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North-South asymmetry of the photospheric magnetic field

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Abstract. It was performed a study of the North-South asymmetry of the magnetic field distribution by comparison of the temporal behavior of long and short term variabilities of the photospheric field at the same latitudes in opposit hemispheres using WSO data sets covered the interval from 1976 to 2005.

Keywords. Sun: magnetic fields, photosphere, activity

The Wilcox Solar Observatory (WSO) data from http://wso.stanford.edu/synoptic.html were used to study the North-South asymmetry of the photospheric field over the cycles of the activity N 21, 22 and 23.

According to magnetic field observations made since the introduction of the Babcock magnetograph the polarities of the sub-polar zones are opposite; they change around the maxima of the activity cycles; before the reversion during odd (even) cycles the polarity in the northern sub-polar regions is positive (negative). The sunspot groups and active regions follow to Hale's low. The problem of the North-South asymmetry was studied by the direct comparison of the magnetic field at the latitudes θ and $-\theta$ in both the hemispheres. In the upper plot of Fig. 1 the solar magnetic field mean over 1 CR is shown again as a function of time and latitude.

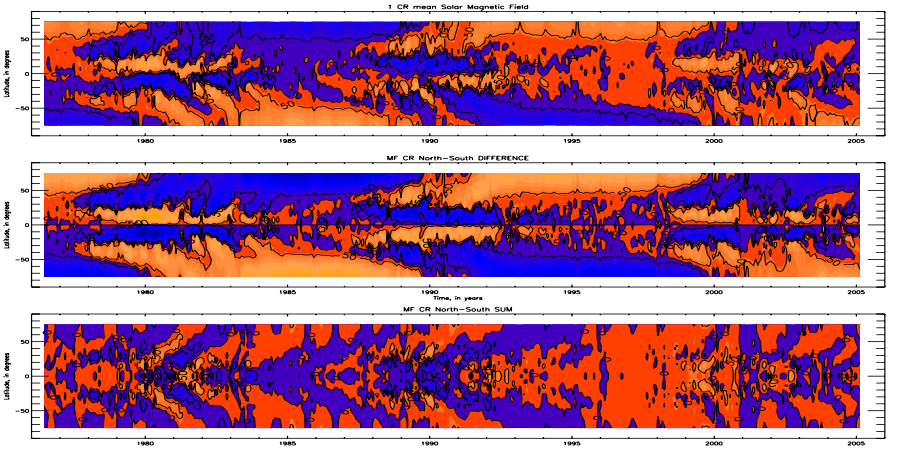

Figure 1. The mean solar magnetic field over 1 CR as a function of time and latitude (upper plot). The difference or antisymmetrical part of the SMF 1 CR running means is shown in the middle plot. The sum the North-South symmetrical part of the 1 CR means of the SMF is shown in the bottom plot. Yellow-red and blue (light and dark in black-and-white version) colors indicate positive and negative polarities. The contours correspond to zero level and to the ±50 micro Teslas.

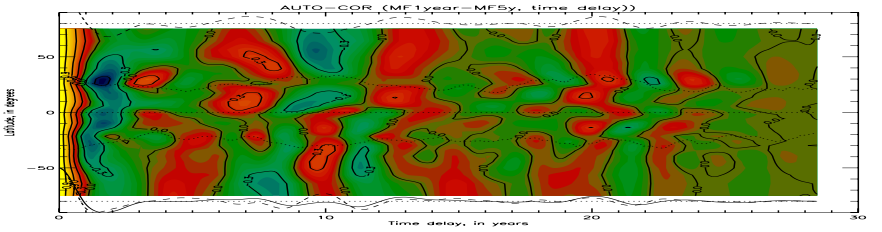

Figure 2. The coefficient of the auto-correlation of the filtered magnetic field FMF data sets as a function of time shift at each latitude.

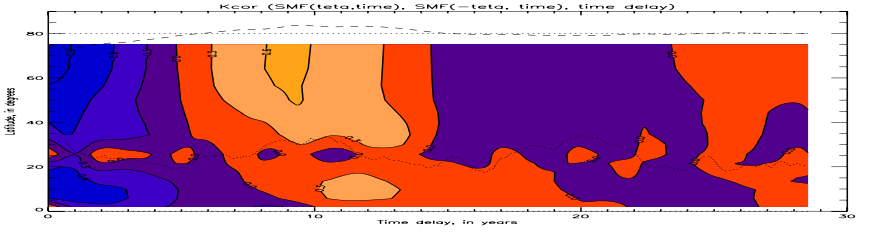

Figure 3. The coefficient of correlation of the yearly mean SMF at θ and $-\theta$ latitudes as a function of time shift and θ.

The antisymmetrical part is deduced for each θ as a difference between the SMF rotational means in the opposite hemispheres at each latitude (middle plot). Four zones are visible even better on this middle plot than on the upper plot, because the amplitudes of the antisymmetric parts of the SMF in both hemispheres are almost the same.

The symmetrical part is deduced summarizing the rotational means of the solar magnetic field in both hemispheres at the same latitudes (bottom plot). The bottom plot shows an interesting feature of the SMF topology: the presence of polarity streams moving from low to high latitudes. Such an interesting phenomenon can be investigated in all the details through several cycles and not only the symmetrical part of these streams. To study the phase relationship between them in both hemispheres it is necessary to use the residuals of the SMF using filters of short term (less than 1 year) and long term (more than 5 years) variabilities (Filtered Magnetic Field – FMF).

In Fig. 2 is shown the periodicity of the drifting latitudinal structure was studied by calculation of the auto-correlation of the FMF data sets as a function of time shift at each latitude. A short-term periodicities are clearly visible (red or light color corresponds to positive correlation). They are different: period of the short term variability in the Southern hemisphere is 25% shorter than in the Northern hemisphere. Due to this they are in fase each 11 years. The mean correlations over all latitudes in each hemisphere are shown at the ± 80 degrees levels (multiplied by factor 30).

The coefficient of correlation between northern and southern yearly mean SMF as a function of time delay at different latitudes is shown in Fig. 3. Strong anti-correlation at zero delay (less than -0.9) is presented over almost all latitudes in 4 zones (except around the zonal boundaries). A quasi 9–11-year periodicity is presented in the North-South SMF correlation. The correlation is the lowest one on the zone boundaries of the $4Z$ – structure. The effective delay between the SMF in the near-equatorial zones equals 11.5 year while in high-latitude zones equals about 9 years. Strong quasi 20-year periodicity of the North-South SMF correlation covers all shorter variations discussed above.

This work was possible thanks to the WSO observations of the SMF.

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