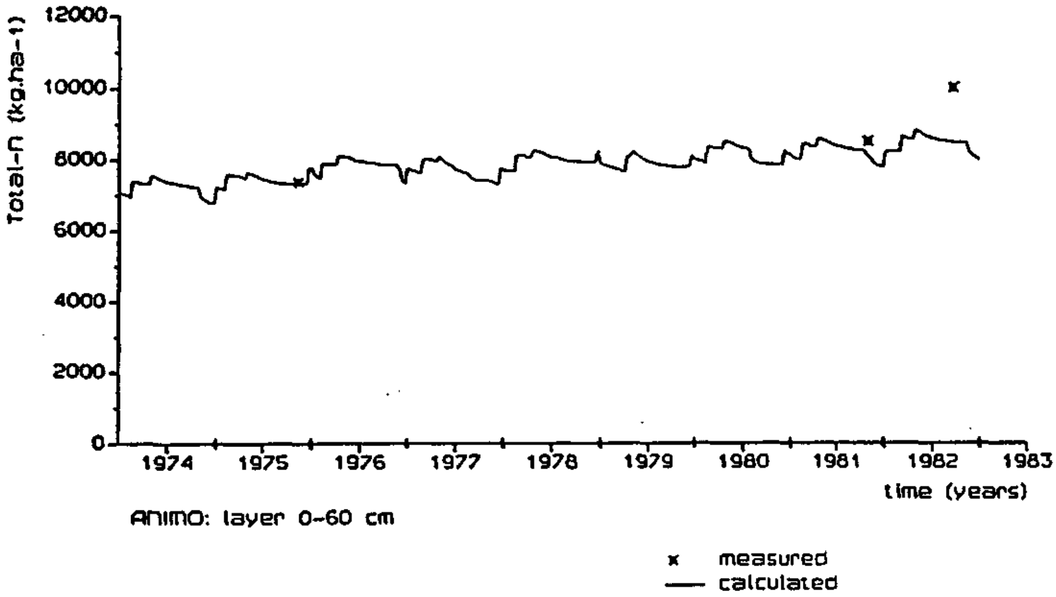


Figure 5.4

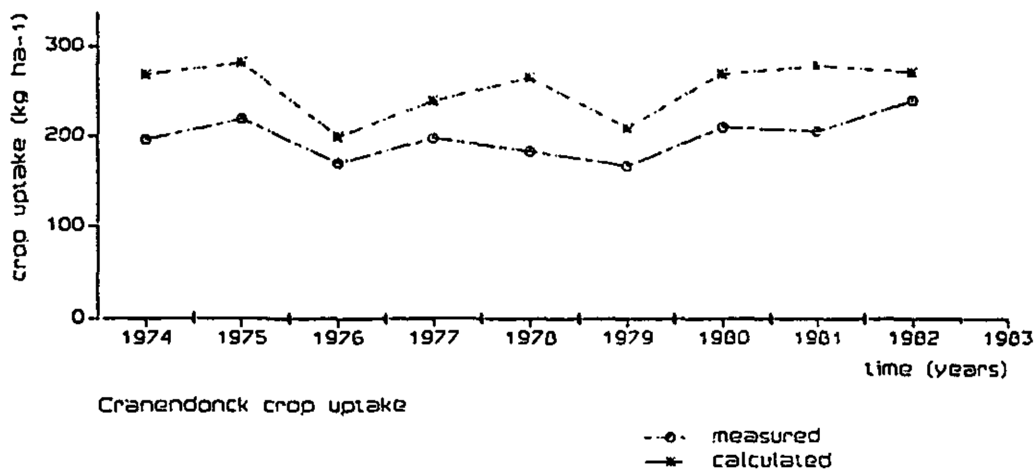
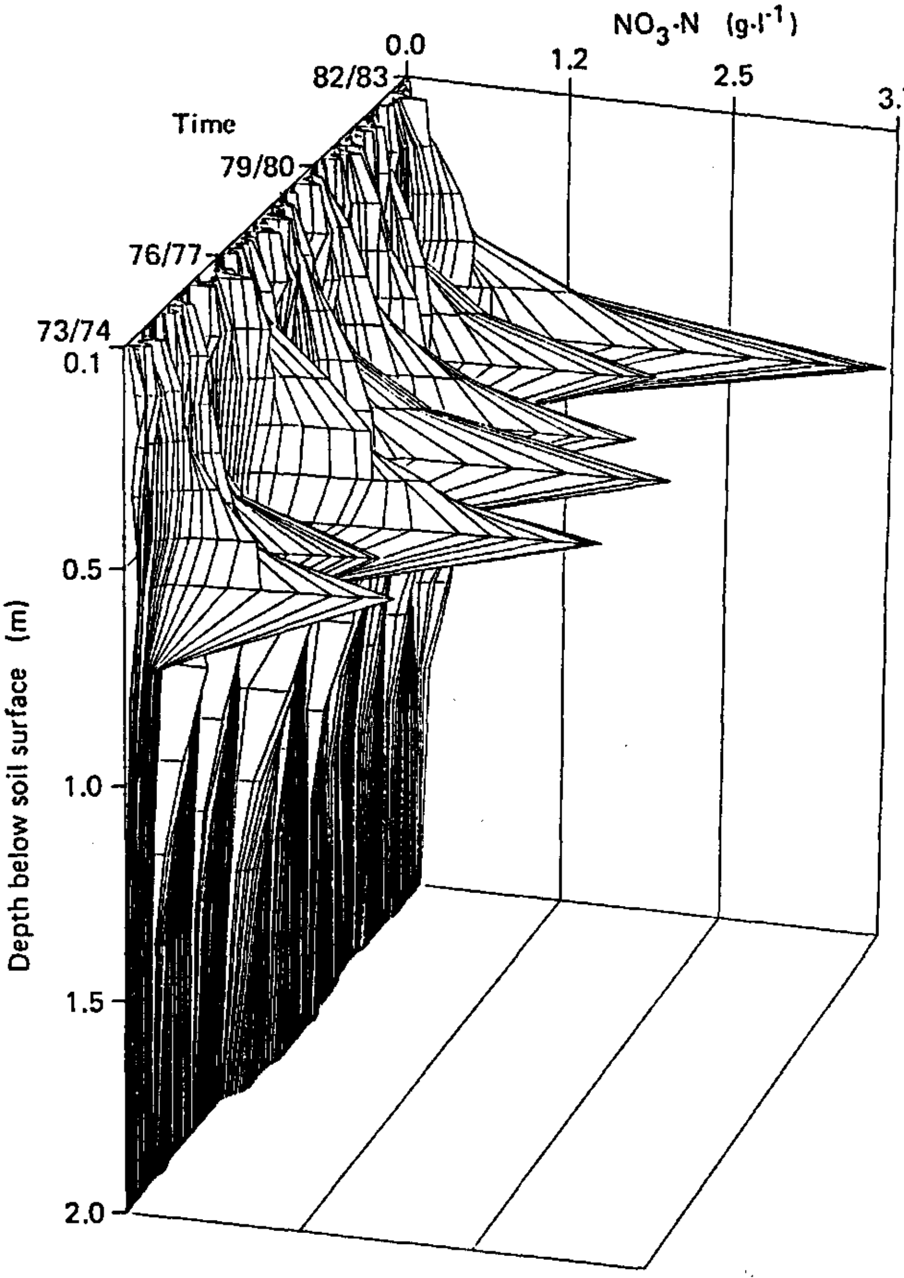


Figure 5.5

Figure 5.6 gives a three-dimensional representation of the simulated NO3-N concentrations against time and depth below soil surface. In this picture one can identify the three manure-additions given each year in the way of nitrate-peaks. The cattle slurry contains a high dosis of ammonium, which is rapidly nitrified into nitrate. Nitrate concentrations may become very high because of two reasons. Precipitation-excess makes nitrate accumulate in the lower layers of the rootzone and low moisture fractions in these layers concentrate it even further.

Figure 5.6 NO3-N concentrations represented against time and depth below surface.



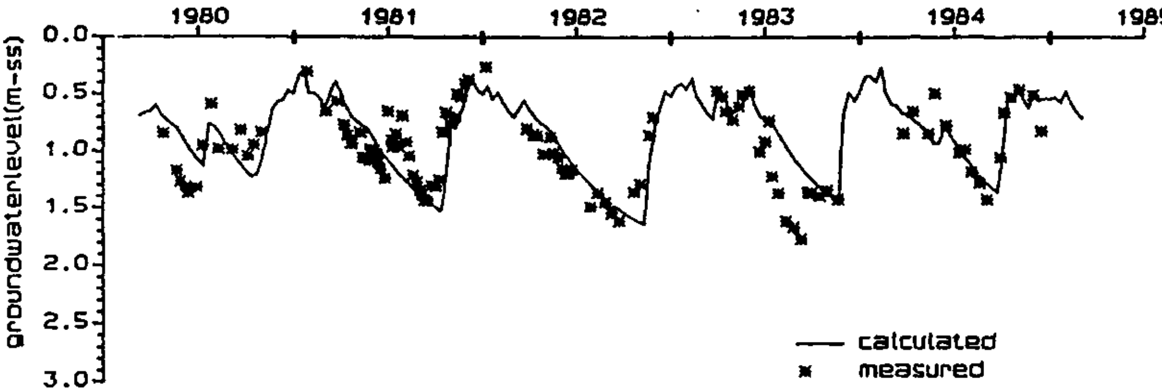
5.1.2 grassland

The application of the model on grassland concerned different kinds of manuring:
- no manure and no fertilizer.
- with a fertilizer-gift of 600 kg N per ha
- with a cattle slurry-injection of 40 ton per ha per year.
- with a fertilizer-gift of 400 kg N per ha and a cattle slurry injection of 40 ton per ha.

This manuring took place on fields of a regional investigation centre (Regionaal Onderzoeks-Centrum Heino; fields are located in Ruurlo, north-eastern part of Gelderland).
There is no extensive description of this application, but most of the explanations given for maize in appendix C are also valid for field-applications on grassland. Appendix D (regional appl.) also includes input-parameters for grassland-applications.
In this paragraph results will only be given of the simulations on the field which received an average fertilizer-gift of 660 kg N per ha. The next page shows subsequently simulation of:
- figure 5.7. Groundwaterlevel measured and simulated (WATBAL)
- figure 5.8. NO3-N measured at one depth and simulated (ANIMO) for 3 layers.
- figure 5.9. Mineral-N measured and simulated (ANIMO) accumulated values for the rootzone.

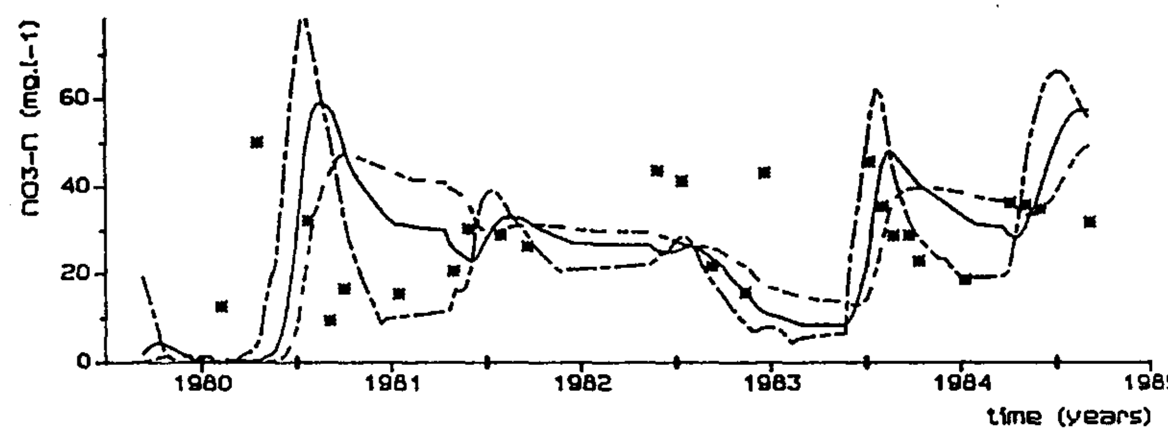
Total N has not been measured.
Crop uptake during the five years had an average measured value of 525 kg.ha-1 (spread: 404-627). Simulated average value is 606 kg.ha-1 (spread: 524-666). Simulations should be higher because a lot of nitrogen remains in the soil.

Figure 5.7



RUURLO: WATBAL-results

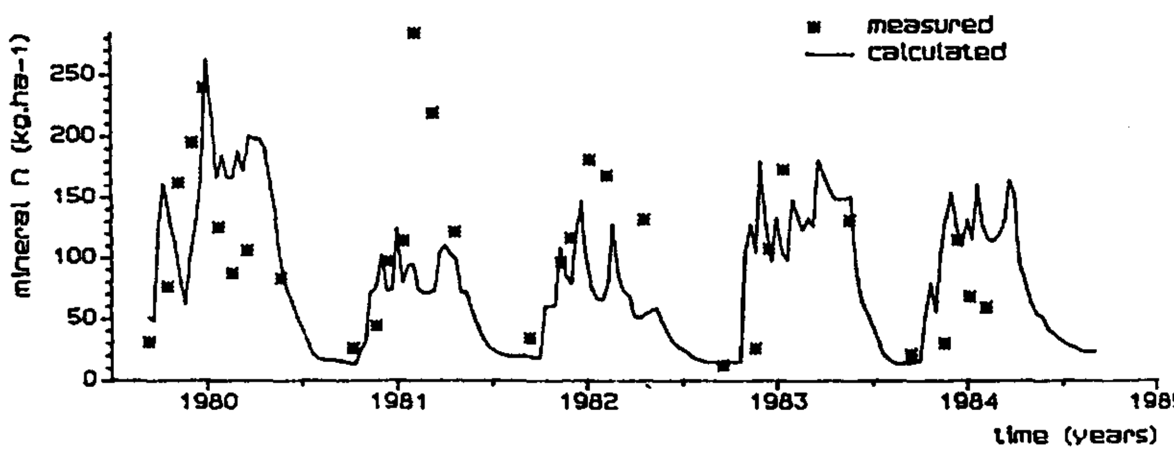
Figure 5.8



RUURLO: ANIMO-results field 37 (01 + 3N)'

- measured
- calculated 0.8-1.0 m
- calculated 1.0-1.2 m
- calculated 1.2-1.4 m

Figure 5.9



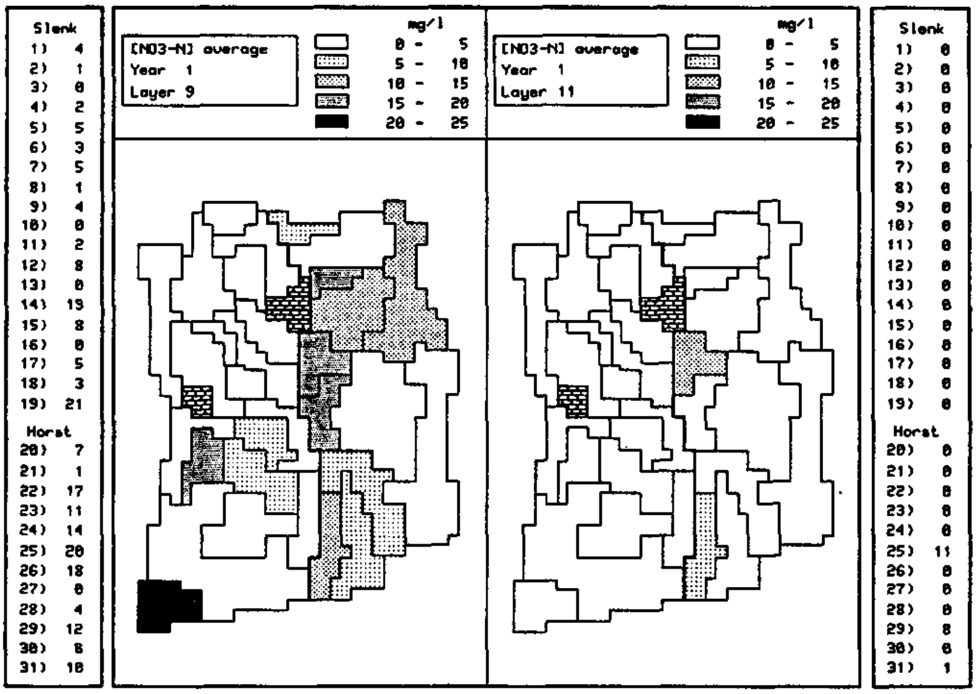
ANIMO: layer 0-50 cm

5.2 regional application

The regional application took place on a region of about 35.000 ha situated in the south-eastern part of the province of N-Brabant. The region was divided into 31 subregions. Each subregion was divided into 12 technologies.
For a further discussion about the results of this application reference is made to ICW rapport 26 (Drent et al., 1988). Figure 5.10 gives one of these results. The output of the model ANIMO was therefore written to a CDS*-file (see paragraph 4.2), which can easily be applied within the Interactive Comparative Display System (Walsum, 1986).

Appendix D gives an extensive explanation of the required input-files GENERAL.DAT, AREA(1-NA).DAT, INI(1-NA).DAT, SIMGROQ.DAT, SIMGRO.FLW, CAPSEVPF.DAT, ADDIT.DAT. The parameter-values given in this appendix relate to five subregions (subregion-nrs 14-18) of which only the first one is discussed in detail.

Figure 5.10 Model results of a regional application;
31 subregions, each divided into technologies.
For each subregion a weighed average NO3-N concentration is given.



6. SENSITIVITY ANALYSIS

The sensitivity of the model has been tested on a serie of important parameters.
For this test parameter values have been changed into relation with the reference with a value of +25% and -25%. Changes in groundwaterlevel were obtained in another way; the waterquantity model WATBAL has simulated a change in groundwaterlevel of +17cm and -17cm. This change in groundwaterlevel was achieved by manipulating the drainage-levels.
The test was applied on a simulation-run with a field-experiment in Cranendonck (Maarheze, N-Brabant, see also par.5.1.1), where 250 ton of cattle slurry per ha per year during 9 years were applied on maize land.
The test was focussed on NO3-N at the soil-compartment of 0-1 m below soilsurface; for this part of the soil the main processes have been followed cumulative during 9 years.
The average groundwaterdepth in the reference-run was 1.31 m below soil surface. Increasing all drain-levels with 0.2 m caused a rise of the groundwaterlevel of 0.17 m (from an average depth of 1.31 m to 1.14 m). Decreasing all drain-levels with 0.2 m caused a drop of the groundwaterlevel of 0.17 m (from an average depth of 1.31 m to 1.48 m).
The diffusion-parameters (PMDF1,PMDF2) are interrelated and should be changed simultaneously. PMDF1 was increased with 25% (from 0.75 to 0.94) and PMDF2 was also increased form 3.2 to 3.3. The decrease of PMDF1 with 25% was executed in a similar way. The simultaneous changes of PMDF1 and PMDF2 were determined with the following relation:

PMDF2' = PMDF2 - log(PMDF1) + log(PMFD1')

in which: PMDF1' = new value of PMDF1
PMDF2' = new value of PMDF2 due to change of PMDF1

In appendix E diagrams represent the results cumulative over 9 years for 11 parameter-changes.
Tabel 6.1 gives the results of the analysis as an average over the whole period in exact data and in percentages to the reference-values.

Table 6.1 Results of the sensitivity analysis.
The reference output-values are the following:
nitrification = 904 kg.ha-1
uptake = 254 kg.ha-1
denitrification = 248 kg.ha-1
leakage = 388 kg.ha-1

parameter (MNEMONIC)	input value	average value nitrif. (in kg.ha-1.yr-1)	uptake	denitr.	leakage	deviation nitrif. (in % from reference value)	uptake	denitr.	leakage
volatilization	0.5	869	254	234	369	-3.86	-0.09	-5.44	-4.94
(FRVO)	0.3	939	254	263	408	3.87	0.00	6.03	5.09
fresh -> humus	0.94	873	257	199	405	-3.36	1.33	-19.61	4.23
(HUFROS	0.56	933	250	306	363	3.27	-1.57	23.26	-6.63
N-fr.humus	0.06	876	252	244	367	-3.07	-0.57	-1.44	-5.36
(NIFRHUMA)	0.036	932	255	250	411	3.07	0.41	0.78	5.90
dec. rate humus	0.025	934	253	273	394	3.33	-0.29	10.14	1.35
(RECFHUAV)	0.015	873	255	218	388	-3.44	0.37	-12.10	-0.01
org.frac.rates	+25%	907	251	263	380	0.40	-0.94	6.21	-2.02
(RECFAV(1-3)	-25%	897	257	232	395	-0.73	1.06	-6.42	1.72
dec. org.in sol.	37.5	905	254	235	404	0.16	0.05	-5.26	4.08
(RECFCAAV)	22.5	902	254	245	389	-0.19	0.00	-1.31	0.27
assimilation	0.31	820	255	191	366	-9.25	0.41	-22.83	-5.85
(ASFA)	0.19	987	253	304	413	9.24	-0.24	22.65	6.29
temp.smooth.	0.0648	904	254	244	392	0.07	0.02	-1.39	1.02
(TESMCF)	0.0388	903	254	247	388	-0.08	-0.02	-0.15	-0.05
diff.coeff.	0.94,3.30	896	258	195	430	0.20	1.44	-14.00	7.33
PMDF1,PMDF2)	0.56,3.08	891	249	278	354	-0.37	-1.93	22.76	-11.84
(referentie- waarden:		895	254	226	401)				
air entry value	2.5	904	254	248	388	0.00	0.00	0.00	0.00
(AIENSCPF)	1.5	903	253	245	391	-0.07	-0.22	-1.19	0.74
groundwater	1.14 m	904	255	275	354	-0.01	0.40	10.81	-8.88
below surface	1.48 m	905	256	247	397	0.10	0.89	-0.24	2.14

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APPENDIX A: Vocabulary of the computerprogram ANIMO

List of letters and combinations of letters which are used to form the names of the variables. In indices sometimes a shorter abbreviation is used because all indices consist of two characters.

A area (in indices)
AC activity
AD addition
AE aerated
AF a-coefficient in Fourier analysis
AI air
AM amount
AN anorganic
AP amplitude
AQ aquifer
AS assimilation
AV average
BA balance
BE below
BF b-coefficient in Fourier analysis
BO bottom
C crop (in indices)
CA organic material in solution
CDS Comparative Display System
CD conductivity
CL column
CO concentration
CF coefficient
CR crop
CX complex
DA day
DC decomposition
DD demand
DE deficit, denitrification
DEV deviation
DF diffusion
DI difference
DM damping
DN density
DP depth
DR drainage
DS diffusion
EV evapo(transpi)ration
EX exudates
F fraction (in indices)
FA factor
FL flux
FO Fourier
FQ frequency
FR fraction
GR grazing

HA harvest
HE height
HU humus
HV helping variable
IC increase
IN in, initial
IT iteration
K kind (in indices)
KI kind
KN known
L layer (in indices)
LA layer
LE level
LN length
LR layer from which reduction in decomposition rate starts
M material (in indices)
MA maximum
MI minimum
MN mineralized
MO moisture
MT material
N number (in indices)
NE next
NH ammonium-N
NI nitrogen, nitrate-N
NT nitrification
NU number
OM organic matter
OR organic
OS organic material added stepwise
OX oxygen
OU out
PA part
PD production
PE percolation
PF pF
PH pH, phase
PL ploughing
PM parameter
PO pore, phosphate, phosphor
PR precipitation
QU quantity
RA rate
RD reduction
RE reaction
RI radius
RO roots
RS rest
RV reservoir
S step (in indices)
SA saturated
SC suction
SE selection
SH shoots
SM smoothing
SO sowing

SQ square
SR storage
ST (time)step
SU sum
TN technology
TE temperature
TI time
TN technology
TO total
TU tuber
TX text
UN under
UP uptake
VO volatization
WA water
WI wilting point
WY way
YR year

The letter behind a variable is a code for the data type: I means integer, R real and L logical.

List of variables which are used:

A R kg m-3
Average concentration (local in TRANSPORT)
ABSFG R m d-1
Absolute value of 3rd order discharge
ABSFK R m d-1
Absolute value of 1st order discharge
ABSFS R m d-1
Absolute value of 2nd order discharge
ADCF R -
Adsorption-exponent in Freundlich-equation (subr. TRANSPHOS)
AEARPEPO R m2 m-2
Aerated area in horizontal direction per pore
AEVO(LN) R m3 m-3
Aerated volume of soil for layer LN
AF(N) R -
a-Coefficient nr. N in Fourier analysis
AG R m
Average distance between modeldrains of 3th order
AIENSCPF R cm
Air entry value of pF curve
AITE(I) R C
Air temperature nr. I
AK R m
Average distance between drains of 1st order
AMOR(FN) R kg m-2 soil surface
Amount of fresh organic material of fraction FN in addition
AMORMT R kg m-2 soil surface
Amount of fresh organic material in addition
AMRO R kg m-2 soil surface
Amount of roots (locally used in module GRASS in kg.ha-1)
AMROTI(KC,I) R kg ha-1
Value nr. I of amount of roots of crop KC
AMSHMA R kg m-2
For grassland-applications: the maximum shoot production
AN I -
Area-number
ANMA I -
Number of the area to end simulation
ANMI I -
Number of the area to start simulation
APFO(N) R C
Amplitude nr. N in Fourier analysis
APTE R C
Amplitude of yearly temperature wave
AR(AN) R m2
Area of subregion AN
AS R m
Average distance between modeldrains of 2nd order

ASFA R -
Assimilation factor
AVCO(LN) R kg m-3 soil-solution
Average concentration in layer LN during timestep
AVCOCA(LN,FN) R kg m-3 soil-solution
Average concentration of organic material in solution fraction FN in layer LN during timestep
AVCOCATO(LN) R kg m-3 soil-solution
Average concentration of organic material in solution in layer LN during timestep
AVCONH(LN) R kg m-3 soil-solution
Average concentration of ammonium-N in layer LN during timestep
AVCONI(LN) R kg m-3 soil-solution
Average concentration of nitrate-N in layer LN during timestep
AVRI(LN) R m
Average radius of airfilled pore in layer LN
AVTE R C
Average yearly temperature
AVTI R d
Average time during timestep
B R m
Upper boundary discharge layer to a certain drain (local in FLUX)
BANI1(LN) R kg m-2 soil surface
Amount of nitrogen disappeared
BAOM(LN) R %
Relative deviation in balance of organic matter layer LN in this timestep
BAOM1(LN) R kg m-2 soil surface
Amount of organic material dissociated
BAPD R kg m-2 soil surface
The side of the massbalance which includes processes expressed a production-term (local in TRANSPORT).
BATR R kg m-2 soil surface
The side of the massbalance which includes transport and storage (local in TRANSPORT).
BF(N) R -
b-Coefficient nr. N in Fourier analysis
BO(LN) R m
Depth of bottom of layer LN below soil surface
C R kg m-3
End concentration (local in TRANSPORT)
CB R kg m-3
Average concentration of layer LN-1 (local in TRANSSUB)
CDSA R m d-1
Saturated conductivity
CF R -
Correction factor (local in MINER2)
CLWA R m
Column of water used for calculation of temporary anaerobiosis
CO(LN) R kg m-3
Concentration at end of timestep
COAQ R kg m-3
Concentration in aquifer
COAQNH R kg m-3
Concentration of ammonium-N in aquifer
COAQNI R kg m-3

Concentration of nitrate-N in aquifer
COB(LN) R kg m-3
Average concentration in layer above layer LN
COCA(LN,FN) R kg m-3 soil-solution
Concentration of organic matter fraction FN in solution in layer LN
COCATN(TN,LN,FN) R kg . m-3 soil-solution
Concentration of organic matter fraction FN in solution in technology in fraction FN (local in ANIMO)
COCATO(LN) R kg m-3 soil-solution
Concentration of organic matter in solution in layer LN
CODRG R kg m-3
Concentration in the 3rd order drains
CODRGCA R kg m-3
Concentration of total organic matter in the 3rd order drains
CODRGNH R kg m-3
Concentration of NH4 in the 3rd order drains
CODRGNI R kg m-3
Concentration of nitrate in the 3rd order drains
CODRK R kg m-3
Concentration in the 1st order drains
CODRKCA R kg m-3
Concentration of total organic matter in the 1st order drains
CODRKNH R kg m-3
Concentration of NH4 in the 1st order drains
CODRKNI R kg m-3
Concentration of nitrate in the 1st order drains
CODRS R kg m-3
Concentration in the 2nd order drains
CODRSCA R kg m-3
Concentration of total organic matter in the 2nd order drains
CODRSNH R kg m-3
Concentration of NH4 in the 2nd order drains
CODRSNI R kg m-3
Concentration of nitrate in the 2nd order drains
COID R kg m-3
Concentration in the infiltration water
COIDCA R kg m-3
Concentration of 'organic material in solution' in infiltration water
COIDNH R kg m-3
Concentration of ammonium-N in infiltration water
COIDNI R kg m-3
Concentration of nitrate-N in in infiltration water
COMA R kg m-3 soil-solution
Maximal concentration of nitrate-N for plant uptake
COMA1(KC) R kg m-3 soil-solution
Maximal concentration of nitrate-N for uptake by crop KC in first period
COMA2(KC) R kg m-3 soil-solution
Maximal concentration of nitrate-N for uptake by crop KC in second period
CON R kg m-3 soil-solution
Average concentration of layer LN+1 (local in TRANSSUB)
CONH(LN) R kg m-3 soil-solution

Concentration of ammonium-N in layer LN
CONHTN(TN,LN) R kg m-3 soil-solution
Concentration of ammonium-N in technology TN in layer LN (local in ANIMO)
CONH4(LN) R kg m-3 soil-solution
Estimated concentration of ammonium-N in layer LN (local in MINER2)
CONI(LN) R kg m-3 soil-solution
Concentration of nitrate-N in layer LN
CONICDS(TN,YR,LN,AN) R mg 1-1 soil-solution
Concentration of nitrate-N in technology TN, year YR, layer LN, area AN (local in ANIMO and used for output to Comparative Display System)
CONITN(TN,LN) R kg m-3 soil-solution
Concentration of nitrate-N in technology TN layer LN (local in ANIMO)
CONO3(LN) R kg m-3 soil-solution
Estimated concentration of ammonium-N in layer LN (local in MINER2)
CONTO(LN) R kg m-3 soil-solution
Estimated concentration of N-total in layer LN (local in MINER2)
COO(LN) R kg m-3 soil-solution
Concentration in layer below layer LN (local in TRANSPORT)
COPR R kg m-3
Concentration in precipitation
COPRNH R kg m-3
Concentration of ammonium-N in precipitation
COPRNI R kg m-3
Concentration of nitrate-N in precipitation
CORE R kg m-3 soil-solution
Real concentration of nitrate-N plus ammoniun-N in the rootzone (local in PLANT)
COTO(LN) R kg m-3
Concentration in layer LN at beginning of timestep
CTO R kg m-3
Initial concentration (local in TRANSSUB)
CV R kg m-3
Concentration of oxygen in soil water at air/water boundary
CXNH(LN) R kg m-2 soil surface
Amount of ammonium-N at the complex in layer LN
DANU(I) R -
Day number for Fourier analysis
DENI(LN) R kg O m-3 soil d-1
Amount of nitrate (expressed as nitrate-oxygen) of layer LN denitrified during one timestep
DFCFOXAI(LN) R m2 d-1
Diffusion coefficient for oxygen in airfilled part of layer LN
DFCFOXSO(LN) R m2 d-1
Diffusion coefficient for oxygen in saturated soil for layer LN
DFCFOXWA(I) R m2 d-1
Value nr. I of diffusion coefficient for oxygen in water
DFCFOXWATE(I) R C
Value nr. I of temperature for which value for diffusion coefficient for oxygen in water is available
DG R m-1
'density' of drains of 3th order

DIC(LN) R kg m-3 soil-solution
Difference (negative part) of the concentration
DIFU R -
Derivative of Newton-Raphson iteration function
DITOMNNI(LN) R kg m-2 soil surface
Difference (negative part) in total amount of mineralized N and the estimated total concentration of mineral N (local in MINER2)
DK R m-1
'density' of drains of 1st order DMDP R m
Damping depth of temperature wave
DP(LN) R m
Distance from soil surface to middle of layer LN (depth of layer LN)
DRAD R -
Distribution ratio for a cation
DRADPO R -
Distribution ratio for phosphate
DRADNH R -
Distribution ratio for ammonium
DS R m-1
'density' of drains of 2nd order
EV R m d-1
Evapo(transpi)ration flux during timestep
EVMA R m d-1
Maximal evapo(transpi)ration flux
EX(LN) R kg m-2 soil surface
Amount of exudates in layer LN
EXPD(LN) R kg m-2 d-1
Exudate production in layer LN
F(LN) R m3 d-1
Discharge flux per layer to a certain drainage system (local in FLUX)
FA,FAA, FB R kg m-1
Parameter in determination of RIAE
FEKMD R d-1
Equivalent average flux density at 1st order drainage systems (channels)
FEV R m3 d-1
Evapotranspiration flux from layer LN (local in TRANSSUB)
FESMD R d-1
Model flux per unit of depth to 2nd and 3rd order drains at the location of 1st order drains
FG R m d-1
Drainage flux of 3th order during timestep
FID R m d-1
Infiltration flux into layer LN (local in TRANSSUB)
FK R m d-1
Drainage flux of 1st order during timestep
FLAB(LN) R m d-1
Flux from layer LN-1 to layer LN
FLB R m d-1
Flux from layer LN-1 to LN (local in TRANSSUB)
FLBE(LN) R m d-1
Flux from layer LN to layer LN+1
FLED R d-1
Flux per unit of length (local in FLUX)

FLEV(LN) R m d-1
Evapo(transpi)ration flux from layer LN
FLG(LN) R m d-1
Drainage flux to 3th order(field drains) from layer LN
FLIB(LN) R m d-1
Flux into layer LN from layer LN-1
FLID(LN) R m d-1
Drainage flux into layer LN
FLIO(LN) R m d-1
Flux into layer LN from layer LN+1(under)
FLK(LN) R m d-1
Drainage flux to 1st order drainage system (channels) from layer LN
FLO R m d-1
Flux from layer LN+1 to LN (local in TRANSSUB)
FLOU(LN) R m d-1
Total flux out of layer LN
FLS(LN) R m d-1
Drainage flux to 2nd order drainage systems (ditches) from layer LN
FM R m d-1
Drain flux of certain order drain (local in FLUX)
FMG R m d-1
Field drain flux (3rd order) to a channel
FMK R m d-1
Total flux to a 1st order drainage system (channel)
FMKS R m d-1
Ditch (2nd order) discharge to a channel (1st order)
FMS R m d-1
Field drain (3rd order) and ditch (2nd order) discharge to a channel (1st order)
FN I -
Number of organic material fraction
FQTE R rad d-1
Frequency of yearly temperature wave
FR(MN,FN) R -
Fraction of fraction-number FN in organic part of material MN
FRCA(MN,FN) R -
Part of organic fraction FN of material MN which is in solution
FRNH(MN) R -
Fraction of ammonium-N in material number MN
FRNI(MN) R -
Fraction of nitrate-N in material number MN
FROR(MN) R -
Fraction of organic material in material number MN
FROSGR R -
For grassland-applications: fraction of the shoots lost by grazing and in the model added to the soil as fresh organic material
FROSHA R -
For grassland-applications: fraction of the shoots lost by harvest and in the model added to the soil as fresh organic material
FRVO R -
Fraction volatization of anorganic N when fertilizer is added on top of the soil

FS R -
Ditch drainage flux (2nd order) during timestep
FUN R m d-1
Total drainage flux out of layer LN (local in TRANSSUB)
FUN R -
Function in Newton-Raphson iteration
HDG R m - soil surface
Height of 3th order drain bottom (field drain)
HDK R m - soil surface
Height of 1st order drain bottom (channel)
HDS R m - soil surface
Height of 2nd order drain bottom (ditch)
HE(LN) R -
Height of layer LN
HECZ R m - lower boundary rootzone
Maximal depth of the groundwaterlevel from which capillary rise can take place to lower boundary of rootzone
HEDR R m
Depth of bend point in moisture fraction - depth relation below rootzone
HELP R
Parameter (local)
HELP1 R
Parameter (local)
HELP2 R
Parameter (local)
HERO R m
Height of root zone
HGB R m
Height of top of 3th order discharge layers
HGO R m
Height of bottom of 3th order discharge layers
HKB R m
Height of top of 1st order discharge layers
HKO R m
Height of bottom of 1st order discharge layers
HSB R m
Height of top of 2nd order discharge layers
HSO R m
Height of bottom of 2nd order discharge layers
HUEX(LN) R kg m-2 soil surface
Amount of humus from exudates in layer LN
HUFROS R -
Fraction of the fresh organic material (OS), which is going directly to more stable organic matter/humus (HUOS)
HUOS(LN,FN) R kg m-2 soil surface
Amount of soil organic material from fresh organic material fraction FN in layer LN
HV R -
Change in moisture fraction with time (local in TRANSSUB)
HVTE I -
Indicator for temperature model
HVTE = 1 : Known air temperatures; Fourier model
HVTE = other value : Sinus model
ICMOFR R -

Increase in moisture fraction

ICRO(LN) R kg m-2 soil surface
Increase in amount of roots in layer LN

INMO I -
Input-variable indicating (if INMO=1) an initial calculation by subroutine INIMO for the moisture fractions per layer.

INPO I -
Input-variable indicating (if INPO=1) initial calculations of phosphor division over solution, complex and precipitate (if INPO =/= 1 these values must be given in the inputfile INI.DAT.

IT I -
Iteration number

IPO I -
Idicator for simulation of phosphor-cycle
(IPO=1 : Phosphor cycle is simulated)

IWA I -
Idicator for type of waterquantity model used
(IWA=1 : SIMGRO, IWA=2 : WATBAL, IWA=3 : SWATRE, IWA=4:ANISWA, IWA=5:DEMGEN)

KC I -
Kind of crop (in indices)

KF R -
Ratio of permeability of rootzone and permeability under rootzone

KICR I -
Kind of crop

LEAK R m d-1
Leakage flux during timestep

LEFARU R m
Leaching factor for runoff; indicating the dilution of the runoff-massflux; raising LEFARU makes less of the added material pass the reservoir additions and therefore lowers the runoff-concentrations.

LEMK R m
Equivalent height of saturated layer with discharge

LEMS R m
Equivalent height of saturated layer with discharge to ditches (2nd order) and field drains (3rd order)

LG R m
Length of drains of 3th order

LK R m
Length of drains of 1st order

LN I -
Layer number

LNMARO I -
Number of layers in the rootzone

LNRO R m
Length of roots

LNROTI(KC,I) R m
Value nr. I of length of roots of crop KC

LOIN R kg
Quantity of matter infiltrated from the drainage system into the soil

LOINCA R kg
Quantity of organic matter infiltrated from the drainage system into the soil

LOINNH R kg

Quantity of NH4 infiltrated from the drainage system into the soil

LOINNI R kg

Quantity of nitrate infiltrated from the drainage system into the soil

LOOU R kg

Quantity of matter discharged to the drainage system

LOOUCA R kg

Quantity of organic matter discharged to the drainage system

LOOUNH R kg

Quantity of NH4 discharged to the drainage system

LOOUNI R kg

Quantity of nitrate discharged to the drainage system

LR I -

Layer number from which decomposition rate of soil organic matter is reduced because of lack of nutrients or microflora

LS R m

Length of drains of 2nd order

MN I -

Material number

MOCORO R m

Moisture content in root zone

MOCOROT R m

Moisture content in root zone at end of timestep

MODERO R m

Moisture deficit in root zone

MODEUN R m

Moisture deficit below root zone

MODIMAUN R -

Maximum moisture deficit fraction under root zone

MOFR(LN) R -

(Average) Moisture fraction in layer LN

MOFRBORO R -

Moisture fraction at bottom of root zone

MOFRO(LN) R -

Moisture fraction in layer LN at beginning of timestep

MOFRPF1(I) R -

Value nr. I of moisture fraction in pF- curve root zone

MOFRPF2(I) R -

Value nr. I of moisture fraction in pF- curve under root zone

MOFRSA(LN) R -

Moisture fraction at saturation for layer LN

MOFRSARO R -

Moisture fraction at saturation for the rootzone

MOFRSAUN R -

Moisture fraction at saturation for layers below the rootzone

MOFRT(LN) R -

Moisture fraction in layer LN at end of timestep

MOFRWIUN R -

Moisture fraction at wilting point under root zone

MT R -

Final moisture fraction layer LN (local in TRANSSUB)

MTO R -

Initial moisture fraction layer LN (local in TRANSSUB)

MTNU(I) I -

Material number of addition nr. I

NA I -
Number of areas in the waterquantity data-file (for regional appl.) or number of areas (in indices).
NF I -
Number of fractions in organic material
NI I -
Unit number for output BALANCE
NIFR(FN) R -
Nitrogen fraction in organic material fraction FN
NIFREX R -
Nitrogen fraction in exudates
NIFRHU R -
Nitrogen fraction in humus determined by NIFRHUMA and LR
NIFRHUMA R -
Maximum nitrogen fraction in humus, given as input and reduced from layer LR with a factor 0.2
NIMN(LN) R kg m-2 soil surface
Mineral nitrogen present in layer LN
NIOR(LN) R kg m-2 soil surface
Nitrogen amount in the organic material present in layer LN
NITO(LN) R kg m-2 soil surface
Total nitrogen (sum of mineral-N and organic-N) present in layer LN
NL I -
Number of layers
NM I -
Number of materials(in indices)
NN I -
Number of first layer where flow is upwards
NRGR R -
Number of livestock-units (for grassland applications)
NS I -
Number of first layer where flow is downwards (again)
NST I -
Number of timesteps in a year
NT I -
Number of technologies in the waterquantity data-file (for regional appl.).
NUAD I -
Number of additions in current timestep
NUAE I -
Number of aerated layers
NUAIPO(LN) R m-3
Number of aerated pores in layer LN
NUAMRO(KC) I -
Number of data on amount of roots for crop KC
NULAAN I -
Number of layers partaking in temporary anaerobiosis
NULNRO(KC) I -
Number of data on length of roots for crop KC
NUOUT I -
Number of timesteps at which output is wanted
NURO I -
Number of layers with roots
O1,O2 R kg m-3
Extreme values for oxygen concentration in soil water, used for

interpolation purposes in DENITR
OS(LN,FN) R kg organic matter . m-2 soil surface
Amount of fresh organic material fraction FN in layer LN
OUT(NUOUT) I days
Day (end of timestep) at which output is given
OUTAN I -
Area-number for which output is given
OUTCDS I -
Output at CDSYR(1-NUOUT) to a file which can be used by the Comparative Display System
OUTGR(1-2) I -
Special output-files for grassland-applications
OUTSE(1-10) I -
Ouput-selection; selection of files to be made by the model
OUTTN I -
Technology-number for which output is given
OUTTO I -
Total output to be given by subroutine OUTPUT (OUTTO=1: output to file TOUT.DAT for every timestep, OUTTO=0: partial output)
OXCO1(LN) R m3 m-3
Oxygen concentration in airfilled part of layer LN
OXCO2(LN) R m3 m-3
Oxygen concentration in airfilled part of layer LN
OXDD(LN) R kg m-2 soil surface
Oxygen demand in layer LN
OXDE(LN) R kg m-2 soil surface
Oxygen deficit in layer LN
OXDDMA(LN) R kg m-2 soil surface
Maximum oxygen demand in layer LN
OXDDRA(LN) R m3 m-3 d-1
Oxygen demand rate in layer LN
OXPDRA(LN) R kg m-3 d-1
Oxygen production rate in layer LN
OXNT(LN) R kg m-2 soil surface
Oxygen demand for nitrification in layer LN
PF(LN) R -
pF of moisture in layer LN
PHBERO R -
pH-value of the layers below the root-zone
PHCF(N) R -
Phi-coefficient nr. N in Fourier analysis
PHRO R -
pH-value of the layers in the root zone
PL(I) I -
Number of layers ploughed after addition I
PMDF1 R -
Parameter 1 in calculation of diffusion coefficient for oxygen in airfilled part of soil
PMDF2 R -
Parameter 2 in calculation of diffusion coefficient for oxygen in airfilled part of soil
PR R m d-1
Precipitation rate during timestep
QIN R m
Increase in water storage in layer LN during the time step

QUMT(I) R kg ha-1
Quantity of addition nr. I of organic material
RATE R d-1
Reaction rate (in functions FEXP and FEXPH)
R1, R2, R3, R4, R5, R6, R7, R8 R m
Standard values for aerated radius of airfilled soilpore used in interpolation in DENITR to find starting value for RIAE
RA, RA1, RA2 R m
Interpolated values for radius of airfilled soilpore used in interpolation in DENITR to find starting value for RIAE
RB, RB1, RB2 R m
Interpolated values for radius of airfilled soilpore used in interpolation in DENITR to find starting value for RIAE
RD R -
Reduction coefficient for plant uptake (local in TRANSPORT)
RDAS R -
Reduction factor to reduce assimilation in case of shortage of N (local in MINER2)
RDFADCHU R -
Reduction factor for decomposition rate of soil organic matter (humus) in subsoil
RDFAMO(LN) R -
Reduction factor (in decomposition- and nitrification-rate) for non-average moisture conditions in layer LN
RDFAOX(LN) R -
Reduction factor for oxygen conditions in layer LN
RDFAPH(LN) R -
Reduction factor in decomposition of organic material for non-average pH conditions in layer LN
RDFATE(LN) R -
Reduction factor (in decomposition- and nitrification-rate) for non-average temperature conditions in layer LN
RDFAUP R -
Reduction factor for mineral N uptake rate by plant roots
RDOXDDRA(LN) R m3 m-3 soil d-1
reduced oxygen demand rate in layer LN
RDOXPDRA(LN) R kg m-3 soil d-1
reduced oxygen production rate in layer LN
RECF(LN,FN) R d-1
Reaction coefficient for decomposition of fraction nr. FN in layer LN
RECFAV(FN) R j-1(input),d-1
Reaction coefficient for decomposition of fraction nr. FN under average conditions
RECFCA(LN) R d-1
Reaction coefficient for decomposition of organic material in solution in layer LN
RECFCAAV R j-1(input),d-1
Reaction coefficient for decomposition of org.mat. in solution under average conditions
RECFEX(LN) R d-1
Reaction coefficient for decomposition of exudates in layer LN
RECFEXAV R j-1(input),d-1
Reaction coefficient for decomposition of exudates under average conditions
RECFHU(LN) R d-1

Reaction coefficient for decomposition of soil organic matter (humus) in layer LN

RECFHUAV R j-1(input),d-1
Reaction coefficient for decomposition of soil organic matter (humus) under average conditions

RECFNT(LN) R d-1
Reaction coefficient for nitrification in layer LN

RECFNTAV R yr-1(input),d-1
Reaction coefficient for nitrification under average conditions

RECFPDCA(LN,FN) R kg m-3 soil system d-1
Production rate of organic material fraction FN in solution in layer LN

RECFPDCATO(LN) R kg m-3 soil system d-1
Production rate of organic material in solution in layer LN

REKI(LN) R d-1
First order reaction coefficient for layer LN (local in TRANSPORT)

REKINH(LN) R d-1
Reaction coefficient of thirst order for ammonium in layer LN (used for nitrification and is always negative)

REKINI(LN) R d-1
Reaction coefficient of first order for nitrate in layer LN (becomes 0 in the model because for nitrate only zero order reaction coefficients are used)

REKO(LN) R kg m-3 soil d-1
Reaction coefficient of order zero in layer LN (local in TRANSPORT)

REKONH(LN) R kg m-3 soil d-1
Reaction coefficient of order zero for ammonium in layer LN (used for ammonification and immobilization; positive means ammonification, negative means immobilization is dominant)

REKONI(LN) R kg m-3 soil d-1
Reaction coefficient of order zero for nitrate in layer LN (used for nitrification and denitrification; positive values indicate more nitrification then denitrification, negative values indicate more denitrification then nitrification)

RESPEX(LN) R kg m-2 soil layer-1
Respiration-term for the decomposition of exudates

RESPHUEX(LN) R kg m-2 soil layer-1
Respiration-term for the decomposition of humus from exudates

RESPHUOS(LN) R kg m-2 soil layer-1
Respiration-term for the decomposition of humus from organic material in solution

RESPOS(LN) R kg m-2 soil layer-1
Respiration-term for the decomposition of fresh organic material

RESU R -
For grassland-application: the relative duration of sunshine

RIAE(LN) R m
Radius of aeration for airfilled pore in layer LN

RIMAPO(LN) R m
Radius of biggest airfilled pore in layer LN

RIMIAIPO(LN) R m
Radius of smallest airfilled pore in layer LN

RKI R d-1

First order reaction coefficient (local in TRANSSUB)
RKO R kg d-1 m-3 soil
Zero order reaction coefficient (local in TRANSSUB)
RM I -
Root material number
RO(LN) R kg m-2 soil surface
Amount of roots in layer LN
RODNMA R kg m-1
Maximal root density
RSCOCA(LN,FN) R kg m-3 soil-solution
Concentration of organic matter fraction FN in solution at end of timestep
RSCOCATO(LN) R kg m-3 soil-solution
Concentration of organic matter in solution in layer LN at end of timestep
RSCONI(LN) R kg m-3 soil-solution
Concentration of nitrate-N in layer LN at end of timestep
RSCONH(LN) R kg m-3 soil-solution
Concentration of ammonium-N in layer LN at end of timestep
RSOS(LN,FN) R kg m-2 soil surface
Rest of fresh organic material fraction FN in layer LN at end of timestep
RSCXNH(LN) R kg m-2 soil surface
Rest of of complexed ammonium-N in layer LN at end of timestep
RSEX(LN) R kg m-2 soil surface
Rest of exudates in layer LN
RSHUEX(LN) R kg m-2 soil surface
Rest of humus from exudates in layer LN
RSHUOS(LN,FN) R kg m-2 soil surface
Rest of humus from stepwise aded material fraction FN layer LN at end
of timestep
RSTON R kg m-2 soil surface
Total amount of nitrogen present in the whole system at the end of the timestep
RSTONI(LN) R kg m-2 soil surface
Total amount of nitrogen present in layer LN at the end of the timestep
RSTOOM(LN) R kg m-2 soil surface
Total organic material present at the end of the timestep in layer LN
RU R m d-1
Runoff water flux
RV1, RV2 R m
Extreme values for radius of airfilled pore, used in interpolation in DENITR to find starting value for RIAE
RVQU R m
Reservoir content; from this reservoir runoff takes place and materials can be added to this reservoir and enter the first layer with precipitation-excess.
SC(LN) R cm
Suction (positive value) of moisture in layer LN
SCPF1(I) R cm
Value nr. N of suction in pF curve of root zone
SCPF2(I) R cm
Value nr. N of suction in pF curve under root zone

SHPDRA R -
For grassland-application: shoot production rate
SLOPE R m-1
Slope of moisture fraction - depth relation below rootzone (local in BALANCE)
ST R d
Length of timestep
SU R -
Sum
SUCA(FN) R kg m-2 soil surface
Sum of organic material in solution in ploughing layer
SUCOG R kg
Sum of products discharge flux and concentration to 3rd order drains
SUCOK R kg
Sum of product discharge flux and concentration to 1st order drains
SUCOS R kg
Sum of products of discharge and concentration to 2nd order drains
SUEVMA1(KC) R m
Sum of maximal (evapo)transpiration in first period for crop KC
SUEVMA2(KC) R m
Sum of maximal (evapo)transpiration in second period for crop KC
SUEX R m3
Sum of exudates in ploughing layer
SUHU(LN) R kg m-2 soil surface
Sum of humus in layer LN at end of timestep
SUHUEX R m3
Sum of humus from exudates in ploughing layer
SUHUOS(FN) R m3
Sum of the amount of humus (soil organic material) from fresh organic material fraction FN in ploughing layer
SUMO R m3
Sum of moisture in ploughing layer
SUNI R kg m-2 soil surface
Sum of nitrate-N in ploughing layer
SUOS(LN) R kg m-2 soil surface
Sum of organic materials stepwise added in layer LN
SUOSPL(FN) R kg
Sum of organic nitrogen in fraction FN in ploughing layer
SUOXDDRA(LN) R kg d-1
Sum of oxygen demand rates of aerated layers below layer LN
SUSQDI R -
Sum of squares of differences
SUUPNI R kg m-2 soil surface
Sum of uptake of N by the crop
SUUPNIMA R kg m-2 soil surface
Maximal possible uptake of N by the crop
T1 R -
Part of a respiration term (local in RESPI)
T2 R -
Part of a respiration term (local in RESPI)
TE(LN) R C
Temperature of layer LN
TESMCF R m2 d-1

Thermal diffusivity

TI R d
Time

TIAMRO(KC,I) R d
Value nr. I of time for which value of amount of roots is available for crop KC

TIAN R d
Duration of temporary anaerobiosis

TIHA(KC) R d
Time of the year for harvesting of crop KC

TILNRO(KC,I) R d
Value nr. I of time for which value of length of roots is available

TIMI R d
Time simulation starts

TIMIAITE R d
Time of the year for which first input of air temperature is given

TIMA R d
Time simulation ends

TINEAD R d
Time of next addition(s) of material to the soil

TISO(KC) R d
Time of the year for sowing of crop KC

TITO R d
Time of the year (daynumber) totalized from start of the simulation

TIUP1(KC) R d
Time after sowing when uptake rate of N by crop alters

TIWA R d
Dummy time parameter used in reading input data from WATBAL.DAT

TIYR R d
Time of the year (daynumber)

TN I -
Technology-number

TODCORMA(LN) R kg m-2 soil surface
Total decomposition of organic material during timestep in layer LN

TOHU(LN) R kg m-2 soil surface
Total amount of humus in layer LN

TOIN(LN) R kg m-2 soil surface
Total amount going into layer LN during timestep (local in TRANSPORT)

TOINCA(LN,FN) R kg m-2 soil surface
Total amount of soluble organic matter fraction FN flowing into layer LN during timestep

TOINCATO(LN) R kg m-2 soil surface
Total amount of soluble organic matter flowing into layer ln during timestep

TOINN R kg m-2 soil surface
Total amount of mineral N going into layer LN during timestep

TOINNH(LN) R kg m-2 soil surface
Total amount of ammonium-N going into layer LN during timestep

TOINNI(LN) R kg m-2 soil surface
Total amount of nitrate-N going into layer LN during timestep

TOMNNI(LN) R kg m-2 soil surface

Total mineralisation of nitrogen in layer LN

TON	R	kg m-2 soil surface
Total amount of nitrogen present in the whole system at the beginning of the timestep		
TONI(LN)	R	kg m-2 soil surface
Total amount of nitrogen present in layer LN		
TOOM(LN)	R	kg m-2 soil surface
Total organic material present at the beginning of the timestep in layer LN		
TOOS(LN)	R	kg m-2 soil surface
Total organic material stepwise added in layer LN		
TOOU(LN)	R	kg m-2 soil surface
Total amount going out of layer LN during timestep (local in TRANSPORT)		
TOOUCA(LN,FN)	R	kg m-2 soil surface
Total amount of soluble organic material fraction FN flowing out of layer LN during timestep		
TOOUCATO(LN)	R	kg m-2 soil surface
Total amount of soluble organic material flowing out of layer LN during timestep		
TOOUN	R	kg m-2 soil surface
Total amount of mineral N going out of layer LN during timestep		
TOOUNH(LN)	R	kg m-2 soil surface
Total amount of ammonium-N going out of layer LN during timestep		
TOOUNI(LN)	R	kg m-2 soil surface
Total amount of nitrate-N going out of layer LN during timestep		
TSTEP	R	d
Timestep (in functions FEXP and FEXPH)		
TUTO(KC)	R	kg m-2 soil surface
Amount of harvested tubers of crop KC		
TURA	R	d-1
For grassland-application: turnover rate for dying of roots		
U	R	m
Lower boundary discharge layer to certain order drain (local in FLUX)		
UPNI(LN)	R	kg m-2 soil surface
Uptake of nitrogen by crop from layer LN		
UPNIMA1(KC)	R	kg ha-1
Maximal nitrogen uptake by crop KC in first period		
UPNIMA2(KC)	R	kg ha-1
Maximal nitrogen uptake by crop KC in second period		
WALE	R	m
water level below soil surface		
WALET	R	m
Water level at end of timestep		
WYAD(I)	I	-
Way of addition of material; number of layers over which material is divided		
YR	I	-
Year		
YRMA	I	-
Year in which simulation ends		
YRMI	I	-
Year in which simulation starts		

APPENDIX B: Summarized input-file description of input-files:
GENERAL.DAT, AREA.DAT, INI.DAT, ADDIT.DAT,
WATBAL.DAT, SWATRE.DAT

F I L E - D E S C R I P T I O N

Filename: GENERAL.DAT

Contents: input-data for ANIMO with general data

number of pages: 4 page-nr: 1

Mnemonic	Description	Unit	F
	.... simulation options		
+IWA	indicator for kind of waterquantity model (1=SIMGRO, 2=WATBAL, 3=SWATRE, 4=ANISWA, 5=DEMGEN)	-	I
IPO	indicator for simulation of P-cycle (1 = N-, C- and P-cycle are simulated)	-	I
*INMO	initialization of moisture fractions by subr.INIMO or given as input in INI.DAT (1 = calculated by subr.INIMO)	-	I
INPO	initialization of P-cycle by subr.INPUT or given as input in INI.DAT (1 = partially calculated in subr.INPUT)	-	I
	.... simulation period and length of timestep ...		
+YRMI	yearnr when simulation starts	-	I
YRMA	yearnr when simulation ends	-	I
TIMI	time of the year when simulation starts	d	R
*If the model DEMGEN is used (IWA=5) NST must be given, else ST			
NST	number of timestep within each year	-	R
ST	length of timestep	d	R
	.... definition of subregions/areas (for IWA=1)..		
+NA	number of subregions in waterquantity-file	-	I
ANMI	areanr to start simulation	-	I
ANMA	areanr to end simulation	-	I
NT	nr of technologies	-	I
TNMI	first technology-nr of one subregion/area	-	I
TNMA	last technology-nr of one subregion/area	-	I
	.... definition of materials		
+NM	nr of materials (max 10; MN = 6 and 10 for fertilizer)		I
FROR(1-NM)	fraction of organic matter in material 1-NM	-	R
FRNH(1-NM)	fraction of mineral NH4-N in material 1-NM	-	R
FRNI(1-NM)	fraction of mineral NO3-N in material 1-NM	-	R
FRPO(1-NM)	fraction of mineral P in material 1-NM	-	R

Filename: GENERAL.DAT

Number of pages: 4 page-nr: 2

Mnemonic	Description	Unit	F
	.... definition of organic fractions		
+NF	nr of fractions in fresh/soluble org mat.	-	I
for MN = 1 to NM			
(MN = 6 should contain artificial fertilizer data)			
*FR(MN,1-NF)	fraction of fractions 1-NF in org.part of MN	-	R
*FRCA(MN,1-NF)	soluted part of organic fractions 1-NF of material MN	-	R
*HUFROS	humus fraction of fresh org.material (not passing a soluble stage)	-	R
	.... definition of decomposition, N-/P-contents..		
+ASFA	assimilation factor	-	R
*RECFAV(1-NF)	average decomp.rate for fractions 1-NF	yr-1	R
RECFCAAV	average decomp.rate for organic material in solution	yr-1	R
RECFHUAV	average decomp.rate for soil org.material	yr-1	R
RECFEXAV	average decomposition rate for exudates	yr-1	R
RECFNTAV	average nitrification rate	yr-1	R
*NIFR(1-NF)	nitrogen fraction in org. fractions 1-NF	-	R
NIFRHUMA	max. nitrogen fraction in soil org.matter (reduced from LR with factor 0.2)	-	R
NIFREX	nitrogen fraction in exudates	-	R
*POFR(1-NF)	P-fraction in org. fractions 1-NF	-	R
POFRHUMA	max. P-fraction in soil org.matter	-	R
POFREX	P-fraction in exudates	-	R
	.... definition of crops		
+for KC = 1 to 5			
*NUAMRO(KC)	nr of data on root amount	-	I
NULNRO(KC)	nr of data on root length	-	I
AMROTI(KC,1-NUAMRO)	NUAMRO values of root mass	kg.ha-1	R
LNROTI(KC,1-NULNRO)	NULNRO values of root length	m	R
TIAMRO(KC,1-NUAMRO)	time for which AMROTI is given	d	R
TILNRO(KC,1-NULNRO)	time for which LNROTI is given	d	R
TISO(KC)	time of sowing	d	R
TIHA(KC)	time of harvesting	d	R
TUTO(KC)	amount of tubers harvested	kg.ha-1	R
UPNIMA1(KC)	max. N-uptake by crop KC in first period	kg.ha-1	R
UPNIMA2(KC)	max. N-uptake by crop KC in second period	kg.ha-1	R
SUEVMA1(KC)	sum of max. evapotransp. in first period	m	R
SUEVMA2(KC)	sum of max. evapotransp. in first period	m	R
TIUP1(KC)	time after sowing when max. N-uptake rate by crop KC alters	d	R
*UPPOMA1(KC)	max. P-uptake by crop KC in first period	kg.ha-1	R
UPPOMA2(KC)	max. P-uptake by crop KC in second period	kg.ha-1	R

Filename: GENERAL.DAT

Number of pages: 4 page-nr: 3

Mnemonic	Description	Unit	F
for KC = 6 (must contain grassland-data)			
*TISO(6)	time of sowing	d	R
TIHA(6)	time of harvesting	d	R
UPPOMA1(6)	yearly max. P-uptake by grass	kg.ha-1	R
SUEVMA1(6)	yearly sum of max. evapotransp.	m	R
*AMSHMA	maximum shoot-production	kg	R
FROSGR	fraction of shoots lost by grazing	-	R
FROSHA	fraction of shoots lost by harvest	-	R
RESU	relative duration of sunshine	-	R
SHPDRA	shoot production rate	-	R
TURA	turnover rate for dying of roots	d-1	R
NIFRMI	minimum total N-fraction of roots	-	R
.... output options			
the following variabels arrange output to the file TOUT.DAT			
+OUTAN	subregion-number with output	-	I
OUTTN	technology-number with output	-	I
*OUTTO	amount of output (1=full, 0=partial)	-	I
NUOUT	nr of timesteps with output	-	I
OUT(1-NUOUT)	timesteps with output	daynr	I
the following variabels arrange output to different files			
*OUTSE(1-17)	selection of kind of output (1 = output)	filename	
	OUTSE(1) = nitrate-n	NITRATE_N.DAT	
	OUTSE(2) = ammonium-n	AMMONIUM_N.DAT	
	OUTSE(3) = organic material in solution	OMS.DAT	
	OUTSE(4) = N-uptake by crop	UPTAKE.DAT	
	OUTSE(5) = mineral-N	MINERAL_N.DAT	
	OUTSE(6) = total-N	TOTAL_N.DAT	
	OUTSE(7) = total mineralization	TOMNNITO.DAT	
	OUTSE(8) = reduction factors(oxygen,total)	RDFA.DAT	
	OUTSE(9) = massbalances per OUT(1-NUOUT)	MASSBAL.OUT	
	OUTSE(10) = NO3-N year-balance	BANIYR.DAT	
	OUTSE(11) = NH4-N year-balance	BANHYR.DAT	
	OUTSE(12) = hydrological year-balance	BAWAYR.DAT	
	OUTSE(13) = NO3-N balance for each tstep	BANIST.DAT	
	OUTSE(14) = NH4-N balance for each tstep	BANHST.DAT	
	OUTSE(15) = for each tstep a water- and massbalance of the reservoir for additions (for NO3-N, NH4-N, Phosphor)	ADDITNI.OUT, ADDITNH.OUT, ADDITPO.OUT	
	OUTSE(16) = Phosphor year-balance	BAPOYR.DAT	
	OUTSE(17) = Phosphor balance for each tstp	BAPOST.DAT	

Filename: GENERAL.DAT

Number of pages: 4 page-nr: 4

Mnemonic	Description	Unit	F
the following variabels arrange output to the files created with OUTSE(10-14),OUTSE(16) and OUTSE(17)			
BALNMI	first layer of massbalance (0=reservoir)	-	I
BALNMA	last layer of massbalance (0=reservoir)	-	I
TIBA	timestep for updating of year-balances	d	R
the following files can only be created for grassland-applications			
OUTGR(1-2)	OUTGR(1) = shoot and root-development and harvest,grazing and root losses	GRASS1.OUT	
	OUTGR(2) = output about production-reduction due to N-shortage	GRASS2.OUT	
the following variabels arrange output to files CDS*.DAT which are to be used with the Comparative Display System			
OUTCDS	output to CDS*.DAT-files (1 = output)		I
NUCDS	number of years for which a CDS*.DAT-file is given		I
CDSYR(1-NUOUT)	years with a CDS*.DAT-file		I

+ = skip record I = data type INTEGER
* = new record R = data type REAL
date: 21-6-1988

F I L E - D E S C R I P T I O N

Filename: AREA.DAT

Contents: input-data for ANIMO with parameter-values valid for one subregion

Number of pages: 3 page-nr: 1

Mnemonic	Description	Unit	F
	geometry		
+NL	number of layers	-	I
HE(1-NL)	height of layers 1-NL	m	R
LNMAROTN(1-NT)	per technology: number of layers rootzone	-	I
	definitions		
+RMTN(1-NT)	per technology: number of the material defined as root material	-	I
KICRTN(1-NT)	per technology: kind of crop grown	-	I
*LR	layernr. from which humus-decomp.is reduced and N-fraction of humus is reduced with factor 0.2	-	I
RDFADCHU	reductionfactor for humus-decomposition	-	R
	drainage		
+DK	drain-density of first order drains (canals)	m-1	R
DS	drain-density of second order drains (ditch)	m-1	R
DG	drain-density of third order drains (trenches, ditches, field drains)	m-1	R
HDK	depth lowerside of first order drains	m-surface	R
HDS	depth lowerside of second order drains	m-surface	R
HDG	depth lowerside of third order drains	m-surface	R
	soil physical parameters		
+HVTE	kind of temperature model to be used (1 = temperatures are given; 2 = sinus model)	-	I
APTE	amplitude of yearly sinus temperature wave	C	R
AVTE	average yearly temperature at soil surface	C	R
FQTE	frequency of yearly temperature wave	rad.d-1	R
TESMCF	thermal diffusivity	m2.d-1	R
*PMDF1	parameter in calculation of diffusion for oxygen in airfilled part of soil	-	R
PMDF2	see PMDF1	-	R
*RVQU	reservoir content for additions	m	R
LEFARU	leaching factor runoff; (1-LEFARU) indicates the dilution of the runoff-massflux	-	R
*CDSA	hydraulic conductivity of the rootzone	m.d-1	R
AIENSCPF	air entry value	cm	R

Filename: AREA.DAT

Nr of pages: 3 page-nr: 2

Mnemonic	Description	Unit	F
	the following variabels only when IWA=3 or IWA=4 (SWATRE-input)		
* MOFRSA(1-NL)	moisture-fraction at saturation	m3.m-3	R
	the following variabels only when IWA=/=3 or 4 (no SWATRE input)		
* MOFRPF1(1-10)	10 moisture fractions with different SCPF1 (pF-curve); valid for the rootzone	m3.m-3	R
SCPF1(1-10)	10 suction-values corresponding to MOFRPF1	cm	R
MOFRPF2(1-10)	10 moisture fractions with different SCPF2 (pF-curve); valid below rootzone	m3.m-3	R
SCPF2(1-10)	10 suction-values corresponding to MOFRPF2	cm	R
MOFRWIUN	moist.fr. at wilting point below rootzone	m3.m-3	R
MOFRSARO	moist.fr. at saturation in the rootzone	m3.m-3	R
MOFRSAUN	moist.fr. at saturation below rootzone	m3.m-3	R
EVROSE	selection in kind of evapotransporation-flux (EVROSE=1: linear reduction in FLEV)	-	I
AR	size of the subregion	m2	R
KF	ratio of conductivities rootz./below rootz	-	R
KA	ratio of conduct. below rootz./aquifer	-	R
AQBO	boundary between toplayer and aquifer	m-surface	R
HECZ	distance between rootzone and lowest groundwaterlevel with capillary rise	m	R
	.... soil chemical parameters		
+PHRO	pH-water rootzone	-	R
PHBERO	pH-water below rootzone	-	R
*DRADNH(1)	distribution ratio of NH4-N in rootzone	-	R
DRADNH(NL)	distribution ratio of NH4-N under rootzone	-	R
	.... in- and outgoing Nitrogen and Carbon		
+COPRNH	NH4-N concentration in precipitation	kg.m-3	R
COPRNI	NO3-N concentration in precipitation	kg.m-3	R
DRDEPNH	atmospheric dry deposition of NH4-N	kg.ha-1	R
DRDEPNI	atmospheric dry deposition of NO3-N	kg.ha-1	R
*COIDNH	conc. NH4-N in infiltr.drainwater	kg.m-3	R
COIDNI	conc. NO3-N in infiltr.drainwater	kg.m-3	R
COIDCA	conc. soluted org.mat. in infiltr.drainw.	kg.m-3	R
*FRVOTN(1-NT)	per technology: fraction of added NH4-N that volatilizes	-	R
	.... only for regional (IWA=1) applications		
+ HEAQ	thickness of aquifer (regional fluxes)	m	R
SPU	soil physical unit	-	I
* ARTN(1-NT)	per technology: the size as fraction of the subregion-size	-	I
* COEXNH	NH4-N concentr. in external surface-waters	kg.m-3	R
COEXNI	NO3-N concentr. in external surface-waters	kg.m-3	R
	.... only for grassland (KC=6) and regional appl.		
+ NRGRTN(1-NT)	per technology: nr of lsu (livestock-unit)	lsu.ha-1	R

Filename: AREA.DAT

Nr of pages: 3 page-nr: 3

Mnemonic	Description	Unit	F
	.... only for P-cycle (IPO=1)		
+ COPRPO	P-concentration in precipitation	kg.m-3	R
COIDPO	P-concentration in infiltr.drainwater	kg.m-3	R
COEXPO	P-concentr. in external surface-waters	kg.m-3	R
DRADPO(1-NL)	fast distribution ratio of P	-	R
COBU(1-NL)	P-conc. which can maximally be in solution	kg.m-3	R
COPOMA(1-NL)	max. P-conc. with fully occupied complexes	kg.m-3	R
AMPOMA(1-NL)	max. P-amount which can be adsorbed	kg.m-3soil	R
ADCF	adsorption-exponent in Freundlich equation	-	R
RECFSO	reaction rate for desorption	d-1	R
	.... only for temperature-input (HVTE=1)		
+ TIMIAITE	daynr of first air temperature measurement	d	R
AITE(1-52)	weekly measured air temperature	C	R

+ = skip record I = data type INTEGER
* = new record R = data type REAL
date: 21-6-1988

F I L E - D E S C R I P T I O N

Filename: INI.DAT

Contents: input-data for ANIMO with parameter-values
valid for one subregion

number of pages: 1 page-nr: 1

Mnemonic	Description	Unit	F
*MOFRO(1-NL)	moisture fractions in layers 1-NL	m3.m-3	R
EX(1-NL)	amount of exudate in layers 1-NL	kg.m-2	R
HUEX(1-NL)	amount of humus from exud. in layers 1-NL	kg.m-2	R
CONH(1-NL)	concentration of NH4-N in layers 1-NL	kg.m-3	R
CONI(1-NL)	concentration of NO3-N in layers 1-NL	kg.m-3	R
*OS	amount of fresh organic material in the	kg.m-2	R
(1-NL,1-NF)	fractions 1-NF in the layers 1-NL		
*HUOS	amount of humus from fresh organic material	kg.m-2	R
(1-NL,1-NF)	1-NF in layers 1-NL		
*COCA	concentration of soluble organic material	kg.m-3	R
(1-NL,1-NF)	in the fractions 1-NF in the layers 1-NL		
*COAQNH	concentration of NH4-N below vert.profile	kg.m-3	R
COAQNI	concentration of NO3-N below vert.profile	kg.m-3	R
the following variabels only if IPO = 1 and INPO=1			
*AMPOTO(1-NL)	total amount of P	kg.m-3soil	R
the following variabels only if IPO = 1 and INPO=0			
*COPO(1-NL)	concentration of P in layers 1-NL	kg.m-3	R
AMPOCX(1-NL)	adsorbed amount of P	kg.m-3soil	R
AMPOPR(1-NL)	precipitated amount of P	kg.m-3soil	R
the following variabels only if IPO = 1			
*COAQPO	concentration of P below model-profile	kg.m-3	R

* = new record

I = data type INTEGER
R = data type REAL

date: 21-6-1988

F I L E - D E S C R I P T I O N

Filename: ADDIT.DAT

Contents: input-data for field-applications of ANIMO with parameters concerning additions to the soil

number of pages: 1 page-nr: 1

Mnemonic	Description	Unit	
TINEAD	time of first addition	d	R
For each planned time of addition:			
*NUAD	number of additions (actions, maximum=7) (addition, fertilization, ploughing)	-	I
*MTNU	material number	-	I
QUMT	amount of material added	kg.ha-1	R
WYAD	way of addition (=nr of layers over which additions is distributed) 0 = to reservoir on top of layer 1 (volatilization) 1 = addition to layer 1 (no volatilization) 2 = distrib. over layers 1 and 2 (no vol.) 3 = distrib. over layers 1,2,3 (no vol.) 4 = etc.	-	I
PL	number of layers to be ploughed	-	I
*TINEAD	time of next addition	d	R
NUAD,MTNU,QUMT,WYAD,PL FOR next addition, etc.			

* = new record

I = data type INTEGER
R = data type REAL

date: 21-6-1988

F I L E - D E S C R I P T I O N

Filename: WATBAL.DAT

Contents: input-data for field-applications of ANIMO with parameters concerning waterquantity per timestep

number of pages: 1 page-nr: 1

Mnemonic	Description	Unit	
First timestep:			
MOCORO	moisture volume rootzone at start of tstep	m	R
WALE	depth of groundwatertable at start of tstep	m	R
MODEUN	moisture deficit under the rootzone at the start of the timstep	m	R
For every timestep:			
*TIWA	time in waterquantity model (dummy value)	d	R
EVMA	maximal evapotranspiration flux	m.d-1	R
PR	precipitation flux	m.d-1	R
EV	evapotranspiraton flux	m.d-1	R
RU	runoff flux	m.d-1	R
FG	trench-flux (3rd order)	m.d-1	R
FS	ditch-flux (2nd-order)	m.d-1	R
FK	canal-flux (1st-order)	m.d-1	R
LEAK	leakage/seepage flux	m.d-1	R
MOCOROT	moisture volume rootzone at end of timestep	m	R
WALET	depth of groundwatertable at end of tstep	m	R
MODEUNT	moisture deficit under the rootzone at the of the timstep	m	R

* = new record
R = data type: REAL
I = data type: INTEGER

remarks: per timestep a balanced waterbalance must be given therefore I/O type should be UNFORMATTED

date: 30-09-1987

F I L E - D E S C R I P T I O N

Filename: SWATRE.DAT

Contents: input-data for field-applications of ANIMO with waterquantity-parameters calculated by SWATRE

number of pages: 1 page-nr: 1

Mnemonic	Description	Unit	
First timestep:			
WALE	depth of groundwatertable at start of tstep	m	R
MOFRO(1-NL)	moisture fraction in layers 1 to NL at the beginning of the timestep	-	R
For every timestep:			
*TIWA	time in waterquantity model (dummy value)	d	R
PR	precipitation flux	m.d-1	R
EVMA	maximal evapotranspiration flux	m.d-1	R
WALET	depth of groundwatertable at end of tstep	m	R
*SC(1-NL)	suction of moisture in layers 1 to NL	cm	R
MOFRT(1-NL)	moisture fraction in layers 1 to NL at the end of the timstep	-	R
*FLEV(1-NL)	evapotranspiraton flux in layers 1 to NL	m.d-1	R
FLAB(1-NL)	flux from above in layers 1 to NL	m.d-1	R
FLBE(1-NL)	flux to below in layers 1 to NL	m.d-1	R
*FLG(1-NL)	trench-flux (3rd order)	m.d-1	R
FLS(1-NL)	ditch-flux (2nd-order)	m.d-1	R
FLK(1-NL)	canal-flux (1st-order)	m.d-1	R

* = new record

R = data type: REAL
I = data type: INTEGER

remarks: per timestep a balanced waterbalance must be given therefore I/O type should be UNFORMATTED

date: 20-10-1987

APPENDIX C: Input description of a field application on maize

In this appendix an input-description is given of all the files needed for a field application on maize land. This description also includes the values that parameters received for the application of the model on a maize field which received 250 ton of cattle slurry per ha per year (paragraph 5.1.1).
A detailed parameter-description is given of the following files: GENERAL.DAT, AREA.DAT, INI.DAT, ADDIT.DAT, WATBAL.DAT

For each parameter the following description is used:

first line:
  The parameter-name (eventual with dimension); the value used for this application; between [ ] the unit in which the value is expressed.
new line:
  - a general parameter-description.
new line:
  - information about the parameter-value which has been used for this application and about literature with parameter-data.

Filename: GENERAL.DAT

```
------------------------ simulation options -------------------------
IWA = 2                                                            [-]
- Indicator for kind of waterquantity-model
  (1=SIMGRO, 2=WATBAL, 3/4=SWATRE, 5=DEMGEN).
- Hydrological parameters were simulated with the model WATBAL
  for the period  1-1-74 t/m 31-12-1982.
IPO = 0                                                            [-]
- Indicator for simulation of P-cycle
- Only if IPO=1 then the P-cycle is also simulated.
INMO = 1                                                           [-]
- initialization of moisture fractions.
- INMO = 1 : initial moisture fractions are calculated by subr.INIMO,
  INMO = 0:  initial moisture fractions as input-data in the
             file INI.DAT.
INPO = 0                                                           [-]
- INPO = 1 : initial phosphor is given as P-total and subr.INPUT divides
             P-total over P-precipitated, P-complexed and P in solution.
  INPO = 0:  P-precipitated, P-complexed and P in solution are given as
             input in the file INI.DAT.
------------------------ simulation period and length of timestep ----
YRMI = 1974                                                       [yr]
YRMA = 1982                                                       [yr]
- year to end simulation (YRMA), resp. start simulation (YRMI)
- Simulation from 1-1-1974 up and till 31-12-1982
TIMI = 0.                                                       [days]
- Initial time (daynr) of the year in which the simulation should start
- 1 January start of simulation.
ST = 10.1458                                                    [days]
- Length of timestep
- The same timestep should be used as in the waterquantity-model.
  This value represents an average decade (365.25/36) and was as used
  in the model WATBAL
------------------------ definition of areas ------------------------
NA = 1                                                             [-]
- Number of subregions.
- Only for regional applications the value should be more than one.
  For this application one field was used; plot 16 of field M5
  (PAGV, 1985) situated in the south-eastern part of the province
  of N-Brabant. This was a plot with an optimal yield of maize, a high
  N-leaching and no extra additions of fertilizer. During the period
  1977-1982 the ICW executed a leaching-investigation program
  (Oosterom, 1984).
ANMI = 1                                                           [-]
- Area-nr to start simulation.
ANMA = 1                                                           [-]
- Area-nr to end simulation.
NT = 1                                                             [-]
- Number of technologies
TNMI = 1                                                           [-]
- Technology-nr to start simulation.
TNMA = 1                                                           [-]
- Technology-nr to end simulation.
- AN, ANMI, ANMA, NT, TNMI, TNMA are > 1 for regional applications.
```

```
----------------------- definition of materials -------------------
NM = 9                                                          [-]
- Number of materials that can be added to the soil system (max.10).
- For this application only the materials 1 and 7 are used, the values
  for the other materials can be regarded as dummy-values.
  material 1 = cattle slurry,
  material 7 = roots (plant rests, mainly roots)
FROR(1-NM) = 0.085, 0.015, 0.063, 0.095, 0.370, 0.0, 1.0, 0.99, 1.0  [-]
- Fraction of organic matter in the materials 1 to NM
- material 1. From measurements given in PAGV (1985, bijlage 4).
  material 7. The material for roots should have a FROR of 1.0 because
              AMROTI is expressed as dry matter.
FRNH(1-NM) =                                                    [-]
       0.0014, 0.0021, 0.00275, 0.0063, 0.0095, 0.5, 0.0, 0.0, 0.0
- Fraction of mineral NH4-N in the materials 1 to NM.
- material 1: Mineral nitrogen of cattle slurry is assumed to be 100%
    NH4-N.  FRNH can now be determined as: NH4-N = N-total - N-organic
    The material cattle slurry is divided into 3 organic fractions (FR)
    with each fraction having its own nitrogen content (NIFR). N-organic
    is determined as followed:
     N-org = (NIFR(1)*FR(1,1)+NIFR(2)*FR(1,2)+NIFR(3)*FR(1,3)) * FROR(1)
     N-org = (0.07*0.1   +   0.05*0.7    +    0.01*0.2) * 0.085
     N-org = 0.0037, which results in a NH4-N of 0.0052-0.0038 = 0.0014
  material 7: roots contain no mineral part, they are 100% organic.
FRNI(1-NM) = 0.0, 0.0, 0.0, 0.0, 0.0, 0.5, 0.0, 0.01, 0.0       [-]
- Fraction of NO3-N of the mineral N in the materials 1 to NM
- material 1: cattle slurry contains no NO3-N
  material 7: roots contain no mineral part, they are 100% organic.
FRPO(1-NM) = 0.0008, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0     [-]
- Fraction of Phosphor of the mineral N in the materials 1 to NM
----------------------- definition of organic fractions -----------
NF = 10                                                         [-]
- Number of organic fractions in the different materials (max.10).
- The organic part of each materials consists of fractions, which
  each have their own decomposition rate and their own nitrogen
  fraction. In this application 5 of the 10 fractions are used.
FR(MN,FN) =  0.1  0.7  0.2  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
             0.1  0.8  0.1  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
             0.1  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  0.9  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  0.9  0.1
             0.0  0.0  0.0  0.0  0.0   1.0  0.0  0.0  0.0  0.0
- fractions of the organic part of the materials
  (only MN=1 and MN=7 are used in this application)
- 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: 3 fractions determined with the model HISTOR
    (Berghuijs,1985, ch.6). With HISTOR decomposition rates and
    nitrogen contents were calibrated with measured data of long term
    decomposition of manure and with measured lysimeter-data.
  material 7: determined with the model HISTOR according to Berghuijs
    (Berghuijs,1985,chapter 6)
```

FRCA(MN,FN) = 0.1 0.05 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
0.1 0.05 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
0.1 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

- Part of the organic fractions of the organic part of the materials which goes into solution.
- material 1: fraction 1: 100% soluble organic matter,
  fraction 2: one part (0.7-0.05=0.65) is defined as fresh organic matter (OS) the rest (0.05) is defined as soluble organic matter (COCA),
  fraction 3: 100% fresh organic matter.
  Fraction-division is determined with model HISTOR (Berghuijs,1985,chapter 6)
  material 7: in roots no soluble parts, also according to HISTOR-calculations

HUFROS = 0.75 [-]
- Humus fraction of the fresh organic matter which does not pass the soluble stage, but decomposes directly to humus.
- This value resulted from simulating lysimeter-experiments (Sinderhoeve) in which the behaviour of organic matter in solution was observed over a certain period of time.

------------------------ definition of rates and contents -----------

ASFA = 0.25 [-]
- Assimilation factor.
- This parameter indicates the fraction of the decomposable fresh organic matter or exudates that can be turned into humus. Berghuijs (1985, p.65) gives this value, which resulted from parameter-fittings with the model HISTOR.

RECFAV(FN) = [yr-1]
1.0 1.68 0.12 2.0 0.22 0.00141 0.0 0.0 2.0 0.22
- First-order average decomposition rate for the organic fractions.
- Fractions 1-3: Fractions used for material nr 1 (cattle slurry); first determination with HISTOR (see also parameter FR). Model-verification resultated in a calibrating of the decomposition-rates for fractions 2 and 3 (fraction 1 has a dummy-value since this fraction goes fully into solution).
  Fractions 4-5: Fractions used for material nr 7 (roots). The values were determined with the model HISTOR and calibrated by a model-verification on grassland, where fraction 5 received a slower decomposition rate.
  Other fractions are not used and receice dummy-values.

RECFCAAV = 30. [yr-1]
- First-order average decomposition rate for soluble organic matter.
- Berghuijs (1985, p.65) gives this value, which was derived from lysimeter-experiments and verified with the model HISTOR.

RECFHUAV = 0.02 [yr-1]
- First-order average decomposition rate for humus.
- Berghuijs (1985, p.56): a low rate for humus of about 1.5-2.0% per year for net humus-decomposition in the long term.

RECFEXAV = 365. [yr-1]
- First-order average decomposition rate for exudates.

- Berghuijs (1985, p.54): a high rate because no exudates should remain in solution.

RECFNTAV = 365. [yr-1]
- First-order average nitrification rate.
- Van Huet (1983) gives some values from a literature-research. For sandy-loam column-experiments resulted in a value of 365. Taking the relatively long timesteps into account this means a full nitrification within one timestep.

NIFR(FN) = [-]
0.07 0.05 0.01 0.01 0.01 0.015 0.0 0.0 0.01 0.01
- N-fractions of the organic fractions (FR)
- fraction 1-3: Fractions used for material nr 1 (cattle slurry); values were determined with HISTOR (see also parameter FR).
  fraction 4-5: Fractions used for material nr 7 (roots). An average value was used of N-content of crop residues above surface and root-rest below surface. Verification took place with the model HISTOR.
  fraction 6-10: dummy-values.
  Berghuijs (1985) gives N-fractions in various materials, division over fractions has to be estimated or calibrated by the model HISTOR. It seems likely that the large fractions have the highest N-content.

NIFRHUMA = 0.048 [-]
- Maximal nitrogen fraction in humus.
- value as given by Berghuijs (1985,chapter 6, p.56). It corresponds to a C/N ratio of 14 if the C-content of the material is 0.58.
  The value for NIFRHUMA is reduced with a factor 0.2 for the layers with a reduced humus-decomposition (controlled by the parameters LR and RDFADCHU). The C/N ratio per layer can be chequed with the optional output-file MASSBAL.OUT.

NIFREX = 0.025 [-]
- Nitrogen fraction in exudates.
- value as given by Berghuijs (1985,chapter 6, p.53)

POFR(FN) = [-]
0.007 0.005 0.001 0.001 0.001 0.0015 0.0 0.0 0.001 0.001
- P-fractions of the organic fractions (FR), derived from data given by Jansen (1986).

POFRHUMA = 0.006 [-]
- Maximal phosphor fraction in exudates.

POFREX = 0.0025 [-]
- Phosphor fraction in exudates.

POFR, POFRHUMA and POFREX were estimated according to N/P ratios given by Jansen (1986)

------------------------- definition of crops -----------------------

Next input-data must follow for 5 kinds of crop; for this application only one kind of crop is used (maize) and therefore only the input-parameters for maize are given. For the 4 other crops dummy-values can be given.

Maize has been defined as the kind of crop nr 2 (KC=2).
The following data for KC = 2:

NUAMRO(KC) = 9 [-]
NULNRO(KC) = 9 [-]
- number of data given for the amount of roots (NUAMRO) and for the root-length (NULNRO).

AMROTI(KC,NUAMRO) =
0. 80. 120. 400. 1880. 3200. 4400. 4800. 4600. [kg.ha-1]

```
 - amount of roots at various daynrs
 LNROTI(KC,NULNRO) =
     0.  0.05  0.20  0.35  0.57  0.75  0.85   0.90  0.90              [m]
 - root-length at various daynrs
 TIAMRO(KC,NUAMRO) =
     115. 130. 151.  166.  181.  196.  212.   232.  290.              [d]
 - daynr (from 1 Jan.) for which AMROTI is given
 TILNRO(KC,NULNRO) =
     115. 130. 151.  166.  181.  196.  212.   232.  290.              [d]
 - daynr (from 1 Jan.) for which LNROTI is given
 - The data above are given by Berghuijs (1985,chapter 6)
 TISO(KC) = 115.                                                     [d]
 - Sowing time (daynr from 1 January)
 TIHA(KC) = 275.                                                     [d]
 - Harvest time (daynr from 1 January)
 - Average sowing and harvest-times over the period 1974-1982
   as given in PAGV (1985).
 TUTO(KC) = 0.                                               [kg.ha-1]
 - Amount of tubers which is harvested.
 UPNIMA1(KC) = 209.                                          [kg.ha-1]
 - Max. N-uptake by maize in the first period
 UPNIMA2(KC) = 116.                                          [kg.ha-1]
 - Max. N-uptake by maize in the second period
 SUEVMA1(KC) = 0.201                                                 [m]
 - Summarized maximal evapotranspiration during the first period
 SUEVMA2(KC) = 0.204                                                 [m]
 - Summarized maximal evapotranspiration during the second period
 TIUP1(KC) = 180.                                                    [d]
 - Time after sowing at which the first period ends.
 - For UPNIMA1 and UPNIMA2 a first estimate was made on base of data
   given by PAGV (1985), Steenvoorden (1985) and Oosterom (1984).
   The final values were achieved by calibrating on field measurements.
------------------------ output options ----------------------------
OUTAN = 1                                                           [-]
- subregion with output
OUTTN = 1                                                           [-]
- Technology-nr with output
OUTTO = 0                                                           [-]
- Output written to the file TOUT.DAT (1=total, 0=partial)
- If OUTTO=1 then the file TOUT.DAT will be filled each timestep with
  information about all the subroutines. If OUTTO=0 then this only done
  for the timesteps indicated with NUOUT and OUT(1-NUOUT)
NUOUT = 3                                                           [-]
- Number of timesteps with output to TOUT.DAT
OUT(1-NUOUT) = 10  20   3287                                        [d]
- timesteps for which output should be written to TOUT.DAT
- a daynr must be given as the nearest integer and can be calculated
  with:   TIMI  +  timesteps * ST.
The parameters OUTSE - CDSYR arrange output to different data-files
(see appendix B)
```

Filename: AREA.DAT

------------------------ geometry --------------------------------
NL = 13 [-]
- Number of layers (max. = 29)
HE(LN) 0.1 0.1 0.1 0.1 0.1 0.1 0.2 0.2 0.2 0.2 0.5 0.5 0.6 [m]
- Height of the layers 1 to NL.
- Layer-division was done with the following limilations:
  * rootzone of 0.6 m (should correspond with the value used in WATBAL)
  * model WATBAL delivered hydrological data for 0-3 m-surface.
    (groundwaterlevel fluctuates between 0.2 and 2.5 m-surface)
  * field measurements at 1 m-surface.

LNMARO = 6 [-]
- Number of layers of the rootzone.
- Value must correspond with:
  * layer-division used in model WATBAL.
  * layer-division given by parameter HE(1-NL).

  The rootzone on this maize field was 0.6 m.

------------------------ definitions -----------------------------
RM = 7 [-]
- Number of the material defined as root material.
- Materials are defined in the file GENERAL.DAT.

KICR = 2 [-]
- Kind of crop grown.
- Crops have been defined in the file GENERAL.DAT.
  One of the 5 defined crops should be choosen here; crop nr 2 was defined as maize.

LR = 10 [-]
- Layer number from which a reduction in humus decomposition occurs and from which the N-fraction of humus is reduced with a factor 0.2.
- From layer 10 (below 1.2 m-surface) these reductions take place.
  Chosen value was estimated as the depth at which humus composition will differ from the humus in the topsoil.

RDFADCHU = 0.15 [-]
- Reduction factor for humus decomposition for the layers LR to NL.
- Value of 0.15 results in a humus-decomposition rate of 0.3 yr-1 (RDFADCHU*RECFHUAV), which is given by Steenvoorden (1983).
  See also Berghuijs (1985, p.48).

------------------------ drainage --------------------------------
DK = 0.0057 [m-1]
- Density of drains of first order (canals)

DS = 0.0 [m-1]
- Density of drains of second order (ditches, drains)

DG = 0.0 [m-1]
- Density of drains of third order (trenches, ditches, field drains)
- DG,DS,DK should correspond to values used in WATBAL. In Cranendonck there is an influence of a river (kleine Aa) on a distance of about 175 m.

HDK = 1.7 [m-surface]
- Depth of the lower side of the first order drain

HDS = 0.0 [m-surface]
- Depth of the lower side of the second order drain

HDG = 0.0 [m-surface]
- Depth of the lower side of the third order drain
- For HDG en HDS dummy-waarden are used. The value for HDK is an

estimation; the large draindistance makes that this parameter will
have no effect on model-results.

------------------------ soil physical parameters ------------------

HVTE = 0 [-]
- Indicator for kind of temperature model to be used
- HVTE = 1 means that air temperatures are known and given in the input;
  Fourier model is used for this year.
  HVTE not equals 1 means that no temperatures are given as input and
  the sinus-model is used.

APTE = 10.0 [gr Celsius]
- Amplitude of yearly temperature wave in sinus model.
- Amplitude of yearly temperature wave in the Netherlands as given
  by Huet (1982),

AVTE = 11.0 [gr Celsius]
- Average yearly temperature at soil surface.
- Given by Huet (1982).

FQTE = 0.01726 [rad.d-1]
- Frequency of the yearly temperature wave
- Used in sinusmodel and Fourier-analyse. (2.0*3.14/365.0 = 0.01726)

TESMCF = 0.01584 [m2.d-1]
- Thermal diffusivity.
- Huet (1982) gives this value (6E-3 cm2.sec-1).
  It is used in sinusmodel and Fourier-analyse.

PMDF1 = 0.75 [-]
PMDF2 = 3.2 [-]
- Parameters in calculation of diffusion coefficient for oxygen in
  the airfilled part of soil.
- Emperical constants dependent on the soil type.
  Some values are given by Hoeks (1983). More values can be found in
  Bakker et al. (1987).

RVQU = 0.02 [m]
- Reservoir content for additions to the soil system.
- An extra reservoir into which the additions take place if the
  input-parameter WYAD = 0. The purpose of this reservoir is to let the
  applied fertilizer get into the upper soil part on base of a
  precipitation excess; from this reservoir the surface runoff also
  takes place.

LEFARU = 0.8 [-]
- leaching factor for runoff
- (1-LEFARU) indicates the dilution of the runoff-massflux.
  The value followed from simulations of field experiments (Achterberg).

CDSA = 0.9 [m.d-1]
- Saturated conductivity of the rootzone.
- Same value as used in hydrological model WATBAL.

AIENSCPF = 2.0 [cm]
- Air entry value of pF curve of the rootzone.
- Value given by Rijtema (personal communication).

MOFRPF1(1-10) = [-]

```
0.0    0.077  0.104  0.183  0.210  0.255  0.368  0.395  0.406  0.410
```

SCPF1(1-10) = [cm]

```
1.E+7  15849. 2511.9 501.2  199.5  100.   31.6   10.    3.16   1.
```

MOFRPF2(1-10) = [-]

```
0.0    0.038  0.064  0.118  0.158  0.230  0.291  0.298  0.316  0.320
```

SCPF2(1-10) = [cm]

```
1.E+7  15849. 2511.9 501.2  199.5  100.   31.6   10.    3.16   1.
```

- Moisture fractions and suctions of 2 pF-curves: rootzone (MOFRPF1

and SCPF1) and of the layers below the rootzone (MOFRPF2 and SCPF2).
- In this case the average values were taken of the in measured pF-curves of 2 fields (PAGV, 1985, bijlage 1: M6 en M3 of blok I).

MOFRWIUN = 0.038 [-]
- Moisture fractions at wilting point in the layers under the rootzone

MOFRSARO = 0.410 [-]
- Moisture fractions at saturation in the layers of the rootzone

MOFRSAUN = 0.320 [-]
- Moisture fractions at saturation in the layers under the rootzone

EVROSE = 0 [-]
- Selection in kind of evapotranspiration flux.
- EVROSE = 1: linear reduction of evapotranspiration.
  EVROSE .ne. 1: evapotranspiration flux proportional to layer-thickness

AR(AN) = 225.0 [m-2]
- Acreage of subregion nr AN
- Acreage of this maize-field (30 x 7.5 m).

KF = 1.0 [-]
- Ratio of conductivities in and below rootzone.
- Estimated value. No influential parameter (local use in subr.BALANCE).

KA = 1.0 [-]
- Ratio of conductivities in aquifer and in toplayer (below rootzone)
- dummy value.

AQBO = 3.0 [m-surface]
- boundary between toplayer and aquifer
- dummy value

HECZ = 0.4 [m]
- Distance between rootzone and lowest groundwaterlevel with capillary rise.
- Same value as used in model WATBAL.

----------------------- soil chemical parameters -----------------

PHRO = 5.63 [-]
PHBERO = 5.7 [-]
- pH-water in the rootzone (PHRO) and below rootzone (PHBERO).
- Value comes from PAGV (1985, bijlage 33); values were presented as measured pH-KCl. Conversion to pH-water was made with a conversion-tabel (TNO, 1956).

	measured	+ correction	= value
PHRO =	4.73	+ 0.9	= 5.63
PHBERO=	4.8	+ 0.9	= 5.7

DRADNH(1) = 13.0 [-]
- Distribution ratio for ammonium in rootzone
- The ratio between the amount of NH4-N at the soil complex and the amount of NH4-N in the soil solution. Values are given by Hoeks (1979), Hoeks (1983, p.15). See also Berghuijs (1985, p.47). The value is given to all layers of the rootzone.

DRADNH(NL) = 2.0 [-]
- Distribution ratio for ammonium below rootzone
- The value is given to all layers below the rootzone.

----------------------- in- and outgoing Nitrogen and Carbon --------

COPRNH = 0.00127 [kg N.m-3 water]
COPRNI = 0.00078 [kg N.m-3 water]
- Concentrations of NH4-N and NO3-N in the precipitation.
- Values are given by Jansen (1983): NH4-N en NO3-N concentraties in the precipitation measured in Eindhoven over the period 1978-1980.

DRDEPNH = 12.0 [kg.ha-1]
- Atmospheric dry deposition of NH4-N

DRDEPNI = 8.0 [kg.ha-1]
- Atmospheric dry deposition of NO3-N
- Deposition was estimated as 20 kg.ha-1, division over NH4 and NO3 according to NIMWAG (1985)

COIDNH = 0.0 [kg.m-3]
- Concentration of NH4-N in infiltrating drainwater

COIDNI = 0.0 [kg.m-3]
- Concentration of NO3-N in infiltrating drainwater

COIDCA = 0.0 [kg.m-3]
- Concentration of soluble organic matter in infiltrating drainwater
- No infiltration in this field.

FRVO = 0.4 [-]
- Fraction of added NH4-N that volatilizes.
- An estimation based on given by Lammers (1984) and on field-observations in Cranendonck.

Filename: INI.DAT

MOFRO(1-NL) = [m3 water.m-3 soil]
0.0 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 layers 1 to NL at the beginning of a timestep
- Dummy-values of 0.0 have been used because the initial moisture fractions are calculated by the subroutine INIMO (see parameter INMO in file GENERAL.DAT).

EX(1-NL) = [kg.m-2 soil]
0.0 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 layers 1 to NL
- De amount of exudates present has been estimated as 0.0 kg. Low amounts and high decomposition rates make this acceptable.

HUEX(1-NL) = [kg.m-2 soil]
2.208 2.208 1.936 1.936 1.796 1.796 1.0 0.6 0.2 0.08 0.0 0.0 0.0
- Amount of humus from exudates present in layers 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. In this case the initialization of organic matter took place with measured values. These measured values of humus must be divided over the organic components HUEX, HUOS, and OS. The model HISTOR was used to indicate the division over these components. The following division was used: HUEX:HUOS:OS = 8:1:1. Measured values were taken from PAGV (1985, bijlage 19), were humus-amounts were given for the 9 years of the experiments. Extrapolation resultated in initial values for 1-1-1974. Of these values 80% became HUEX, 10% as HUOS and another 10% as OS.

CONH(NL) = [kg N.m-3 soil solution]
0.0 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 NH4-N in the layers 1 to NL.
- Measured values were given in PAGV (1985, bijlage 24 e.v.) of 0.0

CONI(LN) = [kg N.m-3 soil solution]
0.07348 0.07348 0.04798 0.04798 0.10502 0.10502
0.04752 0.02138 0.00313 0.0 0.0 0.0 0.0
- Concentration of NO3-N in the layers 1 to NL.
- Measured values were given in PAGV (1985, bijlage 24 e.v.) from 10-11-1975; extrapolation resulted in values for 1-1-1974.

OS(1-NL,1-NF) = [kg dry matter.m-2 soil]

0.0	0.0	0.0	0.138	0.138	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.138	0.138	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.121	0.121	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.121	0.121	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.081	0.081	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.081	0.081	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.05	0.05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.05	0.05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.005	0.005	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.005	0.005	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.000001	0.000001	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.000001	0.000001	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.000001	0.000001	0.0	0.0	0.0	0.0	0.0

- Amount of fresh organic matter present in layers 1 to NL for fractions 1 to NF.
- see parameter HUEX, division over fractions was estimated as 50%-50%.

HUOS(1-NL,1-NF) = [kg dry matter.m-2 soil]

```
    0.0 0.0 0.0 0.138 0.138   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.138 0.138   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.121 0.121   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.121 0.121   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.081 0.081   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.081 0.081   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.05  0.05    0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.05  0.05    0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.005 0.005   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.005 0.005   0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.0   0.0     0.0  0.0  0.0  0.0  0.0
    0.0 0.0 0.0 0.0   0.0     0.0  0.0  0.0  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 fresh organic matter and soluble organic matter present in layers 1 to NL for fractions 1 to NF.
- see parameter HUEX, division over fractions was estimated as 50%-50%.

COCA(1-NL,1-NF) [kg dry matter.m-3 soil solution]

```
    0.0 0.0 0.0 0.0   0.0     0.0  0.0  0.0  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 soluble organic matter.
- For COCA zero's can be given, because the amounts of this organic material are usually negligible compared to three other forms or organic material.

COAQNH = 0.0 [kg N.m-3 water]

- Concentration of NH4-N in the aquifer.
- In situations with seepage COAQNH and COAGNI become the concentrations of the seepage water. In this case there was no seepage, so dummy-values of 0.0 were used.

COAQNI = 0.0 [kg N.m-3 water]

- Concentration of NO3-N in the aquifer.
- see parameter COAQNH.

Filename: ADDIT.DAT

```
TINEAD = 1.                                                          [d]
- Time of the next addition (fertilizing, addition and/or plouging)
- Daynr of the first addition.
  PAGV (1985, p.10) gives exact data of cattle slurry additions.
  These data were used; only the first addition was shifted two
  weeks (from 14-12-1973 to 1-1-1974) to be able to start simulations
  at 1-1-1974.

For each timestep with additions the following 6 parameters:
NUAD = 1                                                             [-]
- Number of additions per timestep (max=7)

For each addition:
   MTNU = 1                                                          [-]
   - Number of the added material
   - One of the materials (MN) defined in the file GENERAL.DAT; in this
     case cattle slurry is material 1
   QUMT = 100000.                                              [kg.ha-1]
   - Amount of material added.
   WYAD = 0                                                          [-]
   - Way of addition and number of layers over which the addition
     is distributed
   - Possibilities:
     WYAD = 0: addition to reservoir on top of layer 1 with
               volatilization of mineral NH4-N
     WYAD = 1: addition to layer 1 (no volatilization)
     WYAD = 2: addition to layer 1 and 2 (no volatilization)
        etc.
   PL = 2                                                            [-]
   - Number of layers to be ploughed.
   - No additions (QUMT = 0.0) but just ploughing is also possible.
TINEAD = 45.                                                         [d]
- Time of the next addition

Next the following additions for the year 1974:
NUAD = 1
   MTNU = 1
   QUMT = 100000.
   WYAD = 0
   PL = 2
TINEAD = 112.
NUAD = 1
   MTNU = 1
   QUMT = 50000.
   WYAD = 0
   PL = 2
TINEAD = 364.
NUAD = 1
   MTNU = 1
   QUMT = 100000.
   WYAD = 0
   PL = 2
TINEAD = 402.
```

For each year additions are made at the following timesteps:

1975:	402.	479.	715.	
1976:	766.	828.	1087.	
1977:	1151.	1213.	1445.	
1978:	1507.	1568.	1816.	
1979:	1926.	1940.	2181.	
1980:	2242.	2297.	2530.	
1981:	2607.	2663.		
1982:	2929.	2986.	3034.	6000.

(last value for TINEAD contains a dummy value)

Filename: WATBAL.DAT

This file contains the results of the waterquantity-model WATBAL. It is a binary file for two reasons: accuracy and speed; this file is read each timestep and unformatted I/O is much faster than formatted I/O, inaccurate waterbalances are useless for waterquantity calculations. In this file-description there will be no data given, because the amount of data is too high and because it is a binary file.

MOCORO = ... [m3 water.m-2 soil]
- initial moisture content (volume) of the rootzone
WALE = ... [m-soil surface]
- initial groundwaterlevel.
MODEUN = ... [m3 water.m-2 soil]
- Moisture deficit under the rootzone

For each timestep the following parameters:
TIWA = ... [d]
- Timestep (daynr) for which results form WATBAL are given.
EVMA = ... [m3 water.m-2 soil.d-1]
- Maximal evapotranspiration flux
PR = ... [m3 water.m-2 soil.d-1]
- Precipitation flux.
EV = ... [m3 water.m-2 soil.d-1]
- Evapotranspiration flux
FG = ... [m3 water.m-2 soil.d-1]
- Third order drain-flux (ditches, trenches, field drains)
- positive = draninage, negative = infiltration
FS = ... [m3 water.m-2 soil.d-1]
- Second order drain-flux (ditches)
FK = ... [m3 water.m-2 soil.d-1]
- First order drain-flux (canals).
LEAK = ... [m3 water.m-2 soil.d-1]
- Discharge to layers below model-profile (leakage to aquifer)
- positive = leakage, negative = seepage
MOCOROT = ... [m3 water.m-2 soil]
- Moisture content (volume) of the rootzone at the end of the timestep.
WALET = ... [m-soil surface]
- Depth of groundwater table at the end of the timestep.

APPENDIX D: Input description of a regional application

In this appendix an input-description is given of all the files needed for a regional application. This description includes the values that parameters received for the application of the model on one region divided into 5 subregions (or areas).

A parameter-description is given of the following files:

filename	contents
GENERAL.DAT	general parameters valid for the whole region
AREA(1-NA).DAT	general parameters for each subregion
INI(1-NA).DAT	initial parameters for each subregion
ADDIT.DAT	manure and fertilizer quantities
SIMGROQ.DAT	waterquantity parameters calculated by SIMGRO
SIMGRO.FLW	waterquantity parameters 1st aquifer by SIMGRO
CAPSEVPF.DAT	pF parameters calculated by CAPSEV.

The parameter-values for the files GENERAL.DAT, AREA1.DAT and INI1.DAT will be discussed in detail.

The files GENERAL.DAT, AREA(1-NA).DAT, INI(1-NA).DAT, CAPSEVPF.DAT and ADDIT.DAT are files which are read with a 'free format'. Reading of these files in the model ANIMO will be executed normally under the following restrictions:

- make sure that the data-type is correct.
- begin a new record when indicated in the description (appendix B)

The files SIMGROQ.DAT and SIMGRO.FLW are output-files created by other programs for which the file-description in this appendix gives more information.

For each parameter the following description is used:

first line:

The parameter-name (eventual with dimension); the value used for this application; between [ ] the unit in which the value is expressed.

new line:

- a general parameter-description.

new line:

- information about the parameter-value which has been used for this application and about literature with parameter-data.

Filename: GENERAL.DAT

```
----------------------- simulation options -----------------------
IWA = 1                                                        [-]
- Indicator for kind of waterquantity-model
  (1=SIMGRO, 2=WATBAL, 3/4=SWATRE, 5=DEMGEN).
- Hydrological parameters were simulated with the model SIMGRO
  for an average hydrological year (1-10-1977 - 31-9-1978)
IPO = 0                                                        [-]
- Indicator for simulation of P-cycle
- Only if IPO=1 then the P-cycle is also simulated.
INMO = 1                                                       [-]
- initialization of moisture fractions.
- INMO = 1 : initial moisture fractions are calculated by subr.INIMO,
  INMO = 0:  initial moisture fractions as input-data in the
             file INI.DAT.
INPO = 0                                                       [-]
- INPO = 1 : initial phosphor is given as P-total and subr.INPUT divides
             P-total over P-precipitated, P-complexed and P in solution.
  INPO = 0:  P-precipitated, P-complexed and P in solution are given as
             input in the file INI.DAT.
----------------------- simulation period and length of timestep ----
YRMI = 1984                                                   [yr]
- year to end simulation (YRMA), resp. start simulation (YRMI)
- Simulation from 1-10-1983 up and till 31-9-2013    (= 30 years)
YRMA = 2013                                                   [yr]
TIMI = 265.                                                 [days]
- Initial time (daynr) of the year in which the simulation starts.
- 1 October start of simulation.
ST = 7.0                                                    [days]
- Length of timestep
- Same timestep as in the waterquantity-model SIMGRO.
C----------------------- definition of areas -----------------------
NA = 5                                                         [-]
- Number of subregions.
- For regional applications this parameter indicates the number of
  subregions that have been distinguished on differences in hydrology
  and soil physics. The value must correspond to the number of
  subregions for which SIMGRO has made calculations.
ANMI = 1                                                       [-]
- subregion-nr to start simulation.
ANMA = 1                                                       [-]
- subregion-nr to end simulation.
- The simulation can be executed for one or more subregion(s)
NT = 4                                                         [-]
- Number of technologies
- For regional applications; a technology is a fraction of a subregion
  and has a specific land-use, it is not geographically fixed. The
  following technologies have been used for this application.
   techn.-nr.  description:
       1       maize land
       2       grassland    sprinkling
       3       grassland    no sprinkling
       4       nature
TNMI = 2                                                       [-]
- Technology-nr to start simulation.
```

```
TNMA = 2                                                            [-]
- Technology-nr to end simulation.
- For regional applications; with TNMA and TNMI one can make a
  simulation-run for one or more technologies.
------------------------ definition of materials -------------------
NM = 9                                                              [-]
- Number of materials that can be added to the soil system (max.10).
- For this application 9 materials are defined and used.
    material 1 = cattle slurry,
    material 2 = calve slurry,
    material 3 = pig slurry,
    material 4 = poultry slurry,
    material 5 = dry poultry manure,
    material 6 = fertilizer,
    material 7 = roots (plant rests, mainly roots) of non-grass crops,
    material 8 = roots (plant rests, mainly roots) of grass crops,
    material 9 = organic matter in the subsoil.
FROR(1-NM) = 0.06, 0.015, 0.063, 0.095, 0.370, 0.0, 1.0, 0.99, 1.0  [-]
- Fraction of organic matter in the materials 1 to NM
- material 1-5: Lammers (1983) gives organic matter contents.
  material 6: fertilizer is 100% anorganic.
  material 7: The material for roots should have a FROR of 1.0 because
              AMROTI is expressed as dry matter.
  material 8: Grass-roots may have a mineral part (special subroutine
              GRASS for grass-roots)
  material 9: 100% organic.
FRNH(1-NM) =                                                        [-]
        0.0022, 0.0021, 0.00275, 0.0063, 0.0095, 0.5, 0.0, 0.0, 0.0
- Fraction of mineral NH4-N in the materials 1 to NM.
- material 1-5: Mineral nitrogen of slurry is assumed to be 100%
    NH4-N.  FRNH can be determined as: NH4-N = N-total - N-organic
    The slurry 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 (1983).
    The following table gives the N-contents used for this application
             |N-mineral +   N-organic                          = N-total
    material | FRNH    + (NIFR*FR +NIFR*FR +NIFR*FR) * FROR
    ---------|--------------------------------------------------
        1    | 0.0022 + (0.07*0.1+0.05*0.7+0.01*0.2)*0.060 = 0.0048
        2    | 0.0021 + (0.07*0.1+0.05*0.8+0.01*0.1)*0.015 = 0.0028
        3    | 0.0027 + (0.07*0.1+0.05*0.8+0.01*0.1)*0.063 = 0.0057
        4    | 0.0063 + (0.07*0.1+0.05*0.8+0.01*0.1)*0.095 = 0.0109
        5    | 0.0095 + (0.07*0.1+0.05*0.4+0.01*0.5)*0.370 = 0.0213
  material 6-9: see  parameter  FRNI
FRNI(1-NM) = 0.0, 0.0, 0.0, 0.0, 0.0, 0.5, 0.0, 0.01, 0.0           [-]
- Fraction of NO3-N of the mineral N in the materials 1 to NM
- material 1-5: slurry contains no NO3-N
  material 6: fertilizer, half NO3-N, half NH4-N.
  material 7: roots contain no mineral part, they are 100% organic.
  material 8: small parts of dying grass-roots (1%) is added as mineral
              NO3-N.
  material 9: 100% organic.
FRPO(1-NM) = 0.0008, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0         [-]
- Fraction of Phosphor of the mineral N in the materials 1 to NM
- just as an example only for the first material the value is given.
```

```
------------------------ definition of organic fractions ------------
NF = 10                                                            [-]
- Number of organic fractions in the different materials (max.10).
- The organic part of each materials consists of fractions, which
  each have their own decomposition rate and their own nitrogen
  fraction. In this application the fractions 7 and 8 are not used.
FR(MN,FN) =  0.1  0.7  0.2  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
             0.1  0.8  0.1  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
             0.1  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  0.9  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  0.9  0.1
             0.0  0.0  0.0  0.0  0.0   1.0  0.0  0.0  0.0  0.0
- fractions of the organic part of the materials
- 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: 3 fractions derived from model-verifications in Ruurlo
                and Cranendonck (see appendix C).
  material 6: fertilizer: 100% mineral
  material 7-8:  see appendix C.
  material 9: no further division into fractions
FRCA(MN,FN) = 0.1  0.05  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
              0.1  0.05  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
              0.1  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
- Part of the organic fractions of the organic part of the materials
  which goes into solution.
- material 1-5: fraction 1: 100%  soluble organic matter,
                fraction 2: one part (0.7-0.05=0.65) is defined as
                            fresh organic matter (OS) the rest (0.05)
                            is defined as soluble organic matter (COCA),
                fraction 3: 100%  fresh organic matter.
                Fraction-division followed from model-verification
                (see appendix C)
  material 6-9: no soluble parts.
HUFROS = 0.75                                                      [-]
- Humus fraction of the fresh organic matter which does not pass the
  soluble stage, but decomposes directly to humus.
- same value as on verifications (see appendix C)
------------------------ definition of rates and contents -----------
ASFA = 0.25                                                        [-]
- Assimilation factor.
- same value as on verifications (see appendix C)
RECFAV(FN) =                                                   [yr-1]
        1.0  1.68  0.12  2.0  0.22  0.00141  0.0  0.0  2.0  0.22
- First-order average decomposition rate for the organic fractions.
- fractions 1-3: Fractions used for materials 1-5 (slurry);
    same value as on verifications (see appendix C)
```

fractions 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
same value as on verifications (see appendix C)
fraction 6: Fraction used for organic material in subsoil;
decomposition-rate was derived from rates given Jenkinson and Rayner (1977) and calibrated with the results of initial simulations of the history of the area (Drent, 1988).

RECFCAAV = 30. [yr-1]
- First-order average decomposition rate for soluble organic matter.
- same value as on verifications (see appendix C)

RECFHUAV = 0.02 [yr-1]
- First-order average decomposition rate for humus.
- same value as on verifications (see appendix C)

RECFEXAV = 365. [yr-1]
- First-order average decomposition rate for exudates.
- same value as on verifications (see appendix C)

RECFNTAV = 365. [yr-1]
- First-order average nitrification rate.
- same value as on verifications (see appendix C)

NIFR(1-NF) = [-]
0.07 0.05 0.01 0.01 0.01 0.015 0.0 0.0 0.01 0.01
- N-fractions of the organic fractions FR(1-NF)
- fraction 1-3: Fractions used for materials 1-5 (slurry);
same value as on verifications (see appendix C)
fraction 4-5 and 9-10: Fractions used for material nr 7 and 8 (roots).
same value as on verifications (see appendix C)
fraction 6: Fraction used for organic material in subsoil; N-content derived from data given by Berghuijs (1985, table 6.16).

NIFRHUMA = 0.048 [-]
- Maximal nitrogen fraction in humus.
- same value as on verifications (see appendix C)

NIFREX = 0.025 [-]
- Nitrogen fraction in exudates.
- same value as on verifications (see appendix C)

POFR(FN) = [-]
0.007 0.005 0.001 0.001 0.001 0.0015 0.0 0.0 0.001 0.001
- P-fractions of the organic fractions (FR)
- same value as on verifications (see appendix C)

POFRHUMA = 0.006 [-]
- Maximal phosphor fraction in exudates.

POFREX = 0.0025 [-]
- Phosphor fraction in exudates.

For POFR, POFRHUMA and POFREX see Appendix C.

------------------------ definition of crops ------------------------

Next input-data must follow for 6 kinds of crop.
For crop-nrs 1-5 any kind of crop can be choosen; crop nr 6 must contain data for grassland.
The following crops are defined in this example:

KC = 1: arable land
KC = 2: maize land
KC = 3: dummy-values
KC = 4: forest
KC = 5: dummy-values
KC = 6: grassland

Only the data for maize land and grassland are used in this application.

```
The following data for KC = 1 (arable land):
  Arable land is a mixture of the principal crops used in the
  Z-Peel region: potatoes, beets, winter- and summer-cereals.
  NUAMRO(KC) = 10                                                 [-]
  NULNRO(KC) = 10                                                 [-]
  - number of data given for the amount of roots (NUAMRO) and for the
    root-length (NULNRO).
  AMROTI(KC,NUAMRO) =
   27.  51.  90.  645.  1824.  2529.  3330. 3780. 4620. 4710.  [kg.ha-1]
  - Amount of roots at various daynrs
  LNROTI(KC,NULNRO) =
   .08  .14  .22  .38   .58    .81    .91   .96   .97   .97         [m]
  - root-length at various daynrs
  TIAMRO(KC,NUAMRO) =
   0.   59.  90.  120.  151.   181.   196.  212.  243.  270.        [d]
  - daynr (from 1 Jan.) for which AMROTI is given
  TILNRO(KC,NULNRO) =
   0.   59.  90.  120.  151.   181.   196.  212.  243.  270.        [d]
  - daynr (from 1 Jan.) for which LNROTI is given
  TISO(KC) = 0.0                                                    [d]
  - Sowing time (daynr from 1 January)
  TIHA(KC) = 262.0                                                  [d]
  - Harvest time (daynr from 1 January)
  TUTO(KC) = 0.0                                             [kg.ha-1]
  - Amount of tubers which is harvested.
  UPNIMA1(KC) = 40.0                                         [kg.ha-1]
  - Max. N-uptake by maize in the first period
  UPNIMA2(KC) = 400.0                                        [kg.ha-1]
  - Max. N-uptake by maize in the second period
  SUEVMA1(KC) = 0.0046                                              [m]
  - Summarized maximal evapotranspiration during the first period
  SUEVMA2(KC) = 0.400                                               [m]
  - Summarized maximal evapotranspiration during the second period
  TIUP1(KC) = 120.0                                                 [d]
  - Time after sowing at which the first period ends.
  UPPOMA1(KC) = 50.    (dummy)                               [kg.ha-1]
  UPPOMA2(KC) = 50.    (dummy)                               [kg.ha-1]

The following data for KC = 2 (maize land):
  - see appendix C
  NUAMRO(KC) = 9                                                    [-]
  NULNRO(KC) = 9                                                    [-]
  AMROTI(KC,NUAMRO) =
      0.  80. 120. 400. 1880.  3200.  4400.  4800. 4600.     [kg.ha-1]
  LNROTI(KC,NULNRO) =
      0.  0.05  0.20  0.35  0.57  0.75  0.85   0.90  0.90            [m]
  TIAMRO(KC,NUAMRO) =
      115. 130. 151.  166.  181.  196.  212.   232.  290.            [d]
  TILNRO(KC,NULNRO) =
      115. 130. 151.  166.  181.  196.  212.   232.  290.            [d]
  TISO(KC) = 115.                                                   [d]
  TIHA(KC) = 275.                                                   [d]
  TUTO(KC) = 0.                                              [kg.ha-1]
  UPNIMA1(KC) = 209.                                         [kg.ha-1]
  UPNIMA2(KC) = 116.                                         [kg.ha-1]
  SUEVMA1(KC) = 0.201                                               [m]
```

```
  SUEVMA2(KC) = 0.204                                          [m]
  TIUP1(KC) = 180.                                             [d]
  UPPOMA1(KC) = 36.     (dummy)                          [kg.ha-1]
  UPPOMA2(KC) = 18.     (dummy)                          [kg.ha-1]

The following data for KC = 4 (forest):
  NUAMRO(KC) = 2
  NULNRO(KC) = 2
  AMROTI(KC,NUAMRO) =   4500.0    4500.0                 [kg.ha-1]
  LNROTI(KC,NULNRO) =   1.0       1.0                          [m]
  TIAMRO(KC,NUAMRO) =   0.0       300.0                        [d]
  TILNRO(KC,NULNRO) =   0.0       300.0                        [d]
  TISO(KC) =     0.                                            [d]
  TIHA(KC) =     290.                                          [d]
  TUTO(KC) =     0.                                      [kg.ha-1]
  UPNIMA1(KC) = 400.                                     [kg.ha-1]
  UPNIMA2(KC) = 400.    (dummy, see TIUP1)               [kg.ha-1]
  SUEVMA1(KC) = 0.460                                          [m]
  SUEVMA2(KC) = 0.460   (dummy, see TIUP1)                     [m]
  TIUP1(KC) =   400.                                           [d]
  UPPOMA1(KC) = 50.     (dummy)                          [kg.ha-1]
  UPPOMA2(KC) = 50.     (dummy)                          [kg.ha-1]

The following data for KC = 6 (grassland):
  TISO(6) =     -10.                                           [d]
  TIHA(6) =     400.                                           [d]
  - The variabels TISO and TIHA indicate the period of nitrogen uptake
    by grass.
  UPPOMA1(6) = 50.0                                      [kg.ha-1]
  - yearly max. P-uptake by grass
  SUEVMA1(6) = 390.0                                           [m]
  - yearly sum of max. evapotransp. for phosphor uptake
  AMSHMA =     0.350                                      [kg.m-2]
  - maximum shoot-production
  FROSGR =     0.20                                            [-]
  - fraction of shoots lost by grazing
  FROSHA =     0.20                                            [-]
  - fraction of shoots lost by harvest
  RESU =       0.321                                           [-]
  - relative duration of sunshine
  SHPDRA =     2.30                                            [-]
  - shoot production rate
  TURA =       0.005                                       [d-1]
  - turnover rate for dying of roots
  NIFRMI =     0.01                                            [-]
  - minimum total N-fraction of roots (only used for IWA=4).

------------------------ output options ----------------------------
OUTAN = 1                                                      [-]
- subregion with output
OUTTN = 2                                                      [-]
- Technology-nr with output
OUTTO = 0                                                      [-]
- Output written to the file TOUT.DAT (1=total, 0=partial)
- If OUTTO=1 then the file TOUT.DAT will be filled each timestep with
  information about all the subroutines. If OUTTO=0 then this only done
```

for the timesteps indicated with NUOUT and OUT(1-NUOUT)
NUOUT = 3 [-]
- Number of timesteps with output to TOUT.DAT
OUT(NUOUT) = 272 279 286 [d]
- timesteps for which output should be written to TOUT.DAT
- a daynr must be given as the nearest integer and can be calculated with: TIMI + timesteps * ST.

The parameters OUTSE - CDSYR arrange output to different data-files (see appendix B)

Filename: AREA1.DAT

For each subregion the input-parameters for the files AREA(1-NA).DAT have to be created. In this description only the parameters for one subregion are discussed in detail.

```
----------------------- geometry --------------------------------
NL = 13                                                      [-]
- Number of layers for local (vertical) model-profile.
HE(1-NL)= 0.05 0.1 0.1 0.1 0.15 0.2 0.3 0.5 3.5 5.0 15.0 17.0 20.0   [m]
- Height of the layers 1 to NL.
- For each subregion the same layer-division for layer 1-11;
  the following limilations:
   * three zones:  rootzone, rest toplayer (rootzone->aquifer), aquifer
   * within a subregion the thickness of rootzones varies per technology.
   * bottom of profile is determined by the imaginary boundary in
     aquifer (paragraph 3.3.).
LNMAROTN(1-NT) = 4  3  3  3                                  [-]
- Number of layers of the rootzone (for each technology)
- Value varies per technology and possibly per subregion and must
  correspond with:
    * rootzone-thicknesses used in model SIMGRO.
    * layer-division given by parameter HE(1-NL).

----------------------- definitions -----------------------------
RMTN(1-NT) =  7  8  8  8                                     [-]
- Number of the material defined as root material (for each technology).
- Materials are defined in the file GENERAL.DAT.
KICRTN(1-NT) =  2  6  6  6                                   [-]
- Kind of crop grown (for each technology).
- Crops have been defined in the file GENERAL.DAT.
  Each technology represented by the following crop:
   kind of crop     technologies
     2 (maize)      1             (maize land)
     6 (grass)      2,3,4         (grassland, nature)
LR = 8                                                       [-]
- Layer number from which a reduction in humus decomposition occurs
  and from which the N-fraction of humus is reduced with a factor 0.2.
- From layer 8 (below 1.0 m-surface) these reductions take place.
  In this application it was estimated that humus decomposition below
  the top-layers will differ from the humus in the topsoil.
RDFADCHU = 0.15                                              [-]
- Reduction factor for humus decomposition for the layers LR to NL.
- same value as on verifications (see appendix C).
----------------------- drainage --------------------------------
DK = 0.0004                                                [m-1]
- Density of drains of first order (canals)
DS = 0.0010                                                [m-1]
- Density of drains of second order (ditches, drains)
DG = 0.0085                                                [m-1]
- Density of drains of third order (trenches, ditches, field drains)
- DK,DS,DG should correspond to data used in SIMGRO.
HDK = 2.00                                           [m-surface]
- Depth of the lower side of the third order drain
HDS = 1.10                                           [m-surface]
```

- Depth of the lower side of the second order drain
HDG = 0.15 [m-surface]
- Depth of the lower side of the first order drain
- DK,DS,DG,HDK,HDS,HDG should correspond to data used in SIMGRO.
------------------------ soil physical parameters ------------------
HVTE = 0 [-]
- Indicator for kind of temperature model to be used
- HVTE = 1 means that air temperatures are known and given in the input; Fourier model is used for this year.
  HVTE not equals 1 means that no temperatures are given as input and the sinus-model is used.
APTE = 10.0 [gr Celsius]
- Amplitude of yearly temperature wave in sinus model.
- Amplitude of yearly temperature wave in the Netherlands as given by Huet (1982),
AVTE = 11.0 [gr Celsius]
- Average yearly temperature at soil surface.
- Given by Huet (1982).
FQTE = 0.01726 [rad.d-1]
- Frequency of the yearly temperature wave
- Used in sinusmodel and Fourier-analyse. (2.0*3.14/365.0 = 0.01726)
TESMCF = 0.05184 [m2.d-1]
- Thermal diffusivity.
- Huet (1982) gives this value (6E-3 cm2.sec-1).
  It is used in sinusmodel and Fourier-analyse.
PMDF1 = 0.75 [-]
PMDF2 = 3.2 [-]
- Parameters in calculation of diffusion coefficient for oxygen in the airfilled part of soil.
- Emperical constants dependent on the soil type.
  Some values are given by Hoeks (1983). More values can be found in Bakker et al. (1987).
RVQU = 0.02 [m]
- Reservoir content for additions to the soil system.
- An extra reservoir into which the additions take place if the input-parameter WYAD = 0 (see subroutine MANURE).
  The purpose of this reservoir is to let the applied fertilizer get into the upper soil part on base of a precipitation excess; from this reservoir the surface runoff also takes place.
LEFARU = 0.8 [-]
- leaching factor for runoff
- (1-LEFARU) indicates the dilution of the runoff-massflux.
  The value followed from simulations of field experiments (Achterberg).
CDSA = 1.7 [m.d-1]
- Saturated conductivity of the rootzone.
- Dependent on soil physical unit, which varies per subregion.
  6 Soil physical units are distinguished (Bloemen, 1982) in the Z-Peel region resulting in 6 different kinds of CDSA, varying between 0.7 and 2.3.
AIENSCPF = 2.0 [cm]
- Air entry value of pF curve of the rootzone.
- same value as on verifications (see appendix C)
MOFRPF1(1-10) = [-]
0.0 0.06 0.14 0.18 0.23 0.30 0.37 0.40 0.43 0.49
SCPF1(1-10) = [cm]

1.E+07 15849. 1000. 501. 200. 100. 50.1 31.6 10. 1.
MOFRPF2(1-10) = [-]
0.0 0.04 0.07 0.08 0.10 0.11 0.16 0.23 0.32 0.372
SCPF2(1-10) = [cm]
1.E+07 15849. 1000. 87.5 77.5 62.5 47.5 32.5 17.5 1.
- Moisture fractions and suctions of 2 pF-curves: rootzone (MOFRPF1 and SCPF1) and of the layers below the rootzone (MOFRPF2 and SCPF2).
- pF-curves for the rootzone were derived from data given by Bloemen (1982) and differ per soil physical unit.
MOFRWIUN = 0.06 [-]
- Moisture fractions at wilting point in the layers under the rootzone
MOFRSARO = 0.49 [-]
- Moisture fractions at saturation in the layers of the rootzone
MOFRSAUN = 0.372 [-]
- Moisture fractions at saturation in the layers under the rootzone
- values for MOFRWIUN, MOFRSARO, MOFRSAUN are derived from pF-curves.
EVROSE = 0 [-]
- Selection in kind of evapotranspiration flux.
- EVROSE = 1: linear reduction of evapotranspiration.
  EVROSE .ne. 1: evapotranspiration flux proportional to layer-thickness
  Model-verification on maize and grassland were satisfactory with EVROSE = 0.
AR(AN) = 7000000.0 [m-2]
- Size of the subregion
- Size differs per subregion and should correspond to the value used or SIMGRO.
KF = 1.0 [-]
- Ratio of conductivities in and below rootzone.
- Rootzone and layers below the rootzone (untill the aquifer) all belong to the same geological formation (formatie van Nuenen). Therefore conductivities are asssumed to be the same.
KA = 311.0 [-]
- Ratio of conductivities in aquifer and in toplayer (below rootzone)
- Derived from transmissivity and resistance values used in SIMGRO.
AQBO = 25.0 [m-surface]
- boundary between toplayer and aquifer
HECZ = 2.2 [m]
- Distance between rootzone and lowest groundwaterlevel with capillary rise.
- KA, AQBO, and HECZ vary per subregion and were derived from data given by Querner and Van Bakel (1984).

------------------------ soil chemical parameters ------------------
PHRO = 5.6 [-]
PHBERO = 6.0 [-]
- pH-water in the rootzone (PHRO) and below rootzone (PHBERO).
DRADNH(1) = 13.0 [-]
- Distribution ratio for ammonium in rootzone.
- Same value as verification; see appendix C; more values shall be given by Kroes (1989).
DRADNH(NL) = 2.0 [-]
- Distribution ratio for ammonium below rootzone
- The value is given to all layers below the rootzone.
------------------------ in- and outgoing Nitrogen and Carbon --------
COPRNH = 0.00127 [kg N.m-3 water]
COPRNI = 0.00078 [kg N.m-3 water]

- Concentrations of NH4-N and NO3-N in the precipitation.
- Values are given by Jansen (1983): NH4-N en NO3-N concentraties in the precipitation measured in Eindhoven over the period 1978-1980.

DRDEPNH = 12.0 [kg.ha-1]
- Atmospheric dry deposition of NH4-N

DRDEPNI = 8.0 [kg.ha-1]
- Atmospheric dry deposition of NO3-N
- Deposition was estimated as 20 kg.ha-1, division over NH4 and NO3 according to NIMWAG (1985)

COIDNH = 0.004 [kg.m-3]
- Concentration of NH4-N in infiltrating drainwater

COIDNI = 0.00015 [kg.m-3]
- Concentration of NO3-N in infiltrating drainwater

COIDCA = 0.0 [kg.m-3]
- Concentration of soluble organic matter in infiltrating drainwater
- Steenvoorden (1987) gives measured values of N-concentrations of inlet-water in this area; inlet-water originates from the river Maas.

FRVOTN(1-NT) = 0.20 0.32 0.32 0.32 [-]
- Fraction of added NH4-N that volatilizes.
- Based on data given by Lammers (1984)

------------------------ for regional (SIMGRO) applications ----------

HEAQ = 8.0 [m]
- Thickness of regional profile (part of aquifer below imaginary boundary (see par. 3.3)
- With a special program this imaginary boundary was determined according to the principals explained in par. 3.3.

SPU = 3 [-]
- Soil physical unit of the subregion.
- Same value as used in SIMGRO; only used to determine the initial moisture deficit under the rootzone.

ARTN(1-NT) = 0.45 0.15 0.30 0.10 [-]
- The fraction of each technology of the subregion.
- Same value as used in SIMGRO.

COEXNH = 0.004 [kg N.m-3 water]

COEXNI = 0.00015 [kg N.m-3 water]
- Concentrations of NH4-N and NO3-N in external surface waters
- Steenvoorden (1987) gives measured values of N-concentrations of inlet-water in this area; inlet-water originates from the river Maas.

------------------------ for grassland (KC=3) applications -----------

NRGRTN(1-12) = 0.0 4.0 3.4 0.0 [lsu.ha-1]
- Number of livestock units per ha if the kind of crop is grass.
- Derived from the 'landbouwmeitellingen 1982' and determined for each grassland-technology by Van Walsum (1988).

Filename: INI(1-NA).DAT

The initial soil profile was determined for the situation around the year 1950. All other initial files were results of ANIMO-simulations. This initialization can easily be done because ANIMO creates output-files INIT(1-NA).DAT which can be transferred into INI(1-NA).DAT This description only explains the initialization in 1950.

For each subregion the input-parameters were created with a special program. All parameters given below were determined per technology. The parameters OS, HUOS, and HUEX for the layers 1 to 7 (0-1 m-surface) received values from Cranendonck (see appendix C).

MOFRO(1-NT,1-NL) = ... [m3 water.m-3 soil]
- Moisture fractions of the layers 1 to NL at the beginning of a tstep
- Dummy-values of 0.0 have been used because the initial moisture fractions are calculated by the subroutine INIMO (see parameter INMO in file GENERAL.DAT).

EX(1-NT,1-NL) = ... [kg.m-2 soil]
- Exudate content of layers 1 to NL
- De amount of exudates present has been estimated as 0.0 kg. Low amounts and high decomposition rates make this acceptable.

HUEX(1-NT,1-NL) = ... [kg.m-2 soil]
- Amount of humus from exudates present in layers 1 to NL.
- Layer 1 till 7 values from Cranendonk; for layers > 1m-mv: HUEX=0.0.

CONH(1-NT,1-NL) = ... [kg N.m-3 soil solution]
- Concentration of NH4-N in the layers 1 to NL; set to 0.0

CONI(1-NT,LN) = ... [kg N.m-3 soil solution]
- Concentration of NO3-N in the layers 1 to NL.
- Only for the layers 1-7 values for Cranendonck were used, lower layers were asumed to contain no NO3-N and NH4-N. (for the technology nature (technology nr 4) NO3-N concentrations were reduced.

OS(1-NL,1-NF) = [kg dry matter.m-2 soil]
- Amount of fresh organic matter present in layers 1 to NL for fractions 1 to NF.
- The organic fraction 6 (parameter FR, file GENERAL.DAT) was used for the organic matter in the subsoil; therefore only this fraction received values according to the following restrictions, also given by Drent (1988):
  * For the layers 8 till 11 (rest of toplayer, Nuenen-formatie): an organic matter content was found of 0.46%
  * For the layers 12 and 13 (1st aquifer, Veghel/Sterksel-formatie): an organic matter content was found of 0.08%

HUOS(1-NL,1-NF) = [kg dry matter.m-2 soil]
- Amount of humus from fresh organic matter and soluble organic matter present in layers 1 to NL for fractions 1 to NF.
- Layer 1 till 7 values from Cranendonk; for layers > 1m-mv: HUEX=0.0.

COCA(1-NL,1-NF) [kg dry matter.m-3 soil solution]
- Concentration of soluble organic matter.
- zero's were given (fast decomposition).

COAQNH = 0.0 [kg N.m-3 water]
- Concentration of NH4-N in the aquifer.

COAQNI = 0.0 [kg N.m-3 water]

- Concentration of NO3-N in the aquifer.
- NO3-N and NH4-N were estimated as 0.0 for all subregions. (Drent,1988)

Filename: SIMGROQ.DAT

This file contains the results of the waterquantity-model SIMGRO. It is a direct-access file, which is read in the subroutine READFEM. SIMGRO adds an extra timestep for the initial calculations.

```
For each timestep the following parameters:
EVMATN(1-NT) =      .....                       [m3 water.m-2 soil.d-1]
- Maximal evapotranspiration flux for each technology (1-NT)
  For each subregion AN
  PR =         .....                            [m3 water.m-2 soil.d-1]
  - Precipitation flux.
  WAEX =       .....                            [m3 water.m-2 soil.d-1]
  - External (from outside the area) water-supply; positive=supply
  IRSU =       .....                                               [-]
  - Fraction of the irrigation which originates from surface waters.
  FG =         .....                            [m3 water.m-2 soil.d-1]
  - Third order drain-flux (ditches, trenches, field drains)
  - positive = draninage,  negative = infiltration
  FS =         .....                            [m3 water.m-2 soil.d-1]
  - Second order drain-flux (ditches)
  FK =         .....                            [m3 water.m-2 soil.d-1]
  - First order drain-flux (canals).
  LEAK =       .....                            [m3 water.m-2 soil.d-1]
  - Discharge to layers below model-profile (leakage to aquifer)
  - positive = leakage,  negative = seepage
  WALET =      .....                                   [m-soil surface]
  - Depth of groundwater table at the end of the timestep.
  STRG =       .....                            [m3 water.m-2 soil.d-1]
  - storage due to differences in groundwaterlevel at the beginning and
    at the end of a tstep.
    For each technology:
    EVTN(1-NT) =         .....                  [m3 water.m-2 soil.d-1]
    - Evapotranspiration flux
    IRTOTN(1-NT) =       .....                  [m3 water.m-2 soil.d-1]
    - irrigation from surface- and groundwater
    MOCOROTTN(1-NT) =    .....                      [m3 water.m-2 soil]
    - Moisture content (volume) of the rootzone at the end of the tstep
    PETN(1-NT) =         .....                  [m3 water.m-2 soil.d-1]
    - Percolation flux (flux from unsaturated to saturated zone)
```

Filename: SIMGRO.FLW

This file contains results of the waterquantity-model SIMGRO. It gives water-quantities on a year-base concerning the fluxes in the first aquifer. The parameter values are read and used in the subroutine AQUIFER.

NAOUT = 1
- Number of outer regions (regions limiting the whole region)

For each subregion AN:
  ANLI(AN,1-10) = ... [-]
  - subregion-nrs of limiting subregions (max=6)
  NALI(AN) = ... [-]
  - number of limiting subregions

For each subregion AN:
  FLAQIN(AN,1-NALI) = ... [m3]
  - Lateral flow into the aquifer coming from limiting subregions (positive values)

For each subregion AN:
  FLAQOU(AN,1-NALI) = ... [m3]
  - Lateral flow out of the aquifer towards limiting subregions (negative values)

LEAKAQ(1-NA) = ... [m3]
- For each subregion the leakage flow from the 1st aquifer towards layers below (pos. values)

SEEPAQ(1-NA) = ... [m3]
- For each subregion the seepage flow into the 1st aquifer from layers below (negative values).

Filename: CAPSEVPF.DAT

This file contains results of the model CAPSEV. The parameter values are read and used in the subroutine READFEM

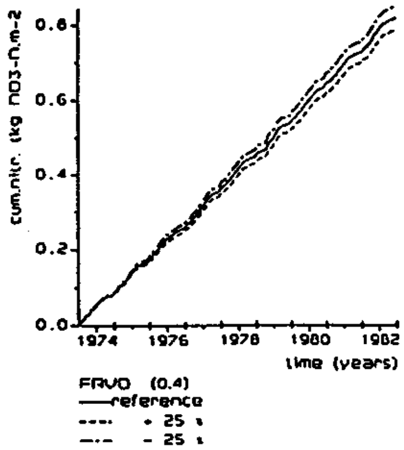
WALEUN(1-17) = ... [cm-soil surface]
- water level below soil surface

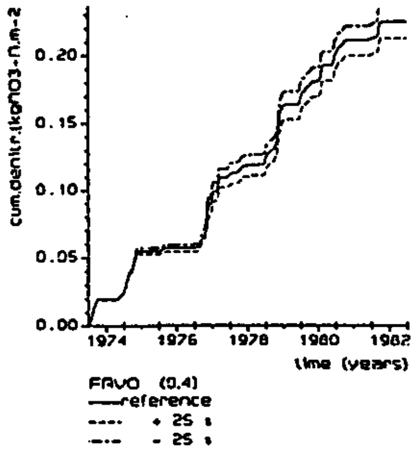
For every soil physical unit I (Bloemen, 1982 and Querner, 1984):
  MOCOUN(I,1-17) = ... [mm]
  - moisture content related to WALEUN(1-17).

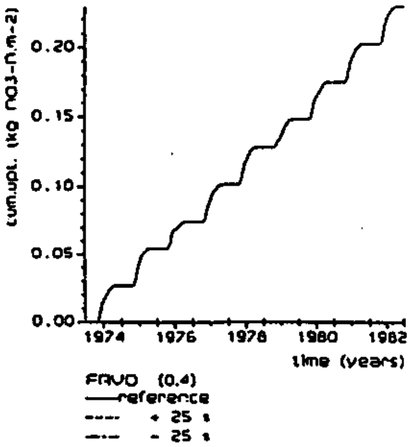
Filename: ADDIT.DAT

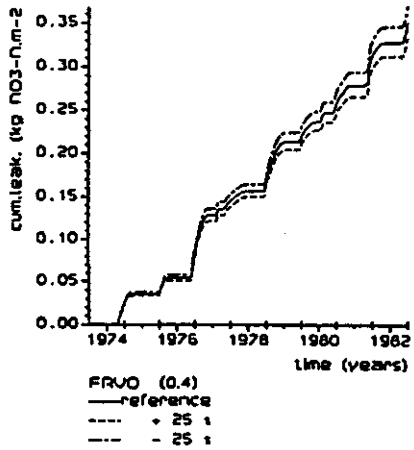
This file contains parameter-values for manure-additions. The values are read in the subroutine INPUT and used in the subroutine MANURE.

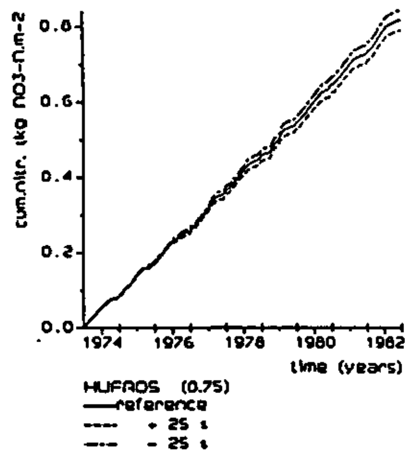
For each subregion AN
  For technologies TN
    AN = ... [-]
    - Subregion-nr for which manure-values are given
    TN = ... [-]
    - Technology-r for which manure-values are given
    QUMTFS(AN,TN) = ... [kg.ha-1]
    - Quantity of material fertilizer applied in spring
    QUMTMS(AN,TN,1-5) = ... [kg.ha-1]
    - Quantity of the 5 kinds of organic manure applied in spring
    QUMTMW(AN,TN,1-5) = ... [kg.ha-1]
    - Quantity of the 5 kinds of organic manure applied in winter

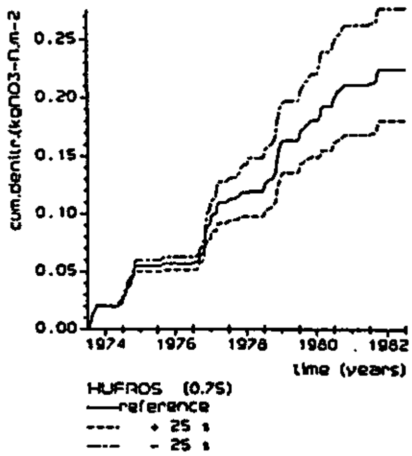

cum.nitr. (kg NO3-N.m-2)
0.0
0.2
0.4
0.6
0.8
1974
1976
1978
1980
1982
time (years)
FRVO (0.4)
—reference
---- + 25 %
-·-· - 25 %

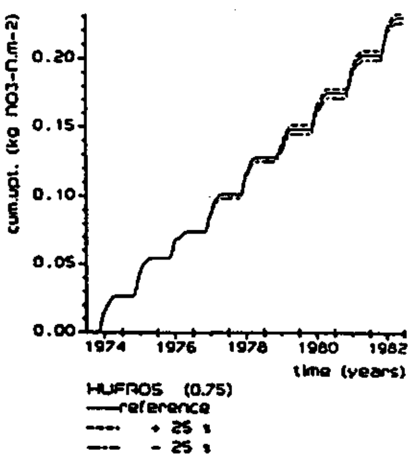

cum.denitr.(kgNO3-N.m-2
0.00
0.05
0.10
0.15
0.20
1974
1976
1978
1980
1982
time (years)
FRVO (0.4)
—reference
---- + 25 %
-·-· - 25 %

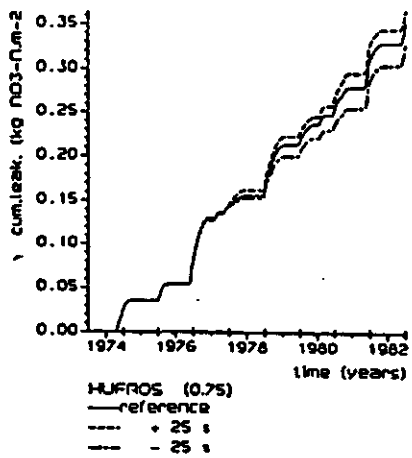

cum.upt. (kg NO3-N.m-2)
0.00
0.05
0.10
0.15
0.20
1974
1976
1978
1980
1982
time (years)
FRVO (0.4)
—reference
---- + 25 %
-·-· - 25 %

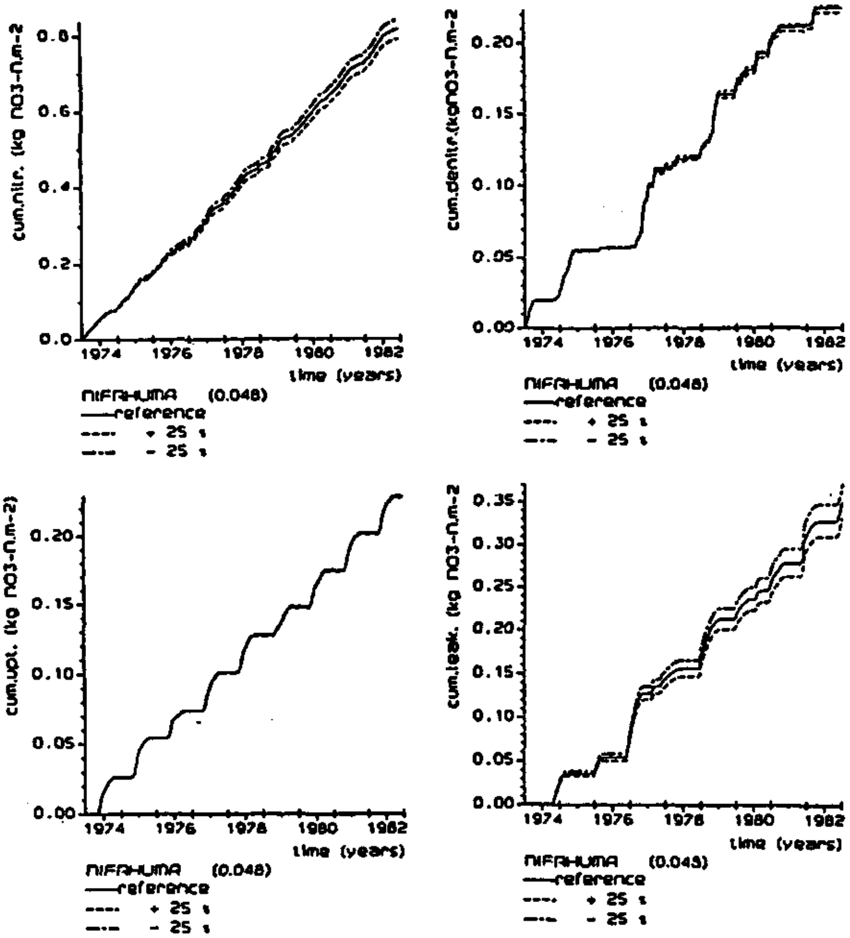

cum.leak. (kg NO3-N.m-2
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
1974
1976
1978
1980
1982
time (years)
FRVO (0.4)
—reference
---- + 25 %
-·-· - 25 %

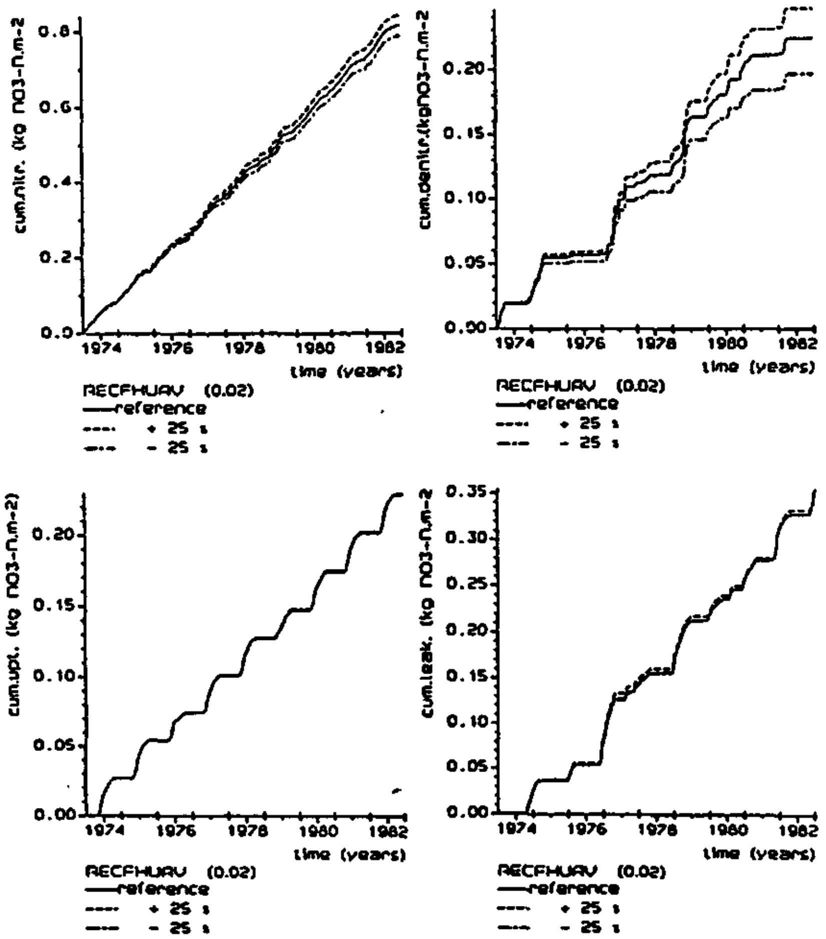

cum.nitr. (kg NO3-N.m-2
0.0
0.2
0.4
0.6
0.8
1974
1976
1978
1980
1982
time (years)
HUFROS (0.75)
—reference
---- + 25 %
-·-· - 25 %

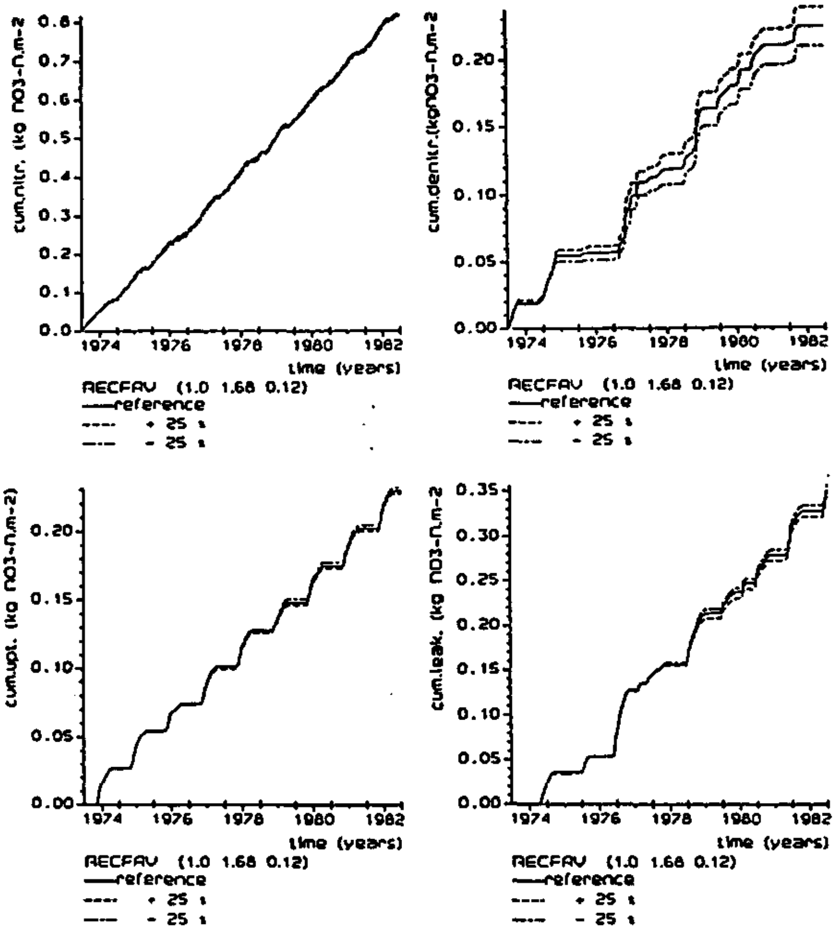

cum.denitr.(kgNO3-N.m-2
0.00
0.05
0.10
0.15
0.20
0.25
1974
1976
1978
1980
1982
time (years)
HUFROS (0.75)
—reference
---- + 25 %
-·-· - 25 %

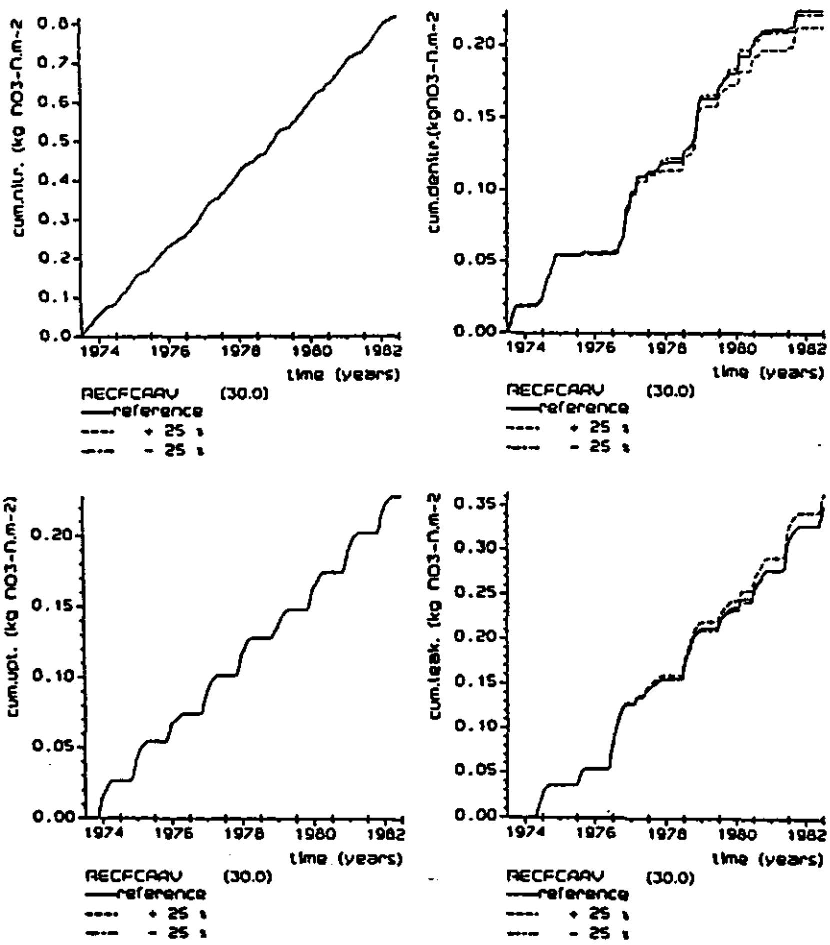

cum.upt. (kg NO3-N.m-2)
0.00
0.05
0.10
0.15
0.20
1974
1976
1978
1980
1982
time (years)
HUFROS (0.75)
—reference
---- + 25 %
-·-· - 25 %

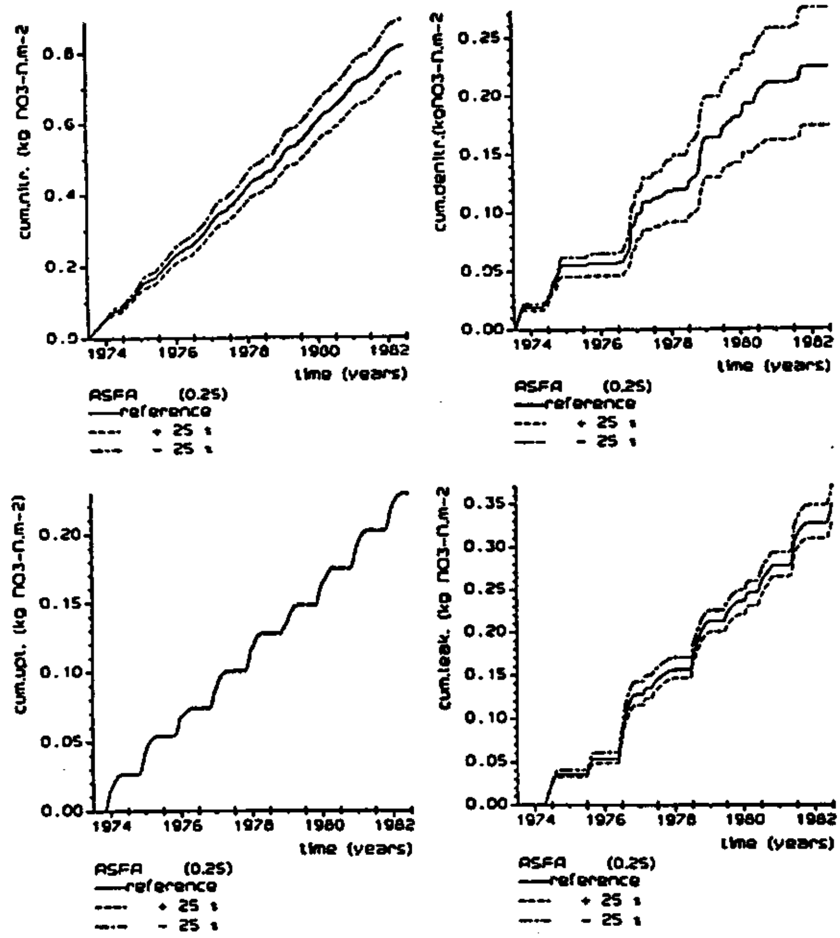

cum.leak. (kg NO3-N.m-2
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
1974
1976
1978
1980
1982
time (years)
HUFROS (0.75)
—reference
---- + 25 %
-·-· - 25 %

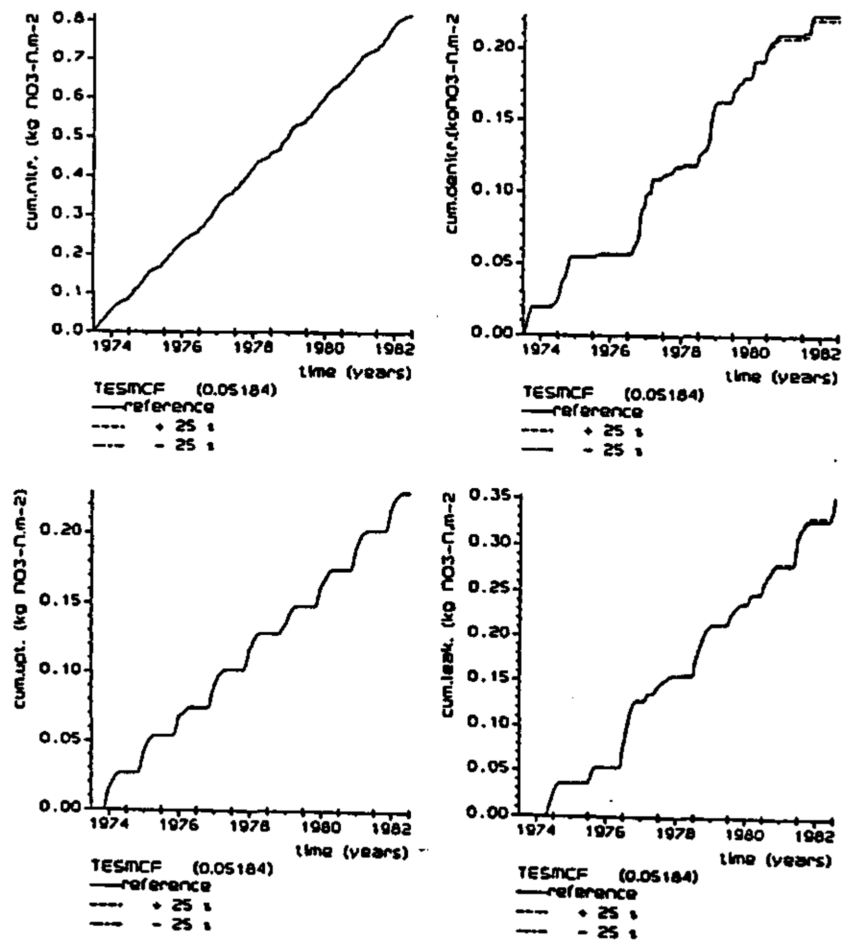

cum.nitr. (kg NO3-N.m-2)
cum.denitr.(kgNO3-N.m-2
cum.upt. (kg NO3-N.m-2)
cum.leak. (kg NO3-N.m-2
time (years)
NIFRHUMA (0.048)
reference
+ 25 %
- 25 %

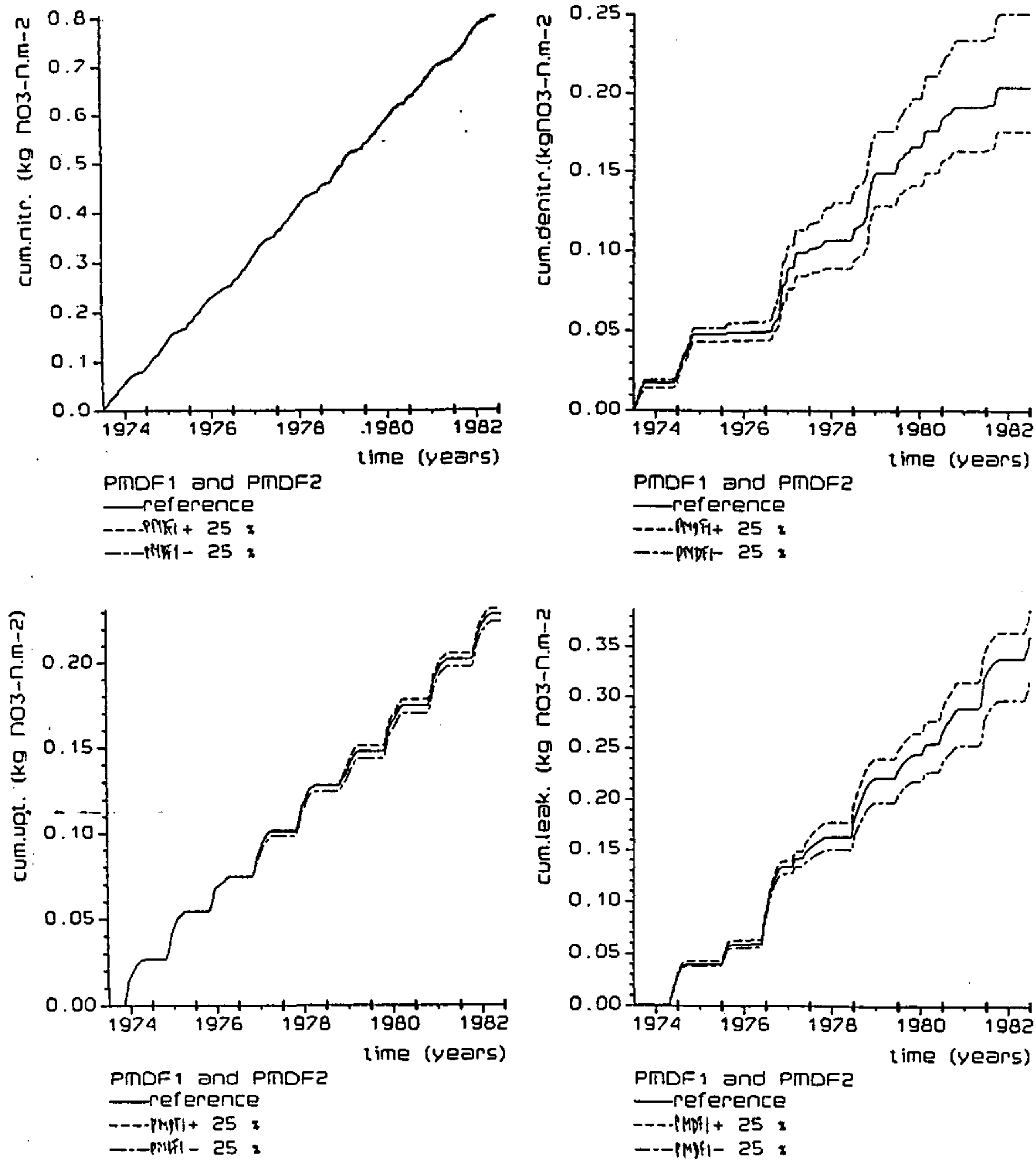

cum.nitr. (kg NO3-N.m-2
cum.denitr.(kgNO3-N.m-2
cum.upt. (kg NO3-N.m-2)
cum.leak. (kg NO3-N.m-2
time (years)
RECFHUAV (0.02)
reference
+ 25 %
- 25 %

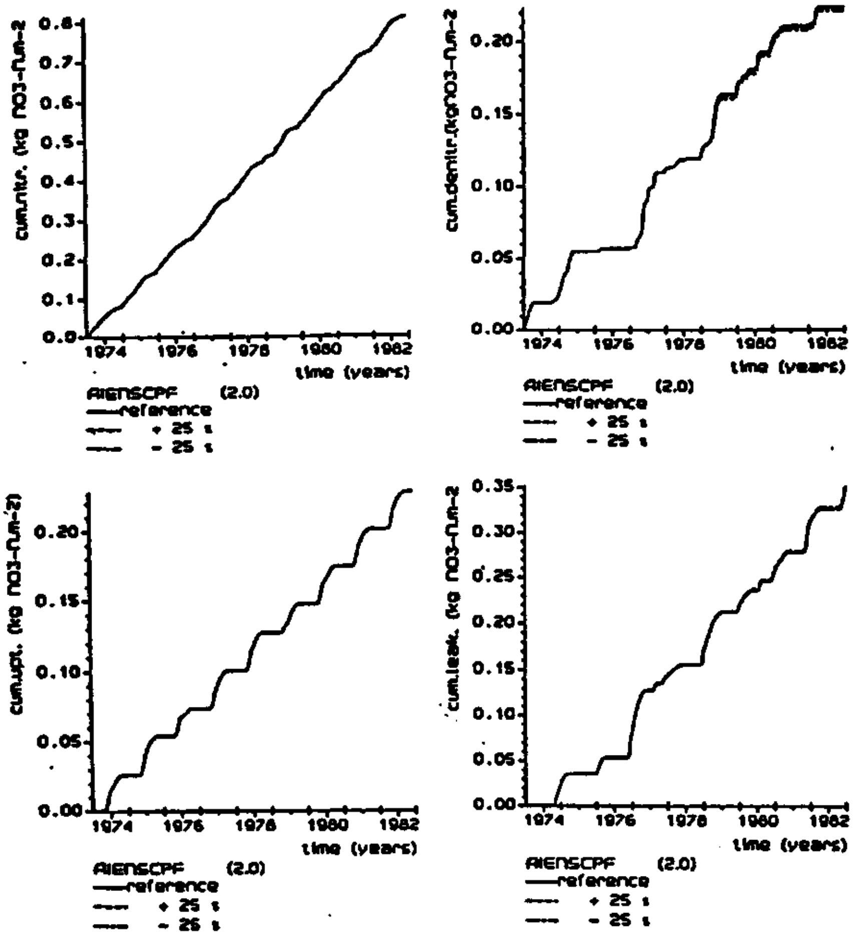

cum.nitr. (kg NO3-N.m-2)
time (years)
RECFAV (1.0 1.68 0.12)
reference
+ 25 %
- 25 %
cum.denitr.(kgNO3-N.m-2
time (years)
RECFAV (1.0 1.68 0.12)
reference
+ 25 %
- 25 %
cum.upt. (kg NO3-N.m-2)
time (years)
RECFAV (1.0 1.68 0.12)
reference
+ 25 %
- 25 %
cum.leak. (kg NO3-N.m-2
time (years)
RECFAV (1.0 1.68 0.12)
reference
+ 25 %
- 25 %

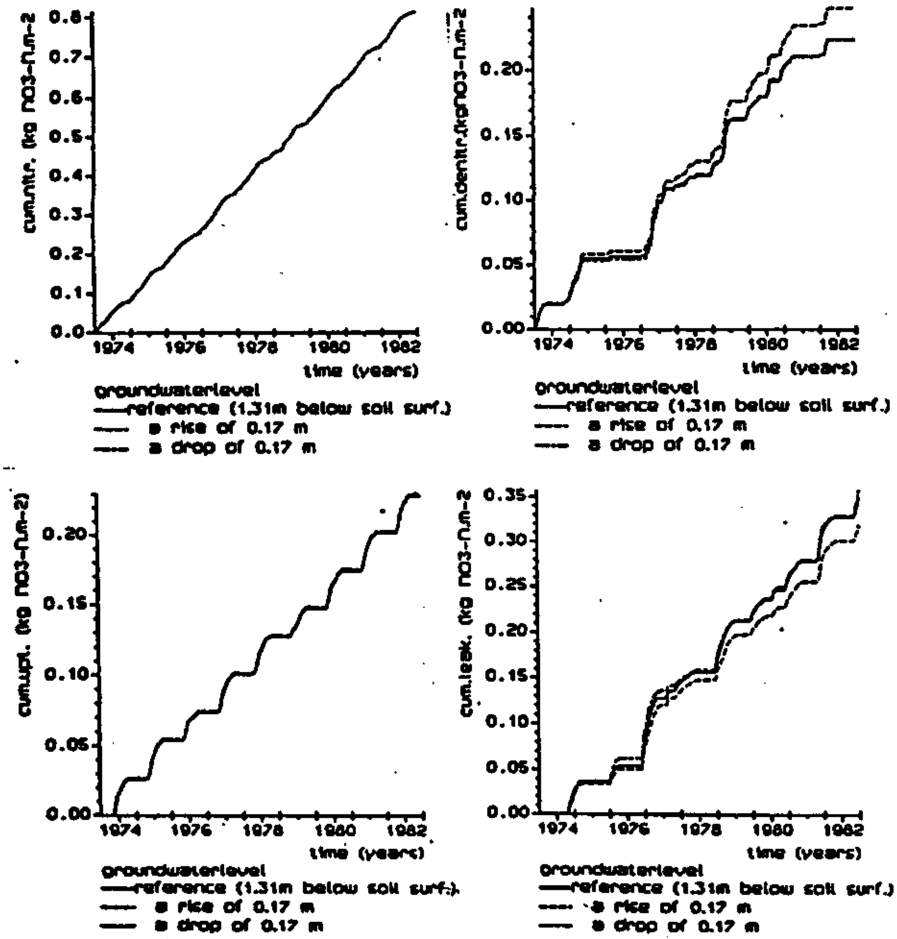

cum.nitr. (kg NO3-N.m-2
time (years)
RECFCAAV (30.0)
reference
+ 25 %
- 25 %
cum.denitr.(kgNO3-N.m-2
time (years)
RECFCAAV (30.0)
reference
+ 25 %
- 25 %
cum.upt. (kg NO3-N.m-2)
time (years)
RECFCAAV (30.0)
reference
+ 25 %
- 25 %
cum.leak. (kg NO3-N.m-2
time (years)
RECFCAAV (30.0)
reference
+ 25 %
- 25 %


cum.nitr. (kg NO3-N.m-2)
cum.denitr.(kgNO3-N.m-2
cum.upt. (kg NO3-N.m-2)
cum.leak. (kg NO3-N.m-2
time (years)
ASFA (0.25)
—reference
---- + 25 %
--- - 25 %


cum.nitr. (kg NO3-N.m-2
cum.denitr.(kgNO3-N.m-2
cum.upt. (kg NO3-N.m-2)
cum.leak. (kg NO3-N.m-2
time (years)
TESMCF (0.05184)
—reference
---- + 25 %
--- - 25 %


cum.nitr. (kg NO3-N.m-2
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
1974 1976 1978 1980 1982
time (years)
PMDF1 and PMDF2
reference
PMDF1 + 25 %
PMDF1 - 25 %
cum.denitr.(kgNO3-N.m-2
0.00 0.05 0.10 0.15 0.20 0.25
1974 1976 1978 1980 1982
time (years)
PMDF1 and PMDF2
reference
PMDF1 + 25 %
PMDF1 - 25 %
cum.upt. (kg NO3-N.m-2)
0.00 0.05 0.10 0.15 0.20
1974 1976 1978 1980 1982
time (years)
PMDF1 and PMDF2
reference
PMDF1 + 25 %
PMDF1 - 25 %
cum.leak. (kg NO3-N.m-2
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
1974 1976 1978 1980 1982
time (years)
PMDF1 and PMDF2
reference
PMDF1 + 25 %
PMDF1 - 25 %


cum.nitr. (kg NO3-N.m-2)
cum.denitr.(kgNO3-N.m-2
cum.upt. (kg NO3-N.m-2)
cum.leak. (kg NO3-N.m-2
time (years)
AIENSCPF (2.0)
reference
+ 25 %
- 25 %


cum.nitr. (kg NO3-N.m-2
cum.denitr.(kgNO3-N.m-2
cum.upt. (kg NO3-N.m-2)
cum.leak. (kg NO3-N.m-2
time (years)
groundwaterlevel
reference (1.31m below soil surf.)
a rise of 0.17 m
a drop of 0.17 m

APPENDIX F: unit-nrs in ANIMO

```
Subroutine: ADDIT.FOR
      OPEN(UNIT=49,FILE='ADDITNI.OUT',STATUS='NEW')
      OPEN(UNIT=50,FILE='ADDITNH.OUT',STATUS='NEW')
      OPEN(UNIT=52,FILE='ADDITPO.OUT',STATUS='NEW')
Subroutine: AQUIFER.FOR
D     OPEN(UNIT=45,FILE='AQUIFER.OUT',STATUS='NEW')
Subroutine: BALANCE.FOR
D     OPEN(UNIT=47,FILE='BALANCE.OUT',STATUS='NEW')
Subroutine: CDSYS.FOR
      OPEN(UNIT=81, FILE=CDS.....DAT, STATUS='NEW'                  !local
Subroutine: GRASS.FOR
      OPEN(UNIT=90,FILE='GRASS1.OUT',STATUS='NEW')
      OPEN(UNIT=91,FILE='GRASS2.OUT',STATUS='NEW')
Subroutine: HYDRO.FOR
D     OPEN(UNIT=48, FILE='HYDRO.OUT', STATUS='NEW')
Subroutine: INPUT.FOR
      OPEN(UNIT=20,FILE='GENERAL.DAT',STATUS='OLD')                 !local
      OPEN(UNIT=24,FILE='ADDIT.DAT',STATUS='OLD')
      OPEN (UNIT=27, FILE='SIMGROQ.DAT', STATUS='OLD',
      OPEN(UNIT=27,FILE='WATBAL.DAT',STATUS='OLD', FORM='UNFORMATTED')
      OPEN(UNIT=27,FILE='SWATRE.DAT',STATUS='OLD', FORM='UNFORMATTED')
      OPEN(UNIT=27,FILE='DEMGEN.DAT',STATUS='OLD', FORM='UNFORMATTED')
      OPEN (UNIT=70, FILE='ADDIT.DAT', STATUS='OLD')
      OPEN (UNIT=21, FILE='AREA.DAT', STATUS='OLD')                 !local
      OPEN(UNIT=22, FILE='INI.DAT', STATUS='OLD')                   !local
      OPEN(UNIT=22,FILE='SIMGRO.FLW', STATUS='OLD')                 !local
Subroutine: MASSBAL.FOR
      OPEN(UNIT=12,FILE='MASSBAL.OUT',STATUS='NEW')
Subroutine: OUTPUT1.FOR
      OPEN (UNIT=25, FILE='TOUT.DAT', STATUS='NEW')
Subroutine: READFEM.FOR
      OPEN (UNIT=44,FILE='CAPSEVPF.DAT',STATUS='OLD')               !local
D     OPEN(UNIT=97, FILE='READFEM.OUT', STATUS='NEW')
Subroutine: SELECT.FOR
      OPEN (UNIT=30, FILE='NITRATE.DAT', STATUS='NEW',
D     OPEN(UNIT=36, FILE='DIC.DAT', STATUS='NEW')
      OPEN(UNIT=31, FILE='AMMONIUM.DAT', STATUS='NEW',
      OPEN(UNIT=32, FILE='OMS.DAT', STATUS='NEW',
      OPEN(UNIT=33, FILE='UPTAKE-N.DAT', STATUS='NEW',
      OPEN(UNIT=34, FILE='MINER-N.DAT', STATUS='NEW',
      OPEN(UNIT=35, FILE='TOTAL-N.DAT', STATUS='NEW',
      OPEN(UNIT=37, FILE='TOMNNITO.DAT', STATUS='NEW',
      OPEN(UNIT=38, FILE='RDFA.DAT', STATUS='NEW',
      OPEN(UNIT=39, FILE='BANIYR.DAT', STATUS='NEW')
      OPEN(UNIT=40, FILE='BANHYR.DAT', STATUS='NEW')
      OPEN(UNIT=41, FILE='BAWAYR.DAT', STATUS='NEW')
      OPEN(UNIT=42, FILE='BANIST.DAT', STATUS='NEW')
      OPEN(UNIT=43, FILE='BANHST.DAT', STATUS='NEW')
      OPEN(UNIT=44, FILE='BAPOYR.DAT', STATUS='NEW')
      OPEN(UNIT=46, FILE='BAPOST.DAT', STATUS='NEW')
Subroutine: TRANSFERT.FOR
      OPEN (UNIT=22,FILE='INIT.DAT',STATUS='NEW')                   !local
```

APPENDIX G: example of dimension-statements for a regional ANIMO-PC-version (file: PARAM.FOR)

```
C                                    maximum number of additions within one tstep
      PARAMETER (MAAD = 7)
C                                    maximum kind of crops
      PARAMETER (MAKC = 6)
C                                    maximum number of areas
      PARAMETER (MANA = 5)
C                                    maximum number of organic fractions
      PARAMETER (MANF = 10)
C                                    maximum number of layers
      PARAMETER (MANL = 15)
C                                    maximum number of materials
      PARAMETER (MANM = 9)
C                                    maximum number of technologies
      PARAMETER (MANT = 4)
```