Applied Groundwater Model Calibration and Uncertainty Analysis Curriculum

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Feb 2020

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** Long boring talk about the false promise of reproducible modeling.

6. **Demo with EAA model — JDub** run thru 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?

9. **run iES and viz in Excel and python — RJH** All defaults, uncertainty from the start

   TUESDAY

10. **Adding transience to a model notebook — JDub/MNF**. flopy/python review

11. **Intro to pyemu — JDub/MNF** show that can start in GUI and flip over to pyemu

12. **Geostatistics, the Prior and pilot points — MNF** Part 1: more on pilot points: Exploring the idea of a model of spatial correlation (e.g. covariance matrix). Variograms as a basis for interpolation, the use of factors, "spatially weighted averaging", all this wrapped up in Kriging. Function for creation and viz. Spectral simulation for unconditional simulation. What are pilot points? Add storage pilot points low level in pyemu?

13. **Setup pest interface notebook — JDub** "what just happened!?". Excersize: experiment with the PstFromFlopy class to setup different pars and obs. competition: who can setup the most parameters? Think a giant macro that pulls together the various elements have seen to far.

14. **WTF is up with transient modeling? — RJH**. Discussion about the allure and pitfalls of transient modeling, esp for history-matching.

15. **Processing obs and setting weights notebook — JDub**. Discussion about observation processing

    WEDNESDAY

16. **Prior Monte Carlo — JDub/RJH**. Do this before even setting obsvals or weights. mechanics of parallel run mgmt - including giveup setting, pestpp-swp. The safety of Prior Monte Carlo. Learning from Prior Monte Carlo. Discuss prior data conflict

17. **GLM — MNF** Derivation of the Gauss-Levenberg-Marquardt Algorithm maths — walking through the PDF with λ images

18. **PESTPP-GLM part 1 notebook: fill a base Jacobian — RJH**. Start this then cover FOSM theory

19. **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.

20. **Dataworth notebook — MNF**

21. **PESTPP-GLM part 2 notebook — JDub**. Actual parameter adjustments (scary!) and posterior parameter and forecast estimation. change the forecasts and do more dataworth

22. **Singular Value Decomposition — MNF** Algorithm at the heart of alot of what we are doing

    THURSDAY

23. **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.

24. **PESTPP-IES notebook part 1 — MNF**

25. **Localization and PESTPP-IES notebook part 2 — JDub**

26. **Prior-data conflict - returning to Prior Monte Carlo — JDub** Bias-variance tradeoff. Pontification around the obession with a good fit vs the reality flawed models and noisey data. Underfitting as a strategy to avoid bias.

27. **PESTPP-IES with PDC activated — MNF**

28. **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

29. **Stuff we didn't get to yet**

30. **Mgmt opt under uncertainty — MNF**: examples from SIRE and Little Plover

31. **PESTPP-OPT notebook — JDub**

32. **Discussion and wrap up — ALL**