Skoltech

Skolkovo Institute of Science and Technology

“Experimental Data Processing”

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

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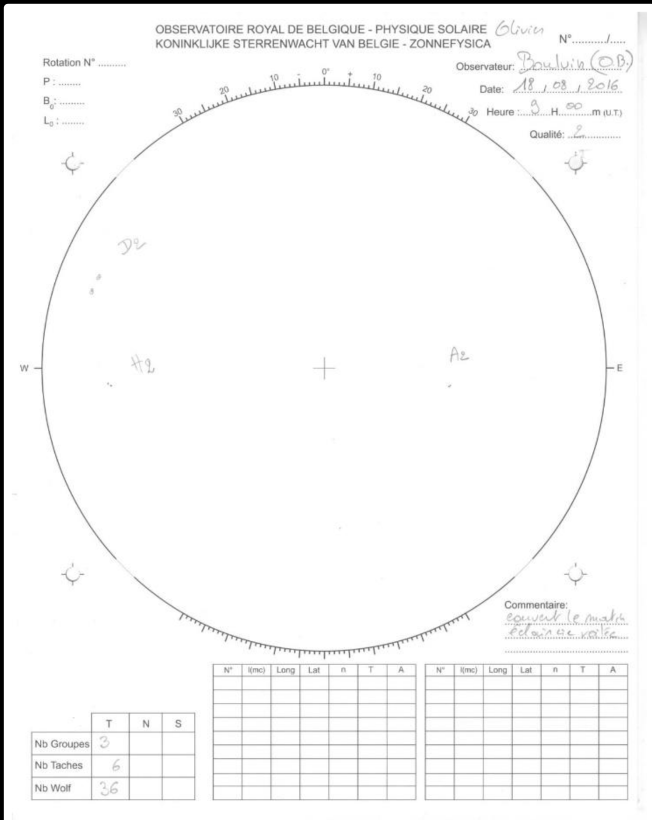
SUNSPOT NUMBER OBSERVATIONS



OBSERVATOIRE ROYAL DE BELGIQUE - PHYSIQUE SOLAIRE
KONINKLIJKE STERRENWACHT VAN BELGIE - ZONNEFYSICA

N°........./.....

Rotation N° ....
P : ....
B_0 : ....
L_0 : ....

Observateur: Boulvin (O.B.)
Date: 18 / 08 / 2016
Heure: 9 H 00 m (U.T.)
Qualité: 2

Commentaire:

N°	I(mc)	Long	Lat	n	T	A

N°	I(mc)	Long	Lat	n	T	A

	T	N	S
Nb Groupes	3		
Nb Taches	6		
Nb Wolf	36		

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

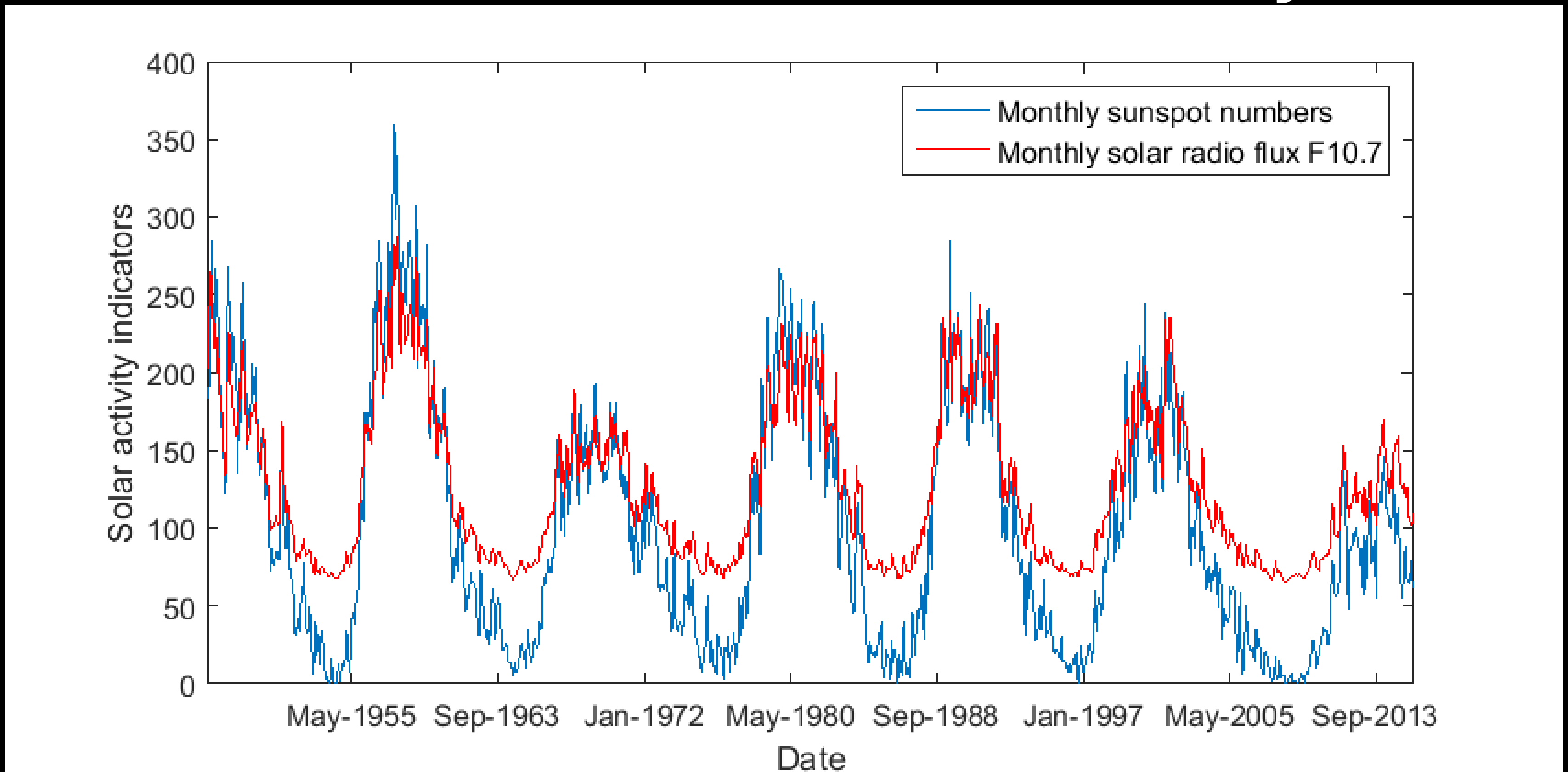
n – number of observed sunspots

g – number of observed sunspot groups

k – coefficient of a telescope

77 cooperating stations over the globe perform observations of sunspot numbers every day

Main indicator of solar activity



Sunspot number

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

n – **number of observed sunspots**

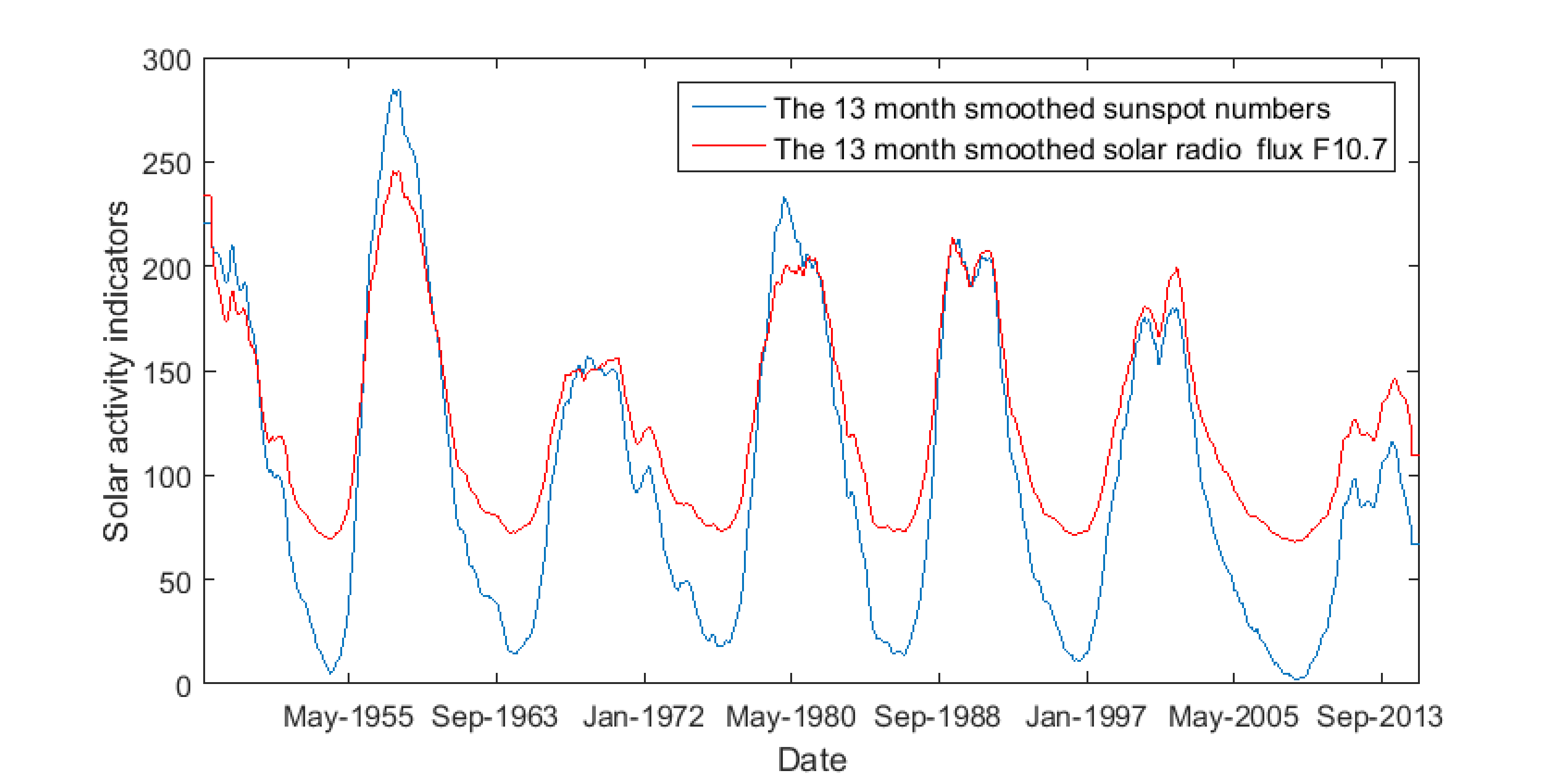
g – **number of observed sunspot groups**

k – **coefficient of a telescope**

Solar radio Flux at 10.7 cm

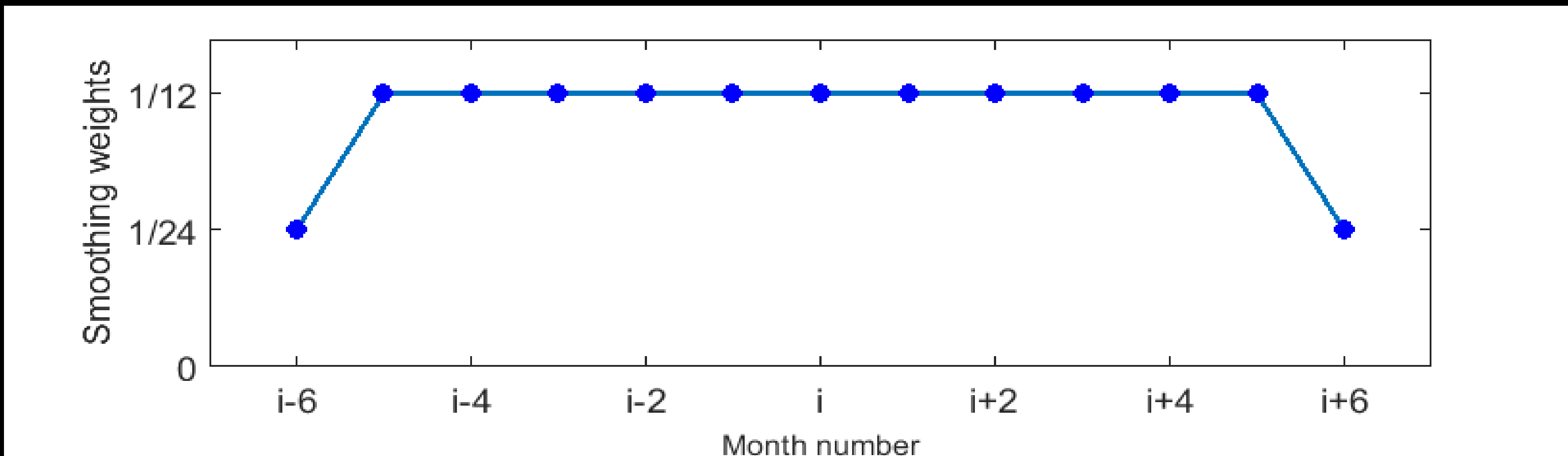
A measurement of radio emission at a wavelength of 10.7 cm (2800 MHz) from all sources present on the solar disk

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 $\overline{R}$

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

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

β_j
Coefficients of regression

R_i
Independent variable
Regressor

ε_i
Unbiased uncorrelated Gaussian noise with constant variance

Coefficients β_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

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