Homework 5: Flownets by Computer
GEOS 4430 - Fall 2011

Due: Nov. 17th

1 Introduction

Paul Hsieh, of the USGS, recently developed two (relatively easy-to-use) computer models for 2-D simulation and visualization of groundwater flow [TopoDrive, *Hsieh*, 2001] and transport of fluid particles (ParticleFlow). Were going to use TopoDrive to explore the effects of fracture heterogeneities on groundwater flow and transport.

The software can be downloaded from the USGS[1]. Note TopoDrive is a Java applet, so for non-WindowsXP operating systems download the *Applet version*. In the instructions below, items you are to type or select in TopoDrive are `indicated like this`. Items that are to be turned in and constitute part of your homework grade are indicated by "⇒."

2 Tasks

We'll simulate a small regional flow system that is approximately 1 km in length.

Use `Start` pulldown menu to set up the model domain:

- Model domain length 1,000 meters
- Vertical Exaggeration 1.0

1. Sloping water table in homogeneous aquifer
    - Water table: Click the `"Water Table"` button to bring up the Water Table Dialog Box, which provides a reminder to draw the water table from left to right.
    - Mesh
        # Columns 100
        # Rows 50
    - Properties
        – Click the `Properties` button to bring up the Properties Dialog Box.

[1] http://water.usgs.gov/nrp/gwsoftware/tdpf/tdpf.html

- select the `isotropic` option.

- Head: select `30 contour intervals`, then compute head
- Flow:
  - Use the `Flow path tracking option`, `Forward and backward` tracking direction
  - Flow paths are added by clicking in the model domain. It s good to try and get a relatively regular vertical spacing of flow lines.
- Animation
  - This steps shows the evolution of the flow paths defined above. You need to specify the amount of time that is equal to 1 second of animation. A good starting point is often to set 1 second (of animation time) to equal to 5 years. Leave the animation smoothness at the default value.
  - start the animation by clicking anywhere within the model domain. You can also pause the animation by clicking anywhere within the model domain. To restart the animation, once again, click within the model domain.

⇒ Sketch or print (e.g. using "Print Screen" screen capture) your results. Note the range of travel times (when first and last particles reach water table). 10 pts

2. Sloping water table with heterogeneity

- Properties
  - return to `Properties` and select one of the colored materials (conductivity values)
  - Five sets of hydraulic conductivity (m/s) and porosity (%) values are available for assignment to model elements. Each set is represented by a color. Default values are initially provided, but users may alter any or all of these values in the edit boxes.
  - Select a set of hydraulic conductivity and porosity values by clicking the color icon. The selected icon is indicated by a thick black frame.
  - Draw a polygon to enclose those elements to which the selected property values will be assigned. A polygon is drawn by clicking at its vertices's. To finish drawing the polygon, double click the last vertex.
  - The elements enclosed by the polygon are filled with the color that was selected in the dialog box.
- repeat `Head-Flow-Animation` steps above

⇒ Sketch or print your results. Note the range of travel times. 10 pts

3. Sloping water table with opposite-sign heterogeneity

   - Properties
     - return to `Properties` and select the "opposite" of the conductivity values, i.e. if you selected a lower conductivity (color below white on the Properties dialog) in item 2, pick a higher conductivity this time
     - make this material polygon slightly larger than your previous polygon
   - repeat `Head-Flow-Animation` steps above

   ⇒ Sketch or print your results. Note the range of travel times. 10 pts

4. Sloping water table sedimentary anisotropy

   - Properties
     - return to `Properties` and select `Anisotropic`
     - remember $K_z \approx \frac{K_z}{10}$ in sedimentary rocks, so set the vertical hydraulic conductivity to $1\text{x}10^{-6}$ $\frac{\text{m}}{\text{sec}}$)
     - `overwrite your polygon` from item 3 with this material
   - repeat `Head-Flow-Animation` steps above

   ⇒ Sketch or print your results. Note the range of travel times. 10 pts

5. Sloping water table fractured granite anisotropy

   - Properties
     - return to `Properties` and select `Anisotropic`
     - remember $K_x \approx \frac{K_z}{10}$ in igneous rocks, so set the vertical hydraulic conductivity to $1\text{x}10^{-4}$ $\frac{\text{m}}{\text{sec}}$)
     - `overwrite your polygon` from item 3 with this material
   - repeat `Head-Flow-Animation` steps above

   ⇒ Sketch or print your results. Note the range of travel times. 10 pts

⇒ Summarize (briefly) general rules for the effects on flowlines of:

(a) zones of heterogeneity (both higher and lower than conductivity of enclosing material) 25 pts

(b) anisotropy, at high and low angles to the head gradient 25 pts

References

Hsieh, P. A., Topodrive and particleflow–two computer models for simulation and visualization of ground-water flow and transport of fluid particles in two dimensions, *Open-File Report OFR 01-286*, U. S. Geol. Survey, Reston, VA, 2001.