BELGIUM

Education evenings 2018

Practical introduction
to groundwater modelling

Computer exercises
02 02 Calibrating the more complex model

Purpose

In this exercise, we will use ModelMate to perform

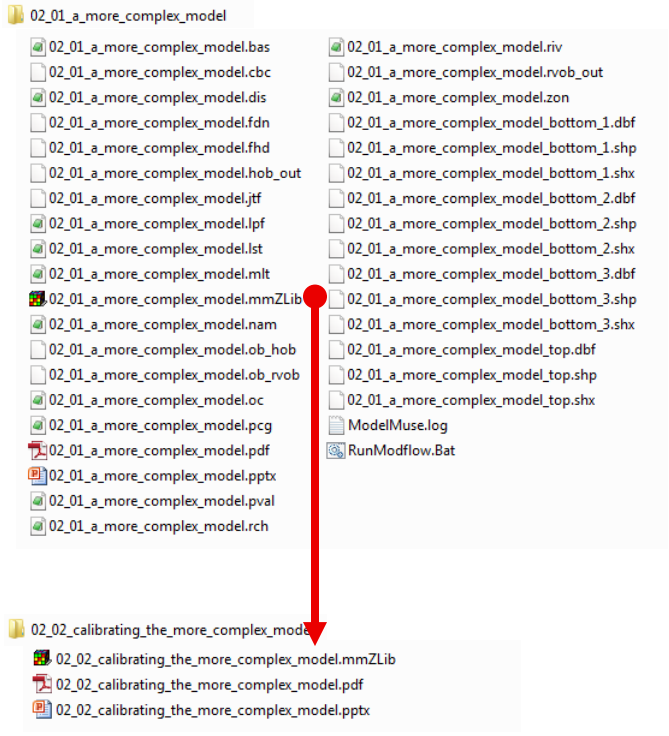
- ✓ local sensitivity analysis and
- ✓ local optimization or calibration

of the parameters we defined in our more complex model, and

- ✓ import the results back to ModelMuse.

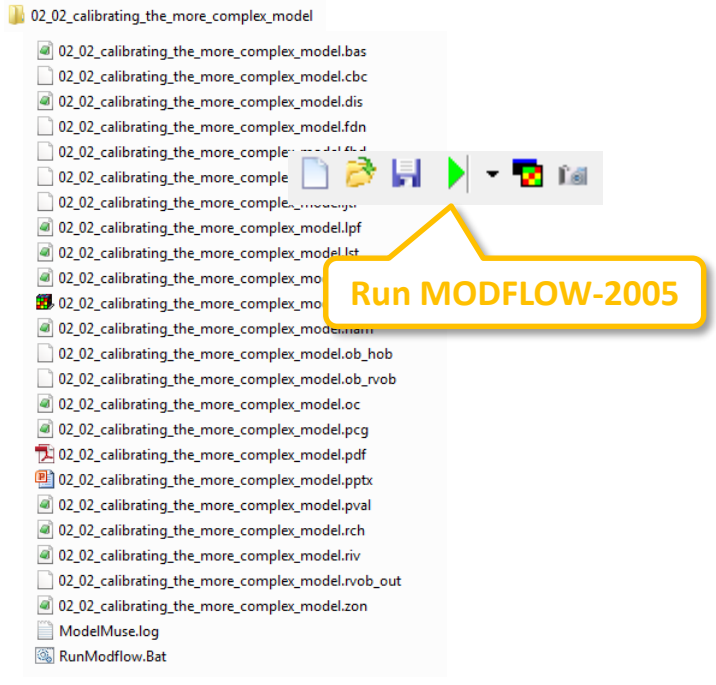
Copy file previous exercise

- ✓ Copy file “/02-01_a-more-complex-model/02-01_a-more-complex-model.mmZLib”
  to folder “/02-02_calibrating-the-more-complex-model/”
- ✓ Change the file name to “02-02_calibrating-the-more-complex-model.mmZLib”



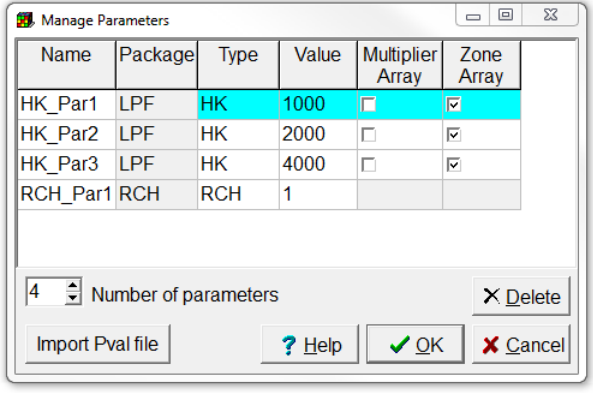
Run MODFLOW again

- ✓ Open ModelMuse file “02-02_calibrating-the-more-complex-model.mmZLib”
- ✓ Press the **Run MODFLOW-2005** button, save the name file and execute the model.
- ✓ Close ModelMonitor, the listing file and the command line window. All necessary files are now available for ModelMate.



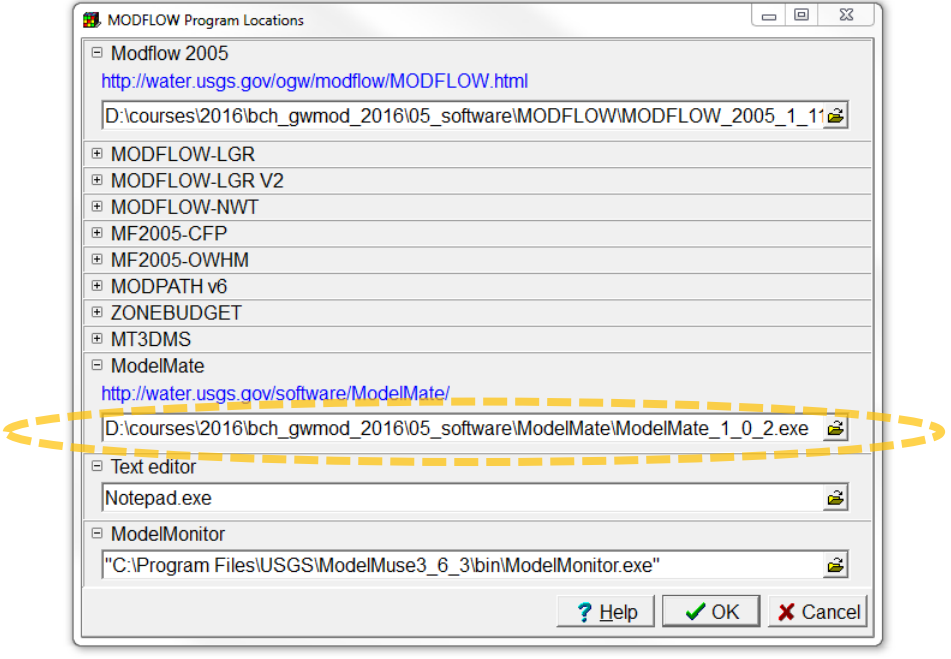
Check model parameters

- ✓ Select **Model | Manage Parameters…**
- ✓ Note that we defined four parameters during the previous exercise:
  - ✓ **HK_Par1** defines horizontal hydraulic conductivity in the left half of our first layer
  - ✓ **HK_Par2** defines horizontal hydraulic conductivity in the right half of our first layer
  - ✓ **HK_Par3** defines horizontal hydraulic conductivity in our third layer, and the vertical hydraulic conductivity of the non-simulated second layer also depends on it
  - ✓ **RCH_Par1** is multiplied with the recharge multipliers to obtain the recharge value



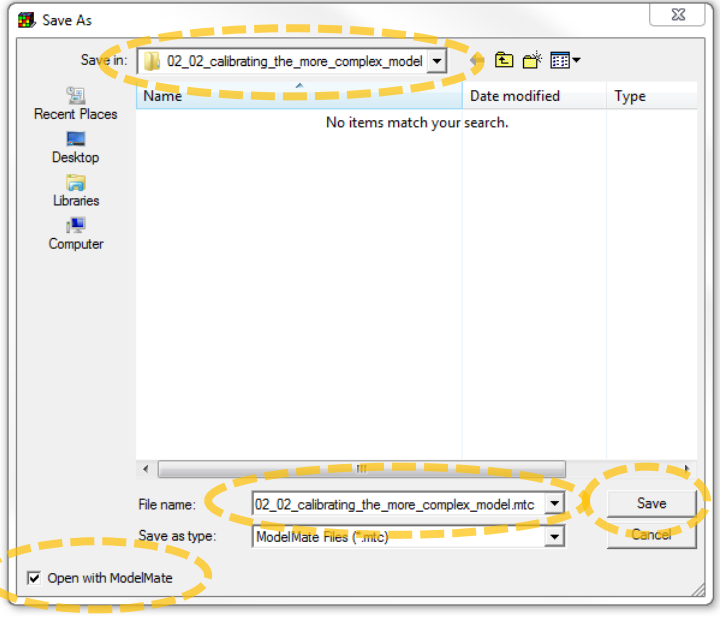
Set ModelMate executable location

- ✓ Choose **Model | MODFLOW Program locations,**
- ✓ fill in the ModelMate executable location "…/bch_gwmod-2018/05_software/modelmate/modelmate-1.0.3.exe", and
- ✓ click **OK**.

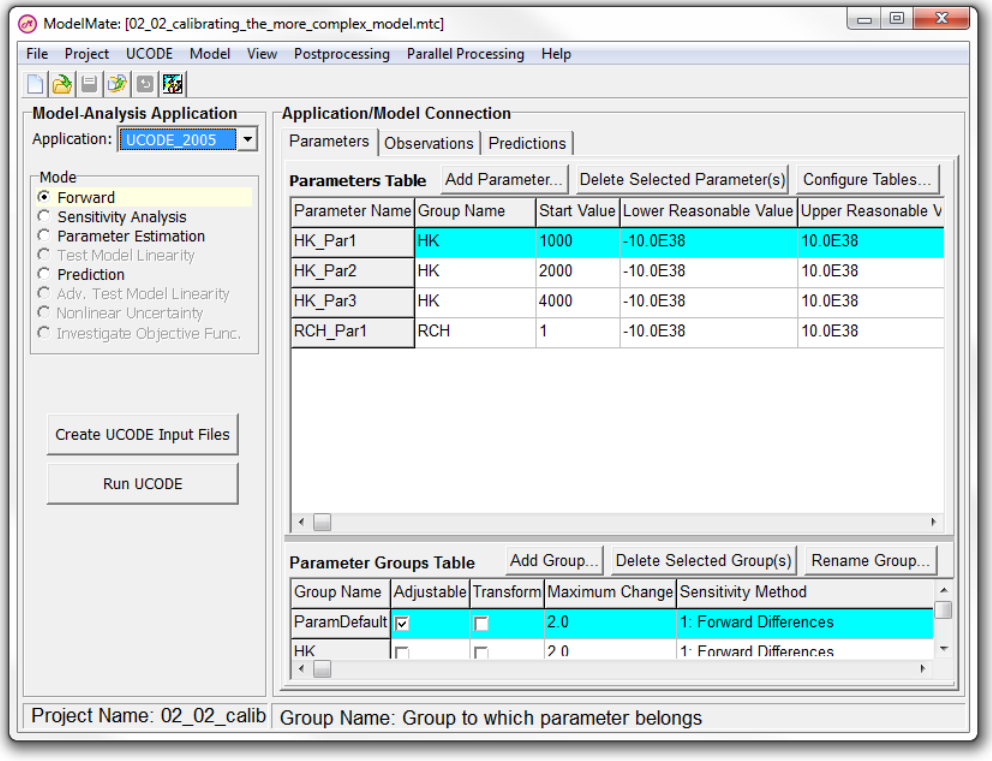


Export ModelMate file

- ✓ Select **File | Export | Export or Update ModelMate File**,
- ✓ use file name “02-02_calibrating-the-more-complex-model.mtc”,
- ✓ make sure the **Open with ModelMate** checkbox is checked,
- ✓ and press **Save**.

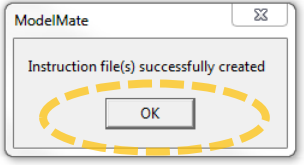


This is what you should get



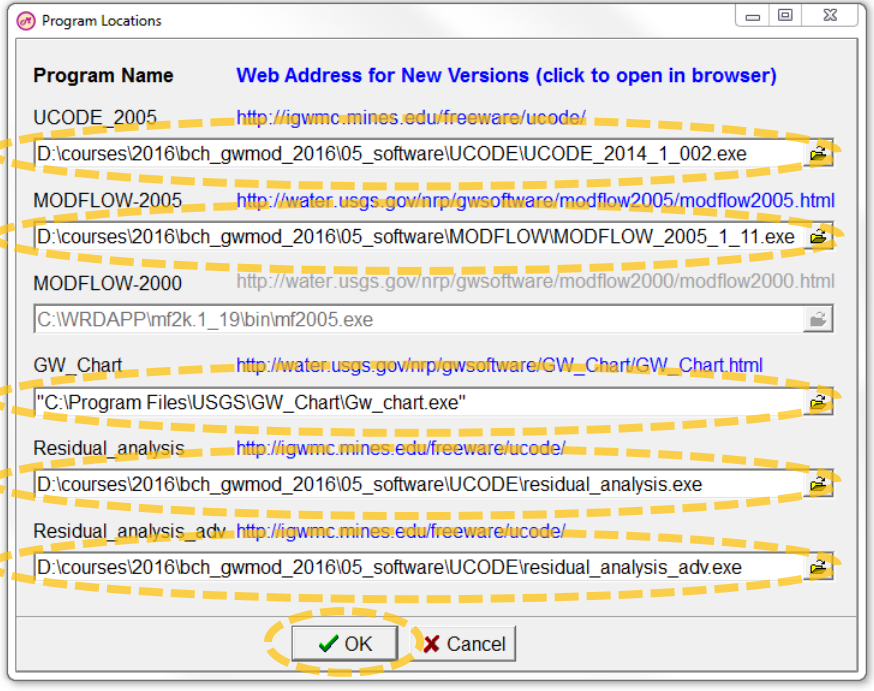
Create instruction files

- ✓ Note that ModelMuse did not automatically create instruction files allowing UCODE to adjust the parameters and read the simulated equivalents of our observations.
- ✓ Select **Model | Create Instruction Files For Observations Defined In ModelMuse** in ModelMate,
- ✓ and press **OK**.



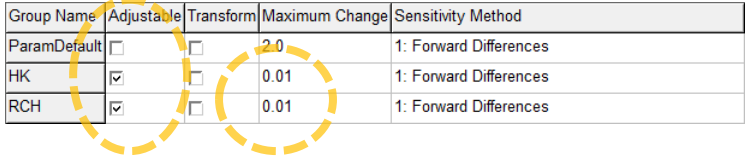
Set program locations

- ✓ Select **Project | Program locations**,
- ✓ and fill in the **UCODE_2005**, **MODFLOW-2005**, **Residual_analysis**, and **Residual_analysis_adv** program names with the corresponding executables in the /05_software/ folder (as in the image on the right).
- ✓ For **GW_Chart**, locate the installation folder of GW_Chart (typically in the C:/Program Files (x86)/USGS/ folder), and select the GW_Chart.exe executable.
- ✓ Then press **OK**.



Adjust Parameter Groups Table

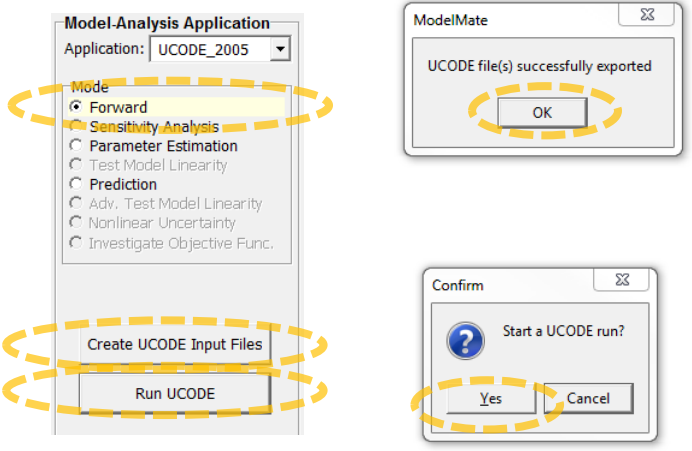
- ✓ In the **Parameter Groups Table**, deselect **Adjustable** for **ParamDefault**, and
- ✓ select it for **HK** and **RCH**. In this way, our hydraulic conductivity and recharge parameters are included in the sensitivity analysis and parameter estimation modes.
- ✓ Set **Maximum Change** to 0.01 for both **HK** and **RCH**, to limit the size of parameter changes in one parameter-estimation iteration.



Group Name	Adjustable	Transform	Maximum Change	Sensitivity Method
ParamDefault	☐	☐	2.0	1: Forward Differences
HK	☑	☐	0.01	1: Forward Differences
RCH	☑	☐	0.01	1: Forward Differences

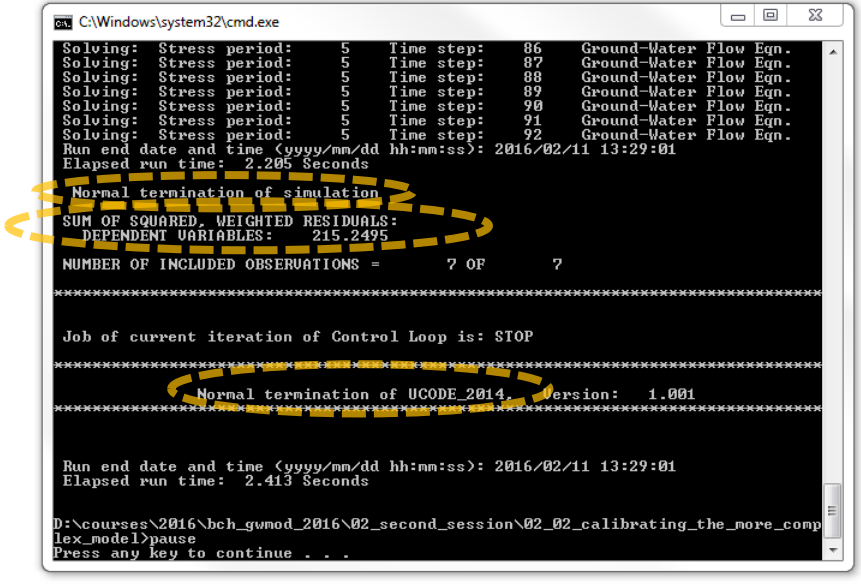
Perform forward simulation

- ✓ Check if the **Forward** UCODE mode is selected,
- ✓ press **Create UCODE Input Files**,
- ✓ and click **OK**.
- ✓ Then click on the **Run UCODE** button,
- ✓ and click **Yes** to start the UCODE run.



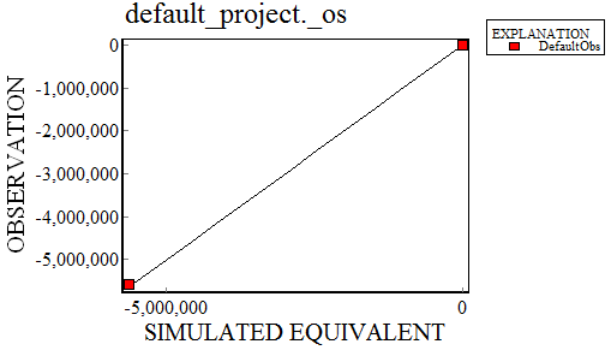
Check normal terminations of codes

- ✓ In the command line window, check for normal terminations of MODFLOW and UCODE.
- ✓ Also note the **SUM OF SQUARED, WEIGHTED RESIDUALS**, which is about 215 with our initial parameter values.
- ✓ Close the command line window.



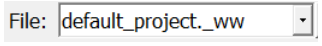
Plot observations vs simulated equivalents (1/2)

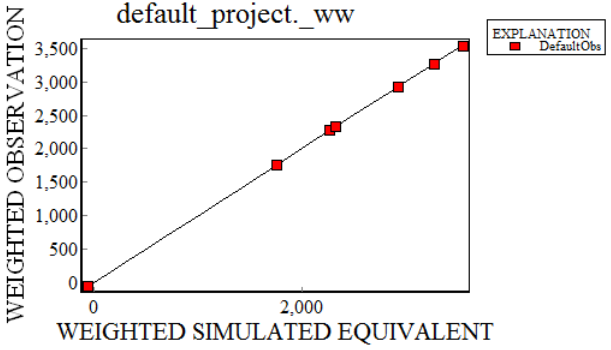
- ✓ Select **Postprocessing | GW_Chart**, or use the corresponding button to bring up the observed compared to simulated values graph.
- ✓ Note this plot is not very useful because of the differences in magnitude between the head and river observations.



Plot observations vs simulated equivalents (2/2)

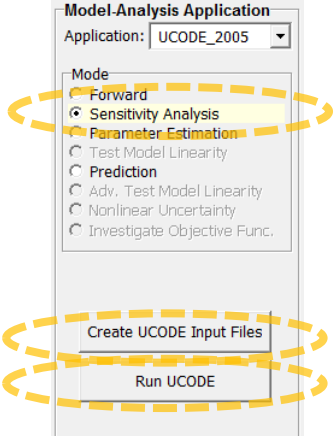
- ✓ Therefore, select **Model Fit| default_project._ww** in the **File:** drop-down list.
- ✓ This displays the weighted observed compared to the weighted simulated values, which is more informative in this case.

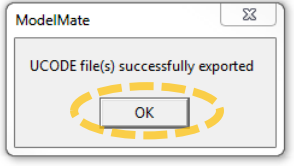


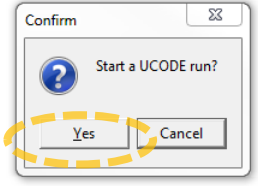


Perform sensitivity analysis

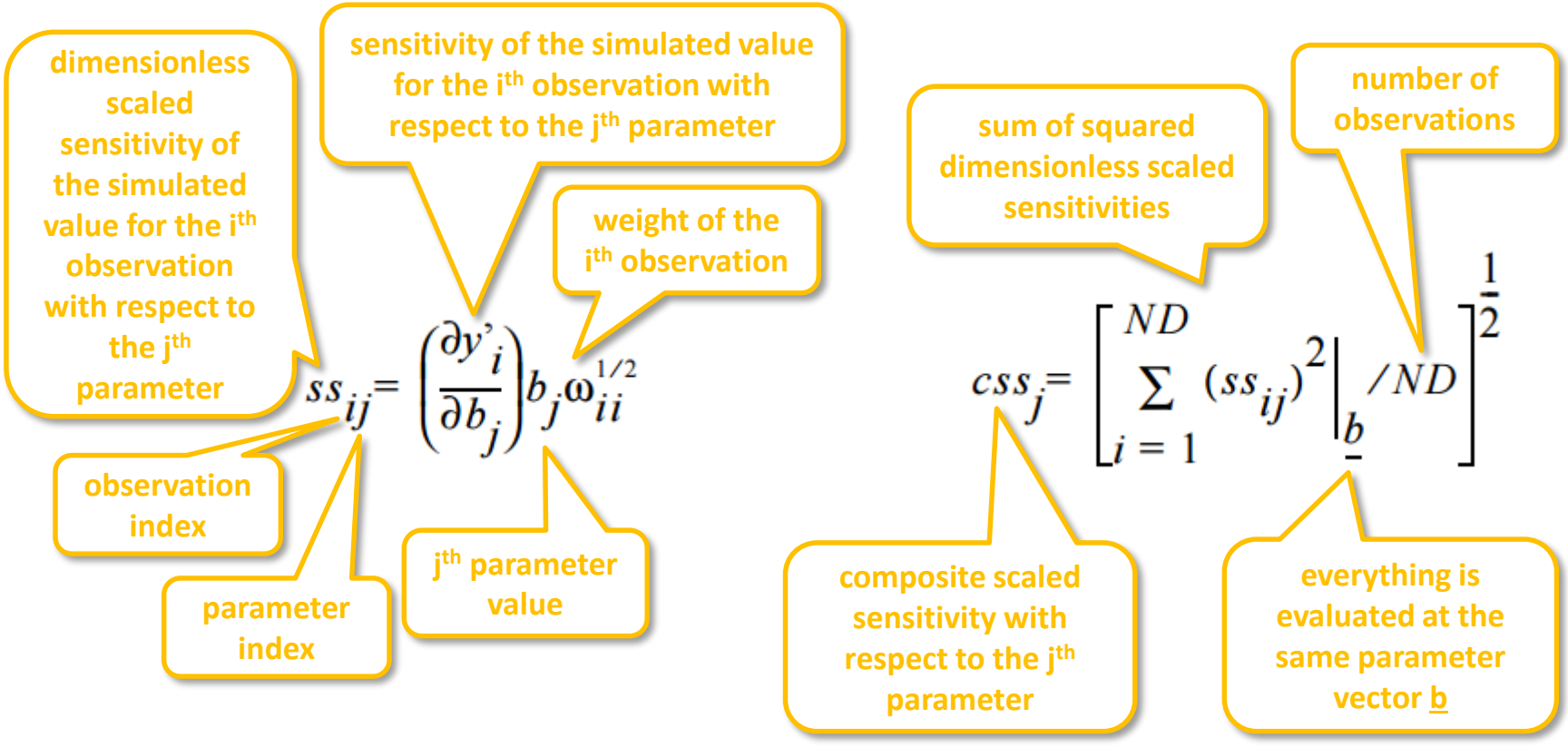
- ✓ Now select the **Sensitivity Analysis** mode,
- ✓ press **Create UCODE Input Files**,
- ✓ and click **OK**.
- ✓ Then click on the **Run UCODE** button,
- ✓ and click **Yes** to start the UCODE run.





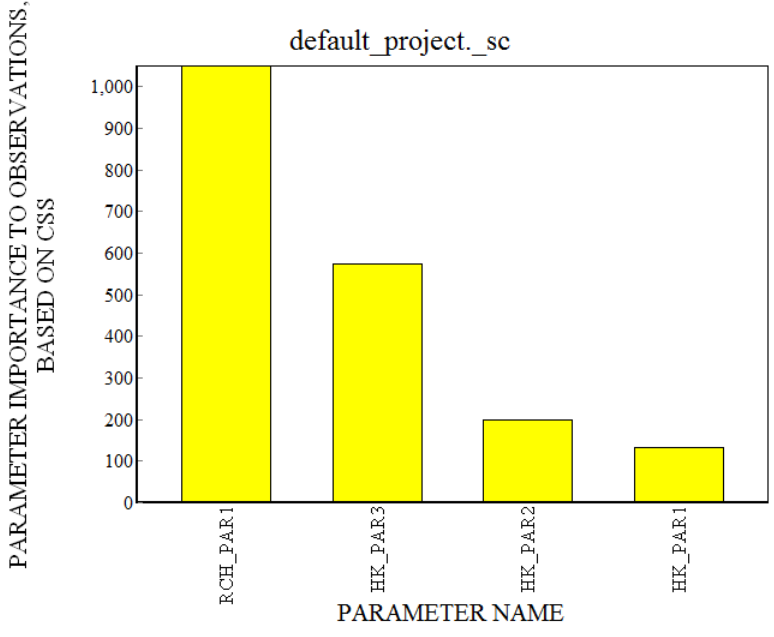


Statistics for sensitivity analysis



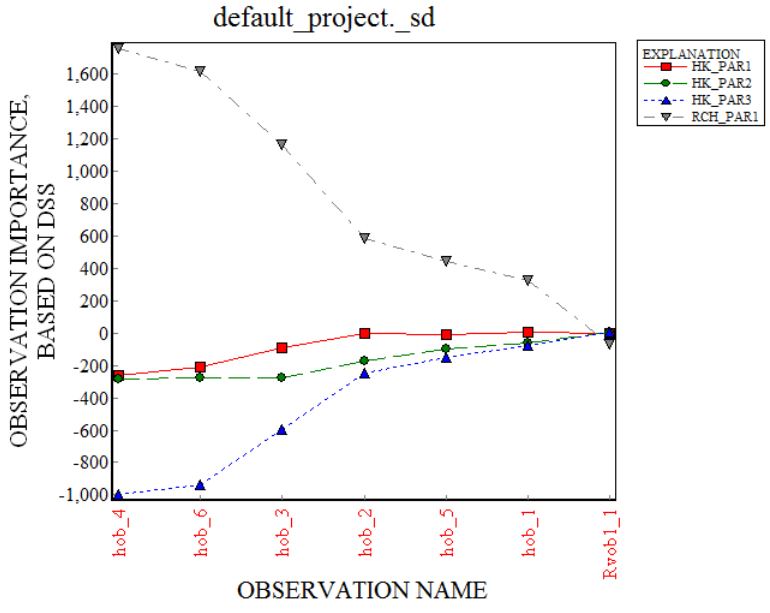
Visualize composite scaled sensitivities

- ✓ Close the command line window after it has finished,
- ✓ and launch GW_Chart again.
- ✓ Now select **O-Par Sens Analysis | default_project._sc** in the **File:** drop-down list.
- ✓ This displays the bar chart of composite scaled sensitivities (indicating parameter importance to all observations).



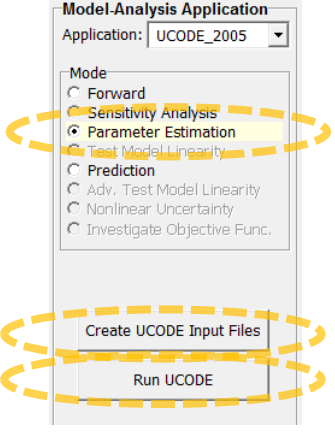
Visualize dimensionless scaled sensitivities

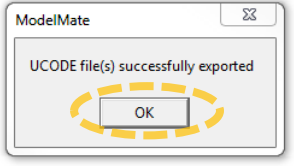
- ✓ Now select **O-Par Sens Analysis | default_project._sd** in the **File:** drop-down list.
- ✓ This displays the dimensionless scaled sensitivity for each observation by parameter (indicating the effect of each parameter on each observation).

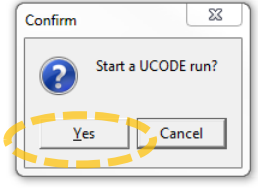


Perform parameter estimation

- ✓ Now select the **Parameter Estimation** mode,
- ✓ press **Create UCODE Input Files**,
- ✓ and click **OK**.
- ✓ Then click on the **Run UCODE** button,
- ✓ and click **Yes** to start the UCODE run.

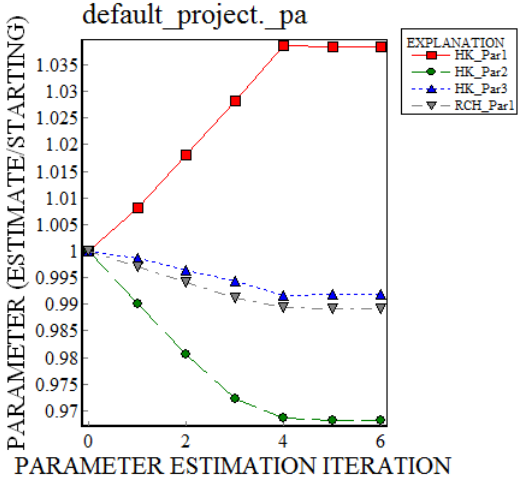






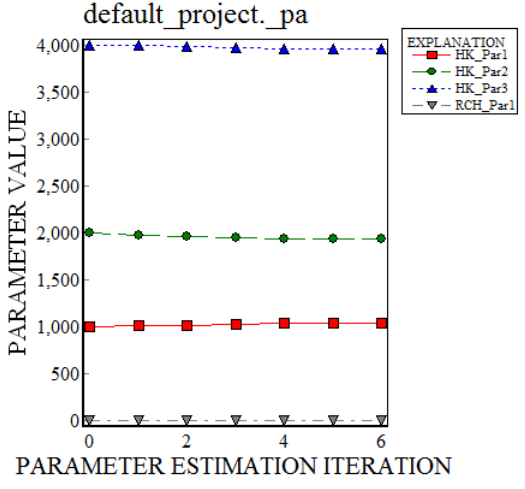
Visualize parameter evolution (1/2)

- ✓ Close the command line window after it has finished,
- ✓ and launch GW_Chart again.
- ✓ Now select **Parameter Values | default_project._pa** in the **File:** drop-down list.
- ✓ This displays the evolution of the different parameters with respect to their initial values.



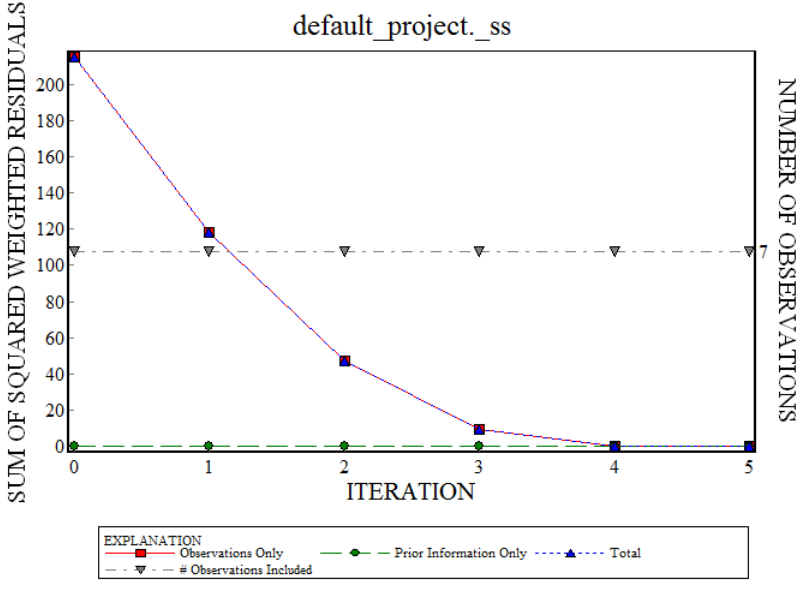
Visualize parameter evolution (2/2)

- ✓ Deselect the **Divide parameter values by their initial values** to display the actual evolution of the different parameters.



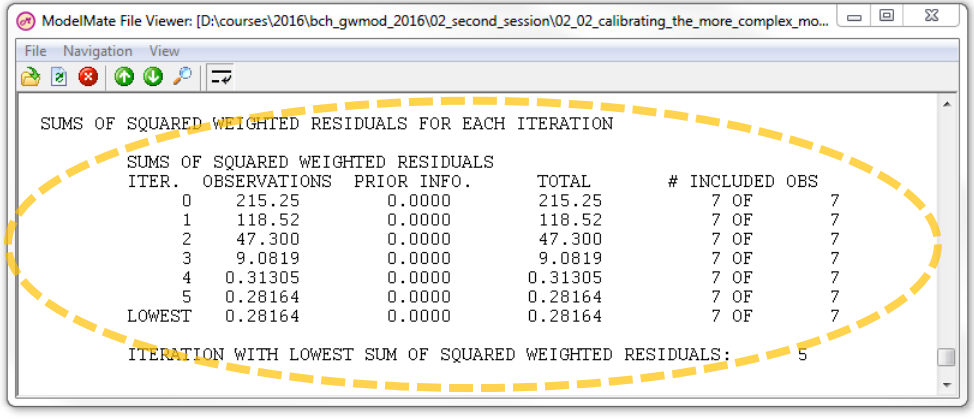
Visualize model performance evolution

- ✓ Now select **Model Fit | default_project._ss** in the **File:** drop-down list.
- ✓ This displays the sum of squared, weighted residuals for each parameter-estimation iteration.



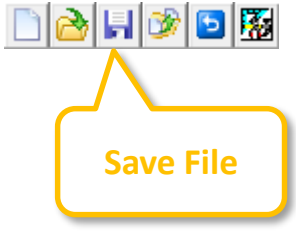
View the UCODE main output file

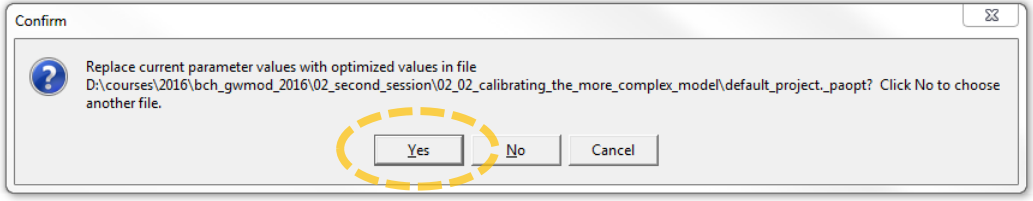
- ✓ Select **View | UCODE Main Output File**,
- ✓ and scroll down to the bottom of the viewer window.
- ✓ Just before the end of the file, you should find the table on the right, which also provides the sum of squared weighted residuals for each parameter-estimation iteration.



Import calibrated parameters in ModelMate

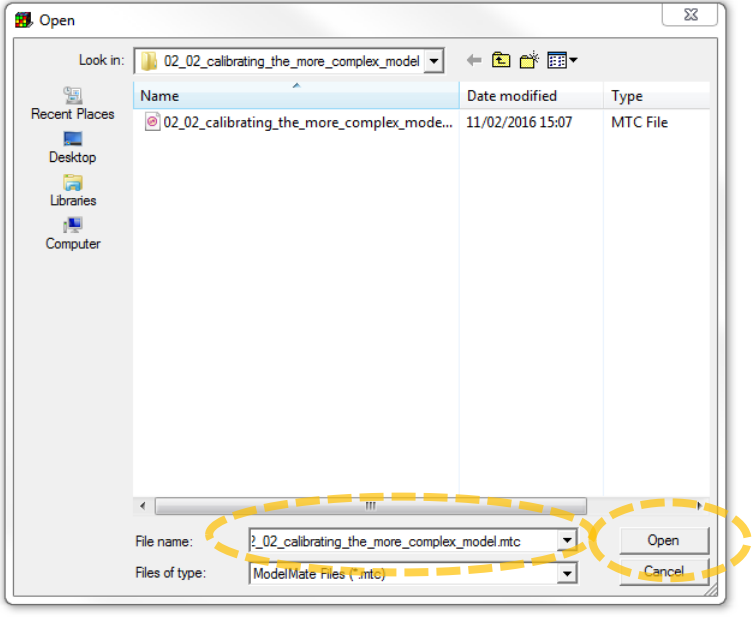
- ✓ Select **File | Import | Optimized Parameters (_paopt file)…**,
- ✓ confirm replacing the current parameter values by clicking **Yes**,
- ✓ and select **File | Save Project**, or use the corresponding button.





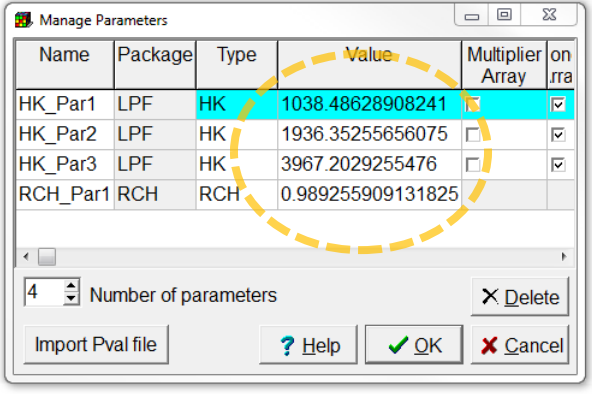
Import calibrated parameters in ModelMuse

- ✓ Return to the ModelMuse window,
- ✓ and select **File | Import | ModelMate Values**.
- ✓ Choose “02-02_calibrating-the-more-complex-model.mtc”,
- ✓ and press **Open**.



Check if parameters have changed

- ✓ Select **Model | Manage Parameters…** to see if the parameter values in ModelMuse have actually been modified.



Run model and visualize calibrated results

02_02_calibrating_the_more_complex_model.lst - Notepad

File Edit Format View Help

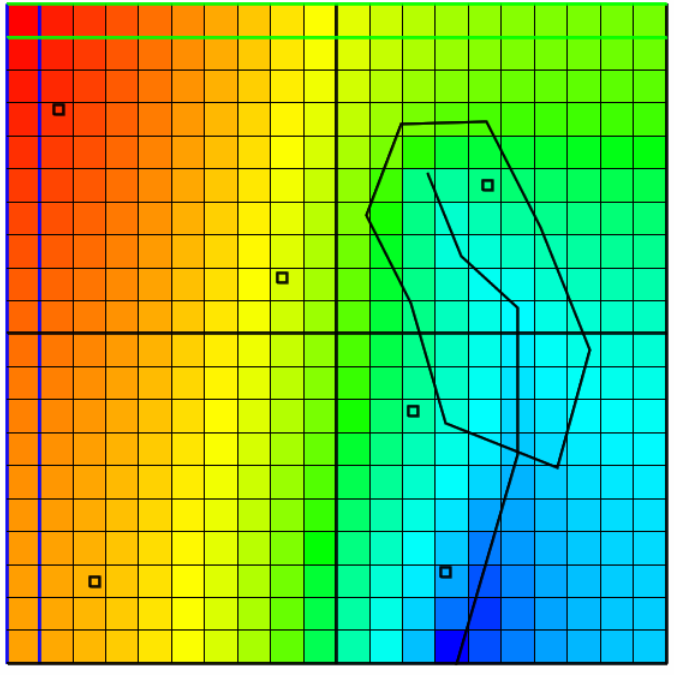
```
HEAD AND DRAWDOWN OBSERVATIONS
OBSERVATION        OBSERVED            SIMULATED
   NAME              VALUE               VALUE              DIFFERENCE
------------------------------------------------------------------------
hob_1           17.590000153        17.592674255       -2.67410278320E-03
hob_2           22.680000305        22.677005768        2.99453735352E-03
hob_3           29.280000687        29.282821655       -2.82096862793E-03
hob_4           35.400001526        35.399196625        8.04901123047E-04
hob_5           23.280000687        23.278230667        1.77001953125E-03
hob_6           32.619998932        32.620189667       -1.90734863281E-04

HEAD/DRAWDOWN SUM OF SQUARED DIFFERENCE:    2.78932E-05

RIVER FLOW OBSERVATIONS
OBSERVATION        OBSERVED            SIMULATED
   NAME              VALUE               VALUE              DIFFERENCE
------------------------------------------------------------------------
Rvob1_1        -5584000.0000       -5578381.0000       -5619.0000000

RIV FLOW SUM OF SQUARED DIFFERENCE:    3.15732E+07

Run end date and time (yyyy/mm/dd hh:mm:ss): 2016/02/11 15:14:48
Elapsed run time:  1.820 Seconds
```



BELGIUM

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Questions? Found an error?
Please contact B. Rogiers at brogiers@sckcen.be.