Example 1 – 1D Multiphase Flow and Transport using Excel

These problems are called 1D but are in fact 2D, with uniform conditions in one direction.

Purpose:

1.) get to know the parameters (what they mean, how to estimate them)

2.) run the model and get a feel for model capability and parameter sensitivity

Approach

Focus attention on learning how to run the code from Excel and then how to generate the graphical representation of the data

Use the example problems to gain an understanding of the different parameters in the code and how they can affect the solutions

See also presentation files:

1d.pdf
io_excel_1D.pdf
Run_Excel_1D.pdf

The excel files are:

1D.xls
1D_NAPL.xls
1D_trans.xls
1D_WG_tran.xls

Part 1: Water drainage (1D.xls)

The problem setup is as pictured in Figure 1. The homogeneously packed column is initially fully water saturated. We impose a constant water head boundary condition on the bottom of the column and open the top to atmosphere. We then let the column drain for 50000s and determine the saturation profile.

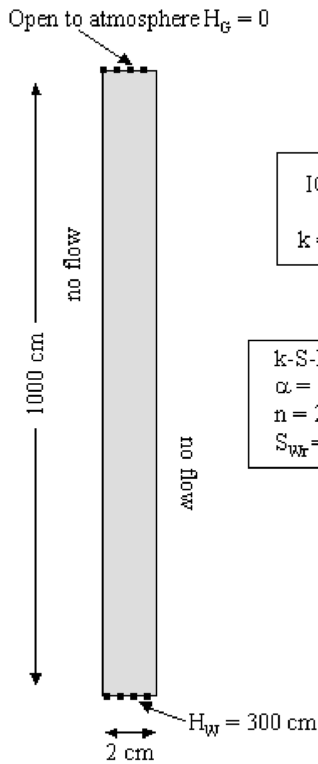

Figure 1: Part 1 Experimental Setup

Run the problem in its given setup and examine the saturation profile.

Then experiment with some different parameters:
Test for appropriate grid scale for various van Genuchten *n* values:

- change S-P parameters in lines 35 & 36
- check retention curve on sheet 'S-P'
- change # of elements (line 6) or domain length (sheet 'space')

Add heterogeneity (line 26)
Add water infiltration (line 73 and sheet 'well')
Inject NAPL (L or D) (either line 73 or in sheet 'bc_flow')
Change the length of time
Look at mass balance masst.out and mass.out – what do you see?

Part 2: DNAPL Imbibition (1D_NAPL.xls)

The problem setup is as pictured in Figure 2. Again, we use a homogeneously packed column that is initially fully water saturated. This time we impose a constant water head boundary condition on both the bottom and the top of the column. We then inject DNAPL just below the top of the column for 1000s and determine both the water and NAPL saturation profile.

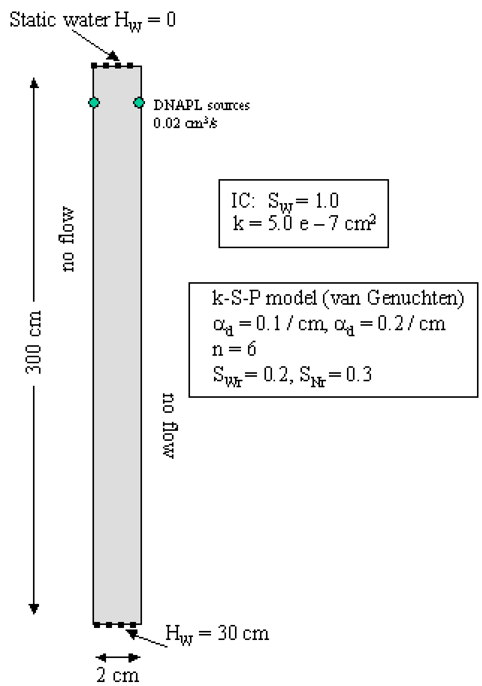

Figure 2: Part 2 Experimental Setup

Run the problem in its given setup and examine the saturation profiles.

Then experiment with some different parameters:
Change the Peclet constraint (line 46)
Change the k-S-P parameters (lines 35 & 36)
Change the discretization (line 6 and/or sheet 'space')
Change the NAPL injection rate (sheet 'well')
Run with and without hysteresis (line 41)
Add heterogeneity (line 26)
Change the length of time (line 9)
Define multiple stress periods (lines 74, 77 and 78)
Use restart (line 65)
- cycle NAPL source on and off (sheet 'well')

Look at mass balance files masst.out and mass.out – what do you see?

Part 3: Residual NAPL in a water flood (1D_trans.xls)

The problem setup is as pictured in Figure 3. Again, we use a homogeneously packed column with constant water head boundaries on the top and bottom. However, this time our column has a block where there is residual NAPL saturation. We then let the water flood the column for 1000s and examine the saturation of NAPL profile as well as the concentration of NAPL species in the water phase.

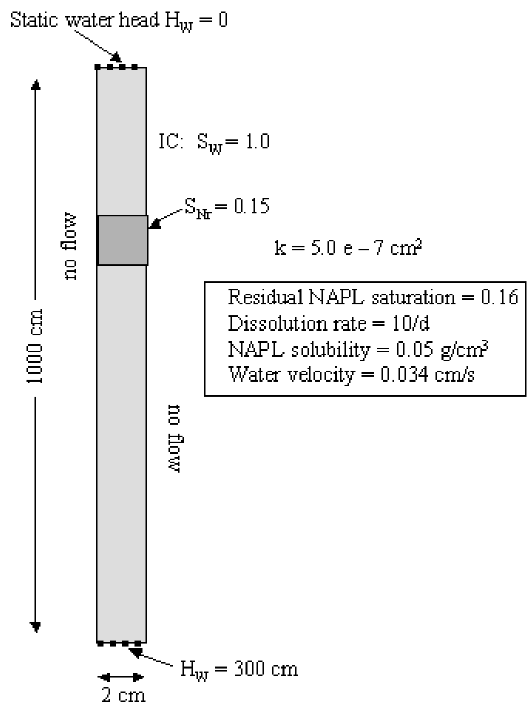

Figure 3: Part 3 Experimental Setup

Run the problem in its given setup and examine the saturation and concentration profiles.

Then experiment with some different parameters:
Change the exchange rate of NAPL into water (line 54)
Change the solubility of NAPL into water (line 55)
Change the water velocity (sheet 'bc_flow')
Change the initial NAPL content (sheet 'sat')
Change the discretization (line 6 and/or sheet 'space')
Change the length of time (line 9)

Part 4: Residual NAPL in a water-gas flood (1D_WG_tran.xls)

The problem setup is as pictured in Figure 4. For this problem, we again use a homogeneously packed column. We have a constant head of water at the bottom, and we leave the top open to atmosphere. In addition, we have water infiltrating in at the top, and Dirichlet concentration conditions for both water and gas transport. Again we have a block within the column that contains some residual NAPL phase. We allow the system to run for 50000s and examine the saturation of both the water and NAPL phases, as well as the concentration of NAPL species in both the water and gas phase.

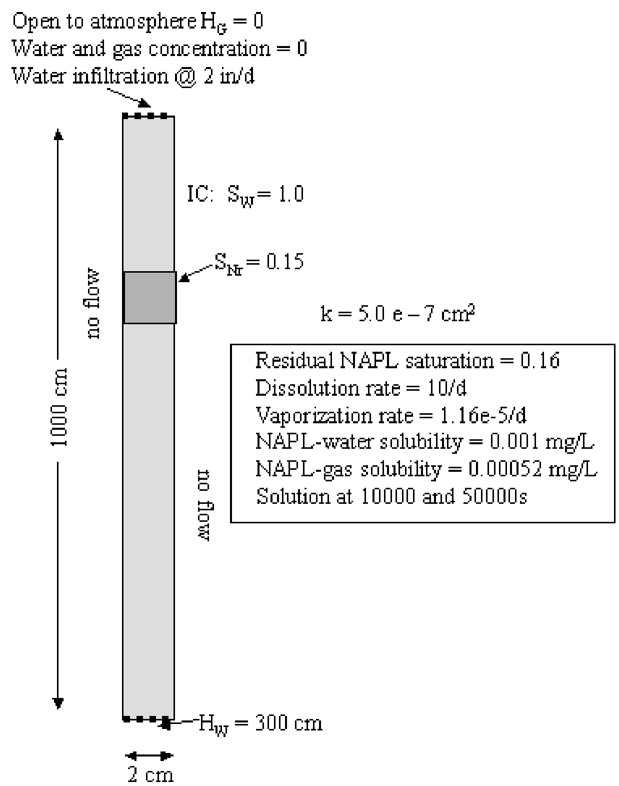

Figure 4: Part 4 Experimental Setup

Run the problem in its given setup and examine the saturation and concentration profiles.

Then experiment with some different parameters:
Change the water infiltration rate (line 73 and sheet ‘well’)
Change the S-P parameters (lines 35 & 36)
Change the discretization (line 6 and/or sheet ‘space’)
Change the length of time (line 9)
Change the exchange rates of NAPL into water and gas (lines 54 & 56)
Change the solubility of NAPL into water and gas (lines 55 & 57)
Change the initial NAPL content (sheet ‘sat’)
Define multiple stress periods (lines 74, 77 and 78)
Use restart (line 65)
Look at mass balance files masst.out – what do you see?