Statistical analysis of Sunspot Area and their Heliospheric Effect for the Period 1986-2016

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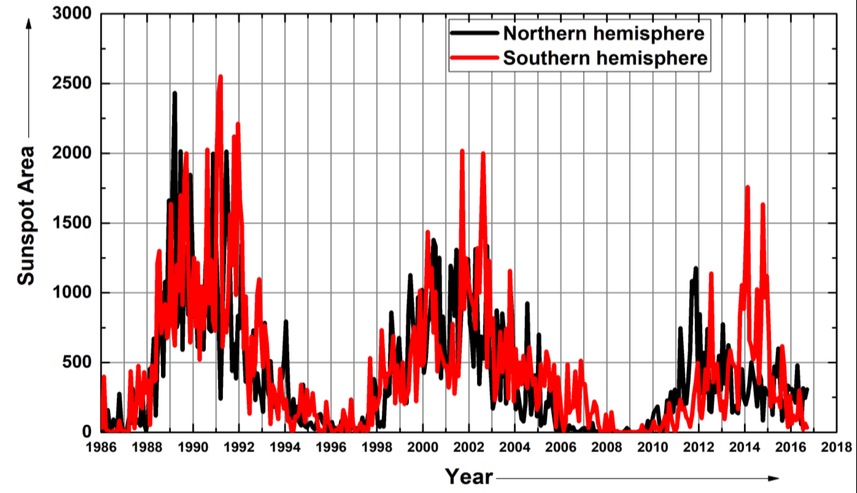
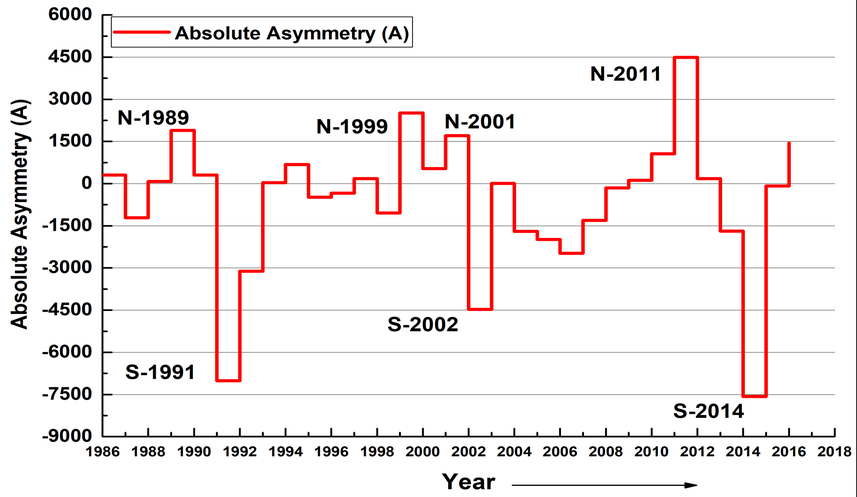
Aim:

The objective of the present study is to examine the asymmetry nature of the sunspot area during solar cycles 22 to 24 (period 1986-2016). The statistical significance of the absolute asymmetry value (A) of sunspot area indicates a real features of the northern and southern hemispheric distribution of the Sun. Periodicity for absolute asymmetry (A) of sunspot area is carried out for quasi-biennial (QBO) period is ~1.94 with high amplitude during 2001 and Rieger-type periods (~124 to ~175 days) have been investigated using Morlet Wavelet Techniques (MWT). We have observed that the galactic cosmic rays recoveries are much faster than the solar parameter (sunspot area) with negative time lag during the descending phase of solar cycles 22 and 24.

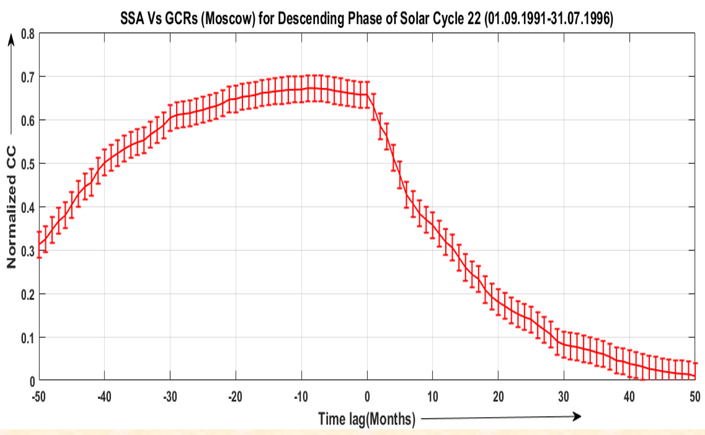
1. N-S Hemisphere of Sunspot Area

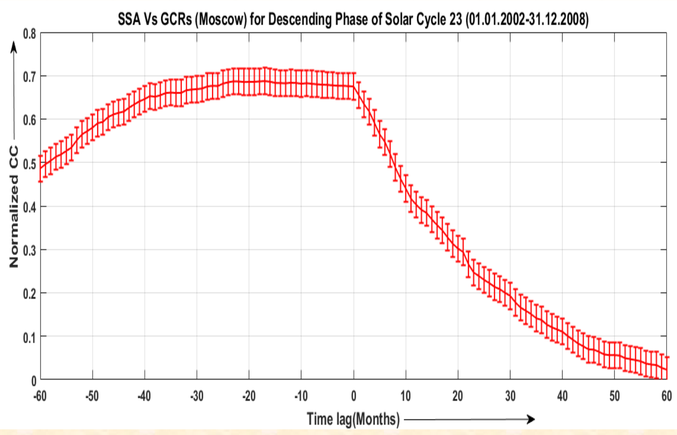


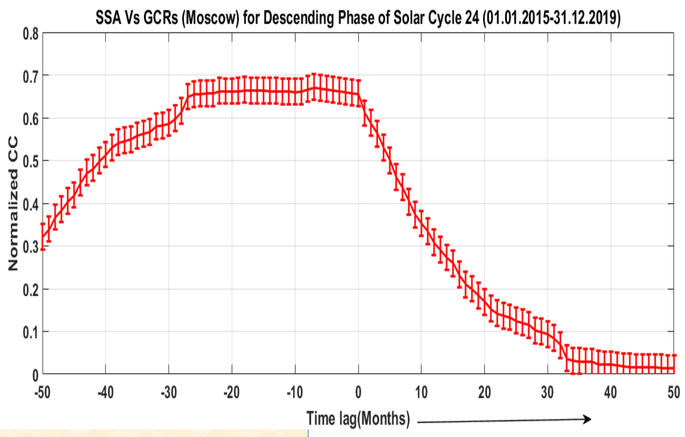


- The northern hemisphere is dominated at very beginning of cycle while southern hemisphere dominates in decline phase of the cycle.
- The value of absolute asymmetry (A) of sunspot area is highly significant for the northern hemisphere in period of 1989,1999 and 2011, and southern hemisphere is 1991, 2002 and 2014 .

2. Heliospheric Effect on Sunspot Area

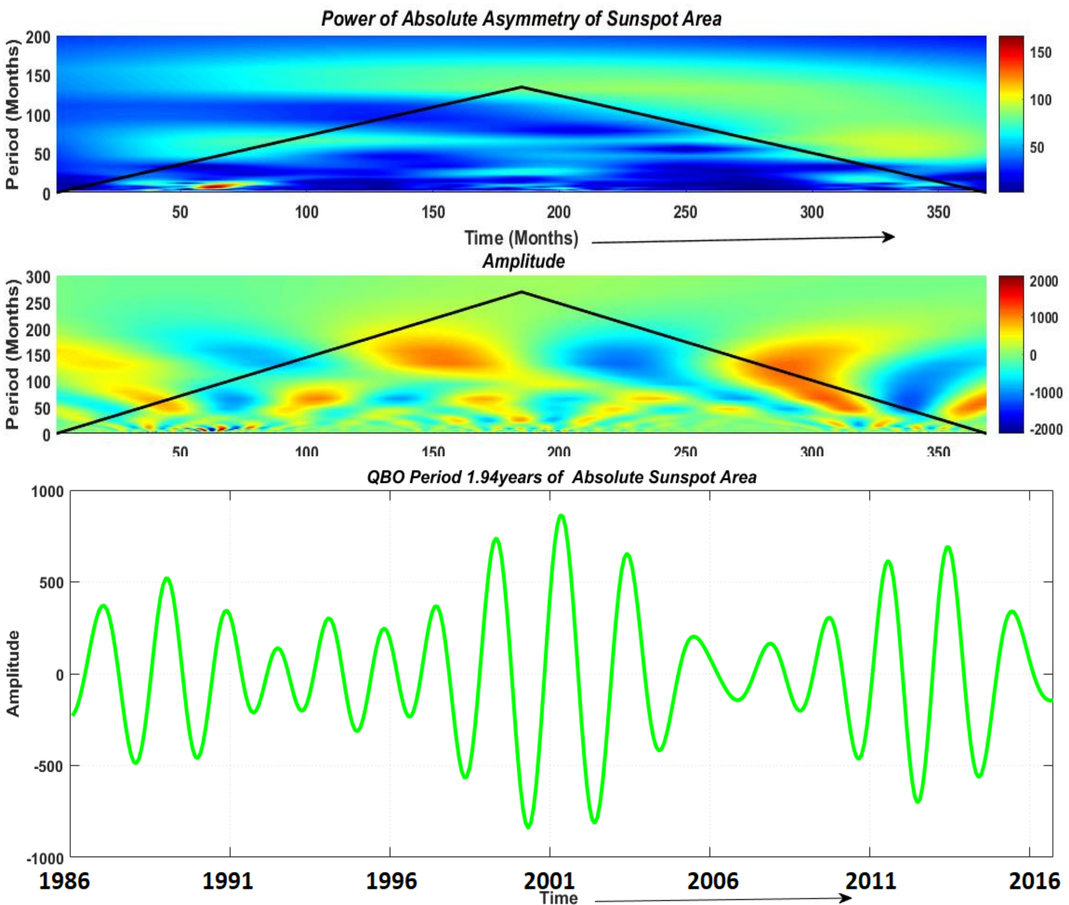






- Heliospheric behaviour of sunspot area shows a highest time lag between GCRs (Moscow NM station) during the descending phase of solar cycles 23 with 12 months and maximum cross-correlation ~0.68.
- But during cycles 22 and 24 are similar time lag ~4 months with cross-correlation of ~0.65.

3. Periodicity for Absolute Asymmetry of Sunspot Area



- The intermediate-term ~247 days of absolute asymmetry is constitute the 9th subharmonic of solar synodic rotation of ~27days.
- Significant period of quasi-biennial varies 1.16 -3.89 years
- QBO period especially variation of ~1.94 years, is assumed as one of the fundamental variations of solar activities
- It is probably intrinsic properties of the Sun and connected to the dynamo mechanism.
- Amplitude profile of yellow colour is representing the mid-term periodicity of absolute asymmetry of sunspot area

4. Summary and Conclusions

- The amplitude of the sunspot area shows a shift of solar activity from northern to southern hemisphere for the period 1990, 2001, and 2012.
- The two hemispheres are asymmetrical between the years 1989 to 1991, 1999 to 2002, and 2011 to 2014 with a high diffusivity forced (magnetic field) present in that year.
- The recovery rate of the GCRs' during the descending phase of solar cycles 22 and 24 is much faster than the solar cycles 23.
- The absolute asymmetry (A) of sunspot area shows a phase shift ~2.5 years between northern and southern hemisphere during the study period.
- The significant period ~1.38 years of absolute asymmetry of sunspot area is the rotational rate at the base of solar convection zone.
- The period ~0.97 years (~350days) of absolute asymmetry of sunspot area is prominent during the study period.
- QBO periods are evidence of a strong asymmetry in both sides of the solar equator with period 1.94years

5. References

[1] Carbonell, M., Oliver, R., Ballester, J. L. 1993, A&A, 274, 497.
[2] Chowdhury, P., Choudhary, D.P., Gosain, S., 2013, ApJ, 768, 188.
[3] Chowdhury, P., Kudela K., 2018, Astrophys Space Sci, 363:250.
[4] Singh, P. R., Tiwari, C. M., Saxena, A. K., Agrawal, S. L., Mishra, A. P., 2019a. Ap.Sp Sci, 364(4), 59.
[5] Singh, P. R.,Tiwari, C.M., Agrawal, S.L., Pant Tarun Kumar, 2019b, Sol. Phys., 294, 218