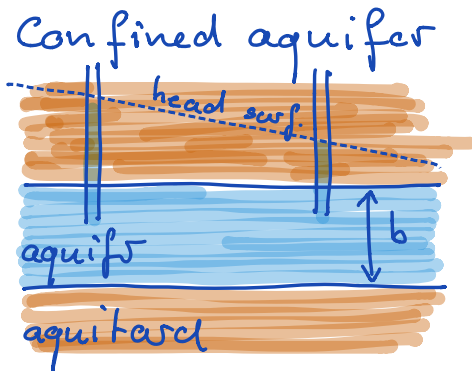


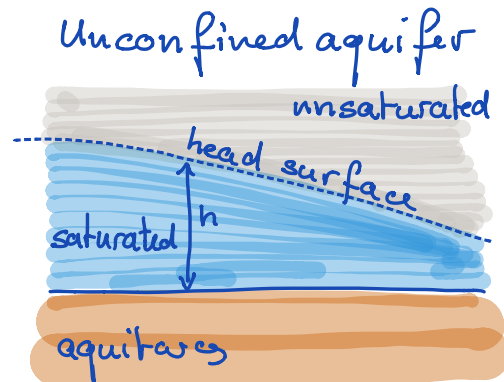
Flow in an unconfined aquifer



Steady flow:

$$-\nabla \cdot [b K \nabla h] = f_s$$

linear in h



Steady flow

$$-\nabla \cdot [h K \nabla h] = f_s$$

non-linear in h !

Non-linear model for unconfined aquifers

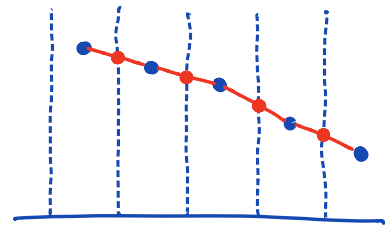
$$\phi \frac{\partial h}{\partial t} - \nabla \cdot [K h \nabla h] = f_s$$

Boussinesq eqn

Consider the discretization of steady problem:

continuous: $-\nabla \cdot [K(h) \nabla h] = f_s$

discrete: $-\underline{D} * [\underline{K_d} ? \underline{G} * \underline{h}] = \underline{f_s}$



We need to interpolate \underline{h} to interfaces

\Rightarrow arithmetic mean: $\underline{H} = \underline{I}_f(\underline{H} * \underline{h})$

$\underline{\underline{I}}_f$ is N_f by N_f diagonal matrix with vector $\underline{\underline{I}} * \underline{h}$ on diagonal

$$\Rightarrow \underbrace{-\underline{\underline{D}} * \underline{\underline{K}}_d * \underline{\underline{H}}(\underline{h}) * \underline{\underline{G}} * \underline{h}}_{\underline{N}(\underline{h})} = \underline{f}_s \quad \underline{N}(\underline{h}) \neq \underline{\underline{L}} * \underline{h}$$

$\underline{N}(\underline{h})$ is a non-linear system of algebraic equations.

We cannot pull \underline{h} out to form the system matrix $\underline{\underline{L}}$!

\Rightarrow solve iteratively with Newton's method.