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%{
    Matlab Practical 6 by Zach Vig
}%

clearvars; clear;

%q1.1
d = importdata("ANMO_z.txt");
t = d(:,1);
c = d(:,2);
figure(1);
plot(t,c,'DisplayName','Raw'); title("Raw Data"); xlabel("Time (s)");
ylabel("Counts");
% xline([200,400,580,700,1300,1450,1640,2400]);
% xlim([580,700]);

%q1.2
%a. There is just some background noise. There is not any signal here, but
it has a frequency of roughly 6 seconds. This could be due to waves hitting
the shore on the continent.

%b. This is the onset in some low amplitude signal and that lasts until 1300
seconds. It has roughly the same frequency as part a.

%c. Here the signal increases in amplitude slightly, but this is pretty
short lived and only occurs in this time interval.

%d. In this interval, the signal is the highest amplitude. It peaks in the
center of the time interval after growing and before fading back to roughly
the signal amplitude seen in part c.

%q1.3
%There is one sample taken every 0.05 seconds, so the sampling frequency is
20 Hz, so the nyquist frequency is 10 Hz.

%q1.4
[b,a] = butter(4,0.01,'low');
% fvtool(b,a);

%q1.5
figure(1); hold on;
c_filt = filtfilt(b,a,c);
plot(t,c_filt,'DisplayName','Filtered');
legend();
hold off;

%q2.1
f = linspace(0,0.1,1000);
figure(2);
spectrogram(c,2048,1024,f,20,'yaxis'); title('Raw Spectrogram');
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%q2.2
c_dtr = detrend(c_filt);
figure(3); hold on;
plot(t,c_filt,'DisplayName','Raw');title('Part 2 Signal');xlabel('Time
(s)'); ylabel('Counts');
plot(t,c_dtr,'DisplayName','Detrended');
legend();
hold off;
figure(4);
spectrogram(c_dtr,2048,1024,f,20,'yaxis');
%{
    Our signal was shifted up so that it is centered around zero and it is
    completly flat except for the amplitude of the signal. The spectrogram no
    longer has a frequency offset in the beginning. Otherwise, the shapes are
    the same.
%}

%q2.3
%{
    There is a low frequency signal early on in the spectrogram, from
    roughly 0-10 minutes. This feature abprutly changes at ~10 minutes to
    include moderate amplitude signals of higher frequeuncies. Then, at ~28
    minutes, a large amplitude signal is seen that curves to later times at
    higher frequencies. This feature starts with low frequencies from ~10-30 Hz
    and ends with higherfrequencies from ~40-60 Hz. This is the result of lower
    frequency waves arriving before higher frequeuncy waves.
%}

%q2.4
%{
    Yes, the speed of Rayleigh Wave propagation is directly related to their
    period. That is, low frequency, long period waves are faster and thus arrive
    before high frequency, short period waves, which are slower. Small period =
    small speed.
%}

%q2.5
%{
    Depths of maximum sensitivity =  $1/3 * \text{wavelength} = 1/3 * \text{velocity} * \text{period}$ 
     $3.9 * 100 / 3 = 130 \text{ km}$ 
     $3.9 * 80 / 3 = 104 \text{ km}$ 
     $3.9 * 60 / 3 = 78 \text{ km}$ 
     $3.9 * 50 / 3 = 65 \text{ km}$ 
     $3.9 * 40 / 3 = 52 \text{ km}$ 
     $3.9 * 30 / 3 = 39 \text{ km}$ 
     $3.9 * 20 / 3 = 26 \text{ km}$ 
%}

%q2.6
%{
    Since the fastest waves are the ones with low frequencies (i.e. long
    periods and the ones that "feel" deep in the Earth), I can infer that
    Vs increases with depth, since Vs and propagation velocity are directly
    related. In other words, the waves that feel the deepest move the fastest

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because V_s is higher at depth.

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%}
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%q2.7
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```
[b1,a1] = butter(4,0.001,'low');
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```
[b2,a2] = butter(4,0.003,'low');
```

```
[b3,a3] = butter(4,0.005,'low');
```

```
[b4,a4] = butter(4,0.01,'low');
```

```
cfilt_1 = detrend(filtfilt(b1,a1,c));
```

```
cfilt_2 = detrend(filtfilt(b2,a2,c));
```

```
cfilt_3 = detrend(filtfilt(b3,a3,c));
```

```
cfilt_4 = detrend(filtfilt(b4,a4,c));
```

```
figure(5); hold on;
```

```
subplot(2,2,1);spectrogram(cfilt_1,2048,1024,f,20,'yaxis');title("N=4,  
Wn=0.001")
```

```
subplot(2,2,2);spectrogram(cfilt_2,2048,1024,f,20,'yaxis');title("N=4,  
Wn=0.003")
```

```
subplot(2,2,3);spectrogram(cfilt_3,2048,1024,f,20,'yaxis');title("N=4,  
Wn=0.005")
```

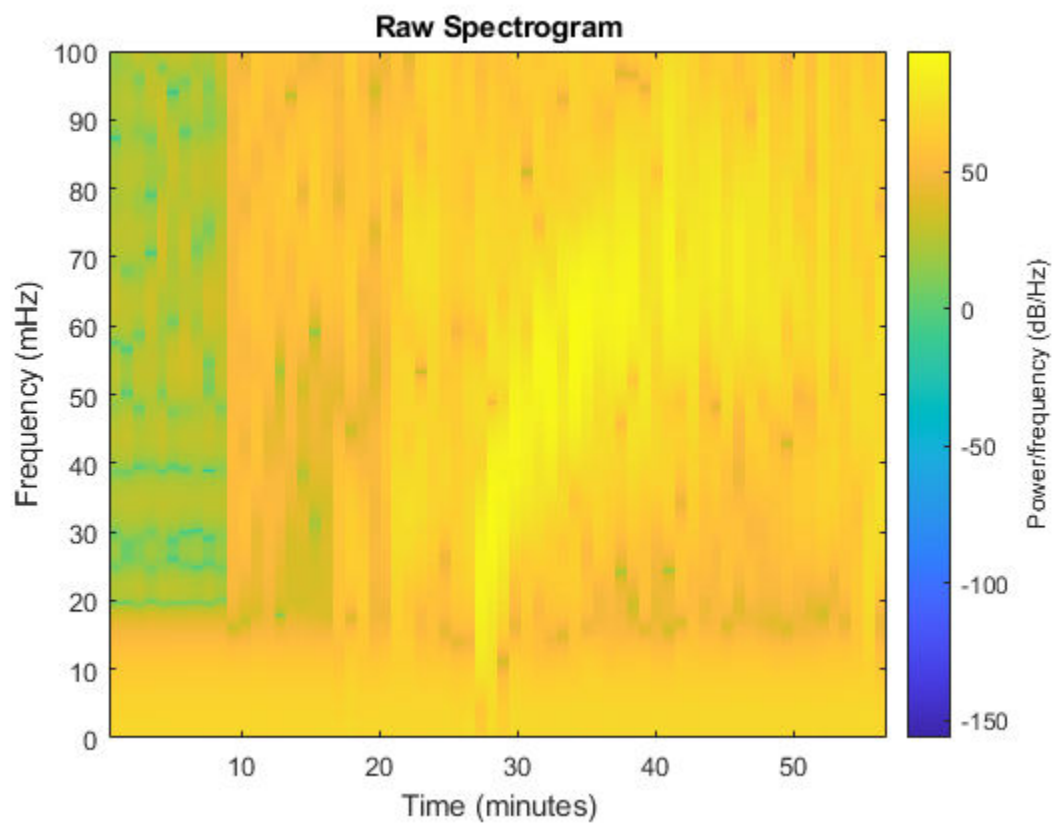
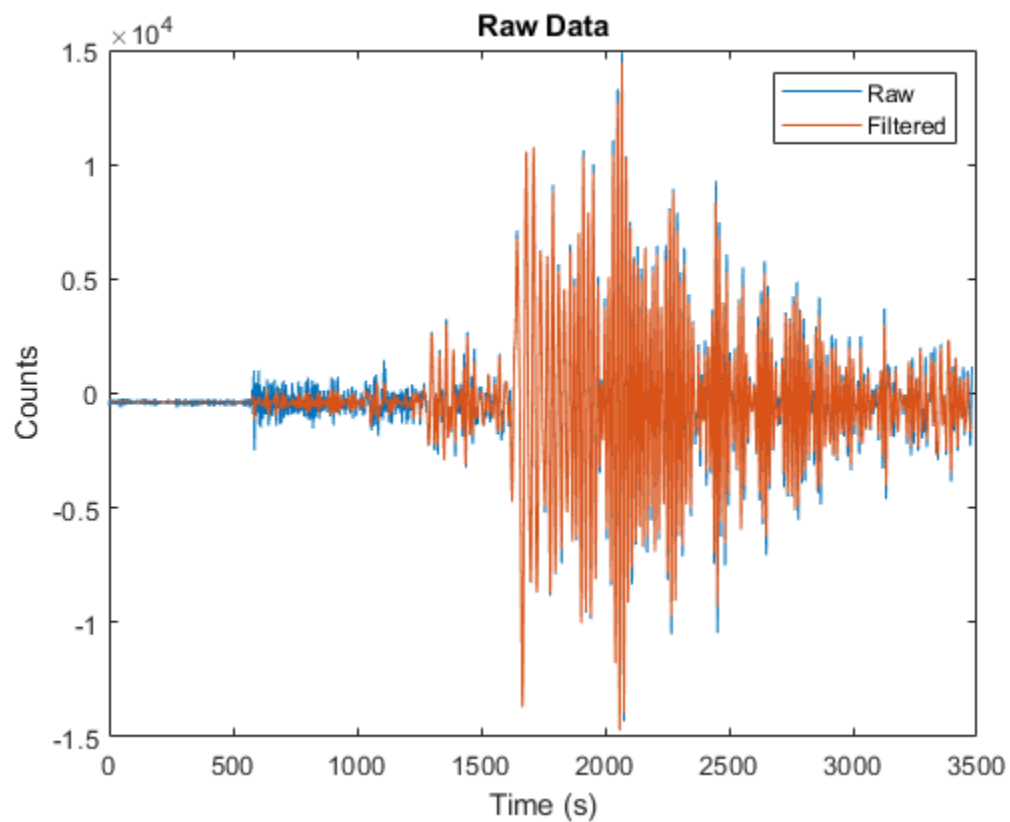
```
subplot(2,2,4);spectrogram(cfilt_4,2048,1024,f,20,'yaxis');title("N=4,  
Wn=0.1")
```

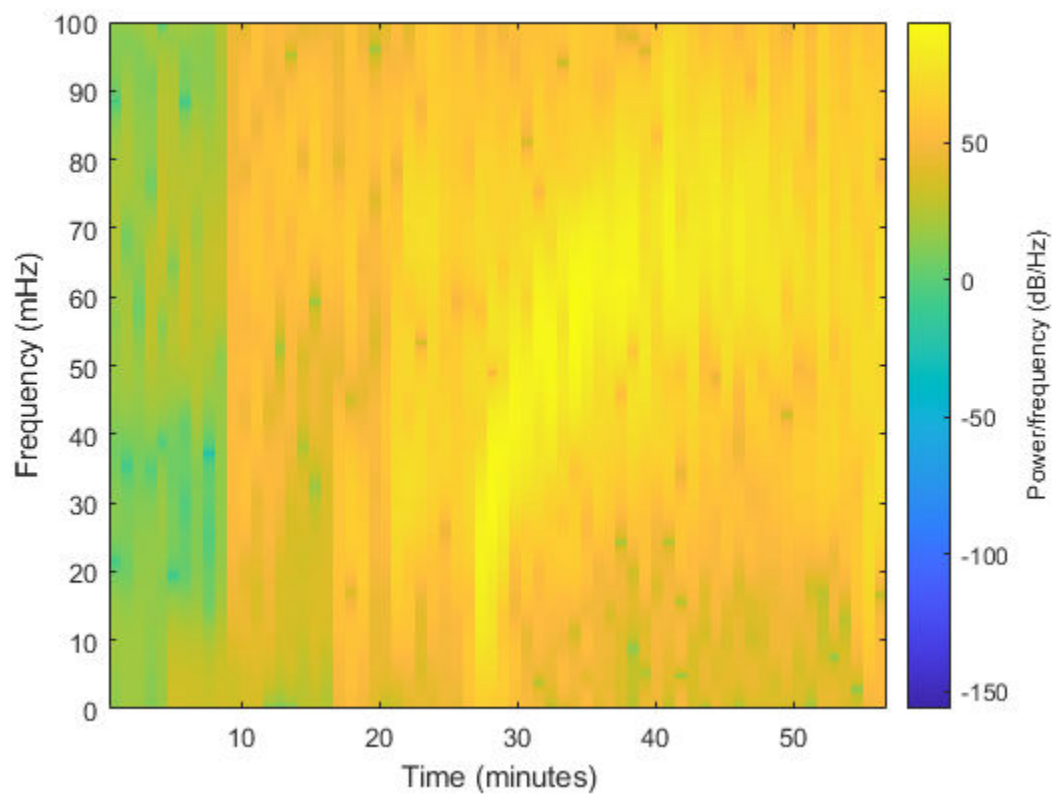
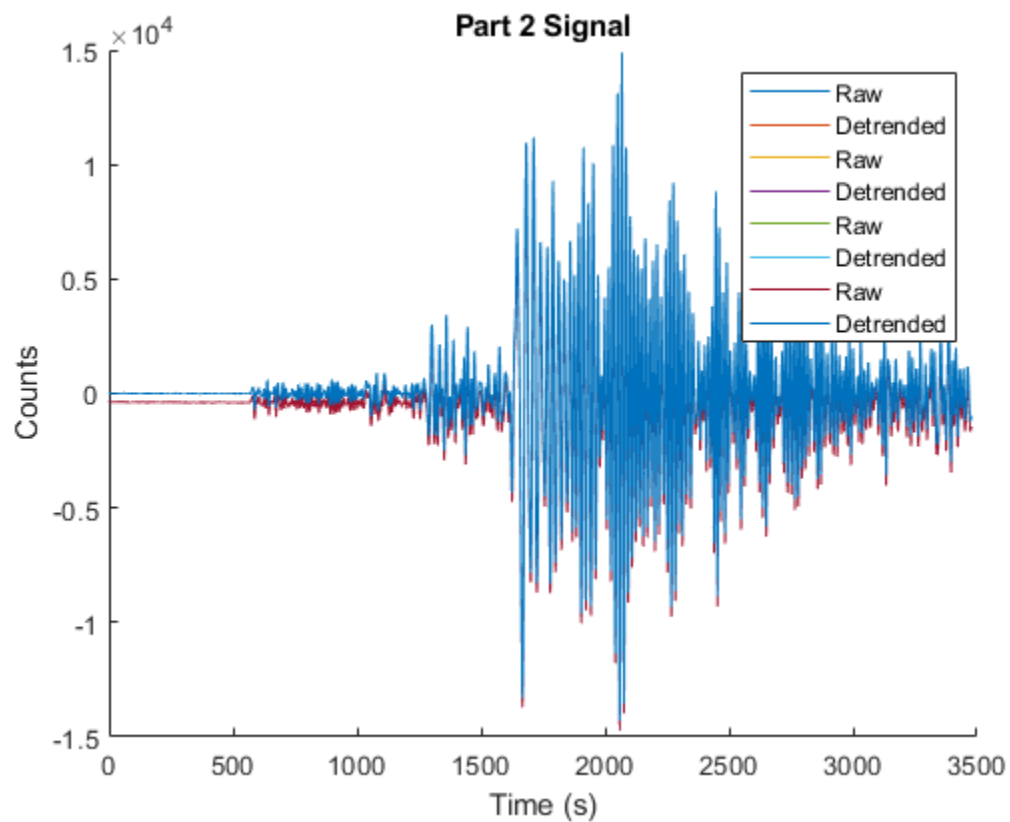
```
hold off;
```

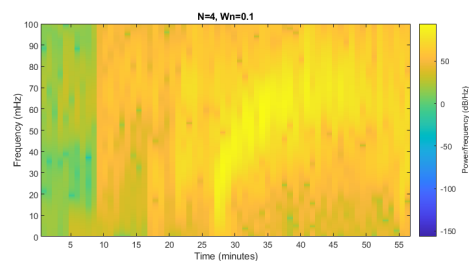
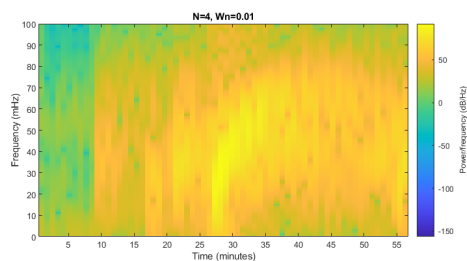
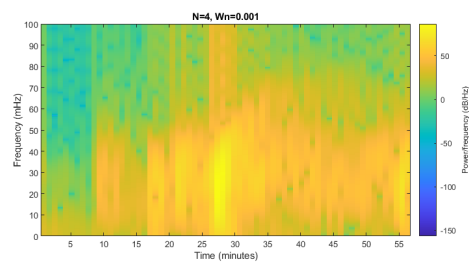
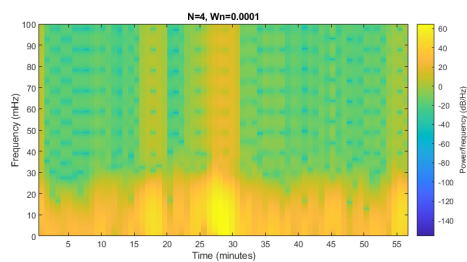
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%{
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Changing W_n , the cutoff frequency for the lowpass filter, affects which frequencies can be seen in the spectrogram. At very low W_n , most of the frequencies in the spectrogram are very low power, but at higher W_n , all the frequencies that are in the signal can be seen at their true power, since they are not being filtered out by the lowpass filter. For example, when $W_n = 0.0001$, only frequencies below $0.001 \times 20\text{Hz} \sim 10\text{mHz}$ could be seen, but at $W_n = 0.1 \times 20\text{Hz} \sim 200\text{mHz}$, all of the frequencies in the signal could be seen.

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%}
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