1. What are initial conditions? Describe various approaches to determining initial conditions for a groundwater model.

Initial conditions can be thought of as a boundary condition in time. They are a baseline set of parameters within the groundwater model, usually taken at a time t = 0, that can be added to or changed in order to analyze model behavior. These initial conditions can include such parameters as constant head boundaries, how many zones of hydraulic conductivity are present in a groundwater model and what the K values are, and initial pumping rates at groundwater wells, among other model parameters. These initial conditions, when adjusted, can have a significant impact on whether the model is in a steady or transient state.

Approaches:

“Therefore, in a transient-state problem, the initial conditions should be determined through a steady-state simulation of the flow system at equilibrium” (Franke, 1987, 11)

Other approaches??

1. What does it mean for a groundwater model to be ‘spun up’? How can we go about achieving this and how would we know if we are done? What can happen if you run transient models on a groundwater model that is not spun up?

Models often need more time to ensure that model outputs are converging, thus the necessity for “spin up” time. This “spin up” time usually varies by model, but for all models, completion of the spin up period is indicated by the model reaching equilibrium in its outputs. Running a groundwater model for a given amount of time until the outputs reach equilibrium indicates that the spin up period has been sufficient, and the model will likely provide better fit thereafter. Failing to include adequate spin up time in a groundwater model may lead to poor model fitting and inaccurate conclusions.

1. Groundwater is generally the slowest moving component of the hydrologic cycle. Describe (1) the speeds at which groundwater flows compared to surface water (2) the time scales over which water tables and groundwater heads respond to changes in pumping vs recharge in both confined and unconfined systems? What are the implications of these timescales for how we model groundwater systems?

Groundwater usually moves orders of magnitude slower than surface waters. A velocity of 1 ft/day is considered fast flow in a groundwater system (USGS, 1999). Surface water generally moves much more quickly, with velocities commonly measured on the order of ft/s. The lower velocity of groundwater flow is mostly a result of the time it takes for groundwater to percolate through pore spaces in the rock rather than moving freely on the surface. When pumping groundwater, time has different effects on head for confined and unconfined systems. Pumping from a confined and unconfined system for the same amount of time will, at first, result in greater head decreases in the confined system. This is due to the ability of unconfined systems to provide more water from storage compared to confined systems. However, at a later time, the effects of confined v. unconfined systems will even out and head decreases will behave the same way regardless of the aquifer type (USGS, 1999). Water tables will respond to changes in pumping and recharge over much longer timescales depending on the spatial extent of pumping and recharge wells. A few shallow wells will have a relatively small impact compared to many deep wells spread out over a large area. Whenever a pumping or recharge well is placed into a groundwater system, it will affect the groundwater flow paths in the subsurface. Depending on the depth of the well, different flow paths and different ages of groundwater could be affected. A deep well could access regional flow paths whereas a shallow well may only impact a local subsystem (see chart below). The interconnection of these flow systems matters when we try to translate them into computer models. The scale of your model, i.e. how much of the real-world system you attempt to model, can have a significant impact on the results you will receive.

Diagram

Description automatically generated

Figure 1: Conceptual drawing of regional groundwater flow system. Flow paths indicated by blue arrows. Smaller subsystem interconnections shown by numbered areas on figure.