HWRS 564B Hydrogeologic Analysis Tools & Methods II
Spring 2026

Catalog Description

This course will present foundational tools and methods for analyzing and modeling hydrogeologic systems. Building from HWRS564a students will perform more advanced quantitative analysis, data processing, and modeling tasks on real-world hydrologic problems. The course will primarily focus on Python, QGIS, MODFLOW and FloPy. Students will apply these software packages and learn how to work with common data types used in hydrogeologic analysis. As a result of these activities, students will expand their understanding of the role of computing and computational methods and develop applied skills to mitigate water resource-related challenges.

Course Prerequisites or Co-requisites

HWRS 564a Hydrogeologic Analysis Tools & Methods I

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. Build, run and visualize transient 3D models with particle tracking in MODFLOW
2. run ensemble MODFLOW simulations and plot model uncertainty
3. open and visualize vector and raster data in QGIS and python and make presentation quality maps
4. manipulate geospatial data in python and QGIS, calculate zonal statistics and overlay spatial features
5. write functions and python and setup reproducible workflows
6. access external datasets through APIs with python
7. open, analyze and visualize common types of hierarchical data

Expected Learning Outcomes

Students will be able to…

1. describe subsurface flow paths and model uncertainty using ensemble simulations and particle tracking in MODFLOW simulations.
2. build data analysis workflows that can access remote data, be shared with others and easily reproduced.
3. visualize and evaluate common types of geospatial data and make professional quality maps in both QGIS and python.

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

While this class has no field trips, there may be field trips in the other courses in the MS Hydrogeology program. The timing of all field trips are coordinated with students' schedules and the instructors of the other courses in the MS Hydrogeology program. This allows us to accommodate the field experience and not have it impact your participation in 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 Spring 2026, the scheduled activities are follows.

Week	Monday date	Topics covered this week	Assignment due this week
Module 1: Working with MODFLOW Models			
1	□ی□ی□□□	**Particle Tracking:** Introduction particle tracking in gridded models, overview of the MODPATH package, adding particles to our MODFLOW simulations and visualizing particle tracking results.	
2	□ی□ی□□□	**Vertical layering, heterogeneity and 3D plotting:** Exploring the different layering options in MODFLOW, building layered models , adding subsurface heterogeneity and learning now to extract data and make plots of 3D models.	HW 1: Particle tracking simulations
3	□ی□ی□□□	**Transient Simulations:** Exploring how MODFLOW handles time, introduction to stress periods and time steps and how to set them up in a simulation, adding transient fluxes to a MODFLOW model, plotting transient simulation results.	HW 2: Layered MODFLOW model Project 4 Analysis Homework 1
4	□ی□ی□□□	**Uncertainty and Ensembles:** Running ensemble simulations in FloPy, reading in outputs from multiple simulations and plotting results, quantifying and visualizing simulation uncertainty.	HW 3: Transient MODFLOW simulations Project 4 Analysis Homework 2
Module 2: Working with Geospatial Data in QGIS			
5	□ی□ی□□□	**Shapefiles (vector data):** What is a shape file and why do we use vector data for geospatial datasets? Overview of shape file features (point, line and polygon data). Introduction to working with shape files in QGIS: opening and viewing files, working with attribute tables, adjusting symbology and basic calculations.	HW 4: MODFLOW ensemble analysis
6	□ی□ی□□□	**Rasters (gridded data):** Understanding the difference between raster data and vector data, common file types for raster data and their differences, data projections and how to work with them, adding basemaps and accessing raster data online.	HW 5: QGIS shapefile exploration
7	□ی□ی□□□	**Map Composition:** The elements of a good map and basics of map compositions, working with print composer in QGIS to build map compositions, guidelines for good graphical communication in maps and making maps that are accessible.	HW 6: QGIS raster data exploration
8	□ی□ی□□□	No Class Spring Break	
9	□ی□ی□□□	**Geoprocessing and Geostatistics:** Basics of joining, merging dissolving and intersecting features and datasets, zonal statistics, processing toolkits available in QGIS.	HW 7: QGIS map production Project 5 Analysis Homework

Module 3: Working with data in Python			
10	□□□□□□	**Geospatial data in python with geopandas:** How to read data into a geopandas dataframe, the differences between geopandas and pandas, reprojecting data, raster calculations and plotting spatial data.	HW 8: Delineating watershed boundaries and calculating watershed statistics.
11	□□□□□□	**Hierarchical data and coding practices:** What is hierarchical data and what are some common hierarchical data types, working with netcdf and JSON files.	HW 9: Geospatial data plotting in python
12	□□□□□□	**Working with remote data in Python:** What's an API and how to use them, commonly used API's for point data, formatting messy data, handling outliers and missing data.	HW 10: NetCDF data practice and plotting Project 6 Analysis Homework 1
13	□□□□□□	**Data workflows:** Finding and accessing cloud based datasets, using remote compute and building reproducible workflows.	HW 11: Working with external point data from APIs
14	□□□□□□	**Data driven modeling 1:** Refresher on basic statistics, ordinary least squares regression analysis, and data science workflows	HW 12: Working with external gridded data from google earth engine
15	□□□□□□	**Data driven modeling 2:** Overview of machine learning landscape, classification and regression, tree based models	HW 13: Regression modeling with scikit-learn Project 6 Analysis Homework 2
16	□□□□□□	**Data driven modeling 3:** Model interpretation, limitations, and robustness	HW 14: My first machine learning model

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. If a student does not meet expectations for participation, they will receive zero class participation points.

The percentage distribution of your grade will be as follows.

Course Assignments (14)	: 60%
Projects – analysis components (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 May 6, 2026, 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.