Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
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Distribution of hemispheric solar activity during various phases of solar cycles

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Abstract. Hemispheric asymmetry is one of the significant parameters related to the action of solar dynamo. Comparison of hemispheric activities during various phases are found out for solar cycles 12 to 23. Asymmetry of solar activity shows extremum values during the cycles 14 and 19. Lowest and highest levels of north-south asymmetry are mainly observed during minimum and maximum phases respectively of solar cycles. A change of phase is found to be existing between the asymmetries at solar maxima and the whole cycle, after solar cycle 15 and 18. Also, for cycles 17-19, the behaviour of the asymmetry is observed to be peculiar and different from that of the other cycles. Periodic behaviour of north-south asymmetry mainly occurs in 8.8 years and noticed very high during the cycles 18-22.

Keywords. Solar cycle, solar activity, sunspot area, etc.

1. Introduction

Sunspots are active regions on the surface of the Sun having strong magnetic fields. If majority of solar activity arises from one of the hemispheres about the equator, then it is referred as North-South (N–S) asymmetry in solar activity. Significant N–S asymmetries are found in many of the solar activity features. So it is important to analyse the behaviour of solar activity separately for the two hemispheres. In the present study, N–S asymmetry in solar activity during solar cycles (SC) 12-23 is analysed using northern and southern hemispheric sunspot area (NSA and SSA) and the periodic variations are estimated using wavelet analysis.

2. Data and methods of analysis

Daily NSA and SSA are taken from https://solarscience.msfc.nasa.gov/greenwch.shtml.

$$N\text{–}S\ asymmetry = |NSA - SSA| \tag{2.1}$$

Wavelet analysis is an alternative method with multi-resolution characteristic compared to Fourier transform. Continuous Wavelet Transform (CWT) is calculated by convolution between signal and analysis function. If ψ is the mother wavelet, CWT of a real signal $x(t)$ is defined as

$$X_{WT}(b,a) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} \grave{\psi} \left[\frac{(t-b)}{a} \right] x(t) dt \tag{2.2}$$

where $\grave{\psi}$ denotes complex conjugate of ψ. Parameters a and b corresponds to the time shift and scale of analyzing wavelet.

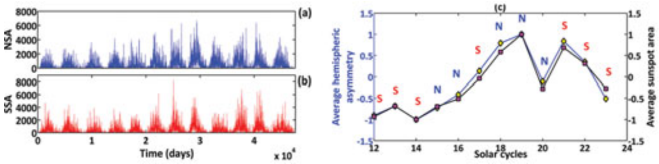

Figure 1. During *SC* 12-23 (a) *NSA* (b) *SSA* (c) Comparison of evolution of average hemispheric asymmetry and average sunspot area (*SA*).

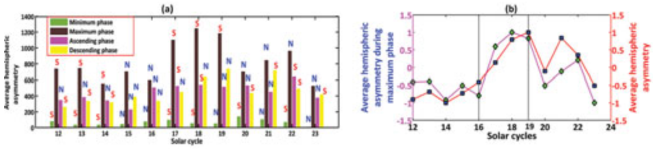

Figure 2. Comparison of *N–S* asymmetry in *SC* 12-23 (a) During various phases (b) Maximum phase and the whole solar cycles.

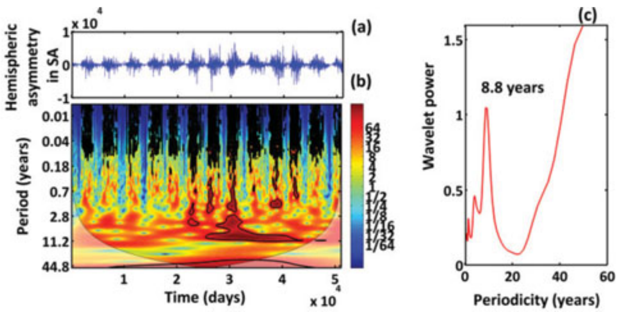

Figure 3. *N–S* asymmetry in *SA* (a) Time series (b) *CWT* (c) Global Wavelet Power Spectrum (*GWPS)*-Temporal variation of average wavelet power of individual periodicities.

3. Results and discussion

Fig. 1(c) shows that sunspot activity of *SC* 15-16 and 18-20 shows northern hemisphere domination (Swinson *et al.* 1986). And the temporal evolution of *N–S* asymmetry and strength of solar cycle varies in a similar way. Comparison of *N–S* asymmetry during various phases of *SC* (12-23) are shown in Fig. 2(a). *N–S* asymmetry in solar activity is highest during solar cycle 19 and lowest during solar cycle 14 (Temmer *et al.* 2006). Highest and lowest *N–S* asymmetries are found during maximum and minimum phases of *SC* respectively. During the *SC* 17, 18 and 19, *N–S* asymmetry during maximum phase is very high compared to all other phases of solar cycle. Fig. 2(b) shows a change of phase existing between the asymmetries at solar maxima and the whole cycle, after solar cycle 15 and 18. Periodicities in the *N–S* asymmetry of solar activity is found out using wavelet analysis. In Fig. 3(b), a contour of high wavelet power is obtained in between 2.8 and 11.2 years periodicities. And the time interval in which the high wavelet contour exists coincide with the interval of years corresponding to *SC* 18-22. Major periodicity associated with this contour is obtained from Global Wavelet Power Spectrum (GWPS) as 8.8 years, shown in Fig. 3(c).

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