Documentation update for PEARL 2.2.2

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Contents

1 Bugs FOCUS_PEARL_1.1.1 solved in FOCUS_PEARL_2.2.2

In FOCUS_PEARL_1.1.1 the values of the parameters HLIM3U and HLIM3L were interchanged inside the model (so a bug); in FOCUS_PEARL_2.2.2 this bug has been corrected. See the manual for the definition of these parameters.

The bug in the graph of pressure head with depth has been removed.

2 Additions and Changes to manual PEARL 1.1.1

This section describes the changes and the additions for the update of the FOCUS_PEARL_1.1.1 manual (Tiktak et al., 2000) to be used in combination with FOCUS_PEARL_2.2.2.

→ Chapter 2: Model description

In Figure 2 the name of the file 'RunId.Apo' is not correct. The name of the file is 'RunId.pfo'.

→ Section 2.3.3 Potential transpiration and potential evaporation

The extinction coefficient for global solar radiation, κ (-), has been replaced by the product of a coefficient for direct global radiation κ_{dir} (-) and a coefficient for diffuse global radiation, κ_{dif} (-). See Equations 6.25 and 6.26 in Van Dam et al. (1997).

→ Section 2.3.5 Evaporation of water from the soil surface

A second method can be used to calculate the reduction of the evaporation of water from bare soil, i.e. the method described by Black (1969):

$$\sum E_a = \beta \sqrt{t_{dry}}$$

in which:

β = empirical coefficient (cm $d^{-0.5}$)

t_{dry} = time after significant amount of rainfall (d)

→ Section 2.5.7 Partitioning over the three soil phases

The effect of temperature on sorption coefficients can be specified via an adsorption enthalpy:

$$K_{F,e} = K_{F,e,r} \exp\left[\frac{-\Delta H_s}{R}\left(\frac{1}{T} - \frac{1}{T_r}\right)\right]$$

in which:

$K_{F,e,r}$ = the Freundlich coefficient at reference temperature T_r (K)

ΔH_s = molar enthalpy of sorption (J mol^{-1})

In FOCUS_PEARL_2.2.2 the default value for the sorption enthalpy is zero and this gives the same calculated sorption coefficients as FOCUS_PEARL_1.1.1.

→ Chapter 3: Model parameterization

→ Section 3.2.6 Freundlich equilibrium sorption

The effect of soil temperature on the sorption coefficient can be taken into account (see above, section 2.5.7).

→ Chapter 4: User's guide for the command line version of PEARL

→ 4.2.7 Section 3: Weather and irrigation data

In FOCUS_PEARL_2.2.2 three more parameters can be specified in the input file. These parameters are:

- FacPrc: Correction factor for precipitation (-)
- DifTem: Correction for temperature (degrees Celsius)
- FacEvp: Correction factor for evapotranspiration (-)

These factors can be used to scale-up or scale-down the data on precipitation, air temperature and evapotranspiration in the file with meteorological data. The default value for FacPrc and FacEvp is set to 1.0 and the default value for DifTem is set to 0.0.

→ 4.2.8 Section 4: Boundary and initial conditions of the hydrological model

In FOCUS_PEARL_2.2.2, an additional drainage option is available, i.e. 'extended drainage'. If this option is selected then for each drainage level considered the following parameters should be specified:

- SysDra   Drainage system
- RstDra   Drainage resistance (d)
- RstInf   Infiltration resistance (d)
- DistDra   Distance between drains or channels (m)
- WidthDra   Bottom width of drain system (m)
- ZDra   Bottom of drain system (m)
- ZGwlInfMax   Depth at which infiltration is maximal (m)
- OptSurDra   Option to consider rapid subsurface drainage

If OptSurDra set to 'Yes' then the following parameters should be specified:

- RstSurDraDeep   Maximum resistance of rapid subsurface drainage (d)
- RstSurDraShallow   Minimum resistance of rapid subsurface drainage (d)
- OptSrfWat   Option to consider surface water system

If OptSrfWat set to 'Yes' then the following parameters should be specified:

- SrfWatLevWinter   Winter surface water level (m)
- SrfWatLevSummer   Summer surface water level (m)
- SrfWatSupCap   Surface water supply capacity (m d^{-1})

If the option 'Basic' is selected then for each drainage level considered the following additional parameters should be specified:

- RstInf Infiltration resistance (d)
- ZSurWat: Depth of the surface water table (m)

→ 4.4.3 Importing data in Excel

The selrec tool has been replaced by the sdwin tool. Using this tool, records with the same identifier can be selected and exported to an Excel file. This tool has much more possibilities, and it is also used when using the GUI. The sdwin32.exe tool is in the bin directory. Below follows a brief explanation of this tool:

sdwin32 uses a small configuration file (or setfile). This file contains lines with selection criteria as follows:

<datafile_name> <Column_X> <Column_Y> <Column_with_LookUpString>
<LookUpString>

A maximum number of 9 datapairs can be used.

For clarification the following example is given (see the format of the output files of PEARL):

2.out 1 4 3 Theta

This means that the X data are taken from column 1, the Y data are taken from column 4, and the datafile is 2.out. Only lines with Theta in the third column will be selected (Note: selection is case sensitive).

If the X-data are in the same column for all data-series, you can replace the value of Column_X with ! (except for the first data-series):

2.out 1 4 3 Theta
2.out ! 5 3 Theta
2.out ! 6 3 Theta

gives the following results (only first part of file shown)

0.000	0.2971	0.2910	0.2860
4.500	0.3039	0.3049	0.3071
11.500	0.2766	0.2824	0.2941
18.500	0.2757	0.2794	0.2885
25.500	0.2824	0.2860	0.2939
32.500	0.3399	0.3405	0.3399

sdwin32 must be called from the command line with the following arguments:

sdwin32 setfile -o outputfile

→ 4.5.1 Annual balances

The flux of each drainage system is now included in the annual water balance (see Table 10).

Table 1 Terms of the annual water balance

Field	Water balance term	Unit	Acronym
1.	Net storage change of water in the soil profile	m a^{-1}	DelLiq
2.	Precipitation flux	m a^{-1}	Prc
3.	Irrigation flux	m a^{-1}	Irr
4.	Seepage flux at the lower boundary of the system	m a^{-1}	FlvLea
5.	Evaporation flux of intercepted water	m a^{-1}	EvpInt
6.	Actual soil evaporation flux	m a^{-1}	SolAct
7.	Actual transpiration flux	m a^{-1}	TrpAct
8.	Total flux of lateral drainage to field drains and ditches	m a^{-1}	Dra
9.	Flux of lateral drainage to primary system	m a^{-1}	Dra_1
10.	Flux of lateral drainage to secondary system	m a^{-1}	Dra_2
11.	Flux of lateral drainage to tertairy system	m a^{-1}	Dra_3
12.	Flux of lateral drainage to tube drains	m a^{-1}	Dra_4
13.	Flux of lateral drainage to surface drainage system	m a^{-1}	Dra_5
14.	Flux of water in run-off	m a^{-1}	Run
15.	Evaporation of ponded water	m a^{-1}	EvpPnd
16.	Potential soil evaporation flux	m a^{-1}	SolPot
17.	Potential transpiration flux	m a^{-1}	TrpPot

Table 2 Terms of the mass balance of compounds in the soil profile. This balance applies to three different layers, i.e. the tillage layer, the FOCUS target layer and the entire soil profile. See further text.

Field	Term of mass balance (kg ha^{-1} a^{-1})	Acronym
1.	Areic mass of compound applied to the soil	AmaAppSol
2.	Areic mass change of compound in the layer	DelAma
3.	Areic mass change of compound in the equilibrium domain	DelAmaEql
4.	Areic mass change of compound in the non-equilibrium domain	DelAmaNeq
5.	Areic mass of compound transformed	AmaTra
6.	Areic mass of compound formed	AmaFor
7.	Areic mass of compound taken-up by plant roots	AmaUpt
8.	Areic mass of compound drained from the soil system	AmaDra
9.	Areic mass of compound drained from the primary system	AmaDra_1
10.	Areic mass of compound drained from the secondary system	AmaDra_2
11.	Areic mass of compound drained from the tertiary system	AmaDra_3
12.	Areic mass of compound drained from the tube drains	AmaDra_4
13.	Areic mass of compound drained from the surface drains	AmaDra_5
14.	Areic mass of compound deposited	AmaDep
15.	Areic mass of compound volatized	AmaVol
16.	Areic mass of compound leached from the target layer	AmaLea

Hysteresis of water retention in soil can be simulated (but is switched off for FOCUS scenarios).

→ Chapter 5: User's Guide for the PEARL User Interface

→ Section 5.1: Overview of the PEARL database

The new GUI uses an Interbase database and installs Interbase on subdirectories within the tree of subdirectories of the PEARL package; thus the new GUI can work without Microsoft Access.

→ Section 5.6 The main form

The main form consists of five tabs, i.e. a scenario tab, a simulation control tab, an output control tab, a SWAP hydrological module tab and a run status tab (See Figure 1; FOCUS_PEARL_1.1.1. Manual Figure 21).

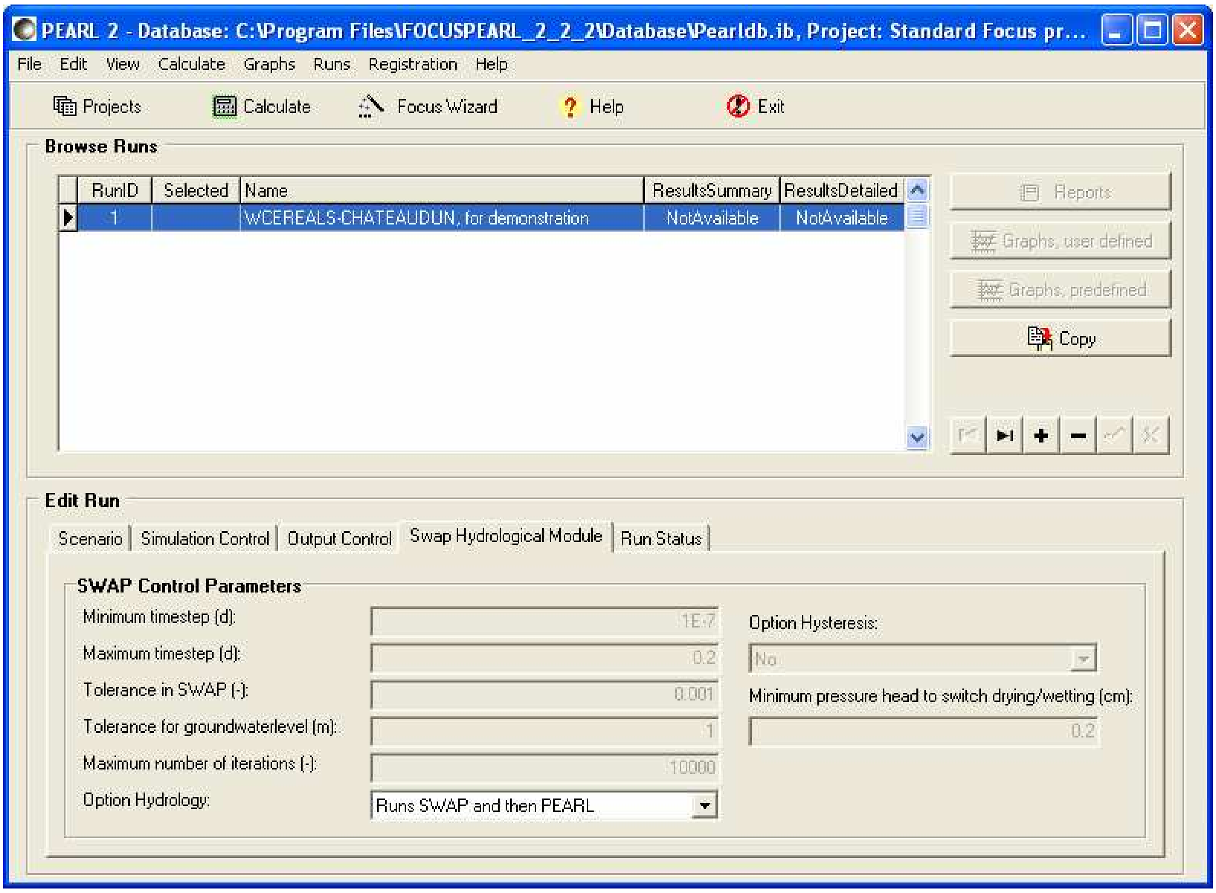

Figure 1 The main form of the PEARL user interface

On the 'SWAP hydrological module' tab, the user has to specify the option to consider hysteresis or not and the minimum pressure head to switch drying/wetting (cm). This option is switched off for FOCUS scenarios.

A facility has been added to generate an overview report of all runs in a project. After clicking on the button 'Reports', the user has to specify whether only the run selected is reported or all runs in the same project (project summary).

An archive option for runs has been added. After clicking on 'Runs' on the menu bar at the top of the main screen, the user can select 'Archive selected run'. Next the user has to specify the drive and the directory where the files should be stored.

→ Section 5.7.1 The locations form

A 'Copy' button has been added to copy a location.

→ Section 5.7.1 The soil form

The depth dependence of transformation and sorption parameters can be specified for each substance, so this dependency can be different for the parent and the metabolites (See Figure 2; FOCUS_PEARL_1.1.1. Manual Figure 23).

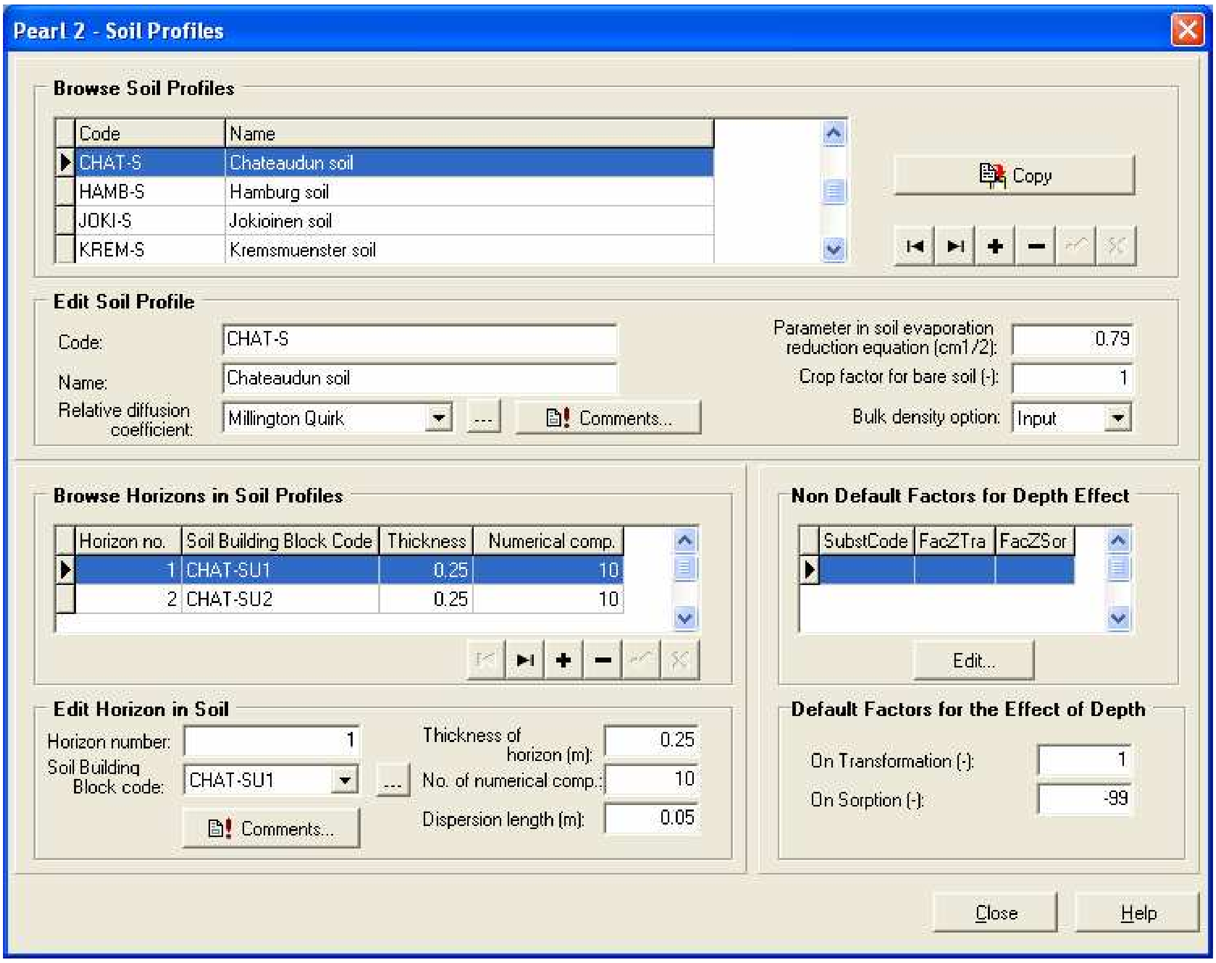

Figure 2 The Soil profiles form

→ Section 5.8.2 The crop and development stage form

In FOCUS_PEARL_2.2.2. the user has also to specify the depth of the virtual tensiometer and the critical pressure head for irrigation (See Figure 3; FOCUS_PEARL_1.1.1. Manual Figure 27). Both parameters are needed when using the SWAP irrigation option that calculates the irrigation amount based on prevailing soil moisture conditions.

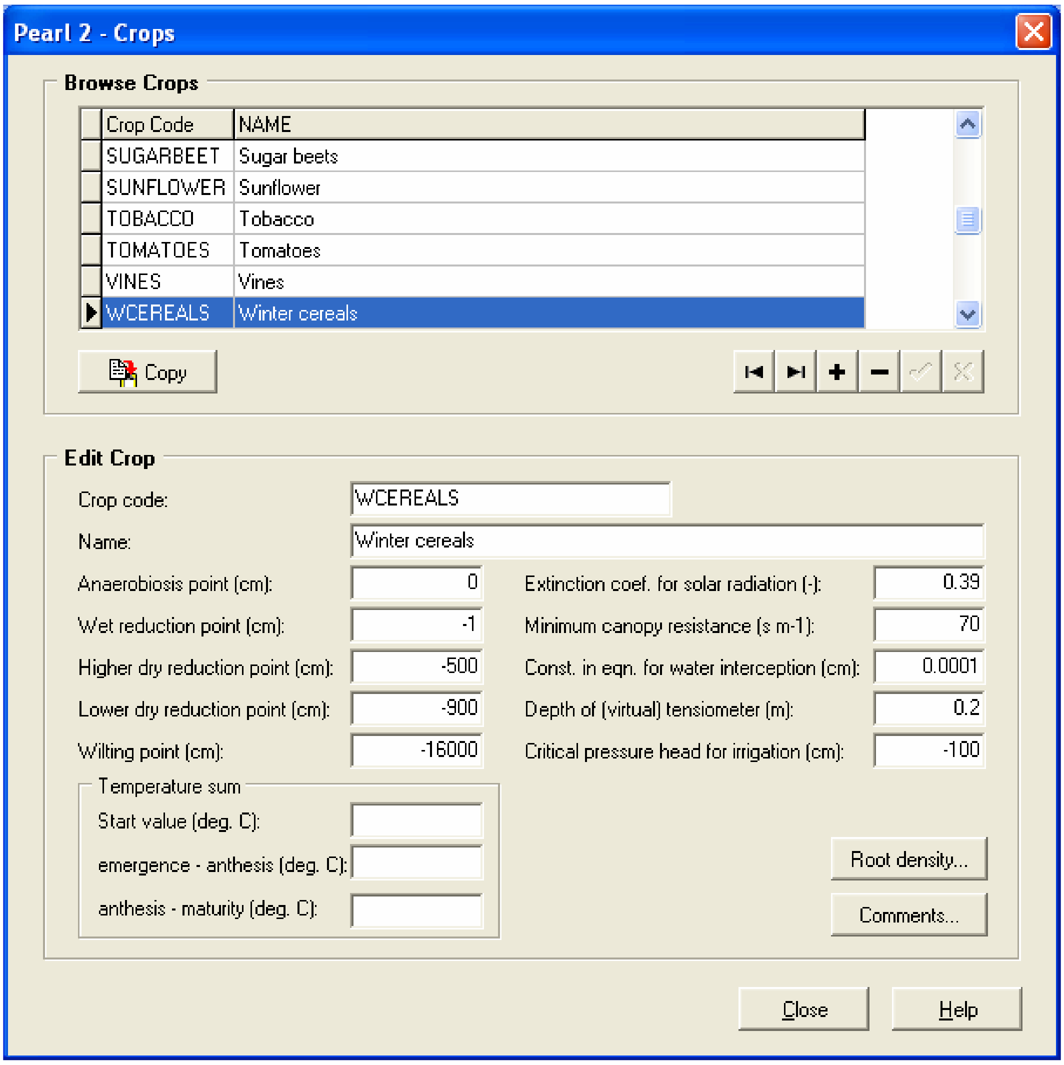

Figure 3 The crops form

→ Section 5.9.1 Editing individual compounds

On the 'Freundlich sorption' tab, the user has also to specify the temperature (K) at which the Kom value has been measured as well as the molar enthalpy of sorption (kJ mol^{-1}).

→ Section 5.10 Editing application schemes

The forms for editing application schemes has been graphically improved (See Figure 4; FOCUS_PEARL_1.1.1. Manual Figure 31).

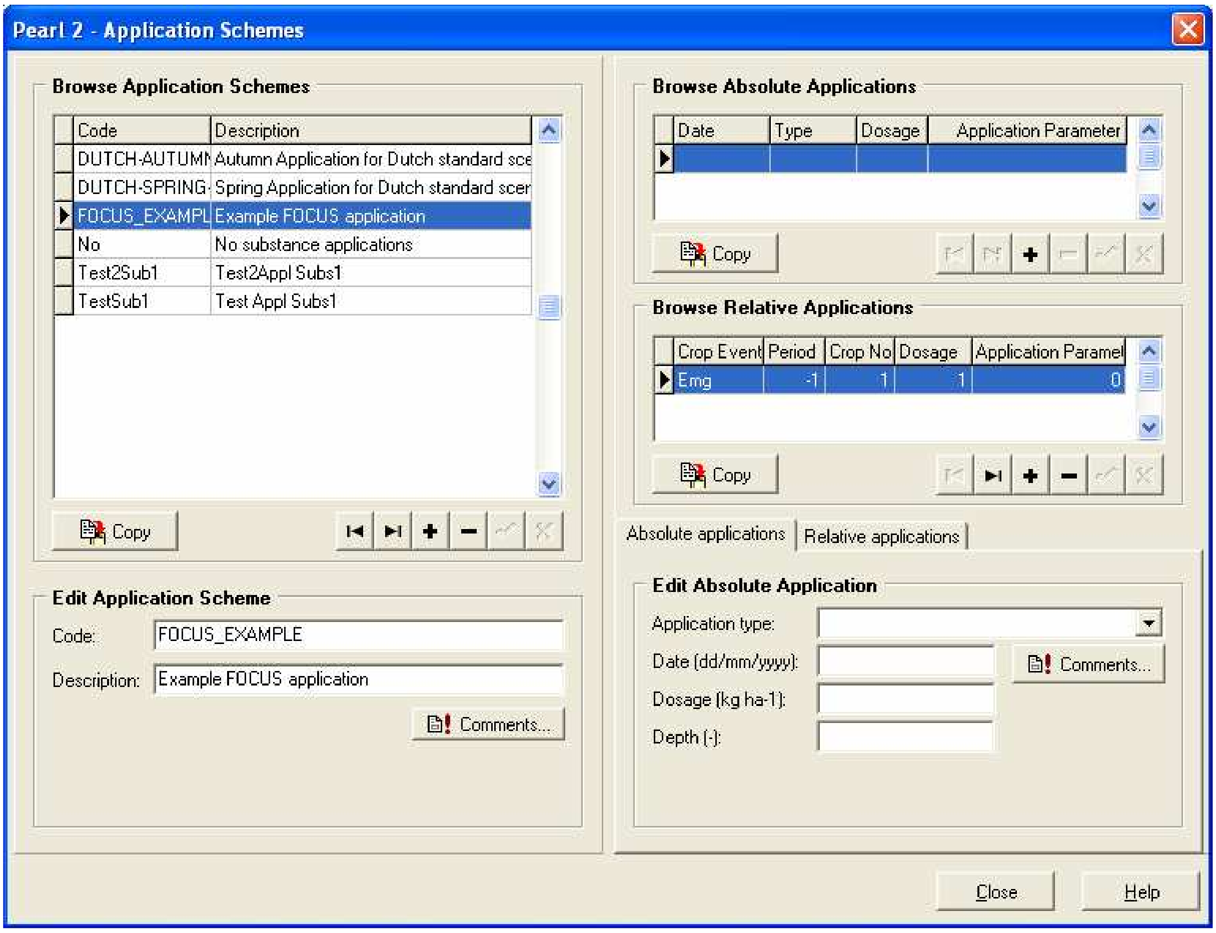

Figure 4 The application schemes form

→ Section 5.11 Editing irrigation schemes

On the 'Irrigation scheme' form the user can select two more options: 1) Surface irrigation, irrigation depth calculated by the model and 2) Sprinkler irrigation, irrigation depth calculated by the model. Moreover, a facility has been added to import irrigation data.

→ Section 5.12.2 The detailed output options form

In the category 'PEARL Concentrations' on the 'Detailed output options form', the user can now select the concentrations in the drainage water to each drain level (primary system, secondary system, etc). In the category 'PEARL Soil Balance' the areic masses drained to each drainage level can be selected for output. In the category 'SWAP Soil Fluxes' the water fluxes to each drainage level can be selected for output.

Another improvement in FOCUS_PEARL_2.2.2 is that output for all calculation nodes can be automatically generated. This facilitates making graphs of concentration and moisture profiles (See Figure 5; FOCUS_PEARL_1.1.1. Manual Figure 32).

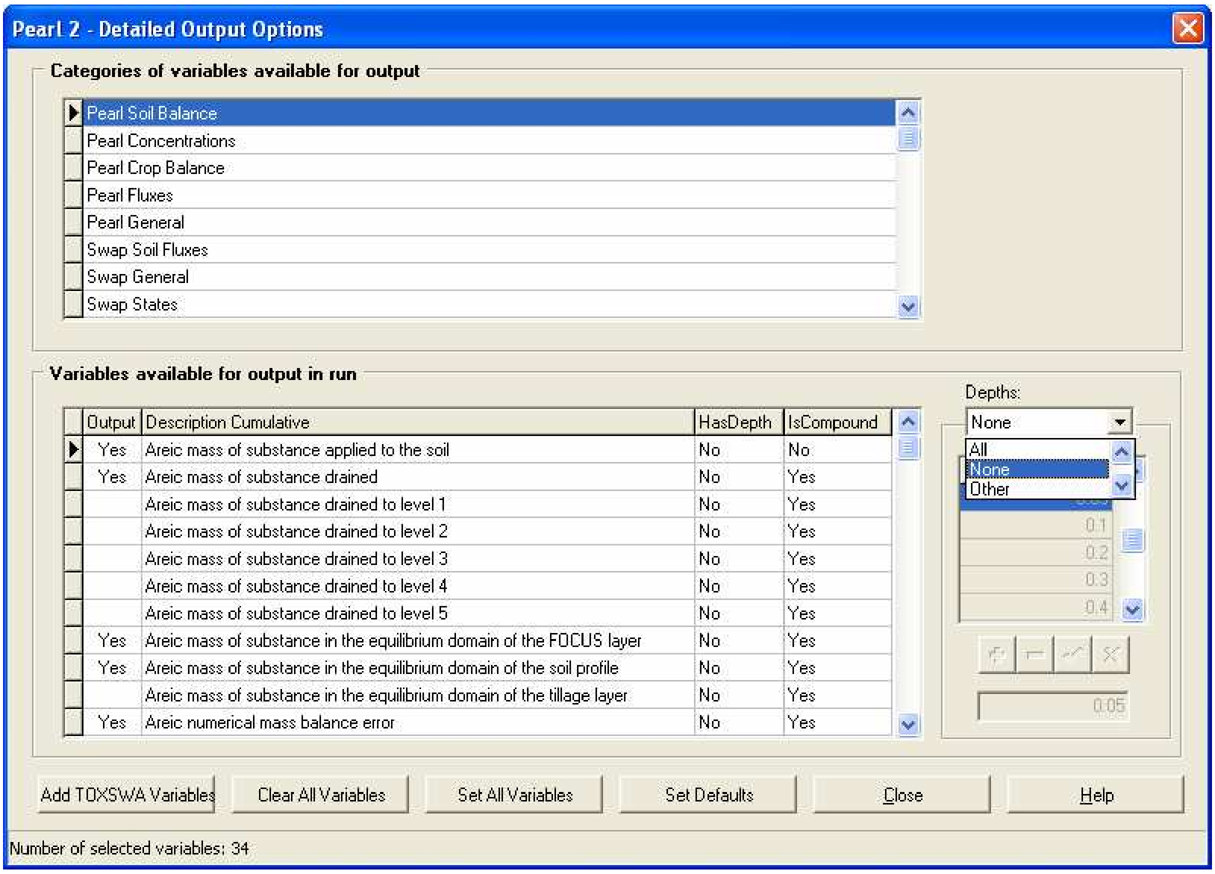

Figure 5 Output control

Literature

Black, T.A., Gardner W.R. and Thurtell, G.W., 1969. The prediction of evaporation, drainage, and soil water storage for a bare soil. Soil Sci. Soc. Am., 33, 655-660.

Kroes, J.G., Van Dam, J.C., Huygen, J. Vervoort, R.W., 2002. User's Guide of SWAP version 2.0. Alterra-rapport 610, 137 pp. Wageningen, the Netherlands.

Tiktak, A., Van den Berg, F., Boesten, J.J.T.I., Van Kraalingen, D., Leistra, M. & Van der Linden, A.M.A., 2000. Pesticide Emission at Regional and Local scales: Pearl version 1.1 User Manual. RIVM report 711401008, Alterra report 28.

Dam, J.C. van, Huygen, J., Wesseling, J.G., Feddes, R.A., Kabat, P., Van Walsum, P.E.V., Groenendijk, P. & Van Diepen, C.A., 1997. SWAP version 2.0, Theory. Simulation of water flow, solute transport and plant growth in the Soil-Water-Atmosphere-Plant environment. Report 71. Department of Water Resources, Wageningen Agricultural University. Technical Document 45. DLO Winand Staring Centre, Wageningen.

3 Sensitivity analysis

FOCUS_PEARL_2.2.2 considers two conservation equations for the pesticide in the soil system, one for the equilibrium domain and one for the non-equilibrium domain (See Leistra et al. (2001) for the description of symbols):

$$\frac{\partial c_{eq}^{*}}{\partial t} = -R_s - \frac{\partial J_{p,L}}{\partial z} - \frac{\partial J_{p,g}}{\partial z} - R_t - R_{u,p} - R_{d,p} \qquad \text{(Eq. 1)}$$

$$\frac{\partial c_{ne}^{*}}{\partial t} = R_s \qquad \text{(Eq. 2)}$$

In most pesticide studies, non-equilibrium sorption is not considered, so the first term on the right-hand side of Eq. 1 can be omitted. Secondly, most of the pesticides are non-volatile, so for these compounds the transport in soil through the gas phase is much smaller that the transport through the liquid phase. Thirdly, lateral drainage is not considered in the first-tier leaching assessments at the EU-level (FOCUS groundwater scenarios), so Eq. 1 can be simplified to:

$$\frac{\partial c_{eq}^{*}}{\partial t} = -\frac{\partial J_{p,L}}{\partial z} - R_t - R_{u,p} \qquad \text{(Eq. 3)}$$

Eq. 3 is equal to the conservation equation used in the precursors of the PEARL model (PESTLA and PESTRAS) to describe the leaching of pesticide in the soil system. Therefore, a sensitivity analysis for FOCUS_PEARL_2.2.2 with the simplifications mentioned above would give the same results as a sensitivity analysis for PESTLA 1.1 and PESTRAS 3.1.

The sensitivity of calculated leaching to the parameters in the conservation equation used in PESTLA 1.1 has been assessed by Boesten (1991). His results show that the most sensitive parameters are:

- the half-life of the substance in the soil system
- the coefficient for sorption on organic matter
- the exponent in the Freundlich sorption equation

Similar sensitivity studies on pesticide behaviour in soil using Eq. 3 have been reported using the PESTRAS model by Tiktak et al. (1994) and Swartjes et al. (1993).

Literature

Boesten, J.J.T.I., 1991. Sensitivity analysis of a mathematical model for pesticide leaching to groundwater, Pest. Sci. 31, 375-388.

Leistra, M., van der Linden, A.M.A., Boesten, J.J.T.I., Tiktak, A. & Van den Berg, F. 2001. PEARL model for pesticide behaviour and emissions in soil-plant systems. Descriptions of the processes in FOCUS PEARL v 1.1.1. Alterra-Rapport 013, RIVM report 711401009.

Tiktak, A., Swartjes, F.A., Sanders R. and Janssen, P.H.M., 1994. Sensitivity analysis of a model for pesticide leaching and accumulation. In: J. Grasman and G. van Straten (eds.). Predictability and non-linear modelling in natural sciences and economics. Kluwer Academic, Dordrecht, the Netherlands, pp. 471-484.

Swartjes, F.A., Sanders, R., Tiktak, A. and Van der Linden, A.M.A., 1993. Modelling of leaching and accumulation of pesticides: Module selection by sensitivity analysis. In: A.A.M. Del Re, E. Capri, S.P. Evans, P. Natali, and M. Trevisan (Eds.). Proceedings IX Symposium Pesticide Chemistry: Mobility and Degradation of Xenobiotics. p. 167-181.

4 Model testing

To date, FOCUS_PEARL_2.2.2 has not been tested against measurements in field experiments. Because the concepts to describe the processes affecting the fate of the pesticide in the soil have not changed in the development from FOCUS_PEARL_1.1.1 to FOCUS_PEARL_2.2.2, the outcome of testing FOCUS_PEARL_1.1.1 as described below is valid for FOCUS_PEARL_2.2.2 too.

Bouraoui et al. (2003) have tested FOCUS_PEARL_1.1.1 to describe the behaviour of pesticides in soil using measurements from field experiments in Vredepeel (NL) and Lanna (S). In the Vredepeel field experiment, KBr, bentazon and ethoprophos were applied to a sandy soil (gley podzol) with no subsurface drainage. The model was tested using a stepwise approach (Vanclooster et al., 2003). The moisture content profiles were used to calibrate the soil hydrological parameters. Using the calibrated soil physical parameters, accurate model predictions were obtained for the bentazone and ethoprophos content profiles in the soil. For the Lanna field experiment, KBr and bentazone were applied on a silty clay soil with a drainage system. The VanGenuchten parameters n and α were calibrated using measured moisture content profiles. The dispersion length was calibrated to give a better description of the Bromide content profile. On average, the computed drain water flow was 13% less than measured. The underprediction of the drain water fluxes might be caused by the occurrence of preferential flow in the field soil, as this type of transport cannot be simulated by PEARL. The predicted concentration profile of bentazone agrees reasonably with the measurements, whereas the concentrations in the drainwater were underpredicted at times and this is probably due to the effect of preferential flow.

Scorza and Boesten (2005) have tested FOCUS_PEARL_1.1.1 against the results of a field experiment on a cracking clay soil at Andelst (NL). In this field experiment, KBr, the mobile pesticide bentazone and the moderately sorbing pesticide imidacloprid were applied to the bare soil. The model was tested using a stepwise approach (Vanclooster et al., 2003). Calibration of the soil hydrological parameters was necessary to obtain a good description of the soil moisture profiles. The dispersion length was calibrated to obtain a good description of the bromide transport in the soil. The concentrations of bentazone in the drainwater and groundwater were described reasonably well by the model. The bulk movement of imidacloprid in the soil was overestimated by the model and the concentrations of imidacloprid in drainwater was underestimated. This indicates that FOCUS_PEARL_1.1.1 cannot be used for accurate simulation of pesticide transport in cracking clay soils.

Vanclooster et al. (2003) have tested FOCUS_PEARL_1.1.1 against the results of field experiments in Bologna (I) and Brimstone (UK). In the Bologna field experiment, aclonifen and ethoprophos were applied to a loamy soil. Calibration of the soil hydrological parameters was needed to improve the description of the soil moisture profiles. The limited movement of both aclonifen and ethoprophos was reasonably described by the model. However, this experiment was not suitable to test pesticide leaching to groundwater. In the Brimstone field experiment, isoproturon was applied in different years to a cracking heavy clay soil. The soil hydrological parameters were calibrated using measured soil moisture content profiles. The average moisture content corresponded well to those measured, but at different occasions there were large differences, presumably due to the occurrence of preferential flow. Measured concentrations of isoproturon occurred several weeks earlier than predicted by PEARL, indicating that preferential flow is an important process for this particular soil..

Literature

Bouraoui, F., Boesten, J.J.T.I., Jarvis, N. and Bidoglio, G., 2003. Testing the PEARL model in the Netherlands and in Sweden. Proceedings XII symposium Pesticide Chemistry, Piacenza, Italy.

Scorza Júnior, R.P. & Boesten, J.J.T.I., 2005. Simulation of pesticide leaching in a cracking clay soil with the PEARL model, Pestic. Management Sci., in press.

Vanclooster, M., Pineros-garcet, J.D., Boesten J.J.T.I., van den Berg, F., Leistra, M., Smelt, J. H., Jarvis, N., Burauel, P., Vereecken, H., Wolters, A., Linnemann, V., Fernandez, E., Trevisan, M., Capri, E., Klein, M., Tiktak, A., van der Linden A.M.A., De Nie, D., Bidoglio G., Bouraoui, F., Jones, A., Armstrong, A., 2003. Effective approaches for assessing the predicted environmental concentrations of pesticides: a proposal supporting the harmonised registration of pesticides in Europe, Final Report August 2003, 158 pp.

Appendix 1 The PEARL_2.2.2 input file – Expert users

This appendix gives a listing of the extended PEARL_2.2.2 input file. This file is intended to be used by expert users. Differences in the input file of PEARL_2.2.2 compared with PEARL_1.1.1 are set in bold face.

```
*------------------------------------------------------------------------------------------
* STANDARD FILE for Pearl version 1.5.8 (16-Jun-2003).
*
* This file is intended to be used by expert users.
* Figures between brackets refer to constraints (maximum and minimum values).
*
* Pearl e-mail address: lbg-pearl@rivm.nl
*
* (c) RIVM/Alterra 7-Aug-2003
*------------------------------------------------------------------------------------------

*------------------------------------------------------------------------------------------
* Sector 0: Run identification
*------------------------------------------------------------------------------------------

DutchRegistration       OptReport            Type of report (FOCUS, DutchRegistration)
Dutch_Location          Location             Location identification
Dutch_Soil              SoilTypeID           Soil identification
Monoculture_Maize       CropCalendar         Crop calendar
A                       SubstanceName        Substance name
One_Spring_Application  ApplicationScheme    Application scheme
No                      DepositionScheme     Deposition scheme
No                      IrrigationScheme     Irrigation scheme

*------------------------------------------------------------------------------------------
* Section 1: Control section
*------------------------------------------------------------------------------------------
FOCUS             CallingProgram             Release type
2                 ModelVersion               Version number of the model
2                 GUIVersion                 Version number of the GUI
2                 DBVersion                  Version number of the database

* Time domain
01-Jan-1980       TimStart                   Begin time of simulation [01-Jan-1900|-]
31-Dec-2000       TimEnd                     End time of simulation [TimStart|-]
1.d-4             AmaSysEnd    (kg.ha-1)     Stop criterion - ignored if zero [0|-]
0                 DelTimPrn    (d)           Print time step [0|-] - zero is automatic

* SWAP control
Yes               RepeatHydrology            Repeat weather data: Yes or No
Automatic         OptHyd                     OnLine, OffLine, Stationary, Only, Automatic
1.d-5             DelTimSwaMin (d)           Minimum time step in SWAP [1d-8|0.1]
0.2               DelTimSwaMax (d)           Maximum time step in SWAP [0.01|0.5]
0.001             ThetaTol     (m3.m-3)      Tolerance in SWAP [1e-5|0.01]
1.0               GWLTol       (m)           Tolerance for groundwater level
10000             MaxItSwa                   Maximum number of iterations in SWAP

Other             OptDelTimPrn               Option to set output interval
Yes               OptScreen                  Option to write output to screen


*------------------------------------------------------------------------------------------
* Section 2: Soil section
*------------------------------------------------------------------------------------------


* The soil profile
* Specify for each horizon:
* Horizon thickness (m)
* The number of soil compartments [1|500]
* Nodes are distributed evenly over each horizon
table SoilProfile
ThiHor NumLay
(m)
0.3      12
0.2      8
```

```
0.2      4
0.3      6
2        20
end_table

* Basic soil parameters
* Specify for each soil horizon:
* Mass content of sand, expressed as a fraction of the mineral soil  (kg.kg-1)  [0|1]
* Mass content of silt, expressed as a fraction of the mineral soil  (kg.kg-1)  [0|1]
* Mass content of clay, expressed as a fraction of the mineral soil  (kg.kg-1)  [0|1]
* Organic matter mass content                                        (kg.kg-1)  [0|1]
* pH. pH measured in 0.01 M CaCl2 is preferred (see theory document) (-)        [1|13]
table  horizon SoilProperties
Nr     FraSand    FraSilt    FraClay    CntOm        pH
       (kg.kg-1)  (kg.kg-1)  (kg.kg-1)  (kg.kg-1)    (-)
1      0.92       0.05       0.03       0.0470       4.7
2      0.96       0.02       0.02       0.0080       4.4
3      0.95       0.03       0.02       0.0019       4.6
4      0.94       0.04       0.02       0.0014       4.6
5      0.93       0.05       0.02       0.0000       4.6
end_table

* Parameters of the Van Genuchten-Mualem relationships (B1 + O1)
* Specify for each soil horizon:
* The saturated water content     (m3.m-3)  [0|0.95]
* The residual water content      (m3.m-3)  [0|0.04]
* Parameter alpha                 (cm-1)    [1.d-3|1]
* Parameter n                     (-)       [1|5]
* The saturated conductivity      (m.d-1)   [1.d-4|10]
* Parameter lambda (l)            (-)       [-25|25]
* New Staring Series - not used for standard scenario

table  horizon VanGenuchtenPar
Nr ThetaSat   ThetaRes    AlphaDry   AlphaWet     n       KSat      l
   (m3.m-3)   (m3.m-3)    (cm-1)     (cm-1)       (-)     (m.d-1)   (-)
1   0.43      0.01        0.0249     0.0498       1.507   0.1746  -0.140
2   0.43      0.01        0.0249     0.0498       1.507   0.1746  -0.140
3   0.36      0.01        0.0224     0.0448       2.167   0.1321   0.000
4   0.36      0.01        0.0224     0.0448       2.167   0.1321   0.000
end_table
Input              OptRho                      Calculate or Input
* If RhoOpt = Input:
table horizon      Rho             (kg.m-3)    [100|2000]
1    1310.0
2    1540.0
3    1640.0
4    1650.0
5    1650.0
end_table
* End If

No                 OptHysteresis               Option to include hysteresis
0.2                PreHeaWetDryMin (cm)        Minimum pressure head to switch drying/wetting

* Maximum ponding depth and boundary air layer thickness (both location properties)
0.01               ZPndMax         (m)         Maximum ponding depth [0|1]
0.01               ThiAirBouLay    (m)         Boundary air layer thickness [1e-6|1]

* Soil evaporation parameters
Boesten            OptSolEvp                   Option to select evaporation reduction method
1.0                FacEvpSol       (-)         "Crop factor" for bare soil [0.5|1.5]
0.63               CofRedEvp       (cm1/2)     Parameter in Boesten equation [0|1]
0.01               PrcMinEvp       (m.d-1)     Minimum rainfall to reset reduction

* Parameter values of the functions describing the relative diffusion coefficients
MillingtonQuirk    OptCofDifRel                MillingtionQuirk, Troeh or Currie

* If MillingtonQuirk:
2.0                ExpDifLiqMilNom (-)         Exponent in nominator of equation [0.1|5]
0.67               ExpDifLiqMilDen (-)         Exponent in denominator of eqn    [0.1|2]
2.0                ExpDifGasMilNom (-)         Exponent in nominator of equation [0.1|5]
0.67               ExpDifGasMilDen (-)         Exponent in denominator of eqn    [0.1|2]

* If Troeh:
0.05               CofDifLiqTro    (-)         Coefficient in Troeh equation     [0|1]
1.4                ExpDifLiqTro    (-)         Exponent in Troeh equation        [1|2]
0.05               CofDifGasTro    (-)         Coefficient in Troeh equation     [0|1]
```

```
1.4              ExpDifGasTro    (-)         Exponent in Troeh equation        [1|2]

* If Currie:
2.5              CofDifLiqCur    (-)         Coefficient in Currie equation    [0|-]
3.0              ExpDifLiqCur    (-)         Exponent in Currie equation       [1|-]
2.5              CofDifGasCur    (-)         Coefficient in Currie equation    [0|-]
3.0              ExpDifGasCur    (-)         Exponent in Currie equation       [1|-]

* End If

* Dispersion length of solute in liquid phase [0.5Delz|1]
Table horizon LenDisLiq (m)
1  0.05
2  0.05
3  0.05
4  0.05
5  0.05
end_table


*-----------------------------------------------------------------------------------------
* Section 3: Weather and irrigation data
*-----------------------------------------------------------------------------------------

defscen          MeteoStation                Maximum 7 (!!) characters.
Input            OptEvp                      Evapotranspiration: Input, Penman or Makkink
52.0             Lat                         Latitude of meteo station [-60|60]
10.0             Alt             (m)         Altitude of meteo station [-400|3000]

* Initial lower boundary soil temperature [-20|40]
* Upper boundary temperature is read from meteo file
9.97             TemLboSta       (C)

* Irrigation section
No               OptIrr
* Options for OptIrr are:
* No: no irrigation
* Surface: Surface irrigation, irrigation depth spec. by user
* Surface_Auto: Surface irrigation, irrigation depth calc. by model
* Sprinkler: Sprinkler irrigation, irrigation depth spec. by user
* Sprinkler_Auto: Sprinkler irrigation, irrigation depth calc. by model

defscen          IrrigationData              Name of file with irrigation data
* Irrigation data have to be provided in a file Station.irr (e.g. debilt.irr);
* Maximum number of characters in filename is 7.
* If RepeatHydrology is set to Yes, the first year is required only
* Format of the file should be as below:
* table IrrTab (mm)
* 01-Aug-1980 10.0
* end_table
1.0              FacPrc (-)                  Correction factor for precipitation
0.0              DifTem (C)                  Correction for temperature
1.0              FacEvp (-)                  Correction factor for evapotranspiration
*-----------------------------------------------------------------------------------------
* Section 4:  Boundary and initial conditions of hydrological model
* Section 4a: Lower boundary flux conditions
*-----------------------------------------------------------------------------------------

* Initial condition
1.00             ZGrwLevSta      (m)         Initial groundwater level [0|50]

* Choose one of the following options:
* GrwLev Flux Head FncGrwLev Dirichlet ZeroFlux FreeDrain Lysimeter
FncGrwLev        OptLbo                      Lower boundary option

* LboOpt = GrwLev (groundwater level boundary condition)
table   GrwLev    (m)                        Groundwater level [0|-]
01-Jan  1.00
31-Dec  1.00
end_table

* LboOpt = Flux (flux lower boundary condition)
-0.250           FlvLiqLboAvg    (m.a-1)     Average annual lower boundary flux [-1|1]
0.10             FlvLiqLboAmp    (m)         Amplitude of lower-boundary flux [0|0.5]
01-Oct           DayFlvLiqLboMax             Day of maximum flux [01-Jan|31-Dec]

* LboOpt = Head (head lower boundary condition)
```

```
Elliptic          OptShapeGrwLev                Elliptic, Parabolic, Sinusoidal, NoDrains
-1.1              HeaDraBase      (m)           Drainage base to correct GrwLev [-100|0]
500.0             RstAqt          (d)           Resistance of aquitard [0|1e4]
-1.4              HeaAqfAvg       (m)           Mean hydraulic head of aquifer [-10|10]
0.2               HeaAqfAmp       (m)           Amplitude of aquifer hydraulic head [0|10]
01-Apr            TimHeaAqfMax    (d)           Day with maximum head [01-Jan|31-Dec]

* LboOpt = FncGrwLev (flux boundary condition - flux is a function of groundwater level)
-0.0112           CofFncGrwLev    (m.d-1)       Coefficient in Q(h) relationship [-1|1]
-2.5              ExpFncGrwLev    (m-1)         Exponent in Q(h) relationship [-100|100]

* LboOpt = Dirichlet (pressure head boundary condition)
table   h  (m)                                  Pressure head [-1e4|1e4]
01-Jan  -1.0
31-Dec  -1.0
end_table

*------------------------------------------------------------------------------------------
* Section 4b: Local drainage fluxes to ditches and drains
*------------------------------------------------------------------------------------------
No                OptDra                        No, Basic or extended drainage module
No                OptSurDra                     Option to consider surface drainage
0                 NumDraLev                     Number of drainage levels (0|5)

* If OptDra set to ‘Basic’ parameters below should be specified for each drainage level:
1                 SysDra_1                      Drainage system
100.0             RstDra_1        (d)           Drainage resistance [1|1e5]
100.0             RstInf_1        (d)           Infiltration resistance
20.0              DistDra_1       (m)           Distance between drains or channels [1|1e6]
1.5               ZDra_1          (m)           Bottom of drain system [0|10]
Drain             TypDra_1                      Type of drain system: Drain or Channel
1.5               ZSurWat_1       (m)           Channel water level (if TypDra_1 = Channel;
                                                otherwise dummy values)

* If OptDra set to ‘Extended’ parameters below should be specified for each drainage level:
1                 SysDra_1                      Drainage system
100.0             RstDra_1        (d)           Drainage resistance [1|1e5]
100.0             RstInf_1        (d)           Infiltration resistance
20.0              DistDra_1       (m)           Distance between drains or channels [1|1e6]
1.0               WidthDra_1      (m)           Bottom width of drain system
1.5               ZDra_1          (m)           Bottom of drain system [0|10]
1.5               ZGwlInfMax_1    (m)           Depth at which infiltration is maximal
Yes               OptSurDra                     Option to consider rapid subsurface drainage
* If OptSurDra set to ‘Yes’ then the following parameters should be specified:
30                RstSurDraDeep   (d)           maximum resistance of rapid subsurface drainage
                                                [1e-3|1e4]]
10                RstSurDraShallow(d)           minimum resistance of rapid subsurface drainage
                                                [1e-3|1e4]]
No                OptSrfWat                     Option to consider surface water system
* If OptSrfWat set to ‘Yes’ then the following parameters should be specified:
1.0               SrfWatLevWinter (m)           Winter surface water level
1.0               SrfWatLevSummer (m)           Summer surface water level
0.0               SrfWatSupCap    (m.d-1)       Surface water supply capacity

*------------------------------------------------------------------------------------------
* Section 5: Compound section
*------------------------------------------------------------------------------------------

* Compounds. First compound is the parent pesticide, the others are metabolites.
table compounds
pest
end_table
200.0             MolMas_pest    (g.mol-1)      Molar mass [10|10000]

* Transformation table (parent-daughter relationships)
* The "end" substance is the final transformation product
* Condition: Sum of rows should be 1 (see theory document)

table FraPrtDau (mol.mol-1)
pest    end
0.00    1.00   pest
end_table

* Example for a pesticide with two daughters, named "met1" and "met2":
* Line 1: pest is transformed into met1 (25%), met2 (70%) and undefined end products (5%)
* Line 2: met1 is transformed into met2 (16%) and undefined end products (84%)
* Line 3: met2 is transformed into undefined end products only (100%)
```

```
* table FraPrtDau (mol.mol-1)
* pest    met1   met2   end
* 0.00    0.25   0.70   0.05   pest
* 0.00    0.00   0.16   0.84   met1
* 0.00    0.00   0.00   1.00   met2
* end_table

* Transformation rate parameters
50.0               DT50Ref_pest   (d)          Half-life time [1|1e6]
20.0               TemRefTra_pest (C)          Temperature at which DT50 is measured [5|30]
0.70               ExpLiqTra_pest (-)          Exponent for the effect of liquid [0|5]
OptimumConditions  OptCntLiqTraRef_pest        OptimumConditions or NonOptimumConditions
1.0                CntLiqTraRef_pest (kg.kg-1) Liq. content at which DT50 is measured [0|1]
54.0               MolEntTra_pest (kJ.mol-1)   Molar activation energy [0|200]

*                                              Factor for the effect of depth [0|1]
table horizon FacZTra        (-)
hor Pest
1   1.00
2   0.95
3   0.74
4   0.33
5   0.00
end_table

* Freundlich equilibrium sorption
pH-independent     OptCofFre_pest              pH-dependent, pH-independent, CofFre
1.0                ConLiqRef_pest  (mg.L-1)    Reference conc. in liquid phase [0.1|-]
0.9                ExpFre_pest     (-)         Freundlich sorption exponent [0.1|1.3]

* If pH-independent (use the coefficient for sorption on organic matter):
70.00              KomEql_pest     (L.kg-1)    Coef. eql. sorption on org. matter [0|1e9]

* If pH-dependent (use pKa value and coefficient for sorption on organic matter):
374.7              KomEqlAcid_pest (L.kg-1)    Coef. for eql. sorption on om - acid [0|1e9]
7.46               KomEqlBase_pest (L.kg-1)    Coef. for eql. sorption on om - base [0|1e9]
4.6                pKa_pest        (-)         Coef. for influence of pH on sorption [0|14]
0.0                pHCorrection    (-)         pH correction [-2|1]

* If CofFre (specify the depth dependence and the coefficient for equilibrium sorption):
1.0                KSorEql_pest    (L.kg-1)    Coef. for equilibrium sorption [0|1e9]
0.0                MolEntSor_Pest  (kJ.mol-1)
20.0               TemRefSor_Pest  (C)

table horizon FacZSor        (-)               Factor for the effect of depth [0|1]
hor Pest
1   1.00
2   0.17
3   0.04
4   0.03
5   0.00
end_table

* End If

* Gas/liquid partitioning
0.0                PreVapRef_pest  (Pa)        Saturated vapour pressure [0|2e5]
20.0               TemRefVap_pest  (C)         .. measured at [0|40]
100.0              MolEntVap_pest  (kJ.mol-1)  Molar enthalpy of vaporisation [-200|200]
33.0               SlbWatRef_pest  (mg.L-1)    Solubility in water [1e-9|1e6]
20.0               TemRefSlb_pest  (C)         .. measured at [0|40]
40.0               MolEntSlb_pest  (kJ.mol-1)  Molar enthalpy of dissolution [-200|200]

* Non-equilibrium sorption
0.00               CofDesRat_pest  (d-1)       Desorption rate coefficient [0|0.5]
0.5                FacSorNeqEql_pest (-)       CofFreNeq/CofFreEql [0|-]

* Uptake
0.5                FacUpt_pest     (-)         Coefficient for uptake by plant [0|10]

* Canopy processes
Lumped             OptDspCrp                   Lumped or Specified

* If Lumped:
1.d6               DT50DspCrp      (d)         Half-life at crop surface [1|1e6]

* If Specified:
```

```
1.d6             DT50PenCrp      (d)         Half-life due to penetration [1|1e6]
1.d6             DT50VolCrp      (d)         Half-life due to volatilization [1|1e6]
1.d6             DT50TraCrp      (d)         Half-life due to transformation [1|1e6]

* End If

1.d-4            FacWasCrp       (m-1)       Wash-off factor [1e-6|0.1]

* Diffusion of solute in liquid and gas phases
4.3d-5           CofDifWatRef_pest (m2.d-1)  Reference diff. coeff. in water [10e-5|3e-4]
0.43             CofDifAirRef_pest (m2.d-1)  Reference diff. coeff. in air [0.1|3]
20.0             TemRefDif_pest  (C)         Diff. coeff measured at temperature [10|30]

*-----------------------------------------------------------------------------------------
* Section 6: Management section
*-----------------------------------------------------------------------------------------
1.0              ZFoc            (m)         Depth of Focus target layer [0.1|Z(N)-1]
NoRepeat         DelTimEvt       (a)         Repeat interval of events [NoRepeat|1|2|3]

* Event table:
* If AnnualEventSameDay is set to Yes, the year is not used.

* Column 1: Date
* Column 2: Event type: AppSolSur, AppSolInj, AppSolTil, AppCrpUsr, AppCrpLAI

* If Event = AppSolSur (soil surface application):
* Column 3: Dosage (kg/ha) [0|-]

* If EventType = AppCrp (application to the crop canopy):
* Column 3: Dosage (kg/ha) [0|-]
* Column 4: Optional: Fraction of dosage applied to the crop canopy (-) [0|1]

* If EventType = AppIrr (application in irrigation water):
* Column 3: Concentration (mg/L) - checked for compatability of Irrigation table (IrrTab)

* End If

table Applications
26-May-1980  AppSolSur 1
end_table

* Tillage table - can be empty
table TillageDates
end_table

*-----------------------------------------------------------------------------------------
* Section 7: Initial and boundary conditions of pesticide fate model
*-----------------------------------------------------------------------------------------
* Initial conditions                         Concentration in equilibrium domain [0|-]

* If using metabolites, ConSysEql should be specified for all metabolites
table interpolate CntSysEql       (mg.kg-1)
z        pest
0.0000   0.000
5.0000   0.000
end_table

* Initial conditions                         Concentration in non-equil. domain [0|-]
* If using metabolites, ConSysNeq should be specified for all metabolites
table interpolate CntSysNeq       (mg.kg-1)
z        pest
0.0000   0.000
5.0000   0.000
end_table

* Upper boundary flux                        [0|-]
table    FlmDep   (kg.ha-1.d-1)
01-Jan-1980  0.0
31-Dec-1989  0.0
end_table

* Concentration in irrigation water
0.0              ConIrr           (mg.L-1)   Concentration in irrigation water [0|-]

*-----------------------------------------------------------------------------------------
* Section 8: Crop section
*-----------------------------------------------------------------------------------------
```

```
Yes              RepeatCrops                 Repeat crop table: Yes or No

* Emergence and harvest date of crop.
* Note: Length of growing season must be constant for one crop
* If reapeat crops: Specification of year not required
table  Crops
16-May-1980      04-Oct-1980   Maize
end_table

* Crop cycle fixed or variable (calculated from temperature sum)
Fixed    OptLenCrp                           Fixed or Variable

* If OptLenCrp = Variable:
0.0              TemSumSta_Maize     (C)     Start value of temperature sum [-10|20]
1050.0           TemSumEmgAnt_Maize  (C)     Sum from emergence to anthesis [0|1e4]
1000.0           TemSumAntMat_Maize  (C)     Sum from anthesis to maturity  [0|1e4]

* End If

* Crop parameters as a function of development stage
* Column 1: Development stage: 0 = emergence; 1 = harvest (-)           [0|1]
* Column 2: LAI: Leaf Area Index                        (m2.m-2)      [0|12]
* Column 3: FacCrp: Crop factor                         (-)           [0|2]
* Column 4: ZRoot: Rooting depth                        (m)           [0|10]
* Column 5: HeightCrp:  Crop height                     (m)           [0|10]
*      LAI   FacCrp  ZRoot  HeightCrp
table  CrpPar_Maize
0.000  0.00  1.00   0.00    0.01
0.099  0.20  1.00   0.10    0.05
0.241  0.95  1.00   0.20    0.20
0.383  1.90  1.00   0.30    1.00
0.525  2.95  1.00   0.40    1.70
0.596  3.40  1.00   0.41    1.70
0.667  3.60  1.00   0.44    1.75
0.738  3.70  1.00   0.40    1.80
0.879  3.60  1.00   0.40    1.80
1.000  3.50  1.00   0.30    1.80
end_table

* Root density table (first column is relative depth)
* Column 1: Relative depth 0 = soil surface; 1 = DepRoot  (-)           [0|1]
* Column 2: Root density distribution                     (-)           [0|1]
Table RootDensity_Maize
0.00        1.00
1.00        1.00
end_table

* Crop water use
-10.0            HLim1_Maize     (cm)        Anaerobiosis point  [-100|0]
 25.0            HLim2_Maize     (cm)        Wet reduction point [-1000|0]
-1000.0          HLim3L_Maize    (cm)        Dry reduction point [-10000|0]
-1000.0          HLim3U_Maize    (cm)        Dry reduction point [-10000|0]
-8000.0          HLim4_Maize     (cm)        Wilting point       [-16000|0]

70.0             RstEvpCrp_Maize (s.m-1)     Min. canopy resistance [0|1000]
0.5325           CofExtDif_Maize (-)
1.0              CofExtDir_Maize (-)
0.2              ZTensioMeter_Maize (m)
100.0            PreHeaIrrSta_Maize (cm)
1.d-4            CofIntCrp_Maize             Constant in Braden eq for interception [0|1]

*------------------------------------------------------------------------------------------
* Section 9: Output control
*------------------------------------------------------------------------------------------

* First, specify the time format in the output file:
* DaysFromSta  : Print number of days since start of simulation
* DaysFrom1900 : Print number of days since 1900
* Years        : Print years
DaysFromSta      DateFormat                  Format of time column in output file
No               OptDelOutput
Yes              PrintCumulatives

table VerticalProfiles
end_table
```

```
* Format of the ordinary output - use FORTRAN notation:
* e is scientific notation, g = general is general notation
* Then follow the number of positions
* Then the number of digits
g12.4           RealFormat                   Format of ordinary output

* Second, specify the nodal heights for which output is requested
table OutputDepths (m)
0.05
0.10
0.15
0.20
0.25
0.50
1.00
1.50
2.00
3.00
end_table

* Finally, specify for all variables whether output is wanted (Yes or No)
* As Pearl can potentially generate large output files, it is recommended to minimise
* the number of output variables

* Section I : Output from the SWAP model, version 2.0.7c

* General variables
No                print_GrwLev           Groundwater level (m)
No                print_LAI              Leaf Area Index (m2.m-2)
No                print_ZRoot            Rooting depth (m)
No                print_FacCrpEvp        Crop factor (-)
No                print_FraCovCrp        Soil cover (-)
No                print_AvoLiqErr        Water balance error (m)
No                print_StoCap           Phreatic storage capacity (m3.m-2)
* State variables
No                print_Tem              Soil temperature (C)
No                print_Eps              Volumic air content (m3.m-3)
No                print_Theta            Volumic soil water content (m3.m-3)
No                print_PreHea           Soil water pressure head (m)

* Volumic volume rates (m3.m-3.d-1)
Yes               print_VvrLiqDra        Volumic volume rate of drainage
Yes               print_VvrLiqUpt        Volume flux of water uptake

* Volume fluxes (m3.m-2.d-1)
No                print_FlvLiq           Volume flux of vertical soil water flow
No                print_FlvLiqPrc        Volume flux of precipitation
No                print_FlvLiqIrr        Volume flux of water in irrigation
No                print_FlvLiqLbo        Volume flux of water leaching from the soil system
No                print_FlvLiqEvpIntPrc  Evaporation flux of intercepted rainfall
No                print_FlvLiqEvpIntIrr  Evaporation flux of intercepted irrigation
No                print_FlvLiqEvpSol     Volume flux of evaporation from the soil surface
No                print_FlvLiqEvpSolPot  Idem, potential
No                print_FlvLiqTrp        Volume flux of transpiration by plant roots
No                print_FlvLiqTrpPot     Idem, potential
No                print_FlvLiqDra_1      Volume flux of drainage to level 1
No                print_FlvLiqDra_2      Volume flux of drainage to level 2
No                print_FlvLiqDra_3      Volume flux of drainage to level 3
No                print_FlvLiqDra_4      Volume flux of drainage to level 4
No                print_FlvLiqDra_5      Volume flux of drainage to level 5
No                print_FlvLiqGrw        Volume flux groundwater recharge

* Section II : Output from the PEARL model
* Remark: All fluxes are averages over the print interval
*--------------------------------------------------------

* Time step
No                print_DelTimPrl        Average time-step during the print interval (d)

* Mass balance (kg.m-2)
Yes               print_AmaEqlPro        Areic mass in equilibrium domain of profile
Yes               print_AmaEqlTil        Areic mass in equilibrium domain of tillage layer
Yes               print_AmaEqlFoc        Areic mass in equilibrium domain of focus layer
Yes               print_AmaNeqPro        Areic mass in non-eql. domain of profile
Yes               print_AmaNeqTil        Areic mass in non-eql. domain of tillage layer
Yes               print_AmaNeqFoc        Areic mass in non-eql. domain of focus layer
Yes               print_AmaSysPro        Areic mass of pesticide in the system
```

```
Yes              print_AmaSysTil        Areic mass of pesticide in the tillage layer
Yes              print_AmaSysFoc        Areic mass of pesticide in the focus layer
Yes              print_AmaAppSol        Areic mass applied to the soil system
Yes              print_AmaDraPro        Areic mass of lateral discharge
Yes              print_AmaForPro        Areic mass of formation
Yes              print_AmaTraPro        Areic mass of pesticide transformation
Yes              print_AmaUptPro        Areic mass of pesticide uptake
Yes              print_AmaDra_1         Areic mass of drainage to level 1
Yes              print_AmaDra_2         Areic mass of drainage to level 2
Yes              print_AmaDra_3         Areic mass of drainage to level 3
Yes              print_AmaDra_4         Areic mass of drainage to level 4
Yes              print_AmaDra_5         Areic mass of drainage to level 5
Yes              print_AmaErrPro        Areic numerical mass error

* Pesticide concentrations (kg.m-3) and contents (kg.kg-1)
No               print_ConLiq           Concentration in liquid phase
No               print_ConGas           Concentration in gas phase
No               print_ConSysEql        Concentration in equilibrium domain
No               print_ConSysNeq        Concentration in non-equilibrium domain
No               print_ConSys           Concentration in the soil system
No               print_CntSorEql        Mass content at soil solid phase
No               print_ConLiqSatAvg     Avg. conc.in liq. phase between 1-2 m

* Pesticide mass fluxes (kg.m-2.d-1)
No               print_FlmLiq           Pesticide mass flux in liquid phase
No               print_FlmGas           Pesticide mass flux in gas phase
No               print_FlmSys           Total pesticide mass flux (FlmLig+FlmGas)
No               print_FlmLiqLbo        Accumulated mass flux at the lower boundary
No               print_FlmLiqInf        Accumulated mass flux of pesticide infiltration
No               print_FlmGasVol        Accumulated mass flux of pesticide volatilisation

* Canopy interaction
*-------------------
No               print_AmaCrp           Areic mass of pesticide at the canopy
No               print_AmaAppCrp        Areic mass of pesticide applied to the canopy
No               print_AmrDspCrp        Areic mass rate of pesticide dissipation
No               print_AmaHarCrp        Areic mass rate of pesticide removal by harvest
No               print_AmrWasCrp        Areic mass rate of pesticide wash-off
No               print_FlmDepCrp        Areic mass rate of pesticide deposited on canopy
*-----------------------------------------------------------------------------------------
* End of Pearl input file
*-----------------------------------------------------------------------------------------
```