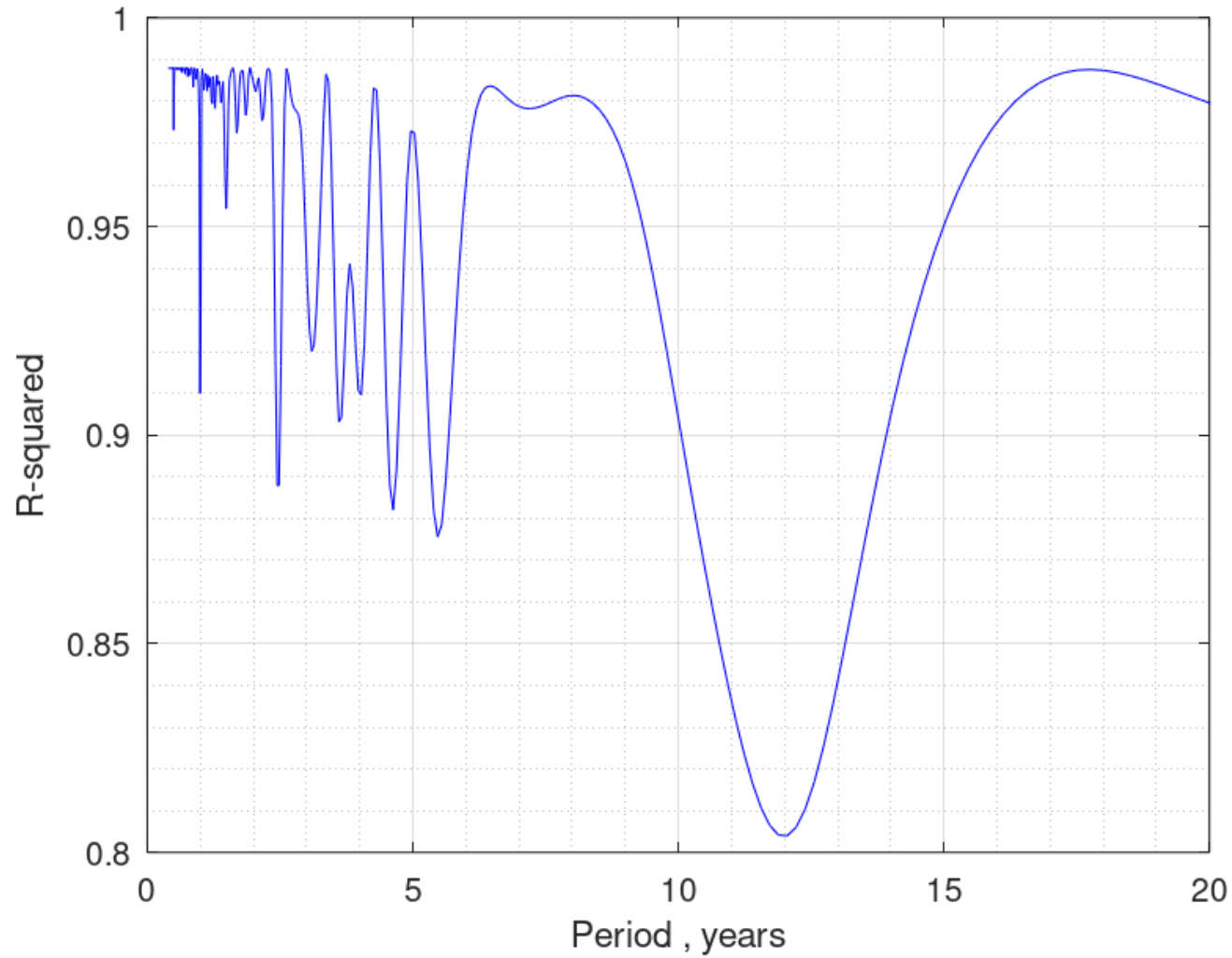
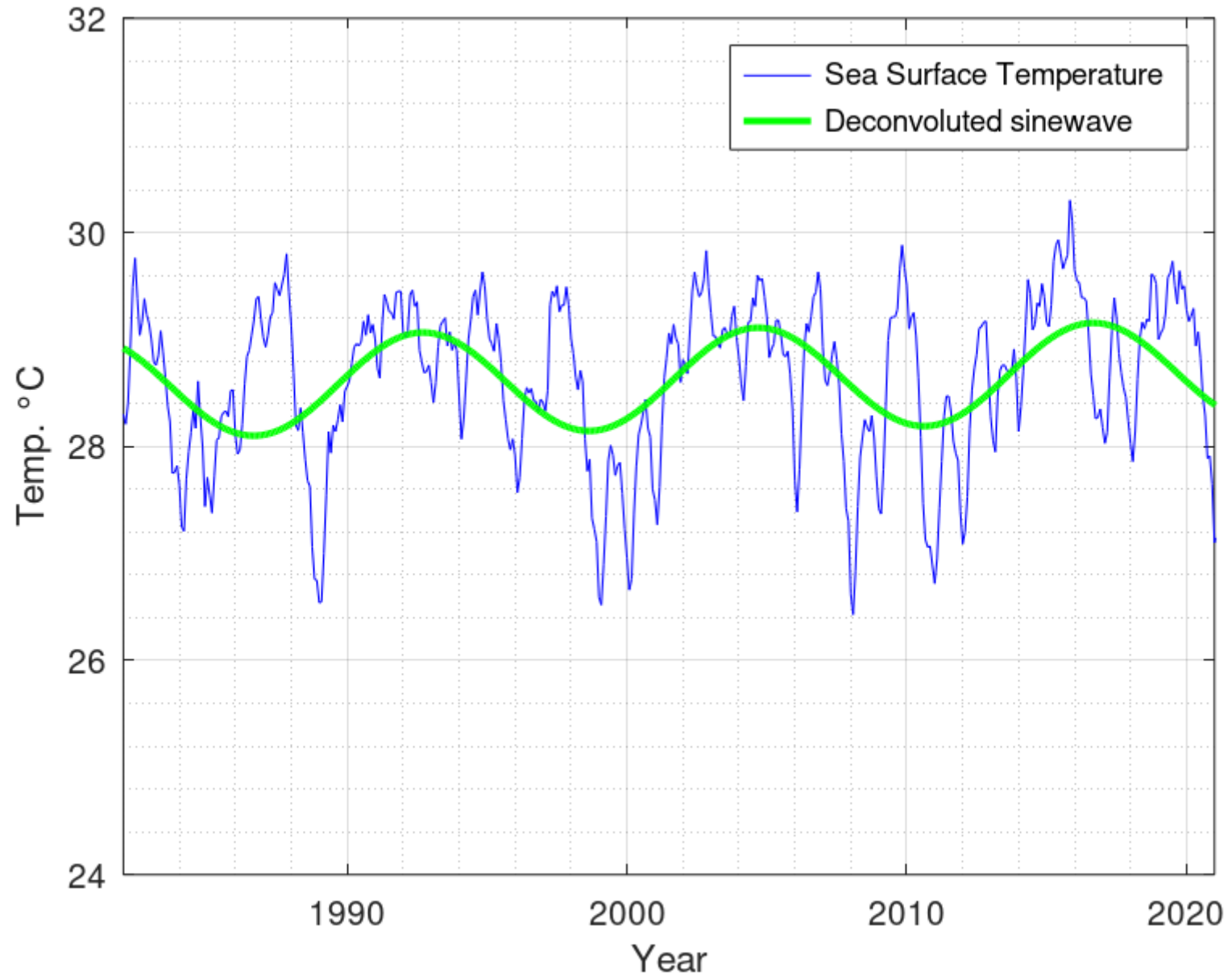


Sea Surface Temperatures - Data from Climate Prediction Center CPC-NOAA  
<https://www.cpc.ncep.noaa.gov/data/indices/sstoi.indices>  
Monthly data from 1980, weekly data from 1990

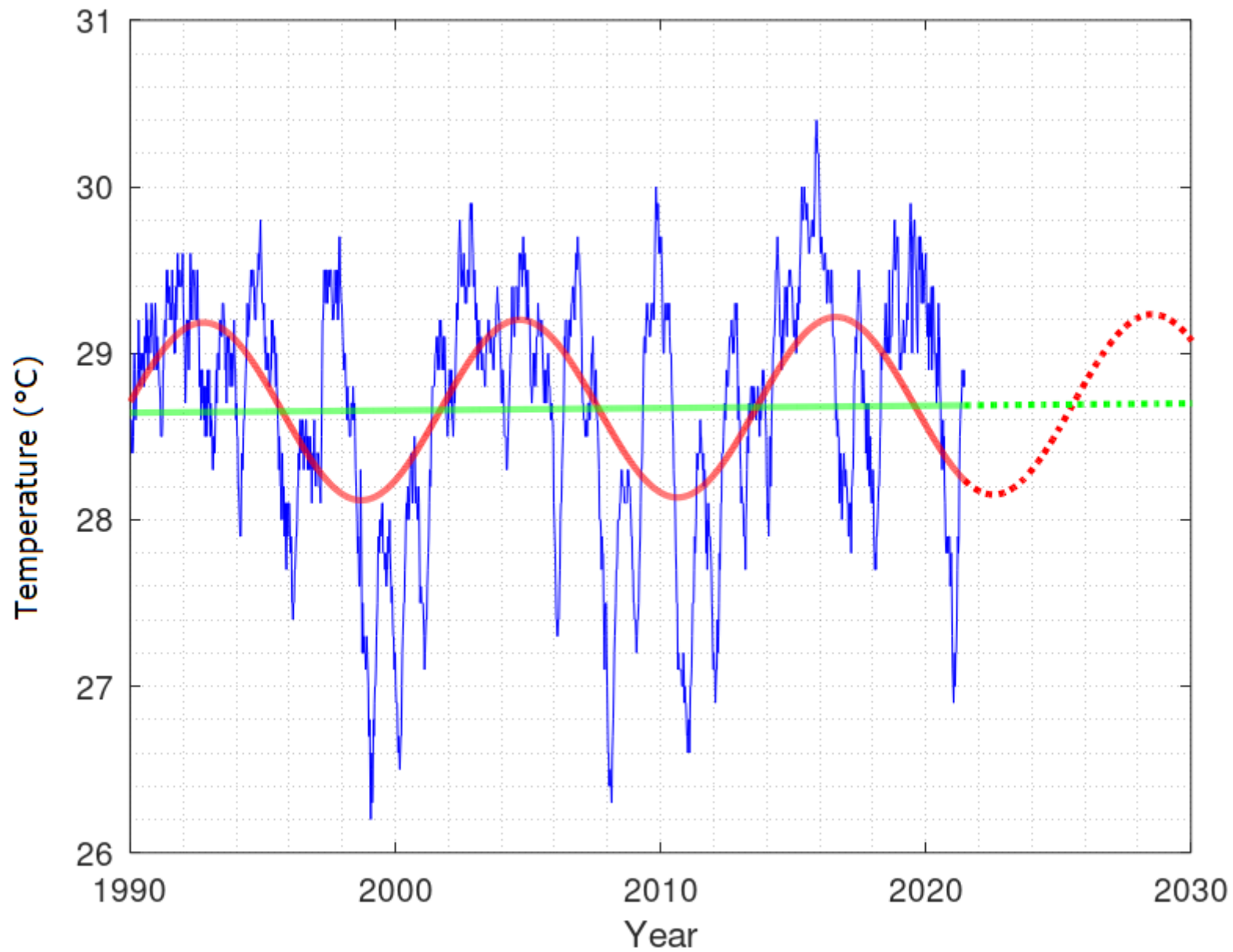
### Frequency Analysis Monthly El-Nino 4 SST



# Monthly El-Nino 4 SST Period = 11.9827 year



Weekly El-Nino 4 SST Rsquared = 0.75655



```

% https://www.cpc.ncep.noaa.gov/data/indices/
% NOAA monthly atmospheric and SST indices
% Nino 1+2 3 4 3+4
% f = urlwrite('https://www.cpc.ncep.noaa.gov/data/indices/sstoi.indices','monthly_.txt');
%(if necessary activate above line to download files)

clear all;clc;format short;format compact;
global Ud yd xd x sumS;
function Rsquared = best(p) % ----- minimizer
    global Ud yd xd x sumS;
    Ud(:,3) = sin(2*pi/p*x); % sin
    Ud(:,4) = cos(2*pi/p*x); % cos
    G = inv(Ud.' * Ud);
    xd(:,1) = G*Ud.'*yd;
    ydR = yd - Ud*xd(:,1); % residuals
    Rsquared = sumsq(ydR)/sumS; % sum of residuals
endfunction % ----- end of minimizer
%f = urlwrite('https://www.cpc.ncep.noaa.gov/data/indices/sstoi.indices','monthly_.txt');
S = fileread('monthly_.txt');
a1 = index(S,'1982');
M = S(a1:end);
X = str2num(M);
x = X(:,1) + (X(:,2)-1)./12; % date in decimal year: Januar = 0

yd = X(':',7);tit='Monthly El-Nino 4 SST'; % El Nino 4 5N-5S 160E-150W

nTot = length(yd);sumS = sumsq(yd - mean(yd));
Ud = zeros(nTot,4);
Ud(1:nTot,1) = 1; % constant plateau
Ud(1:nTot,2) = linspace(-1,1,nTot); % linear trend (orthogonal)
xd = zeros(4,1);
k = 0;
for i = logspace(-0.4,1.4,300);
    ++k;
    xL(k) = i;
    pL(k) = best(i);
endfor
plot (xL,pL,'b');grid on;grid minor on;hold on;
xlabel ('Period , years');ylabel ('R-squared');title (['Frequency Analysis ',tit]);axis([0,20]);
figure;
%-----
pMin = fminbnd(@best,10,13); % 1st call to the minimizer
x2 = best(pMin);pMin % once found , pMin is given again to the best() function

```

```

ySin = Ud*xd(:,1);          % ySin contains SINEWAVE
disp(xd);
plot (x,yd,'b',x,ySin,'g','LineWidth',2);grid on;
grid minor on;axis([1982,2021,24,32]);hold on;
xlabel('Year');ylabel('Temp. °C');
title([tit,' Period = ',num2str(pMin),' year']);
legend('Sea Surface Temperature','Deconvoluted sinewave')
hold on;

```

```

% https://www.cpc.ncep.noaa.gov/data/indices/
% NOAA weekly atmospheric and SST indices
% Nino 1+2 3 4 3+4
%f = urlwrite('https://www.cpc.ncep.noaa.gov/data/indices/wksst9120.for','weekly_.txt');

clear all;clc;format short;format compact;
global Ud yd xd x sumS;
function Rsquared = best(p) % ----- minimizer
    global Ud yd xd x sumS;
    Ud(:,3) = sin(2*pi/p*x); % sin
    Ud(:,4) = cos(2*pi/p*x); % cos
    G = inv(Ud.' * Ud);
    xd(:,1) = G*Ud.'*yd;
    ydR = yd - Ud*xd(:,1); % residuals
    Rsquared = sumsq(ydR)/sumS; % R-squared test
endfunction % ----- end of minimizer

S = fileread('weekly_.txt');
a1 = index(S,'03JAN1990');
M = S((a1-1):end);
M = strrep(M,'JAN',' 0 '); % January is == 0
M = strrep(M,'FEB',' 1 ');
M = strrep(M,'MAR',' 2 ');
M = strrep(M,'APR',' 3 ');
M = strrep(M,'MAY',' 4 ');
M = strrep(M,'JUN',' 5 ');
M = strrep(M,'JUL',' 6 ');
M = strrep(M,'AUG',' 7 ');
M = strrep(M,'SEP',' 8 ');
M = strrep(M,'OCT',' 9 ');
M = strrep(M,'NOV',' 10 ');

```

```

M = strrep(M,'DEC',' 11 '); % December is == 11
M = strrep(M,'-',' -');
X = str2num(M);
x = X(:,1)./365 + X(:,2)./12 + X(:,3); % date in decimal year

yd = X(':',10); tit = 'Weekly El-Nino 4 SST' % 5N-5S 170-120W

nTot = length(yd); sumS = sumsq(yd - mean(yd));
Ud = zeros(nTot,4);
Ud(1:nTot,1) = 1; % constant plateau
Ud(1:nTot,2) = linspace(-1,1,nTot); % linear trend (orthogonal)
n = linspace(1,nTot,nTot);
xd = zeros(4,1);
k = 0;
for i = logspace(-0.4,1.4,300);
    ++k;
    xL(k) = i;
    pL(k) = best(i);
endfor
plot (xL,pL,'b');grid on;grid minor on;hold on;
xlabel ('Period , years');ylabel ('R-squared');title(tit);axis([0,20]);
figure;
%-----
pMin = fminbnd(@best,10,13); % 1st call to the minimizer
x2 = best(pMin);pMin % once found , pMin is given again to the best() function
ySin = Ud*xd(:,1); % y3 contains the SINEWAVE
disp(xd);
plot (x,yd,'b',x,ySin,'g','LineWidth',2);grid on;
grid minor on;axis([1989,2022,24,32]);hold on;
xlabel('Year');ylabel('Temp. °C');
title([tit,' Period = ',num2str(pMin),' year']);
legend('Sea Surface Temperature','Deconvoluted sinewave')
hold on;

```