Saline groundwater on top of fresh groundwater after a flooding event

Variable-density groundwater flow modelling with SEAWAT

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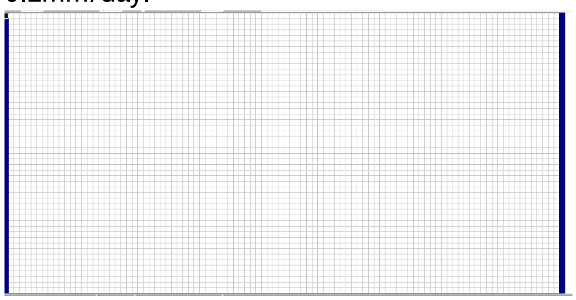
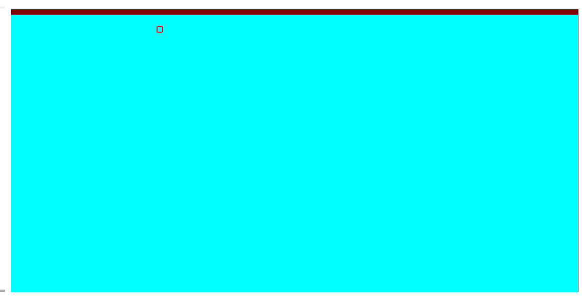
Introduction

A hypothetical problem: a 2D profile in a homogeneous aquifer with the following dimensions: horizontal L=1000.0 m by vertical D=50 m. Boundary Conditions (see in the left figure the blue columns; left head=0m,right head=0.02m). Recharge on top of the groundwater system, 0.2mm/day.



Boundary condition



Initial salinity distribution

Fresh/saline mixing parameters: molecular diffusion D_{mol}=0.000864 m^2/d, α_L=0.1, α_{TH}=α_{TV}= 0.01 m (so α_{TH}/α_L=0.1 and α_{TV}/α_L=0.1) and R_d=1 (so no retardation). The other soil parameters are: horizontal and vertical hydraulic conductivity k=2 m/d and porosity n_e=0.25. In the beginning of the simulation, a saline groundwater layer is inserted; this salt will mix in time with the fresh groundwater below.

Parameters			
Layers	50	K_{hor}	2 m/d
Rows	1		
Columns	100	Anisotropy K_{hor}/K_{ver}	1
Δx	10 m	n_e	0.25
Δy	1 m	α_L	0.1 m
Δz	1 m	α_{TH}, α_{TV}	0.01 m
Stress periods	1		
Initial concentration	0 and 35 TDS g/l in top layer	recharge	0.0002 m/d
Buoyancy	0.025		

The total simulation consists of 1000 time steps Δt of 3.65 days, in 1 'stress periods': the simulation time is 3650 days (10 year; during the modelling, you make have to change the length of simulation). The model uses SEAWAT to simulate variable-density groundwater flow and coupled salt transport.

Exercise 0: download and start up

- Download this Exercise sfi1.zip from the Blackboard/wiki, create a new subdirectory and upzip sfi1.zip in this subdirectory
- During the modelling, to be sure to create new subdirectories for every new case/exercise. The old cases much remain and by opening more PMWIN version, you can more easily compare the results!

Exercise 1: geometry of the problem

- Run the model: (go to Models->MT3DMS/SEAWAT-> Run->OK)
- Check the PMWIN input files: heads, time-characteristics, boundary condition, other input parameters.
- Check the concentration as a function of time (go to Tools->2D Visualization-> MT3DMS/SEAWAT for seeing the salinity in the groundwater as a function of time). What does this mean for shallow groundwater extractions?

Exercise 2: varying the hydraulic conductivity and its effect on the salinization

The hydraulic conductivity is 2m/d in the reference case. Change in one new model the system to a good permeable aquifer and in another model a low-permeable aquitard. Please check first what are values of aquifers and aquitards[1]. Do not forget to change bot the horizontal and the vertical hydraulic conductivity. What is the effect on the salinisation?

Exercise 3: the effect of the aquitards on the salinization

The geology –a homogeneous aquifer- is quite simple now. Introduce some clayey layers by creating low permeable (model)layers and consider the effect on the salinization.

Exercise 4: the effect of the recharge rate on the salinization

The recharge is 0.002m/d, which can be considered as small in tropical settings. Change to reasonable values (5 times larger?) and check the effect on the salinization.

Exercise 5: fixed saline top layer

In contrast with Exercises 1 up to 4, the salinity in the top model layer remains constant to salt, to suggest a continuous source of salt to the groundwater system.

- Download this Exercise sfi5.zip from the Blackboard/wiki, upzip and run the model.
- Explain the contrast to the previous mentioned model concept. Is this concept of a fixed saline top layer realistic?

Exercise 6: effect of more mixing by increasing the hydrodynamic dispersion

Add extra dispersion to the system: α_L=20.0 m; and leaving $\alpha_{TH}/\alpha_L=0.1$ and $\alpha_{TV}/\alpha_L=0.1$).
'MT3DMS / SEAWAT'-> 'Dispersion'.

- Run the new model.
- Analyse the effect compared with the reference case.

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[1] A typical aquifer is 10-25m/d and an aquitard 0.01-0.001m/d