CEE 623/ERTH 656 Groundwater Modeling

Fall 2022

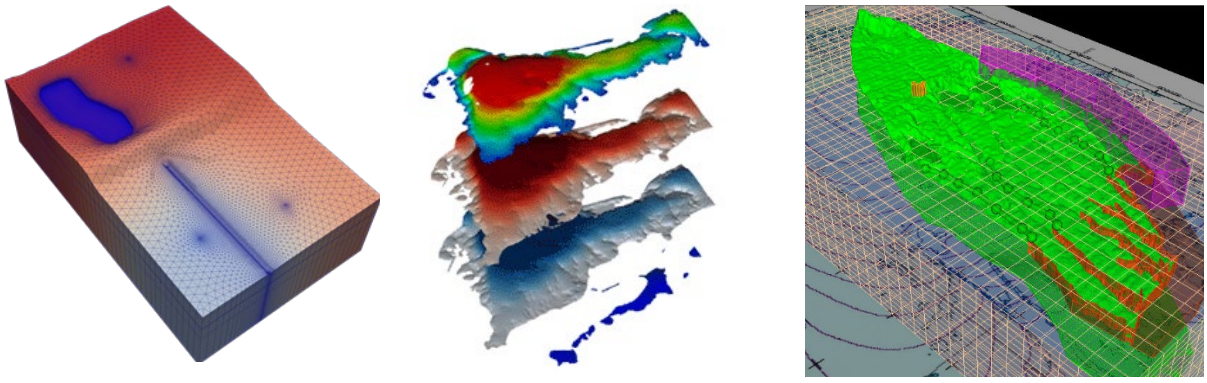

Figure (top) figures from USGS website; left: MODFLOW 6 grid example, middle: model layer visualization, right: Phreeqc-based reactive transport simulation example (bottom) left: seawater intrusion using adaptive meshing, middle: enhanced geothermal system modeling, right: USGS GUI Program ModelMuse

Course Description: This course focuses on the practical aspects of modeling groundwater flow and solute transport in the subsurface. The course utilizes USGS MODFLOW and related programs (such as MODFLOW, MODPATH, MT3D, and SEAWAT) with a USGS python package Flopy for model input preparation, execution, and postprocessing (e.g., visualization). Theory and development are explained throughout the course to understand 1) the mathematical expressions and physical interpretations of flow and transport phenomena and 2) the numerical processes inside the USGS models (e.g., finite volume method formulation, discretization, linear/linearized system, and matrix inversion). Several case studies are presented in the course with hands-on modeling in Google Cloud/UH HPC MANA. Based on the course materials, students are required to complete their own final project. Students who are not familiar with Python programming may use USGS GUI ModelMuse.

Course CRN: 75551 (CEE 623)/76778 (ERTH 631)

Instructor: Dr. Jonghyun "Harry" Lee (jonghyun.harry.lee@hawaii.edu)

Website: https://www2.hawaii.edu/~jonghyun/classes/F22/CEE623/

Textbook: Class notes, slides, and reference materials posted in the class website.

Reference websites:

1. CEE 623/ERTH 656 F21 by Dr. Aly El-Kadi

   https://sites.google.com/a/hawaii.edu/gw-modeling/

2. CEE 696 S18 optimal groundwater supply/pollution cleanup design (*note: outdated materials*)

   https://www2.hawaii.edu/~jonghyun/classes/S18/CEE696/

3. CEE 696 F21 model calibration - inverse modeling and data assimilation

   https://www2.hawaii.edu/~jonghyun/classes/S21/CEE696/

4. CEE 696 F22 advanced modeling in groundwater engineering

   https://www2.hawaii.edu/~jonghyun/classes/F22/CEE696/

Prerequisite: CEE 627 (or similar courses) and instructor consent.

Class Meetings: Mondays and Wednesdays, 9:00 to 10:15 AM at POST Building Rm 733

Grading: Assignments: 30%, Final Project: 70%

Assignments: homework is assigned every 1 or 2-weeks using Google Cloud (Google Colab). Students are also encouraged to use UH HPC MANA's interactive apps such as Jupyter Notebook for CPU-intensive tasks (and their final projects).

Tentative outline of lecture topics:

1. Review of hydrogeology/groundwater engineering
   - PDEs for groundwater flow and reactive transport
   - heterogeneity and scale
2. Numerical solution techniques
   - FDM, FVM, FEM and other numerical methods (see CEE696 F22 for more info)
   - Space/time discretization
   - Linear algebra
3. MODFLOW and related programs
   - MODFLOW, MODPATH, MT3DMS, SEAWAT and others
4. Python interface Flopy
   - program compilation using mfpymake
   - USGS model input structures and output visualization
5. Model Calibration (Inverse Modeling and Uncertainty Quantification)
   - Brief Intro to Model Calibration and Uncertainty Quantification (see CEE696 F21)
6. Potential Engineering Application Examples
   - Groundwater supply

- Contaminant transport and remediation
- Density-driven flow in coastal aquifer
- Geothermal engineering
- Multi-phase modeling
- Reactive transport