SIOC 221A Homework 4 **Julia Dohner**
Prof. Sarah Gille Due Date: October 26th, 2017

1. Fourier transform your data.

The peaks (aside from the peak at 0 for the mean), occur at 1.07, 1.17, and 2.23 cycles per day (cpd) (see figures below). These peaks have periods of 22.5, 20.57, and 10.75 hours, respectively. I'd expect these peaks based on the known tidal frequencies of the O1 (period of 25.82), K1 (period of 23.93), and M2 (period of 12.42) tides.

A side note: I was having problems resolving all three peaks when plotting the subset of my data I worked with in HW 3. I discovered that the issue likely stemmed from my not having been rigorous enough in selecting data with even spacing. For this homework I instead identified a chunk of data (roughly the first 34 days of 2015) that had even spacing and worked with that chunk for the entirety of the assignment.

2. Mean pressure and amplitude.

The mean pressure is 3.49 dbar, and the amplitudes of each peak are (in order of increasing frequency) are 0.18, 0.36, and 0.52 dbar.

3. Alignment of peaks with least squares fit.

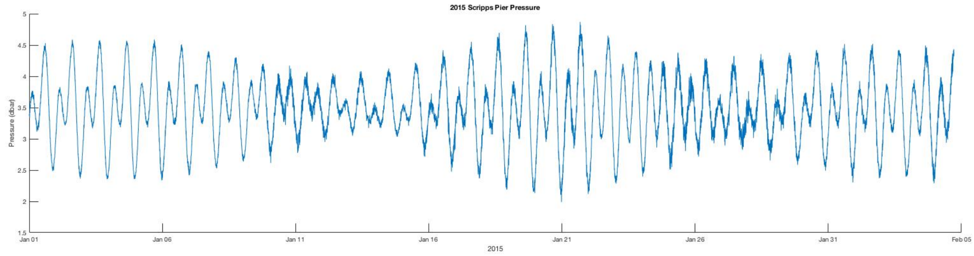
The spectral peaks do align with the results from my least squares fit (LSF). To further check my results, I compared the periods of each peak to the periods of the known tidal frequencies (these are the values we used in the LSF). Though I admit I don't know how well they need to align for the peaks to be considered well-aligned, but they seem to be close enough that each peak is discernibly different from the others and clearly (with myself as the viewer) corresponds to each of the known tidal components.

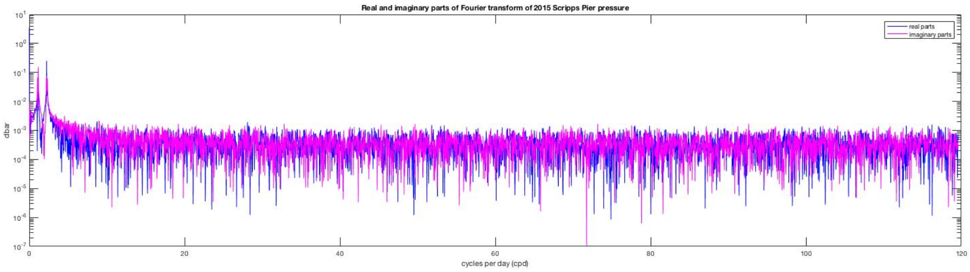
Tidal Component	Spectral Amplitude (dbar)	LSF Amplitude (dbar)	Observed Amplitude (dbar)
O1	0.18	0.17	0.22
K1	0.36	0.38	0.347
M2	0.52	0.52	0.556

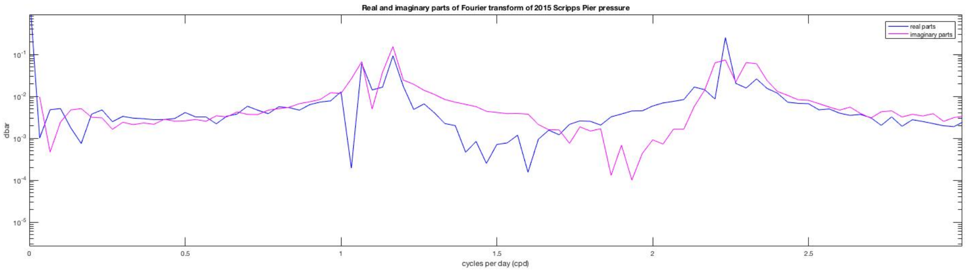
Tidal Component	Spectral Period (hours)	LSF Period (hours)
O1	22.50	25.82
K1	20.57	23.93
M2	10.75	12.42

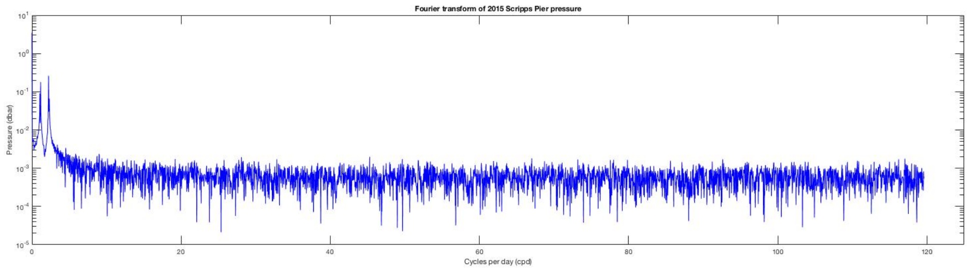
4. Plotting the spectral energy.

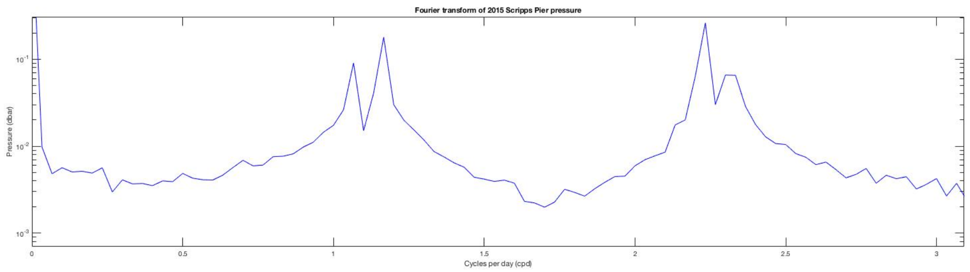
My spectrum is red because the peaks occur primarily at low frequencies (see figures below). If I differentiate my time series in time before Fourier transforming, the y-values at higher frequencies increase. This is to be expected as in frequency space, taking a derivative is equivalent to multiplying the series by $-i2\pi * frequency$. Thus at higher frequencies, the factor by which each point gets multiplied is greater.

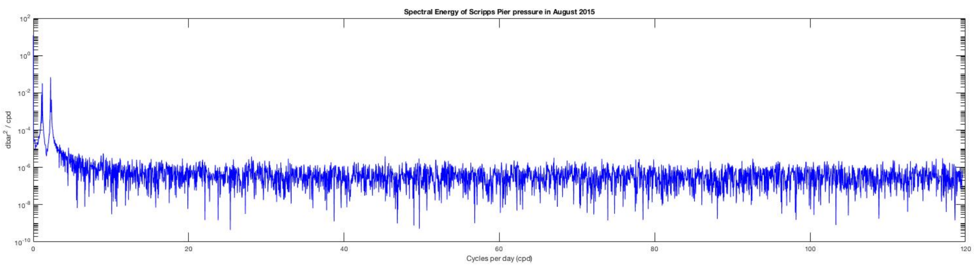

2015 Scripps Pier Pressure
Pressure (dbar)
2015

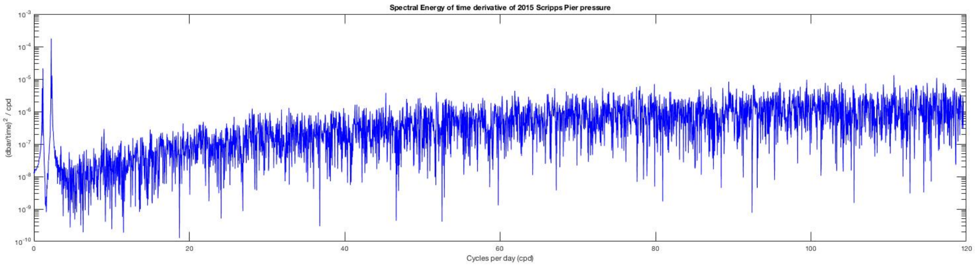

Real and imaginary parts of Fourier transform of 2015 Scripps Pier pressure
real parts
imaginary parts
dbar
cycles per day (cpd)


Real and imaginary parts of Fourier transform of 2015 Scripps Pier pressure
real parts
imaginary parts
dbar
cycles per day (cpd)


Fourier transform of 2015 Scripps Pier pressure
Pressure (dbar)
Cycles per day (cpd)


Fourier transform of 2015 Scripps Pier pressure
Pressure (dbar)
Cycles per day (cpd)


Spectral Energy of Scripps Pier pressure in August 2015
dbar² / cpd
Cycles per day (cpd)


Spectral Energy of time derivative of 2015 Scripps Pier pressure
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
(dbar/time)^2 / cpd
0
20
40
60
80
100
120
Cycles per day (cpd)

```
% file SIOC 221A HW 4
%
% author Julia Dohner, with help from Annie Adelson, Jacob Morgan and Luke
% Kachelein
%
% due date October 26, 2017

clear all; close all;


%% gathering 2015 Pier pressure record

% create empty arrays to hold time and temp data
time = [];
pressure = [];

time = [time; ncread(strcat('http://sccoos.org/thredds/dodsC/autoss/scripps_pier-2015.↙
nc'),'time')];
pressure = [pressure; ncread(strcat('http://sccoos.org/thredds/dodsC/autoss/scripps_pier-2015.↙
nc'),'pressure')];


% remove bad data using the flagged data from .nc file
pressure_flagPrimary = [];
pressure_flagPrimary = [pressure_flagPrimary; ncread(strcat('http://sccoos.↙
org/thredds/dodsC/autoss/scripps_pier-2015.nc'),'pressure_flagPrimary')];

% looping through to remove bad data from pressure record
for i = 1:length(pressure)
    if pressure_flagPrimary(i) ~= 1
        pressure(i) = nan;
    end
end



%% consider a period with equal increments

% this for the first 34 days of the 2015 record

% time differences
time = double(time);
t_diff = diff(time);

% finding segment of data with even spacing
cutoff = find(t_diff(1:82236)>t_diff(1),1);
pressure_sub = pressure(1:cutoff-1); % subsampled pressure
time_sub = time(1:cutoff-1); % subsampled times
date0=datenum(1970,1,1); % give reference date (first date)
time_sub = double(time_sub)/86400+date0; % in units of days (conversion: seconds/day)

figure
hold on

plot(time_sub, pressure_sub, 'LineWidth',1)

ax = gca;
xlabel('\fontsize{12}2015')
ylabel('\fontsize{12}Pressure (dbar)')
```

```
title('\fontsize{14}2015 Scripps Pier Pressure')
datetick('x','mmm dd','keepticks')

%% Fourier transforming my data


f = fft(pressure_sub); % Fourier transform of my data
data = f(1:3590); % only using first half of vector
N = length(pressure_sub);
frequency = (0:7180)/(7181*361)*(24*3600);
frequency = frequency(1:3590)'; % only using first half of vector
data = data/N; % Normalizing the data

figure
semilogy(frequency,abs(real(data)),'-b')
hold on
semilogy(frequency,abs(imag(data)),'-m');
title('\fontsize{14}Real and imaginary parts of Fourier transform of 2015 Scripps Pier↙
pressure');
legend('\fontsize{12}real parts','imaginary parts');
xlabel('\fontsize{12}cycles per day (cpd)');
ylabel('\fontsize{12}Pressure (dbar)');

figure
semilogy(frequency,abs(data),'-b')
title('\fontsize{14}Fourier transform of 2015 Scripps Pier pressure');
xlabel('C\fontsize{12}ycles per day (cpd)');
ylabel('\fontsize{12}Pressure (dbar)');
xlim([0 125]);

%% mean pressure and amplitudes of major peaks
% using Fourier coefficients to find mean pressure, amplitudes of peaks

% mean pressure is the first value in the Fourier coefficient vector
meanPressure = data(1);

absData = abs(data);

% sorting peaks into descending order
[amp ind] = sort(absData,'descend');
amplitudes(:,2) = amp(1:5);
amplitudes(:,1) = ind(1:5); % stores the indices (col 1) and amplitudes (col 2) of major peaks

% multiply amplitudes by 2 to account for both positive and negative
% frequencies
amplitude_a = 2*amplitudes(1,2); % this is the mean
amplitude_b = 2*amplitudes(2,2); % largest non-mean peak
amplitude_c = 2*amplitudes(3,2); % second-largest non-mean peak
amplitude_d = 2*amplitudes(4,2); % third-largest non-mean peak

% indices of peaks
index_cpd_a = amplitudes(1,1);
index_cpd_b = amplitudes(2,1);
index_cpd_c = amplitudes(3,1);
index_cpd_d = amplitudes(4,1);

% frequencies of peaks
cpd_a = frequency(index_cpd_a);
cpd_b = frequency(index_cpd_b);
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cpd_c = frequency(index_cpd_c);
cpd_d = frequency(index_cpd_d);

% periods of peaks
%cpd_a_period = 24/cpd_a;
cpd_b_period = 24/cpd_b;
cpd_c_period = 24/cpd_c;
cpd_d_period = 24/cpd_d;


%% spectral energy vs. frequency

spectralE = abs(data).^2;

figure
semilogy(frequency,spectralE,'-b')
title('\fontsize{14}Spectral Energy of Scripps Pier pressure in August 2015');
xlabel('\fontsize{12}Cycles per day (cpd)');
ylabel('\fontsize{12}dbar^2 / cpd');

% taking derivative of my data
diff_data = diff(pressure_sub);
f_diff = fft(diff_data); % Fourier transform of my data
data_diff = f_diff(1:3590);
data_diff = data_diff/N; % Normalizing the data

spectralE_diff = abs(data_diff).^2;

figure
semilogy(frequency,spectralE_diff,'-b')
title('\fontsize{14}Spectral Energy of time derivative of 2015 Scripps Pier pressure');
xlabel('\fontsize{12}Cycles per day (cpd)');
ylabel('\fontsize{12}(dbar/time)^2 / cpd');
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