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Konkoly Thege Miklós Astronomical Institute

Heliophysical Observatory

VARIATIONS OF SOLAR NON-AXISYMMETRIC ACTIVITY

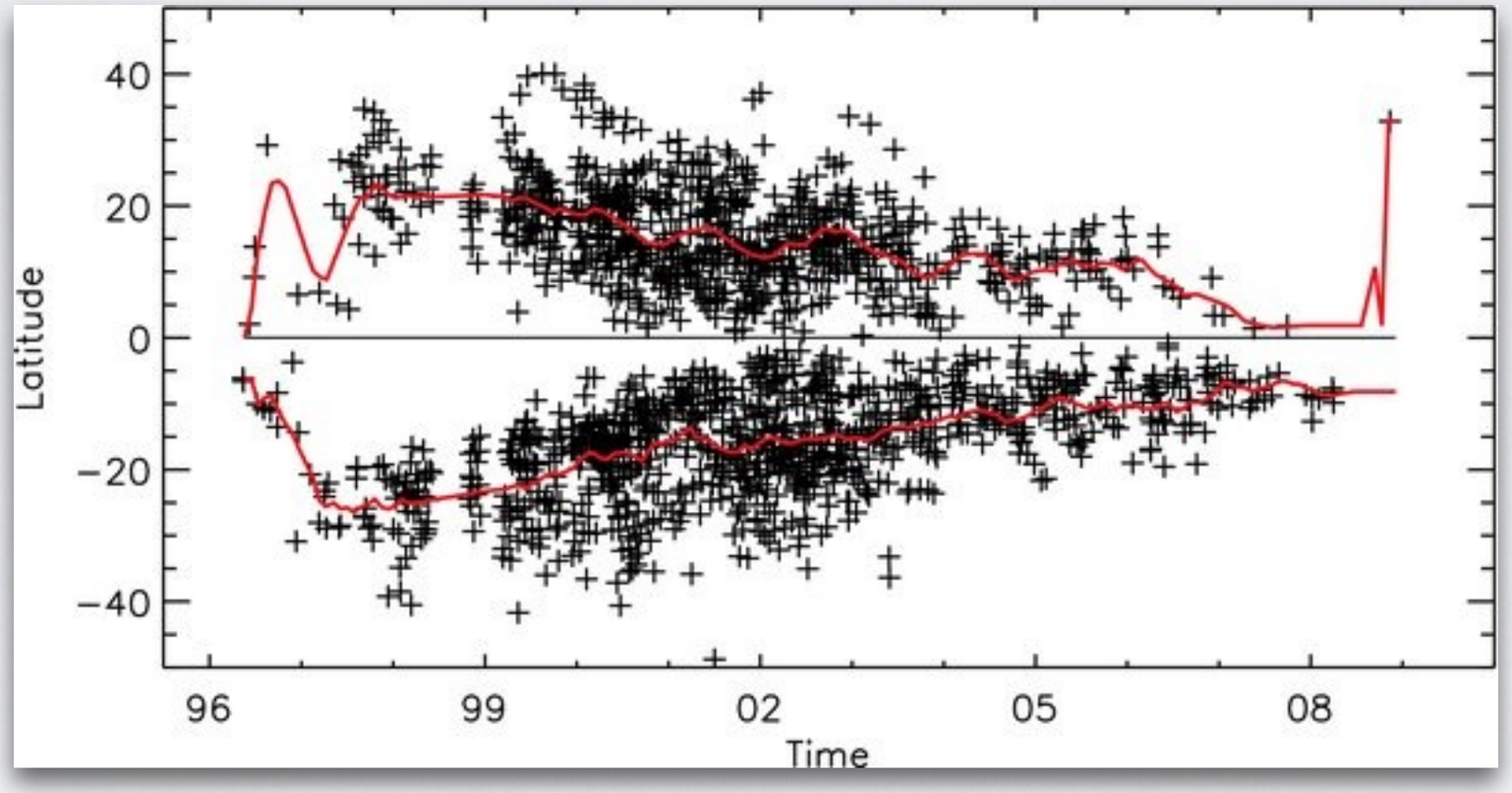
SOLAR FLARE PREDICTION USING ACTIVE LONGITUDES INFORMATION

GYENGE, NORBERT

MOTIVATION

The distribution of solar activities is not uniform in latitude.

Butterfly-diagram



BUT, what about the longitudinal distribution of sunspot groups?

The distribution of solar activities is not uniform in longitude, and **active longitudes exist.**

AIMS

- To study the statistical characteristics of active longitudes of solar activities.
- Improving the performance of solar flare prediction using active longitudes information.

The distribution of solar activities is not uniform in longitude, and **active longitudes exist.**

If the most flare-productive active regions tend to be **located in or close** to the active longitudinal belt…

…this may allow to predict the geoeffective position of the domain of enhanced flaring probability.

So…

…let's find the nature of connection

between active longitudes and solar flares!

1.st step: Find the AL's.

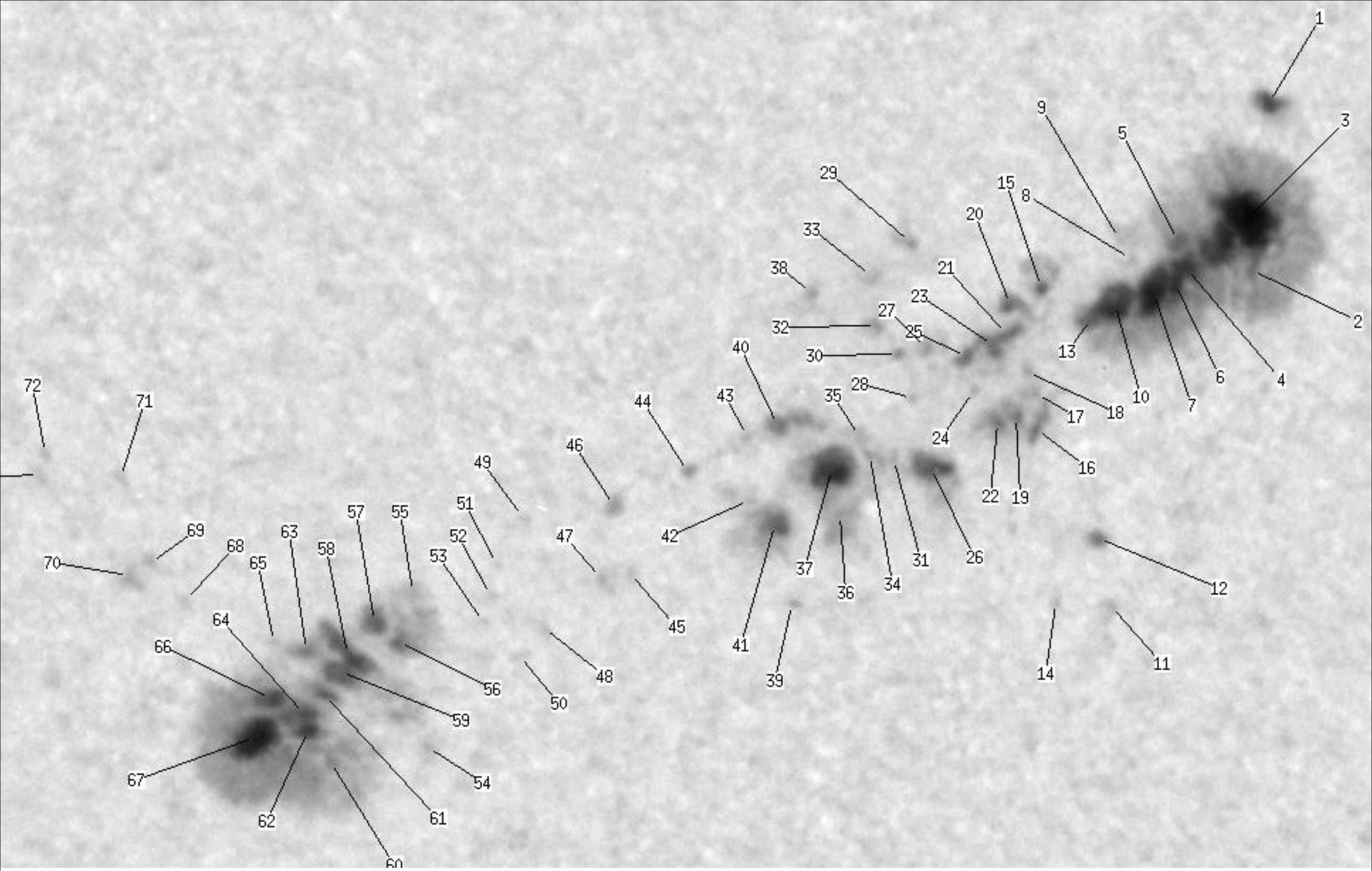
DATABASES

a) DPD sunspot catalogue

- The basic data in a sunspot catalogue are the heliographic positions and the areas of the sunspots.

- The data are supplemented with images of sunspot groups, scans of full-disk white-light observations and magnetic observations.

b) National Geophysical Data Center (NGDC) flare list

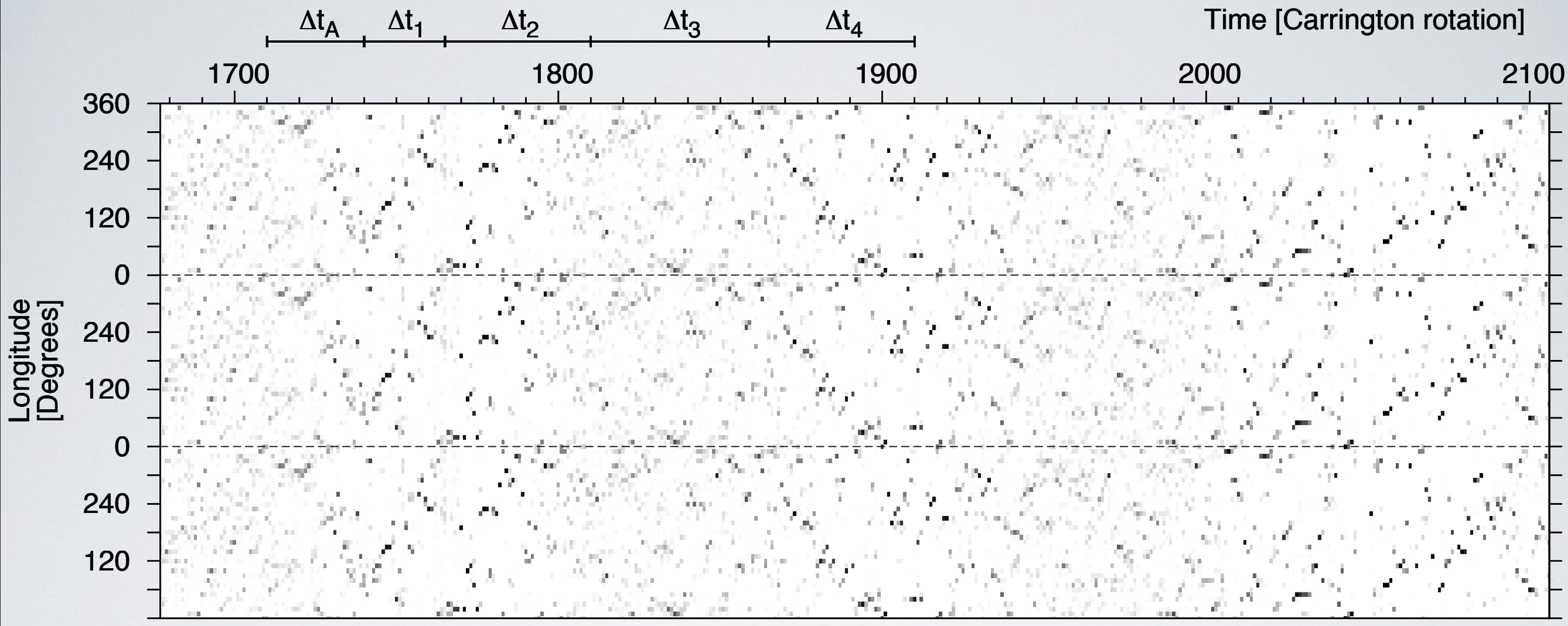


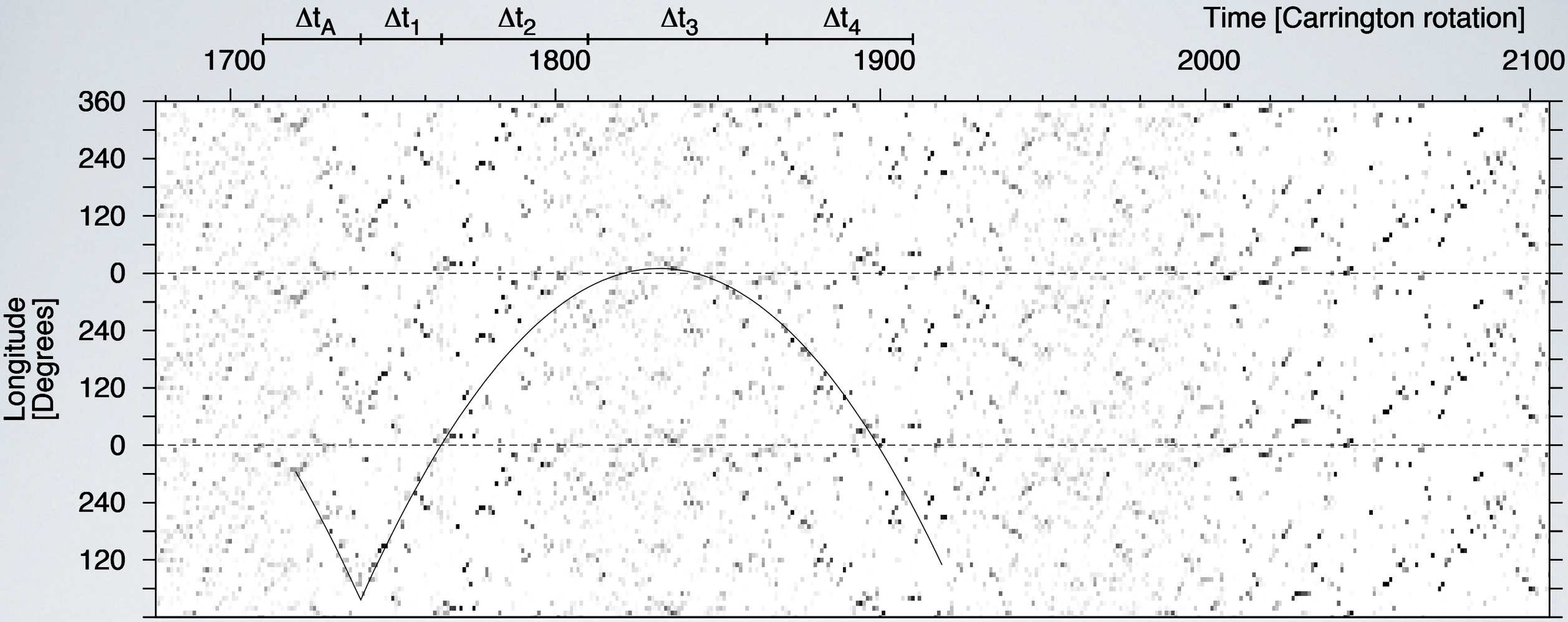
spot	Proj. U	Proj. U+P	Corr. U	Corr. U+P	B	L	LCM	Pos. angle	r
1	3	7	2	4	-6.49	100.41	19.77	238.92	0.3942
2	1	331	1	178	-8.15	99.47	18.88	234.15	0.3968
3	27	-2	14	-2	-7.53	99.65	19.02	235.66	0.393
4	4	-2	2	-2	-7.82	98.78	18.18	233.82	0.3847

ACTIVITY MAPS

The total area of sunspot groups has been computed in each 10° longitudinal bin (A_i) normalised by the entire activity in each Carrington rotation.

$$W_i = \frac{A_i}{\sum_{j=1}^{36} A_j}$$


Δt_A
Δt_1
Δt_2
Δt_3
Δt_4
Time [Carrington rotation]
1700
1800
1900
2000
2100
Longitude [Degrees]
360
240
120
0
240
120
0
240
120


Δt_A
Δt_1
Δt_2
Δt_3
Δt_4
Time [Carrington rotation]
1700
1800
1900
2000
2100
360
240
120
0
240
120
0
240
120
Longitude
[Degrees]

Δt_A Δt_1 Δt_2 Δt_3 Δt_4

1700 1800 1900 2000 2100

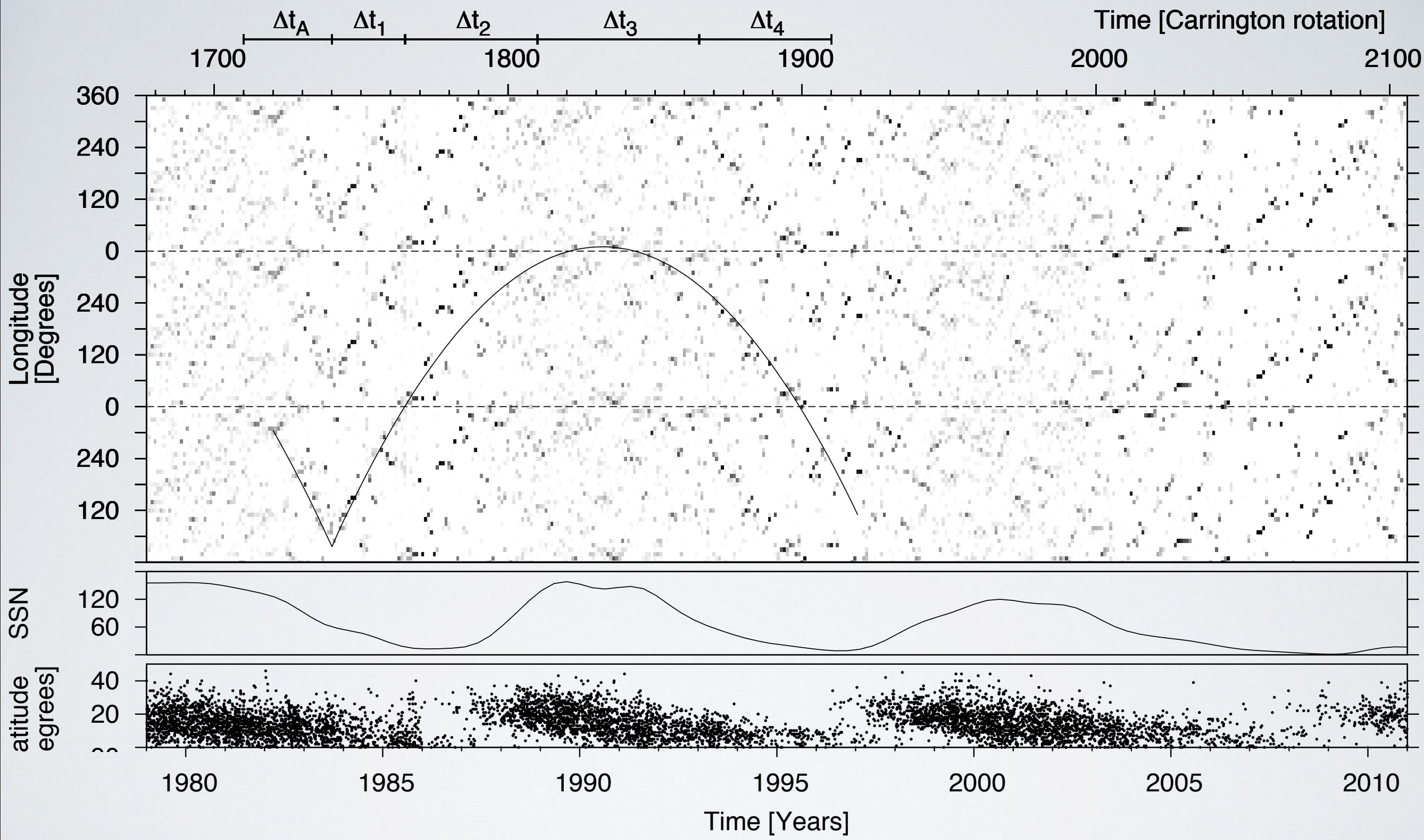
Time [Carrington rotation]

Longitude [Degrees]

360 240 120 0 240 120 0 240 120

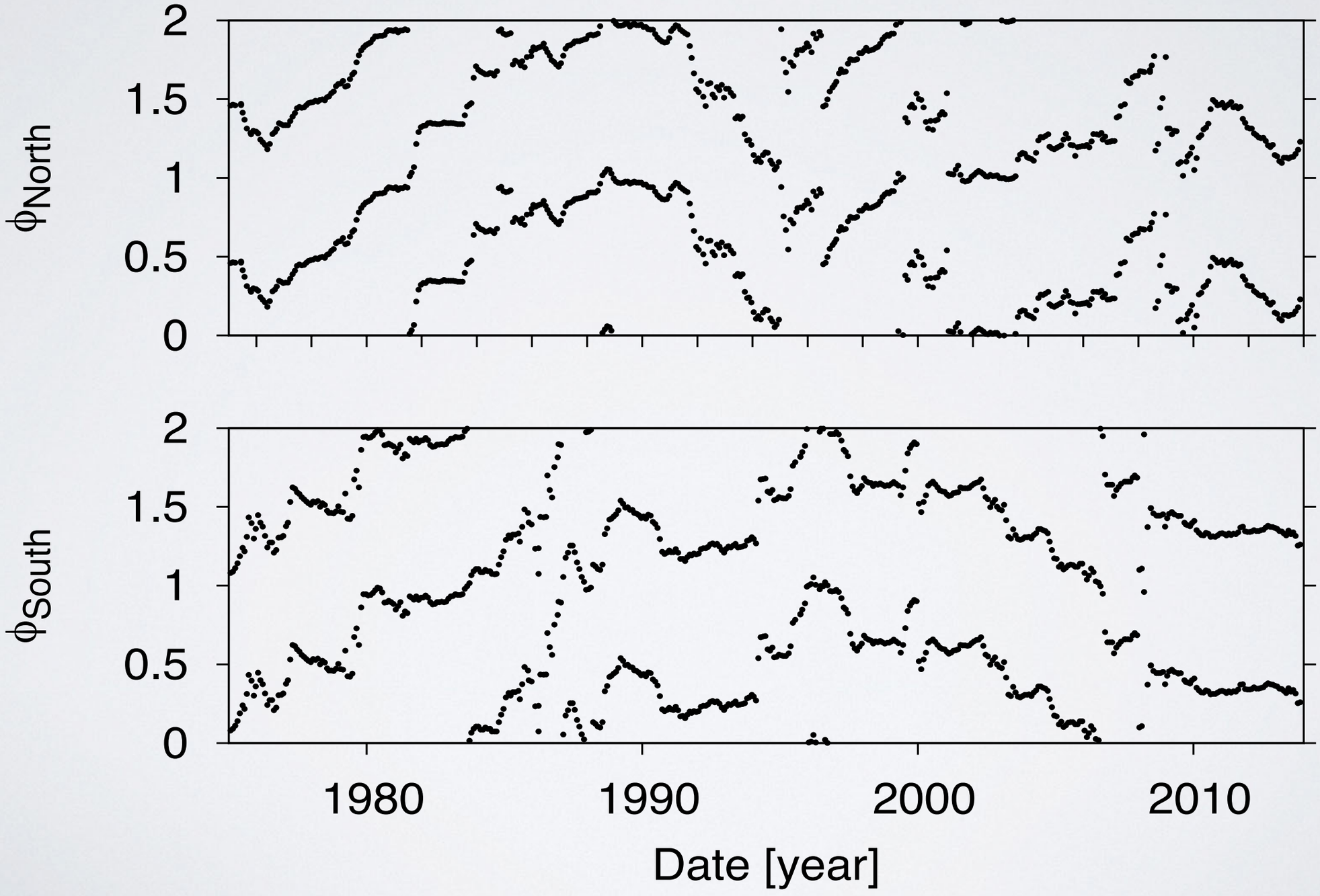
SSN

120 60


Δt_A
Δt_1
Δt_2
Δt_3
Δt_4
1700
1800
1900
Time [Carrington rotation]
2000
2100
360
240
120
0
240
120
0
240
120
Longitude [Degrees]
120
60
SSN
40
20
atitude egrees]
1980
1985
1990
1995
2000
2005
2010
Time [Years]

Weighted average of longitude angles

$$\delta\Phi = \mathrm{AVG}\ (\ \mathrm{Longitude}\ )\ /\ 360$$

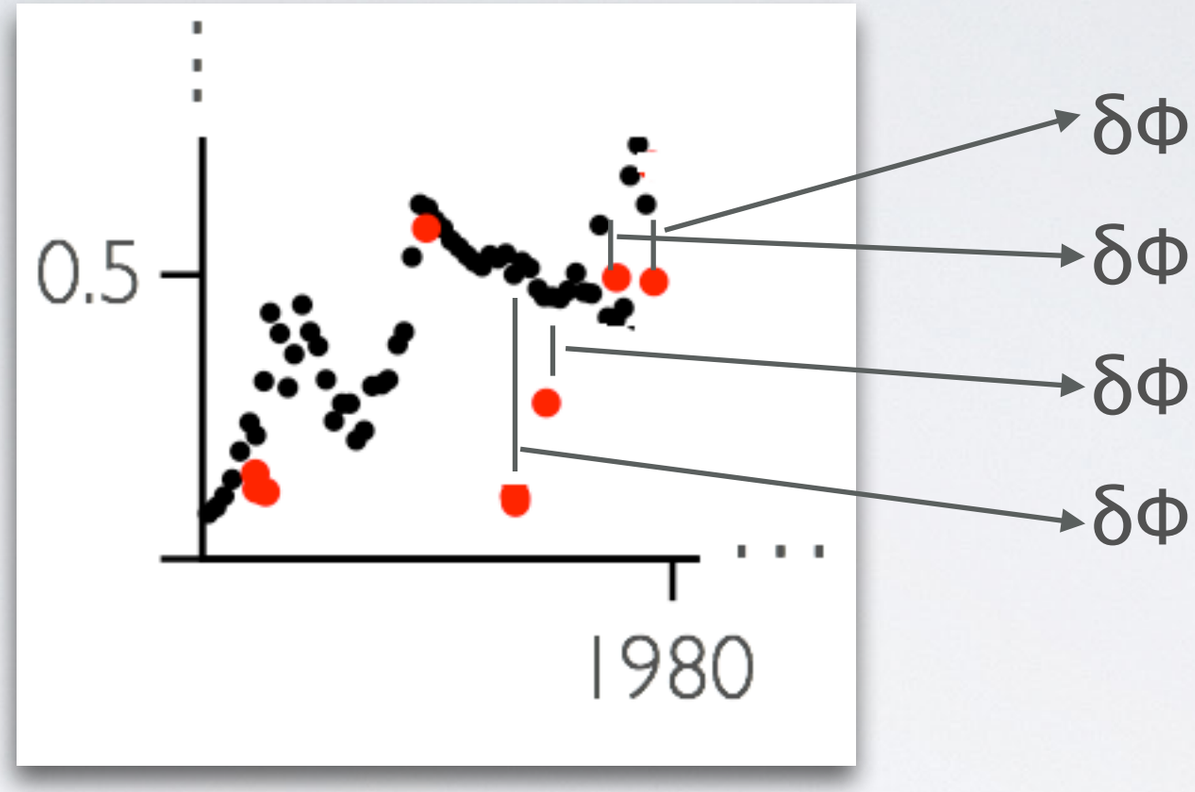


1. st step: Find the AL's. ✔

2. nd step: Find the connection between AL's and solar Flares.

Red dots: Goes flares position (only M and X class)

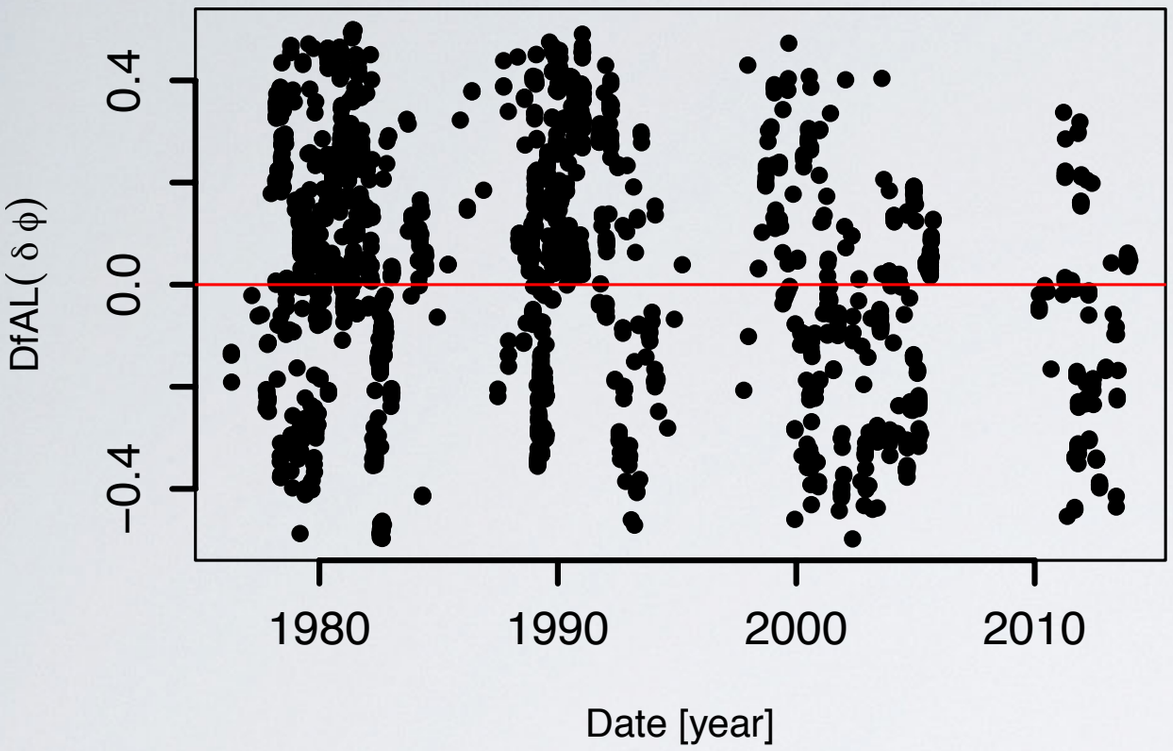
Black dots: Averaged active longitude



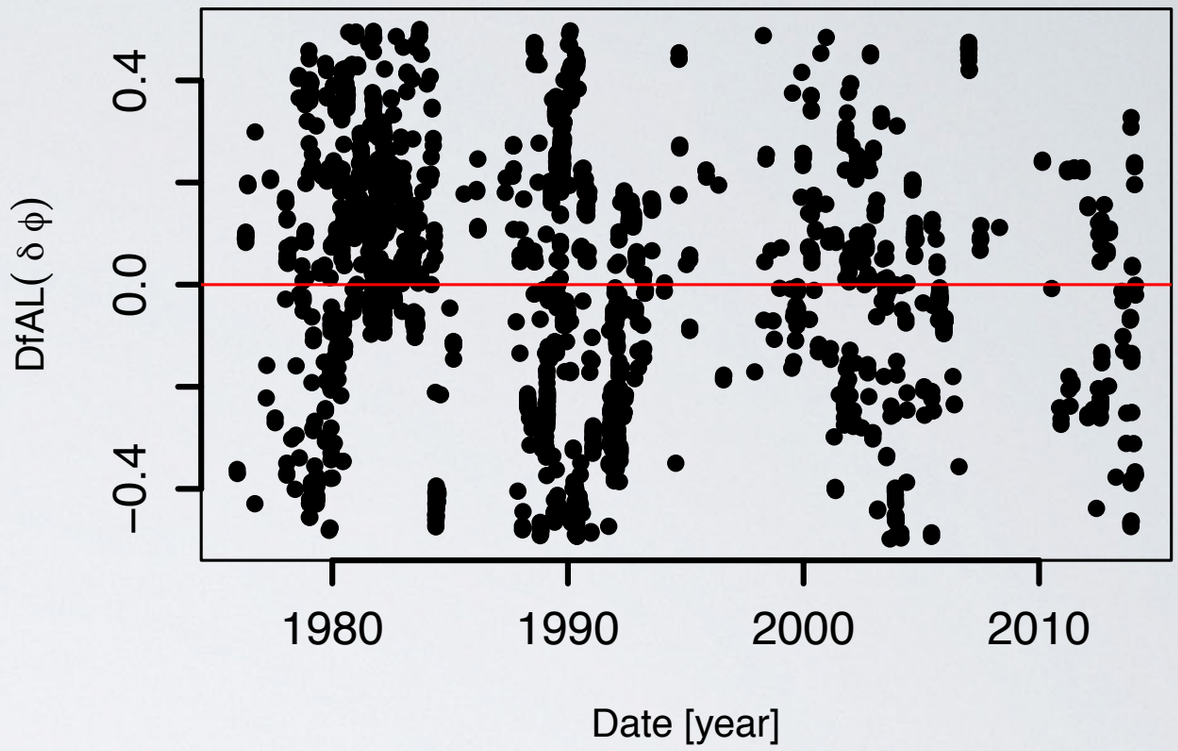
Define a new parameter: **δΦ** (DfAL)

The shortest temporal and spatial distance between the active longitude and the flare event.

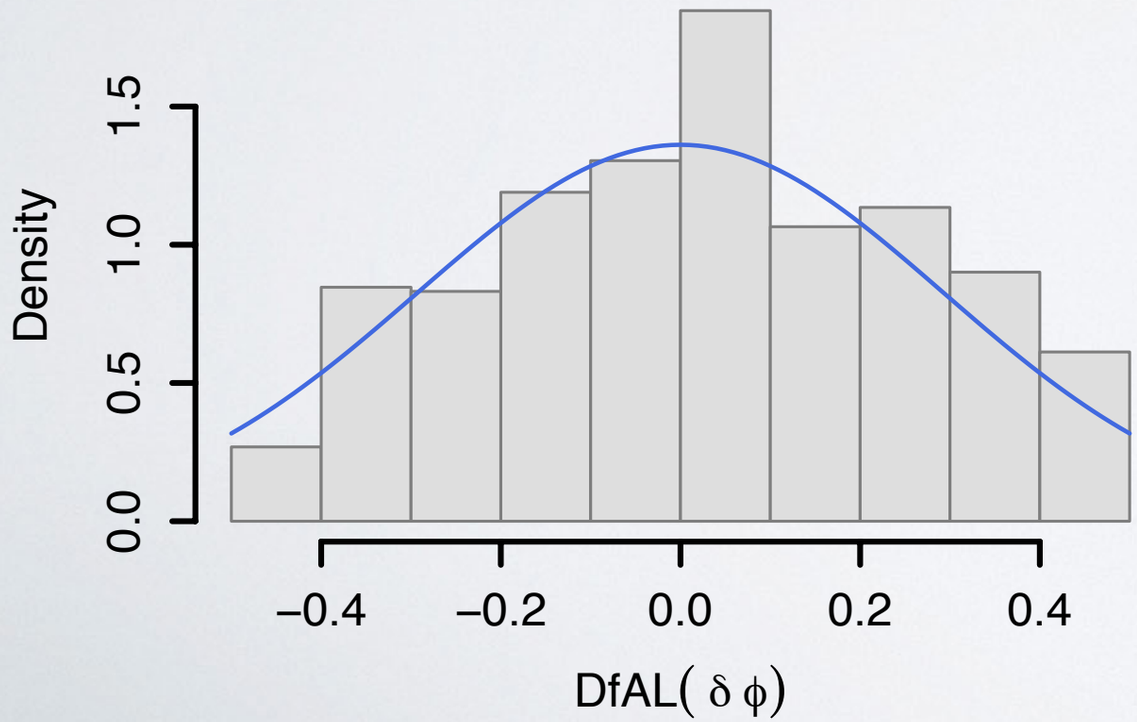
Northern Hemisphere



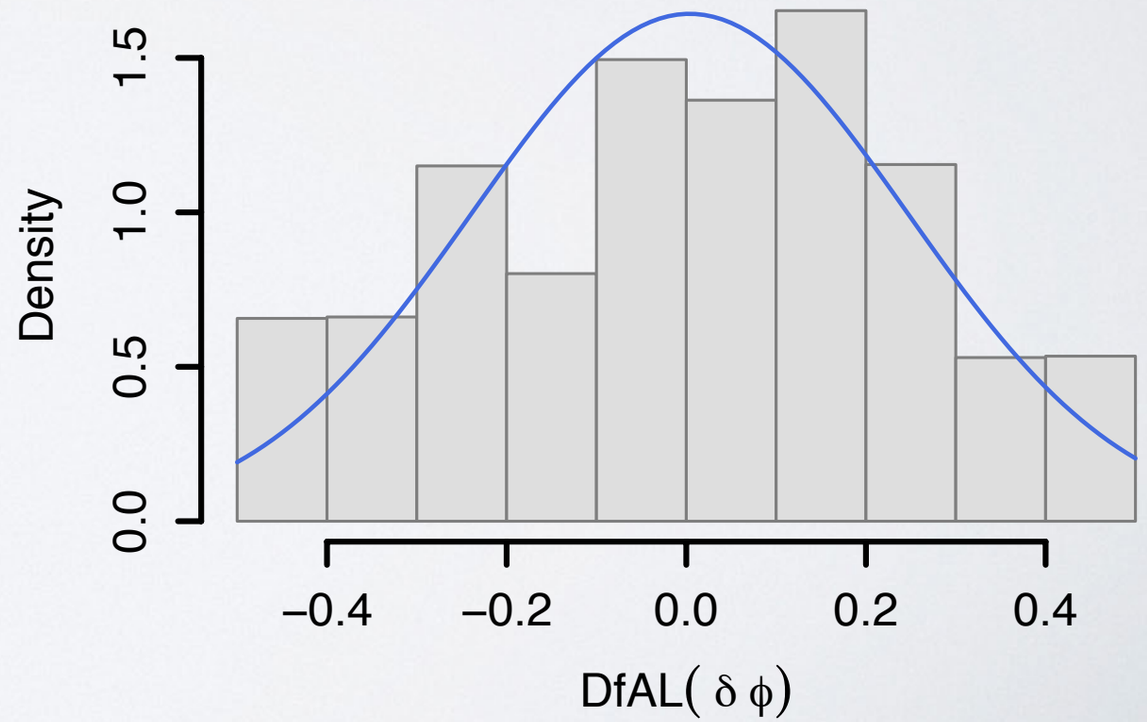
Southern Hemisphere

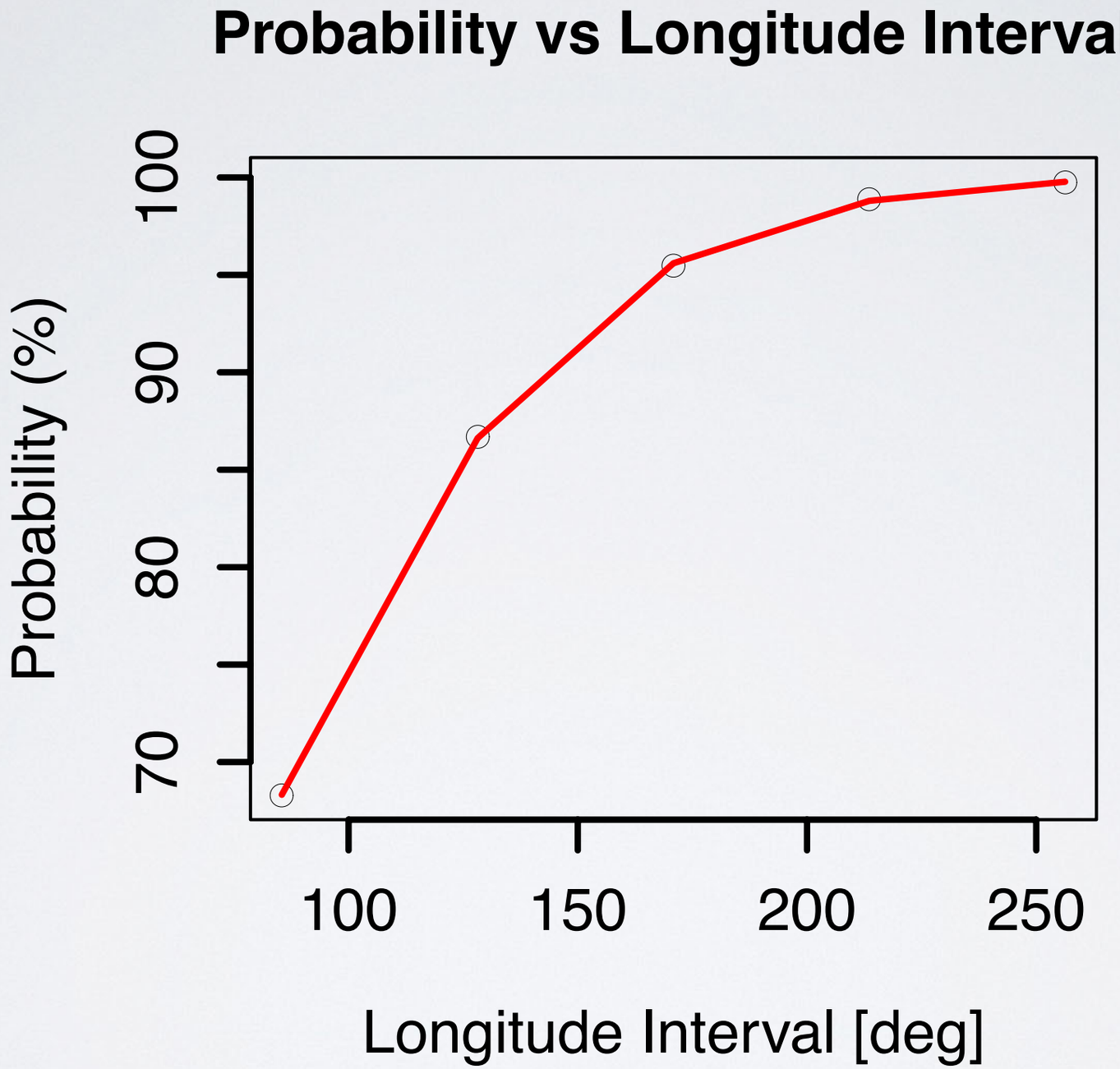


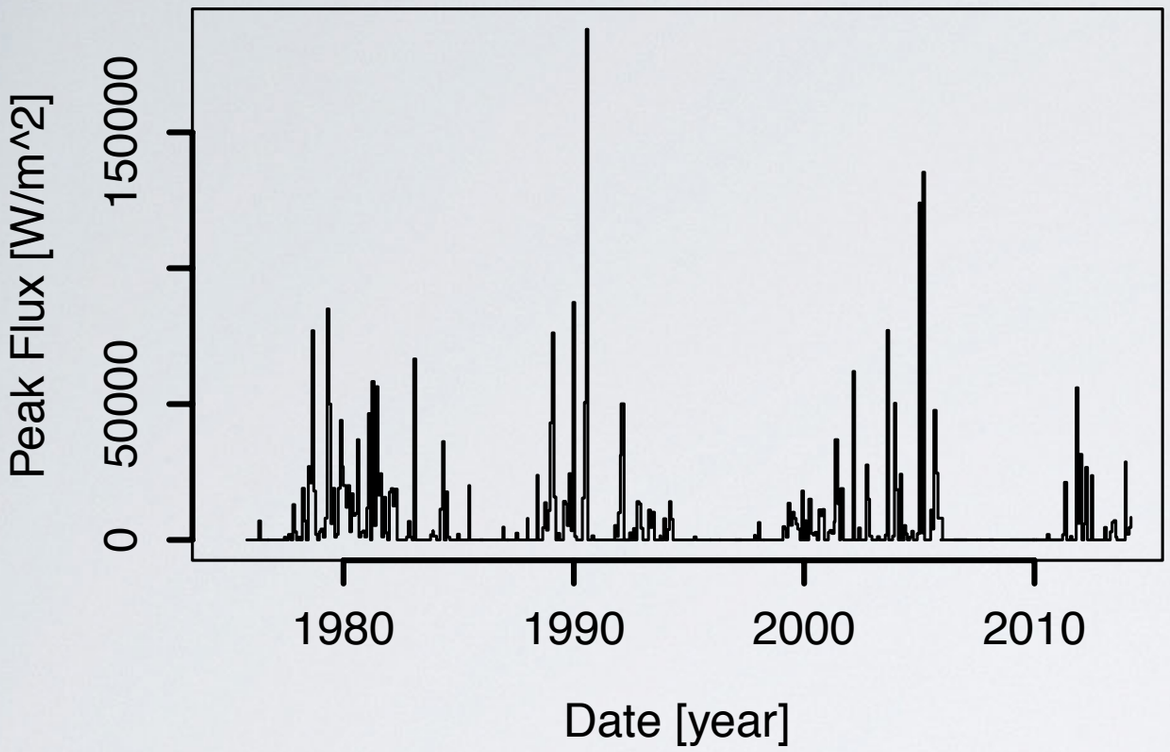
Distribution of DfAL

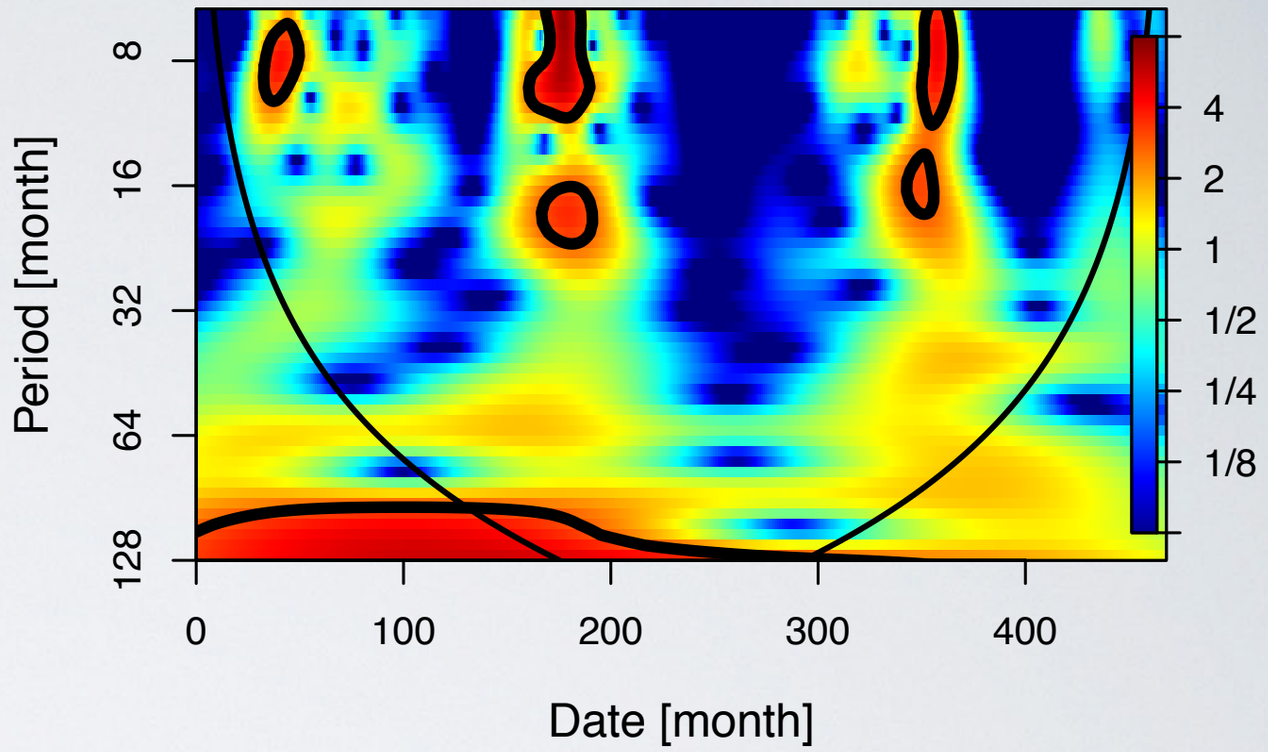


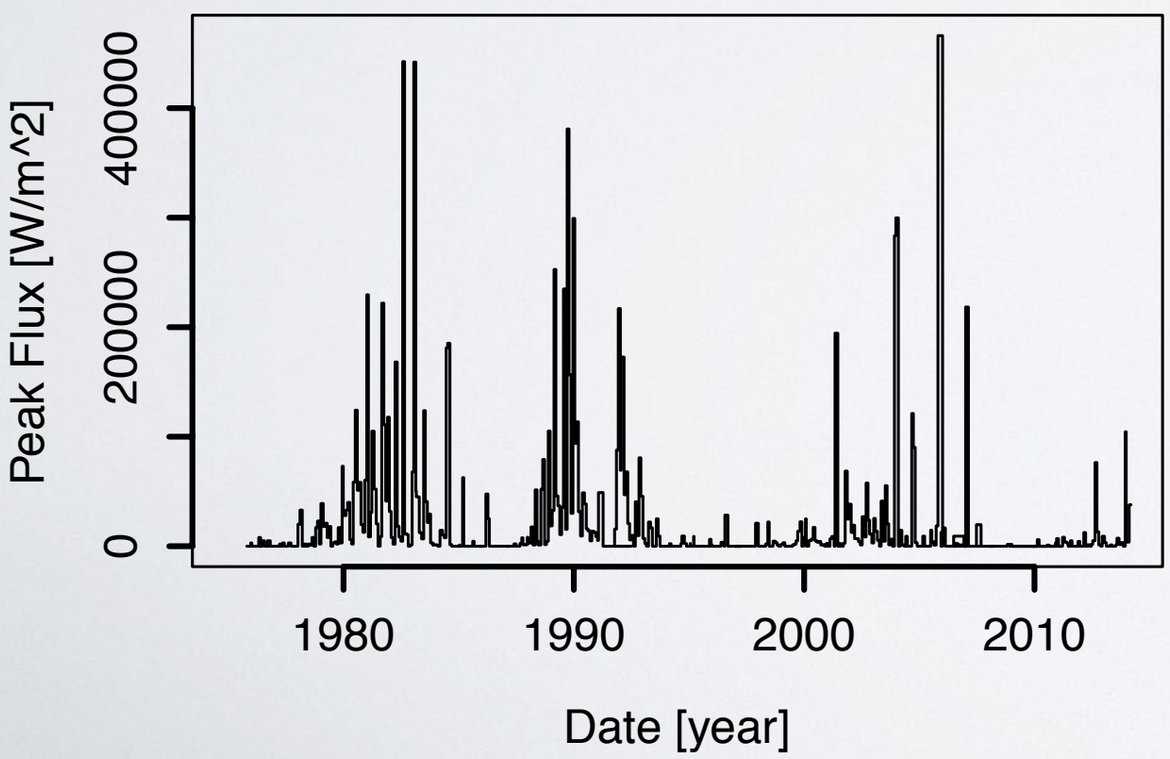
Distribution of DfAL

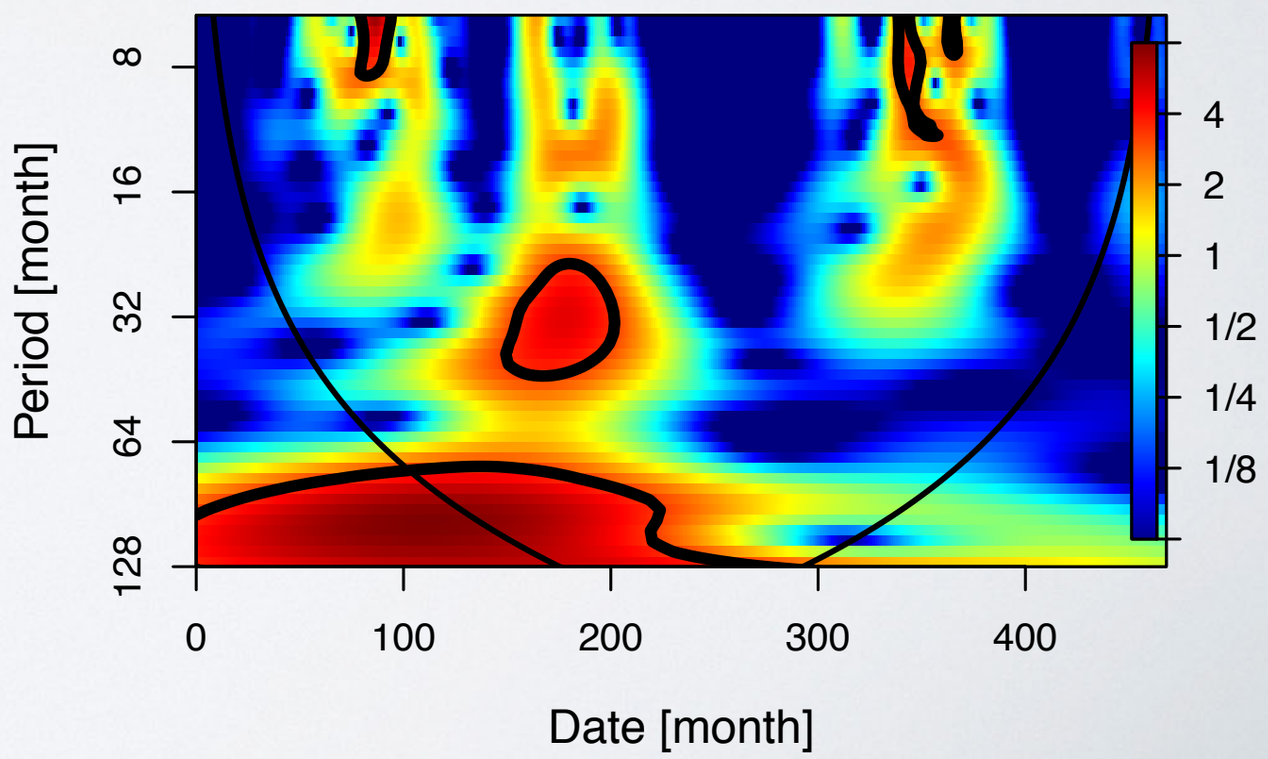


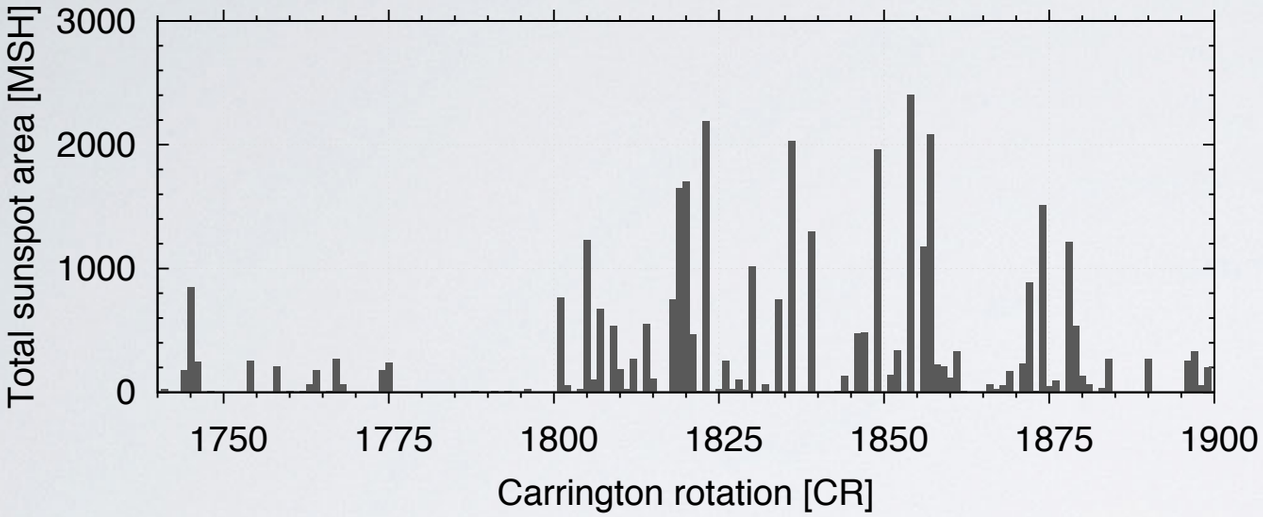

Probability vs Longitude Interval
Probability (%)
70
80
90
100
100
150
200
250
Longitude Interval [deg]

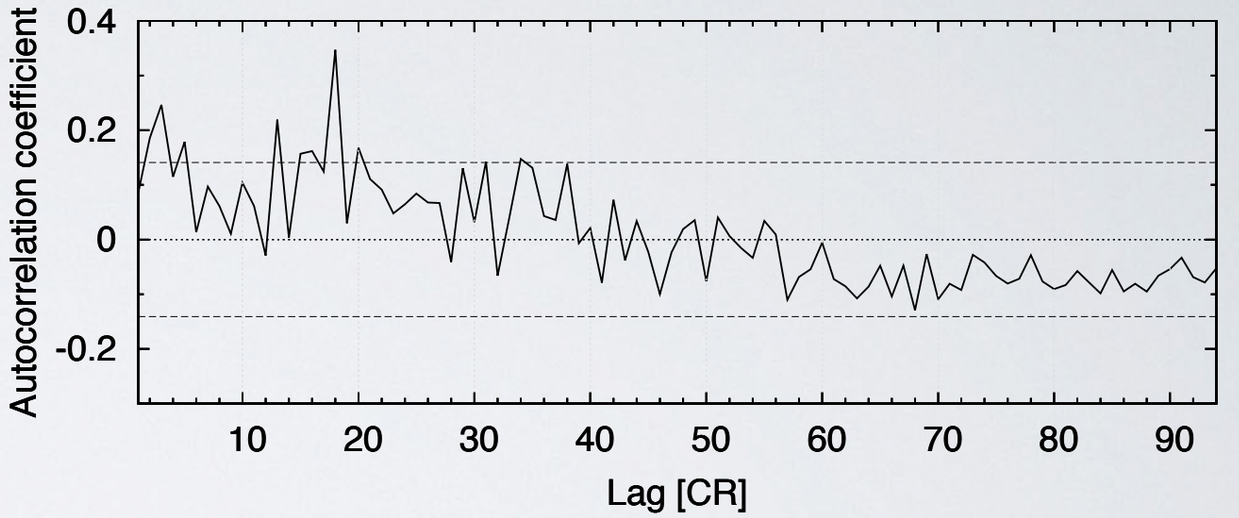

Temporal variation of Peak Flux
Peak Flux [W/m^2]
0
50000
150000
1980
1990
2000
2010
Date [year]

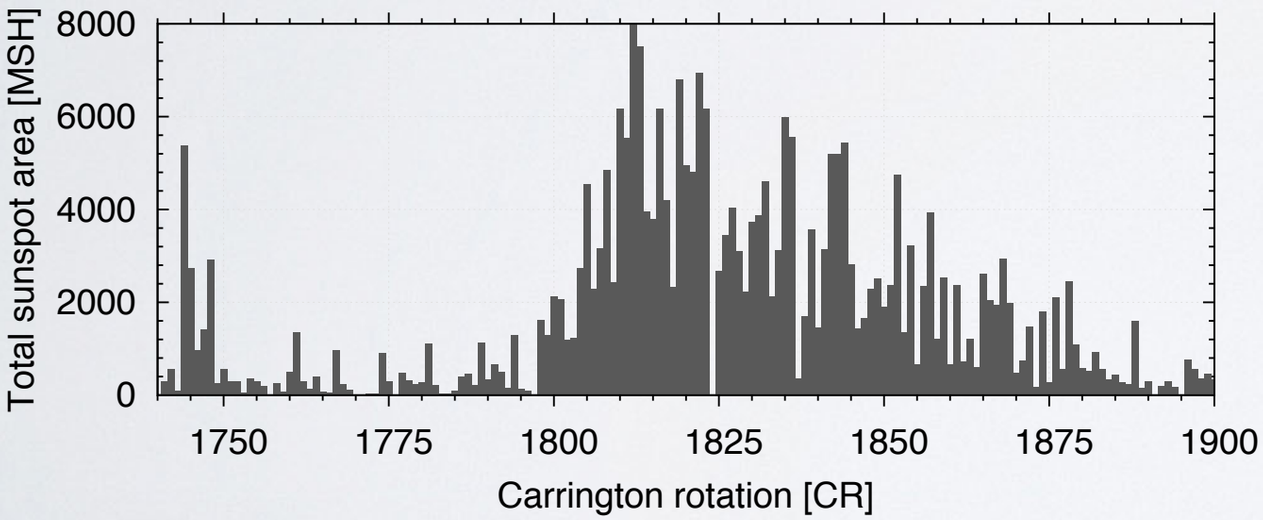

Wavelet Spektrum of Peak Flux
Period [month]
8
16
32
64
128
0
100
200
300
400
Date [month]
4
2
1
1/2
1/4
1/8

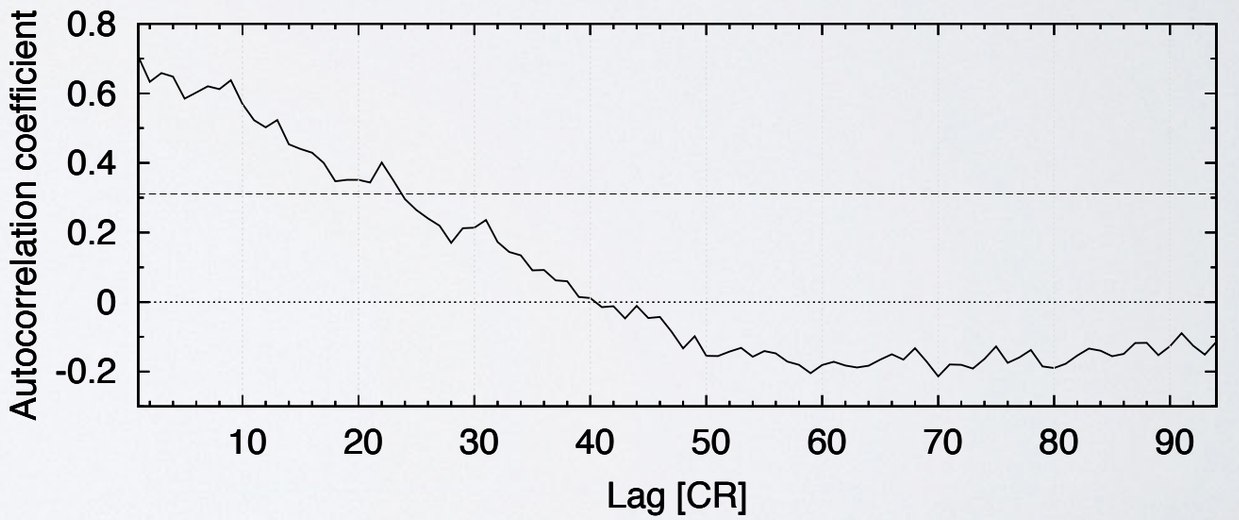

Temporal variation of Peak Flux
Peak Flux [W/m^2]
0
200000
400000
1980
1990
2000
2010
Date [year]


Wavelet Spektrum of Peak Flux
Period [month]
8
16
32
64
128
0
100
200
300
400
Date [month]
4
2
1
1/2
1/4
1/8


Total sunspot area [MSH]
3000
2000
1000
0
1750
1775
1800
1825
1850
1875
1900
Carrington rotation [CR]


Autocorrelation coefficient
0.4
0.2
0
-0.2
10
20
30
40
50
60
70
80
90
Lag [CR]


Total sunspot area [MSH]
8000
6000
4000
2000
0
1750
1775
1800
1825
1850
1875
1900
Carrington rotation [CR]


Autocorrelation coefficient
0.8
0.6
0.4
0.2
0
-0.2
10
20
30
40
50
60
70
80
90
Lag [CR]

Summary

- Two dynamic properties of the active longitudes may be of predictive importance.

- The most flare-productive active regions tend to be located in or close to the active longitudinal belt. This may allow to predict the geoeffective position of the domain of enhanced flaring probability for a couple of years ahead.

- The magnetic flux emergence exhibits a fluctuation of 1.3 years within the active belt, this fluctuation is absent out of this belt.

The above spatial condition and temporal variation allow to assess the probability of geoeffective flares if the location of the active longitude is known.

This may allow a mid-term forecast method.

Thank you for your attention!