Applied Groundwater Model Calibration and Uncertainty Analysis Curriculum

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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 λ 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**