Appendix

Program used

In this study *Asp* (A Statistical package) was used which is a suite of functions for graphing and analysing statistical data. These programs are used with MATLAB, a software package that runs under Microsoft Windows. MATLAB M-files are simply text files for using as follow.

Fig24.m

```
% Figure 2.4
system_dependent(14,'on')
tmin = 1; tmax = 60;
hmax0 = 7; hmin0 = 2;
getfile bang.num
days
ndays =60;
scale = 1;
[l1,l2,h1,h2] = separate(ndays);
axes('Position',[0.08 0.16 0.86 0.76])
h = plot(l1(:,1),l1(:,2),'w.');
set(h,'MarkerSize',14)
text(-3.2,6.7,'Height (decimetres) of first low tide')
xlabel('lunar day of year')
axis([-1 60.5 0 6.4])
```

Fig25.m

```
% Figure 2.5
system_dependent(14,'on')
tmin = 1; tmax = 60;
hmax0 = 7; hmin0 = 2;
getfile bang.num
days
```

```
ndays = 60;
scale = 1;
[l1,l2,h1,h2] = separate(ndays);
l1(:,3) = l1(:,3)+ (l1(:,1)-1)*0.841;
l1(:,3) = rem(l1(:,3),24);
axes('Position',[0.08 0.16 0.86 0.76])
h = plot(l1(:,1),l1(:,3),'w.');
set(h,'MarkerSize',14)
text(-3.9,25.4,'Hour of occurrence (in solar day) of first low tide')
xlabel('lunar day of year')
axis([-1 60.5 0 24])
```

Fig26.m

```
% Figure 2.6
system_dependent(14,'on')
tmin = 1; tmax = 60;
hmax0 = 7; hmin0 = 2;
getfile bang.num
days
ndays =60;
scale = 1;
[l1,l2,h1,h2] = separate(ndays);
axes('Position',[0.08 0.16 0.86 0.76])
h = plot(l1(:,1),l1(:,3),'w.');
set(h,'MarkerSize',14)
hold on
plot([-1 60.5],[24.841/4 24.841/4],'m:')
text(-3.2,9.3,'Hour of occurrence (in lunar day) of first low tide')
xlabel('lunar day of year')
axis([-1 60.5 0 8.9])
```

Fig27.m

```
% Figure 2.7
system_dependent(14,'on')
tmin = 1; tmax = 60;
hmax0 = 7; hmin0 = 2;
getfile bang.num
days
ndays =60;
scale = 1;
[l1,l2,h1,h2] = separate(ndays);
axes('Position',[0.08 0.16 0.86 0.76])
set(gca,'Box','on')
hold on
n = size(l1,1);
for j=1:n
  x = l1(j,1);
  y = l1(j,3);
  h = 0.2*l1(j,2);
  plot([x x],[y-h y+h],'c-')
end
h = plot(l1(:,1),l1(:,3),'w.');
set(h,'MarkerSize',14)
plot([-1 60.5],[24.841/4 24.841/4],'m:')
text(-3.2,9.3,'Hour of occurrence (in lunar day) and height of first low tide')
xlabel('lunar day of year')
axis([-1 60.5 0 8.9])
```

Fig28.m

```
% Figure 2.8
system_dependent(14,'on')
tmin = 1; tmax = 60;
hmax0 = 7; hmin0 = 2;
getfile bang.num
days
ndays =60;
scale = 1;
[l1,l2,h1,h2] = separate(ndays);
axes('Position',[0.08 0.16 0.86 0.76])
set(gca,'Box','on')
hold on
n1 = 1; n2 = 19;
x = l1(n1:n2,1);
h = 0.2*l1(n1:n2,2);
y = l1(n1:n2,3);
y1 = y-h/2; y2 = y+h/2;
y = [y1 ; flipud(y2) ; y1(1)];
x = [x ; flipud(x) ; x(1)];
fill(x,y,'c')
hold on
plot(x,y,'w-')
n1 = 25; n2 = 47;
x = l1(n1:n2,1);
h = 0.2*l1(n1:n2,2);
y = l1(n1:n2,3);
y1 = y-h/2; y2 = y+h/2;
y = [y1 ; flipud(y2) ; y1(1)];
x = [x ; flipud(x) ; x(1)];
```

```
fill(x,y,'c')
hold on
plot(x,y,'w-')
n1 = 54; n2 = 58;
x = l1(n1:n2,1);
h = 0.2*l1(n1:n2,2);
y = l1(n1:n2,3);
y1 = y-h/2; y2 = y+h/2;
y = [y1 ; flipud(y2) ; y1(1)];
x = [x ; flipud(x) ; x(1)];
fill(x,y,'c')
hold on
plot(x,y,'w-')
plot([-1 60.5],[24.841/4 24.841/4],'m:')
text(-3.2,9.3,'Hour of occurrence (in lunar day) and height of first low tide')
xlabel('lunar day of year')
axis([-1 60.5 0 8.9])
```

Days.m

```
% function to convert day & month to day of year
y = getnum;
month = y(:,2);
day = y(:,3);
feb = month==2; day(feb) = day(feb)+31;
mar = month==3; day(mar) = day(mar)+59;
apr = month==4; day(apr) = day(apr)+90;
may = month==5; day(may) = day(may)+120;
jun = month==6; day(jun) = day(jun)+151;
jul = month==7; day(jul) = day(jul)+181;
aug = month==8; day(aug) = day(aug)+212;
```

```
sep = month==9; day(sep) = day(sep)+243;
oct = month==10; day(oct) = day(oct)+273;
nov = month==11; day(nov) = day(nov)+304;
dec = month==12; day(dec) = day(dec)+334;
y = [day y(:,[4 5 6])];
putnum(y)
```

Plottide.m

```
% function plottide(ndays,scale)
% plot the tides for a specified number of days from Jan 1
% the data (obtained using getfile) should be structured as follows:
% column 1: day of year (Jan 1)
%       2: tide (3 = high high, 2 = low high, 1 = high low, 0 = low low)
%       3: water height above the lowest in the year (decimetres)
%       4: hour after midnight
% ndays (default = 365) is the number of days to be plotted
% scale (default = 0.7) is the width of the band denoting the water height
% syntax is  plottide(ndays,scale);
system_dependent(14,'on')
if nargin  <=1
  scale = 0.7;
end
scale = scale/10;
if nargin < 1
  ndays = 365;
end
z = getnum;
dn = getdn;
clf
```

```
% number of hours in a lunar day and
% number of lunar days in a lunar month
lunarday = 24.841;
lm = 27.55*24/lunarday;
upperlimit = [24 6 31 18];
lowerlimit = [12 -6 19 6];
ymax = 30.5; ymin = -3.5;
axes('position',[0.08 0.12 0.87 0.78])
colours = ['y' 'c' 'g' 'm'];
for tidetype = 0:3
  selection = z(:,1)<=ndays & z(:,2)==tidetype;
  if sum(selection)>0
    xhy = z(selection,[1 3 4]);
    hourofyear = xhy(:,3)+24*(xhy(:,1)-1);
    lunardayofyear = ceil(hourofyear/lunarday);
    xhy(:,3) = hourofyear-lunarday*(lunardayofyear-1);
    xhy(:,1) = lunardayofyear;
    toohigh = xhy(:,3)>upperlimit(tidetype+1);
    xhy(toohigh,1) = xhy(toohigh,1)+1;
    xhy(toohigh,3) = xhy(toohigh,3)-lunarday;
    toolow = xhy(:,3)<lowerlimit(tidetype+1);
    xhy(toolow,1) = xhy(toolow,1)-1;
    xhy(toolow,3) = xhy(toolow,3)+lunarday;
    ndata = size(xhy,1);
    t1 =1;
    while t1<ndata
      for t=t1:ndata-1
        if isnan(xhy(t,3))
          break
        end
```

```
        end
        x = xhy(t1:t,1);
        y = xhy(t1:t,3);
        h = xhy(t1:t,2);
        ok = finite(y) & finite(h);
        x = x(ok); y = y(ok); h = h(ok);
        if sum(ok)>0
          x = [x ; flipud(x) ; x(1)];
          y1 = y - scale*h;
          y2 = y + scale*h;
          y = [y2 ; flipud(y1) ; y2(1)];
          fill(x,y, colours(tidetype+1))
          hold on
          plot(x,y,'w -')
          hold on
        end
        t1 = t+1;
      end
    end
end
axis([0 ndays ymin ymax])
title ='Hour of lunar day & relative height of high & low tides at ';
title = [title dn(1,:) ' in 1994'];
text(-5,ymax+2,title)
xlabel('lunar day of year')
yticks = 6*(-2:6);
ylab = str2mat('12','18','0','6','12','18','24','30','36');
plot([0 ndays],[0 0],'w:',[0 ndays],[lunarday lunarday],'w:')
yr = [0 lunarday];
plot([0 lm],yr,'w:',[lm 2*lm],yr,'w:',[2*lm 3*lm],yr,'w:',[3*lm 4*lm],yr,'w:')
```

```
plot([4*lm 5*lm],yr,'w:',[5*lm 6*lm],yr,'w:',[6*lm 7*lm],yr,'w:',[7*lm 8*lm],yr,'w:')
plot([8*lm 9*lm],yr,'w:',[9*lm 10*lm],yr,'w:',[10*lm 11*lm],yr,'w:',[11*lm
12*lm],yr,'w:')
plot([12*lm 13*lm],yr,'w:',[13*lm 14*lm],yr,'w:')
set(gca,'YTick',yticks,'YTickLabels',ylab)
```

Produce ribbon graph

This MATLAB commands were used to create the ribbon graph by using the functions *days.m* and *plottide.m* as the following Figures.

Figures 3.1 and 3.2

```
getfile laemta.num
days
plottide(60,0.7)
figure(2)
plottide(358,0.7)
```

Figures 3.3 and 3.4

```
getfile konu.num
days
plottide(60,0.7)
figure(2)
plottide(358,0.7)
```

Figures 3.5 and 3.6

```
getfile bang.num
days
plottide(60,0.7)
figure(2)
plottide(358,0.7)
```

Figures 3.7 and 3.8

```
getfile pakphun.num
days
plottide(60,0.7)
figure(2)
plottide(358,0.7)
```

Separate.m

```
% function [h1,l1,h2,l2]=separate(ndays)
% restructure the tides data for a specified number of days from Jan 1
% the data (obtained using getfile) should be structured as follows:
% column 1: day of year (Jan 1)
%       2: tide (3 = high-1, 2 = low-1, 1 = high-2, 0 = low-2)
```

```
%       3: water height above the lowest in the year (decimetres)
%       4: hour after midnight
% ndays (default = 365) is the number of days
% syntax is :[h1,l1,h2,l2]=separate(ndays);
if nargin < 1
  ndays = 365;
end
% get data
z = getnum;
% number of hours in a lunar day and
% number of lunar days in a lunar month
lunarday = 24.841;
lm = 27.55*24/lunarday;
upperlimit = [24 6 31 18];
lowerlimit = [12 -6 19 6];
for tidetype = 0:3
  selection = z(:,1)<=ndays & z(:,2)==tidetype;
  if sum(selection)>0
    xhy = z(selection,[1 3 4]);
    hourofyear = xhy(:,3)+24*(xhy(:,1)-1);
    lunardayofyear = ceil(hourofyear/lunarday);
    xhy(:,3) = hourofyear-lunarday*(lunardayofyear-1);
    xhy(:,1) = lunardayofyear;
    toohigh = xhy(:,3)>upperlimit(tidetype+1);
    xhy(toohigh,1) = xhy(toohigh,1)+1;
    xhy(toohigh,3) = xhy(toohigh,3)-lunarday;
    toolow = xhy(:,3)<lowerlimit(tidetype+1);
    xhy(toolow,1) = xhy(toolow,1)-1;
    xhy(toolow,3) = xhy(toolow,3)+lunarday;
    ndata = size(xhy,1);
```

```
    data = [(1:ndata)' xhy(:,2:3)];
    if tidetype==0
      l1 = data;
    elseif tidetype==1
      h1 = data;
    elseif tidetype==2
      l2 = data;
    else
      h2 = data;
    end
  end
end
```

Harmonic analysis

Function *separate.m* was used to separate tides into four types, and analyse each tide type by using *tsplot* or *tsplot1,* and creating M-files as follow.

Figures 4.1 – 4.4 and Figures 4.17 – 4.20

Laemta.m

```
system_dependent(14,'on')
getfile laemta.num
days                                          % convert cols 2-3 to day of year
ndays =358;
scale = 0.7;
plottid(ndays,scale);                                  % create ribbon graph
[l1,l2,h2,h1] = separate(ndays);
putnum(l1)
putfn(str2mat('lunarday','height of  low-1','hour of  low-1'))
setvar x=1 y=2
tsplot pg=2  'harm=1 2 11 13 14 24 26' ar=1 font=8          % height of low-1
```

```
setvar x=1 y=3
tsplot pg=2 'harm=11 13  24'  'ar=1 2' font=9                % hour of low-1
clear functions
putnum(l2)
putfn(str2mat('lunarday','height of  low-2','hour of  low-2'))
setvar x=1 y=2
tsplot pg=2  'harm=1 2 11 13 14 24 26 ' 'ar=1 2' font=8      % height of low-2
setvar x=1 y=3
tsplot pg=2 'harm=11 13  24' 'ar=1 2' font=9                 % hour of low-2
clear functions
putnum(h2)
putfn(str2mat('lunarday','height of  hight-2','hour of  high-2'))
setvar x=1 y=2
tsplot pg=2  'harm=1 2 11 13 14 24 26 ' 'ar=1 2'  font=8     % height of high-2
setvar x=1 y=3
tsplot pg=2 'harm=11 24 26' 'ar=1 2' font=9                  % height of high-2
clear functions
putnum(h1)
putfn(str2mat('lunarday','height of  high-1','hour of  high-1'))
setvar x=1 y=2
tsplot pg=2  'harm=1 2 11 13 14 24 26 '  'ar=1 2' font=8     % height of high-1
setvar x=1 y=3
tsplot pg=2 'harm=11 13'  ar=1 font=9                        % hour of high-1
clear all
```

Figures 4.5 – 4.8 and Figures 4.21 – 4.24

konu.m

```
system_dependent(14,'on')
getfile konu.num
days                                    % convert columns 2-3 to day of year
```

```
ndays =358;
scale = 0.7;
plottid(ndays,scale);                                   % create ribbon graph
[l1,l2,h2,h1] = separate(ndays);
putnum(l1)
putfn(str2mat('lunarday','height of  low-1','hour of  low-1'))
setvar x=1 y=2
tsplot pg=2 'harm=13 14  24 25 26' ar=1 font=9          % height of low-1
setvar x=1 y=3
tsplot pg=2 'harm=11 13  24 25 26 37'  'ar=1 3' font=9  % hour of low-1
clear functions
putnum(l2)
putfn(str2mat('lunarday','height of  low-2','hour of  low-2'))
setvar x=1 y=2
tsplot pg=2  'harm=13  24  25 26 '  ar=1  font=9        % height of low-2
setvar x=1 y=3
tsplot pg=2  'harm=11 13  24  25 37 '  'ar=1 3'  font=9  % hour of low-2
clear functions
putnum(h2)
putfn(str2mat('lunarday','height of  hight-2','hour of  high-2'))
setvar x=1 y=2
tsplot pg=2  'harm=13  24 '  'ar=1 3'  font=9           % height of high-2
setvar x=1 y=3
tsplot pg=2  'harm=13  24  25 '  'ar=1 3'  font=9       % hour of high-2
clear functions
putnum(h1)
putfn(str2mat('lunarday','height of  high-1','hour of  high-1'))
setvar x=1 y=2
tsplot pg=2  'harm=13 24 26 37'  ar=1  font=9           % height of high-1
setvar x=1 y=3
```

```
tsplot pg=2  'harm=11 13 24 37'  'ar=1 3'  font=9              % hour of high-1
clear all
```

Figures 4.9 – 4.12 and Figures 4.25 – 4.28

bang.m

```
system_dependent(14,'on')
getfile bang.num
days                                        % convert cols 1-3 to day of year
fn = getfn;
fn = str2mat('day',fn(4:6,:));
putfn(fn)
[lab,colid] = getlab;
lab = lab(2,:);
colid = 2;
putlab(lab,colid)
describe hist=1                             % summarise the data with histogram
ndays =358;
scale = 0.7;
%plottid(ndays,scale);                      % ribbon graph for Bang Nara
[l1,l2,h2,h1] = separate(ndays);
putnum(l1)
putfn(str2mat('lunarday','height of  low-1','hour of  low-1'))
setvar x=1 y=2
tsplot1 pg=2  'harm=11 13 24 25 26 37'  'ar=1 3' font=9     % height of  low-1
setvar x=1 y=3
tsplot1 pg=2 'harm=11 13 24 25 37 38'  'ar=1 3' font=9      % hour of  low-1
clear functions
putnum(l2)
putfn(str2mat('lunarday','height of  low-2','hour of  low-2'))
setvar x=1 y=2
```

```
tsplot1 pg=2  'harm=11 13 24 26 37' 'ar=1 3' font=9          % height of low-2
setvar x=1 y=3
tsplot1 pg=2 'harm=11 13 24 25 37' 'ar=1 3' font=9           % hour of low-2
clear functions
putnum(h2)
putfn(str2mat('lunarday','height of high-2','hour of high-2'))
setvar x=1 y=2
tsplot1 pg=2  'harm=11 12 13 14 24 26' 'ar=1 2' font=9       % height of high-2
setvar x=1 y=3
tsplot1 pg=2 'harm=11 13  24 25 37' 'ar=1 3' font=9          % hour of high-2
clear functions
putnum(h1)
putfn(str2mat('lunarday','height of high-1','hour of high-1'))
setvar x=1 y=2
tsplot1 pg=2  'harm=11 12 13 14  24 26' 'ar=1 3' font=9      % height of high-1
setvar x=1 y=3
tsplot1 pg=2 'harm=11 13  24  26 37' 'ar=1 3' font=9         % hour of high-1
clear all
```

Figures 4.13 – 4.16 & Figures 4.29 – 4.32

pakphun.m

```
system_dependent(14,'on')
getfile pakphun.num
days                                  % convert columns 2-3 to day of year
fn = getfn;
fn = str2mat('day',fn(4:6,:));
putfn(fn)
[lab,colid] = getlab;
lab = lab(2,:);
colid = 2;
```

```
putlab(lab,colid)
describe hist=1                    % Shows summaries data
ndays =358;
scale = 0.7;
plottid(ndays,scale);                                    % Ribbon graph
[l1,l2,h2,h1] = separate(ndays);
putnum(l1)
putfn(str2mat('lunarday','height of low-1','hour of low-1'))
setvar x=1 y=2
tsplot1 pg=2 'harm=13 14 24 25 26 39 ' 'ar=1 3' font=9          % height of low-1
setvar x=1 y=3
tsplot1 pg=2 'harm=13 14 24 25 26 39 ' 'ar=1 3' font=9          % hour of low-1
clear functions
putnum(l2)
putfn(str2mat('lunarday','height of low-2','hour of low-2'))
setvar x=1 y=2
tsplot1 pg=2 'harm=13 24 25 26 39' 'ar=1 3' font=9              % height of low-2
setvar x=1 y=3
tsplot1 pg=2 'harm=13 24 25 26 39' 'ar=1 3' font=9              % hour of low-2
clear functions
putnum(h2)
putfn(str2mat('lunarday','height of high-2','hour of high-2'))
setvar x=1 y=2
tsplot1 pg=2 'harm=1 11 13 14 24 38 39' 'ar=1 3' font=8  % height of high-2
setvar x=1 y=3
tsplot1 pg=2 'harm=1 11 13 24 38 39' 'ar=1 3' font=8     % hour of high-2
clear functions
putnum(h1)
putfn(str2mat('lunarday','height of high-1','hour of high-1'))
setvar x=1 y=2
```

```
tsplot1 pg=2  'harm=13 24 25 26'  'ar=1 2'  font=9          % height of high-1
setvar x=1 y=3
tsplot1 pg=2  'harm=13 24 25 26'  'ar=1 2'  font=9          % hour of high-1
```

Tidal reconstruction

The method was used simple harmonic models for reconstructing the height at the time of occurrence by using M-files as follow.

Figures 4.33 – 4.36

konusyn.m

```
% synthesis for Ko Nu
%
system_dependent(14,'on')
tmin = 90; tmax = 120;                    % display interval of day of year (y axis)
hmax0 = 14; hmin0 = 5;                    % display interval of height (x axis)
% Hi-2
a = 0.0182;
t = (tmin:tmax)';
h11 = 0.474*cos(11*a*t+1.201);
h13 = 0.760*cos(13*a*t-3.098);
h24 = 0.924*cos(24*a*t+2.641);
h37 = 0.313*cos(37*a*t+1.928);
toccur = (24.78+h11+h13+h24+h37)/24;
h13 = 0.642*cos(13*a*t-1.138);
h24 = 0.410*cos(24*a*t+0.581);
h26 = 0.094*cos(26*a*t-2.131);
h37 = 0.157*cos(37*a*t-0.566);
heighthi2 = 11.68+h13+h24+h26+h37;
toccurhi2 = toccur+(1+24.812/1440)*(t-1);
%
```

```
% Lo-2
a = 0.0182;
h11 = 0.304*cos(11*a*t+1.674);
h13 = 0.727*cos(13*a*t-2.696);
h24 = 0.677*cos(24*a*t+3.025);
h25 = 0.264*cos(25*a*t-0.218);
h37 = 0.24*cos(37*a*t-1.925);
toccur = (18.41+h11+h13+h24+h25+h37)/24;
h13 = 1.818*cos(13*a*t+0.608);
h24 = 0.722*cos(24*a*t-1.856);
h25 = 0.199*cos(25*a*t+1.32);
h26 = 0.114*cos(26*a*t-1.235);
heightlo2 = 8.129+h13+h24+h25+h26;
toccurlo2 = toccur+(1+24.812/1440)*(t-1);
%
% Lo-1
a = 0.0182;
h11 = 0.321*cos(11*a*t-0.292);
h13 = 0.570*cos(13*a*t+2.979);
h24 = 0.634*cos(24*a*t+2.981);
h25 = 0.234*cos(25*a*t+0.066);
h26 = 0.236*cos(26*a*t+0.339);
h37 = 0.307*cos(37*a*t+0.352);
toccur = (6.273+h11+h13+h24+h25+h26+h37)/24;
h13 = 0.961*cos(13*a*t-2.461);
h14 = 0.136*cos(14*a*t+0.743);
h24 = 0.719*cos(24*a*t-2.024);
h25 = 0.266*cos(25*a*t+1.096);
h26 = 0.246*cos(26*a*t+1.507);
heightlo1 = 7.817+h13+h14+h24+h25+h26;
```

```
toccurlo1 = toccur+(1+24.812/1440)*(t-1);
%
% Hi-1
a = 0.0182;
h13 = 0.421*cos(13*a*t-2.694);
h24 = 0.771*cos(24*a*t-3.14);
h25 = 0.251*cos(25*a*t+0.061);
toccur = (12.75+h13+h24+h25)/24;
h13 = 0.958*cos(13*a*t-0.472);
h24 = 0.345*cos(24*a*t+0.898);
heighthi1 = 11.81+h13+h24;
toccurhi1 = toccur+(1+24.812/1440)*(t-1);
%
% synthesise data
toccur = [toccurlo1 ; toccurhi1 ; toccurlo2 ; toccurhi2];
height = [heightlo1 ; heighthi1 ; heightlo2 ; heighthi2];
data = [toccur height];
[st,I] = sort(toccur);
data = data(I,:);
axes('Position',[0.06,0.14,0.9,0.75])
hmin = min(height); hmax = max(height);
if hmin0>0
  hmin = hmin0;
end
if hmax0>0
  hmax = hmax0;
end
hr = hmax-hmin;
hmin = hmin-hr/10; hmax = hmax+hr/10;
%j1 = ceil(hmin); j2 = floor(hmax);
```

```
%for i=(12*tmin+1):(12*tmax)
%   plot([i/12,i/12],[j1,j2],'c-')
%   hold on
%end
%for j=j1:j2
%    plot([tmin,tmax],[j,j],'c-')
%end
h = plot(data(:,1),data(:,2),'w.',data(:,1),data(:,2),'w-');
set(h,'MarkerSize',12,'LineWidth',1.5)
hold on
xlabel('Day of year')
text(tmin-(tmax-tmin)/30,hmax+0.5,'Height of water in decimetres at Ko-Nu')
axis([tmin tmax hmin hmax])
% end
```

Figures 4.37 – 4.40

paksyn.m

```
% synthesis for Pak Phun
%
system_dependent(14,'on')
tmin = 90; tmax = 120;          % displays interval of day of year (y axis)
hmax0 = 17; hmin0 = 6;          % display interval of height (x axis)

getfile pakphun.num
y = getnum;
y(:,1) = ceil(y(:,1)/4);
ok = (y(:,1)>=tmin & y(:,1)<=tmax);
y = y(ok,:);
a = 0.0182;
%
```

```
% Hi-2
ok = y(:,4)==3;
yok = y(ok,:);
tok = finite(yok(:,5));
t = (tmin:tmax)';
t = t(tok);
h1 = 0.177*cos(1*a*t-1.268);
h11 = 0.823*cos(11*a*t+0.172);
h13 = 1.201*cos(13*a*t+2.385);
h24 = 0.924*cos(24*a*t+0.837);
h38 = 0.278*cos(38*a*t-1.3);
h39 = 0.563*cos(39*a*t-0.231);
toccur = (12.61+h1+h11+h13+h24+h38+h39)/24;
h1 = 0.367*cos(1*a*t-0.008);
h11 = 0.320*cos(11*a*t-0.993);
h13 = 2.894*cos(13*a*t+0.742);
h14 = 0.478*cos(14*a*t-2.333);
h24 = 0.811*cos(24*a*t+1.512);
h38 = 0.391*cos(38*a*t-1.234);
heighthi2 = 14.03+h1+h11+h13+h14+h24+h38;
toccurhi2 = toccur+(1+24.812/1440)*(t-1);
%
% Lo-2
ok = y(:,4)==0;
yok = y(ok,:);
tok = finite(yok(:,5));
t = (tmin:tmax)';
t = t(tok);
h13 = 0.629*cos(13*a*t-0.220);
h24 = 0.501*cos(24*a*t+1.01);
```

```
h25 = 0.248*cos(25*a*t-1.587);
h26 = 0.465*cos(26*a*t-1.22);
h39 = 0.300*cos(39*a*t-1.356);
toccur = (18.03+h13+h24+h25+h26+h39)/24;
h13 = 1.692*cos(13*a*t+1.352);
h24 = 1.316*cos(24*a*t+1.419);
h25 = 0.775*cos(25*a*t-1.682);
h26 = 2.136*cos(26*a*t-1.337);
h39 = 1.008*cos(39*a*t-0.365);
heightlo2 = 9.083+h13+h24+h25+h26+h39;
toccurlo2 = toccur+(1+24.812/1440)*(t-1);
%
% Lo-1
ok = y(:,4)==1;
yok = y(ok,:);
tok = finite(yok(:,5));
t = (tmin:tmax)';
t = t(tok);
h13 = 3.025*cos(13*a*t-2.784);
h14 = 0.408*cos(14*a*t+0.988);
h24 = 1.029*cos(24*a*t-0.389);
h25 = 0.256*cos(25*a*t+1.434);
h26 = 0.560*cos(26*a*t+0.817);
h39 = 0.380*cos(39*a*t+1.475);
toccur = (5.792+h13+h14+h24+h25+h26+h39)/24;
h13 = 0.536*cos(13*a*t-2.425);
h14 = 0.367*cos(14*a*t+1.307);
h24 = 0.895*cos(24*a*t+1.767);
h25 = 0.289*cos(25*a*t-0.943);
h26 = 0.581*cos(26*a*t-1.922);
```

```
h39 = 0.559*cos(39*a*t+2.122);
heightlo1 = 9.622+h13+h14+h24+h25+h26+h39;
toccurlo1 = toccur+(1+24.812/1440)*(t-1);
%

%Hi-1
ok = y(:,4)==2;
yok = y(ok,:);
tok = finite(yok(:,5));
t = (tmin:tmax)';
t = t(tok);
h13 = 1.013*cos(13*a*t-2.08);
h24 = 1.538*cos(24*a*t+1.849);
h25 = 0.5*cos(25*a*t-0.699);
h26 = 0.855*cos(26*a*t-0.309);
toccur = (25.53+h13+h24+h25+h26)/24;
h13 = 0.669*cos(13*a*t-2.86);
h24 = 0.814*cos(24*a*t+0.046);
h25 = 0.388*cos(25*a*t+2.133);
h26 = 1.016*cos(26*a*t+1.887);
heighthi1 = 14.09+h13+h24+h25+h26;
toccurhi1 = toccur+(1+24.812/1440)*(t-1);
%
% synthesise data
toccur = [toccurlo1 ; toccurhi1 ; toccurlo2 ; toccurhi2];
height = [heightlo1 ; heighthi1 ; heightlo2 ; heighthi2];
data = [toccur height];
[st,I] = sort(toccur);
data = data(I,:);
axes('Position',[0.06,0.14,0.9,0.75])
```

```
hmin = min(height); hmax = max(height);
if hmin0>0
  hmin = hmin0;
end
if hmax0>0
  hmax = hmax0;
end
hr = hmax-hmin;
hmin = hmin-hr/10; hmax = hmax+hr/10;
%j1 = ceil(hmin); j2 = floor(hmax);
%for i=(12*tmin+1):(12*tmax)
%  plot([i/12,i/12],[j1,j2],'c-')
%  hold on
%end
%for j=j1:j2
%   plot([tmin,tmax],[j,j],'c-')
%end
h = plot(data(:,1),data(:,2),'w.',data(:,1),data(:,2),'w-');
set(h,'MarkerSize',12,'LineWidth',1.5)
hold on
xlabel('Day of year')
text(tmin-(tmax-tmin)/30,hmax+0.5,'Height of water in decimetres at Pak Phun')
axis([tmin tmax hmin hmax])
```