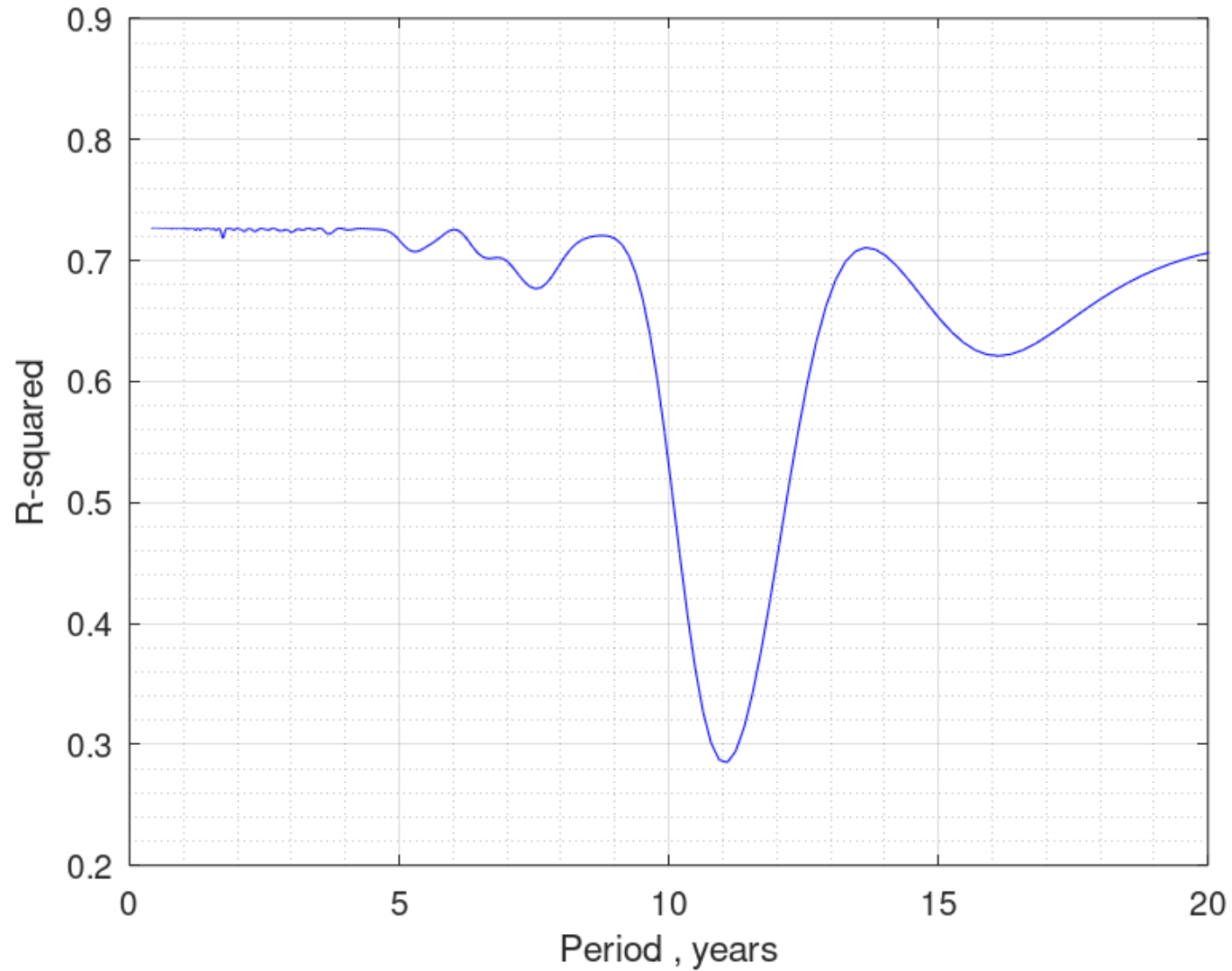


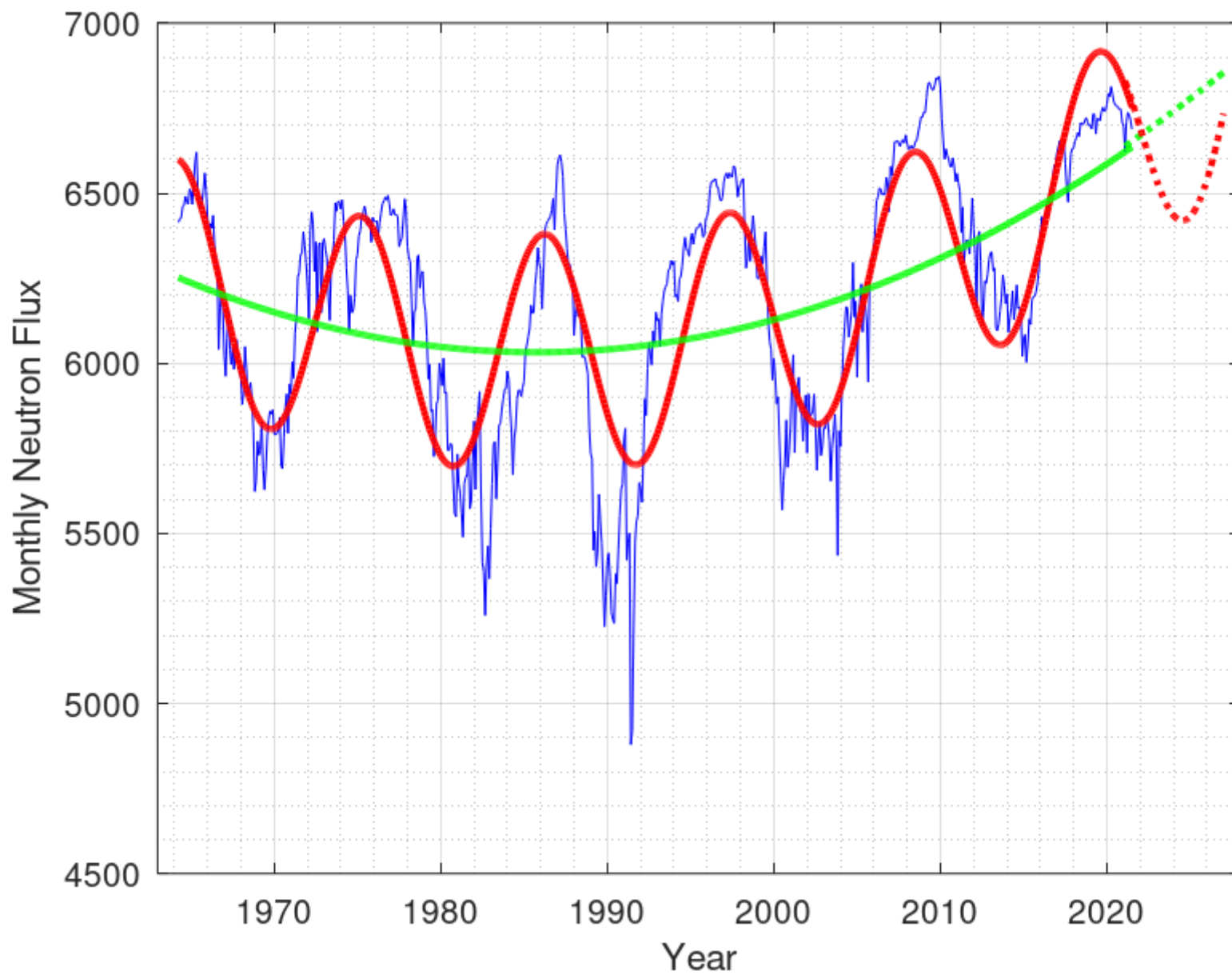
Sinewave analysis of neutron flux (from cosmic rays) from 1964.

Neutron Monitor database query - [OULU, DOMC, DOMB NM detectors]- <http://cosmicrays oulu.fi/>
Station: OULU NEUTRON MONITOR
Units for date column: fractional years
Start: 1964/04/01 00:00 End: 2021/08/27 00:00

Frequency analysis - OULU Monitor



OULU Monitor from 1964



```

% PLOTTER with secon degree polynomial baseline
% Monthly data are downloaded from http://cosmicrays.oulu.fi/ and stored in local file 'OULU_monthly.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(:,4) = sin(2*pi/p*x); % sin
    Ud(:,5) = 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

% ----- data in file are read now -----
S = fileread('OULU_monthly.txt');
a1 = index(S,'1964.04.01'); % january = 0/12
a2 = rindex(S,'CORR') - 1;
M = S(a1:a2);
M = strrep(M, '.', ' ');
M = strrep(M, ':', ' ');
X = str2num(M);
yd = X(:,10); x = X(:,1) + (X(:,2)-1)/12;
nTot = length(yd); sumS = sumsq(yd - mean(yd))
startYear = 1964; % <<<< User
endYear = 2021;
% ----- end of data read -----

Ud = zeros(nTot,5);
Ud(1:nTot,1) = 1; % constant plateau
Ud(1:nTot,2) = linspace(0,1,nTot); % linear trend
Ud(1:nTot,3) = linspace(0,1,nTot).^2; % parabolic trend
xd = zeros(5,1);
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;
xlabel ('Period , years');ylabel ('R-squared');title('Frequency analysis - OULU Monitor');axis([0,20]);
% plot data with first sinewave. Maybe a second is interpolated from residuals ?

```

```

pMin = fminbnd(@best,10,12);      % 1st call to the minimizer          <<<< User
x2 = best(pMin);pMin             % once found , pMin is given again to the best() function
ySin = Ud*xd(:,1);              % ySin is the first SINEWAVE
yLin = Ud(:,1:3)*xd(1:3,1);      % yLin is the first LINEAR TREND
disp(xd);
figure;

n5 = 72 % Number of future months          <<<< User

plot (x,yd,'b',x,ySin,'r','Linewidth',2,x,yLin,'g','Linewidth',2);
grid on;grid minor on;axis([startYear-1,endYear + 1 + n5/12]);hold on;
xlabel ('Year');ylabel ('Monthly Neutron Flux');title('OULU Monitor from 1964');

% ----- future trend -----
for j = 1:n5
    x1(j) = endYear + j/12;
    y1(j) = xd(1,1) + xd(2,1)*(j/nTot + 1) + xd(3,1)*(j/nTot + 1)^2;
    y2(j) = y1(j) + xd(4,1)*sin(2*pi/pMin*x1(j)) + xd(5,1)*cos(2*pi/pMin*x1(j));
endfor
plot (x1,y1,'g','Linewidth',2,'Linestyle',':',x1,y2,'r','Linewidth',2,'Linestyle',':');

return % deactivate 'return' for residuals analysis          <<<< User
figure;
yd = yd - ySin;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;
xlabel ('Period , years');ylabel ('R-squared');title(tit);axis([0,20]);

```