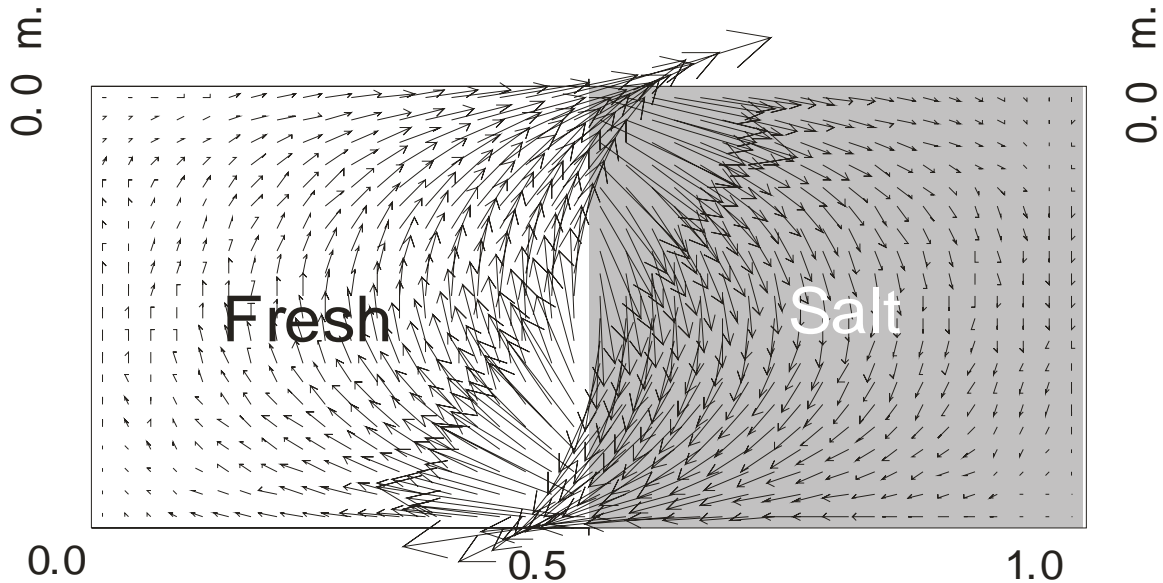


# Vertical interface between fresh and saline groundwater

Variable-density groundwater flow modelling with SEAWAT



Gualbert Oude Essink  
 Deltares  
 Unit Soil & Division Groundwater Systems  
 gualbert.oudeessink@deltares.nl



## Introduction

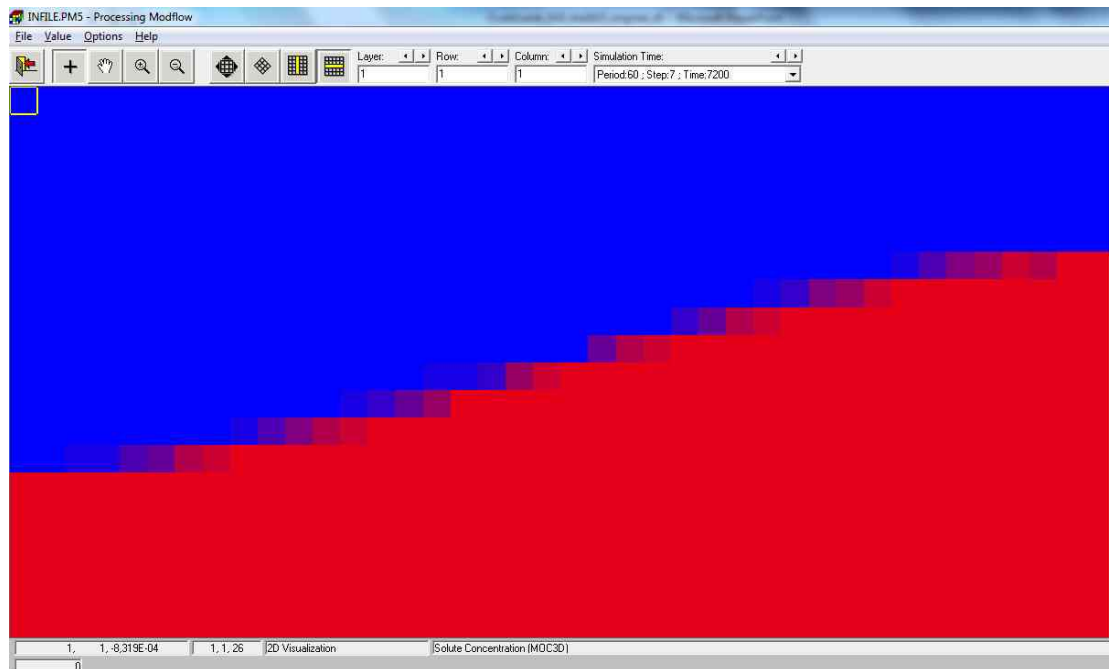
A hypothetical problem: a vertical fresh-saline interface in a homogeneous aquifer with the following geometry: horizontal  $L=1.0$  m by vertical  $D=0.5$  m. Interface approximation is simulated, which means:  $D_{mol}=0$  m<sup>2</sup>/s,  $\alpha_L=\alpha_{TH}=\alpha_{TV}=0$  m en  $R_d=1$  (so no retardation). The other soil parameters are: hydraulic conductivity  $k=10^{-3}$  m/s and porosity  $n_e=0.1$ .

### Parameters

Layers	20	$K_{hor}$	$1 \cdot 10^{-3}$ m/s
Rows	1	T	$2.5 \cdot 10^{-5}$ m/s
columns	40	Anisotropy $K_{hor}/K_{ver}$	1
$\Delta x$	0.025 m	$n_e$	0.1
$\Delta y$	1 m	$\alpha_L$	0 m
$\Delta z$	0.025 m	$\alpha_T$	0 m
Stress periods	15		
Initial concentration	0 and 35000 mg/l		
bouyancy	0.025		

The total simulation consists of 720 time steps  $\Delta t$  of 30 s, divided over 15 'stress periods': the simulation time is 360 min=0.25 day.

The model has already been simulated with MOC3D. This code (MOC3D adapted for density differences) is similar to SEAWAT, and pretty powerful in solving solute transport issues. The result with this code is after 7200sec is:



The number of initial particles is 16, which appears to be enough for this case.

### Exercise 1: geometry of the problem

- Check PMWIN input files: heads, time-characteristics, IBOUND, MODFLOW; SEAWAT parameters.
- Check the concentration and the flow face results and explain what is going on.
- Why do cells exist with a concentration not equal to fresh or saline groundwater? Why does a large number of these cells disappear as a function of time?
- Is the steady-state time reached after 0.25 day (21600sec), based on the concentration distribution?

### Exercise 2: on the best solute solver to reproduce the MOC3D result

As can be seen with the default Advection solver, it is not easy to get a sharp interface (note that no hydrodynamic dispersion is simulated!). Try to find a proper solver among the Advection solvers (Finite Difference Method, MOC, HMOC, MMOC, ULTIMATE). You could also change parameters within the solvers themselves, such as number as particles. Run SEAWAT.

NOTE: to be sure the old cases remain and that you can compare the results, make new cases in new subdirectories!

### Exercise 3: effect of a larger density of saline groundwater

Use the best solute solver from Exercise 2. Change within 'MT3DMS / SEAWAT'-> 'Simulation settings' the value DRHODC in such a way that the saline/brine groundwater has a density of 1050 kg/m<sup>3</sup>. Run SEAWAT.

- Check the concentration results.

NOTE: to be sure the old cases remain and that you can compare the results, make new cases in new subdirectories!

### Exercise 4: effect of dispersion

Use the best solute solver from Exercise 2. Add dispersion to the system:  $\alpha_L=1.0$  m;  $\alpha_{TH}=\alpha_{TV}=0.1$  m. 'MT3DMS / SEAWAT'-> 'Dispersion'. Run SEAWAT.

- Run the file with 'run.bat' in the same subdir.
- Analyse the effect due to the differences compared with the reference case.

NOTE: to be sure the old cases remain and that you can compare the results, make new cases in new subdirectories!

### Exercise 5: effect of length of time step $\Delta t$ : from 30 sec to 900 sec

'Parameters'-> 'Time'. Change the length of each time step to 900 sec by changing the 'No. of time step'. Run SEAWAT.

- Analyse the effect on the concentration distribution, especially during the first time steps.

NOTE: to be sure the old cases remain and that you can compare the results, make new cases in new subdirectories!