GEOL 481.3

POTENTIAL FIELD METHODS

LAB 6
FOURIER TRANSFORMS II

Make a Matlab function to calculate these items

Get LABFTII.mat from PAWS and load LABFTII.mat. This will create the data files (described below) in your workspace that you will need to do the lab. In each of the following exercises, work out the lowest frequency, the highest frequency (Nyquist), the increments to the frequency scale, and the uncertainty on the frequency, before doing the transform. Do the same for periods. In each example, experiment with the drift filter and the tapering.

Use QFT

1) *GRAV* is synthetic gravity tide record for Ottawa, hourly samples, in microgal. Fourier transform and tell me what you see.

2) *STCKHLM* contains the annual mean sea-level observations (in cm) at Stockholm from 1774-1984. The first column is the year, the second is the sea-level. There is a nearly linear decrease in sea-level, of nearly half a cm/yr, ie a drift. In this case, the drift is actually more interesting than the residual. You should know the cause. Fourier transform the sea level data anyway and see if there is anything interesting in it. There are small 18.6 yr and 9.3 yr tides, as well a Chandler 'pole tide', which at 14 month period is aliased. What frequency is it aliased to? This is a very noisy spectrum, and the noise may be caused by a variety of things, the smallest fluctuations, including the aliased Chandler are lost in the noise.

3) *CO2* contains monthly observations of CO_2 at Mauna Loa. Column 1 is year, column 2 is CO2 in ppm and column3 is column 2 minus an annual term. This is a famous data set that is often interpreted as a warning sign for global warming. Some invalid observations have been replaced by interpolation. There are the invalid data to deal with, a drift, and obviously an annual signal, which you can see just by looking at the data. Fourier transform the raw data and interpret?

4) *ILS* contains some latitude observations of the International Latitude Service from 1900 to 1979, at intervals of 1/20 of a year (each row is a year, with twenty equispaced samples in that year). The values are the change in latitude along the Greenwich meridian, in thousandths of a sec of arc. QFT wants to read a single column of data so do *ILS=reshape(ILS',76*20)*. Compute the spectrum of about 10 years of data, and describe it. Compute the spectrum of the whole data set. What is different, and why?

5) *KINGSTN* and *BURLNTN.DAT* are hourly lake level data from Kingston, at the east end of Lake Ontario, and Burlington near the west end. Fourier transform these and interpret. In the raw data you should see one large signal that only lasts for a short time. Estimate the frequency. In the transform, you should see this signal and another, perhaps slightly larger in amplitude. Why is the latter similar or slightly larger than the former in the spectrum, and almost unobservable in the raw record?

6) *sunspot* is a monthly record of the sunspot index from 1749 to 2003. Fourier transform these data and interpret.

7) *belany* is a record from the Belany Islands earthquake of March 25 1998, recorded by the superconducting gravimeter at Cantley, Quebec. The first column is the gravity channel output in volts, the second column is the pressure channel output in volts and the third channel is the gravity earth tide at Cantley. The sample interval is 1 minute. Observed gravity, corrected for tides and atmospheric pressure is $g = -78.5\mu\, gal/V \times col1 - col3 + 0.3\mu gal/mb \times 60.08mb/V \times col2$. Convert all three columns to gravity and look at them separately, as well as gravity after each correction is applied. The final residual contains the surface waves and free oscillations generated by the Belany Island event. One trick to

beat down the noise and make the small signals more noticeable would be to divide the record up into (say) four segments of equal length, Fourier transform each segment and compute the power (that is $real^2 + imag^2$). Finally, add (stack) the separate power transforms. The reason for computing the power is that the phase in each segment is reckoned from the start of the segment, so even with a pure sinusoid the phase in each segment will differ. By computing the power you make the phase irrelevant, so that when you add the transforms together any *frequency* that is common to all segments will stack. If you tried to stack the phase, you would find that the phase of your signal is random from segment to segment, just like the noise, and will not stack. This averaging (it is exactly the same as stacking or averaging in the time domain to suppress noise) will tend to reduce the amplitude of incoherent noise, perhaps revealing something else (no guarantees).

8) Extract a long road Bouguer profile from the complete field school data set. Fourier transform your gravity profile (you may need to interpolate to get evenly spaced samples). The spectrum should peak at low frequencies and tail off to high frequencies. What level does the amplitude spectrum approach as you get towards the Nyquist? What does this mean?

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Use function 'sincdint' to interpolate preserving the spectrum
(you can look at it as performing the forward Fourier transform
on the given irregular grid, and then the inverse transform
on the desired regular grid)
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