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Periodicities Observed in Neutron Monitor Counting Rates Throughout Solar Cycles 20-24

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Periodicities in neutron monitor counting rates

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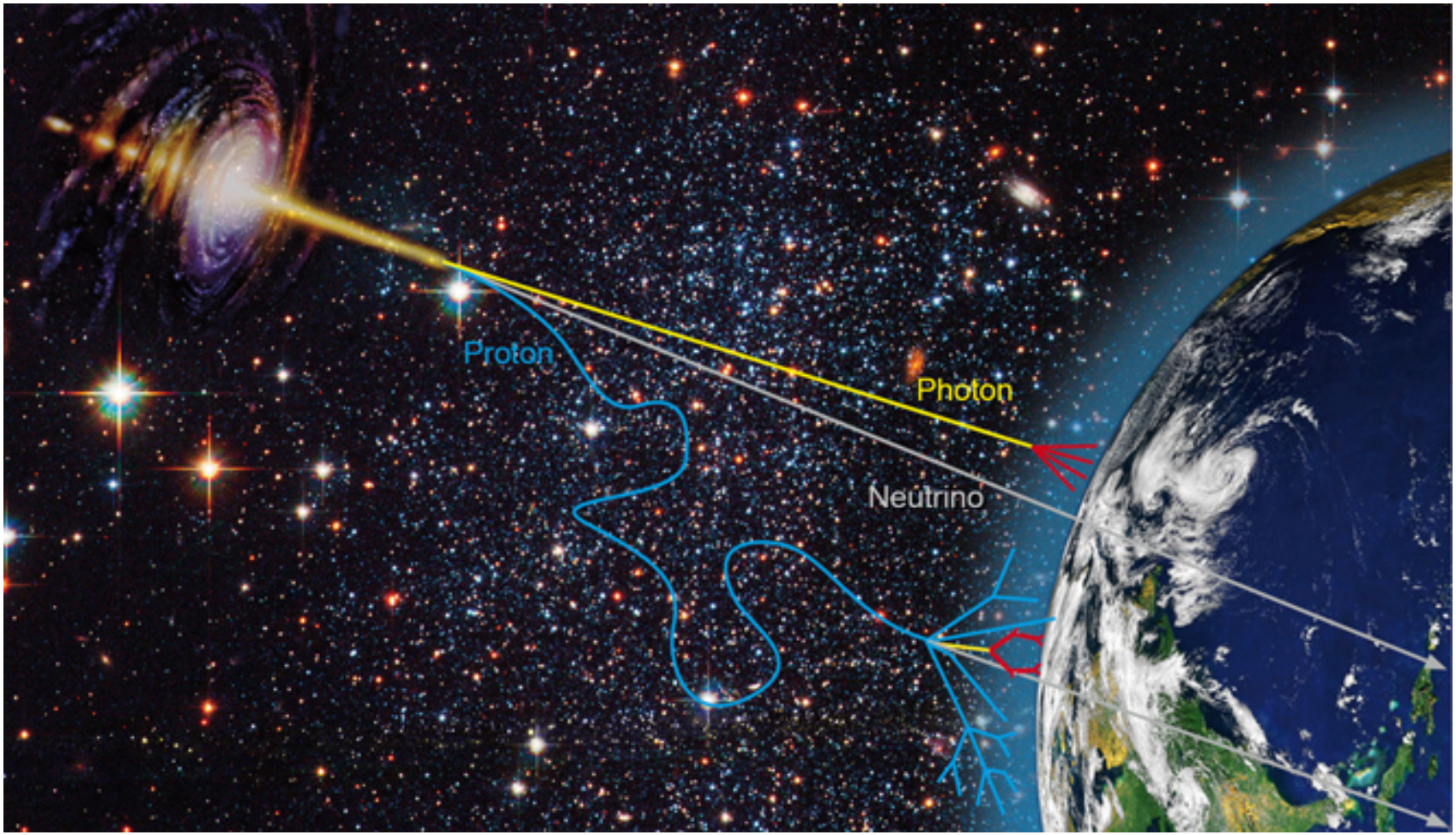
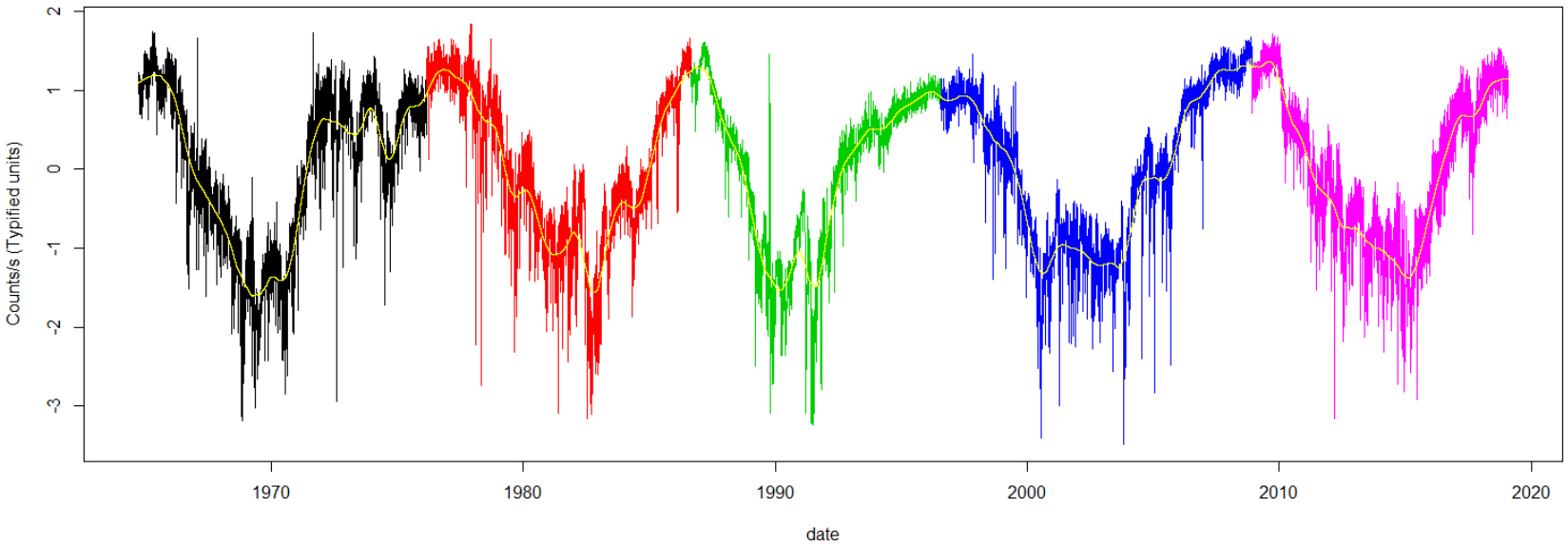
Cosmic rays

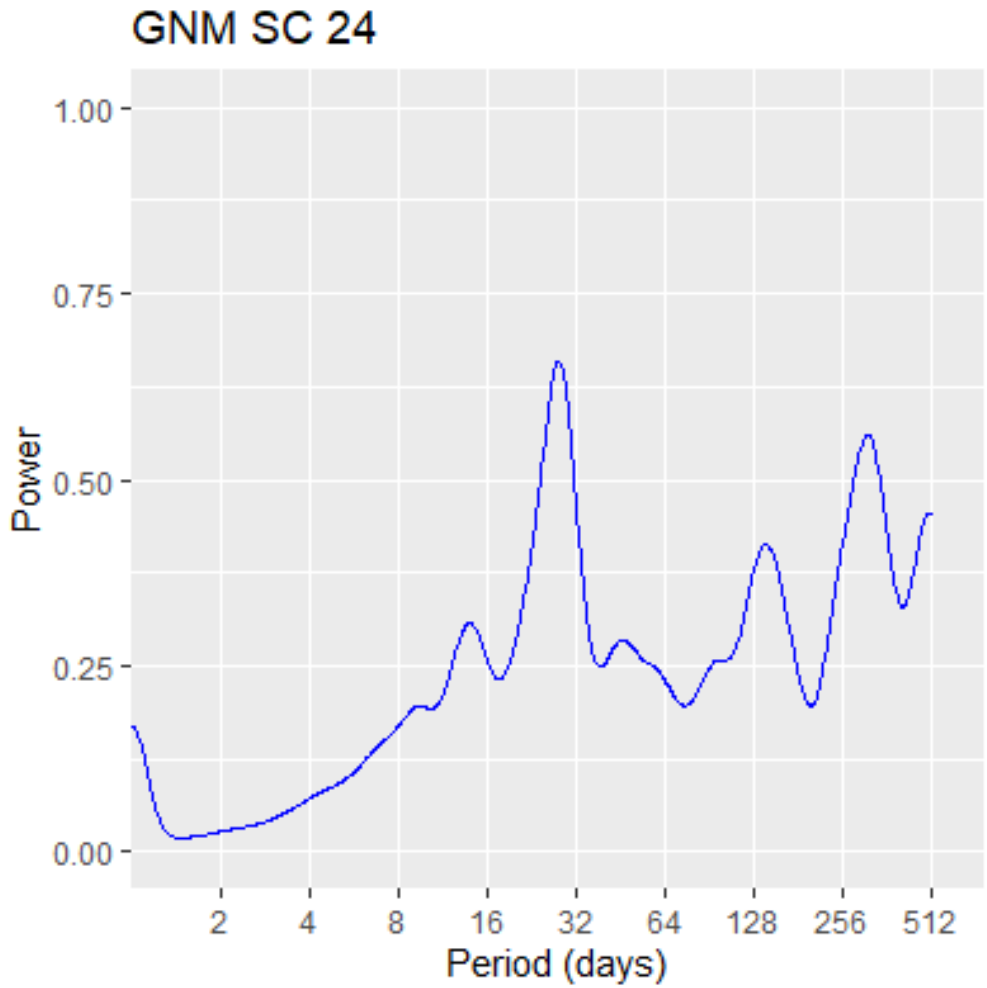


Global Neutron Monitor counting rates



See López-Comazzi, A and Blanco, J.J. (2020)

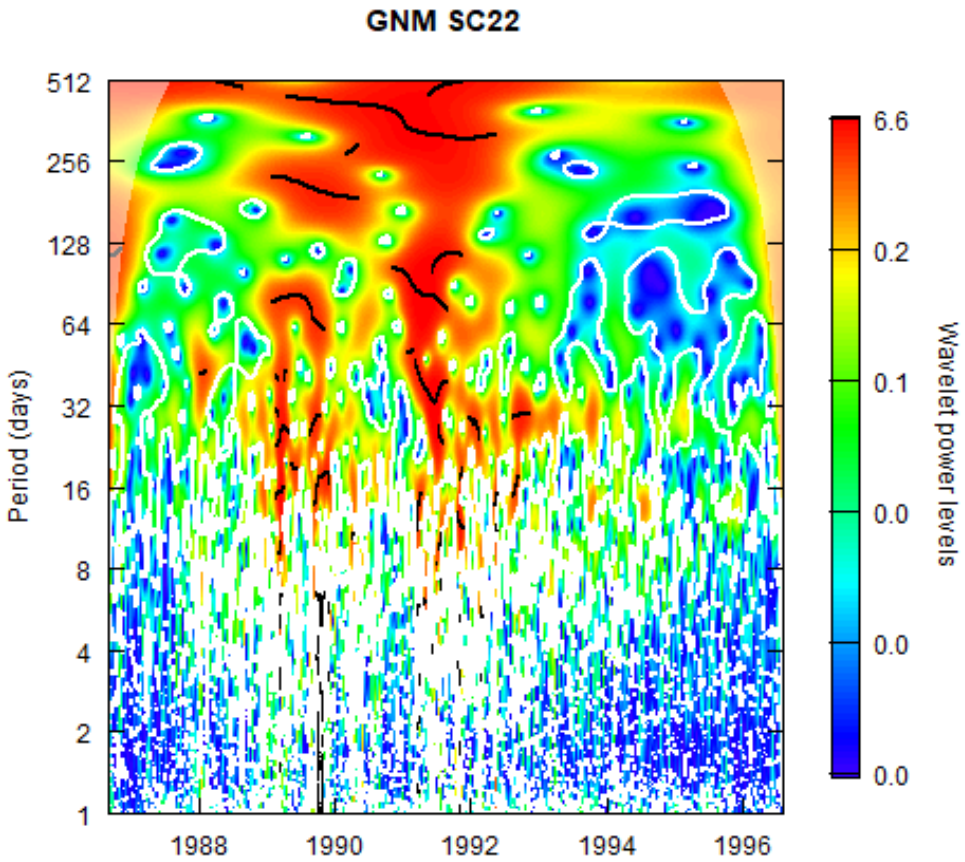
Global Wavelet Spectrum of Neutron Monitor

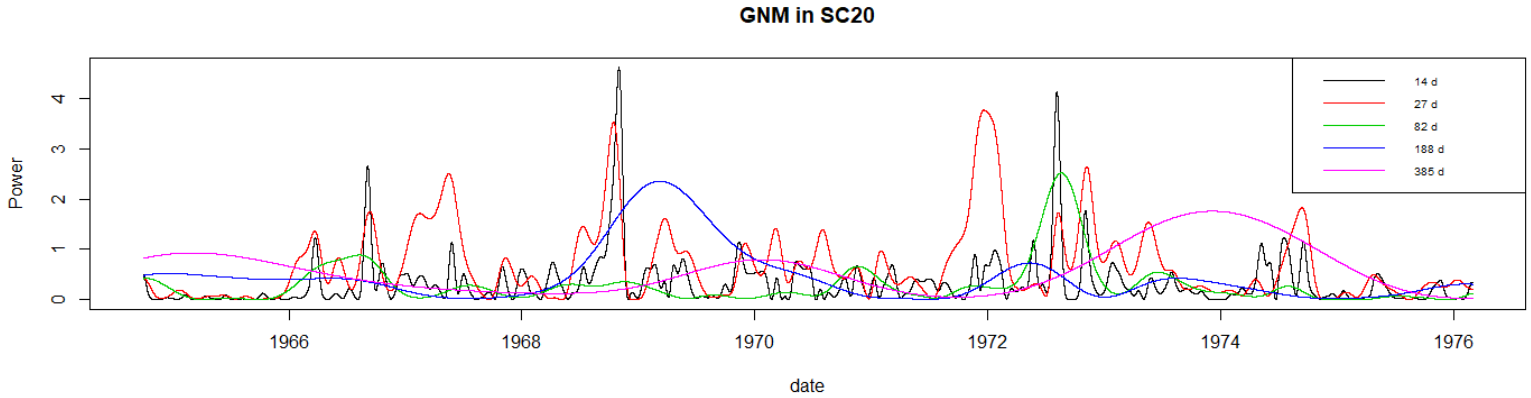


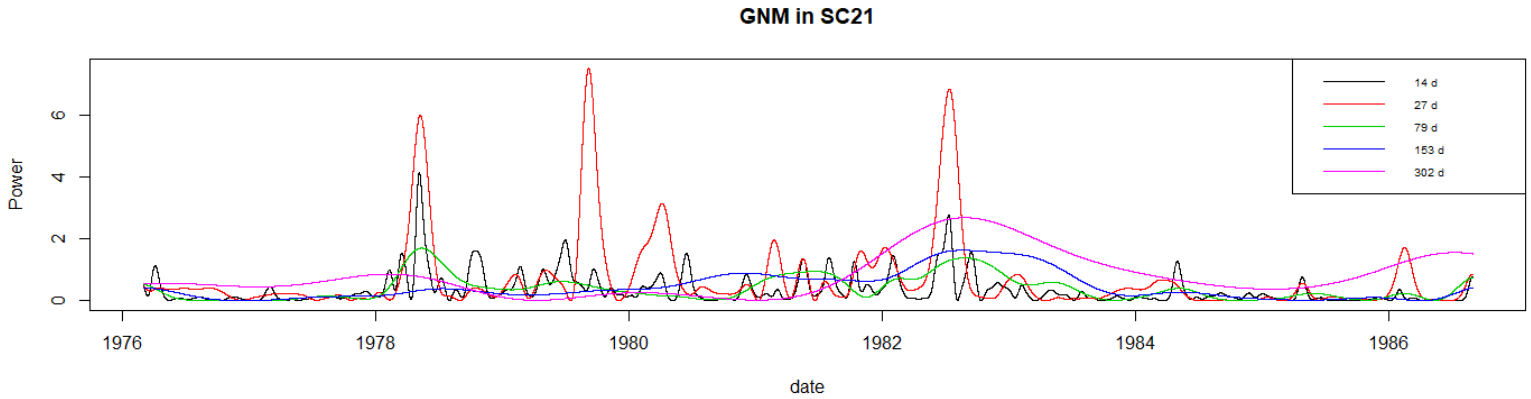
Periodicities detected in Global Neutron Monitor

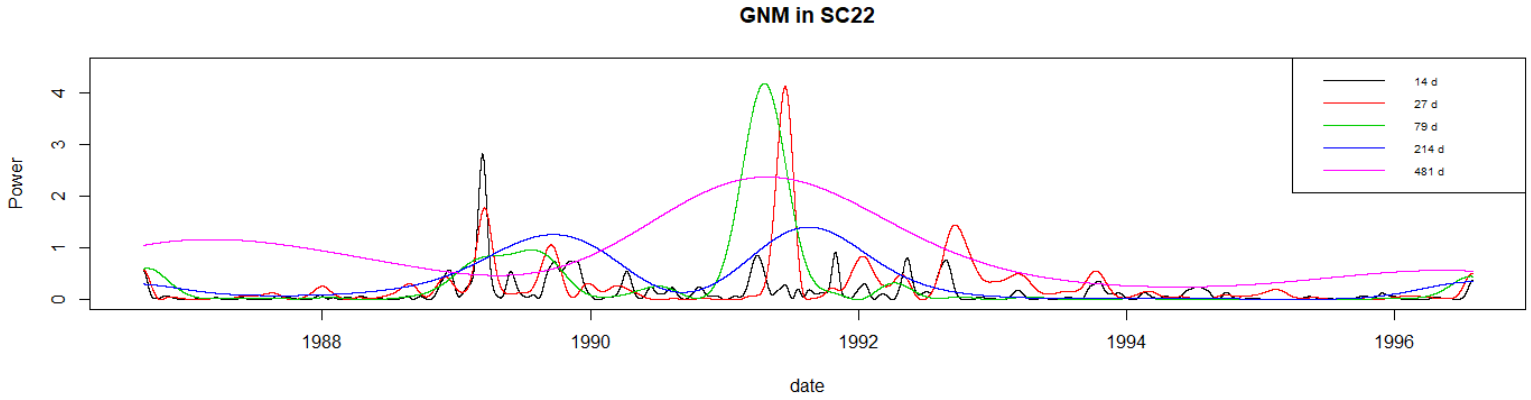
GNM	Period (days)					
SC20	14 ± 1	27 ± 2	82 ± 8	189 ± 17	385 ± 26	–
SC21	14 ± 1	27 ± 3	79 ± 9	153 ± 16	302 ± 21	–
SC22	14 ± 1	27 ± 3	79 ± 8	–	214 ± 17	481 ± 35
SC23	14 ± 1	27 ± 3	63 ± 6	134 ± 14	228 ± 20	407 ± 30
SC24	14 ± 1	27 ± 3	46 ± 7	140 ± 12	311 ± 23	498 ± 32

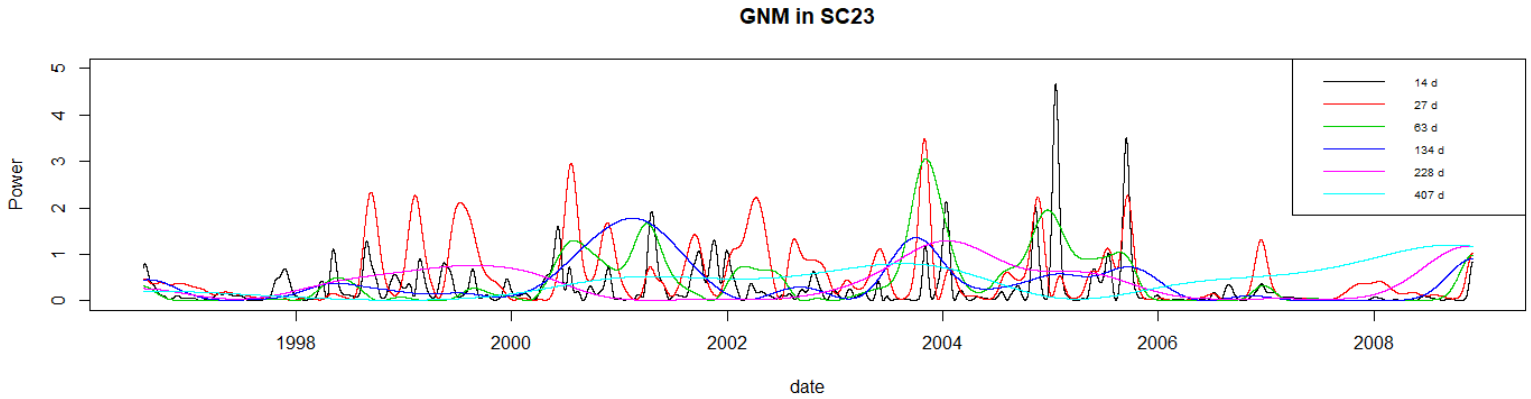
Wavelet Power Spectrum of Global Neutron Monitor

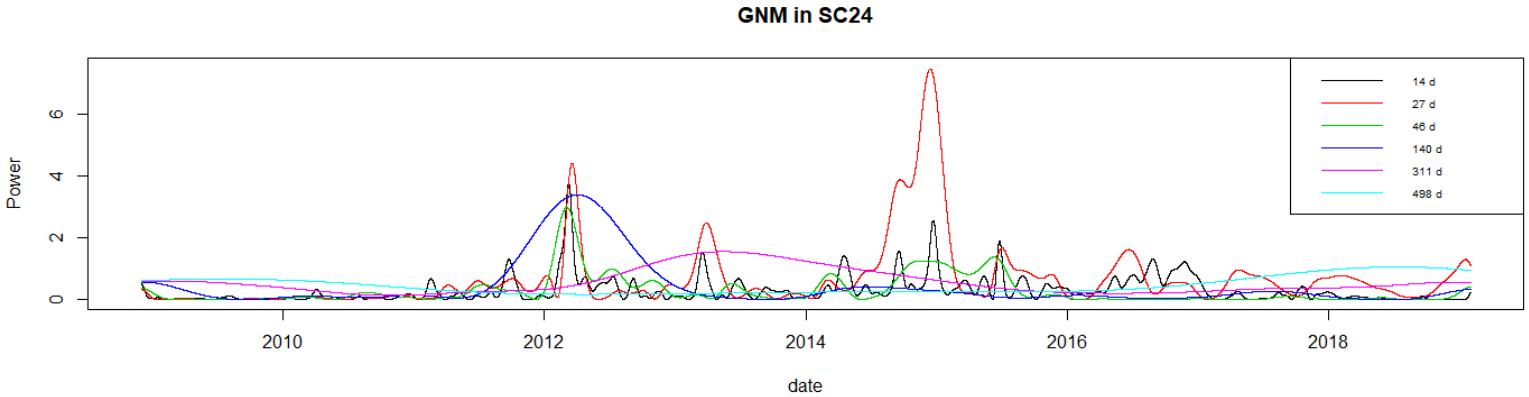



GNM in SC20
Power
0
1
2
3
4
1966
1968
1970
1972
1974
1976
date
14 d
27 d
82 d
188 d
385 d


GNM in SC21
Power
0
2
4
6
1976
1978
1980
1982
1984
1986
date
14 d
27 d
79 d
153 d
302 d


GNM in SC22
Power
0
1
2
3
4
1988
1990
1992
1994
1996
date
14 d
27 d
79 d
214 d
481 d


GNM in SC23
Power
0
1
2
3
4
5
1998
2000
2002
2004
2006
2008
date
14 d
27 d
63 d
134 d
228 d
407 d


GNM in SC24
Power
0
2
4
6
2010
2012
2014
2016
2018
date
14 d
27 d
46 d
140 d
311 d
498 d

- Current models place the solar dynamo in the tachocline, a transition zone between the convective region and the radiative zone. Magnetohydrodynamic "Shallow Water" model predicts the presence of waves in the tachocline.
- Rossby waves are a consequence of the conservation law of angular momentum and their velocity is proportional to the rotational velocity of the system.
- The angular frequency of fast Rossby waves according to blueZaqarashvili, T. V., Oliver, R., Ballester, J. L. 2009, is given by

$$\omega = -\frac{2\Omega_0 s}{n(n+1)}, \tag{1}$$

where Ω_0 is the system rotational velocity, n and s are integer numbers defined as toroidal and poloidal wave number respectively ($n = 1, 2, 3, ...$ and $s = 0, 1, 2, ..., n$).

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Comparison between Rossby waves and detected periodicities

Considering $\Omega_0 = 2.65 \cdot 10^{-6} s^{-1}$, $s = 1$ and $n = 1, 2, 3, 4, 5$, a set of waves with 27-, 82-, 165-, 274- and 412–day period are obtained.

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- Global Neutron Monitor (GNM), has been calculated by averaging the counting rates in typified units of the different selected NMs in each SC.
- Detected Periodicities in GNM counting rates : Solar synodic rotation ($\approx$ 27 days), 13.5 days, Rieger period (134-189 days), a periods in 46-82 days and 214-302 days, and nearly annual period.
- A temporal evolution of the periodicities has been studied. It is suggested that the same phenomenon produces the periodicities since their most significant peaks coincide over time. This physical phenomenon could be a modulation effect related to solar rotation.

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- We suggest the magnetic Rossby waves produce these periodicities in solar activity, which have also been observed in neutron monitor counting rates.
- The Rossby waves model does not consider differential rotation. It would be interesting to extend the model by adding differential rotation in future studies. This new model would increase the accuracy of the periodicities and also decrease the associated error in the periodicities.

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"That's all Folks!"