



Ongespannen rekenen

en de MetaSWAP-UZF koppeling



WAGENINGEN
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Brabant Water

Inhoud

Ongespannen rekenen

- Wat is ongespannen rekenen
- Verschil in berekeningsresultaten ongespannen t.o.v. gespannen rekenen
- Waar is ongespannen rekenen van belang
- Aansturen ongespannen rekenen in iMOD 5 (Modflow 6)

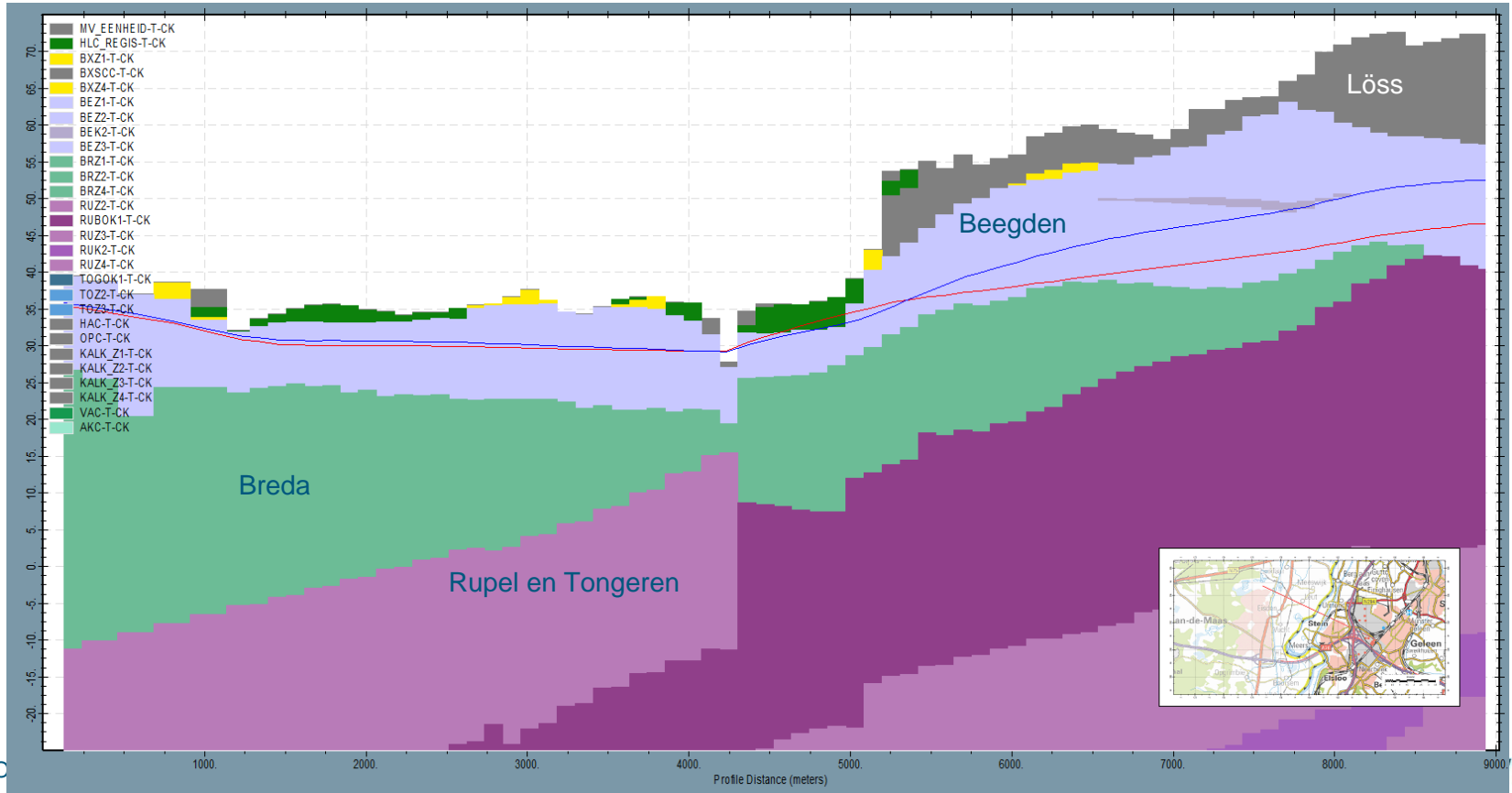
Ongespannen rekenen MetaSWAP-UZF koppeling

- Wat is de MetaSWAP-UZF koppeling
- Aansturing MetaSWAP-UZF koppeling in iMOD 5.5 (Modflow 6)
- Resultaten MetaSWAP-UZF koppeling

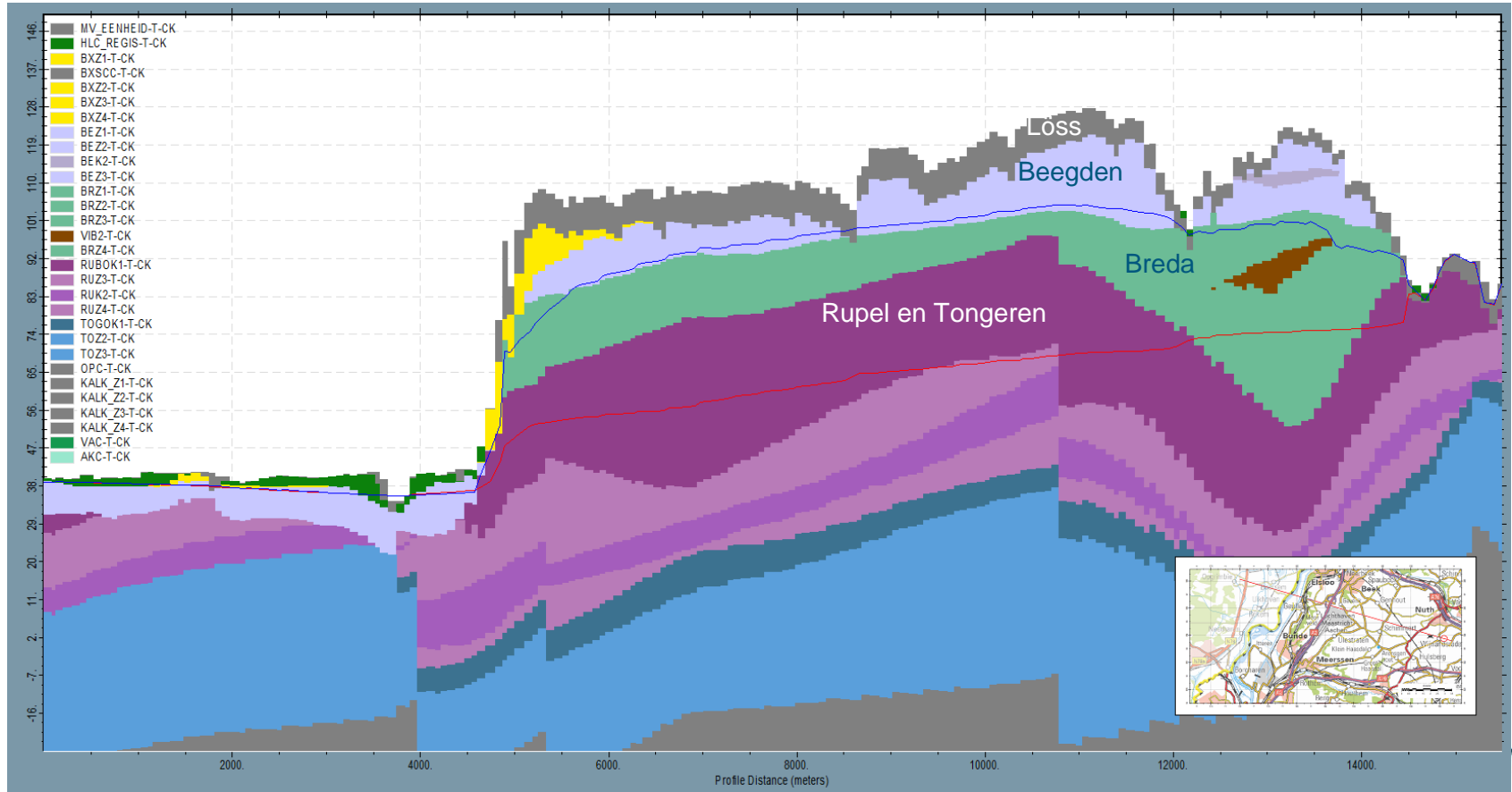
Wat is ongespannen rekenen

- Engelste term UNCONFINED calculations
- Bij ongespannen rekenen is het doorlaatvermogen (transmissiviteit) van een modellaag gelijk aan de doorlatendheid van de modellaag * **watervoerende dikte**
- Bij gespannen rekenen is het doorlaatvermogen (transmissiviteit) van een modellaag gelijk aan de doorlatendheid van de modellaag * **dikte van de modellaag**

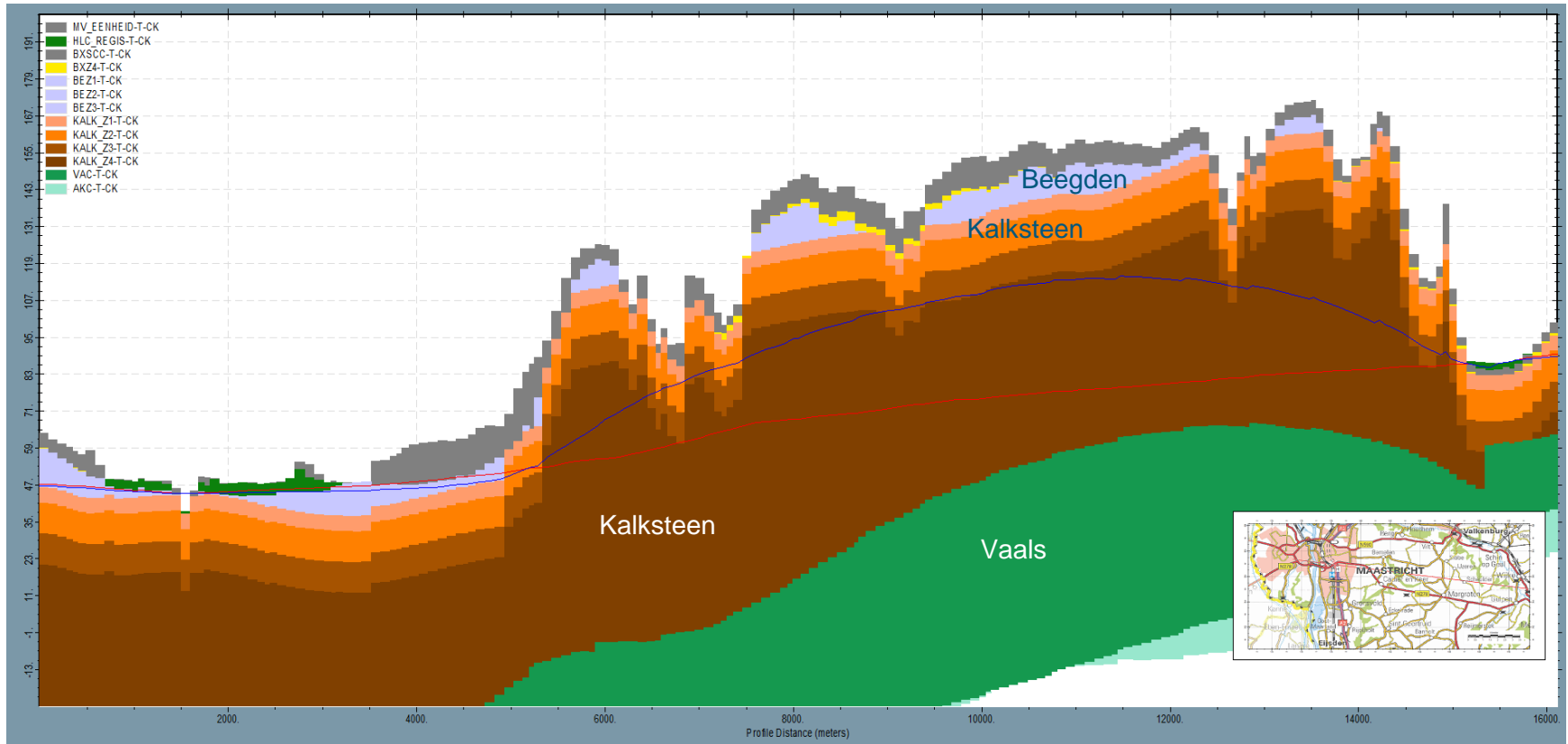
Verskil in berekende gws ongespannen vs gespannen



Verskil in berekende gws ongespannen vs gespannen

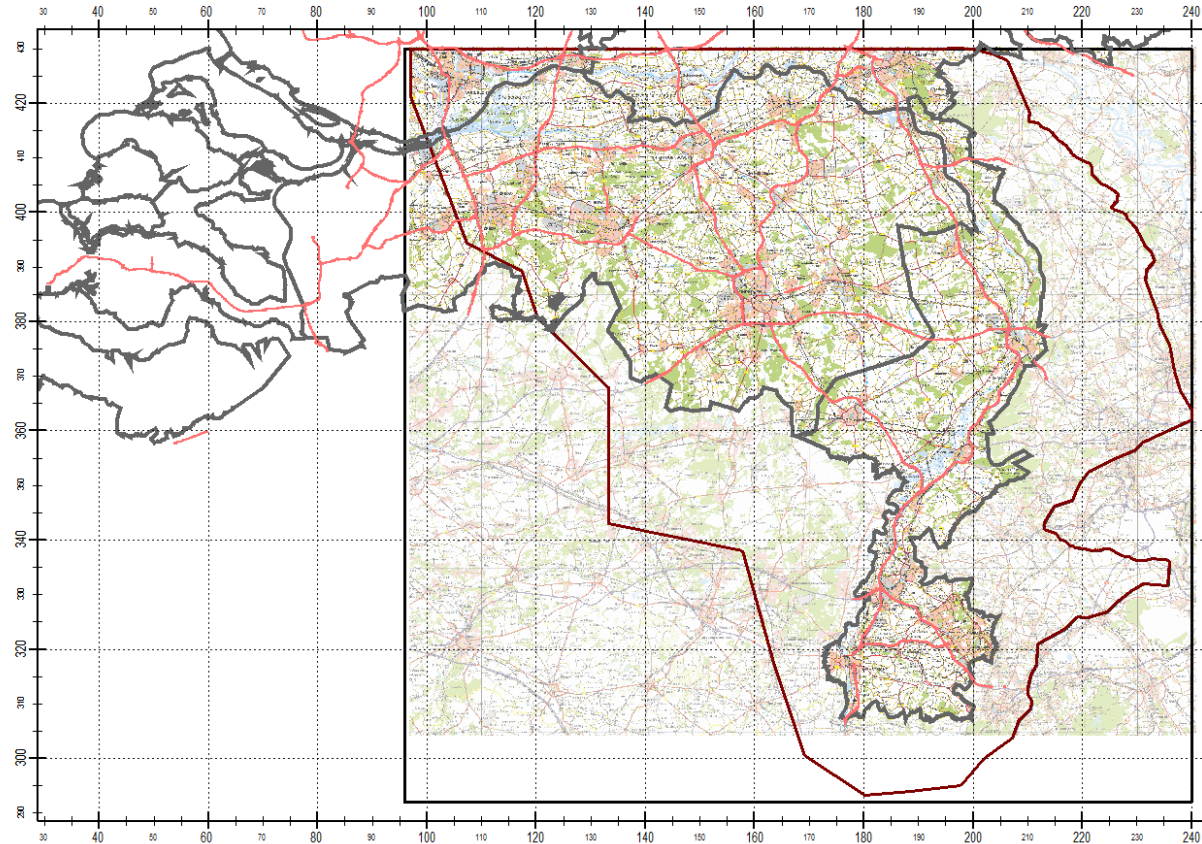


Verskil in berekende gws ongespannen vs gespannen

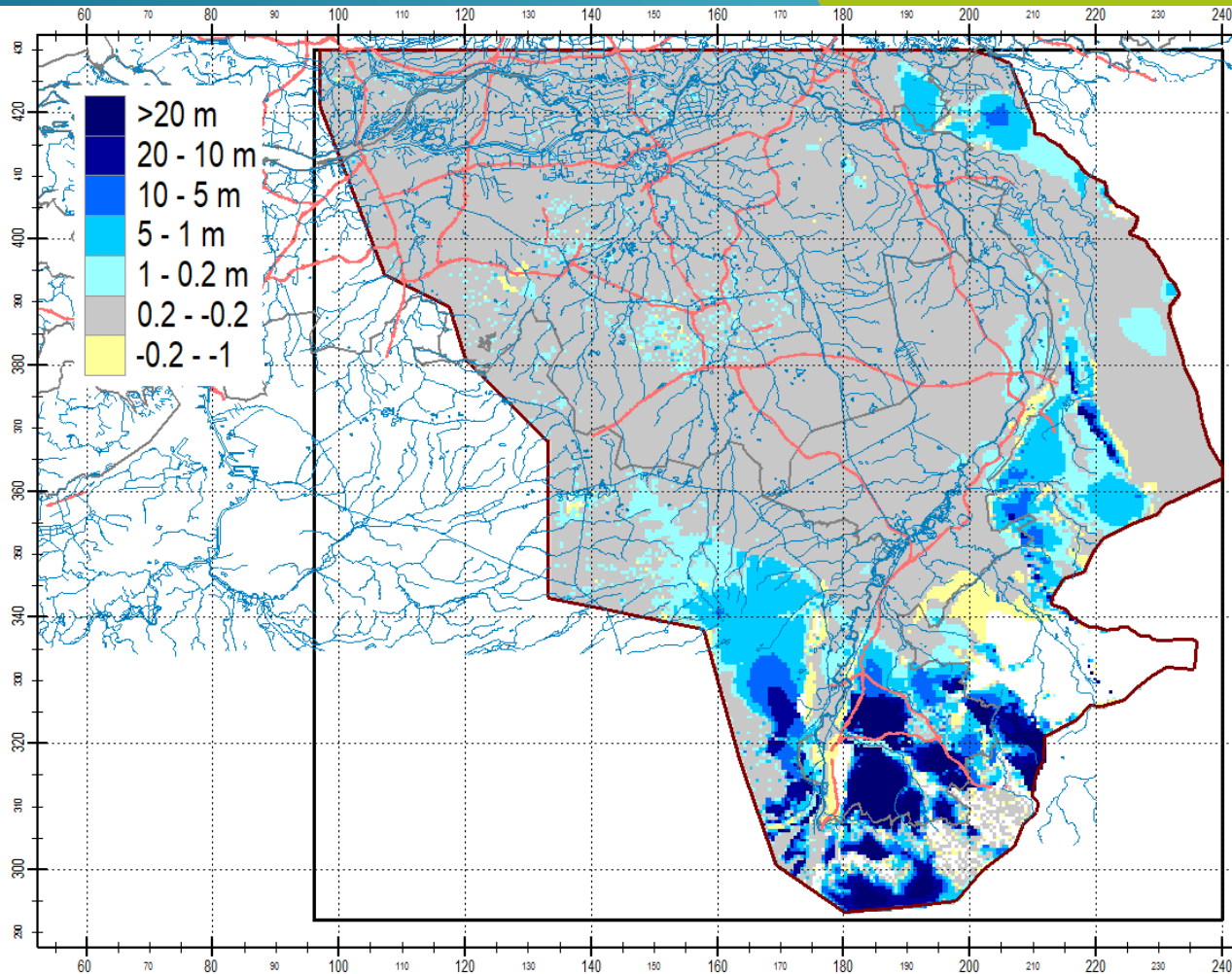


Waar is het van belang

- Vergelijking gespannen berekening met ongespannen berekening voor hele Ibrahym modelgebied.



- Vergelijking gespannen berekening met ongespannen berekening voor hele Ibrahim modelgebied.
- Stationair berekeningen



Aansturing Ongespannen Rekenen

iMOD Handleiding:

UNCONFINED= (optional) Use this keyword to include unconfined conditions for model layers, e.g. UNCONFINED=1,1,1,0,0,0 by default UNCONFINED=0 and model layers are confined. So, if NLAY=10 and UNCONFINED=1,1,1 this means that the first three model layers are unconfined, the remaining layers are confined. The values for UNCONFINED are:

◇ **UNCONFINED 0**

The model layer is confined, the saturated thickness is defined by the top- and bottom elevation per model layer;

◇ **UNCONFINED 1**

The model layer is unconfined, the saturated thickness is defined by the compute hydraulic head and the bottom elevation per model layer. It is obligatory to include the modules STO and SPY whenever unconfined conditioned are simulated for a transient model. For SIM_TYPE=3 (MODFLOW6) the bottom heights of the river package are set to the bottom level of the layer in case they extend this. In case INEWTON=0 (and/or SIM_TYPE=2), iMOD adds and configures the WETDRY option automatically. It assigns at least a 0.1 m threshold for each cell to activate rewetting. For all layers rewetting is achieved by underlying cells only, except the last layer for which rewetting can occur by neighbouring cells. They yield the average head (HeadMean). The head is estimated to be the bottom of the model layer (BottomLayer) + WETFACT * (HeadMean - BottomLayer) Each iteration the rewetting and drying is evaluated (MODFLOW Keywords IHDWET=0, IWETIT=1, WETFACT=0.1).

◇ **UNCONFINED 2**

The model layer is confined by the saturated thickness is defined by the starting heads and the bottom elevation per model layer.

Notice that in combination with MODFLOW6 usage of **NEWTON** solver is highly recommended for unconfined simulations.

NEWTON= (optional) Use this keyword to enforce the Newton-Raphson formulation for groundwater flow between connected, convertible groundwater cells and stress packages that support calculation of Newton-Raphson terms for groundwater exchanges. Cells will not dry when this option is used. By default, NEWTON=0 and the Newton-Raphson formulation is not applied.

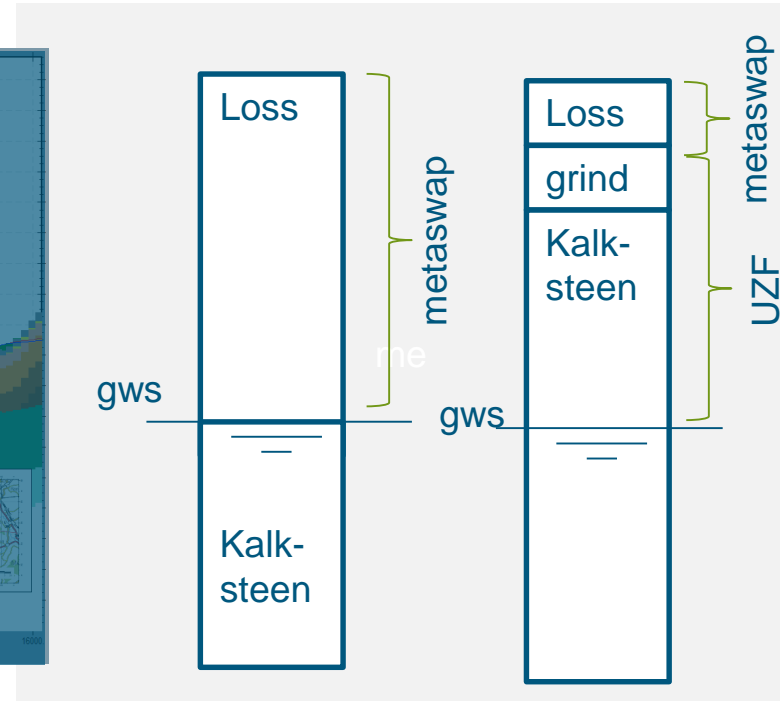
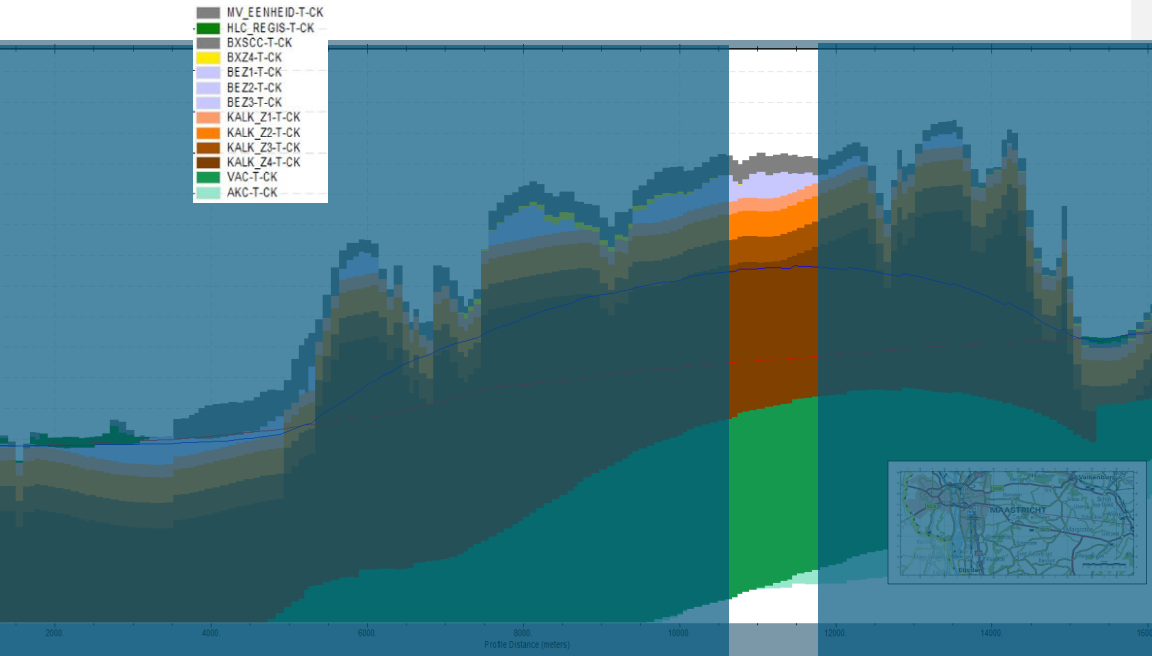
Function=RUNFILE

NEWTON=1
COMPLEXITY=COMPLEX
UNCONFINED=1,1,1,1,1,1,1
QWEL=0.10
DDRN=0.1

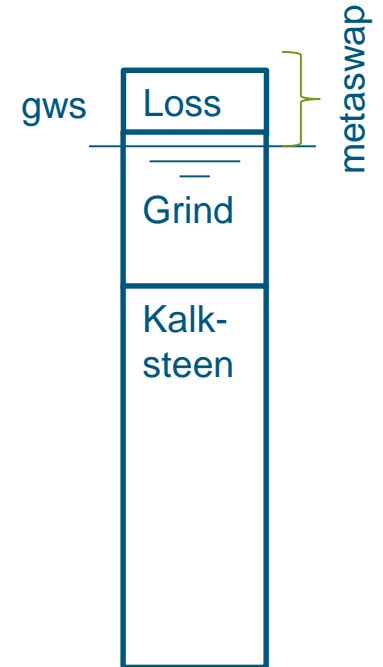
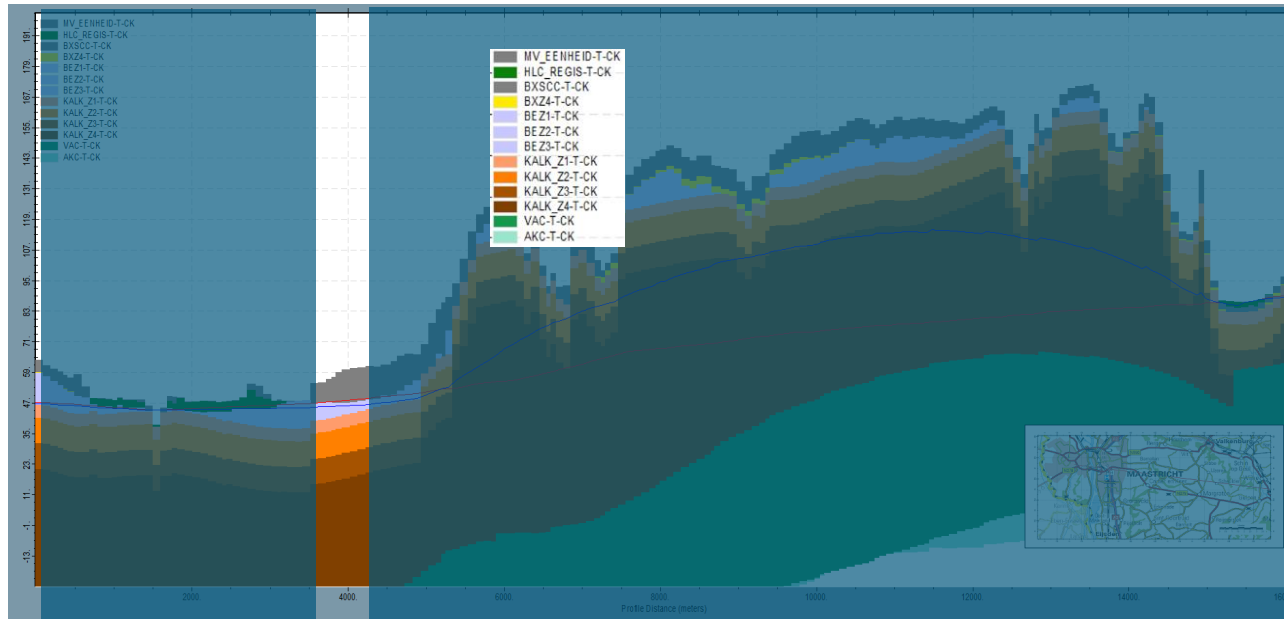
Wat is de MetaSWAP UZF koppeling

- Standaard wordt MetaSWAP gekoppeld met Modflow 6 in modellaag 1
 - MetaSWAP geeft grondwateraanvulling door aan modellaag 1
 - MetaSWAP bepaalt freatische bergingscoefficient voor modellaag 1
 - MetaSWAP rekent met 1 bodemtype voor onverzadigde zone
- De grondwateraanvulling berekend door MetaSWAP wordt bij de MetmaSWAP UZF koppeling doorgegeven aan de Modflow UZF module.
- Freatische bergingscoefficient komt uit SPY package.
- UZF neemt bodemschematisatie onverzadigde zone over uit het lagenmodel

MetaSWAP UZF koppeling methodiek B

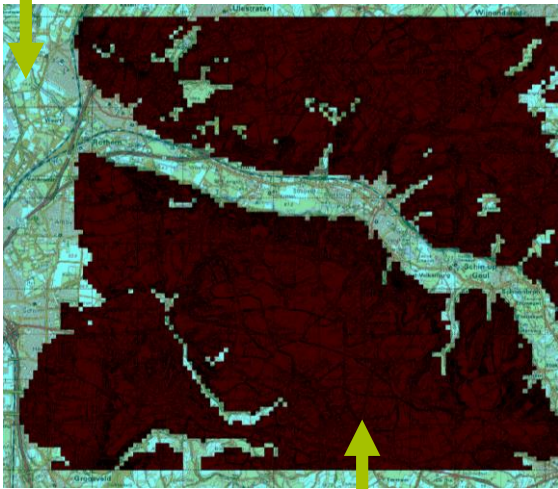


MetaSWAP-ongespannen rekenen koppeling methodiek A



Koppelingsmethodieken MetaSWAP - UZF

Methode A (gelijke resultaten als conventionele koppeling)
Ondiepe grondwaterstanden



Methode B (extra vertraging door complex geologisch profiel)
Diepe grondwaterstanden

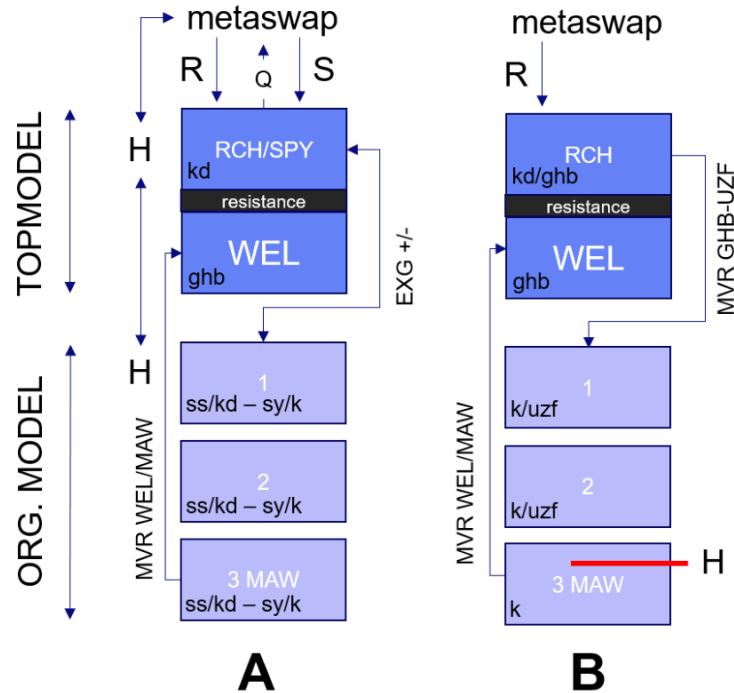


Figure 3.5: Schematic representation of the layout and connections between the top model and the underlying original model.

Aansturing Koppeling MetaSWAP - UZF

iMOD Handleiding:



TOPMODEL=
(optional) Use TOPMODEL=1 to insert the coupling of METASWAP in a dummy model on top of the original model. In case TOPMODEL=0, MetaSWAP is coupled to the original model, this is the default setting. TOPMODEL is set to 1 (and cannot be altered) in case the UZF package is activated in combination with the CAP package that activates MetaSwap. Use TOPMODEL=0 for models without MetaSWAP.



DEPTHUZF=
(optional) Use this keyword to specify the absolute depth in meters+MSL level over which the UZF needs to be applied in the model. This can be an IDF file or constant value, e.g. DEPTHUZF=D:\DATA\DEPTH.IDF or DEPTHUZF=10. The latter represents a constant depthlevel of 10 meter throughout the modelling domain. The UZF is applied until the first model layer which is entirely below DEPTHUZF. **Important** that the UZF is connected to an active hydraulic head at all times, if not the water balance of the UZF component might be incorrect.



DBOTDEPTH=
(optional) Use this keyword to specify the absolute depth in meters minus surface-level to connect with MetaSWAP, e.g. DBOTDEPTH=20.0 means that recharge from MetaSWAP is extracted from 20 meter below surface level. By default DBOTDEPTH=0.0 and the corresponding DBOT_SVAT.INP is not written and therefore not used by MetaSWAP. In case TOPMODEL=1, the default DBOTDEPTH=20.0 for areas connected to the UZF package and set to the lowest box level in the MetaSWAP database for areas connected conventionally with MetaSWAP. DBOTDEPTH is in this case also used to connect the recharge from MetaSWAP to the correct UZF cell at the appropriate vertical position.

Documentatie – iMOD Manual

iMOD, User Manual

2.1.2.1 Top-model
 A top-model is added to the original model that overwrites the original model. How this model interacts with the underlying original model depends on the method A or B selected. The top-model consists of two model layers. The first model layer is used to deliver the required artificial recharge from MetaSWAP, the second layer acts as a layer to deliver the required artificial recharge. In order to avoid any vertical flow between model layer 1 and model layer 2, a high resistivity is applied. For method A and B the following configuration is used:

Parameter	Method A	Method B	Unit
Saturation Top	ConfinEd	ConfinEd	-
Saturation Bottom	0.0	1.0	m + MSL
Hor. Permeability	0.00001	1.0	m + MSL
Storage	100.0	100.0	m/d
Starting Head	SHD	MV - 100.0	m
DRN_COND	SHD	MV - 100.0	m + MSL
MSwap Recharge	ConfinEd	ConfinEd	m
Saturation Top	0.0	1.0	m + ?
Saturation Bottom	1.0	0.00001	m + ?
Hor. Permeability	0.00001	0.0001	m
Ver. Permeability	0.0001	MV - 100.0	m
Storage	SHD	MV - 100.0	m
Starting Head	SHD	SHD	Δz^2
		WEL → MAW	

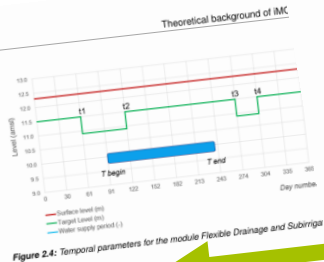


Figure 2.4: Temporal parameters for the module Flexible Drainage and Subirrigation

2.1.2 Coupling MetaSWAP to MODFLOW

The coupling of MetaSWAP and MODFLOW2005 and/or MODFLOW6 is done automatically. Coupling tables are generated to connect elements of MetaSWAP to MODFLOW cells. Here, maximal two SVATs can be coupled to a single MODFLOW cell. An additional extraction of artificial recharge from groundwater introduces an additional section describes briefly how the coupling is done and what alternative of possible.

The following coupling schemes are possible:

- Method A:** here MetaSWAP is coupled via an artificial sub-model on top of the original model and acts similar as the default coupling mechanism. In fact this method is necessary in case the model support Method B as well.
- Method B:** here MetaSWAP is coupled via an artificial sub-model on top of the original model and exchanges the groundwater recharge from MetaSWAP towards the recharge zone package (UZ2).
- Method C:** here MetaSWAP is coupled regularly without an artificial sub-model and exchanges groundwater via the coupling tables direct to the original model, it exchanges groundwater via the coupling tables to an appropriate model layer, slight change is that the underlying model can be using making the exchange depending on the saturation of model layers.

Note: Important to note is that the location of the type of coupling (A or B) is specified by the BND file of the CAP-model. A value of 1 denotes Method A, a value of 2 denotes method C cannot be combined with method A and/or B but can be seen as an alternative original coupling.

Using this type of coupling, it is necessary to include the keyword **TOPMODEL=1** in the FILE function, as described in section section 1.7.6.

Theoretical background of iMOD packages

r Manual

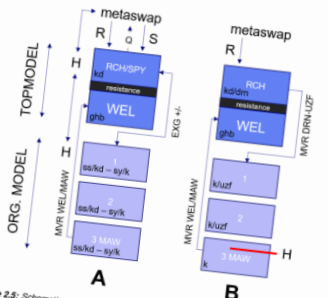


Figure 2.5: Schematic representation of the layout and connections between the top model and the underlying original model.

ge coefficient that is derived from MetaSwap is assigned to the first model layer in order.

is important that the first active model layer in the underlying model, has a confined instead of an unconfined storage coefficient. Otherwise, phreatic storage is computed

1 Model layer

al recharge that is extracted from groundwater is taken from the second model layer top model using the regular connection of MetaSwap and the WEL package. To avoid water from the first to the second model layer, a resistance is set in between the two. This is done by specifying a vertical anisotropy of 0.00001 for the second model layer, ield a resistance of 50,000 days. The source of water, to balance out the extraction is rated by a general head boundary (GHB) condition. This avoid water flowing from the model layer to the second model layer. The water balance in that model layer equals zero at manner by itself. The water mover (MVR) package of MODFLOW6 moves water from appropriate model layer of the underlying model towards the

changes the groundwater recharge from MetaSWAP via the EXCHANGE package of MODFLOW6. The extraction is assigned to the second model layer of the sub-model and via the /R-package it is extracted from the underlying model towards the second model layer of the model. As the strength of the WEL is negative (extraction), moving that water results in an action in the underlying model, however, MODFLOW6 offers the possibility to apply a factor 1.0 to extract water from the underlying model as well.

<https://oss.deltares.nl/web/imod/user-manuals>

The reason for using an artificial top model is for the coupling of MetaSwap and the unsaturated zone model UZF of MODFLOW6.

First Model layer

MetaSwap recharge enters the top model in the first model layer. To limit any lateral flow to adjacent cell, the horizontal permeability is set to 0.00001 m/d. The model layer contains an artificial drainage system to drain all the recharge. In order to avoid any interaction with MetaSwap, the drainage level, as well as the initial head, is set to 100 meter below surface level. In that way, MetaSwap simulate downward flow only and the recharge from MetaSwap to MODFLOW6 is always greater, or equal zero. The conductance of the artificial drainage system is set to the area of the cell which denotes a resistance of 1 day. Important is that the drain, drains all the recharge water and no water is lost to the underlying second model layer and/or the storage. Therefore, the storage is set to 0.0. The water that is drained by the drainage package it moved via the mover (MVR) package to the UZF package to the first active model layer in the underlying model. That water enters the top of the UZF column and routes through the unsaturated zone towards the layer that is saturated by groundwater.

Second Model layer

The configuration of the second model layer, and the connection to the underlying model is

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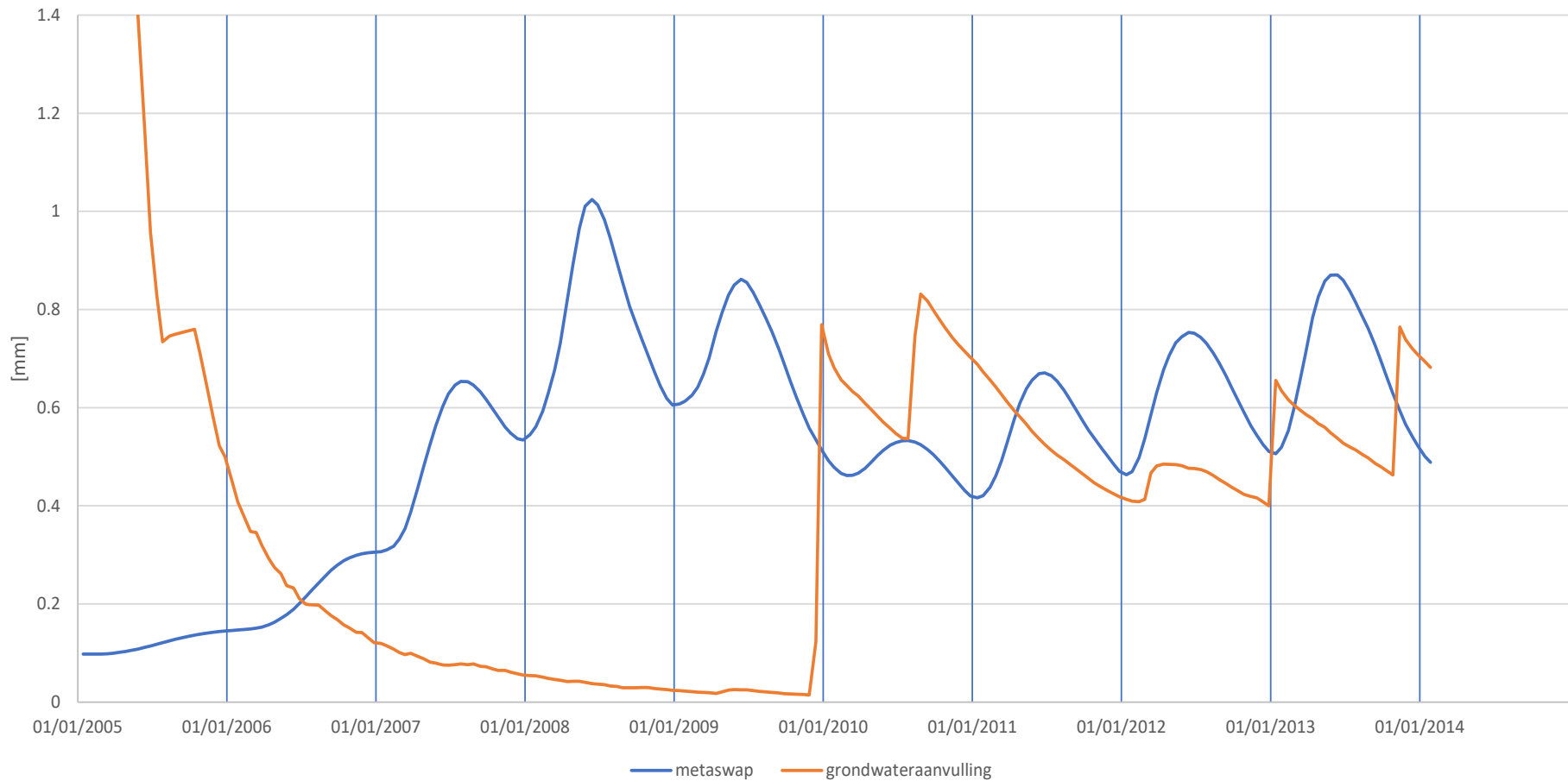
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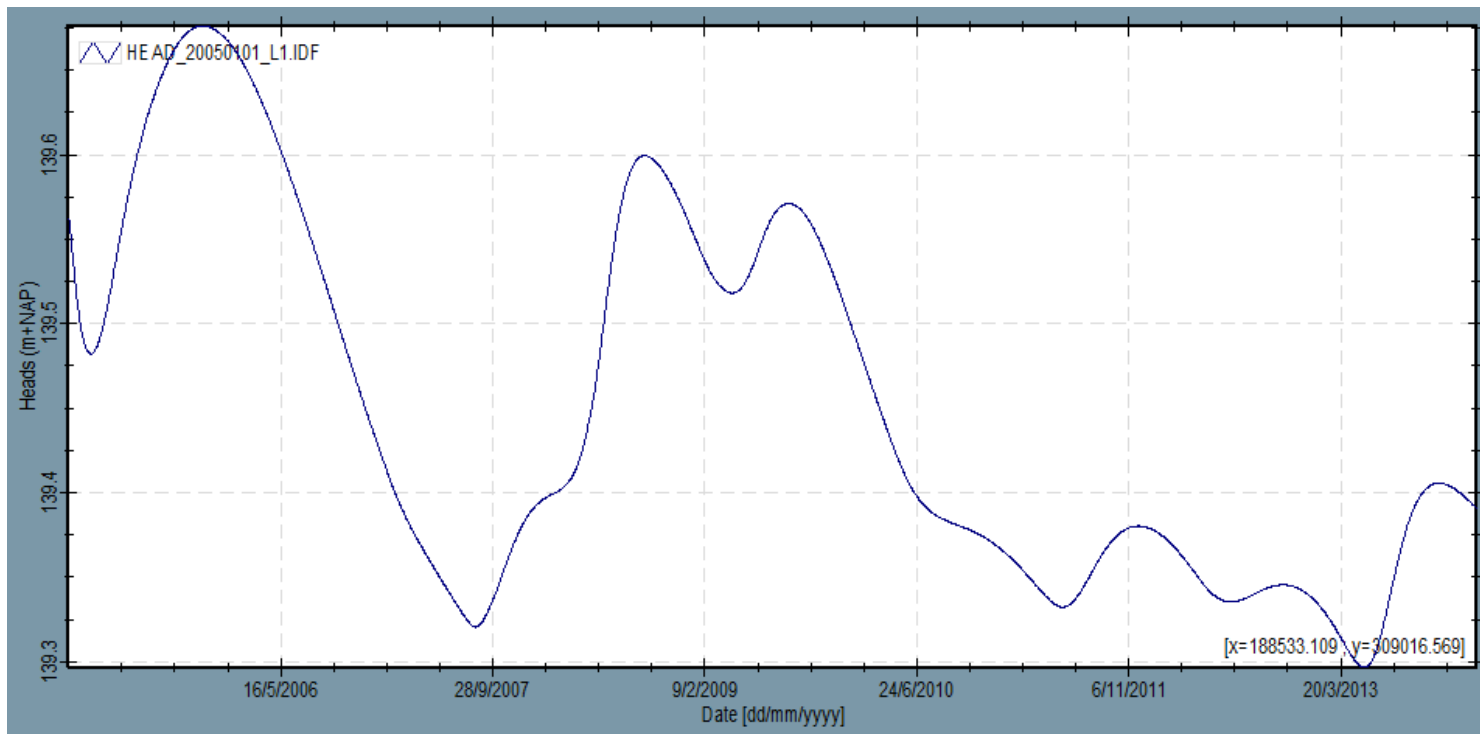
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MetaSWAP out (= UZF in) en UZF out (= grondwateraanvulling)



Resultaat MetaSWAP UZF koppeling



Samenvattend

- Ongespannen rekenen is robuust en eenvoudig te implementeren;
- Methode A en B zijn geïmplementeerd in iMOD v5.5 zodat deze gebruikersvriendelijk toegepast kunnen worden;
- Methodiek is gerapporteerd in de officiële iMOD handleiding;
- Van alle waterbewegingen binnen de methode A en B zijn nauwkeurige waterbalansen beschikbaar