

# Applied Groundwater Model Calibration and Uncertainty Analysis Curriculum

Jeremy T. White, Michael N. Fienen, and Randall J. Hunt

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## MONDAY

1. **Introductions of students/instructors — JDub** Goals for the week and framing
  - (a) The mechanics and theory
  - (b) Learning by doing
  - (c) Please speak up! Everyone learns from discussion
  - (d) Work in pairs !!!
  - (e) Python, GUIs, and all that
2. **Logistics and airing of the IT grievances — JDub:**
  - (a) Did everyone get the software installed?
  - (b) Pull the class from github and make a copy
  - (c) Brief Git tutorial (including modeling workflows with Git)
3. **Regression — MNF** Notebook as simple machine learning
4. **Bayes Theorem and Inference — MNF** Adding context to regression
5. **RRR — JDub** Aspirational goals of groundwater modeling
6. **Demo with EAA model — JDub** Edwards Aquifer modeling workflow
7. **Freyberg model — MNF** Introduce the enhanced Freyberg model. Show "truth" observations, water budget, etc
8. **Connecting a model to PEST++ — RJH** Steady-state GUI Style - how can you connect a model to PEST with a GUI.

## TUESDAY

9. **Adding transience to a model notebook — JDub/MNF.** flopy/python review
10. **Intro to pyemu — JDub/MNF**
11. **Geostatistics, the Prior and pilot points — MNF** Variograms as a basis for interpolation, the use of factors, “spatially weighted averaging”, all this wrapped up in Kriging. Pilot points as a dimension reduction (“parameterization”) device.
12. **Setup pest interface notebook — JDub** Automating the construction of the PEST interface and associated components.
13. **Transient modeling discussion — RJH** The allure and pitfalls of transient modeling, esp for history-matching.
14. **Processing obs and setting weights notebook — JDub.** Discussion about observation processing to align with model stress periods and assigning meaningful weights.

## WEDNESDAY

15. **Prior Monte Carlo — JDub/RJH.** Mechanics of parallel run mgmt - including giveup setting, pestpp-swp and starting a worker manually. The relative safety of Prior Monte Carlo. Learning from Prior Monte Carlo. Foreshadowing of prior-data conflict

16. **GLM — MNF** Derivation of the Gauss-Levenberg-Marquardt Algorithm maths — walking through the PDF with  $\lambda$  images
17. **PESTPP-GLM part 1 notebook: fill a base Jacobian — RJH.** Start this then cover FOSM theory
18. **FOSM theory (including ident and sens) and dataworth — MNF** FOSM as an alternative to MC (rejection sampling). PEST lingo = PREDUNC/GENLINPRED. Posterior residual-based weight adjust and implications.
19. **Dataworth notebook — JDub**
20. **Singular Value Decomposition — MNF** Algorithm at the heart of alot of what we are doing. Super parameters (parameter space reduction).
21. **PESTPP-GLM part 2 notebook — JDub.** Actual parameter adjustments (scary!) and posterior parameter and forecast estimation. change the forecasts and do more dataworth

#### **THURSDAY**

22. **Ensemble-based modeling analyses — JDub.** Considerations for using ensembles. parameter statistical moment changes instead of "sensitivity analysis". Visualizing obs vs sim. more comprehensive pest interface.
23. **PESTPP-IES notebook part 1 — MNF.** Vanilla IES, prior-data conflict and total error covariance workflows.
24. **Localization and PESTPP-IES notebook part 2 — JDub.** using varies forms of localization
25. **Live Demo: ensemble-based scenario modeling — JDub** Create a scenario model, setup a pest interface and run prior or posterior Monte Carlo (pestpp-swp)

#### **FRIDAY**

26. **Stuff we didn't get to yet**
27. **Mgmt opt under uncertainty — MNF:** examples from SIRE and Little Plover
28. **PESTPP-OPT notebook — JDub:** running PESTPP-OPT on the freyberg model to optimize GW use subject to SW-GW exchange constraints.
29. **Discussion and wrap up — ALL**