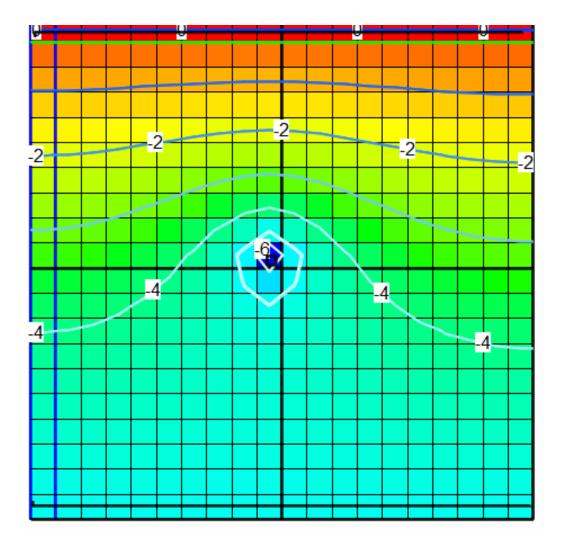
Groundwater modelling with Modflow 6 and ModelMuse

In this exercise you will create a simple groundwater model and use it to test how the hydraulic head is influenced by changes in hydraulic conductivity, pumping rate etc.



Johanna Anjar, University of South-Eastern Norway

Modflow 6, is a groundwater modelling software, and ModelMuse the graphical interface you will use to run Modflow. Both prograps freely available from the USGS.

- Download ModelMuse from: <u>https://www.usgs.gov/software/modelmuse-graphical-user-interface-groundwater-models</u>
- Install ModelMuse
- Download Modflow 6 from:
- https://www.usgs.gov/software/modflow-6-usgs-modular-hydrologic-model
- When you have downloaded the files extract them to the folder C:/WRDAPP/

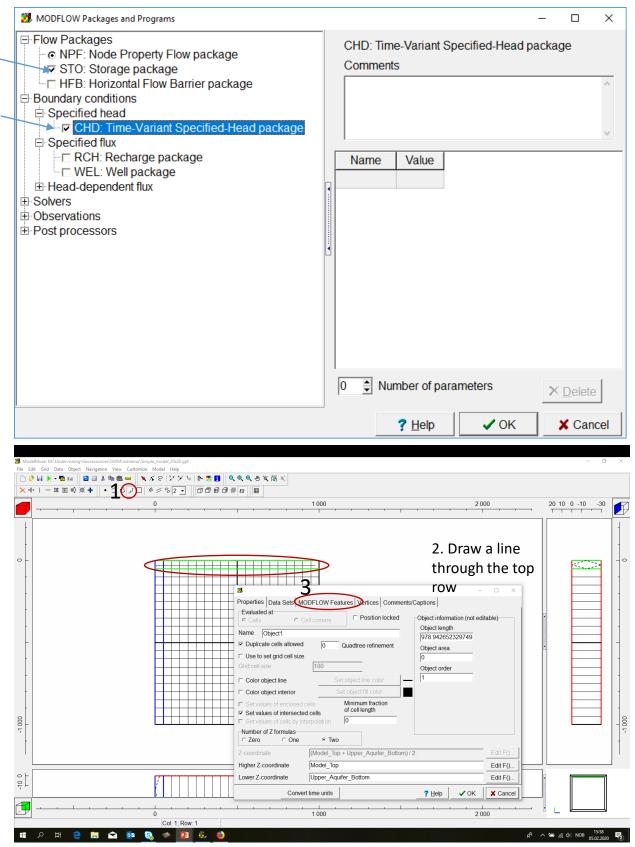
2 ModelMuse	_		×
What do you want to do?			
Create new MODFLOW model			
Create new PHAST model			
Create new SUTRA model			
Create new WellFootprint project			
Open an existing ModelMuse project			
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Model>MODFLOW Packages and programs...



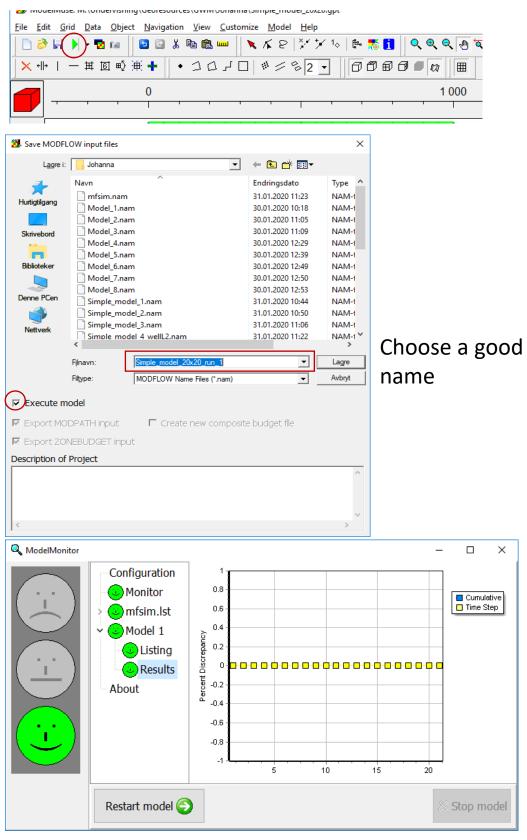
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			Formula					
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Draw another line, this time through the lowermost row

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- Save your model.
- **Discuss:** What will happen with the hydraulic head when you run the model?

Run model



- Successfull run with happy smileys everywhere...
- Close all Model Muse windows apart from the main one

Lo

Filnavn:

Filtype:

Simple_model_20x20_run_1

Common supported file types

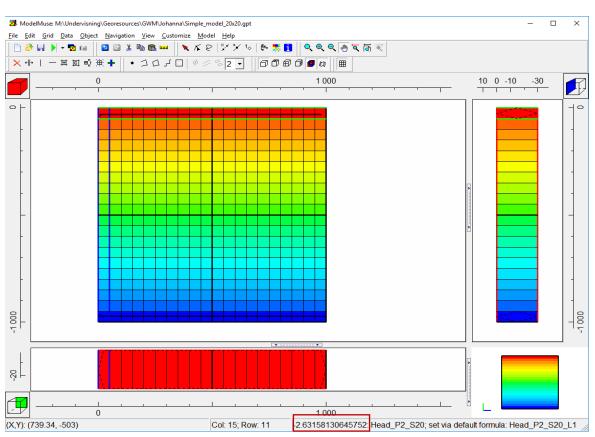
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	Simple_model_2.cbc	31.01.2020 10:50	CBC-fi	
Skrivebord	Simple_model_3.bhd	31.01.2020 11:07	BHD-fi	
-	Simple_model_3.cbc	31.01.2020 11:07	CBC-fi	
-	Simple_model_4_wellL2.bhd	31.01.2020 11:23	BHD-fi	
Biblioteker	Simple_model_4_wellL2.cbc	31.01.2020 11:23	CBC-fi	
	Simple_model_20x20_run_1.bhd	05.02.2020 16:06	BHD-fi	
	Simple_model_20x20_run_1.cbc	05.02.2020 16:06	CBC-fi	
Denne PCen	Test_1.bhd	30.01.2020 14:12	BHD-fi	
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Apne Avbryt

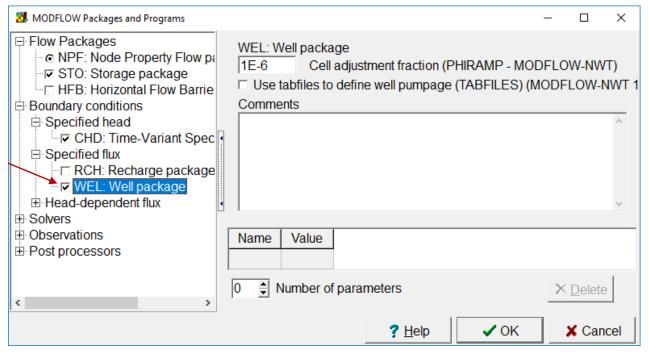
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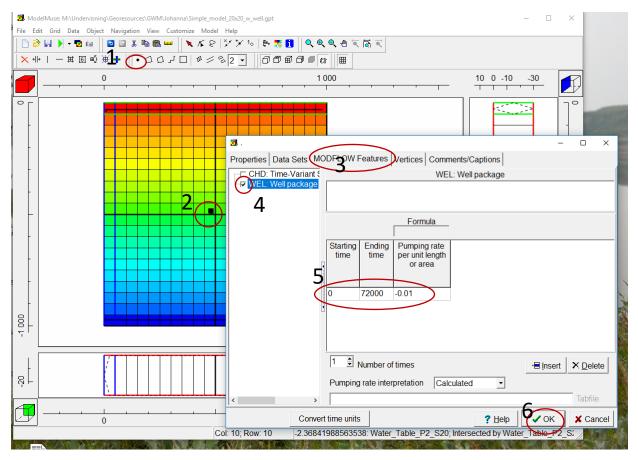


The colours indicate the altitude of the hydraulic head of the layer (red higher, blue lower). Move the cursor over the grid to read the altitudes.

Discuss: How does the groundwater flow in the model?

Model>MODFLOW Packages and programs...

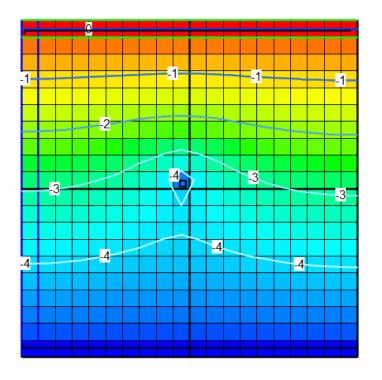




- Run the model again. Save it under a new name.
- Load the data
- Discuss:
 - How did the water table change when you added the well?
 - How will that change the groundwater flow?

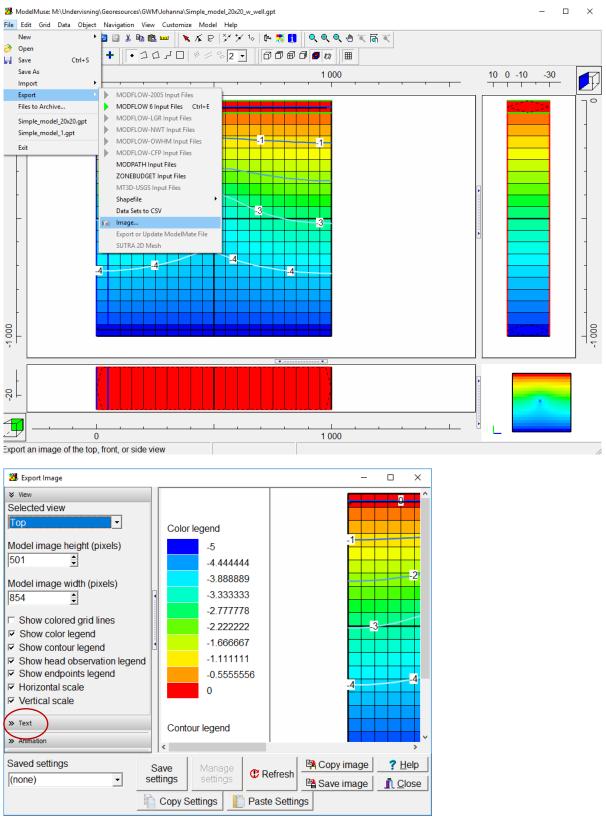
Contour lines can make it easier to see how the groundwater would flow.

🐉 Data Visualization	
Celor Grid Contour Data MODPATH Pathlines MODPATH End Points MODPATH Time Series Head Observation Results SFR Stream Links STR Stream Links SWR Reach Connections SWR Observations /ectors (SUTRA models) Cross Sections	Selection Filters Legend



Save your model

Export your results



	🔀 Export Image		– 🗆 X
Set at start Standard Set when you created the well	» View * Text Title Well experiment 1 Confined aquifer, 30m K = 0.0001, pumping -0.01 Title font Title font Color legend title Contour legend title * Animation Saved settings	Color legend -5 -4.444444 -3.888889 -3.333333 -2.777778 -2.222222 -1.666667 -1.111111 -0.5555556 0 Contour legend -5 -4 -3 -3 Save Manage C Refresh Copy	-1 -1 -1 -1 -1 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2
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- **Discuss:** What would happen with the groundwater flow if the pumping doubled? Make a prediction.
- Save the model in a new file named e.g. Well_experiment_2.gpt
- Use to red arrow and double-click on your well to get its properties.
 - Under MODFLOW Features change the Pumping rate to -0.02

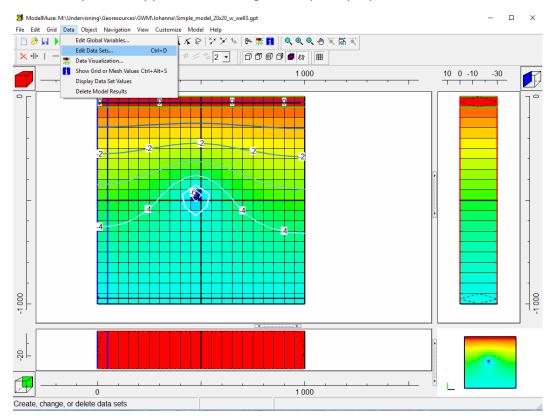
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- Run the model
- Load the data.
- Add contours.
- **Discuss:** Compare the results to your prediction.

• Export the result as an image. In the Title text box write:

🐉 Export Image	
» View	
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Title	
Well experiment 2 Confined aquifer, 30m K = 0.0001, pumping -0.02	~ ~
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Next we'll try what happens if we change the aquifer properties...



😕 Data Sets		-		×
₽ Optional	Basic Comment			
⊡ Model Results	Name			
⊟ 3D Data Head P2 S20	Кх			
	1	Orientation		
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-Modflow_Initial_Head	0.00005			
-Modflow_Specified_Head				
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Layer Definition			_	
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Test using 0.00005, that is half the original level for Kx. As a standard Kx=Ky=10*Kz so we don't have to change Ky and Kz (but we could).

Discuss: Make a prediction for what will happen to the hydraulic head if the pumping remains the same as in the previous model.

- Run the model
- Load the data.
- Add contours.
- **Discuss**. Compare the results to your prediction.
- Export it as an image file Label it: Well experiment 3 Confined aquifer, 30 m K=0.00005, pumping -0.02

Finally we will test what would happen in an unconfined aquifer.

- Discuss: Make a prediction (all other variables remain as in the previous experiment)
- Data>Edit data sets

Optional Basic Comment Name			
Active Cell_Type Type Orie Convertible Integer IDOMAIN Integer Kx Evaluated At Ky Kz Modflow_Initial_Head Interpolation Modflow_Specified_Head none Specific_Storage none	sotropy Edit form quifer,	V	
Add Delete ? Help) y		<u>s</u>

- Run the model
- Load the data.
- Add contours.
- **Discuss:** Compare the results to your prediction.
- Export it as an image file
 - Label it: Well experiment 4 Unconfined aquifer, 30 m K=0.00005, pumping -0.02
- Save your model.
- **Discuss:** Compare the results from your four experiments. What happens when you change the pumping rate or the K-value? What causes the difference you see between the confined and the unconfined aquifer?
- If you have time you may run additional experiments which you decide on yourself.