12.009 Problem Set 7: The Core Issue

Due Tuesday, April 26

1. *Ice Volume*: In class we have looked at various records found in the ice cores which appear to exhibit frequencies consistent with orbital forcing. Specifically, we looked in depth at the record of δ^{18}O as a proxy for the ice volume:

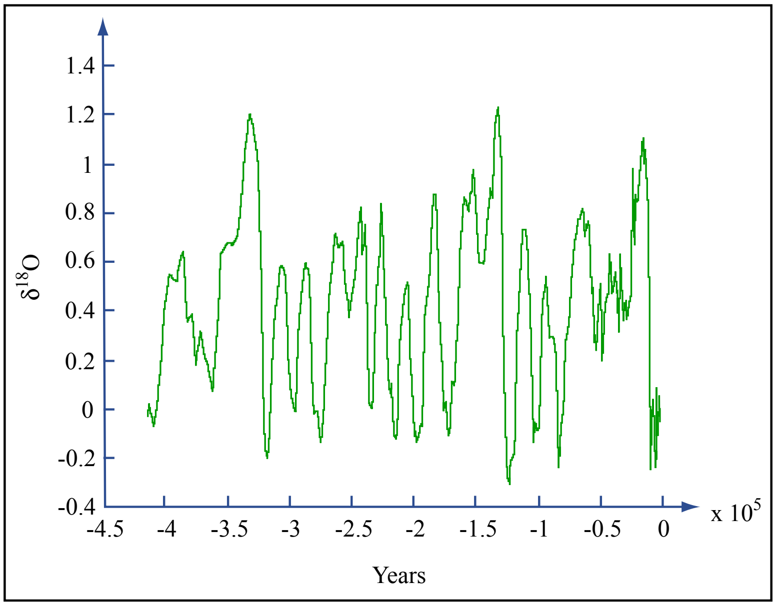


Image by MIT OpenCourseWare.

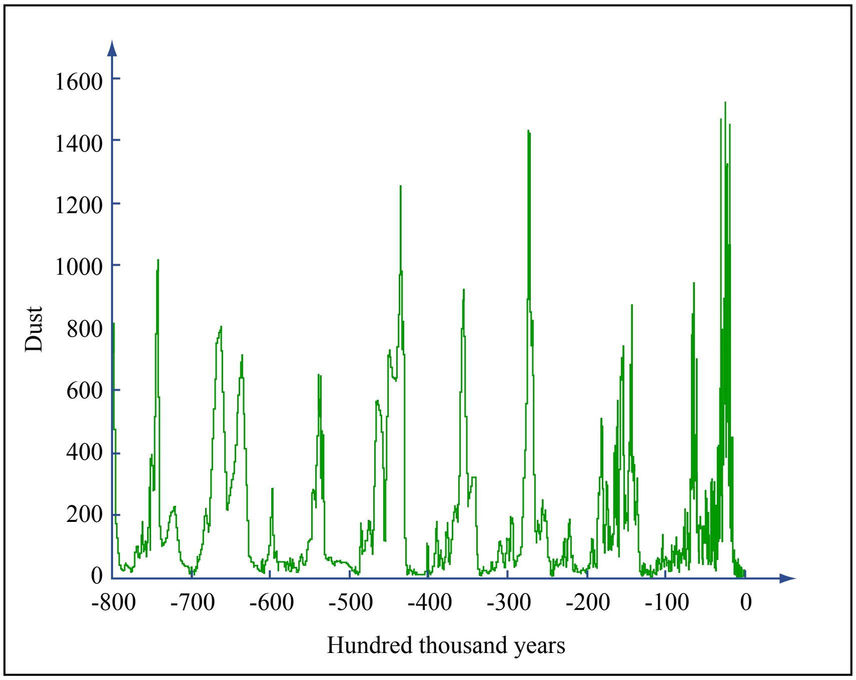
   (a) Explain why and in what direction we would expect δ^{18}O in the atmosphere to change as a result of glaciation and deglaciation.

   (b) Make a plot of the power spectrum for this data using the equally spaced data interpolation found in Vostok.mat.

   (c) On the same plot you just made locate where the peaks due to oscillations in the eccentricity, precession, and obliquity should fall.

   (d) If you have done things correctly, there should be a clear maximal peak in your power spectra. Which orbital oscillation matches the frequency of the largest peak? Based on what we did in class why does this make sense and why is it confusing?

2. *Very Dusty*: Along with oxygen isotopes and a plethora of other gases trapped in air bubbles, ice cores also store an often overlooked tracer, dust. The following 800,000 year record of dust



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was taken in Antarctica from the longest continuous ice record available. This data can be found in dusty.mat.

(a) The data in dusty.mat is the original, unevenly spaced data directly from the core. In order to use normal Fourier Transform methods we must interpolate the data so that it is evenly spaced. Use MATLAB function `interp1` to get an evenly spaced data set and make a plot of the data. How does the dust data set compare to the data set for δ^{18}O? What might cause these differences?

(b) Make a plot of the power spectrum for this data and label the dominant peak with its frequency. How does the power spectrum of dust compare to the power spectrum of δ^{18}O?

3. *Our Noisy Reality*: In both the case of the oxygen isotopes and the dust we ignored the influence of random processes in determining the power spectrum. Here, we ask if the peaks we see in the power spectrum are due to random chance. For this part, we will use the δ^{18}O data set only and compare the spectrum to that of a null-model, uncorrelated random events.

(a) Write a code in MATLAB which will generate a random time series having the same mean and variance as the δ^{18}O data. Make a plot of one of these random time series on top of a plot of the δ^{18}O time series. How do they compare?

(b) We are interested in understanding which peaks in the power spectrum of δ^{18}O are significantly different than what we could expect to be generated from a random, uncorrelated time series. Write a MATLAB script which generates many random time series and their power spectra. On your plot of the power-spectrum for δ^{18}O plot a boundary curve for which 95% of the random spectra did not pass. We will refer to this as a 'noise floor'. What does it mean for a peak to be greater than this?

(c) Which frequencies in the power spectrum are both consistent with orbital forcing and above the 'noise floor' for the random null model?

12.009 Theoretical Environmental Analysis
Spring 2011