ESM 232 Environmental Modeling

Ante-Syllabus ("ante" in the sense of "prior to," but the similarity to "anti" is purposeful)

I hope you're okay with not having a Syllabus. I have a set of topics I would like to cover, but I don't want to pre-ordain the pace.

All models are wrong, but some are useful — George Box

Computer-based modeling and simulation are widely used tools in both practical environmental problem solving and in environmental research. Models give us a way to look at the world through a mixture of data and theory. A good model can help us to understand how the world works and how decisions that we make might change the world in ways that are important to us.

Why MATLAB?

I realize that my colleagues who use R (Naomi, Chris, Ben) or Python (Frew) will probably outlive me, but MATLAB is a better modeling language with not much of a speed penalty compared to lower-level languages like C or FORTRAN. MATLAB is widely used in science and engineering. Even Naomi affirms that while R is useful for designing models, it's not good at actual computationally intensive modeling. I use MATLAB in my research.

One concession, which even the R Aficionados' acknowledge, is that the MATLAB documentation is superior to the alternatives.

However, I understand that if you know R or Python well, you may not want to learn a new language. I have the same view in the opposite direction; I've learned a bit of R, but every time try to solve a problem using R, I revert because I find the task easier in MATLAB. **If you want to use another language, that's okay,** the disadvantage being that I can help you with the model structure but not with the coding. Alternatively, if you want to use MATLAB for your statistics courses, I will help.

Possible Topics (covering different methods, and different environmental domains)

Learn to use MATLAB. It's a rich language, so I continue to learn new tricks, but the basics are not difficult.

Explore the Planck equation, plot in two dimensions (wavelength, temperature), compare numerical integral from 0 to infinity with the analytic solution. Effectively use vectors and matrices in MATLAB.

Analyze statistical datasets that are not normally distributed, forecast probabilistic future, and examine the effect of autocorrelation. Use MATLAB's statistics functions.

Analyze a model of crop yields vs. temperature, and forecast probabilistic future.

Consider a matrix-population model (along with using MATLAB's matrix algebra features).

Analyze a predator-prey model and use MATLAB's differential equation solvers.

Solve the energy balance equation for a lizard.

Explore chaos with the Lorenz equations.

Solve a problem for Ty Brandt's PhD thesis, about orographic precipitation. At what elevation is the precipitation rate maximized?

Revisit the Harte Model from ESM 203, with the help of MATLAB's Symbolic Algebra tools.

Make a nice shaded relief map using MATLAB's Mapping and Image Processing Toolboxes.

Learn about parallel computing (on a multi-core machine, or on the Cloud).

Develop a comprehensive model as a group.

Grading

I cannot teach you to model, but I can help you learn. You will teach yourself by working through the assignments. To encourage you, 60% of your grade will be based on the assignments, and you get full credit for any problem where you make a serious attempt. I will comment on your approach, but I won't assign some fractional number of points. I will also publish my solution to each assignment, hopefully with a quality that you can emulate!

I will, however, grade two assignments: (1) Your choice of a final project, where you code a model of your interest, over the last 2½ weeks, 21 November on. (2) A final exam, where you solve a short coding problem on your schedule during Finals Week (in some companies, such an exercise often comprises part of a job interview).