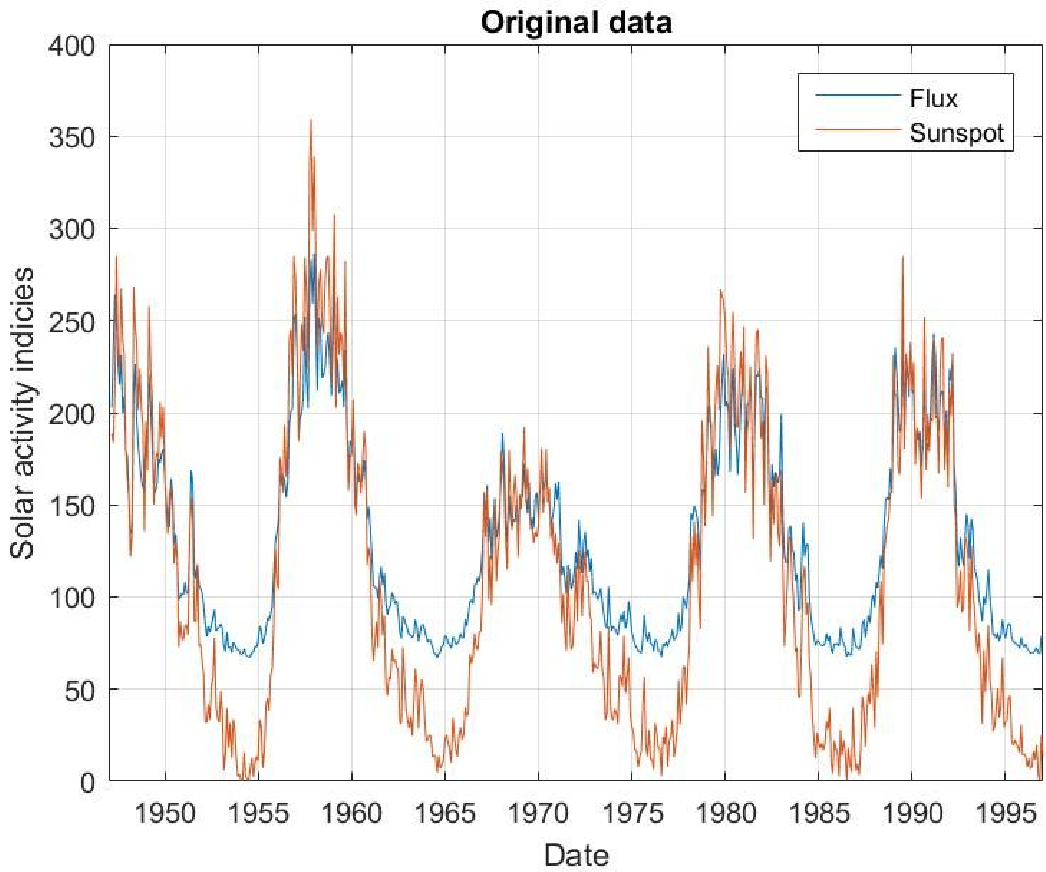
Experimental Data Processing

Lab 1

Relationship between solar radio flux F10.7
and sunspot number

Scatter plot between monthly mean sunspot number and solar radio flux F10.7cm. Original noisy data (group 5) of two types of solar activity indicators.



Smoothed curves obtained from original data using formula:

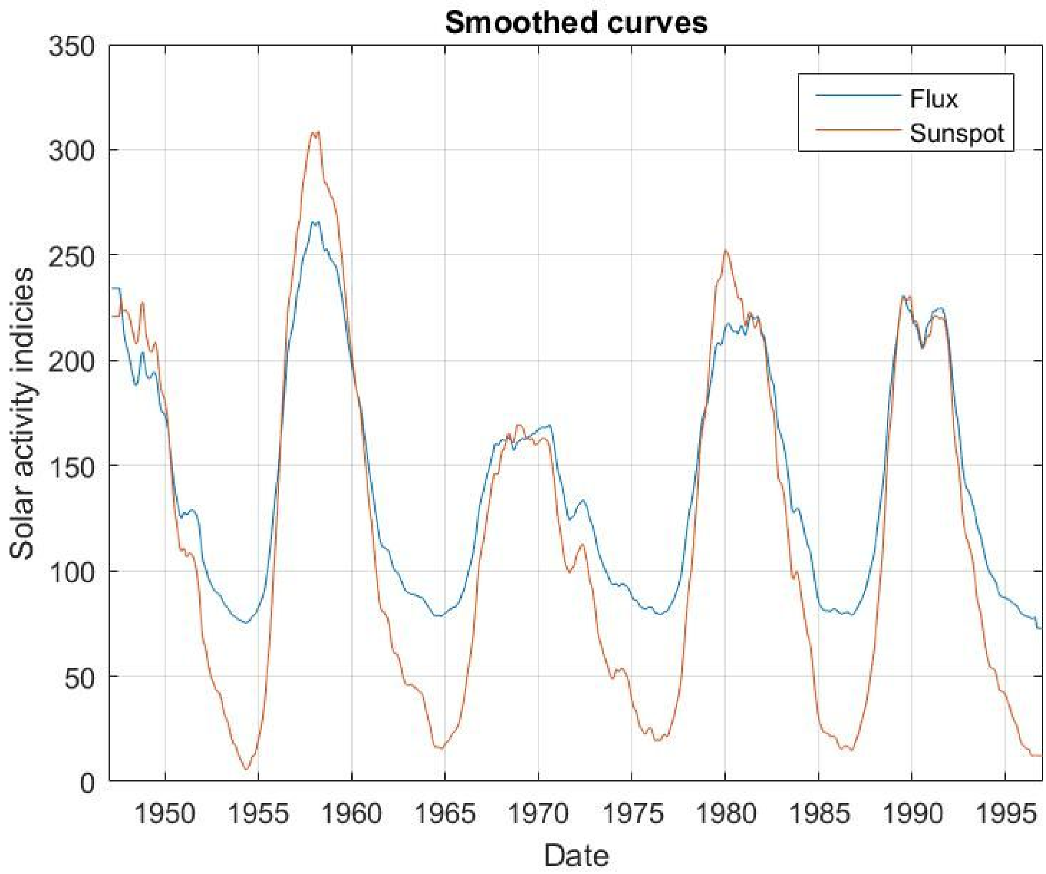
$$\overline{R} = \frac{1}{24}R_{i-6} + \frac{1}{12}(R_{i-5} + R_{i-4} + ... + R_i + ... + R_{i+5}) + \frac{1}{24}R_{i+6}$$

This is implemented in the following function:

```
function smoothed = smoothing(array, m)
N = length(array);
smoothed = zeros(1,N);
smoothed(1:(m-1)/2) = mean(array(1:(m-1)/2));
smoothed(N-(m-1)/2-1:N) = mean(array(N-(m-1)/2-1:N));
for i = (m-1)/2+1 : (N-(m-1)/2)
    R = 1/(2*(m-1))*(array(i-6)+array(i+6)) + mean(array((i-5):(i+5)));
    smoothed(i) = R;
end
end
```

It takes as arguments noisy array and the size of smoothing window m=13 in particular case.

In this way we obtain 13-month running mean result.



According to the graphical data there is clear dependence between solar activity indicators. These values have approximately the same time periods of maximum and minimum.

The next step is construction of multidimensional linear regression. It is done to find mathematical representation of dependence between solar radio flux and sunspot number. The function below describes implementation of the method.

```
function [b, R] = regression(flux, sp)
F = flux';
N = length(sp);
R = zeros(N,4);
% construct matrix R from sunspot
R(:,1) = ones(1,N);
for i=1:N
   R(i,2:4) = [sp(i), (sp(i))^2, (sp(i))^3];
end
```

```
b = inv(R'*R) * R' * F;
end
```

It takes as input two arrays of smoothed data for two indicators of solar activity and gives as output column of coefficients of regression b and matrix R containing data for sunspot number. The last formula in the function *regression* determines vector of coefficients by LSM. These coefficients allows to reconstruct solar radio flux value for each time period. So we obtain dependence between two solar activity indicators.

Further using reconstructed and smoothed values of flux we can estimate the quadratic error of our method of data analysis, variance of estimation error of solar radio flux. The algorithm gives:

$\sigma^2 = 38,2.$

Main script implementing the whole algorithm:

```
close all
plot(t,flux, t,sunspot)

xlim([year(1), year(end)])
grid on
xlabel('Date')
ylabel('Solar activity indicies')
title('Original data')
legend('Flux', 'Sunspot')

% smoothing
flux_sm = smoothing(flux, 13);
sunspot_sm = smoothing(sunspot,13);

figure(2)
subplot(2,1,[1,2])
plot(t,flux_sm, t,sunspot_sm)

xlim([year(1), year(end)])
grid on
xlabel('Date')
ylabel('Solar activity indicies')
title('Smoothed curves')
legend('Flux', 'Sunspot')

[b, R] = regression(flux_sm, sunspot_sm);
```

```
% S = sigma^2
S = degression(b, R, flux_sm);load data

data = data_group5;
year = data(:,1);
month = data(:,2);
t = year + month/12;

flux = data(:,3);
sunspot = data(:,4);

figure(1)
subplot(2,1,[1,2])
```