Lecture 19:

Recap

This is the final session of this course and a chance for us to try to reflect on the content of the entire course.

Putting it all together

In this course, we've looked at a broad range of strategies for analyzing time series. Can we make some decisions about how we might plan an experiment and analyze our data?

Let's consider a central problem of physical oceanography. Can we evaluate the ocean response to wind:

$$\frac{\partial u}{\partial t} + u \cdot \nabla \mathbf{u} - fv = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \frac{1}{\rho}\frac{\partial \tau^x}{\partial z} \quad (1)$$

$$\frac{\partial v}{\partial t} + v \cdot \nabla \mathbf{u} + fu = -\frac{1}{\rho}\frac{\partial p}{\partial y} + \frac{1}{\rho}\frac{\partial \tau^y}{\partial z} \quad (2)$$

Suppose we cross out a few terms. What do we need to measure to evaluate whether we've crossed out the right terms? Can we show that one of these is a reasonable approximation?

$$\frac{\partial u}{\partial t} = \frac{1}{\rho}\frac{\partial \tau^x}{\partial z} \quad (3)$$

$$-fv = \frac{1}{\rho}\frac{\partial \tau^x}{\partial z} \quad (4)$$

$$-fv + -\frac{1}{\rho}\frac{\partial p}{\partial x} = \frac{1}{\rho}\frac{\partial \tau^x}{\partial z} \quad (5)$$

$$(6)$$

Methods we've explored in this class include:

1. Basic statistics: means, standard deviation, variance, standard error
2. Probability density function
3. Least-squares fitting
4. One-dimensional spectra (with windowing and uncertainties)
5. Two-dimensional spectra
6. Monte Carlo methods for evaluating confidence limits
7. Coherence

Intangibles

Besides the formal topics for which you've done problem sets, this class has aimed to start you thinking more like a data analyst. This has thrown you into the thorny world of real data problems, and I'm immensely grateful to you for your persistence. Some life lessons from this class:

1. In science, we favor evidence-based decision making over shoot-from-the-hip opinons. Data analysis gives you a set of tools for this.

2. Your good judgement matters in deciding how to approach a data analysis problem. You should always ask yourself how your understanding of the physics can inform your approach.

3. Even the rigors of the peer review process cannot guarantee the fidelity of published sources of information. Be skeptical and inquisitive.

4. You have the tools at your disposal to address your skepticism. Fake data and Monte Carlo methods are always an option.

5. Many questions have not been answered carefully, and there is room for you to make significant contributions. (I think the pier station staff are still looking for the perfect means to validate the methodology used for the pier samples.)

6. Just because something appears to be significant at the 95% level doesn't guarantee that it is a robust signal.

7. If your results are wildly dependent on the details of your methodology, that might mean that paying attention to methodology matters, but it also could be a warning sign that you're trying to identify a signal that is more wishful thinking than real signal.

8. The methods that we apply to real data can be exactly analogous to problems that we've done in this class, or they can be surprisingly divergent.