HWRS 564a Hydrogeologic Analysis Tools & Methods I
Fall 2025

Class time: Tu/Th 2:00 – 3:15

Class Location: Harshbarger 203

Instructor and Contact Information

Dr. Andrew Bennett (he/him)
Office hours: 1:00-2:00 pm, every Tuesday in Harshbarger 203
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Catalog Description

This course will present foundational tools and methods for analyzing and modeling hydrogeologic systems. Students will learn how to perform quantitative analysis on real world data using a variety of tools including Excel, Python, and QGIS. Students will also learn to simulate groundwater systems using the USGS MODFLOW hydrologic model. Topics covered will include writing iterative solutions, performing timeseries analysis, plotting figures and graphs, and running model simulations. As a result of these activities students will gain a holistic view of the role of computing and computational methods in understanding hydrogeologic systems.

Course Prerequisites or Co-requisites

No pre-requisites, but the student must be enrolled in the MS Hydrogeology program.

Required co-registration in HWRS 599 Section 001 (Recitation), HWRS 561a - Physical Hydrogeology I, HWRS 562a Chemical Hydrogeology I, HWRS 563a Hydrogeologic Measurement Methods I, and HWRS 565a Communications in Hydrogeology I

Required Textbooks/Materials

None

Reference Readings (Optional)

References will be provided as needed through D2L. You will not need to purchase these references.

Course Objectives

Students will…

1. import data into excel, conduct simple calculations and plot data
2. build and run computational notebooks, setting up a python environment and importing the required python packages
3. Use scientific computing packages such as pandas, and matplotlib to analyze and plot timeseries data and gridded hydrogeologic data
4. identify and fill missing or outlier data using python
5. Run and modify steady state and transient MODFLOW models using templates provided by the instructor
6. Understand and use best practices and modern techniques for writing code to conduct scientific analysis

Expected Learning Outcomes

Students will be able to…

1. Manipulate, clean, and analyze major types of hydrogeologic data using common analysis platforms such as Excel and python
2. Interpret and modify MODFLOW Models for both transient and steady state systems.
3. write common programming constructs for data analysis and processing such as loops, control flow, aggregation, and filtering.
4. Build data processing pipelines using industry standard techniques that are reproducible, extensible, and documented.

Course Format and Teaching Methods

This course will consist of a mixture of lectures, discussion and interactive coding activities. Every week, I will present new material, students will present their work and we will have group discussions and code walkthroughs. This is a very interactive course and students are expected to participate in discussions and come prepared to share their work and help others.

Planned Field Trips

The class will begin this course with a field trip during the entire first week of class, and will apply to all courses in the MS Hydrogeology Fall semester (this course, but also HWRS 561a, HWRS 562a, HWRS 564a, and HWRS 565a). The field trip will begin on the first Monday of the first full week. Students should plan to be out of town for the entire week, including camping overnight.

Additionally, there may be field trips in the other courses in the MS Hydrogeology program. The timing of trips is coordinated with students' schedules and the instructors of the other courses in the MS Hydrogeology program. Please plan accordingly. Participation in field trips for the other courses will not impact the schedule of this course.

Schedule of Topics & Activities

The course will be organized around month long projects that give a learning context for all five co-convened classes. following the theory-data-prediction structure, including case-based theory and project-based methodology practice. For Fall 2025, the scheduled activities are follows.

Week	Monday date	Topics covered this week	Assignment due this week
1	8/25/2025	**Road trip- No Class**	
Module 1: Introduction to Excel			
2	9/1/2025	**Data and plotting:** intro to the major types of data and arrays, how to import data into excel, basics of plotting	
3	9/8/2025	**Iterative solutions:** iterative solutions, pivot tables, precision vs accuracy and handling missing data	HW 1: Intro to excel workbook
Module 2: Intro to Python			
4	9/15/2025	**What is python and how do we interact with it:** Jupyter notebooks, setting up a python environment, working with packages, basic python syntax, variables, executing python commands	HW 2: Iterative solutions excel workbook Project 1 Analysis Homework
5	9/22/2025	**Control flow and packages:** Using conditional statement to select data, using for loops, accessing mathematical functions from python packages	HW 3: My first Jupyter notebook
6	9/29/2025	**Intro to arrays and plotting:** Pandas data frames, reading csv data into python, filling missing data, indexing conventions in pandas and selecting subsets of data, doing row wise and column wise operations basics of plotting with matplotlib	HW 4: Iterative groundwater solution in python
7	10/6/2025	**More on functions and control flow:** Basics of how functions work, how to write and modify your own functions, applying an analytical solution to a dataframe using control flow, when to loop and how to avoid unnecessary loops.	HW 5: Working with pandas dataframes Project 2 Analysis Homework Part 1
8	10/13/2025	**More on Matplotlib:** creating basic plots in python, adding and adjusting titles, controlling color, adding legends, plotting more than one thing, creating multi panel plots, finding example plots to start from.	HW 6: Analytical and numerical solutions for transient saturated flow
Module 3: Intro to MODFLOW and FloPy			
9	10/20/2025	**Intro to FloPy and MODFLOW:** basics of the MODFLOW model what it does and why we use it, overview of MODLFOW's modular structure, ways of interacting with MOFLOW, intro to FloPy, Installing and running a MODFLOW model with FloPy	HW 7: Plotting with Matplotlib

			Project 2 Analysis Homework Part 2
10	10/27/2025	**Inputs output and hitting go:** using a 2D steady state model we will walk through the basics of setting up running and visualizing results from a MODFLOW model.	HW 8: MODFLOW structure diagram
11	11/3/2025	**Gridding, initial conditions and boundary conditions in MODFLOW:** using a 2D steady state model to explore basic modeling concepts, setting up a simple grid, type of boundary conditions and how you set them in MODFLOW, interpreting and plotting outputs, confined vs unconfined simulation	HW 8: My first MODFLOW model
12	11/10/2025	**ET Recharge and Pumping in MODFLOW:** running transient models, implementing ET and recharge, choosing between MODFLOW packages and understanding their assumptions, inserting recharge and pumping wells, plotting to compare outputs from multiple simulations.	HW 9: Building a 2D steady state MODFLOW model Project 3 Analysis Homework Part 1
Module 4: Python Part 2			
13	11/17/2025	**Pandas data frames Part 2:** understanding and working with datetime data in python, working with dates using pandas, plotting dates, indexing and selecting data	HW 11: Applying fluxes to a 2D MODLFOW model
14	11/24/2025	No class: Thanksgiving break	N/A
15	12/1/2025	**Coding practices**: Writing your own functions, writing clean code, setting up environments others can use, using python scripts rather than jupyter notebooks.	HW 12: Pandas groupby, resample, and rolling operations Project 3 Analysis Homework Part 2
16	12/8/2025	**Coding practices 2**: Modules and imports, setting up a project structure.	HW 13: Python scripts and functions

Course Assessments and Grading Breakdown

You will be assessed on the basis of weekly assignments. You will also be assessed based on how you apply the understanding gained in this class to the projects. Finally, you will also be assessed based on your participation in the course.

Course Assignments: are designed to develop your understanding of elements of the course and to give you practice in applying that knowledge. A time budget will be given for each Course Assignment. They may include calculations, analysis, synthesis, and written elements. Course Assignments count toward your grade in the course and should be turned in through the D2L site for this course unless otherwise indicated by the instructor. The instructor may provide specific format requirements for assignments. In this course, Course Assignments will be given on Mondays. Assignments that are to be turned in online through D2L will be due at Wednesday at 11:59pm on the following week. Assignments that are to be turned in as hardcopy are due at the beginning of class on the due date.

Project-Relevant Assignments: are designed to help you to apply the content of this class to the program-wide projects. In some cases, these Project-Relevant Assignments will produce outcomes that can be included directly in your project. In other cases, the Project-Relevant Assignments will act as a bridge between the course material and the project requirements. Even if the project is team-based, **every student must complete all Project-Relevant Assignments**. A time budget will be given for each Project-Relevant Assignments. They may include calculations, analysis, synthesis, and written elements. Project-Relevant Assignments count toward your grade in the course and should be turned in through the D2L site unless otherwise indicated by the instructor. The instructor may provide specific format requirements for assignments. In this course, Project-Relevant Assignments will be given on Monday. Assignments that are to be turned in online are to be submitted, through D2L, by Wednesday at 11:59pm the following week. Assignments that are to be turned in as hardcopy are due at the beginning of class on the due date.

Participation: it is expected that all students in the program will participate fully in all aspects of the course. This includes showing up in class, being present and engaged in discussion, answering and asking questions during class, and contributing to the culture of learning of the program. If a student is not meeting expectations, they will be notified by the instructor, given guidance on how to increase their participation, and given a chance to improve. Thereafter, if student continues to fall below meeting the expectations for participation, their class participation points will be reduced.

The percentage distribution of your grade will be as follows.

Course Assignments (12): 60%

Projects – analysis component (5): 25%

Participation: 15%

University policy regarding grades and grading systems is available at this link.

Other Activities – Not Graded/Assessed

Practice Exercises: are designed to help you develop the ability to apply concepts and calculations presented in class. These exercises are NOT GRADED – the answers are provided with the questions. No time budget is given for these assignments. Rather, they are provided as an aide in case you feel that you need help. You may be directed to complete these exercises based on the instructor's assessment.

Final Examination or Project

There is no final examination in this course. However, students will be completing 3 projects this semester that cut across all courses in the MS Hydrogeology program, and will require students to utilize and synthesize the skills they learned in all 5 courses to address a hydrogeologic question/problem. Presentation of the third and last Term Project of the semester will take place on December 10, 2025, the last scheduled day of classes. These presentations will be organized as a mini-conference and professional hydrogeologists will be invited to attend in person or online.

Grading Scale

Your final grade will be informed via D2L. Letter grades are determined using the following scale:

A: >= 90.0%

B: >= 80 - 89%

C: >= 70 – 79 %

D: >= 60 to 69 %

E: below 59 %

University policy regarding grades and grading systems is available at https://catalog.arizona.edu/policy/courses-credit/grading/grading-system.

Latework Policy

This class and the entire program depend strongly on student participation and you are only able to participate fully if you have done the homework on time. Therefore, no late assignments will be accepted for credit. We do understand that life happens, so we will automatically drop your two lowest assignment grades for this course when calculating your final grade.

Incomplete (I) or Withdrawal (W):

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at this link associated with the registrar.

University of Arizona Course Policies

All University of Arizona course and syllabi policies, as well as other helpful information and resources, can be found at this link.

If you are in need of basic needs care, here is another helpful link, in addition to what you can find at the policy link above.

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.