Problem Set 3: MAE 127

due Friday, April 22, 2005

1. In problem set 2, you computed wind velocities from wind speed S and direction θ, (hopefully) using the equations:

$$\begin{aligned} u &= -S\sin(\theta * \pi/180) \\ v &= -S\cos(\theta * \pi/180). \end{aligned}$$

where the minus sign appears, because the angle θ reported in the data set indicates the direction from which the wind comes. Use error propagation to estimate the uncertainties in u and v as a function of uncertainties in S and θ.

2. How much CO_2 can be stored in the ocean? Burning fossil fuels releases CO_2 into the atmosphere, where it is responsible for greenhouse warming, but not all of the fossil fuel remains in the atmosphere. Some is taken up by plants, and some is stored in the ocean. Problems 2 and 3 look at the problem of estimating air-sea CO_2 gas exchange.

The gas transfer velocity defining air-sea CO_2 exchange is a function of wind speed:

$$k = 0.0283u^3(Sc/660)^{-1/2},$$

where u represents the instantaneous wind speed (officially at 10-m elevation, but we won't worry about that for this problem), and Sc is the Schmidt number.

$$Sc = 335.6(MW)^{1/2}(1 - 0.066T + 0.002043T^2 - 0.000026T^3)$$

where MW is molecular weight and is equal to 44 grams/mole for CO_2, and T is sea surface temperature in °C. Use the wind data and sea surface temperature data from buoy.mat, the data set that we began using in problem set 1, to estimate the gas transfer velocity as a function of time. Plot the pdf of the gas transfer velocity. What are its mean and standard deviation?

3. Assuming that temperatures are accurate to ± 0.2°C and velocities to 0.5 m/s, propagate errors through the equation for k to estimate its uncertainty. Show your algebra. Are your uncertainty estimates consistent with the standard deviation computed in problem 2?