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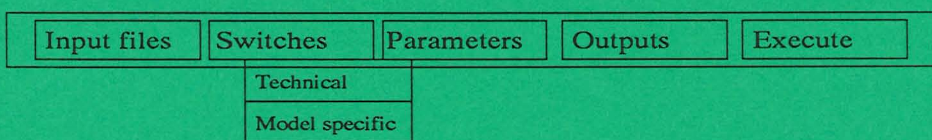
SOIL model
User's Manual



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Department of Soil Sciences
Division of Agricultural Hydrotechnics

Avdelningsmeddelande 91:7
Communications

Uppsala 1991
ISSN 0282-6569
ISRN SLU-HY-AVDM--91/7--SE

Denna serie meddelanden utges av Avdelningen för lantbrukets hydroteknik, Sveriges Lantbruksuniversitet, Uppsala. Serien innehåller sådana forsknings- och försöksredogörelser samt andra uppsatser som bedöms vara av i första hand internt intresse. Uppsatser lämpade för en mer allmän spridning publiceras bl a i avdelningens rapportserie. Tidigare nummer i meddelandeserien kan i mån av tillgång levereras från avdelningen.

This series of Communications is produced by the Division of Agricultural Hydrotechnics, Swedish University of Agricultural Sciences, Uppsala. The series concists of reports on research and field trials and of other articles considered to be of interest mainly within the department. Articles of more general interest are published in, for example, the department's Report series. Earlier issues in the Communications series can be obtained from the Division of Agricultural Hydrotechnics (subject to availability).

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Input files	Switches	Parameters	Outputs	Execute
	Technical			
	Model specific			

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Table of Contents

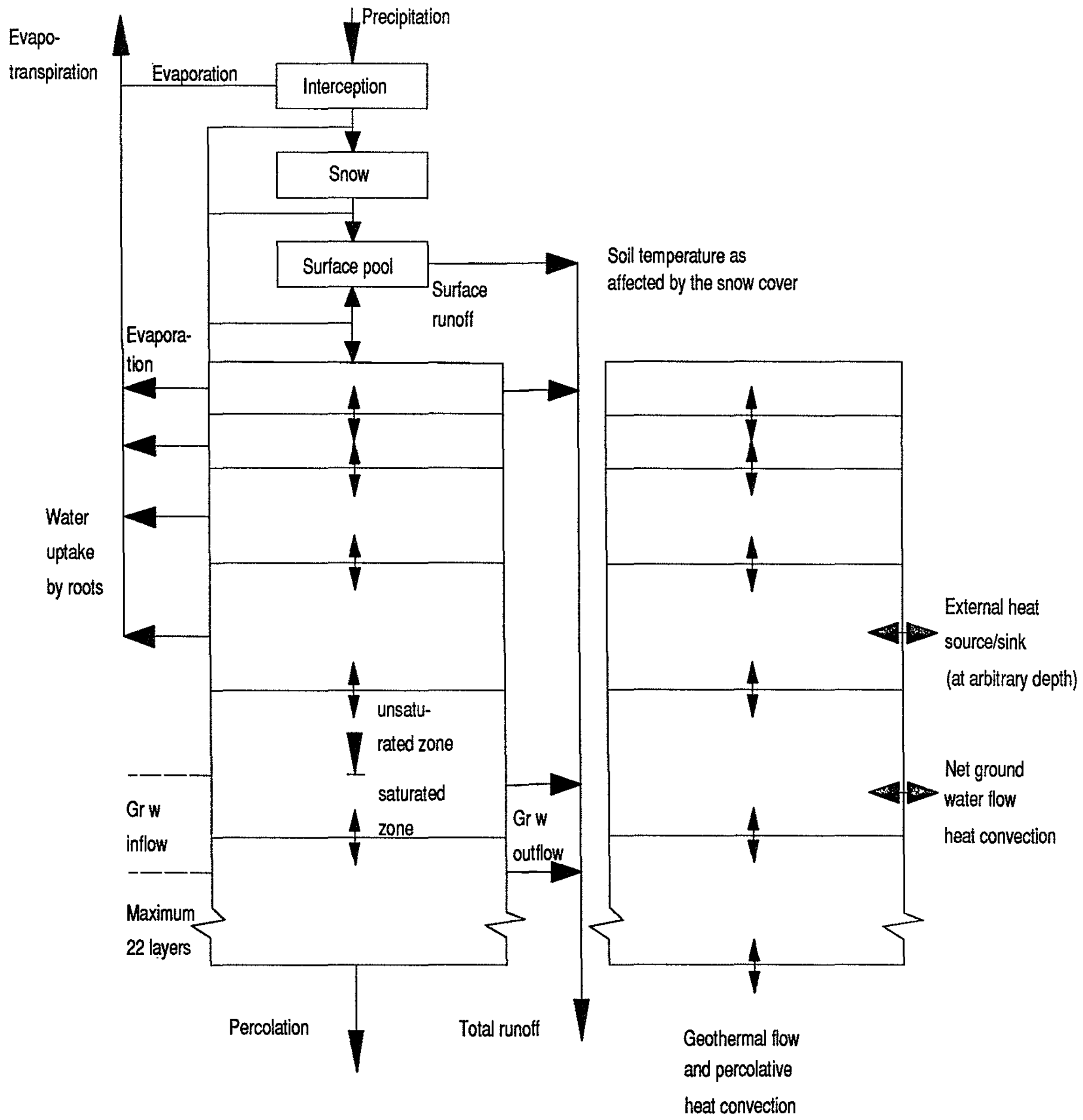
1 Background

An efficient use of simulation models requires a good and "friendly" interface between the computer program and the user. This requirement is especially important if the model includes many options and parameters as is the case for the SOIL model. The SOIL model has been, as with many other hydrological and ecological models, developed during a long period with step wise changes to broaden the applicability of the model. This means that a great number of versions of the models exist. An earlier version of the model (Jansson & Halldin, 1979) was included in the simulation package SIMP (Lohammar, 1979) and input/output data to the model were handled with the ECODATA system (Svensson, 1979). The linkage to the SIMP and ECODATA systems constrained the use of the earlier version of the model to PDP and later on to VAX computers. To enable utilization of other type of computer and to improve the user interface both the SOIL and the SOILN models were adapted to a new system developed for PC-computer during 1988. That system had a number of similarities with the SIMP system but major differences exist in the way the dynamic part of the model is integrated into the parts which handle the initial and final sessions of a simulation.

The present computer program are developed to introduce a totally new way of preparing simulations which should be easy and flexible to use.

The detailed descripton of the equations and the basic assumptions included in the SOIL model is found in the technical description by Jansson (1991). This document is only for how to run the model on the computer.

1.1 Structure of the model



Mass balance (left) and heat balance (right) of the SOIL model.

The SOIL model represents, in one dimension, water and heat dynamics in a layered soil profile covered with vegetation. As the solution to model equations is performed with a finite difference method, the soil profile is divided into a finite number of layers. Compartments for snow, intercepted water and surface ponding are included to account for processes at the upper soil boundary. Different types of lower boundary conditions can be specified including saturated conditions and ground water flow.

2 Getting started

2.1 Installation

The model is normally distributed with a special floppy diskette used for installation. Two different installation diskette can be used depending whether you are a previous user of the Pgraph program or not.

SOIL	requires that the Pgraph program is installed on your computer.
SOILDEMO	contains a demo version of Pgraph called PGDEMO that can be used for testing and using the SOIL model with the supplied data files.

Independent of which diskette you have got you will use the same command for installation which is found on the diskette:

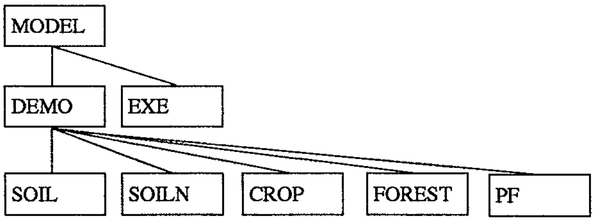
Type the command: $\boxed{\text{A:INSTALL A: C: MODEL}}$

if you have inserted the diskette into a floppy disk drive named A: and you would like to install the model on your hard disk C: with one directory tree MODEL.

In addition to the SOIL model also files for running the SOILN model are normally included on the distribution diskette.

2.2 Files

The installation procedure will create one main directory below which the program files are stored in one subdirectory (named EXE) and the different applications in one directory each.



Directory	Files	Description
MODEL EXE		
	SOILN.EXE	Executable file, SOILN model
	SOILN.DEF	Definition file, SOILN model
	SOILN.HLP	Help file, SOILN model
	SOILN.TRA	Variable name translation file, SOILN
	SOILNFOR.TRA	Variable name translation file, SOILN, special for the FORESTSR submodel
	PREP.EXE	Executable file, PREP program
	PGDEMO.EXE	Executable file, Pgraph program (only if the SOILDEMO diskette is used)
	PG.HLP	Help file, Pgraph program (only if the SOILDEMO diskette is used)
	SOIL.EXE	Executable file, SOIL model
	SOIL.DEF	Definition file, SOIL model
	SOIL.HLP	Help file, SOIL model
	SOIL.TRA	Variable name translation file, SOIL
	PLOTPF.EXE	Executable file, PLOTPF program
	PLOTPF.HLP	Help file, PLOTPF program
MODEL DEMO SOIL		
	DEMO.BAT	Demo file for running the SOIL model and using the PG program for visualizing some results on the screen.
	CLIMATE.BIN	PG-file with climate data for running the model.
	SOILP.DAT CLAY.DAT SAND.DAT	Files with soil hydraulic properties.
	THCOEF.DAT	Files with soil thermal properties.
	SITEPROF.DBA SITEPROF.DBB	Data base with soil physical properties from some selected sites. Use the PLOTPF program to investigate the soils in the data base and to create new data sets with soil physical properties.

ANASOL.PAR	Parameter file for simulating the daily variation of soil temperature in a homogeneous soil profile.
FROST.PAR	Parameter file for simulating the behaviour of a freezing and thawing of the soil.
EVAPO.PAR	Parameter file for simulating the water balance of an agricultural crop during a growing season using climate data from the CLIMATE.BIN file.
YEAR.PAR	Parameter file for simulating the annual course of water and heat flow in an agricultural soil using climate data from the CLIMATE.BIN file.
DRIVN.PAR	Parameter file for creating a driving variable file for the SOILN model.
INFSAND.PAR INFCLAY.PAR	Parameter files for simulating infiltration and redistribution of water in homogeneous soil profiles.
DEMO_S.IN PF.IN	Input files for Pgraph and PlotpF. Used in the DEMO.BAT file.

MODEL
DEMO
SOILN

DEMO.BAT	Demo file for running the SOILN model and using the PG program for visualizing some results on the screen.
DEMO_F.INI	Initial conditions for running the SOILN model.
DEMO_F.PAR	Parameter file for simulating nitrogen dynamics of an agricultural crop during a growing season using driving variables from the DRIV_N.BIN file. The nitrogen demand from the crop is simulated.
DEMO_SOI.PAR	An extra parameter file including changes of DEMO_F.PAR so as to give outputs suitable for the soil presentations.
DEMOXXXX.PG	Input files for PG used in the DEMO.BAT file for showing results from the simulation.
DEMO_FF.BIN	PG-file with climate data for running the SOILN model. The same as DEMO_F.bin but comprising a shorter period.
DEMOZXXX.BIN	Files with modified output variables from the simulation examples aimed to be plotted on screen.
SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.
SOILP.DAT	Files with soil hydraulic properties.

MODEL
DEMO
CROP

DEMO.BAT	Demo file for running the SOILN model using the CROP submodel and with help of the PG program visualizing some results on the screen.
DEMO_C.INI	Initial conditions for running the SOILN model.
DEMO_C.PAR	Parameter file for simulating nitrogen dynamics of an agricultural crop during a growing season using driving variables from the DRIV_N.BIN file. The nitrogen demand from the crop is simulated.
DEMO_CHA.PAR	An extra parameter file including changes of DEMO_C.PAR.

DEMOXXXX.PG	Instruction files for PG used in the DEMO.BAT file when showing results from the simulation.
DEMO_C.BIN	PG-file with climate data for running the SOILN model.
DEMOZXXX.BIN	Files with modified output variables from the simulation examples aimed to be plotted on screen.
SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.
SOILP.DAT	Files with soil hydraulic properties.

MODEL
DEMO
FOREST

DEMO.BAT	Demo file for running the SOILN model using the CROP submodel and with help of the PG program visualizing some results on the screen.
DEMO_F.INI	Initial conditions for running the SOILN model.
DEMO_F.PAR	Parameter file for simulating nitrogen dynamics of an agricultural crop during a growing season using driving variables from the DRIV_N.BIN file. The nitrogen demand from the crop is simulated.
DEMO_CHA.PAR	An extra parameter file including changes of DEMO_F.PAR.
DEMOXXXX.PG	Input files for PG used in the DEMO.BAT file for showing results from the simulation.
DEMO_F.BIN	PG-file with climate data for running the SOILN model.
DEMOZXXX.BIN	Files with modified output variables from the simulation examples aimed to be plotted on screen.
SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.
SOILNFOR.AUT	Annual values of accumulated flows (ASCCII)
SOILP.DAT	Files with soil hydraulic properties.

MODEL
DEMO
PF

PFPROF.DBA PFPROF.DBB	Swedish data base with soil physical properties. Use the PLOTPF program to investigate the soils in the data base and to create new data sets with soil physical properties.
MXX.PFN	Comments to the SOIL physical properties from a site XX.

2.3 Running the model

Before running the model you must make sure that the model and utility programs are correctly installed on your computer. The directory called EXE created by the installation procedure may be renamed or the file may be moved to another directory but it is important that PATH is set to the directory where all the files of the EXE directory is stored. After setting this PATH (most conveniently in the AUTOEXEC.BAT file) you can run the model by using the sample files in the SIMDEMO directory.

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

For running the program interactively use commands as specified in the section 11 Commands in the manual.

```
PREP SOIL ANASOL
```

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

2.4 Evaluating your simulation

An successful simulation will result in two different output files numbered as XXX :

SOIL_XXX.SUM Contains a summary of all instructions used for the simulation and a summary of simulated results. The first part of this file corresponds with a parameter file. This means that you can always rename or copy this file to a file named, for example, MYRUN.PAR which could be used as parameter file for future simulations. If you do not modify the instruction by editing this file or modifying anything by using the PREP program you will reproduce your old run.

SOIL_XXX.BIN A binary file to be used by the Pgraph program for plotting results from the simulation. The file contains all the outputs that where selected in the PREP program. You start the Pgraph program by typing:

```
PG SOIL_XXX   or   PGDEMO SOIL_XXX.
```

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

3 Program structure

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

The different menus can be reached in any order after moving the cursor to the subject using arrow keys and pressing "return" at the chosen subject.

"Return" takes the cursor down in the menus and

"Esc" moves the cursor up one level.

Normally a user will start with the subjects to the left in the main menu and move to the right. It is a good rule to modify the settings of switches and input files before moving to the other menus since the content of the other menus are influenced by the setting of the two first sub menus.

4 Input files

4.1 Driving variable file

A driving variable file is always a PG-file. The variables in the PG-file can be organized in different ways depending on how different parameters are specified. (See parameters in the group Driving variables). The PG-files are normally create from ASCII-files by using the PG-programmes but for those who have no access to the comercial version of the PG-programme the PGDEMO can be used for the same operation. A PGDEMO programme is always supplied with the model on the normal distribution diskette (SOILDEMO). Please see the 11 section for how to run the model with an ASCII-file as driving variable.

4.2 Parameter file

The parameter file is an ordinary DOS-file with ASCII- characters. All parameters with actual numerical values should be included in the file. If any parameter is missing in the file an message is displayed on the screen and a default value of zero is selected. New parameter files may be created prior the execution of the model using the WRITE command (see EXECUTION WRITE).

4.3 Translation file

A translation file have by the default the name SOIL.TRA and this file must exist if the variables in the output PG-file should get their correct identification. If the switch OUTFORN is ON this file will not be used.

4.4 Initial states file

The file contains the initial values of all state variables. The format of this file is fixed and is exactly the same as found in the final state file which is created by the model when the OUTSTATE switch is ON. The initial state file is only used when the switch INSTATE is ON.

4.5 Final states file

This file contains the final values of all state variables and it can be used as input for a further simulation starting at the same date as the previous simulation ended.

4.6 Output file

Normally the output file is created by the SOIL model and given a name that corresponds to SOIL_XXX.BIN where XX is the run number. Only in case of having the ADDSIM switch ON you have to specify the name of the output file since the output file will be the same as used by a previous run with the model.

4.7 Validation file

A validation file is a file with variables that should be compared with simulated variables. The result of the comparison will be found in the SOIL_XXX.SUM file. The first variable in the validation file will be compared with the first variable in the output PG-file, the second with the second and so wider.

4.8 Hydraulic soil properties

This file must exist on the directory where the simulation is to be done. The file is normally created by the PLOTPF program. The table below include all the parameters read from the file.

XPSI - (first line)	The upper limit for the use of the Brook & Corey expression, expressed as a tension (cm water)
A0T, A1T - (second line)	Coefficients in an empirical function for the temperature dependence in hydraulic conductivity
PLACE - (third line)	A 16 character long string with the name of the site from where the soil profile originates.
UNUM - (third line)	Replicate number of soil profile
COUNTY - (third line)	A 5 character long string with the specific letters used for the different counties in Sweden
UPROF - (third line)	The profile number
At each line following the third line the following parameters, representing different layers, are found:	
UDEP	Upper depth of the soil layer (cm) - I3
LDEP	Lower depth of the soil layer (cm) - I3
IPP	A number, not used in the present version of the model (#) - I2
NVAR	Tortuosity factor in the Mualem equation (-) - F3
SATC	Saturated conductivity, excluding contribution from the macro pores. (cm/hour) - F8
LAMBDA	Pore size distribution index used in the Brook & Corey expression (-) - F8
RES	Residual water content in the Brook & Corey expression (vol %) - F8
PORO	Porosity (vol %) - F8
PSIE	Air entry pressure in the Brook & Corey expression (cm water) - F8
WILT	Water content at wilting point (vol %) - F8
SATCT	Saturated conductivity including the contribution from macro pores (cm/hr) - F8

The properties listed above will all be adjusted from the layer thickness given by UDEP and LDEP (in case UTHICK = 0, otherwise see UTHICK) to the first actual representation of layers in the simulation of the model. Properties governing flow calculations are interpolated to the boundary between different layers whereas properties governing the state of a layer is an integrated sum of the variation found within the layer. The result of these adjustments can be seen in the SOIL_XXX. SUM file.

4.9 Thermal soil properties

Coefficient for the Kerstens equation used for estimating thermal conductivity of mineral soils will be found in this file as well as coefficient for an organic soil.

The format of the file is fixed and the coefficients must be arranged as follows:

a_1, a_2, a_3, b_1, b_2, b_3, b_4, h_1, h_2

The first line corresponds to coefficients for a sandy soil and the second for a clay soil. The 3 first coeffients represent an unfrozen mineral soil, the next 4 an frozen mineral soil and finally two coefficents for an organic soil.

A full explanation to the coefficients is found in the technical description of the SOIL water and heat model.

4.10 Initial tension profile

Each line in the file should contain the water tension (cm water) for the layers equal to the line number. Default file name MPOT.DAT

4.11 Additional driving variable file, no 1

An additional Pgraph file with driving variables are used to represent the temporal development of the crop development when the DRIVPG swith is set to a value of 2. Parameters values in the group of evapotranspiration and water uptake will be used to represent crop development if DRIVPG is set to a value of 1. The arrangement of the file should follow the table below.

Variable number	Variable name	Corresponding parameter name
1	Surface resistance	RSV
2	Leaf area index	LAIV
3	Displacement height	DISPLV
4	Roughness lengths	ROUGHV
5	Root depth	ROOTDEP

The four first variables in this file must exist at the same dates but the last variable, the root depth, may be represented at different dates compared to the four first ones. Linear interpolation will be made between dates with values specified in this driving variable file.

4.12 Initial temperature profile

Each line in the file should contain the temperature (°C) for the specific layer that corresponds to the line number. Default file name TEMP.DAT.

4.13 Additional driving variable file, no 2

An additional Pgraph file with driving variables are used for the heat extraction rate. Linear interpolation will be than between missing data in this file.

Variable number	Variable	Name	Unit
1	Heat extraction rate	PUMP	$Jm^{-2}day^{-1}$

5 Switches

The purpose of switches is to make it possible to govern the simulation mode. Switches could be OFF or ON or a numerical value. To toggle the status of a switch put the cursor at the switch and press return key. The switch will then change between the valid values for that switch. Many switches may be hidden if some other switch makes them irrelevant. After you have modified a switch you may escape from that menu and return to it immediately after the escape to see whether some more switches have been visible because of the previous change.

5.1 Technical

ADDSIM

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

AVERAGED

OFF	All requested driving (=D) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval otherwise the date is the middle of each output intervals.
ON	All requested driving (=D) variables will be mean values representing the whole output interval (see 8.4). The output interval is represented with the date in the middle of each period.

AVERAGEG

OFF	All requested auxiliary (=G) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval otherwise the date is the middle of each output intervals.
ON	All requested auxiliary (=G) variables will be mean values representing the whole output interval (see 8.4). The output interval is represented with the date in the middle of each period.

AVERAGET

OFF	All requested flow (=T) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval otherwise the date is the middle of each output intervals.
ON	All requested flow (=T) variables will be mean values representing the whole output interval (see 8.4). The output interval is represented with the date in the middle of each period.

AVERAGEX

OFF	All requested state (=X) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval otherwise the date is the middle of each output intervals.
ON	All requested state (=X) variables will be mean values representing the whole output interval (see 8.4). The output interval is represented with the date in the middle of each period.

CHAPAR

OFF	Parameter values are constants for the whole simulation period.
ON	Parameter values will be changed at different dates during the simulation period. The new parameter values and the dates from which they should be valid are specified in the parameter menu. A maximum of 20 dates can be specified.

DRIVPG

0	Driving variables will be given of analytical functions governed of model parameters.
1	Driving variables will be read from a Pgraph file. The name of the file is specified by the user. Model parameters are used to define the arrangement of variables in the file (see parameters in the group under the heading DRIVING VARIABLES)
2	An additional Pgraph file with driving variables are used to represent the temporal development of the crop development. The variables in the file are: surface resistance, leaf area index, displacement height, roughness length and root depth. If this file is not used parameters values in the group of evapotranspiration and water uptake will be used instead.

INSTATE

OFF	initial state variables will be put to zero if not otherwise specified by model parameters. The soil model make it possible to define many different type of initial values to the model (see the model specific switches INHEAT and INWATER.
ON	initial values of state variables will be read from a file. The name of the file is specified by the user, the format should be exactly the same as in file for final values of state variables, created by the model when the OUTSTATE switch is on.

LISALLV

OFF	only the subset of output variables selected by the user will be found in the summary file.
ON	all output variables will be found in the summary file after the simulation.

OUTFORN

OFF	the variables will be named according to the information stored in the file SOIL.TRA.
ON	all variables in the output Pgraph-file will be named according to their FORTRAN names.

OUTSTATE

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

VALIDPG

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

5.2 Model Specific

ATIRRIG

OFF	No automatic irrigation. However, actual irrigation can be defined as a driving variable.
ON	Irrigation will be given when the water storage of the soil drops below a value given by the ISTOREMIN parameter. The number of layers accounted for will be given by ISTOREL. The rate of irrigation is controlled by IRRIRATE and the total amount to be added at each irrigation is given by IRRIAM.

CRACK

OFF	No explicit account will be taken to the occurrence of macro pores.
ON	A bypass flow will be calculated, accounting for rapid flows in macro pores. The bypass takes place when the inflow rate to a soil compartment exceeds the sorptivity capacity of the soil. The maximal sorption rate to a layer is calculated as: SORP=ASATC*THICK*ASCALE*ALOG10(PSI) where ASATC Saturated conductivity, excluding the contribution from macro pores (see SOILP.DAT) THICK Thickness of the layer ASCALE Empirical scale factor, accounting for the shape of pores (see parameter list) LOG(PSI) Is the pF-value of the soil, accounting for the sorption demand.

DDAILY

OFF	Driving variables will be read from input file (if defined) at each iteration as specified by the time step of the specific run.
ON	Driving variables will be read from input file at one occasion only for each day. The input Pgraph-structured file is read 00:00 each day and the time point is assumed to be set to 12:00 in the driving variable file.

EVAPOTR

0	No evapotranspiration is considered.
1	Potential evaporation is treated as a driving variable and no separation is made between soil evaporation and transpiration
2	Potential evaporation is calculated with the Penman-Monteith formula. No separation is made between soil evaporation and transpiration.
3	Potential transpiration is calculated with the Penman-Monteith formula and evaporation from soil surface is treated separately with the same formula.
4	The same as (3) but the soil surface evaporation is calculated from an iterating procedure where also the soil heat flow and the sensible heat flow to the air is calculated.

FRINTERA

OFF	No interaction between heat and water will be considered because of freezing.
ON	Interaction between temperature and moisture will be considered when the temperature drops below 0 degree.

FRLIMINF

OFF	No reduction of infiltration capacity because of ice will be considered.
ON	The infiltration capacity to the soil will be reduced when ice occur in the uppermost soil layer.

FRLIMUF

OFF	Upward movement of water will be calculated by the ordinary average procedure. This means that the unfrozen water content at the boundary between the layers is used when the unsaturated hydraulic conductivity is calculated.
ON	Upward movement of water towards a frozen soil layer will be minimized by the use of the lowest water content of the frozen soil layer or of the boundary between the adjacent soil layers.

FRLOADP

OFF	No account will be taken for the load.
ON	The total soil water potential during partially frozen conditions will include the load governed by the mass of soil above the specific soil depth.

FRSWELL

OFF	No swelling of soil layers will be considered.
ON	Swelling of soil layers will be considered if the total volume of ice and liquid water exceeds the porosity in a soil layer.

GWFLOW

OFF	No horizontal ground water flow is calculated. The soil profile is assumed unsaturated and a unit gravitational gradient is assumed as driving force for a vertical flow from the lowest soil compartment.
ON	A net horizontal ground water flow is calculated according to the model parameters GFLOW and GFLEV, an initial ground water table is defined according to IGWLEV and a water flow to drainage pipes is calculated if appropiate values are set for DDRAIN and DDIST. An additional net horizontal ground water flow may be considered if GFLOW(1) and GFLOW(2) are specified to values greater than zero.

HEATEQ

OFF	No heat flows will be calculated. A constant soil temperature is assumed according to selected initial conditions.
ON	Heat flows between adjacent soil layers will be calculated.

HEATPUMP

0	No heat extraction from the soil.
1	Heat extraction will be considered as a function of air temperature.
2	Heat extraction will be considered as a driving variable. The heat extraction rate should be arranged in a Pgraph driving variable file.

HEATWF

OFF	Only conduction is accounted for as soil heat flow.
ON	Convection is accounted for when heat flows in the soil are calculated.

INHEAT

OFF	The initial conditions are specified as a uniform soil temperature according to the value of the parameter ITEMPS.
ON	The initial conditions are soil temperatures which are specified in a separate file (Default name TEMP_IN.DAT)

INTERCEPT

OFF	No interception of water in vegetation.
ON	Interception will considered and the evaporation loss will be calculated based on the parameter EPRAT and a potential transpiration rate (if EVAPOTR = 1) or calculated from Penman-Monteith formula based on a resistance INTRS that corresponds to the average distance within the canopy (if EVAPOTR >= 2).

INWATER

0	The initial conditions are water tensions which are specified in a separate file (default name MPOT.DAT)
1	A uniform tension profile according the value of the parameter IPOT. The presence of a shallow ground water table may influence on the tension profile (see parameter IGWLEV).
2	A uniform flow rate profile will be assumed according to the value of IFLOWR and the water content the corresponds to this flow rate will be assumed as initial values. The presence of a shallow ground water table may influence on the tension profile (see parameter IGWLEV).
3	A uniform water content according to the value of ITHETA will be used as inital values. No ground water within the soil profile.

ROOTDIST

0	Root distribution from parameter values, separate fractions are given for each soil layer.
1	A linear decrease of root density from soil surface to the root depth.
2	A constant root density from soil surface to the root depth.
3	A exponential decrease of the root density from soil surface to the root depth. The root depth is defined as the depth where a fraction given by the parameter RFRACLOW remains of the total uptake capacity. The remaining fraction RFRACLOW is distributed at layers above the root depth to make the total uptake capacity to unity.

ROUGHNESS

OFF	The aerodynamic resitance (RA) is calculated as a function of roughness length (ROUGHV), displacement height (DISPLV), van Karmans constant (K) and wind speed (WS): RA=ALOG((HEIGHT-DISPLV)/ROUGHV)**2/(K**2*WS)
ON	The aerodynamic resitance (RA) is calculated as a function of leaf area index (LAIV) and wind speed (WS): RA=(LAIROUGH(1)+LAIROUGH(2)*LAIV)/WS where LAIROUGH(1) and LAIROUGH (2) are empirical coefficients.

SNOW

OFF	No snow is considered. All precipitation will be considered as rain independent of temperature.
ON	Snow dynamics are simulated.

SUREBAL

0	The soil surface temperature will be put to the same as the air temperature except situations when snow occurs on the ground.
1	The soil surface temperature will be calculated form the energy balance at the soil surface using Penman-Monteith equation.
2	The soil surface temperature will be calculated form the energy balance at the soil surface using an iterating procedure taking detailed account for both aerodynamic properties in the air and thermal properties in the soil.

WATEREQ

OFF	No water flows will be calculated. A constant soil water content is assumed according to selected initial conditions.
ON	Water flows between adjacent soil layers will be calculated.

WUPTAKE

0	No water uptake by roots will be calculated.
1	Water uptake by roots will be calculated from soil layers, no compensatory uptake will take place if a deficiency occurs.
2	Water uptake by roots will be calculated from soil layers, a compensatory uptake governed by the parameter UPMOV will take place if a deficiency occurs at some layers simulataneously as an excess of water exist at other layers.

6 Parameters

All parameter values may be modified by pressing the return key when the cursor is located at a certain parameter. A new numerical value may then be specified.

6.1 Driving variables

Driving variables could either be constructed by analytical functions or be read from an external Pgraph-file. Two different arrangements of driving variables in the Pgraph file could be used depending on how evapotranspiration is considered. The value of the EVAPOTR switch and the DRIVPG switch are important to control how driving variable files should be arranged. Se also the CNUMD parameter.

CHOEN
Choice parameter for input of heat variables

Valid only if EVAPOTR <= 1

CHOEN < 0	Synthetic air temperature are used (see YTAM, YTAMP, YCH and YPHAS)
0 < CHOEN < 10	The 3rd variable in Pgraph file is considered as mean temperature of the uppermost soil layer
CHOEN > 10	The 3rd variable in Pgraph file is considered as air temperature

CNUMD

CNUMD corresponds to the number of variables in the Pgraph driving variable file that are pulse formed,i.e., they represent a cetain value during a period of time (normally one day). In case of missing values a value of zero will be used. Variables that are not pulse formed are considered as continuous and linear interpolations are made to substitute missing values if necessary.

<table>
<tr><td rowspan="3">CNUMD = 0</td><td colspan="3">All variables will be considered as continuous. In case YCH = 1 new vales will be read from the Pgraph file at each time step, otherwise YCH = 365 only one daily value is read from the file. In the later case make sure that the time in the Pgraph file corresponds to 1200. The switch EVAPOTR < 2.</td></tr>
<tr><td>Var</td><td>Name</td><td>Unit</td></tr>
<tr><td>1
2
3
4</td><td>Potential transpiration
Precipitation
Air/Soil temperature
Heat Extraction</td><td>mm/day
mm/day
°C
J/m2/day</td></tr>
<tr><td rowspan="4">CNUMD > 1</td><td colspan="3">Daily resolution of variables is assumed when the DDAILY switch is put ON. Make sure that time corresponds to 1200 in the Pgraph file. In case of DDAILY OFF the driving variables will be read at every integration time step.

1-3 continuous type of variable.

4-8 pulse formed variable. Missing values will be replaced with zero, which also represent missing value in case of global and net radiation. Missing value for cloudiness should be any number less than 0.

>8 continuous type of variables</td></tr>
<tr><td>Var</td><td>Name</td><td>Unit</td></tr>
<tr><td>1
2
3
4
5
6
7
8</td><td>Air temperature
Air humidity
Wind Speed
Precipitation
Global radiation
Net radiation
Cloudiness
Irrigation (see also the SIFRAC parameter)</td><td>°C
% / Pa
m/s
mm/day
J/m2/day
J/m2/day
- / min
mm/day</td></tr>
<tr><td>3+CNUMD +1
4+CNUMD +NSOURCE</td><td>Water source flow, uppermost layer
Water source flow, deepest layer</td><td>mm/day
mm/day</td></tr>
<tr><td>CNUMD = 1</td><td colspan="3">Only Precipitation is treated as a pulse-formed variable. The variables in the Pgraph-file should be arranged as given above for variables 1 to 4 but the 5th variable should be cloudiness and not global radiation.</td></tr>
<tr><td rowspan="3">CNUMD = -1</td><td colspan="3">Only two driving variables are required, air temperature and precipitation, AHR, AWS and ACLOUD are used to specify levels of humidity, wind speed and cloudiness.</td></tr>
<tr><td>Var</td><td>Name</td><td>Unit</td></tr>
<tr><td>1
2</td><td>Air temperature
Precipitation</td><td>°C
mm/day</td></tr>
</table>

CIECO
Choice parameter for Water flow boundary conditions

Valid only if EVAPOTR <= 1

CIECO < 0	Synthetic precipitation (see YAINF and YFAINF) and synthetic potential transpiration are used.
0 < CIECO < 10	Synthetic potential transpiration and measured precipitation are used (2nd variable in Pgraph file)
CIECO > 10	Measured potential transpiration (1st variable in Pgraph file) and measured precipitation are used.

HEIGHT
Reference height for climatic input data. (m)

The value of this parameter is normally known from the field but in some cases another reference height must be assumed, for instance when the measurements represents 1.5 m above ground at a clearcut and a mature forest will be simulated. In such a case a reference height above the forest canopy must be given and the measurements may be adjusted to compensate for the different representation in the model.

PRECA0
Wind correction for rain precipitation.

The standard value 1.07 takes account for the aerodynamic error in precipitation measurements, it represents a gauge with wind shelter at 1.5 m height. A value of 1.0 should be used if no adjustments is to be done.

PRECA1
Wind correction for snow precipitation.

The value will be uncertain because of both aerodynamic problems and representativeness problems with snow precipitation measurements. A typical value will be around 0.14 .A value of 0 should be used if no special adjustments is to be done for snow precipitation.

YAINF
The intensity of synthetic generated precipitation. (mm/day)

Only valid when CIECO < 0 and CNUMD = 0.

The frequency of synthetic precipitation is given by YFAINF and the duration is one day.

YFAINF
Frequency of synthetic precipitation, as the length of a period (days) with one occurrence with precipitation (see also YAINF for validity)

YPHAS
Phase shift of analytical air temperature.

YPHAS = 0 implies that the minimum air temperature occurs January 1 (when YCH = 365) or at 2400 (when YCH=1). The unit is in days and a positive value on YPHAS will move the air temperature forward in time. (see YTAM for validity)

YCH

Cycle of analytical air temperature. (days)

The length of the cycle will also determine the assumed resolution in driving variable read from a Pgraph file when CNUMD = 0. (see Pgraph VARIABLES) (see YTAM for validity)

YTAM

Mean value in the analytical air temperature function. (°C)

The function is defined as a sine wave with an amplitude YTAMP, a cycle YCH and a phase shift YPHAS. The parameters value will be used to generate air temperature as driving variable when CNUMD = 0 and CHOEN < 0 The air temperature function will also be used to estimate the lower boundary condition in case GEOTER > 0 (see GEOTER)

YTAMP

Amplitude of analytical air temperature. (°C)
(see YTAM for validity)

ACLOUD

Average cloudiness at a site. (°C)

This parameter is only used when CNUMD = -1, which means that the driving variables are: air temperature and precipitation only.

AWS

Average wind speed at a site. (ms^{-1})

This parameter is only used when CNUMD = -1, which means that the driving variables are: air temperature and precipitation only.

AHR

Average relative humidity at a site. (%)

This parameter is only used when CNUMD = -1, which means that the driving variables are: air temperature and precipitation only.

NSOURCE

Number of water source flows in driving variable file. One flow variable for each layer. (#)

SOILCOVER

The degree of SOILCOVER will govern how much of precipitation, throughfall and drip from the canopy that will infiltrate into the soil. (-)

The parameter can be considered as a physical barrier (like a plastic sheet or a roof) that covers the soil and causes losses as surface runoff instead of infiltration into the soil. Normally the parameter will be put to 0 which means that no physical barrier exist for infiltration of water into the soil. A value of 1 will prevent the soil from any type of wetting because of precipitation.

SIFRAC
The Soil Irrigation Fraction gives the fraction of irrigation applied directly to the soil surface without any interception losses in the canopy of vegetation. (-)

A value of 0 implies that all irrigation water will be considered as ordinary precipitation and interception losses will occur. A value of 1 implies that all irrigation will infiltrate into the soil providing that the infiltration capacity is high enough.

ISTOREMIN
The critical soil water storage which will demand for automatic irrigation. (mm)

ISTOREL
The number of layers to be accounted for when calculating the critical water storage (ISTOREMIN). (#)

IRRIRATE
The intensity of automatic irrigation. ($mmday^{-1}$)

IRRIAM
The amount of automatic irrigation to be applied when the actual water storage drops below the value of ISTOREMIN. (mm)

6.2 Initial conditions

Providing that the switch INSTATE are put off initial conditions can be specified with help of IFLOWR, IGWLEV, IPOT and ITHETA for moisture conditions and with help of ITEMPS for heat conditions. Different options exist for how to use these parameters depending on the INWATER and INHEAT switches. Remember that initial conditions are required for both moisture and heat even if one of the switches WATEREQ or HEATEQ is put off. Initial conditions are valid during the whole simulation if no flows are calculated.

IFLOWR
An initial flow rate that will determine the water content at each soil layer to be used as initial condition. (mm/day)

Valid when the switch INWATER = 2 and INSTATE = OFF.

IGWLEV
Determines the initial ground water level (negative below soil surface). (m)

IGWLEV < 0	The lower boundary in the water flow equation is considered as horizontal ground water flow (The switch GWFLOW is ON). The initial ground water level is taken as the value on IGWLEV. Initial tensions above ground water level, calculated or given by IPOT, are adjusted to an equilibrium profile (no vertical flow).

IPOT
Determines the initial moisture content of the soil. (cm water)

Valid if the switch INWATER = 1 and INSTATE = OFF.

A uniform tension profile is assumed in accordance with the value of IPOT

ITEMPS
ITEMPS is a temperature used as initial condition in a uniform temperature profile. (°C)

Valid if the switch INHEAT = OFF and INSTATE = OFF.

ITHETA
Determines the initial water content when INWATER = 2 and INSTATE = OFF. (vol %)

ITHETA > 0	A constant water content is assumed in the whole soil profile with the volumetric content as given of ITHETA, no ground water is assumed and IGWLEV = 0

6.3 Numerical

Calculations of flows and the correspondent updating of state variables can be adjusted during a simulation depending on how the numerical properties changes with certain conditions as rapid change in some critical flows. The parameters for control of this conditions would be thoroughly examined if you need to reduce CPU-time requirements for a simulation.

XADIV
Division factor for recalculation of integration time step during conditions of frost in the soil, heavy infiltration or a shallow ground water the time step will be shortened. Normal value will be 2 or 4

XINFLI
Lower limit to calculate convective heat flow. The parameter makes only sense when the switch HEATWF is on. A value around 10 mm/day will be sufficient for normal requirements of accuracy

XLOOP
Recalculation frequency for flows in the whole soil profile A value of 1 implies recalculation of flows at each iteration whereas values greater then 1 implies that recalculations only are made ones during a period of XLOOP iterations. The number of layers are given by XNLEV

XNLEV
Number of layers for frequent flow recalculations see XLOOP. The number of layers will be chosen to shorten simulation CPU-time in case of deep soil profiles. A to small value on XNLEV in combination with a high value of XLOOP will cause numeric unstable conditions and erroneous results.

6.4 Soil profile

Model representation of soil profile is determined of the parameters NUMLAY, THICK, and VC. Soil properties are read from a file SOILP.DAT from which a profile identified by UPROF and UNUM is selected. For more information on properties in the SOILP.DAT file look under SOILP.DAT label in the help utility.

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

THICK
Thickness of soil layer 1 to 22 . (m)
Actual thickness of each layer will be determined by THICK multiplied by the VC parameter.

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

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

UTHICK
Thickness of layer 1 to 5 in the hydraulic soil properties file (SOILP.DAT = default name). In normal case the thickness of layers, will be given in the SOILP.DAT (UTHIC(1) is set to 0) file but in case you want to evaluate the importance of varying thicknesses of different soil horizons the UTHIC may be useful (UTHIC will then be set to values greater than 0.). Observe that the unit of THICK is in cm. (cm)

VC
Multiplicative factor for all layers thicknesses (THICK).

ASCALE
This parameter makes only sense when the CRACK switch is put ON. A low value (<0.001)) will result in a poor capacity of the aggregate to adsorb water during infiltration and a high degree will be bypassed in the macropores. High values gives the opposite effect. The value which will be sensitive will be highly dependent on the corresponding values assigned to the SATC coefficient in the hydraulic soil property file (see SOILP.DAT). No experience on how to adjust this parameter to different field soils exist today but some current studies will soon be reported. The CRACK model will be used in this work. Be careful when using the CRACK option of the model, because of the preliminary nature of this feature.

6.5 Evapotranspiration

Evaporation from soil surface will either be calculated from the soil surface energy balance (EVAPOTR switch 3 or 4) or it will be considered similar as water uptake by roots from the uppermost soil layer (EVAPOTR switch 1 or 2). The model will distinguish between evaporation from vegetation surfaces, evaporation from soil surface and transpiration from vegetation in different ways depending on the EVAPOTR switch and type of driving variables that are used. If a Pgraph file with potential transpiration or a synthetic time series of potential transpiration is used (EVAPOTR switch 1) the EPRAT parameter will make sense but in case of when potential transpiration will be calculated from climatic variables (EVAPOTR switch > 2) the INTRS parameter is used. The calculation of potential transpiration (following the combination equation as given by Monteith (1966)) will account for ROUGHV, RSV and DISPLV. These parameters may be given as arrays, with different values for different dates during the year (see DAYNUM and CFORM). Also the LAIV which influence the interception storage capacity (see INTLAI) and the soil surface energy balance (see RNTLAI) will be governed of DAYNUM and CFORM. The crop properties may also be represented in an additional Pgraph driving variable file (DRIVPG switch 2). When net radiation is not read as driving variable from the Pgraph file (the parameter CNUMD < 3) the ALBEDO and the LATID parameters will be used in radiation balance calculations.

ALBEDO
Albedo of vegetation and soil. (%)

Normal range for coniferous forest are 8-12 and for crops 15-30 The value of this parameter can easily be measured in the field or taken from literature.

EPRAT
Ratio between potential evaporation rate from interception storage and potential transpiration.

For short crops a value close to 1 may be reasonable whereas values as as high as 3-5 are relevant for forests. The parameter only makes sense when the potential transpiration is an explicit driving variable. The EVAPOTR switch must be put to 1. See INTRS for cases when the potential transpration is estimated from climate variables (EVAPOTR > 1).

INTLAI
Interception storage capacity per LAI unit. (mm/LAI)

INTRS
Surface resistance when intercepted water occurs.

The value may be in the range from 0-10 s/m, with the higher ones for closed canopies The parameter only make sense when CNUMD > 0. See also EPRAT for other cases

LAIROUGH
Aerodynamic resitance function of leaf area index ()

The aerodynamic resitance (RA) is calculated as a function of leaf area index (LAIV) and wind speed (WS):

RA=(LAIROUGH(1)+LAIROUGH(2)*LAIV)/WS

where LAIROUGH(1) and LAIROUGH (2) are empirical coefficients. Values estimated from a willow stand by Anders Lindroth are 43 and 4 on the two parameters, respectively.

LATID
Latitude of site, for calculation of daylength and global radiation.

The LATID parameter will be treated as a floating point variable which means that the minutes must be converted to decimals.

ROUGHV
Roughness length (m)

with an index defined in the range from 1 to 5 is determined by the day number given of DAYNUM with the same index (1 to 5) The value of the roughness length can be estimated from the stand height. A wellknown relation says 1/10 of stand height.

RSV
Surface resistance (s/m)

with an index defined in the range from 1 to 5 is determined by the day number given of DAYNUM with the same index (1 to 5) The surface resistance can be estimated by fitting techniques or found from micrometeorological measurements. Forest surface resistance will be found in a range from 100-300 s/m, whereas crops is in the range 20-70 s/m.

LAIV
Leaf area index with an index defined in the range from 1 to 5 is determined by the day number given of DAYNUM with the same index (1 to 5)

DISPLV
Displacement height (m)

of vegetation cover with an index defined in the range from 1 to 5 is determined by the day number given of DAYNUM with the same index (1 to 5) The value can as a rule of thumb be put to 70% of the stand height. For short crops the displacement will be close to zero.

DAYNUM
Day numbers (indexed 1 to 5) which governs the annual course of ROUGHV, RSV, LAIV and DISPLV. Only values greater than zero will be accounted for.

CFORM
Form factor (indexed 1 to 4) governing the interpolation between adjacent day numbers, DAYNUM. The index correspond to the 4 intervening periods in DAYNUM. Prior DAYNUM(1) and after DAYNUM with the highest index and given a value bigger than 0, a constant, is assumed. The weight coefficient at day ADAY between DAYNUM (n) and DAYNUM (n-1) will be:

W=((ADAY-DAYNUM(n-1))/(DAYNUM(n)-DAYNUM(n-1)))**CFORM(n-1)

PSIRS
Governs the relationship between the actual surface resistance of the soil surface and the soil water tension of the uppermost layer and the suface gradient of soil moisture. The surface resistance, RSSOIL, is given by:

RSSOIL=PSIRS*(LOG(MAX(100,PSI))-1-SURFMOS)

where	PSI	The actual tension of the uppermost layer (cm water)
	SURFMOS	Is the surface storage of water (mm)

A typical value of PSIRS may be around 300.

6.6 Water uptake

Water uptake by roots will be governed by a calculated or assumed potential transpiration (see EVAPOTRANSPIRATION), a depth distribution (see switch ROOTDIST and parameters ROOTF, ROOTDEP, ROOTT and RFRACLOW), the moisture conditions in the soil (see switch WUPTAKE and the parameters WUPCRI, WUPF, WUPFB and UPMOV) and the soil temperatures (see WUPATE and WUPBTE).

RFRACLOW
The fraction of roots that remains below the rootdepth when an exponential decrease is assumed from the soil surface. This fraction is subsequently added to the root distribution above the root depth using the same exponential decrease.

ROOTF
Relative distribution factor for respectively layer (1 to 10) at maximal root depth, the sum must be 1.00 The factors correspond to the layers in the model and not to layer thickness in the SOILP.DAT file. Note that this means that you have to change ROOTF if you have changed THICK or VC but still want the to keep the roots within the same depth. The root distribution may also be specified as a linear function, a constant root density or an exponential function (see ROOTDIST).

ROOTDEP
The deepest level with roots (indexed 1 to 3) at the day number with the same index ROOTT (indexed 1 to 3). Negative downwards. (m)

The root depth may also be specified in a PG-file (see Additional driving variable file and the DRIVPG switch).

ROOTT
Daynumber (indexed 1 to 4) for deepest root layer as given of ROOTDEP (indexed 1 to 3). At the daynumber given of ROOTT(4) the number of layers are given of ROOTDEP(1).

UPMOV
A compensatory uptake of water will be calculated if a deficiency occurs because of too high water tensions at some layers in the soil profile simulataneously as the water tension is below the critcial level (WUPCRI) at other layers. The degree of compensation is governed by UPMOV. A value of unity will cause total compensation which means that water will be extracted at the potential rate from the soil until all layers within the root zone reach the critical tension as given by the parameter WUPCRI.

WUPATE
Temperature coefficient in uptake function. Normal value 0.8

WUPBTE
Temperature coefficient in uptake function. Normal value 0.4

WUPCRI
Critical tension (cm water) for reduction of potential water uptake A wide range (100-3000 cm water) of values have been reported in the literature. The lower values are expected for sandy soil with low root densities and higher values are expected for clayey soil and high root densities

WUPF
Coefficient for the dependence of potential water uptake in the reduction function. The dependence of the potential uptake rate has frequently been reported as an important phenomena for reduction of water uptake.

WUPFB
Coefficient in reduction function. The steepness of reduction when the actual soil water tension exceeds WUPCRI is controlled by this coefficient together with WUPF and the potential transpiration rate (see WUPF)

6.7 Ground water

Drainage of the soil profile can be controlled by horizontal flows to drainage pipes (see DDIST and DDRAIN) and/or by a net horizontal ground water flow to a natural sink (see GFLEV and GFLOW). A constant source flow may also be specified by the use of the parameters GWSOF and GWSOL. If a source flow with temporal changes is to be used, this flow should be distributed between the different layers in the soil profile and the variables should be included in the Pgraph driving variable file (see NSOURCE and Pgraph VARIABLES). Saturated conditions may also occur at the soil surface drained directly to a stream from the surface pool (see SURDEL).

DDIST
Distance between drain pipes, or more exactly the denominator when estimating the gradient necessary for the calculation of the horizontal water flow to drainage pipe (m).

DDRAIN
Level of drain pipes, negative downwards (m).

DDRAIN < 0	Horizontal ground water flow to drainage pipes is calculated when ground water level is above the
DDRAIN = 0	No drain pipes are considered.

GFLEV
Level, negative downwards, for ground water flow to diffuse sink (m)

Index (1) represents the level where the PEAK ground water flow ceases and index (2) represents the level where the BASE ground water flow ceases. The values of these parameters depend of local geological and hydrological conditions at each site.

GFLOW
Maximal rates of ground water flow to diffuse sink (mm/day)

Index (1) represents the maximum PEAK ground water flow rate and index (2) represents the maxmimum BASE ground water flow rate. The values of these parameters depend on local geological and hydrological conditions at each site.

GWSOF
Constant rate of ground water source (mm/day)

GWSOL
Layer for the ground water source flow

SURDEL
First order rate coefficients used when calculating the surface runoff from the surface pool SURPOOL. (1/day).

6.8 Thermal properties

Soil thermal properties, i.e. volumetric heat capacity and thermal conductivity are treated as functions of the volumetric fractions of solid material, liquid water and ice. For the thermal conductivity, different coefficients are used in these functions depending on whether the soil is dominated by clay, by sand or by organic material. Soil with a pore size distribution below 0.5 and a volumetric water content at wilting point above 10 % are classified as clay soils. The coefficients valid for organic soils are used from the soil surface down to the depth assigned to the HUMUS parameter. The coefficients used for mineral soil originates from Kersten (1949) and the ones used for organic soils are based on data from de Vries (1973). All coefficients are read from the thermal soil properties file with default file name THCOEF.DAT.

GEOTER
Geothermal heat flow at the bottom of the soil profile. (J/m^2 day)
GEOTER < 0)

In case of GEOTER > 0 the lower boundary condition will be given as the temperature calculated from the analytical solution of the heat equation based on a sine variation at the soil surface. The soil surface variation is determined of YTAM, YPHAS, YTAMP and YCH (see DRIVING VARIABLES).

MUS
ckness of the humus layer. (m)

s parameter is only used as a thermal property. A value greater than 0 may be used in case you want to introduce or account for a thermal barrier ween the atmosphere and the soil.

9 Snow

now conditions are considered both as a water storage and boundary condition for soil water flows and as an important factor influencing the soil heat boundary condition. Precipitation is divided into rain and snow, depending on the values assigned to PRLIM and PSLIM. Melting of snow is based on global radiation (SMRIS) and on air temperature (SMTEM). The melting caused by global radiation is to some extend controlled by snow age (SAGEM1, SAGEM2, SAGEZP and SAGEZQ). Liquid water retained in the SNOW (SRET) can also refreeze (SMAFR). The thermal conductivity of snow is estimated from snow density (SD10L, SD20M and SDENS) and a coefficient (STCON). During melting the soil surface temperature is put to 0 (SLWL0).

PRLIM
Rain temperature threshold. (°C)

Normal value 2, above this temperature all precipitation is rain.

PSLIM
Snow temperature threshold. (°C)

Normal value -2, below this temperature all precipitation is snow.

SAGEM1
Radiation melt factor for old snow A value of 0 implies that the melting of snow is independent of snow age. The normal value 2 implies that melting of old matured (see SAGEM2) snow because of global radiation is 3 times as efficient as the melting of new snow (see SMRIS)

SAGEM2
Snow age coefficient in radiation melt function. (1/day)

The coefficient is used in an exponential function, which determines how fast the melting because of global radiation is approaching the value valid for old mature snow. The normal value of 0.1 (1/day) implies that 63 % of the change from new to old snow takes place after 10 days.

SAGEZP
Snowfall limit for snow age updating. (Kg/m^2 day)

The normal value 5 (kg(m2day) implies that the age of snow will put to 0 for all snowfalls that exceed this value providing that the thermal quality also exceed the value given of SAGEZQ.

SAGEZQ
Precipitation thermal quality limit for snow age updating.

The normal value 0.9 implies that 90% of precipitation must be as snow if the counter for snow age is to be put to 0 (see also SAGEZP)

SD1OL
Liquid water coefficient in snow density function. (Kg/m^3)

The normal value 200 kg/m3 implies that the snow density increase with this value when the liquid water content in the snow pack becomes equal to the total retention capacity (see SRET).

SD2OM
Water equivalent coefficient in snow density function (1/m)

Independent density changes because of liquid water in snow, an linear increase with overburden pressure, i.e. with water equivalent is assumed The normal value 0.5 (1/m) implies that a snow pack with 200 kg/m3 water equivalent will get an increased density of 100 kg/m3.

SDENS
Density of new snow (kg/m^3)

The normal value is 100 (kg/m^3)

SLWL0
Liquid snow water limit for 0 °C soil surface temperature. (kg/m^2)

The normal value 3.0 kg/m^2 implies that the surface temperature will always be put to 0 when the amount of liquid water exceeds this value.

SMAFR
Refreezing efficiency constant. During conditions of air temperatures below 0 refreezing of liquid water is calculated with the same temperature coefficient as in the snow melt function (SMTEM) adjusted for the depth of snowpack. The normal value on SMAFR .10 (m) implies that refreezing will be become successively more inefficient when the snowpack increases above 0.1 m. The double thickness of snowpack will reduce the refreezing efficiency to 50%.

SMRIS
Global radiation coefficient in snow melt function. (Kg/J)

A normal value for forests 1.5E-7 implies that a global radiation of 15 MJ/m^2 during a sunny day in the spring will melt 2.2 mm of new snow or 6.6 mm of old snow with the value SAGEM1 put to 2. Values of SMRIS for open fields may be 2-3 times larger.

SMTEM
Temperature coefficient in snow melt function. ($Kg/°C/m^2/day$)

A value of 2 is normal for forests. Similar as for SMRIS a two or three fold increase is expected if adaption to an open filed is to be done. Also notice that if you put SMRIS to 0, SMTEM will be the traditional day degree coefficient, commonly used in snow melt modelling.

SRET
Retention capacity of snow, fraction of total storage.

The normal value is 0.07.

STCON
Thermal conductivity coefficient for snow. (Wm^4/kg^2)

The normal value 2.86E-6 (Wm4/kg2) implies the thermal conductivity function for snow is valid in a range of density from 100 to 900 kg/m3. The highest density correspond to pure ICE. A square dependence of the snow density is assumed in the whole range.

6.10 Frost

Account for freezing of water in the soil can be done in a number of different ways (see the different switches FR...). Make sure that the switches are put to the appropriate mode for your simulation. Two empirical parameters FDF and FWFRAC can together with the soil properties read from the SOILP.DAT file be used to estimate the freezing point depression for the soil. The FCOND parameter can be used to account for differences between liquid water flow in unfrozen soils and in partially frozen soils.

FCOND
Decrease of unsaturated conductivity because of freezing (power of ten at completely frozen soil) The value of this parameter will be above zero in case of developing ice lenses or other actions which disturb possible flow path for liquid water. A reasonable range is from 0 to 10. The lower values can preferable be used when FRLIMUF is ON. The difference between putting FRLIMUF to ON or putting FCOND to a high value as 8 may be tricky to evaluate

FDF
The influence of the parameter of the FDF parameter can be demonstrated with the use of the PLOTPF program. Normal values are found in the range from 10 - 60 with the highest values for clayey soils

FWFRAC
Fraction of wilting point remaining as unfrozen water at -5 °C. Normal values will be in the range between 0.3 and 1.0.

6.11 Surface energy balance

Two different types of boundary conditions exist for the soil surface temperature and soil surface evaporation/condensation. The SUREBAL switch is used to determine how to use the two options. If SUREBAL = 0 the soil surface temperature equals the air temperature at the reference height. If the SUREBAL switch is put greater than zero the energy balance equation at the soil surface will be used to estimate the soil surface temperature. The solution is either based on the Penman-Monteith equation (SUREBAL=1) or it is based on an iterative solution of the basic heat flow equations (SUREBAL=2). The aerodynamic resistance between soil surface and the reference height is the sum of the resistance above and below stand (RALAI). To estimate the vapor pressure at the soil surface account is taken for a possible moisture gradient close to soil surface as indicated by the auxiliary variable SURFMOS. The SURFMOS is then used to calculated the surface resitance together with the PSIRS parameter and the water tension of the uppermost soil layer in the Penman-Monteith approach. The SURFMOS variable is used in the iterative solution also, but in a different way, togehter with the EGPSI parameter and the water tension of the uppermost layer to calculate the vapour pressure at soil surface.

EGPSI
Factor to account for differences between soil water tension in middle of top layer and actual tension at soil surface. The SUREBAL switch must be equal to 2.

Normal values from 0 to 1. 0 implies that no difference exist between the tension at soil surface and the tension in the top layer. 1 implies that the driest conditions can be two order of magnitudes drier at the surface and the moistest conditions can be one order of magnitudes wetter at the surface.

RALAI
The contribution of LAI to the total aerodynamic resistance from measurement height (reference level) to the soil surface. The SUREBAL switch must be put greater than 0 or the EVAPOTR switch must be greater or equal to 3.

RNTLAI
A coefficient for calculation of net radiation at soil surface from LAI. The SUREBAL switch must be put greater than 0 or the EVAPOTR switch must be greater or equal to 3.

6.12 Heat extraction

The heat extraction requires that the HEATPUMP switch is put ON. Heat can be extracted from a specified soil layer (HPLAY) at a rate either regulated of air temperature (HPBAS and HPAMP) or determined from a driving variable (HPBAS). In case the extraction rate is controlled by air temperature a maximal extraction capacity may be specified (HPMAX). The extraction rate may also be limited when the soil temperature drops below a certain temperature (HPCUT) and a further linear decrease will take place until the extraction rate ceases (HPZERO).

HPAMP
Temperature dependence of heat extraction. (J/(m^{2}day°C))

Valid when the switch HEATPUMP is equal to 1.

HPBAS
Base rate of heat extraction. (J/(m^{2}day))

Valid when the switch HEATPUMP is equal to 1.

HPCUT
Soil temperature at which heat extraction rate is decreased (°C)

HPLAY
Layer from which heat is extracted. (#)

HPMAX
The air temperature where the maximal heat extraction rate is reached.

Valid when the switch HEATPUMP is equal to 1.

HPZERO
Soil temperature at which heat extraction ceases. (°C)

7 Outputs

Output variables are stored in a Pgraph-structured result file named SOIL_XXX where XXX is your run number and in addition a list of output variables are found in the summary file named SOIL_XXX.SUM. The output variables are divided into states (=X), flows (=T), auxiliaries (=G) and drivings (=D). States and flows are represented as floating point numbers with double precision to avoid numerical inaccuracies in calculations.

7.1 State variables

Variable	Explanation	Unit
HEAT	Heat storage in each soil layer	(Jm^{-2})
HSNOW	Snow depth	(m)
PLANT	Accumulated plant water uptake	(mm)
STREAM	Accumulated water transport from soil	(mm)
SURPOOL	Water storage on the soil surface	(mm)
WATER	Water storage in each soil layer	(mm)
WSNOW	Water equivalent in snow pack	(mm)

7.2 Flow variables

Variable	Explanation	Unit
DEEPCONV	Heat flow from the bottom of the soil profile	(J/m^2day)
DEEPPERC	Water flow from the bottom of the soil profile	(mm/day)
DFLOW	Ground water flow from each soil layer	(mm/day)
DRIVF	Heat flow into soil surface	(J/m^2day)
EFLOW	Heat flow between soil layers	(J/m^2day)
EVAG	Evaporation from soil surface	(mm/day)
HEATSINK	Heat flow from layers in the soil profile	(J/m^2day)
INFIL	Water flow infiltration to the soil surface	(mm/day)
PUMP	Heat flow from each soil layer to sink	(J/m^2day)
SPOOLA	Water flow into the surface pool	(mm/day)
SPOOLINF	Infiltration from surface pool to soil	(mm/day)
SURR	Surface runoff from surface pool	(mm/day)
WFLOW	Water flow between soil layers	(mm/day)
WUPRATE	Water uptake by plants from each soil layer	(mm/day)

7.3 Auxiliary variables

Variable	Explanation	Unit
DENSS	Density of snow	(kg/m^3)
DINFIL	Potential infiltration rate	(mm/day)
DISPL	Displacement height	(m)
EACT	Actual water uptake from soil by plant	(mm/day)
EACTI	Actual evaporation rate from intercepted water	(mm/day)

EINTPOT	Potential evaporation rate from intercepted water on vegetation	(mm/day)
ETR	Ratio between actual and potential water uptake	(-)
EVAPO	Actual evapotranspiration	(mm)
FROSTBL	Frost boundary of lower boundary	(m)
FROSTBU	Frost boundary of upper boundary	(m)
INTCAP	Interception capacity of vegetation	(mm)
INTERC	Maximal interception storage of vegetation	(mm)
ISTORE	Intercepted storage on vegetation	(mm)
LAI	Leaf area index of vegetation	(-)
LATENT	Latent heat flow from soil surface	(J/m^2day)
PERC	Loss with horizontal ground water flow to diffuse sink or vertical flow to deep ground water	(mm/day)
PIPEQ	Total drainage to pipes in the soil	(mm/day)
PREC	Corrected precipitation	(mm/day)
PSI	Tension in each soil layer	(cm water)
RA	Aerodynamic resistance	(s/m)
RAC	Aerodynamic resistance between soil and atmosphere	(sm^{-1})
RNTG	Net radiation at soil surface	(J/m^2day)
RNTG	Net radiation at soil surface	(J/m^2day)
ROOTDEPTH	The root depth	(m)
ROUGH	Roughness length	(m)
RS	Surface resistance of vegetation	(s/m)
RSSOIL	Resistance of soil surface for evaporation	(s/m)
SAGE	Age of snow, i.e. number of days since last snowfall.	(days)
SATLEV	Ground water level	(m)
SENSE	Sensible heat flow from soil surface	(J/m^2day)
SURFMOS	Surface water content	(vol %)
SURRE	Surface runoff generated because of limited capacity for water flow in the soil profile beneath the uppermos horizon.	(mm/day)
SWATS	Unfrozen water in the snow pack	(mm)
SWELL	Total swelling of whole soil profile	(m)
TEMP	Temperature in each soil layer	(°C)
THETA	Volumetric water content in each soil layer	(vol %)
THQUAL	Thermal quality in each soil layer	(-)
TOTQ	Total runoff and drainage from soil	(mm/day)
TQUALP	Thermal quality of precipitation (0= liquid, 1= ice)	(-)
TTSTEP	Integration time step (10-log)	(-)
VPA	Vapour pressure in air at reference height	(Pa)
VPD	Vapour pressure deficit in air	(Pa)
VPS	Vapour pressure at soil surface	(Pa)

WUPPOT	Potential water uptake from soil by plant	(mm/day)

7.4 Driving variables

Variable	Explanation	Unit
CLOUDN	Cloudiness/duration of bright sunshine	(-)
EPOT	Potential transpiration from trees and ground vegetation	(mm/day)
HR	Relative humidity of air (at reference height)	(%)
IRIG	Water irrigated above vegetation	(mm/day)
PRECMM	Precipitation at reference height or at nearby open field	(mm/day)
RIS	Global radiation above vegetation cover	(J/m^2day)
RNT	Net radiation above vegetation cover	(J/m^2day)
SPSOURCE	Input of horizontal water flow at soil surface	(mm/day)
TA	Temperature of air (at reference height)	(°C)
TD	Temperature at/in soil surface/top soil layer	(°C)
WS	Wind speed above vegetation (at reference height)	(m/s)
WSOURCE	Input of horizontal water flow to different layers in the soil.	(mm/day)

8 Run options

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

8.1 Run no.:

May be set to any integer between 1 and 999.

8.2 Start date:

Start for a simulation is specified by Year, Month, Day, Hour and Minute.

8.3 End date:

End for a simulation is specified similar as the start.

8.4 Output interval:

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

8.5 No of iterations:

The time step must be small enough to avoid numerical problems but still large enough to minimize the total CPU-time consumption. A strong influence of both compartment sizes, soil properties and boundary conditions makes sometimes the choice difficult. To handle the influence of shifting boundary conditions the default time step may be changed during the simulation according to values specified to parameters in the group NUMERICAL. To avoid truncation errors you are advised to specify a number of iterations with a number which could be represented exactly in a binary form, e.g. make use of the series 2, 4, 8, 16, 32, 64, 128, ... Remember that the relationship between compartment size and the time step is quadratic, i.e., in case a stable solution exist with 128 iterations and 5 cm thick layers you can reduce the number of iterations to 32 if you increase the thickness to 10 cm. Also remember that you normally can increase the compartment size with increasing depths in your profile because of the slower rates of water and heat flows deeper in the soil.

8.6 Run id:

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

8.7 Comment:

May be any string of ASCII characters.

9 Execute

9.1 Exit

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

9.2 Run

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

9.3 Write parameter file

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

10 Warnings and Errors

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

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

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

11 Commands

You start the preparation of a simulation by pressing

```
PREP SOIL
```

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

You can also start the interactive session with default values taken from another parameter file by entering that parameter file name at the command line:

```
PREP SOIL LANNA
```

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

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

```
PREP -b SOIL LANNA
```

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

```
PREP -b SOIL LANNA NEWEVAP NEWTIME
```

This means that the PREP program will first read the intructions in the LANNA.PAR file then the NEWEVAP.PAR file and finally the NEWTIME.PAR file. The information read last will be used. But remember that the parameter files may not be complete. They can be organized with only information about evaporation in the NEWEVAP.PAR file information about run options like time periods in the NEWTIME.PAR file.

11.1 Running the model with an ASCII-file

The PREP program can initiate the PGDEMO or the PG program to convert an ASCII-file prior the start of an simulation. This is recommended for those who would like to use their own graphical programme instead of Pgraph. The command line may then look like below:

```
PREP -b -c"meteor.dat -fmeteor.in" SOIL ASCII
```

where -b is the batch option -c is the option for converting an ASCII-file named METEOR.DAT using the instruction in the file meteor.in (the -f option is recognized by the PGDEMO program). The command above is similar to first running the PGDEMO program:

```
PGDEMO meteor.dat -fmeteor.in
```

and then running the PREP program:

```
PREP -b SOIL ASCII
```

Details about how the ASCII file can be organised and how instructions to the PGDEMO program are specified will be found in the section 12.4.

12 Additional information

12.1 News

Important changes in new versions will be mentioned here.

April 88
A possibility to run the model with only precipitation as pulse-formed variable and cloudiness as governing for the radiation balance has been introduced. See parameter CNUMD and Pgraph VARIABLES.

The help utility has been updated. All parameter and output variables are now included in the general help utility. The specific HELP is not available any longer. Please use the F1 key for help at all stages in the simulation dialogue when you need help.

Bugs of importance for snow and frost conditions were found in the PC-version of the model.

The snow melt function is now corrected,i.e. both air temperature and global radiation is accounted for in the melt function.

Infiltration to the soil during partially frozen conditions is now made with the correct estimate of hydraulic conductivity in case of FRLIMINF switch is put ON.

The soil surface temperature is also estimated based on the correct value of thermal conductivity of the uppermost soil layer.

The bugs may have caused simulation with too deep frost in the soil,too high rates of infiltration and a delayed snow melt in the spring during conditions of high insolation.

January 89
The model has been adapted to the new Pgraph file format using a file with extension .BIN. It is now possible to make simulations which covers more than one century.

May 89
Two new parameters were introduced to handle to upper boundary condition in case of infiltration within a canopy (SIFRAC) and in case of roof above the soil surface (SOILCOVER).

The model have also modified to handle driving variable with within day resolution using the set of variables that is given when the CNUMD parameter has a values greater than 0. The DDAILY switch will be put of to handle within day resolution (driving variables are read at every integration time step) otherwise driving variables will be read once during a day.

December 89
Missing value for cloudiness/duration of bright sunshine has been introduced in the handling of the driving variable file. The missing value for cloudiness can be put to any number lesser than zero. During conditions when missing values occurs cloudiness will be calculated from global radiation. If also missing values are found for global radiation the cloudiness will be put equal to the value of ACLOUD.

January 90
Soil evaporation will now be calculated independently from transpiration also in case when the switch SUREBAL is put off. The Penman-Monteith equation is used both for transpiration and evaporation but the net radiation, aerodynamic and surface resitances will be put different. The RNTLAI parameter will be used for splitting up net radiation and RALAI will be used to calculate the total aerodynamic resistance. The surface resistance of soil surface will be calculated from actual water tension, surface gradient of soil moisture and a new empirical parameter called RSPSI.

A new option (switch ATIRRIG) is introduced which makes it possible to simulate different possible irrigation controls using criterias defined by the user. Four new parameters are used to define automatic irrigation: ISTOREMIN, ISTOREL, IRRIRATE and IRRIAM.

May 90
A bug occuring when using the CRACK switch together with a shallow ground water level found and deleted. Water contents tended to exceed saturation at certain conditions of recharge.

July 90
The Help utility is update according with the standard used in the PG program.

August 90
Bug corrected in the time specification used for change of parameter values when the CHAPAR switch is ON. Dates given incomple, i.e., between 9 and 11 characters were not correct in the old version. A full date including the time of the date like 199008101200 was handled correct but not 19900810. In the new version of the model 19900810 will be interpreted the same as 199008100000.

February 91
A number of improvements for how to specify the mode of a simulation have been introduced. This is best found by looking in the sections: Getting started, Commands and in the Switch section.

One conceptual modification is the possibility to calculate soil surface temperature from the Penman-Monteith approach of calculating soil evaporation. (Se switches EVAPOTR and SUREBAL)

The root distributions can be handle in a new way (see the switch ROOTDIST) and the water uptake can also be calculated in a new way accounting for compensatory uptake when a deficiency occurs at any layer in the soil profile (see the switch WUPTAKE and the UPMOV parameter).

Plant related properties may be handled as driving variables read from an ordinary pgraph file (see the switch DRIVPG and the additional driving variable file).

An important new technical feature is the introduction of the VALIDPG switch which enables comparisions between simulated and measured variables.

Updating input files from simulations with previous model versions

Old input files can to some extent be used to run the new version of the model. The most important change is that the command files (normally called *.in and used with the -f switch on the command line) used to run the previous version of the model in batch mode does not exist any longer and they can consequentially not be used. The instructions previously stored in this command file will in the new system be found in the parameter file.

The following files from previous versions of the model can be used:

File	Name	Comments
Initial values	*.INI	No change in format
Final values	*.FIN	No change in format, can be used as initial values for state variables
Driving variables	*.BIN	No change in format
Hydraulic soil properties	SOILP.DAT	No change
Thermal soil properties	THCOEF.DAT	No change
Parameter file	*.PAR	Can be read, but a number of old parameter names do not exist any longer and new parameters have been introduced. The PREP program will tell you about parameter names that have been deleted and you are asked to correct your parameter file. An important difference is that the old parameter file contained all parameter names but no other information. The new parameter file contains only the valid parameters that have relevance for your run but in addition to that all other type of information that is needed to design a run with the model.

In the old parameter file the following parameters may be found which now have been deleted:

Old parameter name	Substituted with
CINIT	Not used any longer, see INSTATE switch
ROOTL	ROOTDEP, the depth of roots is specified as a depth not as the number of layers.
CHOWUP	Switch WUPTAKE
GFLEV	GFLEV will now be specified negative downward - change old positive numbers to correspondent negative ones.

March 91

The ROUGHNESS switch was introduced together with the two parameters LAIROUGH(1) and LAIROUGH(2). Old parameter files will not be possible to run without any modifications.

The auxiliary variable REDF has been renamed to ETR.

June 91
The PREP programme was modified to allow the model to use an ordinary ASCII-file as driving variable file instead of a Pgraph binary file.

July 91
A bug which caused erroneous results when the switch EVAPOTR was 1 and the parameter CNUMD was 0 was discovered and deleted.

August 91
The option with heat extraction from soil (see switch HEATPUMP) has been modified. 1) Heat extraction can always be selected if HEATEQ is on independent of which type of driving variables that are used. 2) An additional driving variable file (no 2) is used if the HEATPUMP switch is chosen to 2.

12.2 Help

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

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

12.3 Supporting programs

A number of programs are available on the PC to handle input/output data to the model. PLOTPF is used for visualizing your soil properties, stored in the SOILP.DAT and THCOEF.DAT files or in a data base. Pgraph is used for graphic and numerical evaluation of your time series (Driving variables, simulated variables and observed variables).

In addition the SOILN and the DECO models are using data generated by the SOIL model as driving variables.

12.4 Creating a PG-file from an ASCII-file

Input data may be organized in normal ASCII files. The program reads either sequential data files with a formatted structure or Pgraph structured direct access files. When your input file consists of ASCII characters the information will be converted to Pgraph structured direct access files.

The file name used by Pgraph should be given including the file extension in the case of sequential files and with file extension excluded in the case of direct access files.

```
PG METEOR.DAT
```

The example above shows how you specify an ASCII-file as input to the PG program by typing the full file name on the command line.

Sequential files can be organized in different ways but limitations exists, especially concerning how the time variable should be specified. Study the examples below (section [XREF] and [XREF]) prior to the creation of the required input file.

Time variable

There are alternative ways of specifying the time:

1. Give time by 10-12 characters: YEAR-MONTH-DAY-HOUR-MINUTE
   Ex: 198502140830 (YYYYMMDDHHMM)
2. Give time by 6-8 characters: YEAR-MONTH-DAY
   Ex: 850214 (YYMMDD)
3. If your data consists of a number of time points, all separated by the same time interval, you do not need to specify each of them in the file. Instead, you can give the first time specification and the time interval, when Pgraph reads your data the first time.
4. If you have a different time specification in your input file you can use the extended format to read your data.
5. An ASCII file derived from the Campbell data logger has normally time specified in three separate variables. (Year, daynumber and time-of-day). This type of format is handled separately.

If your time is specified in another way, e.g. as daynumber or minutes you can always read this type of time specification as a separate variable and later, by using a feature in the subsection C1 (S13) convert this time to the ordinary time specification as a string of 12 characters. In this case you can request a common time to all your records.

Format
You can either use fixed format, free format or extended format. If a time variable exists in the input file it should be given in the first column independent of the type of format used.

Fixed format

If you use fixed format you have to use a format statement as in FORTRAN. Remember to give time as A10 or A12 and all other variables in F field descriptions, because all variables, except time, will be dealt with as floating point variables. Make sure that you always use decimal points in your input files if you have any decimal values, otherwise you have to be very careful when specifying format statements.

Example

Example of an input file
8502140830 3.0 2.8
8502140900 7.9 4.4
8502140945 11.8 6.5
etc.

For this example you should enter (A10, 2F5.0). This means that you use the first 10 characters for time followed by 2 variables allocating 5 characters each. For more details on writing format statements, please see any FORTRAN manual.

Free format

When you use free format, it is not necessary to know the exact position of the variables in your file, as long as they are separated by a space or a comma.

The time variable has to be given within apostrophes. Example below:

'8502140830' 3.0 2.8,3.1 2.0 3,3
'8502140900' 7.9,4.4 3.5 3.2 3.2

Extended format

This is an attempt to make it possible to read data from text files in many formats. The following format specifiers may be used: Note: in lower case only.

(1)Codes

Format	Signifies
y	Year. 2-4 positions. 80,1987.
yy	Year. Exactly 2 pos. 80,86
m	Month. 1-2 pos. 01,1,12
mm	Month. Exactly 2 pos.
mmm	Month. Exactly 3 letters. Jan,FEB,Oct
d	Date 1-31.
h	Hour. 1-2 pos.
hh	Hour. Exactly 2 pos
i	Minute. 1-2 pos
ii	Minute. Exactly 2 pos.
v	Data. Delimited of character which is not a digit or one of E, D,+ , - .
x	Skip one char.
s	Skip spaces until next non space.

(2)Rules

- Characters in the format string which are not format specifier, must correspond exactly to characters in the data file.
- Format specifications, may be repeated e.g.: 10(x) or 4(sxxv) but parenthesis cannot be nested.
- Time specifications given using one (1) format specifier letter must be limited by a non-digit e.g. y, m, h...
- Line breaks in the input file are not implemented.
- More than one format may be given, if time specification varies between records. Ex. Month is only given if, change in month.
- The "v" data format need not be specified if data observations are separated only by spaces.
- An expanded format line can not be longer than 132 chars.

(3)Examples

Examples of formats to read the following types of data files:

```
Use: sy-m-d
     80-01-01 9.283099 2.377541 8.012897
     80-01-01 5.088338 6.233387 8.425648
     80-01-10 0.211389 6.818182 5.779749
     80-01-11 7.366003 6.043690 7.828479
Use: sy-m-dsh:ii:xx   (3 data points) Seconds won't be read.
     80-01-01 00:00:00 1.407930 0.340819 4.006003
     80-01-06 11:10:22 5.185625 8.431309 6.039198
Use: sy-m-dxh:i:xx
      sh:i:xx
     80-01-05 05:13:15 5.385658 8.322591 2.693153
              06:09:02 9.312413 9.208962 9.516258
     80-01-12 02:21:50 4.927451 6.841755 8.943993
     80-01-16 20:15:44 5.024314 4.072683 8.386088
Use: s3(x)ddmm8(x)yy16(x)hhiix2(sxxv) or
     sxxxddmmxxxxxxxxyyxxxxxxxxxxxxxxxxhhiix2(sxxv)
     01+0102.  02+0087.  03+0183.  04+0800.  05+4.845  06-0.589
Use: sdd-mmm-yyyy
     09-May-1987 12.3 13.4...
```

From Campbell data logger

Three types of output formats from the Campbell data logger is supported: comma delimited ASCII, printable ASCII and binary.

Normally three different time variables (Year, Day number and time of day) are needed from the Campbell data file for transfer to the time variable in Pgraph. If the Year or the Day number is missing in the file you must specify a common value to be used for all records in the file.

12.5 Acknowledgement

The SOIL model is the result of many years work. A number of persons have contributed with ideas and suggestions. The programming of the new interface (January 91) was made by Jan Claréus. Other contibutions could easily be seen from the reference list. For a future successful work with the model you are welcomed with your contribution.

If you get problems, find bugs or just want to report an interesting phenomena please let me know about it. Write to:

Per-Erik Jansson
Department of Soil Science
Swedish University of Agricultural Sciences
P.O. Box 7014
S-750 07 Uppsala
Sweden

Remember to send a copy of your input data files and the commands used when you get any problems.

12.6 References

A number of papers and reports have been published with relevance for the SOIL model. Under the headings below preliminar list of April 88 are given.

Water and heat processes

Alvenäs, G., Johnsson, H. & Jansson, P.E. (1986). Meteorological conditions and soil climate of four cropping systems: Measurements and simulations from the project "Ecology of Arable Land". Report 24. Swedish University of Agricultural Sciences.

Borg, G. Ch. & Jansson, P-E. 1988. Simulation of moisture and temperature conditions in a clay arable soil, STRIAE, University of Uppsala (in press)

Dressie, Z. 1987. Recharge and Soil Water Studies Using different Models and Measurement Methods. PhD thesis, Uppsala Universitet, Avd. f hydrologi, Rep A no 2 and 39

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