G572 Group Project Spring 2022

This semester, we will be creating maps (and perhaps an animation? Time will tell) of chloride accumulation originating from road salt applications in the shallow aquifers of McHenry County. This will be conducted in three phases:

1) Model development (Part 1 Due 4/8)
2) Model troubleshooting, calibration, and preparation of chloride data (Part 2 Due 4/20)
3) Solute transport - chloride (Part 3 Due 5/9)

Key Downloads:

1) Groundwater Vistas 7: [Environmental Simulations Incorporated - Groundwater Modeling Software Specialists (groundwatermodels.com)]
    a. This is used to read McH_only_shallow2_no_noflow.gwv
    b. The Groundwater Vistas model for McHenry County is available on Box at: https://uofi.box.com/s/c7nk1e8cc1fr7ungxraqyp7q52z2xdrk
2) A GIS interface of your choosing (I will be using ArcGIS but can provide guidance on QGIS or even Python if you prefer)

Group Project Part 1: Due 4/8

You will serve as lead on the development of one of three MODFLOW packages. Collaboration is strongly encouraged since every student will face similar difficulties.

1) By 4/8, you should set goal to prepare a file to be read into FloPy. Specifically, you should ensure that FloPy reads in this file and writes the appropriate MODFLOW package. It is not essential that the MODFLOW model successfully runs at this stage; just that files are written

While not necessary to complete by 4/8, you should set a goal to make significant progress on updates to the Wiki page on GitHub:

2) For your specific package, create a tab on the Wiki page and discuss:
    a. The specific MODFLOW package used to add data to the model
    b. A summary of the data (either in map or time series form)
    c. Uncertainties in the data
    d. Source of the data (in this case, it will always be Meyer et al. 2013: IDEALS @ Illinois: Groundwater Simulation Modeling and Potentiometric Surface Mapping, McHenry County, Illinois)

In addition to your package, you should select one of three background topics and create a tab for this in GitHub. Background topics should include:

1) Discussion of the geology in McHenry County (Anne)
2) Water supply and ecological concerns in McHenry County (Geoff)
3) A discussion of water level and water quality monitoring in McHenry County (Andy)

Additional Material for Part 1

This year, Daniel will create the river and drain packages to represent surface water boundary conditions in the model. This work will be featured during the Thursday workshops and available for students who are unable to attend live. Students will develop three packages following similar methodologies:

1. Andy: Add **hydraulic conductivity** to the 10 layers of the model; use "hydraulic_conductivity.shp"
    a. The student responsible for developing this package should also make at least three maps (layer 1, layer 9, and an intermediate layer) to highlight the geology of the model
    b. The student working with geology should create a few north-south cross sections from the Groundwater Vistas model. (these can just be screenshots)
2. Anne: Add **top of layer one and bottom of all 10 layers** to the model; use "top_layer1.shp" and "bottom_alllayers.shp" for this analysis
    a. The student should create a map of land surface (top of layer 1) and the bedrock surface (top of layer 10)
    b. The student working with geology should create a few east-west cross sections from the Groundwater Vistas model. (these can just be screenshots)
3. Geoff: **Current Pumping** in the model; use "pumping_wells.shp" for this analysis. Only one stress period is needed (current pumping); we will be running a steady state flow simulation for this analysis.
    a. The student should create a map of current pumping in the shallow aquifer
    b. The student should also create a time series of pumping in the model. Hint: The model simulation starts in 1863. The length of each time step/stress period in days can be found in the groundwater flow model (Groundwater Vistas) under the menu: Model>MODFLOW>Stress Period Setup.

All values are in units of feet and days. This means that hydraulic conductivity is in units of ft/day, elevations are in units of feet above mean sea level, and pumping is in units of ft^3/day.

You can view the Groundwater Flow Model by downloading Groundwater Vistas 7 from Environmental Simulations Incorporated - Groundwater Modeling Software Specialists (groundwatermodels.com)

Group Project Part 2: Recommended to make significant progress by 4/20

For a brief overview of this assignment, check out this video:
https://mediaspace.illinois.edu/media/t/1_qidcyf55

You are tasked with developing input data for the chloride model. While you are completing this, I will be preparing the groundwater flow model for use in Group Project Part 3. In all cases, you will be taking data in its original form (in some cases this is a report, in other cases it is a shapefile), conducting a few GIS exercises to prepare the data, copying/pasting the attribute data from the shapefiles into a CSV, and finally loading that data into Python.

There are three tasks that I would like for you to complete:

Task 1: Compile chloride data for calibration purposes

- Refer to the file "gwmchenry_deep.xlsx", which you used in Homework 5 to develop potentiometric surfaces (https://github.com/dbabrams/G572-Lecture-Notes-6). You are going to add the following data to this data set, where available:
    - Add and populate a column for **Chloride** concentrations in mg/L that were measured in 2010. This data can be found in this USGS report: https://pubs.usgs.gov/sir/2017/5112/sir20175112.pdf
    - Add and populate a column for latitude and a column for longitude information (while you have already seen that you can write a code to grab this information from a web service, you may find it easier to just do this step manually by clicking on the hyperlink associated with the sitenumber in "gwmchenry_deep.xlsx", then clicking on "Summary of all available data for this site")
- After you have added the requested information into the Excel file, save it as a .csv file. Then, import this .csv file into ArcGIS. Once in ArcGIS, change the spatial coordinate system to Lambert (the same as the shapefiles that I originally posted to GitHub for Part 1 of the Group Project). Please reference this brief video for an overview of how to bring in .csv data and do a coordinate conversion: https://mediaspace.illinois.edu/media/t/1_dnkmnu7k
- Add lambert x and lambert y coordinates to your attribute table of your shapefile.
- At this point, you are ready to make maps for the Wiki showing how chloride concentrations vary spatially and copy/paste the data from the attribute table into a .csv file for import into Python.
- Either in Excel before importing into Python or after importing into Python (it does not matter to me), please convert the lambert x and lambert y coordinates into rows and columns. **Geoff** developed this methodology when working with the wells in Part 1.
- Once you are at this point, you will have developed calibration targets for use in Part 3 of this assignment!

Task 2: Create inputs for chloride into the model

- Chloride entering the aquifer of McHenry County is primarily from winter deicers from heavily paved surfaces. Download some helpful shapefiles to get you started:
    - Major interstates/roads in Illinois: https://catalog.data.gov/dataset/tiger-line-shapefile-2019-state-illinois-primary-and-secondary-roads-state-based-shapefile/resource/754a432a-664d-46fd-9d89-dcbb125d2c3d
    - Major municipality boundaries: https://clearinghouse.isgs.illinois.edu/data/infrastructure/municipal-boundaries-incorporated-places-2000
- Download the hydraulic conductivity shapefile from: https://github.com/dbabrams/G572McHenryCountyGWModel/tree/main/GISuploads
- Load the three shapefiles that you have downloaded into ArcGIS
- Look at Zone 1 (hydraulic conductivity zones for layer 1) in the hydraulic conductivity shapefile.
    - There should be two zone numbers by default, 73 and 74. These are going to be zones where we apply low chloride into the aquifer.
    - Create zones 75 and 76 to represent where the major interstates/roads shapefile overlays the hydraulic conductivity shapefile.
    - Create zones 77 and 78 to represent where the major municipality boundaries shapefile overlays the hydraulic conductivity shapefile
    - Create zones 79 and 80 to represent where both major interstates/roads and major municipality boundaries overlays the hydraulic conductivity shapefile.
    - Note: Even numbers are high permeable and odd numbers are low permeable
    - Please check out this video about how to modify an attribute table: https://mediaspace.illinois.edu/media/t/1_psfjpqp7
- These zones represent areas where we will be applying chloride at different rates into the groundwater flow model. Take a look at the chloride concentrations that your team members come up with in Task 1 and make your best guess at what chloride concentrations applied to the aquifer in recharge should be. No right or wrong answers, this is why we calibrate! You don't' need to add this data to the attribute table, just mark it down for when we move into Part 3 of the Group Project.
- At this point, you are ready to make maps for the Wiki showing where you anticipate chloride will be entering the aquifer (particularly focusing on high permeable zones with overlying paved surfaces)
- Read into Python. There is no need to take further action, we will reshape later, once we investigate what the input file actually looks like. You do not have this information quite yet.

Task 3: Wiki Maintenance

At this point, the Wiki on GitHub is in pretty bad shape (https://github.com/dbabrams/G572McHenryCountyGWModel/wiki). **To be clear, you are not behind, I am pleased where everybody is at right now in the project overall, but it is time that somebody gives the Wiki a close eye.** This page is going to serve as your final group project deliverable, in lieu of a report. It is important at this stage of the milestone that somebody spends their time over the next week or so to make the initial steps to getting the Wiki organized and adding content so that you aren't scrambling last minute. Here are some ideas of what to add in:

1) **Create a crude outline** with places to add content for Milestones 1 and 2, right now this includes:
    a. Hydraulic conductivity (Andy)
    b. Model layer elevations (Anne)
    c. Pumping (Geoff)
    d. Discussion of the geology in McHenry County (Anne)
    e. Water supply and ecological concerns in McHenry County (Geoff)
    f. A discussion of water level and water quality monitoring in McHenry County (Andy)
    g. Boundary conditions (Daniel)
    h. Cross-sections from Groundwater Vistas (Andy and Anne from milestone 1- just a reminder because that would be an easy one to miss)
    i. Observed chloride maps (Task 1 of Milestone 2- ????)
    j. Chloride inputs into the aquifer (Task 2 of Milestone 2- ?????)
2) **Whoever takes this task is not responsible for writing the above sections, but rather creating an initial organization to tell a story (so a crude outline will be okay).** While I want all the above topics discussed in the Wiki, they all don't need their own Wiki Page in the final version (that would make it harder to navigate). For example, Anne and Andy may decide to combine their hydraulic conductivity, model layer elevations, geology discussion, and cross-sections into a single Geology tab. That will make the Wiki more manageable. So give some thought to how to start to organize everything. **The most important thing is that I want this Wiki to tell a cohesive story! You, as a group, have flexibility on how to do this.**
3) Whoever is responsible for this should reach out to your teammates to see if they have any figures that they have made in ArcGIS that they can add before April 18th. That will make everybody's life easier as we move into the last Milestone after the 18th. If some images are not ready, that's okay, you may add a placeholder for them.

Here is an example of a Wiki of a FINAL PROJECT from a couple of years back (https://github.com/dbabrams/ShallowDolomite_Group/wiki). I don't want you to exactly replicate this format, make it your own! However, it should give you a good idea of what I am looking for in the final version of the Wiki.

Note that this Wiki was a FINAL PROJECT from when the class was in person, so not everything will be relevant (such as the field trip and aquifer test), and we are also covering some different material (for example, we are now investigating road salt). Keep in mind that this group also had five people, so it's okay if your Wiki ends up being a bit smaller than this. I am looking for a concisely told, clear story that we can share with the water resource specialist in McHenry County- so **quality over quantity**!

Group Project Part 3: Chloride simulation, model calibration, and final wiki (Due 5/9)

Version of the model that you should be working from (I recommend starting from the develop group branch but you can also start from the main): https://github.com/dbabrams/G572McHenryCountyGWModel/tree/develop_group.

We are now in the home stretch! I'm not assigning tasks to people at this point, your group must work together and determine how you would like to distribute tasks. Please update and track the GitHub Projects Tool so that I know who is responsible for individual tasks: https://github.com/dbabrams/G572McHenryCountyGWModel/projects/1. Please make sure that every group member has a mix of coding and Wiki tasks. However, be pragmatic, if somebody ends up doing a bit more on the Wiki and somebody else a bit more on the coding, that's perfectly fine.

As you work on things over the next two weeks, please remember that I am going to track participation over the rest of the semester using GitHub:

- I will review who has made changes to the Wiki
- I will review who has posted code onto GitHub

How can you ensure that you earn a **B** on this group project?

1. As a group, ensure that chloride is added via recharge to the model in a network representative of urban areas and roads.
2. As a group, ensure that a code is developed to compare observed to simulated chloride in a 1:1 plot, similar to the existing head calibration plot in the code. *Pay particular attention that the observed chloride data are compared to the simulated chloride in the appropriate layer.
3. As a group, attempt to improve both head and chloride calibration. Note that the model is already calibrated fairly well to heads, but if you can improve it all the better. I have no idea how the model will calibrate to observed chloride, that is brave new territory. Do your best and show the effort to improve calibration, as best you can. Please refer to the list of calibration improvements for the head model that I attempted that are in the .ipynb file for an idea on how to document your work.
4. Make sure all of the Wiki topics discussed in **Task 3 Wiki Maintenance** are covered in your completed Wiki. Remember that you can combine topics into a single page- I am more concerned with a cohesive story. **Right now, I don't see a story, I see a series of disconnected pages so make sure to get that narrative together by organizing your pages in a sensible manner.**
5. As a group, add a discussion about the chloride modeling (including assumptions about how chloride enters the aquifer), head and chloride calibration, and results. Include maps showing chloride in the basal sand (Layer 9) during the following years: 1980, 2000, and 2020
6. As an individual, demonstrate coding activity on GitHub. Please view this video to see how you can work in a group setting and still ensure that everybody's activity level is fairly represented (https://mediaspace.illinois.edu/media/t/1_qriapm21).
7. As an individual, demonstrate activity on the Wiki.

How can you ensure an **A** on this group project? Make an honest effort to address the following question with your code.

1. In the existing model, the chloride simulation runs for 70 years (from 1950 to 2020), applying a constant concentration over that entire period. Run a model simulation where these same chloride applications continue until 2050.
2. Let's assume that management strategies and sensible salting practices reduce chloride that enters the aquifer via recharge by 50% starting in 2025. Run a model simulation to determine the resulting chloride distribution in the aquifer in 2050.
3. Create a Wiki page discussing possible future outcomes, including 2050 maps of basal sand (layer 9) showing constant applications into the future and a 50% reduction starting in 2025.

How can you ensure an **A+** on this group project? Wow me. Here are some ideas that people have done in previous semesters. Note that one of these will wow me, please don't try to do everything! Also, this is just a list of things I have seen in the past, feel free to run with your own ideas on this one:

1. Add county boundaries to the maps of McHenry County that are created by Python in the FloPy code
2. Export the results of the model (such as the chloride maps) and bring those into ArcGIS to create professional looking maps
3. Create a map in the FloPy Python code showing where your calibration errors are largest (this is not always evident in a 1:1 map)
4. Create a video in Python of chloride changes through time

Wiki Tips:

- The word "data" is plural!!!!!!
- Tell a story, don't just create multiple stand-alone pages
- To order your story, use numbers before the headings (Wiki pages are ordered by default in alphabetical order so this helps keep your story cohesive)
- Add images for GitHub into the appropriate folder on the Main