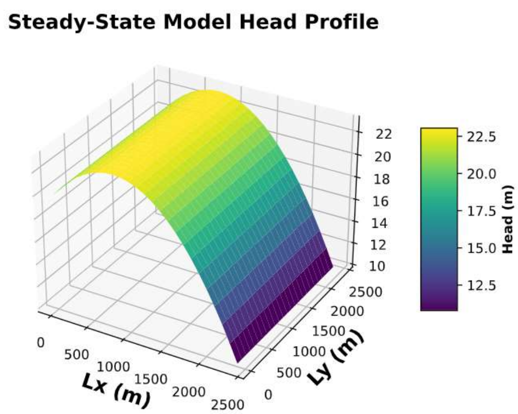
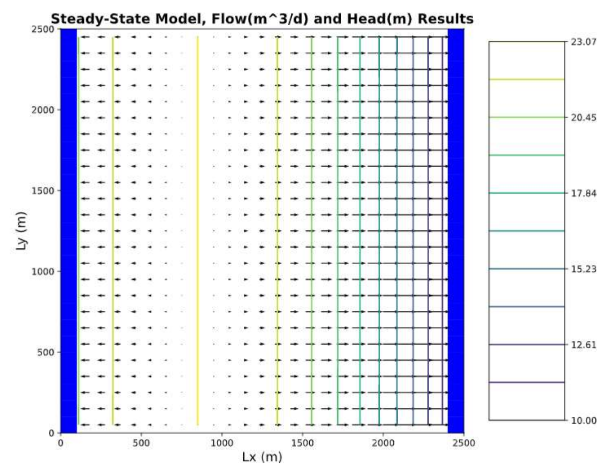
The Challenge
For the initial boundary head values and pumping and recharge rates, compare the head versus x distance - along a transect from the middle of one constant head boundary to the other - to the results for the BoxModel. Now reduce the boundary heads to 15 and 5. Compare this result and explain any observed differences. The overall gradient is the same, as is the K of the medium ... is the flow the same for both boundary conditions? Why or why not?

When looking at the head vs distance charts for both of these models, they look, more or less, the same with the initial values(a linear decrease from the left to right boundaries). After changing them both the right and left sides both models show a head line that curves down. The flow in these two models diverge. It seems intuitive that box model would see a dip in flow towards the center because of the inclusion. The flow profile on the recharge seems erratic and the overall shape of that profile changed significantly with the change in heads. In both scenarios the left and right flow profiles differed in the recharge model. I'm not sure what I'm looking at here.

Now add recharge at a constant rate of 1e-4 m/day over the entire top boundary. Explain the head transect and boundary flows. Is flow in this system 2D or 3D? Is it represented as 2D or 3D? Explain what you mean by your answers.

My impression is that this system is 2D. I think that if it were 3D the charts would not change this appreciably because the recharge would just add to storage and not change the head gradient. The gradient shifting to one where the high point is no longer on the left side seems to indicate that if there was unutilized storage for this model, it became fully saturated. I ran this under both of the head scenarios in the first question and the profile is the same although when the 15-5 head scenario was run the peak head didn't exceed 20. Since this is an unconfined model, I'm lead to believe that the head profile not exceeding 20 shows that the thickness of the model is not playing a role.





Now model a system with zero recharge except for a farm located in [6:10, 6:10] - in python terms. Recharge beneath the farm is 1e-4 m/day due to excess irrigation. First, calculate the annual excess irrigation, in meters, that has been applied to the farm. Second, assuming that the crop is cotton, it is located in southern Arizona, and cotton is grown all year (for simplicity), calculate the total irrigation rate on the farm that would be associated with this amount of excess irrigation. Finally, identify the area within the domain that might be subject to contamination if the recharge water was somehow tainted.

Unable to set recharge parameter – circle back to this

Lastly, start the well pumping at a rate of 8 m3/day. Using one color, identify the capture zone of the well. Using a second color, show the area that might be contaminated by the irrigated farm fields. Comment on the impact of the well on the pattern of potential contamination.

Correct Key Figures

OK, we're stepping it up another notch this week. I am going to ask you to post what you believe to be the correct plots in Slack. When at least three of you agree that the plots are correct, package them up and send them to me to check! I will tell you that they are correct, or I will point out what is still incorrect, in Slack. We will iterate until all of the plots are correct so that everyone can move forward!

Discussion Points
In addition to The Challenge, start thinking about the following ideas

How can MODFLOW, which does not model unsaturated flow, represent an unconfined aquifer?

By modeling everything in 2D, I think MODFLOW can just neglect changes in storage and focus on flows and heads.

What do you think would happen (in MODFLOW) if you pumped an unconfined aquifer so hard that the water level dropped below the bottom of the aquifer? Explain this from the point of view of what is happening in the model ... then think about what would happen in real life!

In real life, the aquifer would try up. Without modeling the thickness of an aquifer or the associated storage, MODFLOW has no way of representing that.

How will the steady state capture zone of a model with recharge differ from that in the same model without recharge?

I think that recharge would would shrink the capture zone since it could pull water from the recharge as opposed to more distant areas. After testing this idea in MODFLOW, it turns out that the capture zone was increased but for a reason I didn't think of(I should have though). Without the recharge the head distribution returned to the linear decrease and the well started pulling all the way from the left boundary as opposed to the crest of the head in the recharge scenario.

What is recharge? What does it mean to define recharge for a MODFLOW model? How is it related to defining ET and precipitation? Where, exactly, is the top boundary of the model?

It seems that in MODFLOW recharge is really just used as a term in water budgeting. ET would subtract from that budget. Precip and recharge would add to that budget. I guess the model would probably be the ground surface, though I'm not sure how much the term "top" really means in a 2D model.