

Release notes MetaSWAP V8.0.1.0 / iMOD5.2/ LHM4.1

Implementation of WOFOST and oxygen stress

For the implementation of WOFOST and oxygen stress the reader is referred to the release notes of V8.0.0.7 / iMOD5.0/ LHM4.0/ LHM4.1 (below).

Oxygen stress requires the use of PostMetaSWAP. A special option *postmsw_opt=2* has been added for when the salt simulation is not required. This option shortens the PostMetaSWAP calculations. For only drought stress in combination with indirect effects of Waterwijzer the PostMetaSWAP option is not required anymore.

A more detailed explanation of the changes in MetaSWAP for the new database is described in Implementation proposal 57 vs3, improvement in SIMGRO version V8_0_1_0, May 30, 2020.

Download from: ftp://ftp.wur.nl/simgro/doc/Change_log/Implementation_proposals/

The MetaSWAP-databases that are available are listed in <ftp://ftp.wur.nl/simgro/unsaf/>

The parameters of LHM that are as much as possible compatible with Waterwijzer 2.0 are given in ftp://ftp.wur.nl/simgro/par/V8_0_1_0/Waterwijzer20. For this compatibility a database with the exponential root distribution should be used.

Differences from Waterwijzer that cannot be addressed by the user are:

- The use of macropores for extra water storage, 3% in clay and peat building blocks, 1% in sand building blocks;
- The reduction of theta-sat by 15% from 50 cm b.s.s.

For compatibility of the simulated oxygenstress with Waterwijzer 2.0 it is required to set the Jarvis-parameter of wet stress to 0.7. This parameter has been squeezed into the *luse_svat.inp* format in column 33-35, with the parameter for drought stress in 36-38.

In the LHM4.1 release it was decided to deviate from Waterwijzer with respect to the drought stress, using Jarvis=1.0 instead of 0.7. So the parameters for compatibility of wet stress with Waterwijzer and drought stress with LHM4.1 are ".7 1" in column 33-38.

For compatibility with LHM4.1 one of the databases with the uniform root distribution should be used. The parameters that are compatible with LHM4.1 (with disabled oxygen stress) are given in ftp://ftp.wur.nl/simgro/par/V8_0_1_0/LHM4.1b/

It is possible to use oxygen stress in a way that only impacts the crop production, but not the transpiration, activated by *oxygenstress_mdl= 3* (which, it should be realized, is not conform Waterwijzer 2.0). The idea behind this new option is that the standard simulation method (=2) can lead to a reinforced feedback, with the reduction of the transpiration hindering the drying out and thus prolonging the wet situation for an unrealistically long time. In reality the soil evaporation can provide some negative feedback by increasing due to the presence of small pools etc.

With respect to the wet stress in relation to Waterwijzer it should be realized that there are other differences that cannot be directly reset by the user. In LHM there are for instance macropores of 3% for clay and peat soils, and 1% for sandy soils, which influence the groundwater dynamics and also the oxygen stress. But the influence is only via the theta-pF table and not through extra conductivity

Restart of WOFOST

The restart of WOFOST had become disrupted due to a change in the code. The change is that for WOFOST crops the root zone is set at 0.15 m minimum. The advantage is that for running WOFOST with indirect effects (delay due to land preparation conditions, etc.) it is then not anymore necessary to enable PostMetaSWAP if only the drought stress is being used.

Implementation of the database with Staring Reeks 2018 used in LHM4.1

Information about the new database can be found at <ftp://ftp.wur.nl/simgro/unsa>

This database can only be used in combination with MetaSWAP versions V8.0.1.0 and upwards. Actions by the user to “repair” the database so that it can run with older versions will lead to erroneous results.

With the new database the amount of sprinkling can increase by 100% for soils with the building block B2. In the latest runs with the LHM (extension of 4.1) the sprinkling parameters have been adjusted, see luse_41_beregening.inp in ftp://ftp.wur.nl/simgro/par/V8_0_1_0/LHM4.1/LHM2018_v02vrz/

Relative path of unsa_database

The relative path of the unsa database could be hard to use for the regional models because iMOD wants to modify it. In order to avoid this a \$-sign can now be added at the very beginning of the string, just after the opening quote.

Control over the output period for the NHI-configuration

The output periods of the NHI-configuration were previously determined by the calls from the NHI-conductor. It is now possible to separately control the output periods, which makes it for instance possible to output the idf's for each day. This can be useful for comparing output with satellite images for instance. The option is activated via parameter outputperiod_opt=1 in para_sim.inp

| | | |
|------------------|---|--|
| outputperiod_opt | 1 | special LHM-option (simgro_opt=0) for using timing of output by means of tiop_sim.inp instead of following the demand/realization cycle of the NHI-conductor |
|------------------|---|--|

Control over the output period for the NHI-configuration

The calling of PostMetaSWAP is normally coupled to the output period. It is now also possible to control it via *postmsw_tim* parameter of para_sim.inp:

| | | |
|-------------|---|--------------------------------------|
| postmsw_tim | 0 | Run for each dtper, see tiop_sim.inp |
| | 1 | Run for each day |
| | 2 | Run for each dtgw |

Release notes SIMGRO V8.0.0.7 / iMOD5.0/ LHM4.0 /LHM4.1 (updated)

Windows10

Problems are being experienced with Windows10: on some machines the code will not run, on others it does. Check this location for progress on the issue.

Project Robust MetaSWAP

In the runs for the National Water Model on an external computing facility the model could crash with the message 'floating invalid'. On the NHI-server the bug had not been experienced before, so initially it was thought that it was caused by the external computing facility. But at the beginning of the summer of 2018 it became clear that the model code was causing the problems.

In the course of project Robust MetaSWAP in 2019 the bug that caused the sporadic crashes has been fixed. In order to reduce the chance of bugs and to clear the floor for adding new options like the coupling to Modflow6 and DFlow-FM a substantial part of the legacy code of SIMGRO has been removed. Many improvements have been made to make the code more robust, for instance with respect to memory management and transfer of data between modules. From tests it has become apparent that, fortunately, the effect of the bug and the code reduction on the results was minimal, as has been reported in the *Veranderingsrapportage* of LHM 4.0.

Bug fix of sprinkling extraction from groundwater

The previously reported problem with sprinkling extractions from groundwater (see notes for V7.3.3.2) has been addressed. The neutrality of the bug fix has been tested for the LHM. But that model application does not involve situations with a spatial separation between extraction and application, which the code did not handle correctly in the past. Pending further testing of the newly coded option it is advised to only implement extractions that are locally applied to the same SVAT, and with the extractions all from the same layer.

Extra options for output to idf files

The default option for output to idf files was (and still is) to write the files in m3 per actively covered m2. This gives values that have the most meaning for visual interpretation, with for instance rainfall shown with the same numerical values as in the input. But for further processing as a water balance term it is expedient to have the option for output in m3. This has been facilitated by expanding the options for the selection parameter in the *sel_key_svat_per/dtgw.inp* files:

Options

| ioptkey | description |
|---------|--|
| 0 | do not include variable in database |
| 1 | include variable in database, make idf file with unit m (m3 per active m2) |
| 2 | include variable in database, make idf file, with unit m3 |
| 3 | include variable in database, make idf file, with unit m and m3 |

In the output directory of the idf-files there will also be written a file AREA_L1.IDF with the conversion factors from m to m3. The m3 files are written to a separate directory with the m3 included in the name. Also these directories include area files. With the

availability of the area files it becomes an option to avoid the duplication of files involved in `ioptkey =3`, since the areas are always at hand for conversion of the idf's when required.

***Para_sim.inp* revision**

The user is strongly advised to check the manual for each parameter that is used in *para_sim.inp* file and to remove obsolete parameters (e.g. *dpgwtb_extra*). Double entry of the same parameter is strongly advised against. To check that this is not happening the *para_sim.inp* file in the *work*-directory should be inspected, since it can contain extra entries from iMOD. Only the first entry is actually used by the program. So a second entry does not over-rule the first !

Parameter *fxsp_opt*. It has been noticed that several regional models have in the past been given *para_sim.inp* files with the setting *fxsp_opt=1*. This setting has long been removed from the manual (for instance V7_2_27 did not contain it anymore). Until recently the (secret) parameter has been in use for the compatibility with the national water model LHM, so that the model knew to expect sprinkling realizations from Mozart. By nevertheless using it for regional models this demand realization never happened and then sprinkling from surface water will always be zero (which would hopefully have been noticed). In the new code (Project Robust MetaSWAP) the role of this parameter has been ended. This can mean that the new version can produce results different from those with the old code: not because the new code is different, but because the *parameter* setting for the *old code* was wrong.

Parameter *infilimsat*. In the new code the infiltration simulation has been changed for situations with ponding and near-saturation of the soil column. The infiltration is calculated for each *dtsw* step of the fast cycle. The algorithm can include an anticipation for the amount of water that can be infiltrated in a nearly saturated soil. In the previous version the default was *infilimsat_opt =1*, and setting it to zero did not turn the option off if the maximum ponding depth had been set to a normal value (i.e. not 9999.). In the new code the latter dependency has been removed. In order to get results that are as near as possible to those of previous simulations with *infilimsat=0* the parameter should now be set to 1, which is somewhat confusing. But after the compatibility check has been done it is advised to set it to zero again for the time being, pending further revision of this option.

Parameter *postmsw_opt*. The parameter for activating the PostMetaSWAP model has been given an extra option for when this model is only needed to support the oxygen stress model of Waterwijzer. By setting *postmsw_opt=2* the PostMetaSWAP model is activated without the downscaling of drainage flows that is needed for TRANSOL. This saves computer time and resources (memory).

Parameter *oxygenstress_mdl*. For simulating oxygen stress with the method of Waterwijzer 2018 set *oxygenstress_mdl=2*. The default is 1 for Feddes(1978). Note that it is not possible to turn the simulation of oxygen stress off completely via the option parameter like is possible in SWAP. To turn it off completely the parameters *p1fd* and *p2fd* in *luse_svat.inp* should be set to 99.0. (and set *oxygenstress_mdl=1*, or completely omit it from the *para_sim.inp* file.)

Parameter *interception_mdl*. The choice of interception model is now done at the level of the land use, so the parameter *interception_mdl* which was once used should be removed from the file if still present.

Parameter *soilevaporation_mdl*. This parameter controls the use of the soil evaporation model. For the NHI-method the default (=0) is Boesten-Stroosnijder and reduction of the coefficient (for some of the soil units with low conduction) based on the calibration done by the automated database procedure. For Penman-Monteith the default is 1, which triggers the use of the soil moisture content for reducing the evaporation under extremely dry circumstances, like is done in SWAP. This parameter setting applies to all land use types. So if Penman-Monteith is used for the agricultural land-use types the remaining land use types are also done with the new soil evaporation method, even though the transpiration is still done with the NHI-crop factor method.

Parameter *co2*. For simulation of the crop growth model the CO₂-concentration of the atmosphere must be given. The default is 404.21 ppm.

PostMetaSWAP parameter file *writecontrol.inp* replaced by *para_post.inp*

The PostMetaSWAP parameter file *writecontrol.inp* has been replaced by *para_post.inp*, using different parameter names for some of the options. So if the file is used the documentation should be checked. Duplication with respect to *para_sim.inp* has been removed (parameters of idf-files). The file now used for LHM4.1 can be found at

ftp://ftp.wur.nl/simgro/par/V8_0_1_0/LHM4.1/LHM2018_v02vrz/

For regional models the file will be needed when the simulation of oxygen stress is required. This also requires the temperature simulation by setting *dotempr=1*, but not the TRANSOL simulation; so set *dotransol=0* if the salt simulation is not required. The use of TRANSOL for salt stress simulation with respect to the transpiration (Maas-Hoffman like in SWAP) is not yet operational, though very near completion, mainly requiring testing.

***Luse_svat.inp* revision**

The format has been expanded with options that are expected to become available in the foreseeable future. This will hopefully avoid the necessity of soon having to change the format again.

The new code is *not* backwards compatible with old versions of *luse_svat.inp* (signaled by a crash with error message), and *neither* is the old code compatible with the new version of *luse_svat.inp* (no crash, wrong simulation of interception). The choice for non-compatibility was made in order to keep the parameters grouped together in a logical manner.

The modeler is strongly advised to check out the revised documentation and to not copy-paste files from other users without thoroughly checking and understanding the used values. This file is, after *para_sim.inp*, the most unforgiving for the use of erroneous copy-paste values, since there is a lot of flexibility with respect to the used options, like the mixed use of Penman-Monteith for the agricultural land use types, and the old NHI-method for the rest.

The file is the same for the column positions 1-144, with the difference that from now the Jarvis parameter in column 33-38 is an actively supported option. This parameter only influences the drought stress, like published by Jarvis (1989). Application to oxygen stress is not considered to be conceptually sound and also not done in

Waterwijzer 2018. Parameter values of the Feddes (1978) drought stress function have changed in Waterwijzer 2018. For values the user is referred to the [example file of LHM](#). (updated for LHM41)

The changes in the rest of the file are:

- *albedo* (column 145-152) with the reflection coefficient of radiation is a parameter of Penman-Monteith (PM) and also of the crop growth model WOFOST. If a land use is linked to WOFOST via the *vg*-index (mapped in *vg2crp_svat.inp*) then the albedo is taken from the *crp* file. For the non-mapped vegetations the model looks at the albedo value in *luse_svat.inp* to decide what evapotranspiration model to use: in the case of Nodata (-9999.) it uses the crop factor method, otherwise it switches to PM. It is advised to set the whole column to -9999. as long as we do not have the PM-parameters for non-agricultural land-use types;
- *rsc* and *rsw* (column 153-168) with the PM-resistances should be set to respectively -9999. and 0. respectively until values become available;
- *rsoil* (column 169-176) with the soil evaporation resistance of the modified Penman-Monteith method. For the land use types that are grass the value should be set to 600.0 s/m. And for the remaining types to 150.0 s/m; this parameter is *not* contained in the *crp* files.
- *kdif* and *kdir* (column 177-192) with the extinctions coefficients are used in both the Penman-Monteith method and in the crop growth model. They are taken from *crp* files for the WOFOST crops. Values in *luse_svat.inp* should be set to -9999. as long as values are not available for forest etc.;
- *eic_opt* (column 193-198) is the option switch for the interception model, which is now at the level of the land-use; for the NHI-method it should be set to 0, which is for all land-use types that have a *vg*-index *not* mapped to WOFOST in *vg2rcp_svat.inp*. For vegetations that are mapped to WOFOST the value should be set to 1 for the Von-Hoyningen method. But be aware of the fact that this method is only compatible with *dtsw=dtgw=1* d.
- *vxiclai* (column 199-206) is the interception storage per unit of LAI, which is not operational yet; it will be used for Rutter-type interception evaporation like now in LAI, for small time steps in combination with PM;
- *fecmn* (column 207-214) of the NHI-interception method has been moved. It should be set to 1.0 for all land use types, even if the NHI-method is not used (safest);
- *cofab* (column 215-222) is the interception storage of the Von Hoyningen method now used in combination with WOFOST; the Waterwijzer 2018 value is 0.5. This value can be entered for the whole column (safest);
- columns 223-278 contain parameters that are not operational yet, of the Gash interception model and salt stress, It is advised to set the Gash-parameters to 0. and the salt stress parameters to -9999.

Implementation of WOFOST

The coupling of WOFOST to MetaSWAP has been strongly revised in the course of the Lumbricus project of 2017/2018 to conform with Waterwijzer 2018 (August version). In the course of 2019 there was a NHI-project with a strong focus on testing, using the new testlab for comparing to SWAP. One of the things this testlab revealed was that there is a significant impact of the root distribution assumed in Waterwijzer 2018. To follow this with MetaSWAP required a revision of the database procedure, see [Implementation proposal 50](#). Extensive testing is reported in the [Test report 50](#). These tests refer to the database used in LHM with 370 units. A shortened version is available for the modified BOFEK2012 database, which is reported in test report 51. The modified databases are available at <ftp://ftp.wur.nl/simgro/unsaf/>. The

[tests](#) (100 Gb) for the BOFEK2012 database are available but not yet the tests for the LHM database (1.2 Tb).

The implementation of WOFOST requires the following actions and [files](#):(updated for LHM4.1)

- setting of *evapotranspiration_mdl=3* and *vegetation_mdl=3* in *para_sim.inp*.
- setting of *oxygenstress_mdl=2* for the method of Waterwijzer 2018; this option has not been implemented in LHM because it is not considered to be mature enough for that; it also enormously increases the cpu-time of the whole model by a factor 4.
- setting *postmsw_opt=2* in *para_sim.inp* if the oxygen stress model of Waterwijzer is used; in that case also include the file *tiop_sim.inp* with a time step of 1 day;
- setting *dotempr=1* in *para_post.inp* for activating the temperature simulation;
- setting the *co2-concentration* in *para_sim.inp*;
- setting the reference to the modified database in *para_sim.inp*;
- copying the mapping file *vg2crp_svat.inp* to the working directory of MetaSWAP via the modified run-file;
- copying the used *crp* files to the work directory via the modified run file;
- copying the file *hcrit_svat.inp* with extra soil parameters to the work directory via the modified run file; this *hcrit_svat.inp* file contains the criteria for the so-called indirect damage due to less optimal the pre-season conditions; it is coupled to the building blocks of the Staring Reeks, so it is the same for both the LHM database of 370 units and the BOFEK2012 database of 72 units.
- setting the *rsoil* parameter in *luse_svat.inp*, with *rsoil = 600 s/m* for grassland and *rsoil = 150 s/m*; carefully check all records with a *vg-index* that gets mapped by *vg2crp_svat.inp*; the records at the bottom end of the file (if present like in LHM) are easily forgotten;
- setting the choice of interception model to Von Hoyningen with *eic_opt=1* in *luse_svat.inp* for the land use types that involve a *vg-index* mapped to WOFOST; see also remark above about records at the bottom end of the file;
- setting the Von Hoyningen parameter *cofab=0.5* in *luse_svat.inp*;

Implementation of WOFOST in combination with Penman-Monteith requires much more meteorological information than what was needed for the NHI crop factor method. The extra data should either be in *mete_svat.inp* or *mete_grid.inp*. In *both* cases there should also be the file *mete_stat.inp* with the station information about latitude and height of the wind measurement *with respect to the soil surface*. The published data of KNMI are all for 10 m, even though at some of the stations the measurement is at 20 m. Care should be taken with the vapor pressure, as explained in the manual. The use of separate stations without interpolation for constructing the grids causes transition effects at the borders of influence zones. This is strongly apparent along the coast. The advice is to ask KNMI to provide the grids after correct downloading of data, conversion, and interpolation.

Release notes SIMGRO V7.3.3.2 / NHI_v3.3.0

MetaSWAP database

The MetaSWAP update is compatible with the new distributed format of the unsaturated zone database. The distributed format has a separate database for each of the soil types. This format has the advantage that new soil types can more easily be added, and the files are kept a manageable size. Extracting the zip archive does however yield a large number of files in a directory tree; these files form part of the documentation of how the database was generated. In the *para_sim.inp* file the path to the root of the tree should be specified.

The distributed version of the database with 72 units for NL can be downloaded from: ftp://ftp.wur.nl/simgro/unsat/LHM2016_v01.zip

This distributed version can yield results that are somewhat different from those with the previous database because (apart from using updated soil physical tables) the new procedure also recalibrates the thickness of the layer that provides capillary rise even in situations with deep groundwater levels, by recirculation of percolation water. For more details the user is referred to change proposal, implementation proposal and test report number 48, available at <ftp://ftp.wur.nl/simgro/doc/>

There is also a new database with 370 units for NL. For assistance in using it please contact the iMOD helpdesk. It can be downloaded from ftp://ftp.wur.nl/simgro/unsat/LHM2016_v02.zip

Compatibility of the code with the old database format has technically been maintained. But one should be aware of the fact that exhaustive testing of all combinations with all old databases is not feasible. In the case of problems we will first advise to update to the latest database. Apart from containing the latest available soil information the new database in combination with the latest code version also generates storage coefficients that are not smaller than 0.01, which substantially speeds up the running of the model.

Reduction of memory use for database

The model only reads the database of a soil if it is actually used. Even so, especially with the database of 370 units, the use of RAM can become a bottleneck. Running the pks-version with parallel execution also increases the memory use. But the increase is not linear with the number of used cores, because the smaller the subdomains become, the less soil units they contain. For reducing memory use an option has been created for coarsening the pressure head table of the database. The database is generated for root zone pressure heads in steps of 0.1 for the pF. By increasing the steps to 0.2 we found with the LHM that the simulated evapotranspiration was reduced in the order of 1%, which is not considered significant, whereas the required RAM for the database is halved. The reduction of memory use is done by selectively reading the database, not by reducing the database itself. So an extra download is *not* needed. The option is implemented by including in the file *para_sim.inp* the record

ipstep = 2

Robustness

The MetaSWAP code has been made more robust for situations with extremely sensitive relationships in the MODFLOW model. Since the model no longer crashes in such a situation, this makes it easier to diagnose where the sensitivity is located and thus address the issue.

Known issues with sprinkling extractions from groundwater

Sprinkling using groundwater from multiple model layers of the same cell does not work correctly. All extractions are set to a single layer. But the water balance of the combined models is not violated. The option of extractions from multiple layers will probably be blocked in the next release, because it is a very uncommon practical situation and the multiple layers are most likely due to a data error.

There is also a more serious issue with situations where a sprinkling extraction is from a different cell than its own one, and that the cell where the extraction is from does not have a sprinkling extraction from its own cell or a layer beneath it. In such a case the extracted sprinkling water will not be communicated to MODFLOW, which means the water is not accounted for, thus violating the water balance of the combined models. This will go unnoticed. A temporary work around is available, which is to add a dummy record to *scap_svat.inp* with a sprinkling capacity of 0.11 mm (instead of the usual 25 mm) for sprinkling of the cell where the extraction is from. For further advice consult the iMOD helpdesk.

Bug with message 'Floating invalid'

On rare occasions an error condition 'MSWP-error: update rootzone - floating invalid' could cause the model to crash. The issue seems to have been fixed by making the dynamic array allocations of local arrays more strictly in accordance with standard Fortran than is required by the Intel compiler.

MODFLOW-MetaSWAP coupling

In the N:1 coupling of iMODFLOW and MetaSWAP the second MetaSWAP-column coupled to a MODFLOW-cell was not included correctly. These second MetaSWAP-columns usually represent the paved/urban fraction of a cell area which results in a relatively small share of the water balance. This has been corrected in the current version.

Standard parameterization of urban area

The standard iMOD parameterization for urban fraction of a cell has been made more realistic, including a surface elevation comparable with the rest of the cell and including a small threshold (2 mm) to allow runoff calculated by MetaSWAP. Deltares and Alterra will communicate more recommendations regarding runoff- and evaporation of paved areas.

Optional pause for over-writing standard MetaSWAP files

The iMOD GUI generates input for MetaSWAP according to a standard protocol. To make it possible for the user to over-rule these standard files an option has been created to pause the model at the first call of MetaSWAP from MODFLOW. This optional pause is activated by putting a file named *MetaSWAP_pause.txt* in the MetaSWAP working directory (where also the file *info_sim.out* appears at runtime). The file should not have any content. After over-writing the files the run can be continued by hitting RETURN.

Note for users of MODFLOW88

The configuration of the software that is coupled to MODFLOW88 will not be continued. Future updates are only of the components version coupled to MODFLOW2005 and higher. That version is distributed via Deltares.

Release notes SIMGRO V7_2_26/27 / NHI_v3.1.0

PostMetaSWAP/TRANSOL

With this update the coupling to the tracer simulation module TRANSOL has reached an operational status and the model output options have been greatly enhanced. The first results with the LHM-model for the Netherlands are promising.

Release notes SIMGRO V7_2_25

Curve Number method for runoff simulation

The Curve Number method for simulation of runoff has been implemented, in the same manner as in SWAT. The implementation in SIMGRO is still a beta-release.

Release notes SIMGRO V7_2_24

SIMGRO surface water module for large basins

The SIMGRO surface water module was programmed with 'single precision' real variables (REAL*4). For large (international) basins this leads to numerical inaccuracies. This has been remedied by converting to 'double precision' variables for the surface water calculations (REAL*8). (Change proposal 37.)

Infiltration simulation

The infiltration rate is influenced by a number of limiting factors, i.e. available water for infiltration, maximum infiltration rate (input parameter), saturation deficit, and flows to/from the soil column. The available space for infiltration has to be estimated at the beginning of the time step, because the flow terms are not known yet. The estimation method used in the old code version hindered the full saturation of the column in situations with ponding, leading to excessive triggering of the irrigation water demand of glasshouse horticulture in NHI. In the adaptation the old values of the evapotranspiration terms (transpiration, soil evaporation) are used in the estimation of the available space for infiltration. (Change proposal 38.)

Hot start

The hot start has been inspected. That has been done by comparing runs:

- a 4 day run, with the state saved on the second and fourth day
- a 2 day run starting from the saved state on the second day of the 4 day run.

For achieving a really close resemblance between the final states of the two runs it is important to let the Modflow model converge using a pcg dh-criterion of 1.0e-5, and also letting MetaSWAP make enough outer cycles.

This extra strict convergence has been done for the update of change proposal 34. For well converged models the differences between the final states are very small, with only two units differing more than 1 cm in the final state. Analysis of the differences two small numerical problems in routine msw1unsa, involving near-saturated situations; these have been fixed. (Change proposal 34, update)

Release notes SIMGRO V7_2_23

Stand-alone SIMGRO

The stand-alone version of SIMGRO has been made operational without the need of a 'dummy' MODFLOW model. The stand-alone version is the most convenient option for running water quality simulations using groundwater boundary conditions that have been derived from a coupled MODFLOW-SIMGRO run. The first application of this version is within the NHI2WQ project.

Release notes SIMGRO V7_2_22

Perched water table option

The perched water table option (MIPWA project) had become corrupted due to the bug fix for shallow water tables in version V7_2_17.

Release notes SIMGRO V7_2_21

Surface water output files

An extra option has been added for writing the output data of surface water links to file.

Release notes SIMGRO V7_2_20

Groundwater levels below the database

The model has been made robust for groundwater levels that drop below the bottom of the database.

Storage coefficients

The model in combination with the database based on soil physical tables did not converge completely, even if the iteration cycle was extended. This was due to oscillation of SVATs with loamy soils. The model code has been adjusted, and also the making of the database. The new database of NHI is located at

Release notes SIMGRO V7_2_19/ components version svn 804 (mf2005 svn 785)

Merging of codes for components version and NHI-light version

The codes of the components version used in NHI and the “NHI-light” version used in regional studies has been merged, with the exception of *postmetaswap* and *transol*. During the merge process two minor bugs were detected, documented in change proposals 30 and 31. They affect the numerical stability of simulated groundwater levels, which is the same or is improved.

Release notes SIMGRO V7_2_17

Bug fix of transpiration for situations with shallow groundwater level just below the root zone

The top-system routine for computing evapotranspiration terms contains a check for the availability of water in the root zone. This check did not take the capillary rise of the current time step into account. For situations with a shallow groundwater level just below the root zone the omission could cause unjustified reduction of the transpiration. For situations with lower groundwater levels the error is very small and insignificant.

Release notes SIMGRO V7_2_15

Bug fix Penman-Monteith evapotranspiration

The routine for calculating the evapotranspiration with using Penman-Monteith had two options for handling the temperature data: using T_{av} , T_{min} , T_{max} values or using values for each hour of the day. The detection between these two options was based on an assumption with respect to the data. That detection was not valid for data sets that have a mean temperature deviating from the arithmetic mean of T_{min} and T_{max} . Since there are no known applications using hourly data this option has been removed.

The revised calculation method yields a 6.25% higher long-term average of the reference crop evapotranspiration for the period 1981-2010:

- ET_{Mak} : 559 mm/yr
- ET_{PM_old} : 550 mm/yr
- ET_{PM_new} : 584 mm/yr

Release notes SIMGRO V7_2_13

Influence of flow-resisting layer

A flow resisting layer can lead to the build-up of a perched watertable. The current model concept cannot adequately simulate this, for two reasons. The first is that the database does not contain profiles that completely saturate the storage above the flow resisting layer. The second reason is that the maximum percolation flux in the layers above the flow resisting layer are based on steady state profiles including the flow resisting layer. Thus the fluxes during the build-up phase are inhibited by this. The proposed change allows a build-up of the perched watertable without this inhibition of the flow. In the changed code, only after the profile above the flow resisting layer has been filled does the flux across the flow-resisting layer become determining for the flow in the upper layers. This change of code can be implemented by making use of profiles already in the database. With this increased flux there is the danger that the boxes (above the flow resisting layer) receiving the percolation become over saturated. This is avoided by limiting the percolation so that such a condition cannot occur.

Macropore flow

Macropore flow is introduced in the MetaSWAP concept in a simplified manner, to start with. This is done in such a manner that the concept can be made more advanced as experience is gained with using it and when the user demands for further sophistication is clearly there.

The macropore geometry is represented by a vertical crack that has a fixed geometry in time. Water can enter the crack internally in the column at locations where a perched watertable is caused by a flow-resisting layer. Re-entry into the matrix is at the bottom of the crack or when the groundwater level is reached.

Water entering the at the soil surface and lateral runoff from the perched watertable is not enabled in the current adaptation, but are conceivable as an extensions.

Acceleration of database generation

By rearranging the order of the computations for the steady state profiles the computation time has been reduced.

Release notes SIMGRO V7_2_12 SVN revision XXX / NHI3.0

Preprocessing

The formats of input files for preprocessing with PreMetaSWAP have been made suitable for using string identifiers of soil physical units and of the used 'building blocks'.

A new database used in combination with a new SIMGRO code outputs these string-id's to the PreMetaSWAP.key file, giving more possibilities for the user to check that the intended soil physical data are indeed being used.

The selection of the unit in AREA_SVAT.INP can either be done via the string-id or via the index.

The following compatibility checks have been made:

- Old executable with new database;
- New executable with old database.

Release notes SIMGRO V7_2_11 SVN revision 669

Preprocessing

The preprocessing with PreMetaSWAP has been changed to accommodate table functions for the soil physical parameters, instead of the formerly used Van Genuchten method.

All soil physical parameter input files are now in **m**, as opposed to **cm**. Input file formats have been revised to avoid confusion between 'thickness' and 'depth' of a layer. Examples in ftp://ftp.wur.nl/simgro/tests/PreMetaSWAP_V7_3_0/

The database files are compatible with older versions of MetaSWAP, but **not** with older versions of **Post**MetaSWAP.

Extra item Suz in output

The output variable *Suz* is now available, giving the total amount of water in the unsaturated zone above the phreatic level

Extra parameter MANA_RES.INP (SVN 669)

An extra option parameter *iorc* has been added to MANA_RES.INP. With this parameter the runoff concept can be specified per subcatchment. It overrules the PARA_SIM.INP setting.

Field capacity and wilting point.

The FCWP_svat.csv output file now contains the wilting point for a deep groundwater depth and the field capacity for the specified depth.

Release notes SIMGRO V7_2_9 SVN revision 540

Evapotranspiration

The method for partitioning of evapotranspiration has been revised in order to make it more 'climate proof', i.e. making it easier to adjust for changes of CO₂-concentration in the atmosphere. We now use an adaptation of the 'dual crop' coefficient approach of FAO-56 (Wright, 1982):

$$T_p + E_p = K_{cb} * ET_0 + K_e * ET_0$$

where

- T_p – potential transpiration (mm/d)
- E_p – potential soil evaporation (mm/d)
- ET_0 – reference crop evapotranspiration (mm/d)
- K_{cb} – basal crop coefficient of transpiration (mm/d)
- K_e – crop coefficient of soil evaporation (mm/d)

The equation has been further expanded to include the interception term, in the same fashion. The sparse method of Valente has been replaced by a 'diffuse' implementation of the Rutter method. A full description of the new method is given in the updated Theory report.

The modification is not just a question of making the code change. The parameters have had to be adjusted to make them consistent with the new method. **This means that the new version requires the new fact_svat.inp file and new .crp files. The parameters are dependent on the gauging interval of the precipitation. If hourly data are available, and the model is also run with a dtsw=1hr, then the hr files should be used. In the para_sim.inp file fact_beta2=1.07 should then be included. Parameters at: ftp://ftp.wur.nl/simgro/par/V7_2_9/**

Coupling to WOFOST

Coupling to WOFOST has been completely revised. The new method is described in the article that has been submitted to HESS. The version that was used for answering comments of reviewers is available at

ftp://ftp.wur.nl/simgro/doc/Articles/SIMGRO-WOFOST_20120302.pdf

Infiltration

In situations where the infiltration capacity in terms of storage space is limiting, the subroutine msw1top makes an estimate of the amount that can be infiltrated. In the SIMGRO main program this estimate was updated after the routine msw1unsa for the unsaturated zone had been called. But this update in SIMGRO-main introduced a numerical error (but not a water balance error). To fix it this, the extra provision in SIMGRO-main has been completely removed, because to get it right would severely complicate the code, with relatively little conceptual gain in efficiency.

Numerical accuracy and table search

For very deep groundwater levels the numerical accuracy of single precision is rather stretched. But if one assumes precision up to 7 digits (safe estimate), then to attain an absolute accuracy of 0.01 mm the single precision suffices for a total soil moisture deficit of up to $9999999 * 0.01 \text{ mm} = 999.99999 \text{ m}$. So for groundwater levels within 1 km depth this precision should suffice. But there is also a limit to the accuracy of the tables generated by the preprocessing. To estimate that precision is not straightforward. Limitations in this precision can lead to non-uniqueness in the back-calculated rootzone pressure heads for deep groundwater levels. Especially when the groundwater level is dropping, this can lead to non-realistic 'rootzone pressure heads' of deep compartments. That is because the search in the table starts from the dry side

in the code version V7_2_7 and lower. This has been remedied by starting the search from the wet end of the table.

Release notes SIMGRO V7_2_7 SVN revision 515

Technical

Output via idf- and netcdf-files

It is now possible to generate period-output via *idf*- and/or *netcdf*-files. The use of these options requires:

- parameter settings in PARA_SIM.INP
- specification of grid locations in IDF_SVAT.INP and/or NETCDF_SVAT.INP

The netcdf-option is only available in the 32-bits version. A 64-bits version will follow in the near future.

Running the code now requires the following dll's in the path:

- *libiomp5md.dll* (different version for 64-bit ..)
- *netcdf.dll*

Input of meteorological data via mete_grid.inp

The input format has been modified, allowing the input of a grid via a single Real value. This can be useful when e.g. a single meteo-station is available for temperature data. The specification "-1" has been replaced by "==". All columns must now be filled; if no data are available, then "NoValue" should be given.

The new code is **not compatible** with the files of older versions.

Release notes SIMGRO V7_2_6 SVN revision XXX

Conceptual

Partitioning of evapotranspiration terms for situation with ponding, rice

The model did not function correctly for the following combination of circumstances:

- Ponding;
- Crop that is not sensitive to waterlogging (rice);
- Partial soil cover.

This combination has not occurred in any known application. The changes are described in Change proposal 6 and in the revised Theory Report.

Release notes SIMGRO V7_2_5, SVN revision 483

Technical

Initialisation file

The *init_svat.inp* file contains a.o the last day that sprinkling was initiated. This information is needed for making a hot start after interrupting a run and renaming *init_svat.out* to *init_svat.inp*. But if the *init_svat.inp* file has been obtained after a rename of *init_svat.out* of a long run that was made for obtaining realistic starting conditions, then the information about the last day of sprinkling will block any sprinkling during the re-run. To avoid this, the code now checks whether the last day of sprinkling is not later than the starting date of the re-run. If necessary, the date is reset, so that sprinkling is not blocked.

Netcdf output grids

Output to Netcdf grid files is an option that is under construction. For the 32-bit version it is operational, but the included meta-information is still insufficient. The library for the 64-bit version is not yet available. Since this output option is not yet complete, it has not been documented yet. But if someone is interested in using the option, the information will be given. Running the model now requires two dll's in the run directory or at the location of the main exe itself:

- *libiomp5md.dll* (different version for 64-bit ..)
- *netcdf.dll* (64-bit version not yet available, option disabled in the compiler); for the 32-bit version the *netcdf.dll* should from now on be in the path, even though it is not being used yet.

In the near future, an installation procedure (using a self-extracting file) will be made available, so that the dll's automatically get put in the 'path'.

Release notes SIMGRO V7_2_1, SVN revision 401

Conceptual

Extra options have been implemented for the simulations of processes:

- *dqmodfdh_opt* option, for improved anticipation of infiltration capacity (default = 1)
- *infilimsat_opt* option for disabling dynamic infiltration limitation, but only for SVAT's with the MetaSWAP runoff disabled ($vxmu(k) = 9999$).

The latter option is useful for when the surface runoff is simulated in MODFLOW, within the implicit scheme.

A sprinkling demand that was not realized due to supply limitation remained in the model memory, even though rainfall had caused the pressure head to rise above the trigger-threshold. A triggered demand has is now reset to zero if after the number of days of the cycle the pressure head has risen above the threshold due to rainfall.

Technical

Model output

The databases for model output have been given an extra variable option in the form of the 'demand of sprinkling from surface water', *Psswdem*.

Release notes SIMGRO V7_2_0, SVN revision 350

General

The version *V7_2_0* is the first version that has been certified with 'Status A' of the *Planbureau voor de Leefomgeving*. The certification applies to the MetaSWAP module. In the certification report special attention is paid to the calibration and validation of MetaSWAP on the SWAP model.

Conceptual

Infiltration at soil surface

The infiltration at the soil surface has been given an extra constraint in the form of *ksat(1)* of the first layer. This improves the consistency with SWAP. If the user wants to maintain backward compatibility with earlier versions, the influence of *ksat(1)* can be cancelled by setting high values in file THSAT_SVAT.INP.

Soil evaporation

In situations with crop stress due to wet conditions, the model could get 'locked' into a situation with zero transpiration and zero potential soil evaporation. This has been remedied by a modification of Eq. 19 in Report 913.1; see the remark directly below Eq. 20.

Ponding evaporation

The activity of ponding evaporation is dependent on the following three circumstances:

- water on the soil surface;
- interception evaporation;
- transpiration.

Interception evaporation and transpiration have priority over the ponding evaporation. The way in which this is taken into account has been made consistent with the way

the activity of interception evaporation reduces the activity of the other terms. The new method is described in par. 2.4.3 of Report 913.1

If ponding occurs, the sum-terms of the Boesten method are now reset to zero. This is consistent with SWAP. In most situations this would anyhow occur via the precipitation. So the differences are expected to be minor.

Crop stress

In the coupling to WOFOST the crop moisture stress r_E is now done with:

$$r_E = \frac{E_{ic} + T_{act}}{E_{ic} + T_{pot}}$$

Formerly, the E_{ic} terms were left out of the expression. This expression takes into account that if the interception evaporation is active the crop has no reason for closing its leaf pores (and thus reducing CO2 assimilation), even in situations with an extremely low pressure head in the root zone.

Scaling of soil physical parameters

Calibration of the soil physical parameters via adjustment of the basic 'building blocks' (or by adding new ones) requires running of the preprocessing package PreMetaSWAP. And the more soil physical units that are defined, the larger the size of the database file becomes. That also increases the memory requirement for running the model. To circumvent these drawbacks, an option has been added for 'scaling' the soil physical parameters, in a manner that can be different for each of the SVAT-units. This method does not require the running of PreMetaSWAP, and thus the size of the database remains the same. The following adjustments can be made via factors in the optional file USCL_SVAT.INP, for:

- scaling of the soil moisture content;
- scaling of the conductivities;
- scaling of the process parameters involving pressure-head dependence, i.e. the Feddes parameters given in file LUSE_SVAT.INP, and the trigger for starting sprinkling.

In the Report for 'Status A' (see General section above) a sensitivity analysis has been included, for investigating whether the scaling adjustments affect the 'validation status' in relation to the calibration on the SWAP model. It appears that adjusting the moisture content by a factor 0.5 hardly affects the validation. Adjustment of the conductivities by a factor 0.1 had a mild effect on the differences between the models.

Technical

Online coupling of postmsw and transol

Via the option parameter *postmsw_opt* it is now possible to run *postmsw* without having first to save the output data to file. Also the salt simulations with TRANSOL can now be done 'online'.

Hot start

The sprinkling management regime has been added. It is now also possible to do an 'online' hot start. This option has been tested for the NHI model, for use in an iteration scheme.

The file INIT_SVAT.INP has now been given a time stamp; the version-string of the SIMGRO programme has also been added. The time stamp is to check whether the used initialization file for the right day of the year: the hot start file of e.g. January 1 can not be used February 1. That is because of the parameterization of the plant system. If a file for the desired starting date is not available the user should use of one the two other options (e.g. RootzonepF).

Input of SIMRES discharge tables

The input option of the discharge in the unit [l/s/ha] was out of order. This has been remedied.

Release notes SIMGRO V7_1_5

Conceptual

Bottom flux coupling Modflow-Metaswap (q-link)

The option of coupling MetaSWAP via a bottom flux has been added. This option can be chosen per individual SVAT. It is enabled by specifying a value of the *cbot*-parameter in INFI_SVAT.INP.

Release notes SIMGRO V7_1_4

Conceptual

Reduction function for transpiration

The Feddes relationship for simulating the pressure-head dependent reduction of the transpiration is linear. An option has been added for basing the reduction on the pF instead of on the head. This only applies to the trajectory from p3 to p4. The option parameter replaces a redundant parameter in the LUSE_SVAT.INP file. The IO-format adjustment is not backwards compatible.

Simulation of bare soil evaporation for hourly rainfall data

The Boesten method for simulating bare soil evaporation is sensitive for the time interval of the rainfall data. If hourly values are used, then the simulated bare soil evaporation becomes lower than when daily rainfall data are used. The *beta2*-coefficient of Boesten has originally been calibrated for daily data. Experimentally we found that for hourly rainfall data a value of roughly 1.2X the value for daily data should be used. This calibration factor can be entered via the new parameter *fact_beta2* in PARA_SIM.INP. To avoid a potential misunderstanding: This factor is not needed when daily averages are used in combination with a *dtsw* time step for the fast processes. It is the averaging of the *rainfall* over the days that causes the mentioned effect, not a short time step *dtsw* itself. However, if hourly rainfall data are used in combination with a *dtsw* of 1 day, then the *fact_beta2* parameter should be set to 1.0, because such a *dtsw* causes the rainfall data to after all be averaged over the days.

Technical

Output of energy balance terms

The SVAT-model output has been expanded with two items of the energy balance:

- the net radiation, discounting the reflection (albedo) and the long-wave emission;
- the rest term of the energy balance, i.e. the net radiation minus the latent heat flux of the evapotranspiration terms

Hot start

The file for the hot start has been expanded with the 'old' terms of the saturation deficit for the first three boxes. These 'old' values of the saturation deficit are needed for ensuring that the administrated *decSi* values (changes from one time step to the next) are the same for a continuous run and for a run that is restarted. This is only relevant if there is a root zone update at the end of the day.

An error has been fixed in the writing of the INIT_SVAT.OUT for situations with dynamic root zones. This is only significant for models with repeated hot starts for each day of the simulation run.

Numerical stabilization

The (numerical) stabilization of the groundwater level in dynamic situations has been slightly improved.

Release notes SIMGRO V7_1_3

Technical

Fixed:

- Groundwater time steps of e.g. 1 hr ($dtgw=0.0416777$) caused the period output to be generated the *tiop* time minus one step; to avoid this a recalculation is made of *dtgw* in double precision.

Release notes SIMGRO V7_1_3

Technical

The numerical handling of small percolation fluxes in situations with deep groundwater levels has been improved.

The file INIT_SVAT.INP/OUT FOR initialization from a saved state did not contain the root zone depth. This caused 'jolts' in the simulated groundwater level at the beginning of the hot start, especially if the crop had just been harvested.

The reading of a path specification for locating the soil physical data base did not function correctly for strings longer than 80 characters. The maximum length has been expanded to 256 characters.

The relative transpiration T_{act}/T_{pot} is now set to 1.0 in the cases that $T_{pot}=0$.

Release notes SIMGRO V7_1_2

Technical

The option to *not* couple a MetaSWAP column to MODFLOW has been made possible. This option is e.g. useful for simulating greenhouse horticulture that uses substrate on shelves above the ground surface.

Extensive testing of version 7 for the NHI model revealed a number of problems that required fixing:

- problem with initialization from saved state, for deep profiles;
- problems with hot start of evapotranspiration simulation, required modifications of format INIT_SVAT.INP/OUT; not compatible with earlier versions;
- problem with calculation of interception evaporation for $dtsw < dtgw$; the interception evaporation itself was correct, but the influence on the crop transpiration was not;
- problem with root zone update for situations with ponding.

Initialization via specified percolation fluxes has been made possible;

Conceptual

As announced in the notes of V7_0_0, the dependency of the crop factor on the 'development stage' simulated by WOFOST has been changed to a dependency on the leaf area index. A separate paper is available describing the calibration for three crops. That paper also includes a description of the way that the crop factor file of the 'simple' crop model has been derived from WOFOST runs for grassland, maize, and

potatoes. The crop factors and interceptions capacities of 3 forest types are also given, as are those for the remaining vegetation types used in the NHI-model.

Release notes SIMGRO V7_0_0

General

An overview of the novelties in SIMGRO7 is given in the preface of the reports.

Conceptual

Soil physics

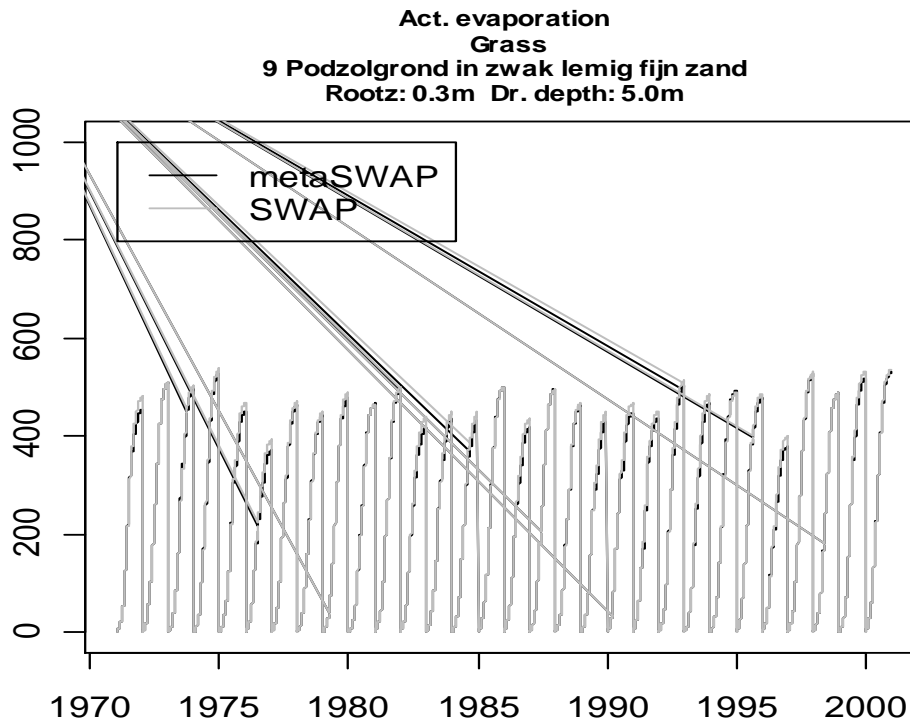
Extra aggregation boxes haven been added, thus greatly improving the simulation of soils with deep groundwater levels. The thickness of the second box has to be calibrated on the SWAP model. For the PAWN soil units this has already been done. The test facility needed for the calibration will become available for external users in 2010. The new database is available on the ftp-server, with a schematization of 18 aggregation boxes reaching to a depth of 100 m.

Comparison between MetaSWAP and SWAP: 30-year means of ETact, for a drainage depth of 5m and a root zone depth of 0.3m. The calibration has been based on root zone depths of 0.3 and 1.0m. Values in mm/year

| Soil number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Etot_SWAP | 567.5 | 575.2 | 545.2 | 536.5 | 560.9 | 561.2 | 491.3 | 527.3 | 538.1 | 553.7 |
| Etot_mSWAP | 567.9 | 573.1 | 545.3 | 541.5 | 569.0 | 558.3 | 502.1 | 522.0 | 530.8 | 549.0 |
| difference (%) | 0.1 | -0.4 | 0.0 | 0.9 | 1.4 | -0.5 | 2.2 | -1.0 | -1.3 | -0.8 |

| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 575.3 | 542.1 | 539.3 | 492.8 | 560.8 | 554.2 | 523.5 | 519.8 | 549.5 | 557.4 | 537.4 |
| 574.5 | 544.2 | 530.4 | 497.6 | 565.3 | 548.9 | 532.1 | 520.0 | 539.3 | 547.2 | 545.3 |
| -0.1 | 0.4 | -1.7 | 1.0 | 0.8 | -1.0 | 1.6 | 0.0 | -1.9 | -1.8 | 1.5 |

In addition, the annual values show a good fit, as can be seen below. The MetaSWAP model is slightly more drought sensitive than SWAP. The impression is that both MetaSWAP and SWAP are not sensitive enough to drought. Partly this is due to the fixed vegetation parameters; see the section about coupling to WOFOST.



Variable root zone depth

It is now possible to let the root zone depth vary in the course of time; the time control is implemented via file FACT_SVAT.INP or via the vegetation model WOFOST. The root zone thickness in AREA_SVAT.INP then acts as a maximum value. The used depth (vegetational value *dprzvg* and the rounded value due to discrete availability in soil database, *dprztb*) are outputted to the SVAT* database files. The variable rootzone depth requires an online downscaling of the moisture profiles. That is the main reason for the fact the UNSA_SVAT.BDA database has become so much larger. (However, the extra data are only read by the program if the dynamic rootzone option is actually being used.)

Interception of rainfall by vegetation canopy, FACT_SVAT.INP

Interception of rainfall by the vegetation canopy and subsequent evaporation is now modelled with the 'sparse' Gash concept, plus some modifications. This involves an extra parameter *fecmn* (in LUSE_SVAT.INP) which gives the relative evaporation for a canopy saturation just above zero. The method is backwards compatible with the previous one if the parameter is set to the unit, if the user only had 0/1 values for the soil cover (FACT_SVAT.INP).

A full description of the method can be found in the revised Alterra report 913.1 (on the SIMGRO Office Live workspace).

Extra columns have been added to the FACT_SVAT.INP file, see the IO-manual.

Partitioning of evapotranspiration terms

The energy-partitioning between subprocesses involving evapotranspiration that can be active is now done in the following steps:

- the interception evaporation is interpreted as a vertical process, involving the area of the soil that has 'soil cover' (input via FACT_SVAT.INP); from the actual canopy evaporation the fraction W_{frac} is obtained by dividing through the evaporation of a wet canopy that covers the whole area;
- the factor $(1 - W_{frac})$ is used for reducing the potential values of all other terms: transpiration, soil evaporation, ponding evaporation;
- for the partitioning between the potential canopy transpiration and the potential soil/ponding evaporation a formula involving light extinction coefficients and the leaf area index is used.

The recipe for obtaining backwards compatibility with the previous code version is to set the extinction coefficients (LUSE_SVAT.INP) to a high value of e.g. 99.99. If not available the leaf area index is computed by the model from the soil cover and the light-extinction coefficients. Formerly the potential ponding evaporation was seen as a potential rest-term of the energy balance; there can be differences between the old and new versions due to this change, but in most models these differences will be small.

Penman-Monteith method for evapotranspiration

The Penman-Monteith method is now available as an alternative for 'Makkink'. (The option control is via parameter *evapotranspiration_mdl* in PARA_SIM.INP). The method is not necessarily better than 'Makkink', because it assumes for instance that the measured humidity is not influenced by the soil cover and water availability of a model run. If these differ substantially from the current situation errors can result. The Penman-Monteith method can be used in two ways:

- for computing the reference evapotranspiration (grass of 0.12 m), and then the same procedure as with 'Makkink';
- for computing vegetation-specific evapotranspiration terms.

This method requires input of data for:

- crop height (FACT_SVAT.INP), for vegetation-specific calculations;
- temperature;
- relative sunshine duration and net shortwave radiation;
- humidity;
- wind speed.

The relative sunshine duration is used in the calculation of the net longwave radiation. It could have been computed from the meteo-station location and the net shortwave radiation, as is done in SWAP; but to reduce the computational burden it has been made into an input variable.

The above input variables can also be supplied in the form of GIS-grids.

Coupling to crop growth model WOFOST

The coupling to WOFOST has been realized. Simulation of crop growth is enabled by setting *vegetation_mdl*=2 (=without feedback to the hydrological simulation) or 3 (=with feedback, including the root zone depth) in file PARA_SIM.INP, and by supplying the link between the *vg*-index and the crops of WOFOST in the file CRPFILE_SVAT.INP. Not all of the *vg*-index values listed in LUSE_SIM.INP need to be linked: each *vg*-link is optional. The crop input file format is described in the SWAP documentation.

However, the user should not directly use the original SWAP crp-files, because they contain data in *cm*'s, for instance the root zone parameters! There is also a section that differs completely, see the IO-manual. The two available crp-files for MetaSWAP are included in the T-model data on the ftp-server. The available files are for grass

and potatoes; the results for these have been checked with SWAP. Other crops will follow, but only after they have been tested.

For documentation on the WOFOST model the user is referred to the SWAP manual which is included in the docs of the Office Live workspace.

The current feedback from WOFOST to the crop factors is based on the so-called development stage. That makes the feedback relatively weak. During the first quarter of 2010 this feedback will be under investigation. Changes can be expected.

Salt stress and movements of solutes

For taking into account the effect of salt stress on the actual transpiration, we make use of the Maas & Hoffman method. The master switch for using the option is called "saltstress_mdI", which should be set to 1 in PARA_SIM.INP. This option and the simulation of salt movements (option of the *postmetaswap* program) is still being experimented with by the NHI modelling group. Some of the documentation is also still lacking. Therefore, we advise that this option be not used by others for the time being.

Technical

Soil physical database

The Boesten *beta2*-parameter for bare soil evaporation is given in a separate file. The standard value of *beta2* = 0.054 m^{1/2} is used in SWAP. In that model, also the conductivity of the top layer can inhibit the soil evaporation. To compensate for the fact that MetaSWAP does not have the latter feature, a value of *beta2* < 0.040 m^{1/2} is advised.

The building blocks of the schematization must now also include information about mineral composition; this information is needed for the temperature simulation.

All files involving a certain soil schematization contain a pincode in the first record. This allows the model to check the consistency, also in the post-processing. And at each access of the files the program outputs the PREMETSAP.KEY file that is produced when making the database with *premetaswap* (in the log directory) This makes it easy to check the identity of the files.

It is now possible to specify a path for the location of the files. This greatly simplifies the handling of large files (a schematization of NL in 300 units is in preparation, based on the 1:50 000 soil map), and makes it possible to give them a name, via the directory name of where they are stored.

For interpreting the model results (and the validity of the database), it is very convenient to have information about the field capacity, wilting point and available soil moisture. This information can now be obtained via input file FCWP_SVAT.INP plus the optional file GXG_GG_SVAT.INP with the groundwater levels for which the moisture contents are determined from the metafunctions (If the gw-levels are not given a depth of 100 m used in combination with specified pF's of FC and WP.) The data are written to FCWP_svat.csv.

Initialization

It is especially important to take care with the initialization of deep profiles, because it can otherwise take years for a profile of e.g. 50 m to reach some sort of equilibrium flow. It appeared that even experienced users were not giving the initialization much thought, and were often simply using the default option in the form of an equilibrium

profile, by not specifying the optional file INIT_SVAT.INP. This file is now compulsory; there is no default option anymore. It can now be used for three different options of initializing the model. The choice of option is specified by means of a string in the first record of the file; the options are:

- Equilibrium, requiring no further input data;
- Rootzone_pF, requiring a pF on the second record;
- Saved_State, requiring information that has been saved from a previous run.

Note that a saved state from SIMGRO6 is not compatible with SIMGRO7. The quickest way of obtaining a good initialization file is by first doing a run starting from a root zone pF init, and then after completion of the run renaming the file INIT_SVAT.OUT to the inp version.

Infiltration parameters

The infiltration capacity has been moved from AREA_SVAT.INP to a new file INFI_SVAT.INP. The file can include extra parameters, see the documentation.

Temperature simulation

The temperature simulation is a new option of the postprocessing. To make that possible it is necessary to specify the bottom temperature boundary condition in file AREA_SVAT.INP, and to include the surface temperatures in the METE_SVAT.INP file. The heat parameters of the soil are obtained from the lithological parameters that are now included in the soil physical database.

Land use parameters

The file LUSE_SVAT.INP has extra columns for:

- *fecmn*, parameter in interception simulation; use value of 1 for backwards compatibility;
- *kdif* and *kdir*, parameters for light extinction, used in partitioning of *ET*-terms; use values of 99.99 for backwards compatibility.

Time-dependent vegetation parameters

Extra data are required in FACT_SVAT.INP:

- leaf area index; if not available, then leave out altogether; the model will compute it from the soil cover, via the light extinction coefficients, and an exponential relationship;
- evaporation factors for potential bare soil evaporation and ponding below vegetation; use 1.0 for backwards compatibility;
- crop height (for *evapotranspiration_mdl* = 3)
- dynamic root zone depth (which is capped by the value in AREA_SVAT.INP).

Disabling of runoff

Runoff is disabled by setting *vxmu* to a value ≥ 9999 m. In the new version this does not anymore cause excess memory use. Values of e.g. 1000 m should be avoided for the disabling; otherwise the excess memory use will occur after all.

Output for surface water locations

Extra items have been added for the flow over boundaries of parts of the domain coupled to a certain surface water submodel (SurfW, SOBEK, SWQN.): The flow that directly goes to the non-coupled *swnr*'s is now made explicitly available. Also the upstream inflow item has been redefined to include what comes from the region boundary, to make the 3 upstream inflow items consistent with the downstream ones:

- the upstream inflow from outside the complete domain;
- inflow from subdomain of *other* sw-submodel;
- inflow from within subdomain of *same* sw-submodel.

The definition of terms on the downstream side follows the same pattern.

Output for SVAT units

Many extra items have been added to the SVAT*.BDA files, for instance:

- total storage decrease *decStot*;
- upward seepage *qmodfbot* in the MODFLOW cell that is coupled to a SVAT;
- root zone depths: vegetation value *dprzvg* and actually used value *dprztb*.

If the file for the selection of key variables (SEL_SKEY_SVAT_PER/DTGW.CSV) was non-compatible with the used SIMGRO version, then the programme writes the latest version of the respective file to the work directory, for easy recovery by the user. All variables are enabled in that new file, so they should be modified to suit one's needs.

A recovery-procedure has been implemented for when output files are temporarily being blocked by a virus-scanner or other system-process with high priority.

Parallelization

The OpenMP protocol has been used for parallelizing nearly all of the SIMGRO calculations. In addition, the OpenMP library is now statically linked to the program; so there is no more the need for placing *libguide40.dll* in the work directory.

To test whether the parallelization has been implemented correctly, a test was devised with the one-cell model. This test is available on the ftp-server. The test involves replacing the one SVAT by two of them, linked to the same MODFLOW cell; the two SVATs have been given half the area of the one SVAT in the other model. In addition, the drainage records have been split. Instead of 1 drainage record, the 'cloned' model has $2 \times 2 = 4$ records. Comparison of the results for the MODFLOW gw-level showed maximum deviations between $-3e-5$ m and $3e-5$ m. The numerical scheme includes if-statements, that can go one way or the other, leading to small disturbances. This kind of difference can also occur when testing the "hot start" option. Of the model with 2 SVATs the results for the separate SVATs are identical. We also tested the results of the test-bench for comparing with SWAP, by making separate runs with the sequential code and the parallel code; the differences were not significant.

The MODFLOW1988 version used by Deltares has not yet been parallelized. We expect that MODFLOW2005 will soon be coupled to SIMGRO, for which a parallel PCG solver is available.