COMPARISON OF SOHO AND DEBRECEN PHOTOHELIOGRAPHIC DATA SUNSPOT AREAS FOR THE YEARS 1996 AND 1997

L. Győri[1] **and T. Baranyi**[2]

[1]*Debrecen Heliophysical Observatory, Gyula Observing Station, 5701 Gyula, P.O. Box 93, Hungary*
[2]*Debrecen Heliophysical Observatory,4010 Debrecen, P.O. Box 30, Hungary*

ABSTRACT

Abstract. An important attribute of the sunspots is their areas. For example, sunspot area data are used in the investigation of the evolution of sunspots and in study of their impact on solar irradiance. For a long time, these data have been derived from ground-based observations. But for 10 years, these areas can be determined from space-borne observations of SOHO, too. Based on SOHO observations, we compile a sunspot catalogue the SOHO Debrecen Data (SDD) at Debrecen Observatory. In this presentation, we compare SDD with the ground-based DPD (Debrecen Photoheliographic Data) areas for the years 1996 and 1997. Moreover, as among the SOHO images there are solar magnetic flux images too, we investigate how the magnetic flux (averaged separately over the penumbra and the umbra) of the sunspots depends on the penumbra and umbra areas, respectively.

Key words: sunspots; sunspot area; sunspot magnetic field.

1. INTRODUCTION

Sunspots are important manifestations of solar activity. Because of their importance, they have long been observed and measured on white-light full-disk solar images in several ground based observatories. Starting in 1996, space observations by the Michelson Doppler Imager (MDI) on SOHO (Scherrer et al., 1995) have also become available.

The two parameters that decisively characterize a sunspot are its area and its magnetic field. So their determination, as accurately as it is possible, is of high importance. These data are used in various fields of the solar physics: emergence, growth, and decay of spots; evolution of the sunspot groups and interaction between them; axial tilt and rotation rate of the groups; periodicity in solar activity; fragmentation of flux tubes; solar irradiance variations.

2. OBSERVATIONS AND DATA

One of the aim of this paper is to compare the sunspot areas derived from two full-disk image series. One of them is the SOHO/MDI images (1024x1024 pixel) obtained as proxies for the continuum intensity near the Ni-I absorption line at 676.8 nm by combining the standard five filtergrams (Scherrer at al. 1995). The other image set contains daily ground-based photoheliograms taken to film or glass plates gathered from several observatories (Gyula, Debrecen, Kanzelhoehe, Kislovodsk, etc.), which are used in the compilation of the Debrecen Photoheliographic Data (DPD) catalogue (Győri et al. 2004).

From these two image series we derived two sunspot databases with the same automated sunspot recognition techniques (Győri, 1998). One of them is the DPD catalogue which has 1 observation/day time resolution. Recently a similar sunspot catalogue compilation has been started by using the SOHO/MDI continuum (Ic) images. It is called SOHO/MDI- Debrecen Data (SDD) catalogue (Győri et al. 2005a). We use the Full Disk Continuum images from the hourly data sets level 1.8. This catalogue is similar to that of DPD in its data format and image products but the time cadence is 1 hour when SOHO/MDI observations allow it. Two years (1996, 1997) of SDD are ready and we use them to compare their sunspot areas with that of DPD.

3. AREAS: DPD - SDD

Figure 1 depicts the total area of sunspots on the whole disk obtained from the DPD and the SDD catalogues. As we can see, the SDD areas are 17 % larger than the DPD ones. In a previous paper (Győri et al. 2005b) we have already compared DPD and SDD areas for the year 1996. Then we have got that the SDD areas are 14 %larger than the DPD ones.

But the number SDD data for 1996 is small because it was solar minimum at that time and the usefull SOHO observations only began in May of 1996. We attribute this small difference (4 %) to the small number of SDD data for year 1996.

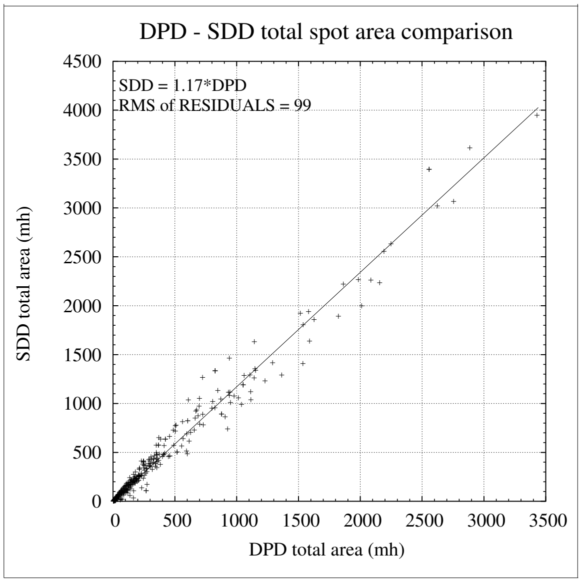

Figure 1: SDD sunspot (umbra + penumbra) area (in millionths of the solar hemisphere) summed up on the whole disc vs DPD area. .

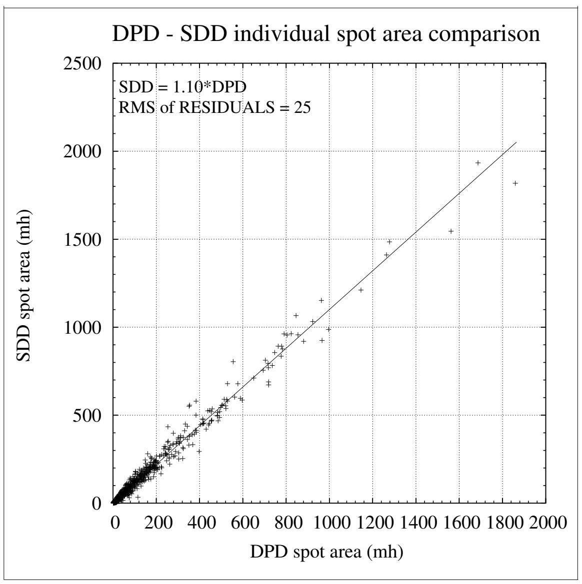

Figure 2: SDD individual (identified with DPD) sunspot (umbra + penumbra) area (in millionths of the solar hemisphere) vs DPD area.

Figure 2 shows the comparison of individual sunspot areas obtained from the DPD and the SDD catalogues. Here, before the comparison, we indentified DPD and SDD sunspots and used only the indentified sunspots in this comparison. In this case also, as we can see in Figure 2,the SDD areas are 17 %larger than the DPD ones.

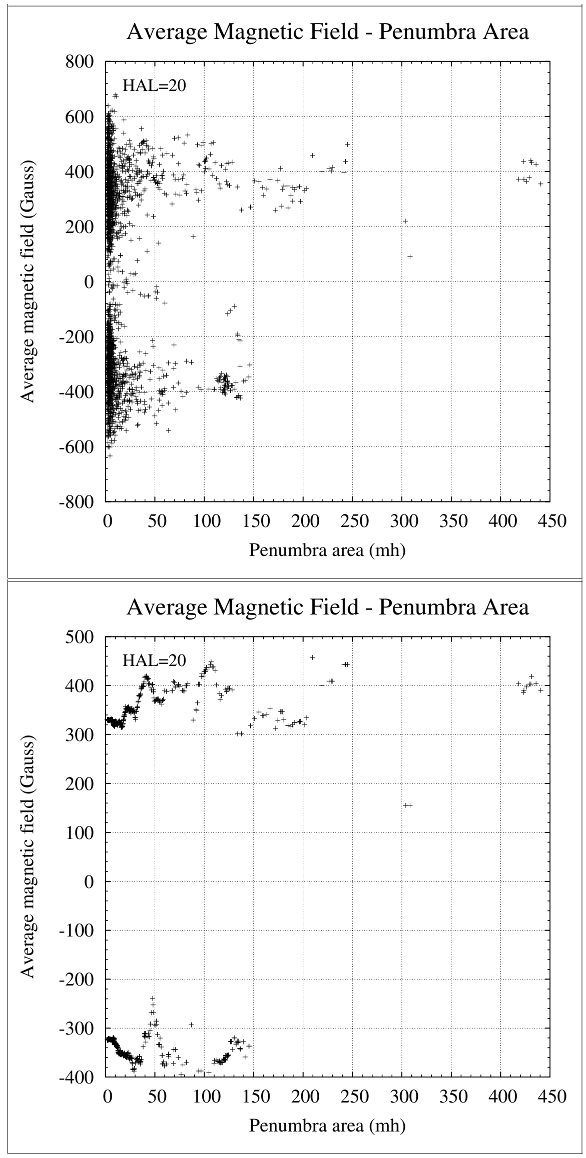

Figure 3: Top: LOS magnetic field averaged over the penumbra vs penumbra area measured in millionth of the solar hemisphere (mh). To decrease the effect of the foreshortening only sunspots within the 20 heliocentric angle limit are used here, and the line-of-sight magnetic field is divided by the cosine of the heliocentric angle of the sunspot. Bottom: same as the top image but the data are smoothed by averaging over a running window centered at the data points, with width of 10 mh, to see the trend clearer. .

4. AVERAGE MAGNETIC FIELD - SUNSPOT AREA

When determining the magnetic field in the sunspots, we used from the 5 min integrated and from the 1 min MDI magnetograms the nearest one for the white light images that were chosen for the SDD. As the solar differential rotation changes the heliographic position of the solar surface points, so the magnetograms were differential rotated to the observation time of the MDI intensity images.

Figure 3 shows the line-of-sight (LOS) magnetic field averaged over the penumbra plotted against the penumbra area. Similarly, Figure 4 shows the LOS magnetic field averaged over the umbra plotted against the umbra area. The LOS component of the magnetic field depends not only the magnetic field structure of the sunspot itself but also on the geometry of the observation of the sunspot. So as to decrease this effect, only sunspots within the 20 heliocentric angle limit (HAL) are used here. We tried to decrease further this effect by dividing the line-of-sight magnetic field by the cosine of the heliocentric angle of the sunspot.

5. CONCLUSIONS

Comparing SDD and DPD sunspot areas, we have found that the MDI quasi-continuum images gives about 17% larger MDI spot areas than DPD areas. The larger MDI spot areas can be attributed to the smaller scale of MDI image as it was pointed out by Győri et al. (2004)

As can be observed in Figure 3, the average penunbral LOS megnetic field does not show any significant dependency on the penumbral area. Its value is about 480 Gauss. But the scatter is large, especially at smaller penumra areas. Larger penumbrae can harbour magnetic field with different polarity. This (due to the averaging over the whole penumbra) decreases the average magnetic field of the penumbra. So we plan to handle the different polarity domains of the penumbra separately in the SDD catalogue.

The umbral fields are below the expectation. For example, Solanki & Schmidt (1993) find that the field strength over the whole umbra of several large symmetric sunspots is approximately 2250 G. But, in our case, the average magnetic field for umbra with larger area is only about 1400 G as it can be seen in Figure 4. At smaller areas the average umbral magnetic field increases with the area, this may show that the role of the stray light in measurement of the magnetic field of the sunspot can not be ruled out.

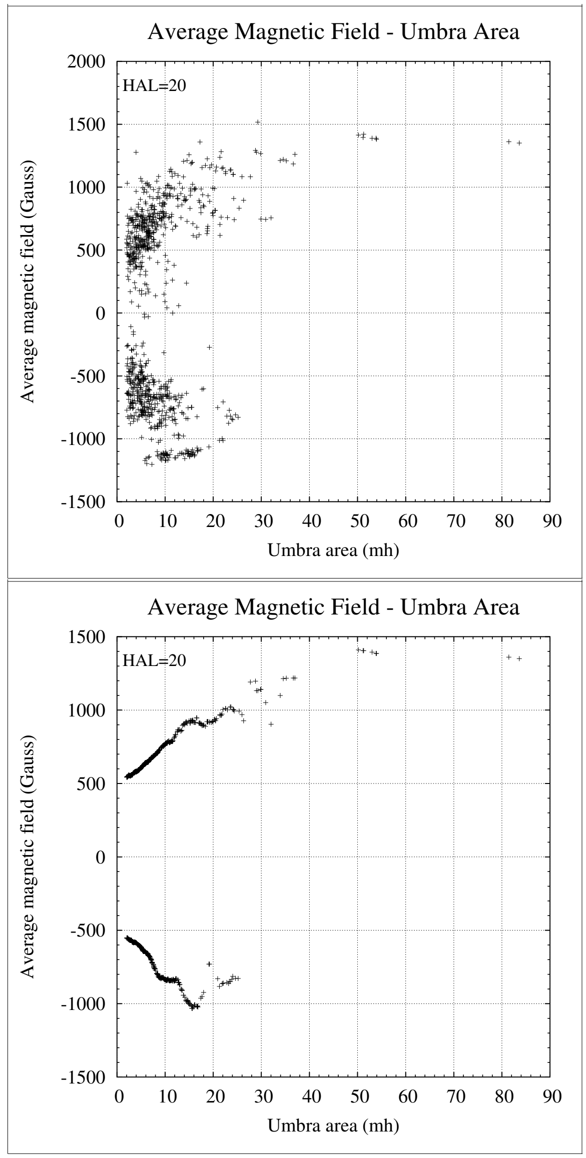

Figure 4: Top: LOS magnetic field averaged over the umbra vs umbra area measured in millionth of the solar hemisphere (mh). To decrease the effect of the foreshortening only sunspots within the 20 heliocentric angle limit are used here, and the line-of-sight magnetic field is divided by the cosine of the heliocentric angle of the sunspot. Bottom: same as the top image but the data are smoothed by averaging over a running window centered at the data points, with width of 4 mh, to see the trend clearer. .

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