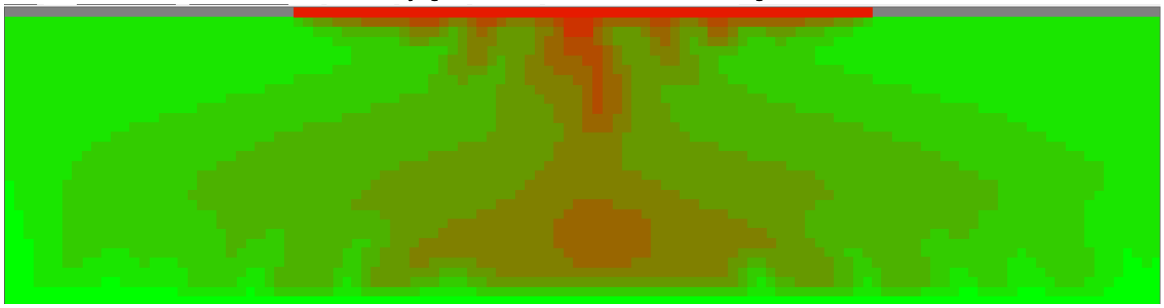
Benchmark Elder's case

Variable-density groundwater flow modelling with SEAWAT



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

Yangxiao Zhoy
UNESCO-IHE

Introduction

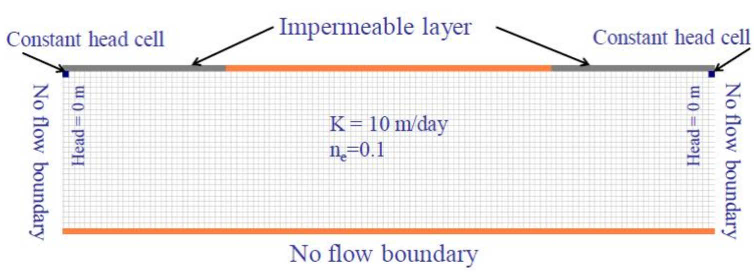
Elder salt convection flow is modelled in a rectangular box in a cross-section. A complex pattern of fingering of the denser water to mix through the box can be reproduced by a density-dependent flow model.

Parameters			
Layers	31	K_{hor}	10 m/d
Rows	1	Anisotropy K_{hor}/K_{ver}	1
Columns	120	Eff. porosity n_e	0.1
Δx	5 m	α_L	0.0 m
Δy	1 m	α_T	0.0 m
Δz	5 m	Moleculair diffusion	0.308 m^2/d
Stress period	1	Specific storage	0.0001
Length of time	7300 days	Salinity seawater	285.7 kg/m^3
		Buoyancy	0.2

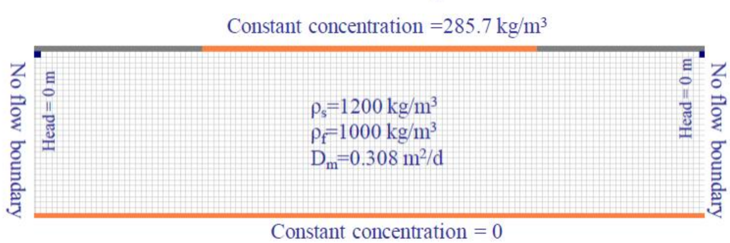
Profile of Elder's case: aquifer thickness 155m; length=600m

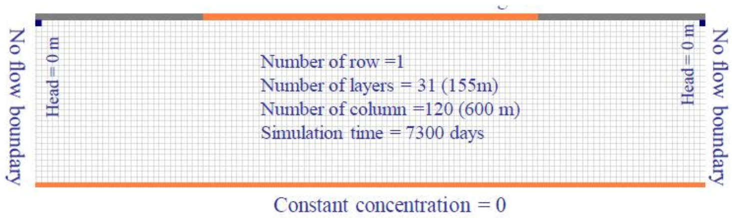
Parameters

Head:



Concentration





Grid

Step 1 Numerical model grid

(1) Mesh size:

a. Number of layers=31; Model thickness=155m; Model top elevation=5m

b. Number of rows=1; Model extent=5m

c. Number of columns=120; model extent=600m

d. Vertical exaggeration=1

(2) Layer property

a. All layers=confined

(3) Boundary (IBOUND-MODFLOW)

a. First row, column 1 to 30 cell values = 0 (inactive)

b. First row, column 31 to 90, cell values =1 (active)

c. First row, column 91 to 120 cell values = 0 (inactive)

d. Second row, column 1 and column 120; cell values = -1 (constant head)

e. All other cells, IBOUND=1 (active)

(4) Boundary (ICBUND-Transport models)

a. First row, column 31 to 90, cell values =-1 (constant concentration)

b. Last row, all cells, ICBUND=-1 (constant concentration)

c. All other cells, ICBUND=1 (active)

(5) Top elevation

a. Layer 1=5m; ....; layer 31= -145m

(6) Bottom elevation

a. Layer 1=0m; ...; layer 31= -150m

Step 2 Parameters

(1) Time:

a. Time unit=days

b. Simulation=transient

c. Stress period=1

d. Period length=7200 days

e. Number of time steps=720

(2) Initial hydraulic heads

a. Constant head cells =0m

b. All other cells=10m

(3) Horizontal hydraulic conductivity

a. All cells=10m/d

(4) Vertical hydraulic conductivity

a. All cells=10m/d

(5) Specific storage

a. All cells=0.0001m

(6) Effective porosity

a. All cells=0.1

Step 3 MODFLOW packages

(1) Solver package

a. PCG2, default values

Step 4 MT3DMS/SEAWAT packages

(1) Simulation settings

a. Species: Salt

b. SEAWAT (default)

(2) Initial concentration

a. All cells =0

b. First row, column 31 to 90, cell values =285.7 kg/m^3

(3) Advection

a. Use default (ULTIMATE)

(4) Dispersion

a. α_T/α_L=0.1

b. α_L=0m for all cells

(5) Species dependent diffusion

a. D_m=0.308m^2/d for all cells

(6) Sink/Source concentration

a. Constant head cells: we just take Salt=35 kg/m^3; (other cells: Salt=0 kg/m^3)

b. Well: salt=0

(7) Solver

a. GCG

(8) Concentration observations

a. OBS1: x=250m, y=5m, layer=15

b. OBS1: x=300m, y=5m, layer=15

c. OBS1: x=400m, y=5m, layer=15

(9) Output control

a. Output times: minimum=30; maximum=7200; interval=30

Step 5 Run models

(1) Run MODFLOW and Run SEAWAT

Step 6 Presentation of model results

(1) Contour map of salt concentrations

(2) Break-through curves

(3) Animate evolution of mixing