Quasi-periodic changes in the galactic cosmic rays intensity related to the α-ω effect on the Sun

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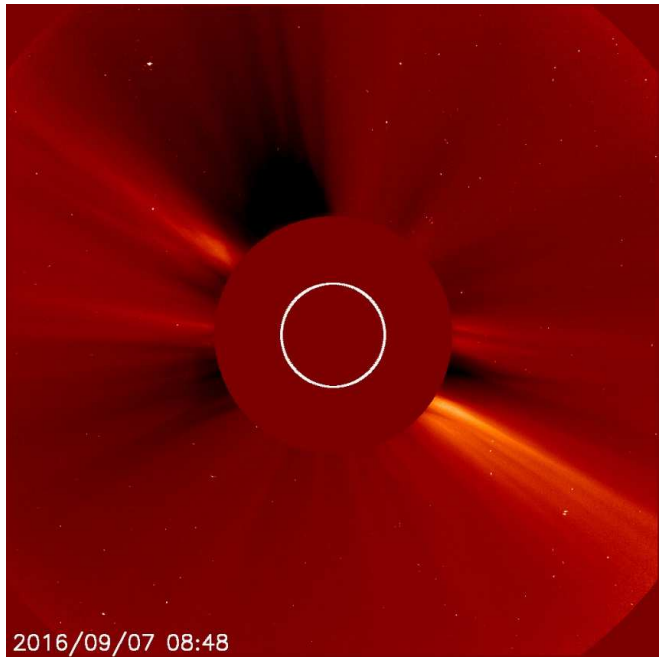
Outline

- Motivation
- Long-term changes of the amplitudes of the 27-day variation of the GCR intensity (1964-2016)
- The 3-4 CRP in the harmonics of the 27-day variation of the GCR intensity
- The 3-4 CRP in 27-day variation of the solar wind and solar activity parameters
- The 3-4 CRP in the coronal green line intensity
- Mechanism
- Summary



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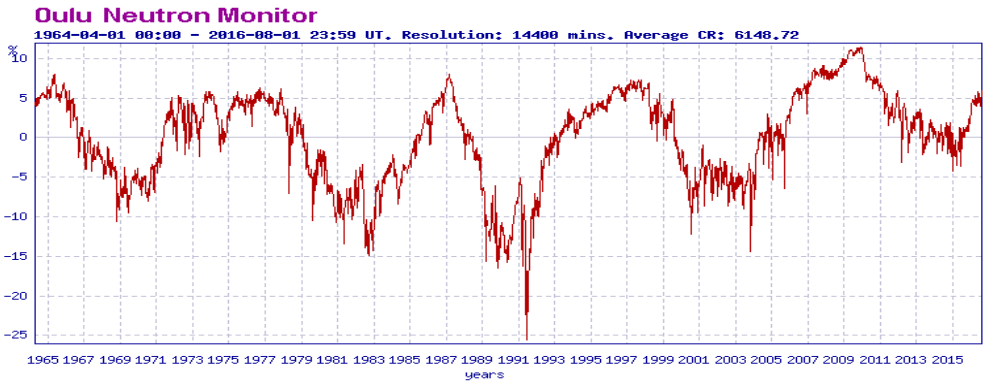

http://cosmicrays.oulu.fi

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Motivation

Amplitudes of the 27-day varitation of GCR intensity and several parameters of SA and SW manifest a periodicity of duration from 3 to 4 Carrington rotations period (3-4 CRP).

We ascribe this phenomenon to the existence of a spatial topological structure (STS) of magnetic field lines. The STS is created by α–ω efect in the inner solar atmosphere. STS exists owing to the asymmetry of turbulent solar dynamo and solar differential rotation transforming the Sun's poloidal magnetic field into the toroidal, and vice versa.

3-4 CRP, corresponds to the extreme interval ΔT of differential rotation periods, ΔT = 35 days -25 days (from poles to equator, respectively) of the Sun. However, we assume that the α–ω process appears in time intervals corresponding to the intermediate differential rotation periods, as well, e.g. ΔT_1 = 26 days -25 days, ΔT_2 = 27 days - 25 days, ΔT_3 = 28 days - 25 days, and so on, up to ΔT = 35 days -25 days. Thus, a wide range of quasi-periodicities of GCR intensity, solar wind and solar activity parameters may be related to the joint effect of the turbulent solar dynamo and differential rotation of the Sun being a cause of creation of the STS.

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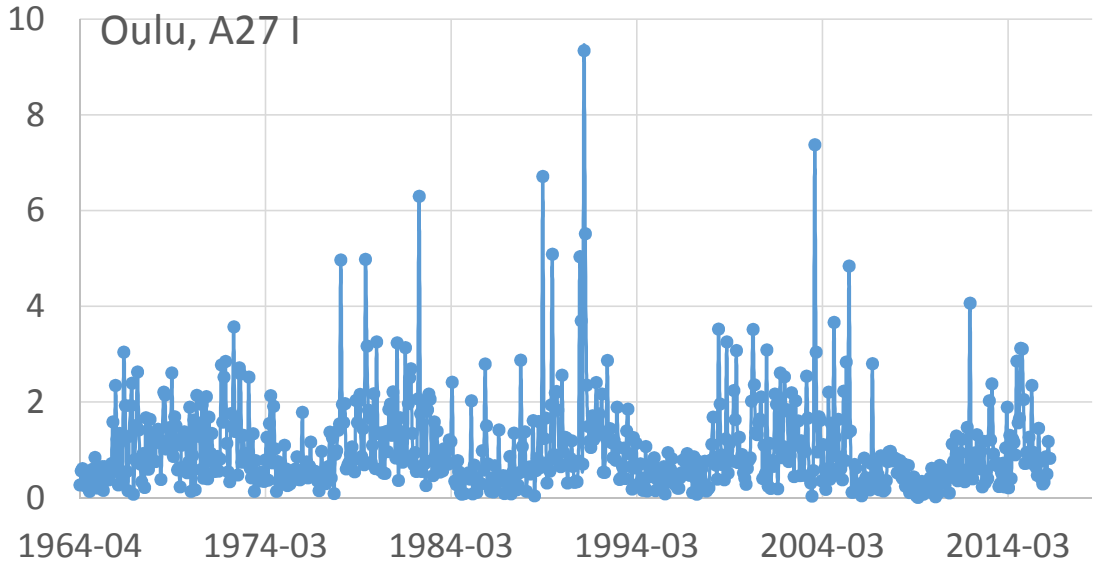

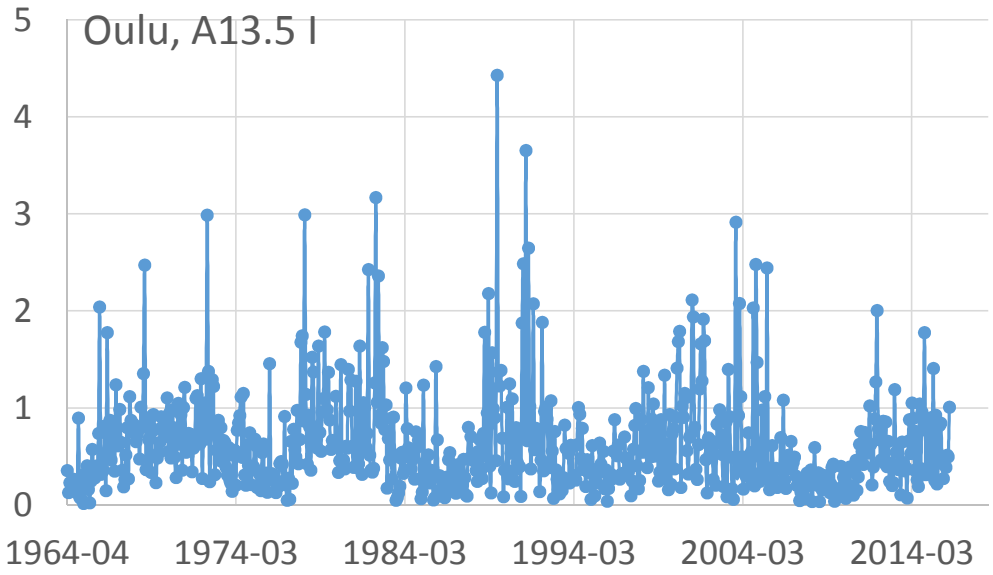

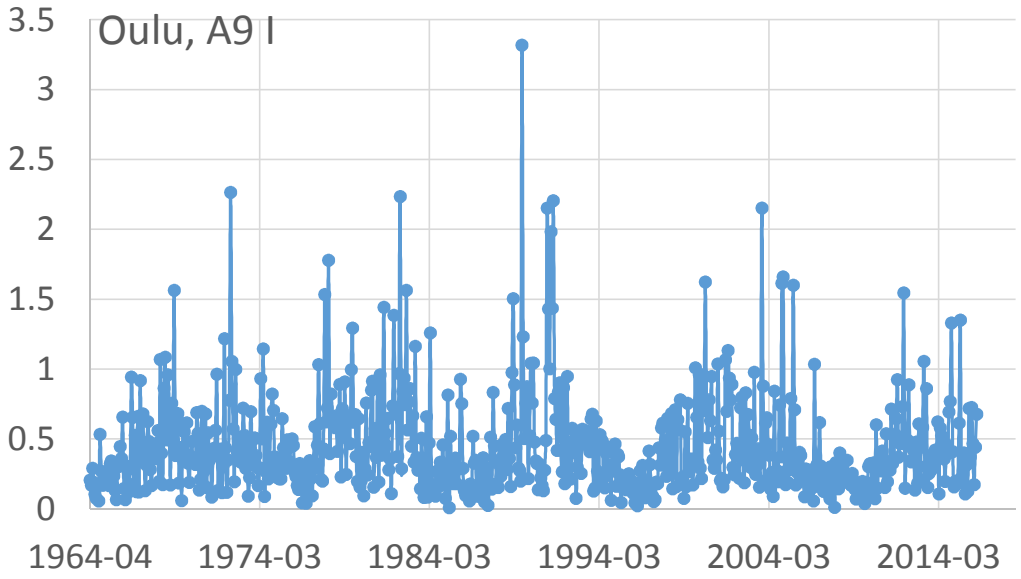

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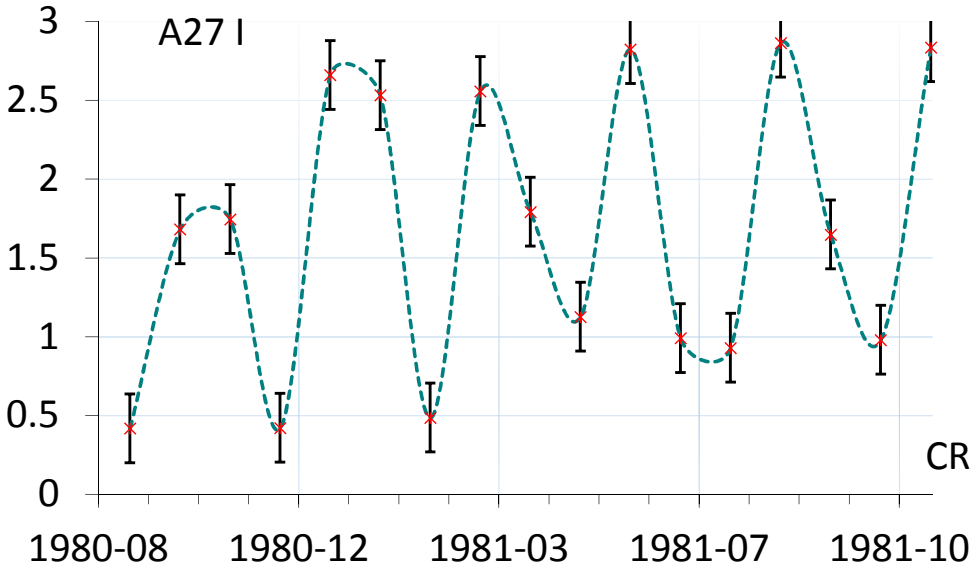
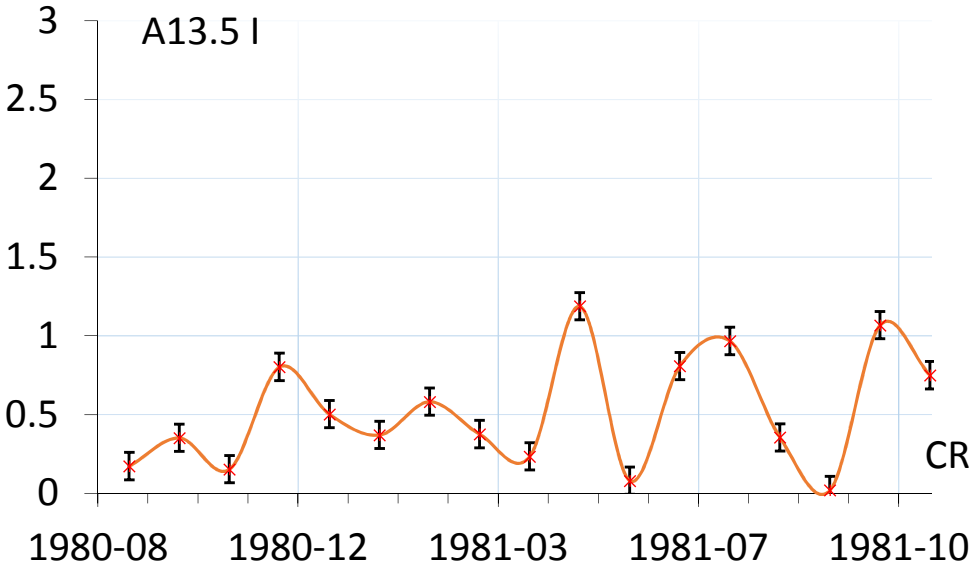
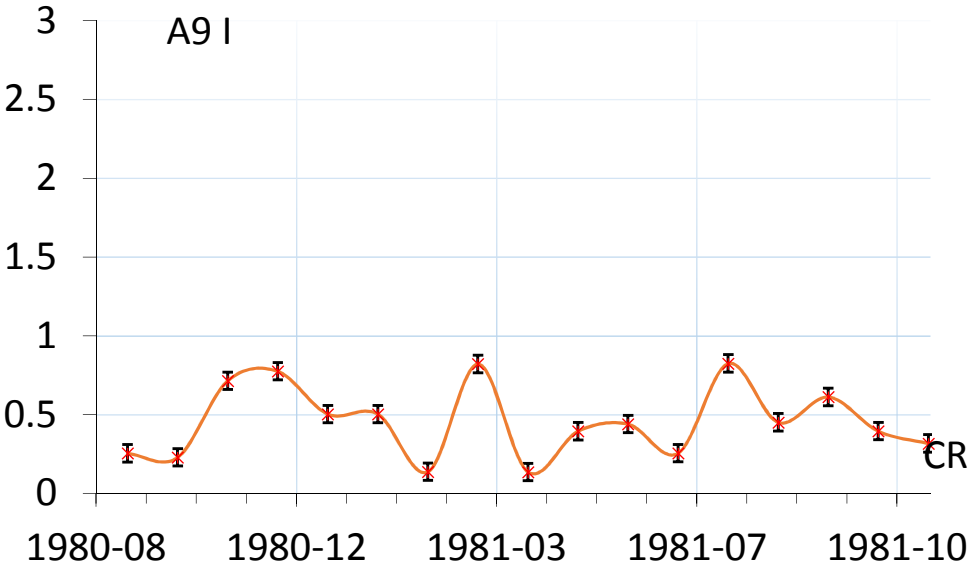
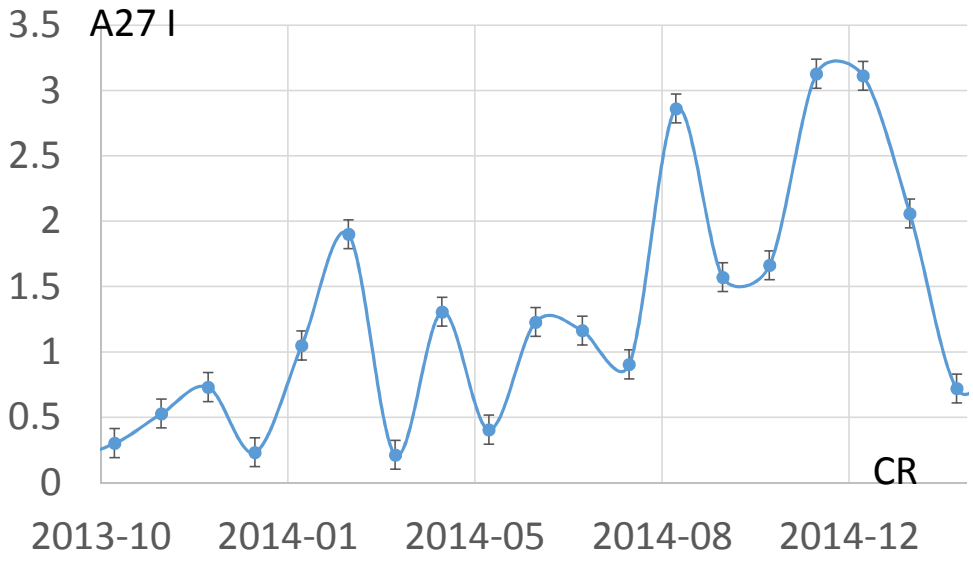
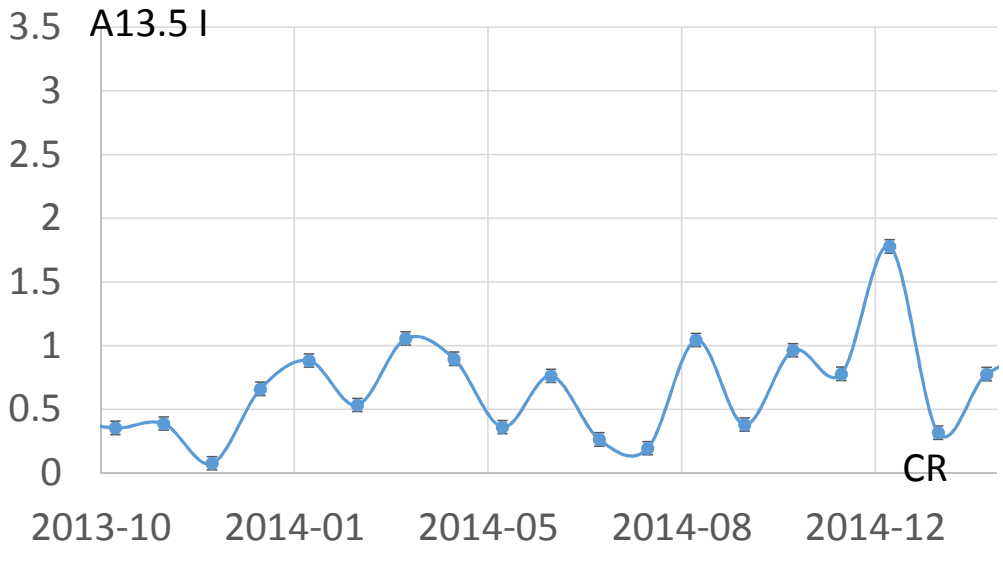




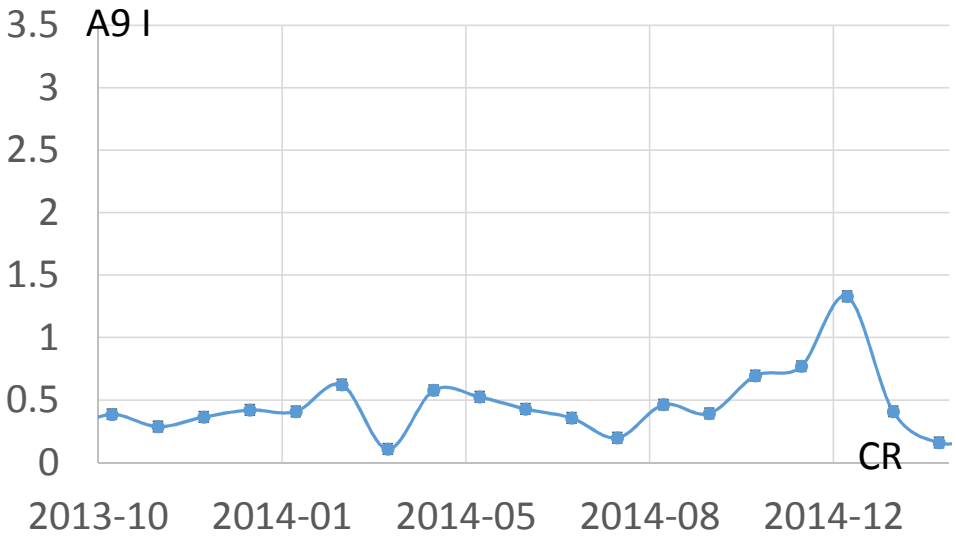


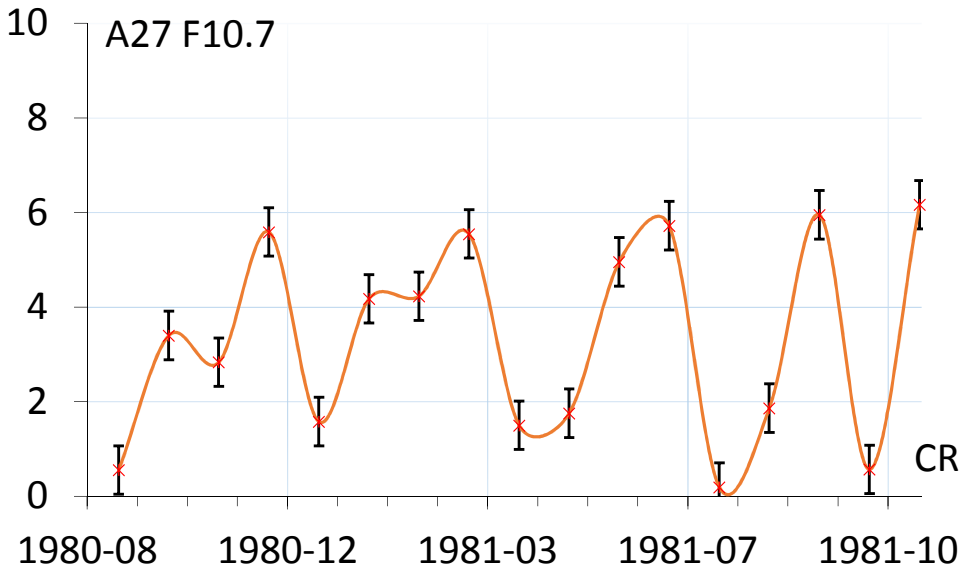
Gil, Alania, 2011

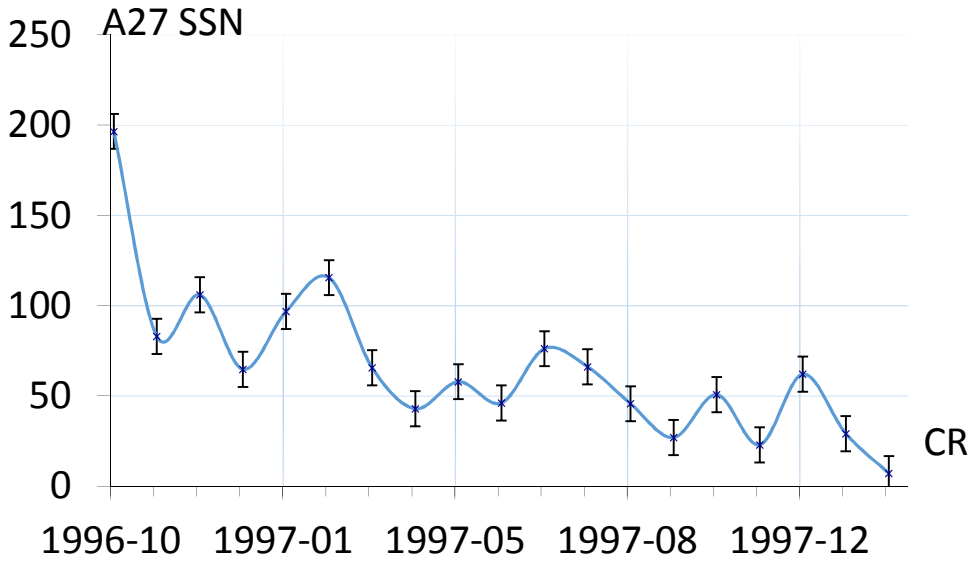

A27 I
3.5
3
2.5
2
1.5
1
0.5
0
2013-10
2014-01
2014-05
2014-08
2014-12
CR

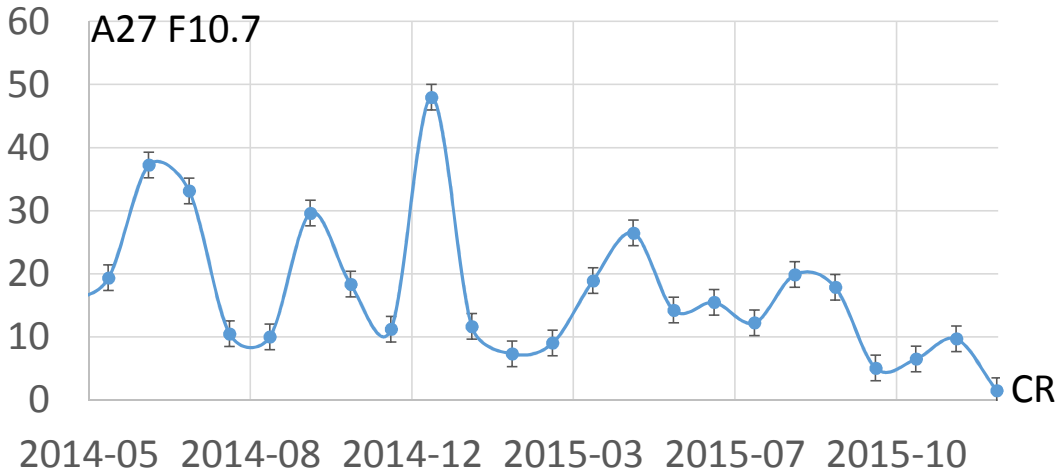

A13.5 I
3.5
3
2.5
2
1.5
1
0.5
0
2013-10
2014-01
2014-05
2014-08
2014-12
CR

SC 24

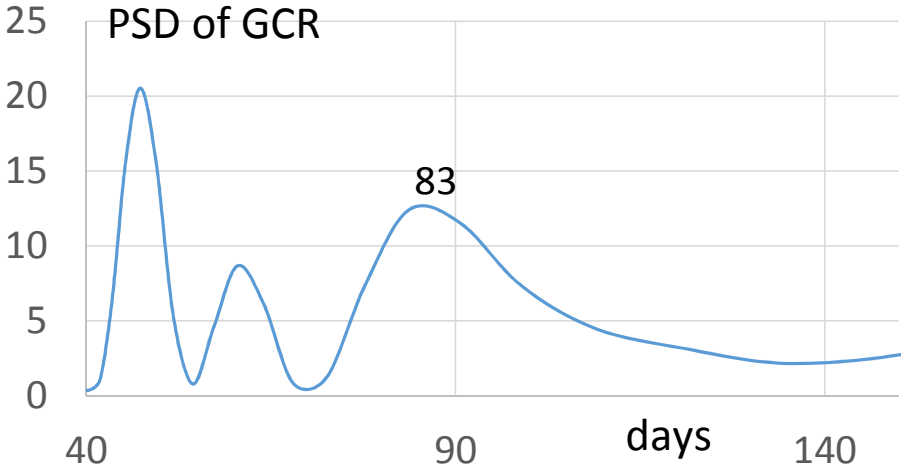

A9 I
3.5
3
2.5
2
1.5
1
0.5
0
2013-10
2014-01
2014-05
2014-08
2014-12
CR

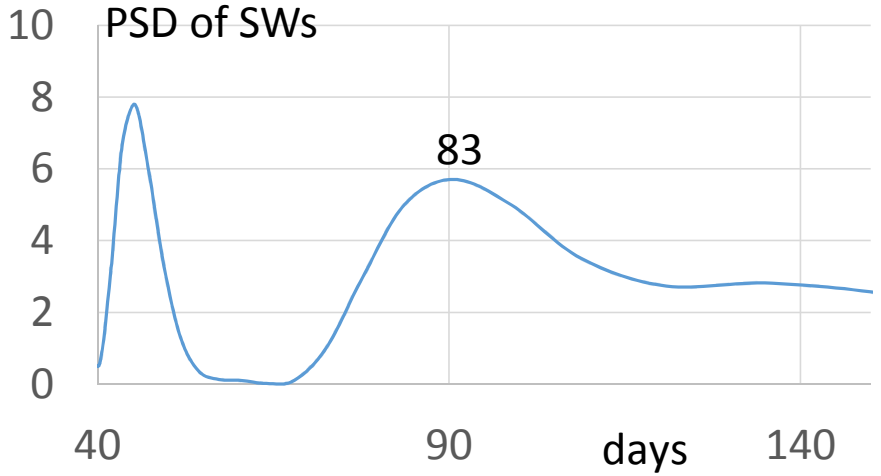

A27 F10.7
10
8
6
4
2
0
1980-08
1980-12
1981-03
1981-07
1981-10
CR

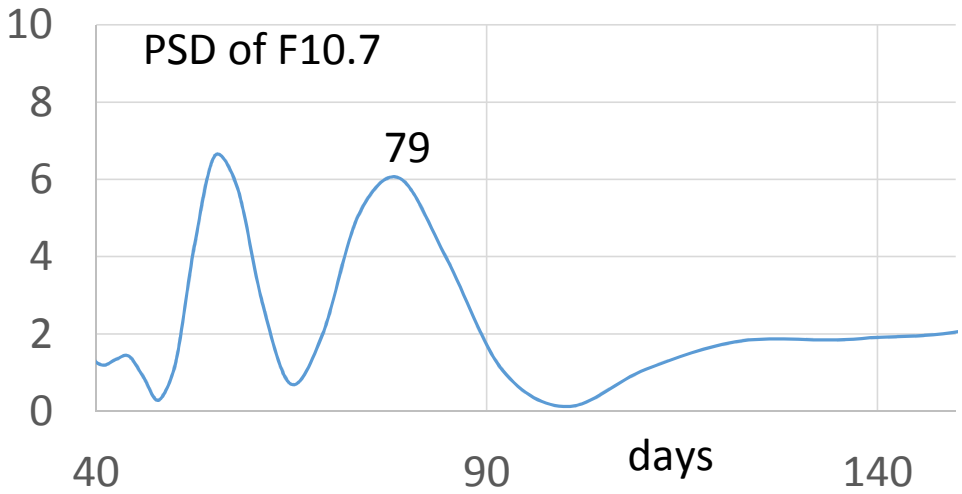

A27 SSN
250
200
150
100
50
0
1996-10
1997-01
1997-05
1997-08
1997-12
CR

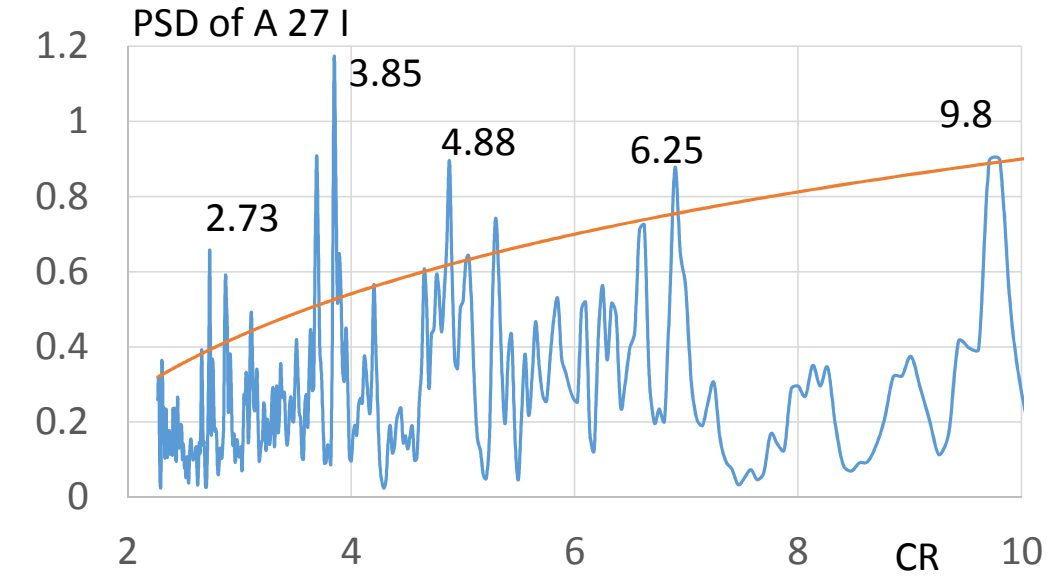

A27 F10.7
60
50
40
30
20
10
0
2014-05
2014-08
2014-12
2015-03
2015-07
2015-10
CR

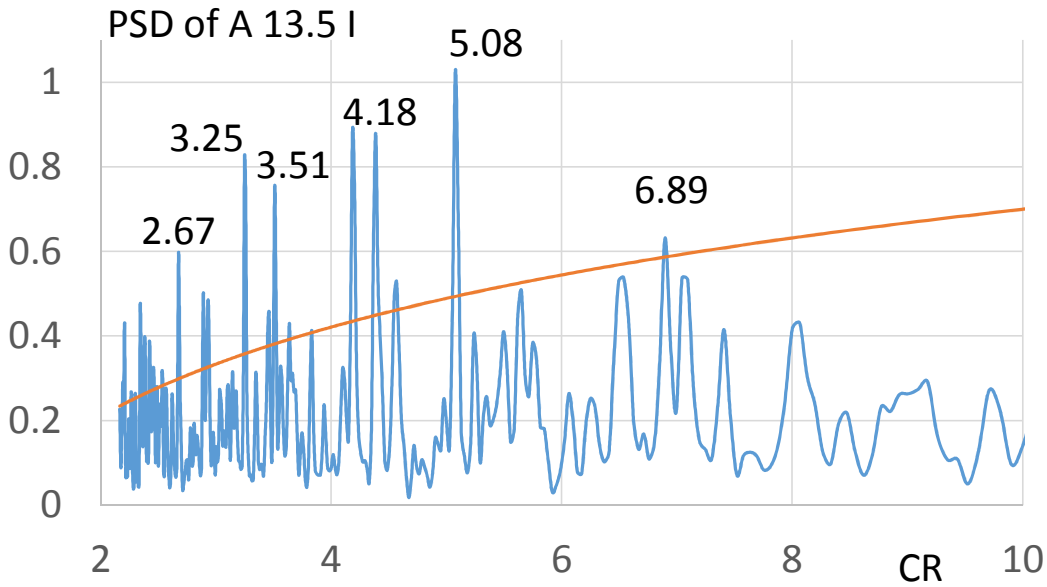
SC 24

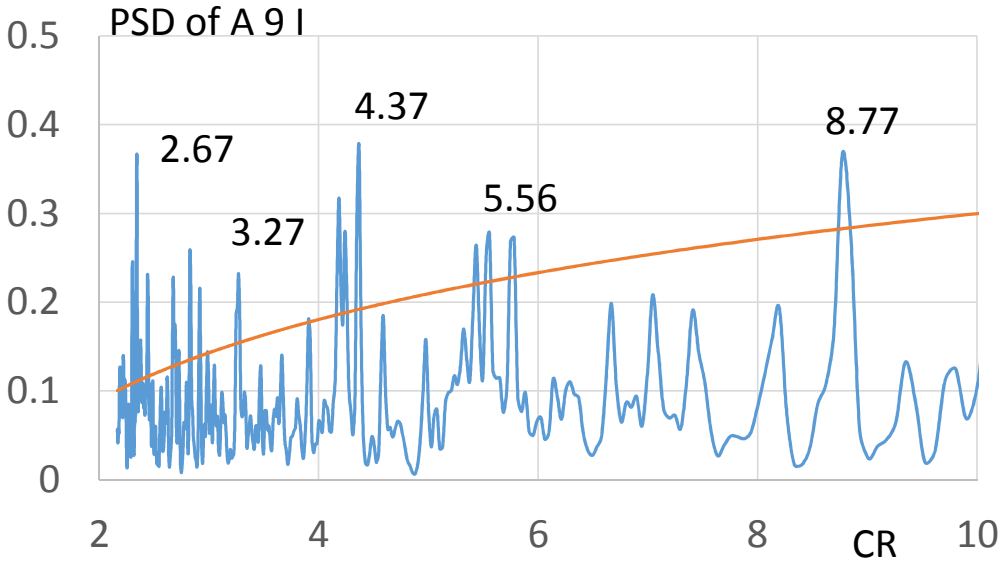

PSD of GCR
25
20
15
10
5
0
83
40
90
days
140


PSD of SWs
10
8
6
4
2
0
83
40
90
days
140


PSD of F10.7
10
8
6
4
2
0
79
40
90
days
140


PSD of A 27 I
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
CR
2.73
3.85
4.88
6.25
9.8


PSD of A 13.5 I
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
CR
2.67
3.25
3.51
4.18
5.08
6.89


PSD of A 9 I
0.5
0.4
0.3
0.2
0.1
0
2
4
6
8
10
CR
2.67
3.27
4.37
5.56
8.77

1964-2016

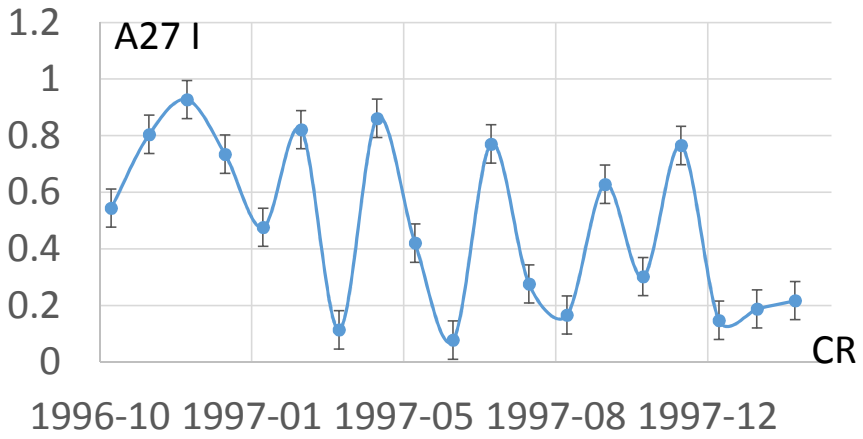
Rieger et al. (1984) : 154-day periodicity in the hard solar flares occurance

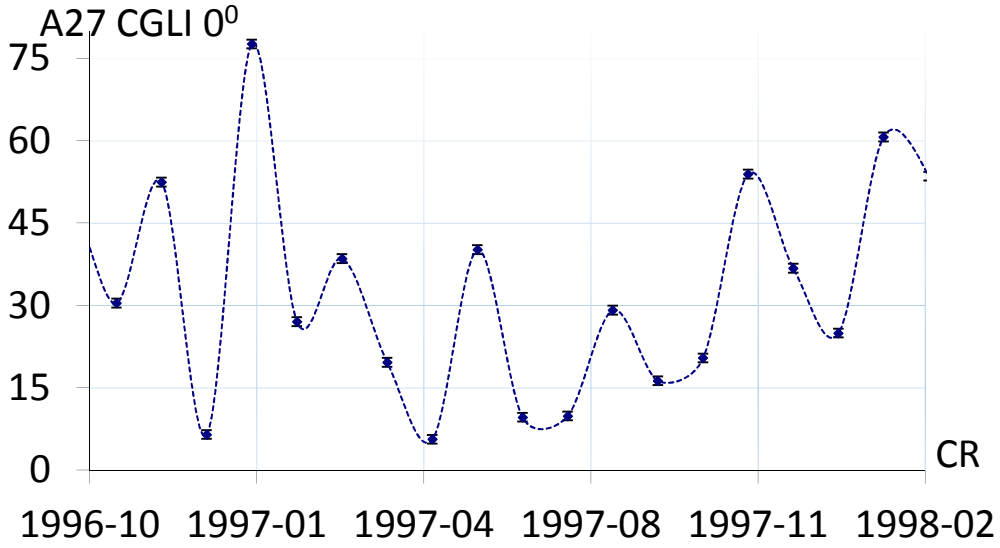
Bai and Sturrock (1991), Bai (2003): periodicity of 84 days in the solar flare data during solar cycle 20. The same periodicity in Joshi et al. (2006) in SSN and sunspot area in the southern hemisphere during cycle 23.

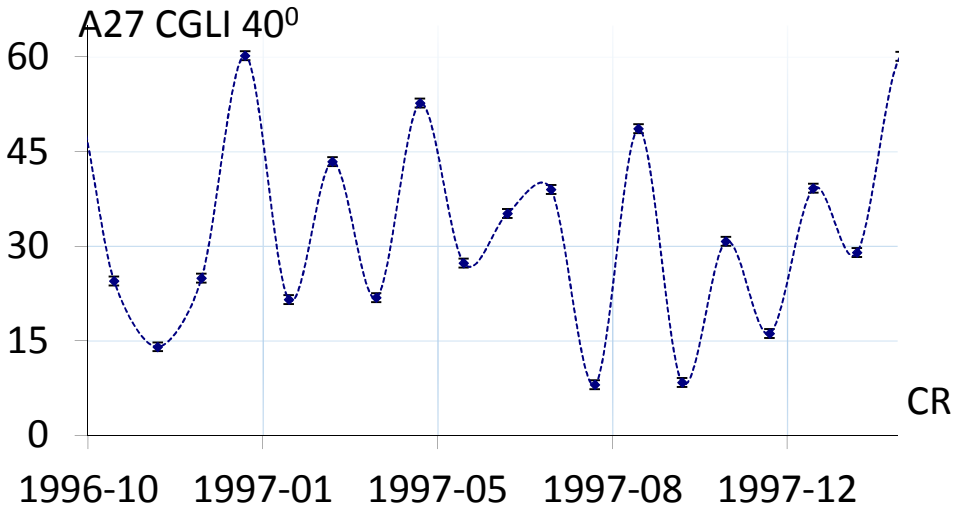
Le Mouël et al. (2007): the 27-day indicator in SSN and the solar dynamo

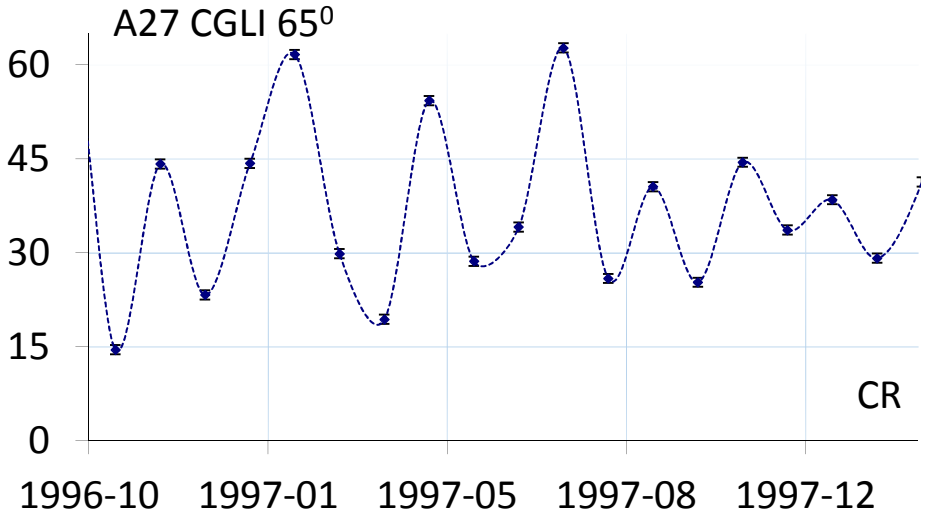
Gil and Alania (2011): new type of quasi-periodicity of three to four Carrington rotations periods (3-4 CRP) in changes of the amplitudes of the 27-day variations of the GCR intensity, parameters of solar activity and solar wind

Sabbah and Kudela (Kudela, 2012): the frequency corresponding to ~ 3 CRP clearly visible in muon data

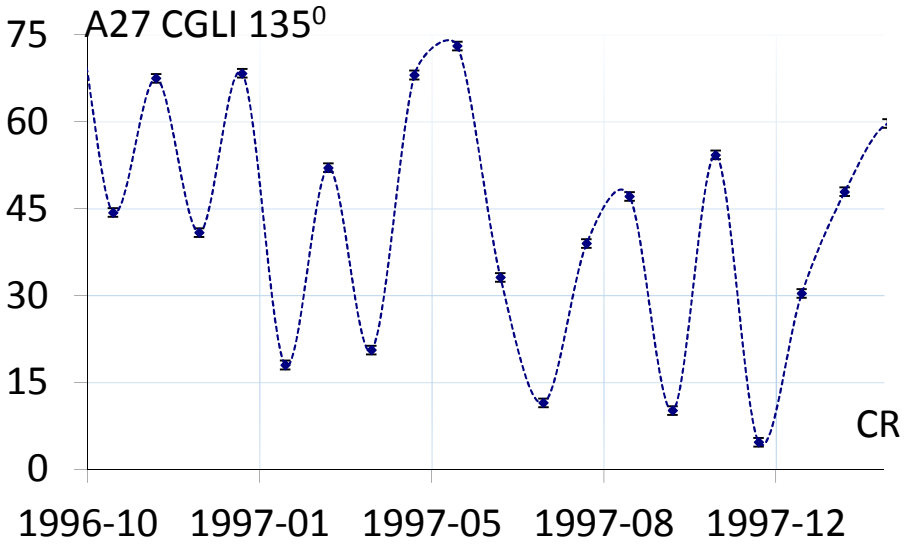


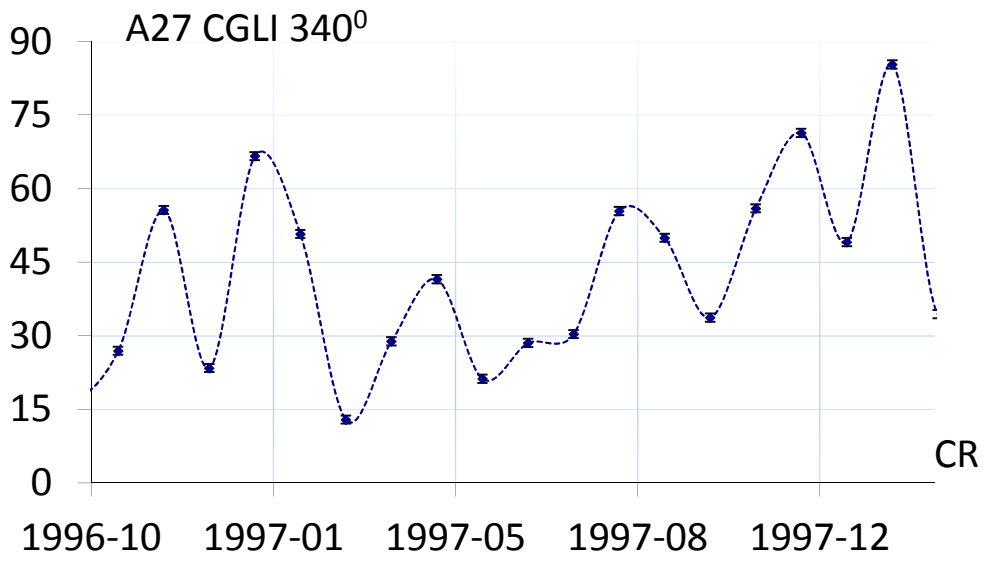


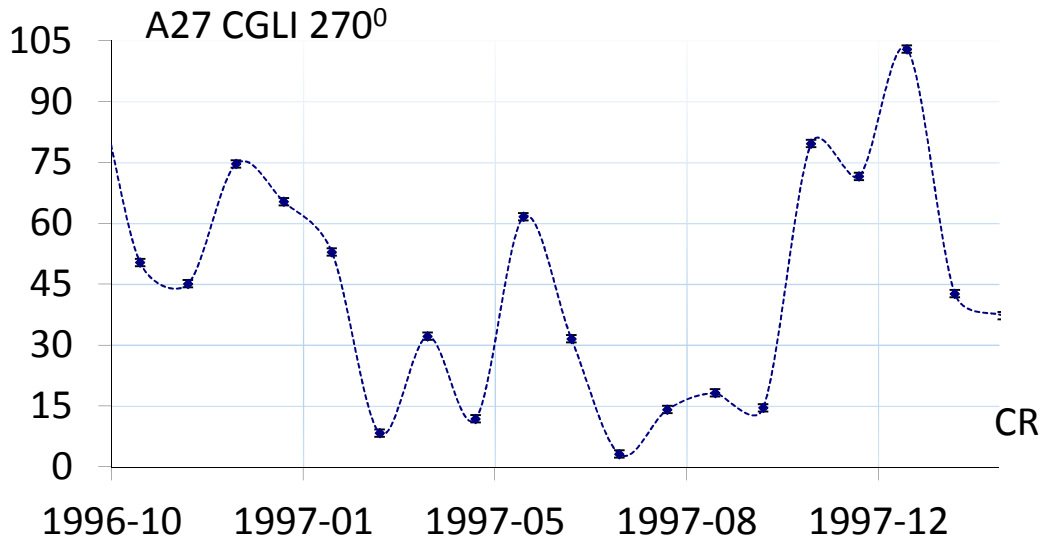


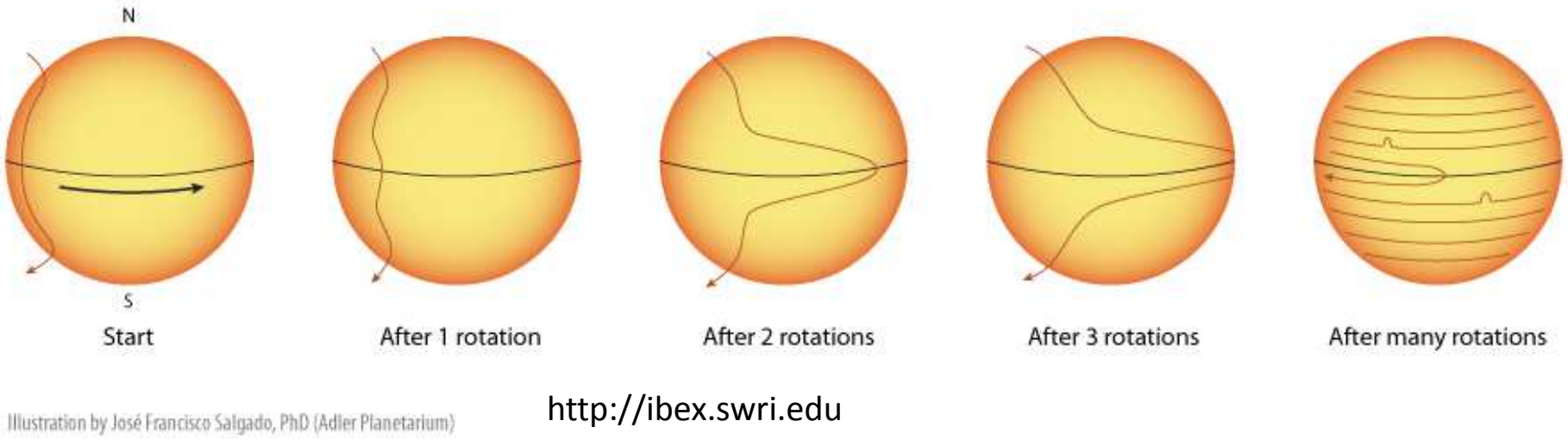


Coronal Green Line Intensity-
wavelength of 530.3 nm,
emitted by ionized iron Fe XIV


A27 CGLI 135⁰
75
60
45
30
15
0
CR
1996-10
1997-01
1997-05
1997-08
1997-12

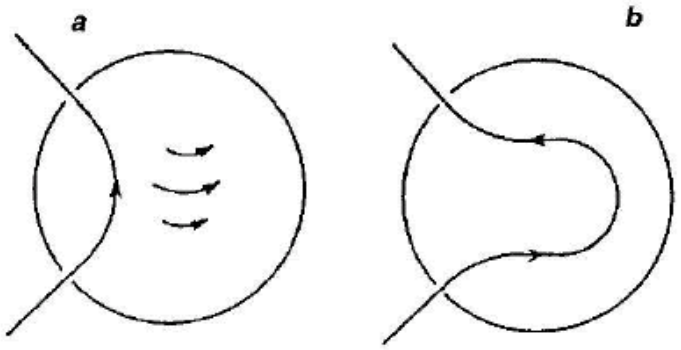

A27 CGLI 340⁰
90
75
60
45
30
15
0
CR
1996-10
1997-01
1997-05
1997-08
1997-12


A27 CGLI 270⁰
105
90
75
60
45
30
15
0
CR
1996-10
1997-01
1997-05
1997-08
1997-12

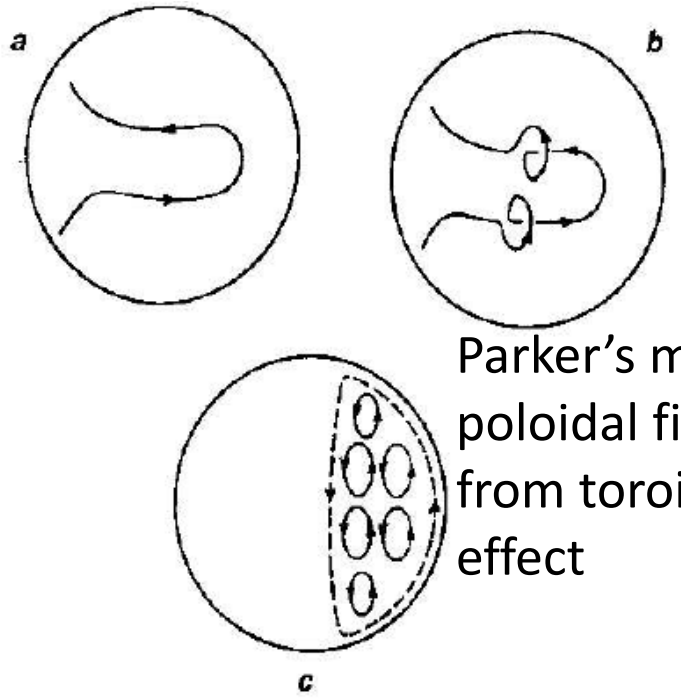


http://ibex.swri.edu

Due to differential rotation of the Sun, the helioequatorial regions perform 3-4 rotations (sidereal rotation period of ~25 days, or sinodic period of ~27 days), but polar regions perform only 2-3 rotations (sidereal ~34-35 days, or sinodic ~36-37 days). Owing to ω effect the equatorial toroidal magnetic field lines are fully wrapped around the Sun and reach to the heliolongitudes with the origin of the poloidal magnetic field lines (in the polar regions) from which the toroidal field was created.



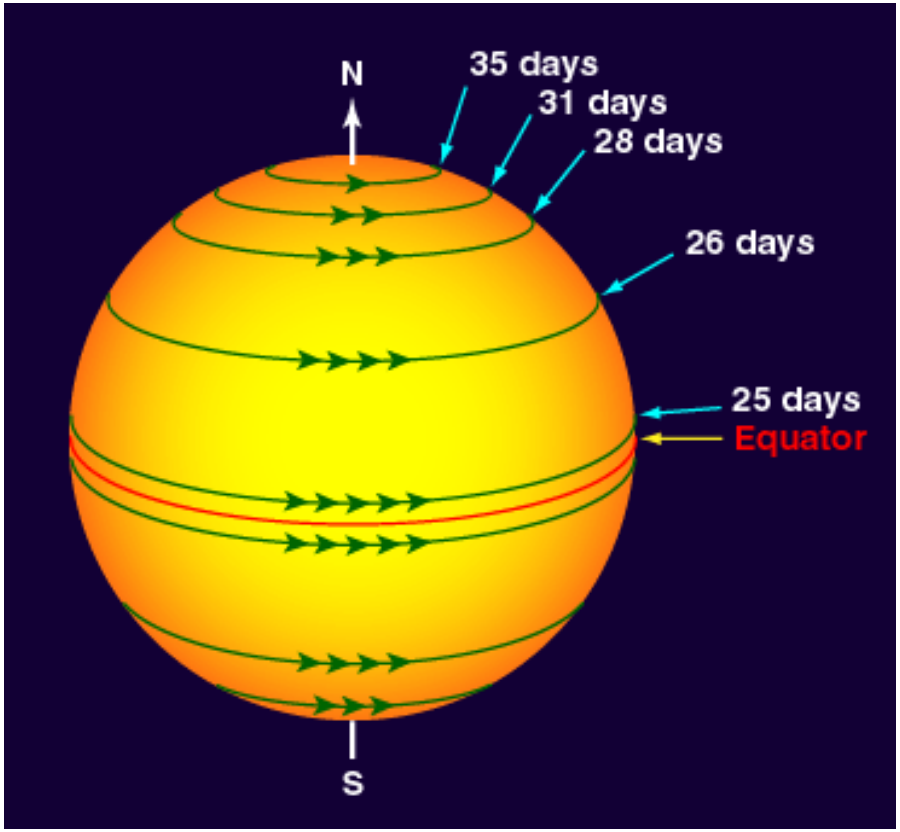
Due to differential rotation: toroidal field produced from poloidal



Parker's mechanism: poloidal field produced from toroidal field – α-effect

It seems that fully wrapped toroidal magnetic field lines create a topological structure of magnetic field on the Sun (created owing to the existence of the asymmetry of solar dynamo and solar differential rotation transforming the Sun's poloidal magnetic field to the toroidal)

We assume that the α–ω process appears in time intervals corresponding to the intermediate differential rotation periods, as well, e.g. ΔT_1 = 25-26, ΔT_2 = 25-27, and so on, up to ΔT= 25-35 days including practically unlimited quasi-periodicities caused by superposition of the basic modes corresponding to various quasi-recurrent periods ΔT. Thus, we suggest that different combination of basic modes of ΔT and their superposition can be considered as a source of great of majority types of quasi-periodical changes of parameters of solar wind and solar activity, as well, as the GCR intensity.



www.star.bris.ac.uk

CONCLUSIONS

- We identified quasi-periodicity with duration of three to four Carrington rotations period (3-4 CRP) in the changes of the amplitudes of the 27-day variations (also during the current SC 24) of the GCR intensity, parameters of solar wind and solar activity.
- We showed the 3-4 CRP in the amplitudes of the 27-day variation of the CGLI, generally in mid-latitudes and near the polar regions, especially in North hemisphere. It migth be an indicator of North-South asymmetry of solar dynamo.
- We ascribe the existance of the 3-4 CRP to the presence of a spatial topological structure of the magnetic field lines. Wide range of quasi- periodicities of GCR intensity, SW and SA parameters may be related to this joint effect of the turbulent solar dynamo and differential rotation.

Thank you!

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