Skoltech

Skolkovo Institute of Science and Technology

# “Experimental Data Processing”

Laboratory work 1
Relationship between solar radio flux F10.7 and sunspot number

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**Term 1B, October 2017**

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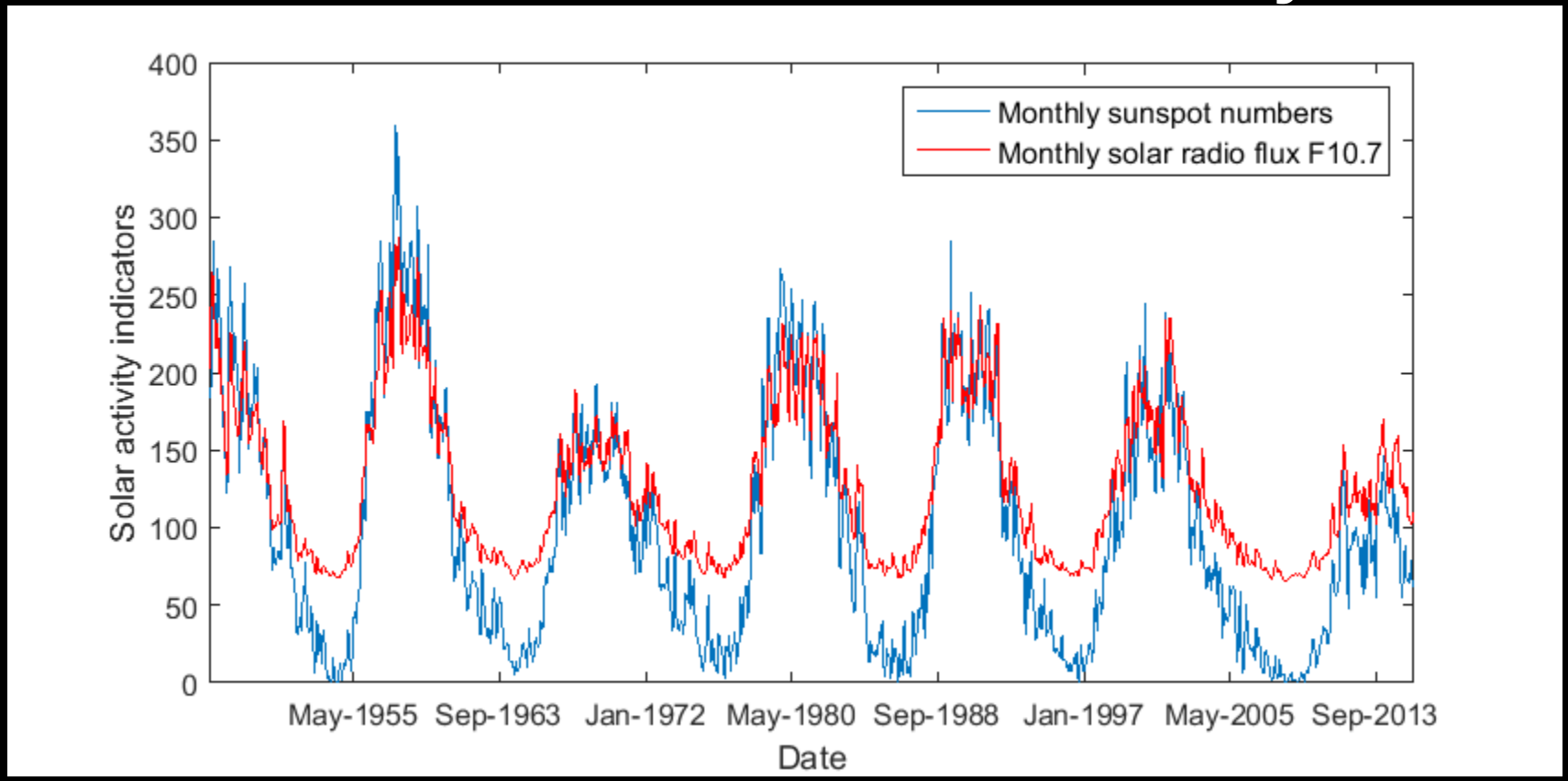
# Main indicator of solar activity




***Sunspot number***

$$R = k(n + 10g)$$

**$n$ – number of observed sunspots**

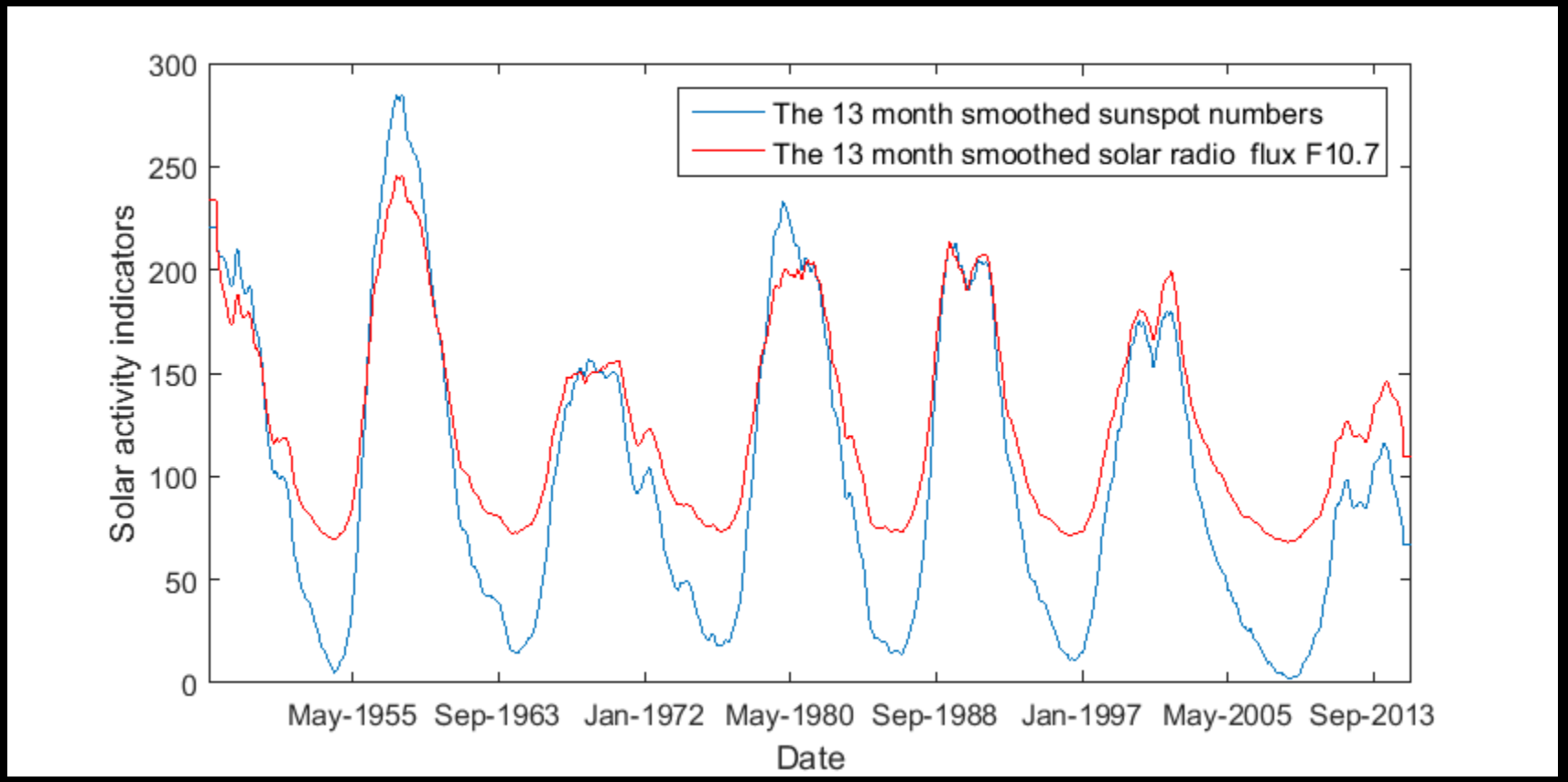
**$g$ – number of observed sunspot groups**

**$k$ – coefficient of a telescope**

***Solar radio Flux at 10.7 cm***

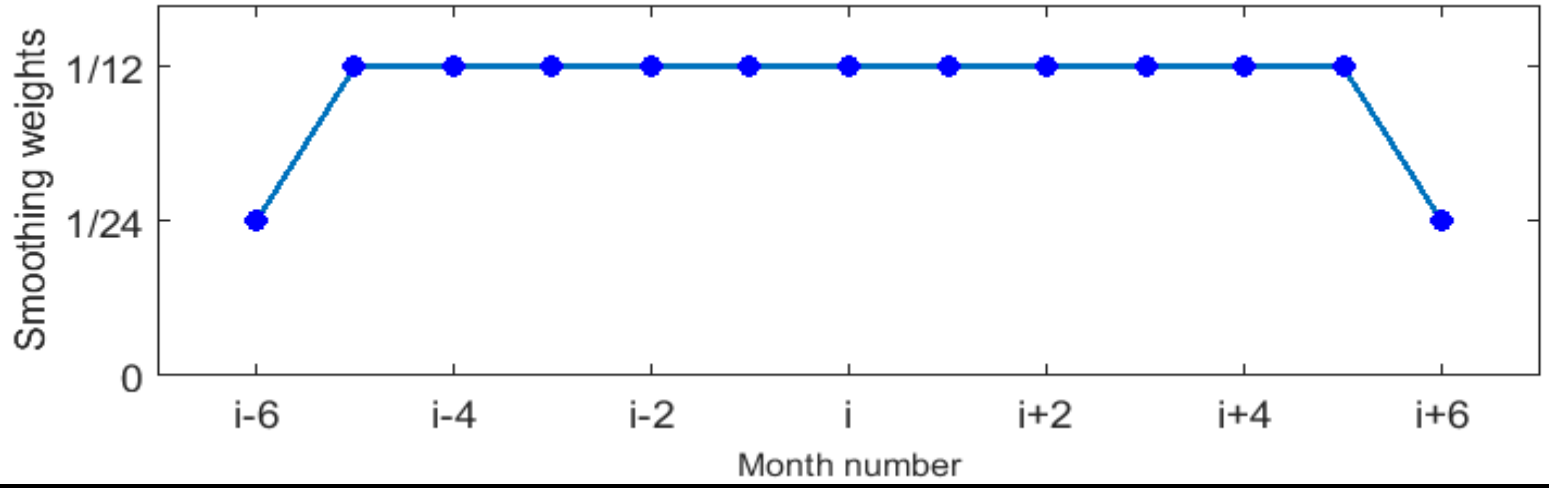
**A measurement of radio emission at a wavelength of 10.7 cm (2800 MHz) from all sources present on the solar disk**

# Smoothing: 13-month running mean



# 13-month sequent monthly mean sunspot numbers

$i$-6 $i$-5 $i$-4 $i$-3 $i$-2 $i$-1 **$i$** $i$+1 $i$+2 $i$+3 $i$+4 $i$+5 $i$+6




***13-month running mean $\bar{R}$***

$$\frac{1}{24}R_{i-6}+\frac{1}{12}(R_{i-5}+R_{i-4}+\cdots+R_{i-1}+R_i+R_{i+1}+\cdots+R_{i+5})+\frac{1}{24}R_{i+6}$$

# Multi-dimensional linear regression

$$F_i = \beta_0 + \beta_1 R_i + \beta_2 R_i^2 + \beta_3 R_i^3 + \varepsilon_i$$

$$i = 1, \ldots . N$$

$F_i$
Dependent variable
Regressand

$\beta_j$
Coefficients of regression

$R_i$
Independent variable
Regressor

$\varepsilon_i$
Unbiased uncorrelated Gaussian noise with constant variance

Coefficients $\beta_j$ are determined by LSM

$$\sum_{i=1}^{N} \varepsilon_i^2 \rightarrow min$$

# Multi-dimensional linear regression

$$F = \begin{vmatrix} f_1 \\ f_2 \\ \dots \\ f_N \end{vmatrix}$$

Vector of dependent variables

$$\beta = \begin{vmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{vmatrix}$$

Vector of coefficients

$$R = \begin{vmatrix} 1 & r_1 & r_{1^2} & r_1^3 \\ 1 & r_2 & r_2^2 & r_3^3 \\ \dots & \dots & \dots & \dots \\ 1 & r_N & r_N^2 & r_N^3 \end{vmatrix}$$

Matrix of independent variables

$$\varepsilon = \begin{vmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \dots \\ \varepsilon_N \end{vmatrix}$$

Vector of random errors

Linear regression in matrix form

$$F = R \cdot \beta + \varepsilon$$

$$\hat{\beta} = \left(R^T R\right)^{-1} R^T F$$

Linear Regression Analysis,
G.A.F. Seber and J. Lee, Wiley, N.Y., 2003

# Estimation error of solar radio flux F10.7

**Covariance matrix of estimation error**

$$\sigma^2 = \frac{1}{N-1}\sum_{i=1}^{N}\left(f_i - \hat{f}_i\right)^2$$