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% file SIOC 221A HW 3
%
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% Annie Adelson
%
% due date October 19, 2017

clear all; close all;

numYears = 2017-2005 + 1;

%% plotting the Scripps Pier 2015 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

% examining the time increments between adjacent measurements
X = diff(time);
%figure
%plot(X);
%plot(X(1:4000))

% plot the time series
date0=datenum(1970,1,1);% give reference date (first date)
time2 = double(time)/24/3600+date0;% divide the time by 24*3600 to convert seconds into↙
days since 1970
figure('name','Scripps_Pier_Pressure_2015');
plot(time2, pressure,'LineWidth',1);

% label the x-axis in months
set(gca,'FontSize',16);
title('Scripps Pier Pressure');
xlabel('Date');
datetick('x','mm/dd/yy')
ylabel('Pressure (dbar)');


%% plotting just the first month of 2015
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```matlab
% 2592000 seconds in 30 days
% If a measurement is taken every 361 seconds, then 30 days into the record
% should be roughly the first 7180 measurements (2592000/361) in the 2015
% series. My record is 30 days long.
time3 = time(1:7180);
pressure2 = pressure(1:7180);

% plot the time series
date0=datenum(1970,1,1);% give reference date (first date)
time4 = double(time3)/24/3600+date0;% divide the time by 24*3600 to convert seconds into days since 1970
time4_string = datestr(time4);
figure('name','Scripps_Pier_Pressure_January_2015');
plot(1:length(pressure2),pressure2,'LineWidth',1);
title('Scripps Pier Pressure in January 2015');
xlabel('Date');
set(gca, 'xtick', 1:1000:length(pressure2),'xticklabel', time4_string(1:1000:length(pressure2),1:6));
ylabel('Pressure (dbar)');

%% Least squares fit

% defining sine and cosine components of major tidal constituents

% convert period to days (to match x axis time units)
O1_sin = sin(2*pi*time4/(25.83/24));%O1: principal lunar diurnal
O1_cos = cos(2*pi*time4/(25.83/24));
K1_sin = sin(2*pi*time4/(23.93/24));%K1: luni-solar diurnal
K1_cos = cos(2*pi*time4/(23.93/24));
M2_sin = sin(2*pi*time4/(12.42/24));%M2: principal lunar
M2_cos = cos(2*pi*time4/(12.42/24));


A2=[ones(length(time4),1) O1_sin O1_cos K1_sin K1_cos M2_sin M2_cos];
x2=inv(A2'*A2)*A2'*pressure2;
figure('name','Pier_Pressure_Tidal_LSF');
matrixProd = A2*x2;
plot(1:length(matrixProd),matrixProd,'LineWidth',1);
hold on
plot(1:length(pressure2),pressure2,'LineWidth',1);
set(gca, 'xtick', 1:1000:length(pressure2),'xticklabel', time4_string(1:1000:length(pressure2),1:6));
title('Pier Pressure Least Squares Fit of 3 Major Tidal Constituents');
xlabel('Time');
ylabel('Pressure (dbar)');


% Total amplitude = square root of the sum of the squares of the sine and
% cosine amplitudes)
% Units of mean and amplitude are decibars
amplitude_O1_jan = sqrt((x2(2,1))^2 + (x2(3,1))^2);
amplitude_K1_jan = sqrt((x2(4,1))^2 + (x2(5,1))^2);
amplitude_M2_jan = sqrt((x2(6,1))^2 + (x2(7,1))^2);

%% Stationarity of the tide

% Repeating the least squares fit for 30 days roughly near August 2015
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% Starting 7/12 of the way through the time record (82237 measurements).
% If a measurement is taken every 361 seconds, then 30 days into the record
% should be roughly the next 7180 measurements (2592000/361). My record is
% 30 days long.
kAugustStart = floor((7/12)*82237);
kAugustEnd = kAugustStart + 7180;
timeAugust = time(kAugustStart:kAugustEnd, 1);
timeAugust = double(timeAugust)/24/3600+date0;% in units of days
pressureAugust = pressure(kAugustStart:kAugustEnd, 1);

% defining sine and cosine components of major tidal constituents

% convert period to days (to match x axis time units)
O1_sin_aug = sin(2*pi*timeAugust/(25.83/24));%O1: principal lunar diurnal
O1_cos_aug = cos(2*pi*timeAugust/(25.83/24));
K1_sin_aug = sin(2*pi*timeAugust/(23.93/24));%K1: luni-solar diurnal
K1_cos_aug = cos(2*pi*timeAugust/(23.93/24));
M2_sin_aug = sin(2*pi*timeAugust/(12.42/24));%M2: principal lunar
M2_cos_aug = cos(2*pi*timeAugust/(12.42/24));


A3=[ones(length(timeAugust),1) O1_sin_aug O1_cos_aug K1_sin_aug K1_cos_aug M2_sin_aug
M2_cos_aug];
x3=inv(A3'*A3)*A3'*pressureAugust;
figure('name','Pier_Pressure_Tidal_LSF_Summer');
plot(timeAugust,A3*x3,'m','LineWidth',2)
hold on
plot(timeAugust, pressureAugust,'LineWidth',1);
set(gca,'FontSize',16);
title('Pier Pressure Least Squares Fit of 3 Major Tidal Constituents - Summer');
xlabel('Date');
datetick('x','mm/dd/yy')
ylabel('Pressure (dbar)');


% The mean is 3.4898 (first row in x2 vector)
%
% Total amplitude = square root of the sum of the squares of the sine and
% cosine amplitudes)
% Units of mean and amplitude are decibars
amplitude_O1_aug = sqrt((x3(2,1))^2 + (x3(3,1))^2);
amplitude_K1_aug = sqrt((x3(4,1))^2 + (x3(5,1))^2);
amplitude_M2_aug = sqrt((x3(6,1))^2 + (x3(7,1))^2);


%% Chi squared and the misfit. (Good name for a short story)

% y is vector containing pressure data (pressureAugust)
% A is the matrix containing ones, sines and cosines (A3)
% x is matrix containing mean and amplitudes (x3)

% looping to create array of differences between two adjacent points
diffArray = [];
for i = 1:(length(pressureAugust)-1);
    diffArray(i) = pressureAugust(i+1) - pressureAugust(i);
end

sigma = std(diffArray);
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```
% initializing variable before loop
chiSquared = 0;

for i = 1:length(pressureAugust)
    ax_prod = 0;
    for j = 1:length(x3)
        ax_prod = ax_prod + (A3(i,j)*x3(j));
    end
    chiSquared = chiSquared + ((pressureAugust(i) - ax_prod)^2);
end
chiSquared = chiSquared / (sigma^2);% sigma is out of for loop because is
% already a sum of uncertainties of individual points


% How much does the misfit change if you fit with 5 frequencies instead of
% 3?

% convert period to days (to match x axis time units)
S2_sin_aug = sin(2*pi*timeAugust/(12/24));%S2: principal solar semidiurnal
S2_cos_aug = cos(2*pi*timeAugust/(12/24));
N2_sin_aug = sin(2*pi*timeAugust/(12.66/24));%N2: larger lunar elliptic semidiurnal
N2_cos_aug = cos(2*pi*timeAugust/(12.66/24));


A4=[ones(length(timeAugust),1) O1_sin_aug O1_cos_aug K1_sin_aug...
    K1_cos_aug M2_sin_aug M2_cos_aug S2_sin_aug S2_cos_aug N2_sin_aug N2_cos_aug];
x4=inv(A4'*A4)*A4'*pressureAugust;

% recalculate misfit now with the 5-frequency fit (using A4 and x4)

chiSquared_5 = 0;

for i = 1:length(pressureAugust)
    ax_prod_5 = 0;
    for j = 1:length(x4)
        ax_prod_5 = ax_prod_5 + (A4(i,j)*x4(j));
    end
    chiSquared_5 = chiSquared_5 + ((pressureAugust(i) - ax_prod_5)^2);
end
chiSquared_5 = chiSquared_5 / (sigma^2);% sigma is out of for loop because is
% already a sum of uncertainties of individual points

nu = length(pressureAugust)-length(x3);% number of DOF (N-M)
nu_5 = length(pressureAugust)-length(x4);% number of DOF (N-M)

p = gammainc(chiSquared/2, nu/2);
p_5 = gammainc(chiSquared_5/2, nu_5/2);

p_subtraction = gammainc(nu/2, nu/2);
p_subtraction_5 = gammainc(nu_5/2, nu_5/2);
```