Homework #5

ErSE 253 – Data Analysis in Geosciences, Fall 2014

Due in class on Thursday, 30 October

In this homework we will practice some time-series analysis methods.

Problem 1 (5 points)

Here we will work with a 2.5 million year long time-series of oxygen isotope ratios that are indicative of climate variations during the long time period. Download the following data file:
https://dl.dropboxusercontent.com/u/6221783/ErSE212/HW5P1.mat

The file contains two variables “oxr” and “tax”. The “oxr” values are the oxygen isotope ratios and “tax” is time in years. The oxygen ratio, $\delta^{18}O$, measures the ratio between stable isotopes ^{18}O and ^{16}O and it is commonly used as a measure of paleo-temperature. The ratio is in “per mill” (parts per thousand, sometimes denoted as ‰)

$$\delta^{18}O = \left(\frac{\left(\frac{^{18}O}{^{16}O}\right)_{sample}}{\left(\frac{^{18}O}{^{16}O}\right)_{standard}} - 1 \right) * 1000\ ‰$$

a) plot up the time-series as a function of time in years (or millions of years). Make sure to mark both axes.
b) What is the sampling interval and the Nyquist frequency?
c) Remove the mean from the time-series, and then calculate and plot the power-spectrum of the time-series and mark the axes appropriately.
d) At what frequencies can you identify major peaks in the spectrum? To what temporal intervals (in years) do these peaks correspond? Can you find an explanation for them?
e) Convolve a wavelet b_k=[0, 1, 2, 2, 2, 2, 1, 0]/10 with the time-series and display the result together with the original time-series. Explain the differences.

Problem 2 (5 points)

In this problem we will work with a noisy seismic recording and will first filter the sequence and then attempt to find hidden earthquakes in the noise. Download the following file:
https://dl.dropboxusercontent.com/u/6221783/ErSE212/HW5P2.mat

The file contains two variables, the seismic recording "sr" and a recording of an earthquake "eq". Both variables are sampled at 100 Hz.

a) Plot the seismic recording "sr" as a function of time and mark your axes correctly.
b) Filter the recording "sr" with a Butterworth filter, choose a reasonable cut-off frequency w_c, e.g. 10 Hz.
c) Plot the first 2 seconds of the original unfiltered trace and add on top the filtered traces, using Butterworth exponents n=2 and n=8. Use different colors for the three curves. Describe the outcome in a few words.
d) Now use the earthquake recording "eq" as a template to locate earthquakes in the noisy recording sequence. Use this earthquake recording and cross-correlate it with the entire seismic recording (the original "sr", not the filtered version) to identify hidden earthquakes in the sequence. How many events do you find and at what time do they occur in the recording?