

## Introduction of the new version of MetaSWAP

A new version of MetaSWAP is available in the release of iMOD 5.6. In this version the simulation of flow through resisting layers has been improved. The improved model code should be used in combination with a new database of MetaSWAP, in which the Van Genuchten conductivity parameters for heavy textured soils have been adjusted. Some input files of MetaSWAP have been changed in the new release to include additional functionalities. In addition, various (optional) functionalities for calculation of measures for the Freshwater Delta Programme in particular were added, tested and further improved.

The MetaSWAP release is closely related to the latest developments in the national hydrological model, LHM. For an explanation of how to use the new version of MetaSWAP and how to set parameters, please refer to the LHM 4.3 report (Janssen et al, 2023). Examples of MetaSWAP settings and input files can be requested from the NHI helpdesk.

This release document regularly refers to background information described in change and test proposals. This information can be obtained via the NHI website or requested via the NHI helpdesk.

## Improved calculations in the core of MetaSWAP

### Simulation of flow resisting layers

The simulation of flow through resisting layers has been improved in the computational core of MetaSWAP. In developments for the regional model AZURE it was concluded that the model simulation in shallow profiles with flow resisting layers had to be improved. When water percolated and reached a layer with very low permeability, the limits of the database were reached. In the calculation, too much overpressure was then created in the relevant MetaSWAP calculation box, as a result of which the water was forced through a flow resisting layer.

The model code has been adjusted to ensure that in this situation the excess water is redistributed from bottom to top to the boxes above. A box is first filled to saturation, after which the upper box is filled. If the upper box is also saturated and the ponding threshold has also been used, the remaining surplus immediately drains to the surface water. Further information about the implementation can be found in Implementation\_proposal 71 and test\_report 71.

Testing of the adjusted modelling code within the national model (LHM) resulted in too much simulated runoff. This has been traced to an artifact of the Van Genuchten relationship for clay in near-saturated conditions. The repair of the artifact required a new database, as explained below.

### A new MetaSWAP database

The new MetaSWAP database is based on the original soil schematization of the SCR654 report. It also contains a repair of the Van Genuchten relationships for heavy textured soils, based on a proposal published by Schaap and Genuchten

(2006). The changes are documented in implementation proposal 76 and test\_report 76.

The new release should only be used in combination with the new database, otherwise excessive runoff will be generated. And, vice versa, the new database should only be used with the new release. The database contains both the SCR654 database with 370 units and the BOFEK2020 version.

The database has been finetuned with respects to the following parameters:

- FPRZUNI\_SVAT.INP
- HZN\_CEBS.CSV

The fine-tuning and results of the benchmark test can be found in Implementation\_proposal/test\_report 81. The user can overrule these files by including their own version in the MetaSWAP work directory.

The new database can be requested via the website NHI or the NHI helpdesk.

If desired, the database can be applied in accordance with parameters settings as applied in the national model, LHM 4.3. In that case amongst others scaling factors in file USCL\_SVAT.INP are adjusted and bypass factors in the file FBYPASS\_SVAT.INP. More information about the settings and input files of LHM can be requested via the NHI helpdesk.

## Improved functionalities

### Adjusted functionality for the bypass flow

Bypass flow can be simulated with a conceptually basic method, with a specified fraction (FBYPASS\_SVAT.INP) of the infiltration percolating directly to the phreatic level. A recent extension is that the bypass fraction can be made dependent on the degree of saturation of the root zone, SR01. Activating this option requires an extra column in FBYPASS\_SVAT.INP, and also *bypass\_md=1* in PARA\_SIM.INP.

### Adjustment of the crop files for stopping root growth under wet conditions

In the previous version the 'crp files' did not specify the parameter *aeratecrit*. A default value of 0.0001 was used instead. Only when the *Trelwet* (oxygen stress) became nearly zero the growth of roots in WOFOST was stopped.

Note: this new parameter is not optional, so the new release does not run with the old crp files.

In the new crp files for LHM the parameter is set to 0.5, comparable with the approach in Waterwijzer Landbouw (WWL). Examples of input files of the LHM can be requested via the NHI helpdesk.

### Option for correction of the root zone depth

MetaSWAP uses a uniform root distribution. Comparison with literature values shows that for root zone depths deeper than 30 cm the uniform distribution can be too optimistic with respect to the availability of water for crop extraction. A root density which linearly decreases from 30 cm to zero at the extent of the root zone seems most realistic.

However, it is not possible to define such a transition at 30 cm in MetaSWAP. That is because, like in SWAP, the root distribution in the model is made dimensionless. To adjust the model in such a way that the transition can be approximately taken into account, an option has been created that reduces the root zone depth during the run. The reduction consists of halving the extra depth below 30 cm. For example, a root zone depth of 100 cm is reduced to:  $30 + 0.5 \cdot (100 - 30) = 65$  cm.

The transition point is specified in file PARA\_SIM.INP with the record: *dprztbfunc* = 0.3. Further documentation of this functionality is available in Implementation\_proposal 77 and test\_report 77.

### **Truncation of MetaSWAP profiles**

The MetaSWAP profiles can now be truncated at 5 m and used in combination with UZF, without the danger of a water balance error (file DBOT\_SVAT.INP).

*Note:* A depth of 5 m is recommended for regional models. In LHM the profiles are truncated at 13 m depth or more. That is driven by the need to avoid conflicts with the TRANSOL implementation.

## **Improved handling of input and output files**

### **Reading of meteorological grids**

The reading of meteorological grids has been made exactly identical to iMOD. The changes made are:

- use of Real\*8 (float64) for reading data
- double implied loop, instead of a DO-loop and nested single implied loop

*Note:* the previous version could crash with 'floating overflow' if the data was written with more than 7 digits.

### **Output of idf's directly from MetaSWAP.**

It is now possible to generate output moisture profiles directly from MetaSWAP. This is activated by the parameters *idf\_theta\_per* and *idf\_theta\_per\_lb* in PARA\_SIM.INP

### **Output of groundwater recharge for use in MODFLOW calibration**

For the regional model AZURE, a method for dealing with input and output files has been developed to write the groundwater recharge in such a way that it can be used for MODFLOW calibration. For more information, please contact the NHI helpdesk.

## Added and improved functionalities for calculation of measures

### Changed functionalities for flexible drainage and subirrigation (RDI)

In iMOD 5.4 an option for flexible drainage and subirrigation is introduced in MetaSWAP (see release notes MetaSWAP, iMOD 5.4, 2022). The option for the soil water pressure during the spring has been removed. Instead, the groundwater trigger option has been given an extra critical level for the period outside the crop season. The file FLEXDSUB\_SVAT.INP now has the following format, with the changes indicated in red:

#### Variable format and description

col	Format	name	unit	description
1-10	I10	lu	-	land use id
11-20	F10	t1_h2l_tarlu	d	Julian time that target level goes from high to low level specified in modsub_svat.inp.
21-30	F10	t2_l2h_tarlu	d	time that target level goes from low to high level.
31-40	F10	t3_h2l_tarlu	d	time that target level goes from high to low level.
41-50	F10	t4_l2h_tarlu	d	time that target level goes from low to high level.
51-60	F10	tbeginsublu	d	time that subirrigation supply period begins
61-70	F10	tendsublu	d	time that subirrigation supply period ends
71-75	F5	tcutsublu	d	time that subirrigation supply is temporarily cut
76-80	F5	tresublu	d	time that subirrigation supply resumes
81-90	F10	Trelwetsublu	-	value of Trelwet (o2stress) for triggering drop to low target level, when Trelwet < Trelwetsublu
91-100	I10	ioptNoJlu	-	option parameter for using the <u>un</u> compensated value (ioptNoJlu=1) or the Jarvis-compensated value (ioptNoJlu=0) for the trigger Trelwetsublu
101-110	I10	dpgwcm1u	cm	depth of groundwater level for triggering drop to low target level when dpgwcm < dpgwcm1u, only <b>inside</b> growing season, with LAI > 0.01
111-120	I10	dpgwcm2u	cm	depth of groundwater level for triggering drop to low target level when dpgwcm < dpgwcm2u, only <b>outside</b> growing season, with LAI < 0.01

The new groundwater level trigger for outside the growing season is *dpgwcm2u*. It is now also possible to interrupt the surface water supply period with *tcutsublu* and *tresublu*. However, the latter option has not yet been extensively tested.

The module has been made more robust and flexible so that it is not anymore necessary to use the lowest SVAT for the management decisions (input in MODSUB\_SVAT.INP) .

Further information about the implementation can be found in Implementation\_proposal and test\_report 79.

The module has also been made available to interact with the surface water module MOZART in the national model (LHM). Further information about this implementation can be found in Implementation\_proposal and test\_report 80.

## Drip irrigation

The drip irrigation introduced in the previous release has been expanded with the option for 'deep drip', where the application of irrigation takes place below the soil surface. This can reduce the losses from ponding evaporation. It should be realized, however, that via the soil moisture the soil evaporation can still be influenced by the drip irrigation. More information about the implementation can be found in `implementation_proposals` and `test_reports` 68 and 73.

## Restriction of irrigation via limitation of groundwater lowering

It may be policy to stop the extraction of groundwater for sprinkling if the groundwater in a 'target' location drops below a certain critical level. This is implemented in the file `SCAP_SVAT.INP`. More information about the implementation can be found in `Implementation_proposal` and `test_report` 75.

## Additional developments for the Freshwater Delta Programme

### Option for simulation intervals of 10 days

Running with simulation intervals of 10 days is now available. Extensive documentation is provided in `implementation proposal` and `test_report` 72.

The implementation of 10-day simulation intervals requires some preparatory work and modification of the input files to do this properly.

#### PARA\_SIM.INP

The following settings must be adjusted:

- `vegetation_mdl= 1`
- `dtgw = 10` (the time step `dtsw` for the fast processes should be left at 1.0 d)

#### FACT\_SVAT.INP

For groundwater models that use the full Penman Monteith evaporation model and the WOFOST dynamic crop growth model various files need to be updated. This is needed because WOFOST cannot be used for 10 days simulation intervals. Therefore, a preparatory run should be performed with the dynamic WOFOST model for a minimum of 10 years, with time step of 1 day. The following variables should then be averaged by calendar day of the year and stored in the file `FACT_SVAT.INP`: `csvg`, `laivg`, `chvg`, `drpzvg`, `fco2vg`.

The `fco2`-parameter can be computed from the `CO2TRATB` table in the `crp` file. It has the same value for all days of the year.

#### LUSE\_SVAT.INP

The following parameters should be given values obtained from the `crp` files: `albedo`, `rsc`, `rsw`, `kdif`, `kdir`.

The soil resistance `rsoil` must already be in the file: 600.0 s/m for grass, and 150.0 s/m for other crops.

For implementation in a model area with multiple main meteorologic stations, the correct method is to introduce additional versions for each station for each of the original WOFOST crops.

## Use of 'vanggewas' in combination with WOFOST

Sowing of a 'vanggewas' is legal requirement in the Netherlands. This implementation is done with the rotation scheme of LUROTA\_SVAT.INP in combination with the new VG2CRP\_SVAT.INP. A recent revision of the law is to sow on October 1. But that is being contested 'real time' by the farmers, because in 2023 the crops have started very late due to a wet spring, followed by extremely dry conditions not conducive to the start of growth.

Note, it should be realized that the implementation of 'vanggewas' is not included in the crop factor file FACT\_SVAT.INP. Such an update is not foreseen, since the crop factor method for agriculture has been deprecated.

## Parameter setting for PostMetaSWAP in combination with WOFOST

For WOFOST it is not necessary to use the most extensive version of PostMetaSWAP. But PostMetaSWAP is needed to deliver the temperature profile. This can be achieved by setting *postmsw\_opt* = 2, to the 'minimum' option. Alternatively, the model can set this value automatically by leaving the parameter in PARA\_SIM.INP at zero. This option is sufficient for the output of PostMetaSWAP, but not for running TRANSOL. The option still needs a list of times that the PostMetaSWAP is called, in TIOP\_SIM.INP. The interval between the profiles should not be more than 10 d. But at the other extreme, 1 d consumes a lot of extra CPU time and is not recommended.

## Crop damage output in combination with WOFOST

A postprocessing procedure has been developed for converting the idf output into maps of drought damage (in %) and oxygen stress damage (%) and indirect damage (%). The procedure is not officially part of the iMOD release. For more information about this option, please contact the helpdesk NHI.

The indirect damage is defined with respect to the spring situation. For this purpose, a groundwater level of 1 m b.s.s. is recommended. That is considered more realistic than using deeper groundwater levels (e.g. 5 m b.s.s).

For more information about the specific settings and input files (SEL\_KEY\_WOF\_PER.INP) examples of LHM can be requested via the NHI helpdesk.

## Known issue

### Floating invalid at start of the model on virtual machines

When running MetaSWAP in a virtual machine, initialization of variables is a critical issue. If the initialization is omitted in the code, the run may crash sporadically on startup. Normally a restart can be performed and the problem will not occur right away. If the issues persists, it is advisable to request support by sending an e-mail with a screenshot to the NHI helpdesk.