Exercise 6. Filtering Elevation Data


It is organized so that longitude varies in the first index and latitude in the second index of the array.

(a) Plot the map. You can make a map with the following commands:

```matlab
contourf((0:120:1023*120)/1000,(0:120:1023*120)/1000,flipud(z'))
colorbar
axis('equal')
xlabel('X, km')
ylabel('Y, km')
```

Note because Matlab’s contouring and image rendering functions plot a matrix in the configuration you would write it out on paper (first index in columns increasing downwards and second index in rows) you have to transpose the matrix and then invert it vertically to get the data to plot out properly.

(b) Demean the elevation data, calculate a two-dimensional FFT and plot its log amplitude with the DC signal in the middle of the plot. You can do this with the following commands

```matlab
z = z-mean(mean(z));
Z = fftshift(fft2(z));
k = linspace(0,1/0.12,1025);
k = k(1:1024)-k(512);
Zp = log(abs(Z));
Zp = 64*Zp/max(max(Zp));
figure(2); clf
image(k,k,flipud(Zp'))
set(gca,'ydir','norm')
xlabel('1/wavelength(X) (1/km)');
ylabel('1/wavelength(Y) (1/km)');
```

Do not try to use the `contourf` command since the fft will be very jagged? I use `image` which maps values onto the default `colormap` which has 64 elements but it is not very elegant and the way I scale is rather ad hoc. (If you know of a better plotting commands that preserves the absolute logarithmic values and plots them on a color bar, let me know.)

(c) You can create taper (window) that attenuates the elevation within the 64 samples of the edges of the maps the following commands

```matlab
n = 64;
taper = hanning(2*n)';
taper = [taper(1:n) ones(1,1024-2*n) taper(n+1:end)];
taper = repmat(taper,1024,1);
taper = taper.*taper';
taper = taper / sqrt(mean(mean(taper.*taper)));
```

Explain how the above commands work and plot the taper.
(d) Apply the taper to the elevation data, demean it, and plot the two dimensional amplitude spectrum as in (b).

(e) What is the primary difference between the plots from (b) and (d)? Explain its cause.

(f) You can create a two-dimensional $4^{th}$-order low-pass Butterworth filter with a cutoff wavenumber of $0.1$ km$^{-1}$ (i.e. a minimum wavelength of 10 km).

```matlab
kmat = repmat(k,1024,1);
r = sqrt(kmat.*kmat + kmat'.*kmat');
G = sqrt(1 ./ (1 + (abs(r)/0.1).^8));
```

Explain how the above commands work and plot the amplitude spectrum

(g) Apply the filter to the FFT of the tapered data with the following command

```matlab
zfilt = real(ifft2(ifftshift(G.*Z)));
```

Plot a map of the filtered data. The data has clearly been degraded near the edges where we applied a taper. Have you any ideas how you might generate a filtered map that avoids this?

(h) Select a 512x512 segment of the grid covering Puget sound. Plot its two-dimensional FFT after demeaning and applying an appropriate taper. In Puget Sound, large scale elevation features are clearly aligned north-south. How is this manifested in the amplitude spectrum?