Solar and Astrophysical Dynamos and Magnetic Activity
Proceedings IAU Symposium No. 294, 2012
A.G. Kosovichev, E.M. de Gouveia Dal Pino, & Y. Yan, eds.

doi:10.1017/S1743921313002421

Large scale magnetic helicity fluxes estimated from MDI magnetic synoptic charts

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Abstract. To investigate the characteristics of large scale and long term evolution of magnetic helicity with solar cycles, we use the method of Local Correlation Tracking (LCT) to estimate the magnetic helicity evolution over the 23rd solar cycle from 1996 to 2009 by using 795 MDI magnetic synoptic charts. The main results are: the hemispheric helicity rule still holds in general, i.e. the large-scale negative (positive) magnetic helicity dominates the northern (southern) hemisphere. However, the large scale magnetic helicity fluxes show the same sign in both hemispheres around 2001 and 2005. The global, large scale magnetic helicity flux over the solar disk changes from negative value at the beginning of the 23rd solar cycle to positive value at the end of the cycle, which also shows the similar trend from the normalized magnetic flux by using the magnetic flux. The net accumulated magnetic helicity is negative in the period between 1996 and 2009.

Keywords. Sun: magnetic fields

1. Introduction

Hemispheric helicity rule with negative (positive) helicity in the northern (southern) hemisphere has been revealed by many observations. Injection of magnetic helicity from solar active regions has been statistically analyzed by some authors, e.g. LaBonte *et al.* (2007) and Georgoulis *et al.* (2009). However, the long term evolution of large scale magnetic helicity and the relationship with the statistical results of current helicity in solar active regions in solar cycles are still interesting questions. In this paper we follow the method of Local Correlation Tracking (LCT) (Chae 2001), and use MDI magnetic synoptic charts to investigate the possible large scale and long time magnetic helicity evolution over the 23rd solar cycle.

2. Calculation and Results

We have calculated the large scale magnetic helicity fluxes evolution over the 23rd solar cycle by 795 MDI magnetic synoptic charts. Fig.1(a,b) depicts the large scale magnetic helicity fluxes in northern and southern hemispheres between $-40°$ and $40°$ latitude over the 23rd solar cycle. Fig.1c shows the global large scale magnetic helicity fluxes evolution inferred from magnetic synoptic charts in the 23rd solar cycle from 1996 to 2009.

It is found that the global large scale magnetic helicity changes from the negative value in the beginning of 23rd solar cycle to the positive value in the end of solar cycle. The negative minimum appears in 2001 and the positive maximum appears in 2005. The net accumulated magnetic helicity is $-2.9 \times 10^{46}\mathrm{Mx}^2$. The hemispheric helicity rule still holds in general that negative (positive) magnetic helicity dominates solar northern

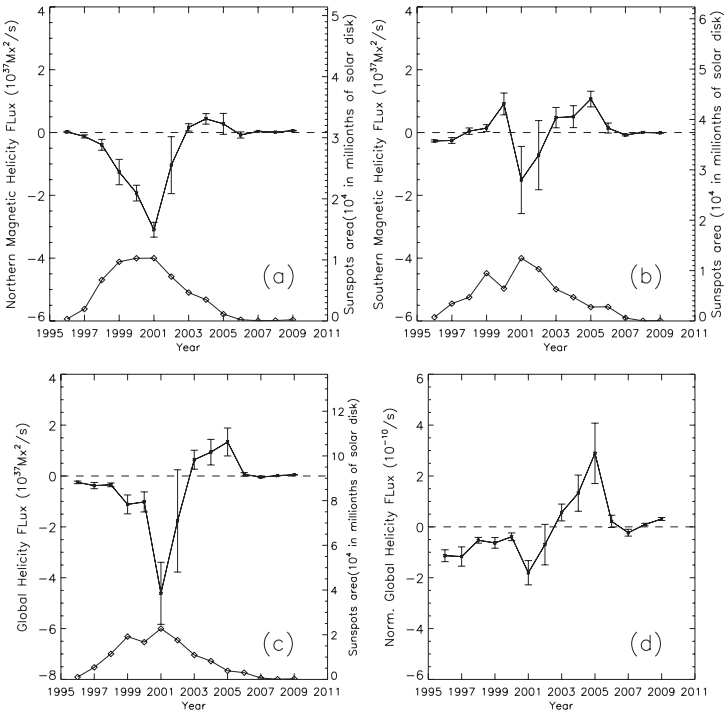

Figure 1. (a,b) Large scale magnetic helicity fluxes in the northern and southern hemisphere between $-40°$ and $40°$ latitude over the 23rd solar cycle. σ-error bars are shown by vertical lines. The diamond line indicates the total sunspots area of a year in millionths of solar disk over the 23rd solar cycle (readings in the right ordinate). (c) Large scale magnetic helicity fluxes in the northern and southern hemisphere between $-40°$ and $40°$ latitude over the 23rd solar cycle. σ-error bars are shown by vertical lines. The diamond line also indicates the total sunspots area of a year (d) Normalized magnetic helicity flux by the magnetic flux.

(southern) hemisphere. However, it is found some imbalance of magnetic helicity accumulation between the northern and southern hemispheres. $-3.1 \times 10^{46}\mathrm{Mx}^2$ magnetic helicity accumulated in northern hemisphere and just only $2.0 \times 10^{45}\mathrm{Mx}^2$ magnetic helicity in southern one. In our calculation, the global large scale magnetic helicity fluxes profile in the northern hemisphere shows a similar trend with the total flux from both hemispheres, while that in the southern hemisphere is different and there is an obvious positive peak in the beginning of solar cycle. Fig.5d shows the normalized magnetic helicity flux by the magnetic flux. It is also could be found that the normalized magnetic helicity flux still changes from negative value at the beginning of the 23rd solar cycle to positive value at the end of the cycle. The net normalized helicity is negative as well.

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Yang, Shangbin & Zhang, Hongqi 2012, ApJ, 758, 61

https://doi.org/10.1017/S1743921313002421 Published online by Cambridge University Press