MPO 634 - Assignment 02 Spring 2020

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Ivenis, might you be able to use the Matlab code of problem eda06_02.m in the supplemental code .zip file at this site to do the above exercise: fitting your data as a mean, seasonal cycle, and trend without any need for gap filling.

d = **G m** + residual

d'd = **d'G m**

m = **(d'G)\(d'd)** in Matlab's clever notation for left-multiplying by an inverse.

```
clear variables
close all

stn=50250;%Station ID

%% reading data
load(['/MATLAB Drive/Data_Analysis/Assignment_02/mat_' num2str(stn) '.mat']);clear titl

eval(['time=mat_' num2str(stn) '(:,1);'])
eval(['elev=mat_' num2str(stn) '(:,2);'])
clear mat_*

%% organizing time
time=time - 1721058.5;%datenum format
ind_t=time>=datenum([2002 9 18 0 0 0]);%selecting data from Sep/2002 to Aug/2004
time=time(ind_t);
elev=elev(ind_t);
clear ind_t

time=datestr(time,'dd-mm-yyyy HH');
time=datenum(time,'dd-mm-yyyy HH');
t=min(time):1/24:max(time);
t=datestr(t,'dd-mm-yyyy HH');
t=datenum(t,'dd-mm-yyyy HH');
d=nan(size(t));
[ind1,loc1]=ismember(time,t);
[ind2,loc2]=ismember(t,time);
d(ind2)=elev(ind1);
d=d-nanmean(d);

%harmonical Analysis
[tide_struc,xout]=t_tide(d,'interval',1,'start_time',t(1));
```

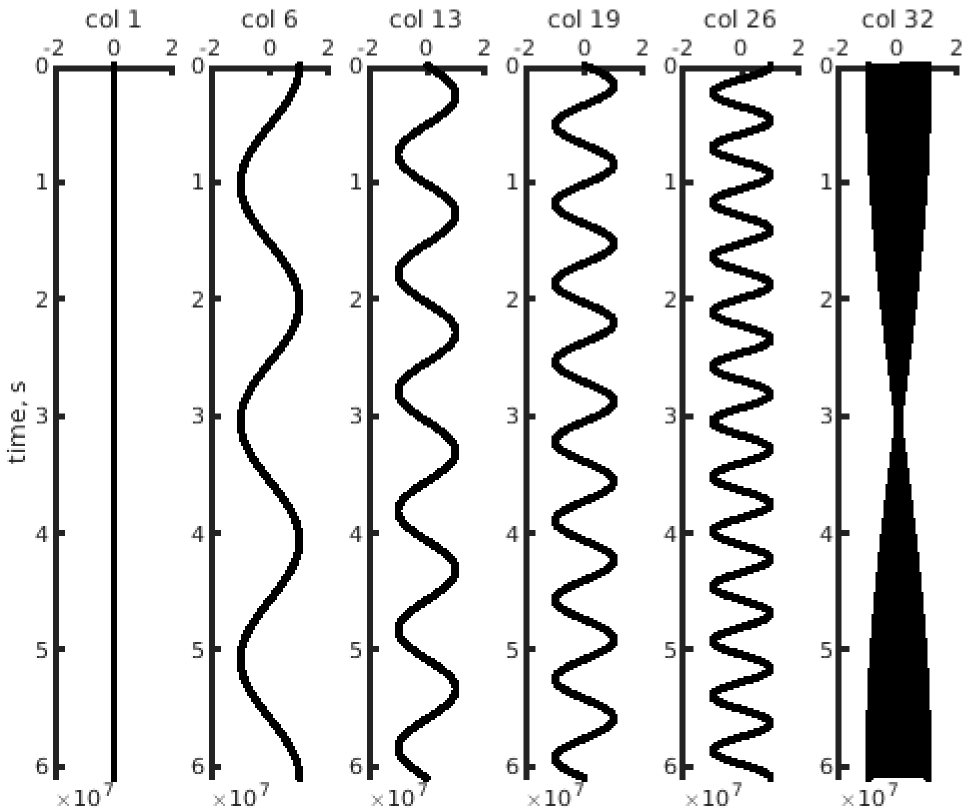
```
number of standard constituents used: 68
Points used: 16935 of 16935
percent of var residual after lsqfit/var original: 25.04 %
Greenwich phase computed, no nodal corrections
```

```
   Using nonlinear bootstrapped error estimates
   Generating prediction without nodal corrections, SNR is 2.000000
   percent of var residual after synthesis/var original: 26.12 %
-----------------------------------
date: 31-Mar-2020
nobs = 16935,  ngood = 16935,  record length (days) = 705.62
start time: 18-Sep-2002
rayleigh criterion = 1.0
Greenwich phase computed, no nodal corrections

x0= -0.00203, x trend= 0

var(x)= 0.16306   var(xp)= 0.12057   var(xres)= 0.042595
percent var predicted/var original= 73.9 %

     tidal amplitude and phase with 95% CI estimates

tide   freq       amp     amp_err    pha    pha_err     snr
*SA   0.0001141    0.0537    0.038   113.85    45.27        2
 SSA  0.0002282    0.0257    0.033    85.72    96.55     0.61
 MSM  0.0013098    0.0091    0.026   189.09   178.38     0.12
 MM   0.0015122    0.0213    0.032   146.58   115.16     0.45
 MSF  0.0028219    0.0204    0.029    72.13   120.33      0.5
 MF   0.0030501    0.0419    0.040    39.86    58.41      1.1
 ALP1 0.0343966    0.0012    0.002   203.53   115.70     0.29
 2Q1  0.0357064    0.0038    0.003   200.85    47.74      1.5
 SIG1 0.0359087    0.0032    0.003   207.69    54.36      1.3
*Q1   0.0372185    0.0347    0.003   254.95     5.05  1.4e+02
*RHO1 0.0374209    0.0089    0.003   248.37    17.60      7.2
*O1   0.0387307    0.1262    0.003   289.69     1.30  1.8e+03
 TAU1 0.0389588    0.0035    0.003   136.95    50.31      1.5
 BET1 0.0400404    0.0029    0.003   300.81    69.99        1
*NO1  0.0402686    0.0073    0.003    47.02    23.56      5.5
 CHI1 0.0404710    0.0010    0.002   349.30   157.30     0.22
 PI1  0.0414385    0.0029    0.002    27.33    53.15      1.4
*P1   0.0415526    0.0258    0.003    15.43     6.93       67
*S1   0.0416667    0.0167    0.003   177.90    10.53       36
*K1   0.0417807    0.0686    0.003    22.33     2.24  4.8e+02
 PSI1 0.0418948    0.0013    0.003    87.08   120.19     0.26
 PHI1 0.0420089    0.0012    0.002    48.71   129.50     0.28
 THE1 0.0430905    0.0031    0.003   117.82    53.68      1.3
 J1   0.0432929    0.0027    0.003    18.56    61.87        1
*SO1  0.0446027    0.0043    0.003   160.69    41.50      2.4
 OO1  0.0448308    0.0035    0.003   236.75    50.58      1.5
 UPS1 0.0463430    0.0015    0.002   305.16   119.45     0.44
 OQ2  0.0759749    0.0044    0.005   174.46    68.34     0.97
 EPS2 0.0761773    0.0003    0.003   300.78   217.23    0.008
*2N2  0.0774871    0.0190    0.005   220.85    13.86       17
*MU2  0.0776895    0.0247    0.005   228.60    11.10       29
*N2   0.0789992    0.0580    0.005   242.95     4.51  1.5e+02
*NU2  0.0792016    0.0089    0.004   258.11    26.81      4.2
 GAM2 0.0803090    0.0062    0.005   193.83    45.88      1.8
*H1   0.0803973    0.0084    0.005    20.78    32.22        3
*M2   0.0805114    0.3630    0.005   177.93     0.78  5.8e+03
 H2   0.0806255    0.0061    0.005   297.83    42.19      1.5
 MKS2 0.0807396    0.0044    0.004   260.86    59.93     0.99
*LDA2 0.0818212    0.0081    0.004   118.29    27.51      3.6
*L2   0.0820236    0.0093    0.004   222.61    29.97      5.1
*T2   0.0832193    0.0081    0.004   215.54    31.15      4.1
*S2   0.0833333    0.2389    0.005   195.84     1.13  2.4e+03
*R2   0.0834474    0.0077    0.005   201.97    33.33      2.8
*K2   0.0835615    0.0903    0.005   201.16     3.10    4e+02
 MSN2 0.0848455    0.0042    0.004   341.44    63.69     0.87
*ETA2 0.0850736    0.0131    0.004   218.99    19.44       12
*MO3  0.1192421    0.0446    0.005   344.59     6.66       92
```

```
*M3   0.1207671    0.0679    0.004   189.21     3.70  2.6e+02
*SO3  0.1220640    0.0217    0.005    99.61    12.42       20
*MK3  0.1222921    0.0295    0.005    91.43    10.62       36
*SK3  0.1251141    0.0188    0.005   270.15    13.26       15
*MN4  0.1595106    0.0296    0.002   312.99     4.89  1.9e+02
*M4   0.1610228    0.0558    0.002    11.67     2.42  5.9e+02
 SN4  0.1623326    0.0019    0.002   113.53    71.72     0.87
*MS4  0.1638447    0.0299    0.002   137.02     4.29  1.6e+02
*MK4  0.1640729    0.0111    0.003   147.82    12.35       19
 S4   0.1666667    0.0011    0.002   213.60   108.13     0.37
 SK4  0.1668948    0.0013    0.002   219.70    99.58     0.43
*2MK5 0.2028035    0.0032    0.001   210.49    25.23      6.6
 2SK5 0.2084474    0.0014    0.001   288.34    59.95      1.3
 2MN6 0.2400221    0.0004    0.001    70.31   121.51     0.33
*M6   0.2415342    0.0024    0.001   131.54    18.29       11
*2MS6 0.2443561    0.0065    0.001   151.01     6.71       74
*2MK6 0.2445843    0.0027    0.001   160.20    18.23       12
*2SM6 0.2471781    0.0035    0.001   190.77    13.63       21
*MSK6 0.2474062    0.0024    0.001   207.31    16.66       11
 3MK7 0.2833149    0.0008    0.001    22.96    67.08      1.1
*M8   0.3220456    0.0012    0.001   201.78    33.30      2.4
```

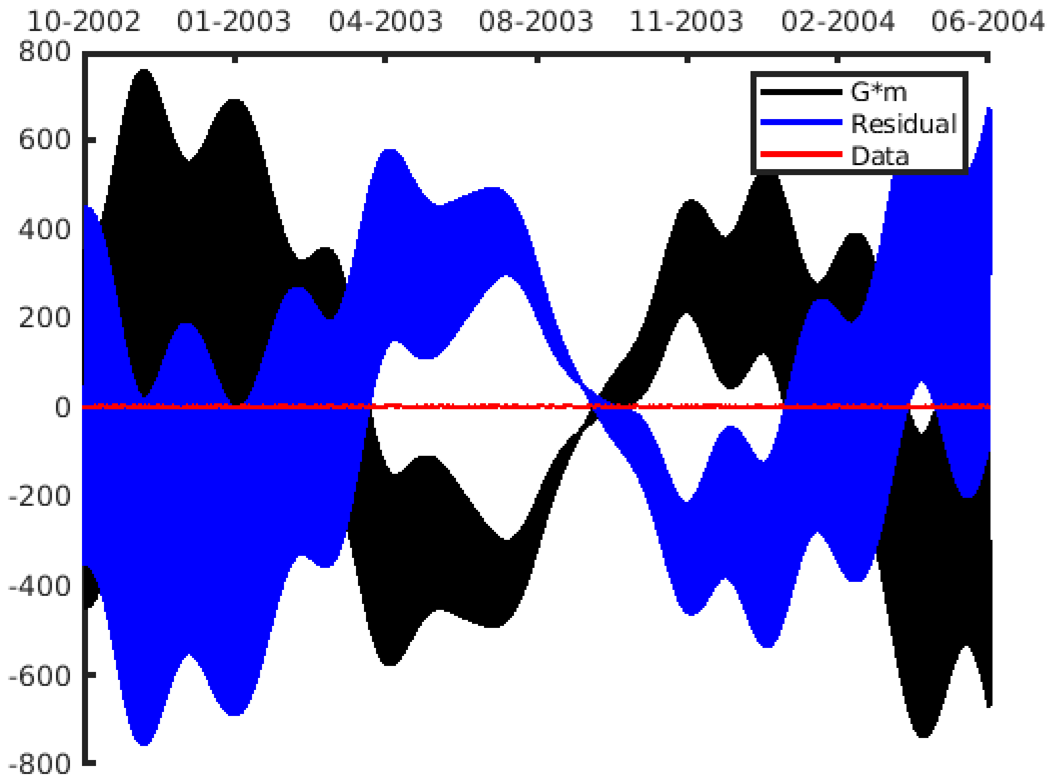
```
d=d-xout;

%Deliberating add NaN into my timeseries

%d(10000:11000)=nan;

%Setting matrix length
M=32;%number of frequencies I'd decompose my data
N=length(d);

tt=t;
clear t

% set up time
Dt=60*60;% [s]
tmin=0.0;
tmax = tmin+Dt*(N-1);
t = tmin + Dt*[0:N-1]';

% nyquist frequencies
%Nf=(Dt)/2;
Nf=N/2+1;
fmax = 1/(2*Dt);
Df = fmax/(N/2);
f = Df*[0:Nf-1]';
Nw=Nf;
wmax = 2*pi*fmax;
Dw = wmax/(N/2);
w = Dw*[0:Nw-1]';

% set up G
G=zeros(N,M);

% zero frequency column
G(:,1)=nanmean(d);
```

```
% interior M/2-1 columns
for i = [1:M/2-1]
    j = 2*i;
    k = j+1;
    G(:,j)=cos(w(i+1).*t);
    G(:,k)=sin(w(i+1).*t);
end

% nyquist column
G(:,M)=cos(w(end).*t);
%G(:,M)=cos(w(Nw).*t);


% plot spectral density
figure(1)
clf;

% plot columns of G vs time
j=1;
for i = [1 round([M/5:M/5:M])]
    subplot(1,6,j);
    j=j+1;
    set(gca,'LineWidth',2);
    hold on;
    set(gca,'XAxisLocation','top');
    axis( [-2, 2, tmin, tmax] );
    axis ij;
    plot( G(:,i), t, 'k-','LineWidth',2);
    plot( G(:,i), t, 'k.','LineWidth',2);
    xlabel(sprintf('col %d',i));
    if (i==1)
    ylabel('time, s');
    end
end
```



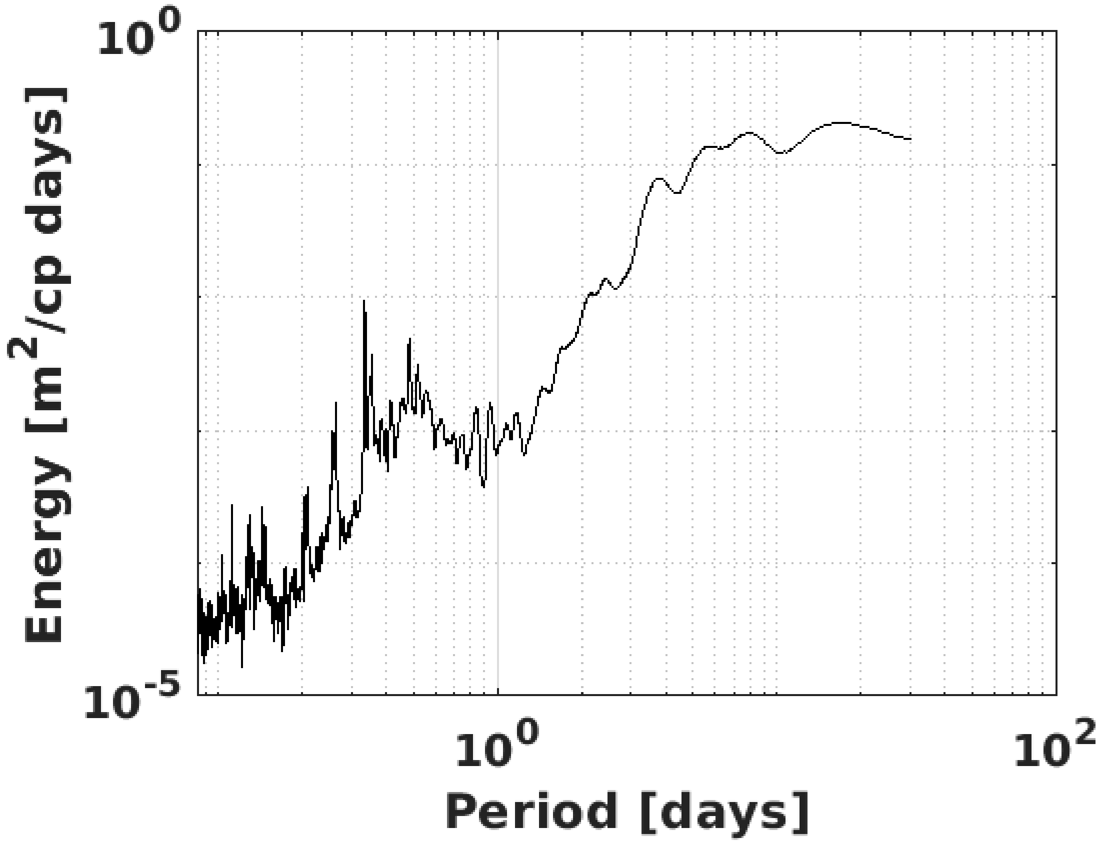
Calculating m and the residual

```
m=nan(size(G,2),1);
for j=1:size(G,2)
    m(j) = (d'*G(:,j))\(d'*d);
end

residual=d-G*m;

%% Plot the data, predicted and residual
figure
clf
set(gca,'LineWidth',2);
hold on;
set(gca,'XAxisLocation','top');
xlim( [tt(1) tt(end)] );
plot(tt,G*m,'k-','linewidth',2)
hold on
plot(tt,residual,'b-','linewidth',2)
plot(tt,d,'r-','linewidth',2)
datetick('x','mm-yyyy','keepticks')
legend('G*m','Residual','Data')
```



Spectral Analysis

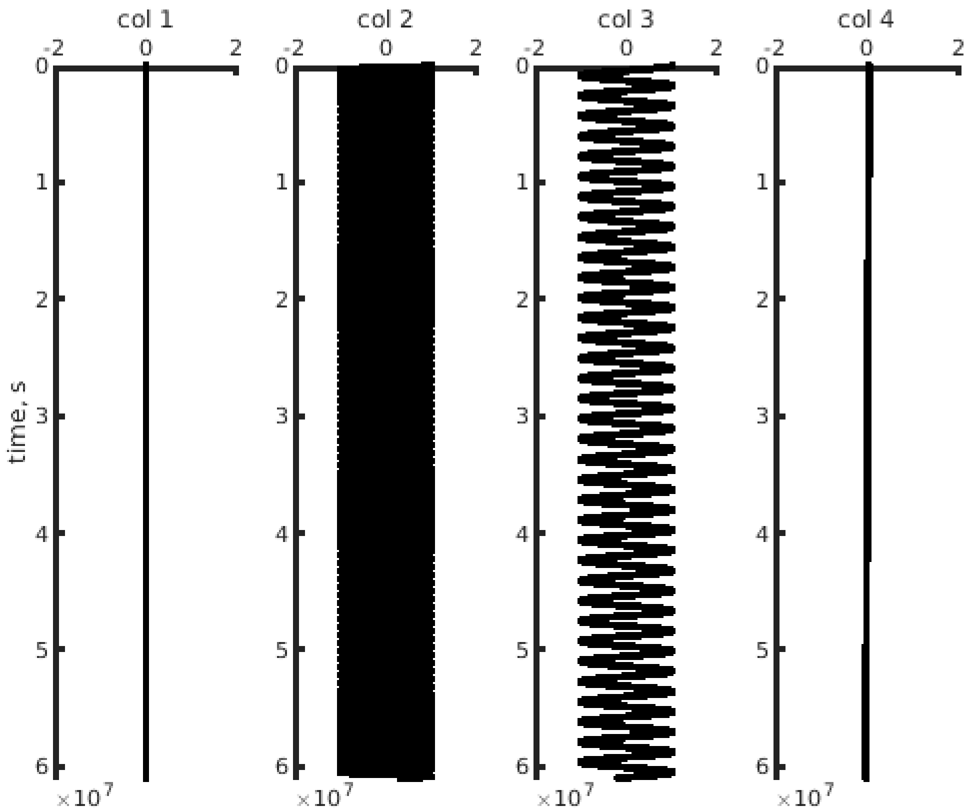
```
win =1; %Hanning window
ci  =95; %Confidence interval 95%
smo =2*24; %no smoothing

[h0,f,c]=specs(d,length(d),1/24,win,smo,ci);
sc        =1-(ci/100);
chi1      =c(:,3);
clo1      =c(:,4);
med       =c(:,5);
T         =1./f; %Period

figure %plot spectral analysis
%loglog(f,abs(h0),'k'), hold on
loglog((1./f),abs(h0),'k'), hold on
%line([.25 .25], [clo1(1)+5 chi1(1)+5],'color', 'r', 'Linewidth',4)
ylabel('Energy [m^2/cp days]')
%xlabel('Frequency [c/days]')
xlabel('Period [days]')
grid on
set(gca,'FontName','Helvetica','FontSize',16,'FontWeight','Bold')
```



Creating a new G matrix with specific frequencies

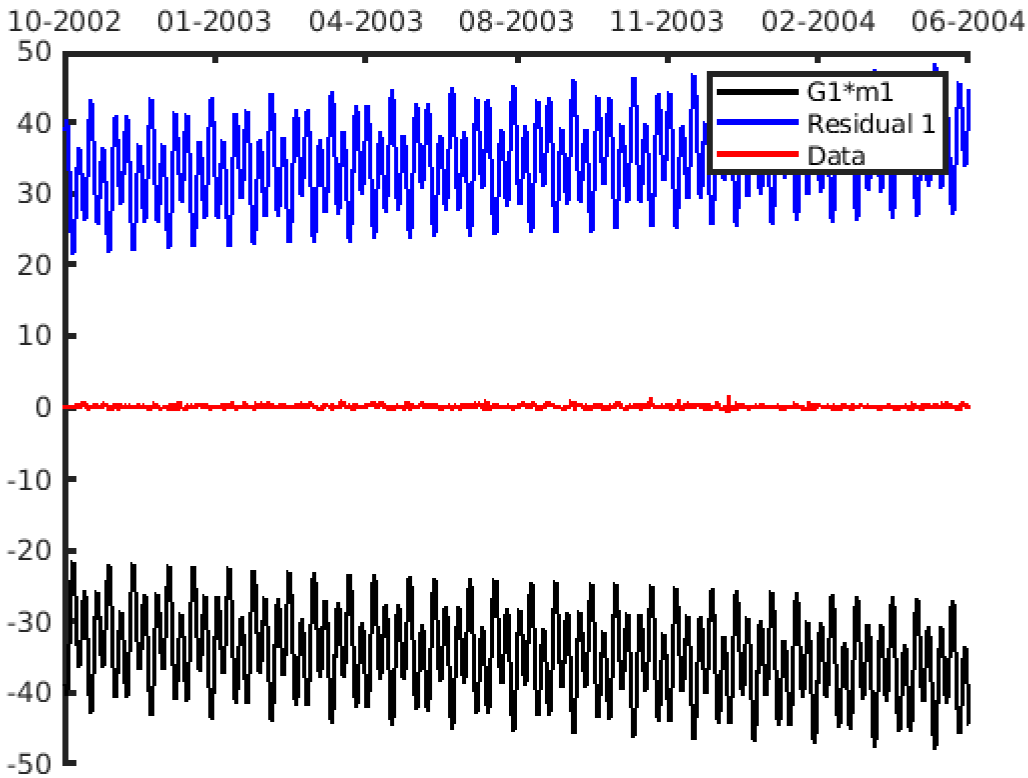
```
M=3;%number of frequencies I'd decompose my data

%T_specific=[0.25, 0.35,0.5,1,4,8,15];%days
T_specific=[8,20];%days
T_specific=T_specific.*(24*60*60);
f_specific=(1./T_specific);%[Hz]

% % nyquist frequencies
% %Nf=(Dt)/2;
% Nf=N/2+1;
% fmax = 1/(2*Dt);
% Df = fmax/(N/2);
% f = Df*[0:Nf-1]';
% Nw=Nf;
% wmax = 2*pi*fmax;
% Dw = wmax/(N/2);
% w = Dw*[0:Nw-1]';


% set up G
G1=zeros(N,M);

% zero frequency column
G1(:,1)=nanmean(d);
```

```
%% interior M/2-1 columns
% for i = [1:M/2]
%     j = 2*i;
%     k = j+1;
%     G1(:,j)=cos(2*pi.*f_specific(i).*t);
%     G1(:,k)=sin(2*pi.*f_specific(i).*t);
% end
% interior M/2-1 columns
for i = [2:M]
    G1(:,i)=cos(2*pi.*f_specific(i-1).*t);
end

%Calculating trend
G1(:,4)=d-detrend(d);

% plot spectral density
figure(1)
clf;

% plot columns of G vs time
j=1;
for i = 1:4

    subplot(1,4,i)
    set(gca,'LineWidth',2);
    hold on;
    set(gca,'XAxisLocation','top');
    axis( [-2, 2, tmin, tmax] );
    axis ij;
    plot( G1(:,i), t, 'k-','LineWidth',2);
    plot( G1(:,i), t, 'k.','LineWidth',2);
    xlabel(sprintf('col %d',i));
    if (i==1)
    ylabel('time, s');
    end
end
```



Calculating m and the residual

```
m1=nan(size(G1,2),1);
for j=1:size(G1,2)
    m1(j) = (d'*G1(:,j))\(d'*d);
end

residual1=d-G1*m1;

%% Plot the data, predicted and residual
figure
clf
set(gca,'LineWidth',2);
hold on;
set(gca,'XAxisLocation','top');
xlim( [tt(1) tt(end)] );
plot(tt,G1*m1,'k-','linewidth',2)
hold on
plot(tt,residual1,'b-','linewidth',2)
plot(tt,d,'r-','linewidth',2)
datetick('x','mm-yyyy','keepticks')
legend('G1*m1','Residual 1','Data')
```


10-2002
01-2003
04-2003
08-2003
11-2003
02-2004
06-2004
50
40
30
20
10
0
-10
-20
-30
-40
-50
G1*m1
Residual 1
Data