Long-Term Datasets for the Understanding of Solar and Stellar Magnetic Cycles
Proceedings IAU Symposium No. 340, 2018
D. Banerjee, J. Jiang, K. Kusano & S. Solanki, eds.

doi:10.1017/S174392131800131X

Long-term variations in meridional motion of sunspot groups: comparison of DPD and SOON data

J. Javaraiah†

#58, BSK 5th Stage, Bikasipura, Bengaluru-560 078, India.
email: jajj55@yahoo.co.in; jdotjavaraiah@gmail.com

Abstract. We have analyzed the Debrecen Photoheliographic Data (DPD) and the Solar Optical Observing Network (SOON) sunspot group data during the period 1977 – 2015 and find that during the maximum of solar cycle 23 there is a large difference in the mean meridional motion of sunspot groups determined from DPD and SOON data.

Keywords. Sun: activity, Sun: magnetic fields, (Sun:) sunspots

1. Introduction

The solar cycle behavior of the mean meridional motion of sunspots (a proxy of the meridional plasma flow) is not yet clearly known. Javaraiah (2010) analyzed the combined Greenwich and SOON sunspot group data during the period 1879 – 2008 and found that variation in the mean meridional motion of sunspot groups is considerably different during different solar cycles. During the maximum of solar cycle 23 the mean meridional motion was reasonably strong (about 10 m s^{-1}) and northbound direction in both northern and southern hemispheres. Since this behavior in the motion of the sunspot groups during cycle 23 was found quite different from that during any of the solar cycles 12 – 22, it was attributed to anomalous behavior of solar cycle 23, in the sense the cycle pair (22, 23) violated the well known Gnevyshev-Ohl rule of solar cycles (Gnevyshev & Ohl 1948). According to this rule an odd-numbered solar cycle is stronger than its preceding even-numbered cycle. Recently, the corrected and updated DPD are available (Győri, Baranyi, & Ludmány 2010). Here we have reexamined the consistency of the above result from a comparative study of the solar cycle variations in the mean meridional motion of sunspot groups by analyzing DPD and SOON sunspot group data during 1977 – 2015.

2. Data analysis and results

Here we have used both DPD (available at http://fenyi.solarobs.unideb.hu/pub/DPD/) and SOON (available at http://solarcience.msfc.nasa.gov/greenwich.shtml) sunspot group data during the period 1977 – 2015. Both these datasets contain, beside other parameters, the date and the time of observation (t), heliographic latitude (ϕ) and longitude, and central meridian distance (CMD) of a sunspot group for each day during its appearance on the solar disk. The meridional velocity v (in deg day^{-1}) is calculated as $v = \frac{\Delta\phi}{\Delta t}$, where $\Delta\phi = \phi_n - \phi_{(n-1)}$ and $\Delta t = t_n - t_{(n-1)}$ of nth and $(n-1)$th days' latitudes and times of observations (dates with fractional day) of a sunspot group (0.01° $day^{-1} \approx 1.3$ m s^{-1}). In order to reduce foreshortening effect, the data correspond to $|CMD| > 75^\circ$ are not used.

† Formerly with Indian Institute of Astrophysics, Bengaluru-560 034.

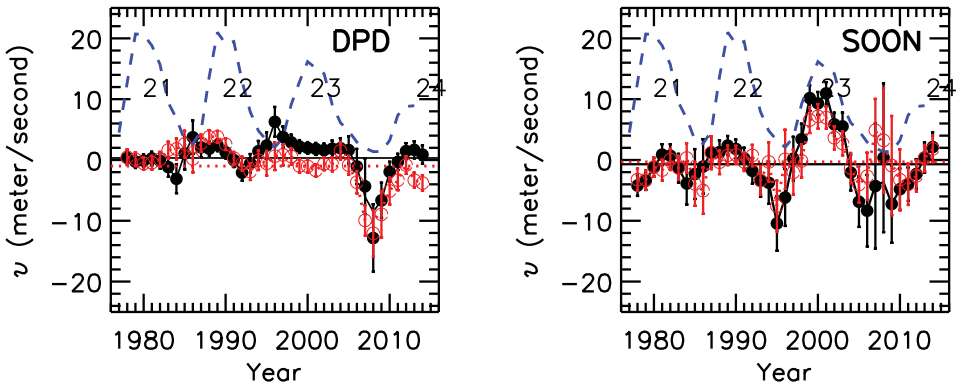

Figure 1. Plots of the mean meridional velocity of sunspot groups determined from the DPD and SOON sunspot group data in 3-year moving time intervals successively shifted by one-year 1977 – 1979, 1978 – 1980,...,2013 – 2015 versus the middle year. The *filled and open circles* represent the original data in the Sun's northern and southern hemispheres, respectively. The *continuous and dotted curves* represent the corresponding corrected data obtained by replacing the values having uncertainty $\geqslant 2.6\sigma$ with the mean of the value and its neighboring values. The *dashed curve* represents yearly variation of R_Z during 1977 – 2013. In both the hemispheres the positive and negative values of v indicate the northbound and southbound motions, respectively.

Fig. 1 shows the variations in the mean meridional motion of sunspot groups determined from DPD and SOON sunspot group data in 3-year moving time intervals successively shifted by one year during 1977 – 2015. In this figure the variation in the yearly mean international sunspot number (R_Z) is also shown for comparison sake. As can be seen in Fig. 1 the temporal behavior of the meridional velocity determined from DPD and SOON data largely similar during cycles 21, 22, and 24, whereas during cycle 23 it is highly different. That is, the values of the velocity determined from SOON data during the maximum of the solar cycle 23 indicate that the meridional motion was reasonably strong (8 – 10 m s^{-1}) and northbound direction in both the northern and southern hemispheres. However, the corresponding values determined from DPD data during the maximum of solar cycle 23 suggest a weak (insignificant) poleward motion in both the northern and southern hemispheres. During the recent minimum (between cycles 23 and 24) the meridional motion of sunspot groups is reasonably strong (about 10 m s^{-1}) and equaterward direction in both northern and southern hemispheres (this behavior can be seen clearly mainly in DPD data).

Acknowledgements

The author thanks IAU for kindly providing me a partial financial support to attend IAUS340.

References

Gnevyshev, M. N. & Ohl, A. I. 1948, *AZh*, 25, 18
Györi, L., Baranyi, T., & Ludmány, A. 2010, in *Proc. Intern. Astron. Union 6, Sympo. S273* , 2011, 403 DOI: 10.1017/s174392131101564X
Javaraiah, J. 2010, *A&A*, 509, A30