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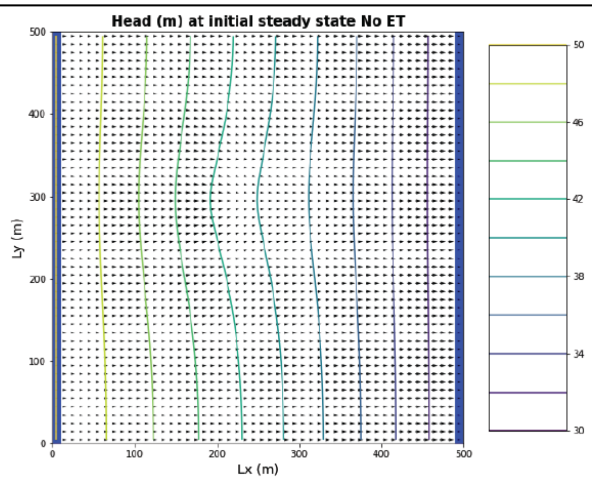
Homework 9 Discussion

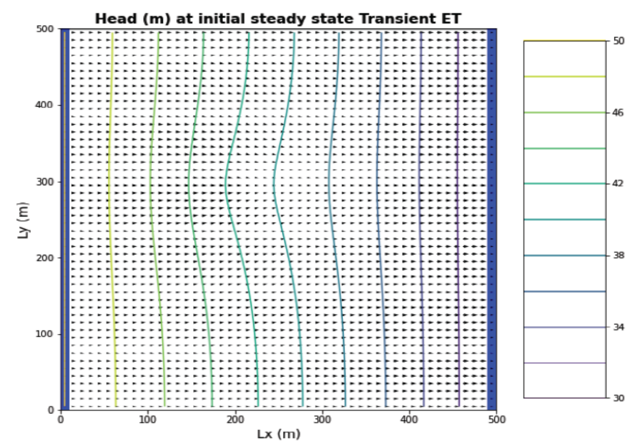
1. Compare your results for the case with no ET to the modified ET case and explain how your results differ. To do this I'm expecting you will create some plots as well as looking at the water balance.

    a. Figures 1 and 2 below show head contours with no ET and with transient ET, respectively. The scenario with ET shows a more significant change in head gradient around the pumping well at [0,20,20]. Also, flow across the left boundary is slightly greater in the ET scenario, while flow across the right boundary is slightly less. This is because there is now another water sink in play, which would then allow more water to enter the domain from the left boundary. However, not as much water would leave the right boundary, because some of it is now leaving through ET. ET has no effect on pumping rate—that remains constant.




```
Left Flux = 788.2169   Right_flux= 842.16095   Difference = 53.94403
```

**Fig. 1 Head contours for period with no ET**




```
Left Flux = 793.723   Right_flux= 836.1856   Difference = 42.462585
```

**Fig. 2 Head contours for period with transient ET**

The fact that there is only a slight change in boundary fluxes between the two scenarios can be explained best by figures 5 and 6 below. These drawdown charts show that while there is a slight increase in drawdown with the ET scenario (and therefore a decrease in head around the well), the difference is only a fraction of a meter.

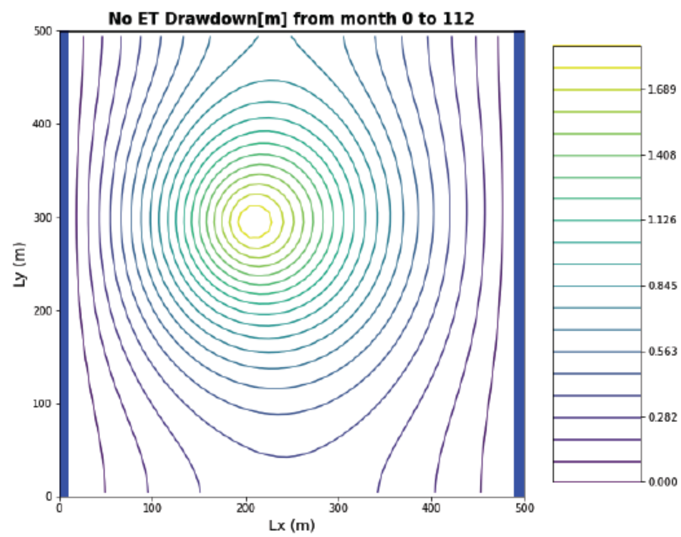



Fig. 5 Drawdown with no ET

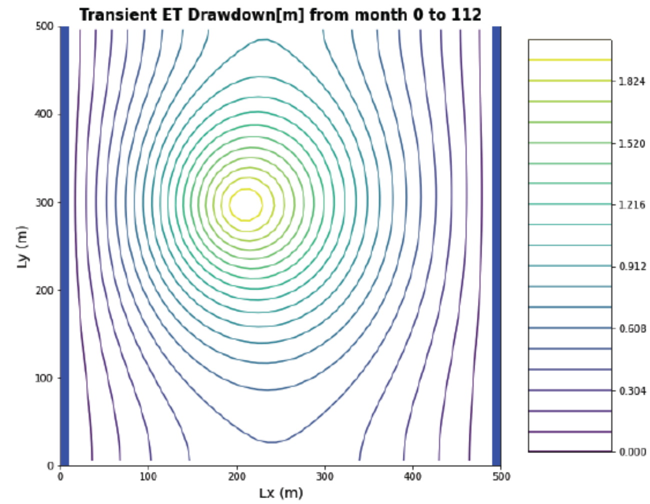



Fig. 6 Drawdown with ET

2. Modify the model so that the ET only occurs in a square area around the well that is 200m by 200m. Discuss how this changes your results using plots and water balance calculations.

   a. When ET is set to occur only in a 200x200m box around the well, the head contour plot (Fig 9) closely resembles the plot with no ET at all (Fig 1). This makes sense, considering ET across the entire 25,000 $m^2$ domain barely made a difference, and now the area of ET has been reduced to only 4,000 $m^2$, less than a quarter of the original area. Fluxes into the left boundary and out of the right boundary, shown below, are also nearly identical to the "no ET" scenario.

```
Left Flux = 788.2183   Right_flux= 842.1594   Difference = 53.9411
```

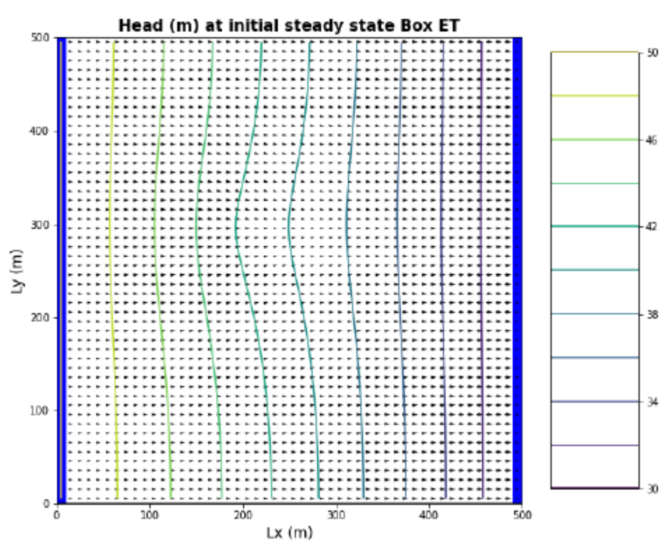



Fig. 9 Box ET

3. Modify the recharge in the model so that it is also transient. It's up to you how you want to modify it. Provide and explanation for the scenario you ran and explain how it impacts your results.

    a. Figure 14 shows drawdown of the transient recharge scenario, with a recharge rate of 5e-4 m/day. Although the shape of the contours look similar to previous plots, the main take-away is that drawdown is lower than in scenarios with no recharge. This make sense, since there is now a new source of water that is being applied to the domain.

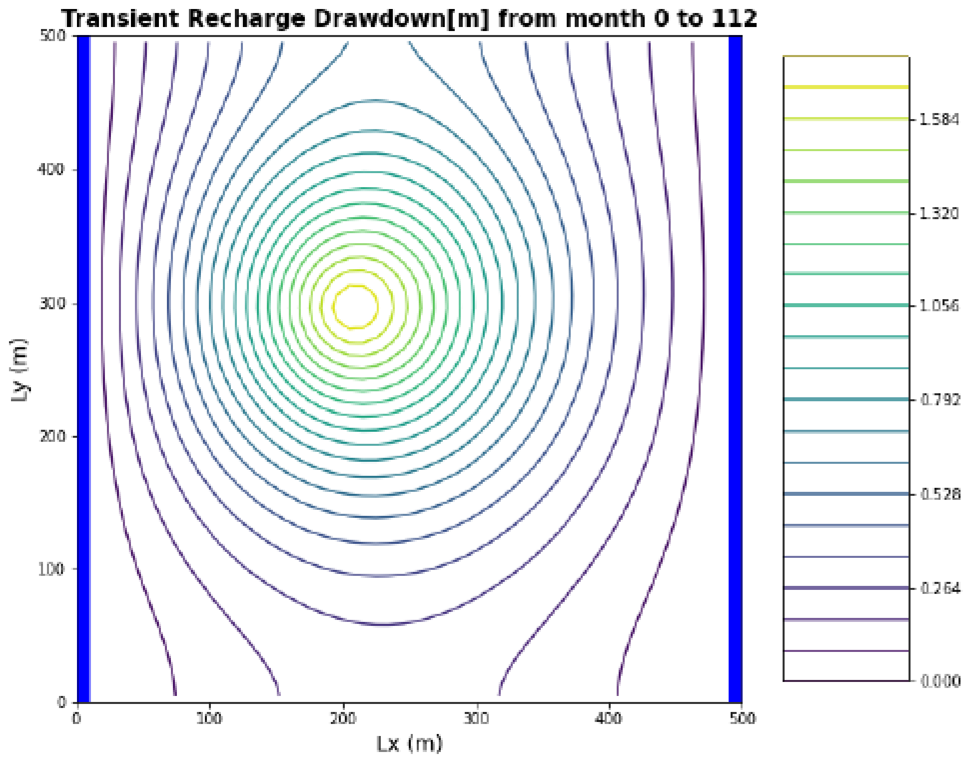



**Fig. 14 Transient recharge and 20x20 box ET**

The below figures show the fluxes during the transient recharge scenario. The big difference here is that the flux entering the domain from the left is now greater than the flux leaving the domain from the right.

```
total ET -0.7082099393464887
total recharge 3600.000321865082
Left Flux = 843.20557  Right_flux= 787.80054  Difference = -55.40503
```

Glossary Terms

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

    a. An initial condition is similar to a boundary condition, but while boundary conditions are with regard to space, an initial condition is with regard to time. An initial condition can be determined through observations that occur before an expected change in conditions (with respect to time) occurs.

2. 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?

    a. Spinning up a groundwater model means letting it run through enough time steps to where parameters aren't fluctuating wildly, and an equilibrium is reached. If this isn't done properly, it could cause errors in mass conservating calculations, creating an apparent over or under-estimation of groundwater in the model.

3. 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?

    a. Groundwater flows on the order of $10^{-1}$ to $10^{0}$ m/day. Compared to surface water, which flows on the order of 1 meter per second, or ~$10^{5}$ m/day, a rate of about 100,000 to 1,000,000 times faster than groundwater. In a confined aquifer, there is less opportunity for recharge, since it can only enter the aquifer through certain points (such as with mountain block recharge). In an unconfined aquifer, recharge could potentially enter through the entire surface area of the aquifer (minus any localized aquatards between the aquifer and the surface). Any natural form of recharge (e.g., precipitation or a losing stream) is going to added to an aquifer at a significantly slower rate than the amount of water removed from practically any pumping rate. This means that managing aquifer pumping to reasonable rates is extremely important to model.