COURSE: GROUNDWATER MODELLING USING MODFLOW

Session 9: Simulation a groundwater model

Objective:

The objective of this session is define package and programs, assign the boundary conditions CHD, RCH, EVT and RIV, run the model, analyze the water balance, import the results and represent the water table in a profile view.

Go to

Course_GroundwaterModellingMODFLOW\Week_9\Practice\Models

Then open Model1_a.gpt.

Defining package and program

To define the boundary conditions it is necessary that they are active. Go to **Model/ MODFLOW Packages and Programs** and activate **MODFLOW-NWT**. Then, go to **RCH** and change the Recharge Location Option to **Top active cell**.

MODFLOW Packages and Programs		-		×
 ➡ Flow Packages ➡ Flow Packages ➡ Specified head ➡ ⊂ CHD: Time-Variant Specified ➡ ⊂ FHB: Flow and Head Bounda ➡ Specified flux ➡ ♥ RCH: Recharge package ➡ ♥ WEL: Well package ➡ ♥ WEL: Well package ➡ FHB: Flow and Head Bounda ➡ Head-dependent flux ➡ DRN: Drain package ➡ DRT: Drain Return package ➡ ETS: Evapotranspiration pack ➡ GHB: General-Head Boundar ➡ CHX: Lake package ➡ MNW1: Multi-Node Well pack ➡ RES: Reservoir package ➡ FR: Stream-Flow Routing pa ➡ T STR: Stream package ➡ Solvers ➡ Solvers 	RCH: Recharge package Comments Recharge location option Top active cell Recharge assignment method ^c Objects overwrite values of previous objects Sum values of all objects Name Value Value Name Value		Time va	irying
Observations S	0 J Number of parameters	×	<u>D</u> elete	
	? <u>H</u> elp ✔ OK	:	🗙 Cano	:el

Defining MODFLOW Time

Verify the time values in **Model/ MODFLOW time**. The values should be the ones shown below.

🎒 мог	FLOW Time						-	
			Length	Max first time step length	Multiplier	Steady State/ Transient		
Stres: perio	s Starting t time	Ending time	Length	Max first time step length	Multiplier	Steady State/ Transient	Drawdown reference	Number of steps (calculated)
1	-1	0	1	1	1	Steady state		1
2	0	631152000	631152000	31557600	1	Transient		20
2	Number	of stress peri	ods second	ds (1) 🔽	Time unit ((ITMUNI)	Delete	Insert
Con	vert time ur	iits				? <u>H</u> elp	✓ OK	X Cancel

Defining boundary conditions

To import the boundary conditions, go to File/ Import/ Shapefile. The file is found in:

Course_GroundwaterModellingMODFLOW\Week_9\Practice\Data, and it is called **river.shp.** Click OK

🔀 Import Shapefile - C:\Users\Comp	outer\Documents\Gidanas\Curs	os\Course_GroundwaterMod	lellingMODFLOW\	- 🗆 ×
Options 1 Options 2 CSV	(Optional) Data Featu	ures Coordinate Con	version	
 ✓ Import shapes as objects ✓ Set values of enclosed ce ✓ Set values of cells by inter ✓ Import grid Import criterion Import shapes as a single Imported shapes should be 	multipart object	Cells Cell corners	Number of shap Minimum X = 25 Maximum X = 27 Minimum Y = 87 Maximum Y = 87	es = 53 5071.98515 75755.9649 739736.6460 × Edit F()
Number of Z formulas	C Two]		
Z-coordinate	Model_Top			Edit F()
Higher Z-coordinate	0			Edit F()
Lower Z-coordinate	0			Edit F()
		• • • • • •		
Number of shapes = 53		<u>₹ H</u> elp	✓ OK	X Cancel

Then double click on the river and go to **MODFLOW Features**, select **RIV** and fill the values as in the image.

🐉 Object Properties							_		×
Properties Data	Sets MC	DFLOW	eatures	Vertices	Comments/	Captions			
CHD: Time-	Variant §				RIV: Rive	r package			
-□ EVI: Evapo -□ RCH: Recha	otranspira arge pacl ackage								
	раскаде				Formula	,			
		Starting time	Ending	time	River stage	Conductance	River botto	om	
		-1	6311520	000 Mo	odel_Top - 1.	0.001	Model_Top -	3.	
	[
		1 🔹	Number o	ftimes			• ⊟ Insert	X <u>D</u> e	elete
		Conduct	ance inter	pretation	Direct	-			
<	>	Time-ser	ies interp	olation	STEPWIS	E			
	Conver	t time units	;			? <u>H</u> elp	🗸 ОК	×c	ancel

To generate the recharge boundary condition, create a rectangle that encompasses the whole basin area, double click and consider the same values shown in the below image.

🕺 Object Properties		_	
Properties Data Sets MODF	LOW Features Vertices Comments/C	aptions	
Evaluated at © Cells Name	ormers Position locked	Object information (not ed Object length	itable)
Turne RCH Duplicate cells allowed Use to set grid cell size Grid cell size	Quadtree refinement	13797.1870604767 Object area 11894100.3041992 Object order	
Color object line	Set object fill color		
Set values of enclosed cells Set values of intersected ce Set values of cells by interpertent of the terminal set values of the terminal set values of terminal set values	Minimum fraction of cell length		
	⊂ Two		
Z-coordinate	/liddle_Aquifer_Bottom + Lower_Aquifer	Bottom) / 2.	Edit F()
Higher Z-coordinate	liddle_Aquifer_Bottom		Edit F()
Lower Z-coordinate	ower_Aquifer_Bottom		Edit F()
Convert tim	ne units	? Help ✓ ОК	X Cancel

Go to **MODFLOW Features**, select **RCH** and fill the values as in the image.

Object Properties					_		\times
Properties Data Sets MC	DFLOW Features	Vertices	Comments/Ca	ptions			
CHD: Time-Variant S			RCH: Recharge	e package			
RCH: Recharge pac							
RIV: River package							
MEL. Weil package			Formula				
	Starting Ending	n time	Recharge rate	e			
-	time		noonargo rat	<u> </u>			
	-1 631152	.000 2.8	538812785388	1E-8			
	1 Number	oftimes					1
		nolation		-	• ⊟ Insert	× <u>D</u> ele	ete
< >>	inne-senes lille	polation	JOILE WIGE				
Conver	t time units			<u>? H</u> elp	🗸 ОК	🗙 Car	ncel

Then generate the evapotranspiration boundary condition, create a rectangle that encompasses the whole basin area, double click and consider the same values shown in the below image.

😕 Object Properties		-	
Properties Data Sets MOD	FLOW Features Vertices Comments/C	aptions	
Cells Cell	corners Position locked	Object information (not edit	able)
Name EVT		13732.2081575262	
Duplicate cells allowed	0 Quadtree refinement	Object area	
Use to set grid cell size		11782914.1816406	
Grid cell size	100	Object order	
Color object line	Set object line color	6	
Color object interior	Set object fill color		
 Set values of enclosed cell Set values of intersected of Set values of cells by inter 	Is Minimum fraction of cell length polation 0		
Number of Z formulas	-		
	⊂ Two		
Z-coordinate	Middle_Aquifer_Bottom + Lower_Aquifer	_Bottom) / 2.	Edit F()
Higher Z-coordinate	/liddle_Aquifer_Bottom		Edit F()
Lower Z-coordinate	_ower_Aquifer_Bottom		Edit F()
Convert ti	me units	<u>? Н</u> еlp	X Cancel

Select the **ETP** option and insert the values according to the emerging window. Click **OK**.

Ø Object Properties						_		\times
Properties Data Sets MC	DDFLOW I	eatures Vert	ices	Comments/Ca	ptions			
CHD: Time-Variant S			EVT	Evapotranspir	ation package	•		
RCH: Recharge pacl								
RIV: River package								
				Formula				
	Starting	Ending time	+	Evapo	Evano	Evapo		
F.	time		tran	spiration rate	transpiration surface	transpiratio depth	on	
	-1	631152000	2.88	623E-8	Model_Top	0.5		
							_	
ŀ	1							
	1	Number of time	es			• ⊟ Insert	×D	elete
Conver	t time units	5			? <u>H</u> elp	✔ ОК	×c	ancel

To define the perimetric Constant_Head, go to **File/ Import/ Shapefile**. The file is found in:

Course_GroundwaterModellingMODFLOW\Week_9\Practice\Data, and it is called **chd_high.shp.** Click **OK**

Import Shapefile	e - C:\Users\Com	puter\Documents\Gidanas\	Cursos\C	ourse_GroundwaterMo	dellingMODFLOW\	- 🗆 ×
Options 1 Opt	ions 2 CSV	(Optional) Data F	eatures	Coordinate Co	nversion	
🗵 Import shap	es as objects	5	Eva	luated at		0
🗖 Set values d	of enclosed c	ells	@ C	Cells	Number of shap Minimum X = 3	bes = 2 ^
Set values of	of intersected	cells	0.0	Cell corners	Minimum $X = 3$	53165.4208
Set values of	of cells by inte	erpolation			Maximum Y = 8	549286.638
🗖 Import grid					<	>
Import criterior	n True					Edit F()
Import shapes	as a single	e, multipart object		•		
Imported shap	es should be	visible but not sele	ected	-		
-Number of Z f	ormulas		1			
 Zero 	 One 	⊂ Two				
Z-coordinate		Model_Top - 4.32	-			Edit F()
Higher Z-coord	linate	0				Edit F()
Lower Z-coord	inate	0				Edit F()

Double click the object. Insert the data of the **MODFLOW Features**. Click OK.

Object Properties						_		\times
Properties Data Sets M	ODFLOW F	eatures Verti	ces Comments/Ca	ptions				
CHD: Time-Variant S		CHD	Time-Variant Spec	ified-Head p	ackage			
CONTRACT EVApotranspira CONTRACT EVApotranspira								
□ WEL: Well package			Formula					
	Starting time	Ending time	Starting head	Ending h	ead			
	-1	631152000	Model_Top - 4.32	Model_Top	- 4.32			
	•							
	1 ÷ N	lumber of time	S		• ⊟ <u>I</u> nsert	;	× <u>D</u> ele	te
<	Time-ser	ies interpolatio	INEAR-END	-				
Conve	rt time units			? <u>H</u> elp	🗸 ОК		🗙 Ca	ncel

Define the second constant head with the same instructions of **chd_high.shp** for **chd_lower.shp**

🔀 Object Properties	– O X	😕 Show or Hide Objects — 🗆 🗙
Properties Data Sets MODE	LOW Features Vertices Comments/Captions	
	CHD: Time-Variant Specified-Head package	
	Formula	
	Starting Inding time Ending time Starting head Ending head 1 631152000 Model_Top - 4.32 Model_Top - 4.32	enii RV: River package enii WEL: Well package
L		Show or select objects Choice Choice Choice Corientation
< >>	I I Number of times Image: Second s	
Convert tin	ne units ? Help V OK X Cancel	

To increase the model iterations, go to **Model/Packages and Programs/Solvers** and activate **PCG**. Change the maximum number of outer iterations to 50 (MIXITER) and ITER 1 as 30.

Elow Packagos		
Boundary conditions	PCG: Preconditioned Conjugate Gradient pac	kage
-Solvers	Comments	
 PCG: Preconditioned Conjugate 		
 C PCGN: Preconditioned Conjugat C GMG: Geometric Multigrid packa 		
C SIP: Strongly Implicit Procedure	Max, number of outer iterations (MXITER):	50
 DE4: Direct Solver package NWT: Newton Solver 	Max. number of inner iterations (ITER1):	30
Subsidence	Matrix preconditioning method (NPCOND):	Modified incomplete Cholesky (-
⊕ Output	 Convert active cells to dry when surrounded 	by dry cells (0)
Surface-Water Routing Post processors	 Convert active cells to dry when surrounded and storage flow is zero (1) 	by dry cells AND head-dependant
HT3DMS or MT3D-USGS	Max. abs. change in head (HCLOSE):	0.001
	Max. abs. residual (RCLOSE):	0.001
	Relaxation parameter (RELAX):	1
	Upper bound of the max. eigenvalue (NBPOL):	Calculated (1)
	Printout interval (IPRPCG):	1
	Printing control (MUTPCG):	Solver information (0)
	Damping factor (DAMPPCG):	1
< >	Transient damping factor (DAMPPCGT):	1
	2 H	ielp 🖌 OK 🖌 🗶 Cance

Run the flow model. The happy face indicates that the convergence criteria has been reached. That means that all that all the fluxes that enter the model are equal to the ones exiting (water balance).



Import the hydraulic heads to the model (.fhd file). Click to **Open.**

Select Model Results to Import	- [X
 □ Head: Period: 2; Step: 7; Total Time: 220903200 □ Head: Period: 2; Step: 8; Total Time: 252460800 □ Head: Period: 2; Step: 9; Total Time: 284018400 □ Head: Period: 2; Step: 10; Total Time: 315576000 □ Head: Period: 2; Step: 11; Total Time: 315576000 □ Head: Period: 2; Step: 12; Total Time: 378691200 □ Head: Period: 2; Step: 13; Total Time: 470248800 □ Head: Period: 2; Step: 14; Total Time: 441806400 □ Head: Period: 2; Step: 15; Total Time: 473364000 □ Head: Period: 2; Step: 16; Total Time: 504921600 □ Head: Period: 2; Step: 16; Total Time: 50492100 □ Head: Period: 2; Step: 16; Total Time: 508036800 □ Head: Period: 2; Step: 19; Total Time: 599594400 ☑ Head: Period: 2; Step: 20; Total Time: 631152000 		~
Model Results Classification Pref	х	
Display choice ⓒ Color grid ○ Contour grid ○ Neither		
Data used to color or contour grid		
Head: Period: 2; Step: 20; Total Time: 631152000		•
Select all data sets data sets ? Help	×	Cancel

The result should look like the image:

