Transient Models

HWRS 482 - 3/19/20

$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} + \frac{\partial^2 h}{\partial z^2} = \frac{S}{T}\frac{\partial h}{\partial t}$$

Steady state = 0
transient ≠ 0

1. In transient simulations Storage terms matter
   - heads changing over time which is a function of how easily water is released from storage

S_s = specific storage ← confined
S_y = specific yield ← unconfined

2. Stress periods + time steps
   - now we discretize space + time!
   - Just like with space smaller time steps are desirable (less error)
     But trade off with computational costs
   - Goal: use largest time step possible impacting our results
   -

$$\Delta t_c = \frac{Sa^2}{4Kb}$$

Storativity — $\Delta x = \Delta y = a$ — layer thickness — Conductivity

$\Delta t_c \propto$ grid size (smaller Δt if grid resolution ↑)
$\Delta t_c \propto 1/K$ (smaller Δt if things move faster)
$\Delta t_c \propto$ Storativity
↳ Large S means lots of water out per Δh ⇒ less sensitivity of Δh to storage changes
↳ smaller Δt if Δh is more sensitive.
$\Delta t_c \propto 1/b$
↳ thicker layers transmit more water
↳ smaller Δt for larger layers

- timesteps can often ↑ as time goes on if your system is stabilizing.
  (i.e. when largest changes occur in early stress periods)
- growth ts can be used for this ⇒ set an initial Δt and a max Δt and some growth rate

Timestep vs Stress period

- Timestep = Δt = time between modflow solutions
- Stress period = period of time where all of the stresses are constant (ie. Boundaries/wells etc)
- Stress periods are broken up into timesteps, heads are calculated at the end of each timestep.

Vertical Layers

- Layers that are thin enough to capture heterogenities
- if your layers are too thin you will have too many & that hursts computation
- All layers must have the same xy spacing
- Δz is determined by the elevation of our layer boundaries
  - ↳ Δz & K are used to calculate T
  - ↳ T can be different in each node in each layer (Δz can vary across rows & columns)
- # layers depends on vertical head gradients & variability in K
  - ↳ Need 3 or more layers to represent variability in vertical leakance.
  - ↳ for particle tracking you need 3 or more "transition" units to capture head radients across sharp contrasts in K

- Vertical conductance: leakage between layers ← average K_z between 2 layers divided by distance betwen centers

Layer types

(1) Confined ⇒ Saturated thickness constant
  - easiest (cheapest) to calculate
  - problematic if head drops below top of layer

(2) confined/unconfined -
  - simulating WT (unconfined) as a confined
  - assuming saturated thickness not changing much in time
  - faster convergence more stable.
  - use Sy instead SS
  - T is constant (ie always saturated!

(3) Unconfined
  - head is below top of layer
  - saturated thickness = elevation of WT
  - T changes with WT, S = Sy

(4) Convertible (default)
  - automatically switch confined ⟺ unconfined with head changes

- T varies with saturated thickness
- S varies between SS & Sy