PUBLICATIONS OF DEBRECEN HELIOPHYSICAL OBSERVATORY
Heliographic Series No.1
Appendix 1

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A COMPARISON BETWEEN GREENWICH AND DEBRECEN MEASUREMENTS OF SUNSPOT POSITIONS

1. INTRODUCTION

As a possibility was given for us to examine some original Greenwich heliograms, an opportunity has also been offered to check whether the "Photoheliographic Results" of Debrecen can be regarded in respect of sunspot positions as a homogeneous continuation of those of the Greenwich. Therefore some comparisons were made between Greenwich and Debrecen measurement data. Thus spot positions on original Greenwich and Debrecen plates were remeasured using our method in Debrecen. The outcome of this test is indicated here through some examples and, in addition, our present-day accuracy in position measurements is illustrated, too.

2. MEASUREMENTS ON GREENWICH AND DEBRECEN PLATES

The Royal Greenwich Observatory loaned us 39 original heliograms which were used for its Photoheliographic Results. The selected 27 and 12 daily photographs of the solar image (of 19 cm diameter) have been choosen from such a day on which we also had our own observations and were taken in the periods of January - July 1968 and July - November 1971, respectively. In this material of observation one third of the sunspot groups (91) are groups of a single spot and in addition 5 principal spots of a group were also a separated single spot. At the same time, each one of the spots consisted of not more than a single umbra. Thus, in the 39 plates a total of 96 single spots were available for our purpose of comparison. More than two-thirds of the plates contained two or more such a single spots.

I. First the positions of all 96 single spots were measured by three persons with the method used in Debrecen and the three sets of heliographic coordinates determined have been utilized to make a comparison. The measurements were carried out by the author and two of her colleagues, Lidia Gesztelyi and I.Nagy. The deviations of Gesztelyi's data from that of the author are shown in Figure 1. It is to be seen that the measurements are in good agreement and obviously the scatter of the data are slightly larger only in longitude near the solar limb. A similar comparison using Nagy's measurements have almost the same result. Therefore, in the following, the author's measurements are used exclusively.

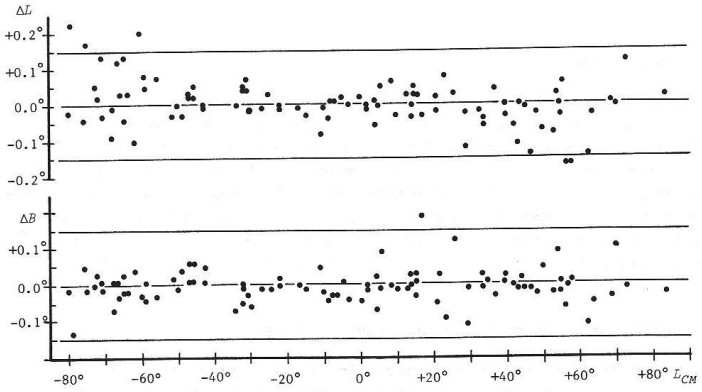

Fig.1 The differences in heliographic longitudes (ΔL) and latitudes (ΔB) of single spots between two sets of independent measurements on Greenwich plates. The differences are plotted according to longitude from central meridian (L_{CM}). (Cf. also Table 1.)

II. The deviations of the author's measurements of Greenwich plates from the published Greenwich measurements are plotted in Figures 2 and 3. (It should be mentioned that the Greenwich data are given to one decimal place, while that of the Debrecen to two decimal places.) The author's data are exactly the same as the ones used in Figure 1. Only in ten cases

are the deviations in one of the coordinates larger than |0.30|°. These ten pairs of deviation are marked with arrows (↑ or ↓) and among them those of >|0.30|° are only indicated on the lines of |0.30|°. Out of the ten spots three were tiny, indistinct and very faint, while the other seven were large asymmetric spots (of U > 20; as seen in Fig.3). Since the results of the three Debrecen measurers agreed with one another, it became quite clear that the few larger discordances arose from the fact that in Debrecen we measured the position of the umbra, while the Greenwich position relates to the centre of gravity of the whole spot. This view is supported by the following: among the used 96 spots, eleven other were found that also revealed some slighter asymmetry and therefore their positions relating to the centres of gravity of the whole spots were determined, too. Indeed there were differences between the two kinds of positions, however, they were not larger than ±0.1°. (Of course in Figure 2 the umbra positions are given as anywhere else, too.)

Table 1

The rough probable discordance in heliographic coordinates between different sets of measurements of sunspot positions

Sets		Coordinate differences and their frequency distribution in percentages								σ	Number of spots available
		±0.1°	-0.3°	-0.2°	-0.1°	0.0°	+0.1°	+0.2°	+0.3°	[°]	
I.	ΔB	99	0	0	13	76	10	1	0	0.05	96
	ΔL	95	0	2	13	67	15	3	0	0.07	
II.	ΔB	92	1	1	26	38	28	5	1	0.09	86
	ΔL	81	2	5	21	38	22	11	1	0.11	
III.	ΔB	74	4	12	22	30	22	9	1	0.13	85
	ΔL	72	2	12	22	28	22	10	4	0.13	

Measurements carried out { I. by two persons (cf.Fig.1); II. in Greenwich and Debrecen on Greenwich plates (cf.Fig.2); III. on Greenwich and Debrecen plates in Debrecen }

(σ : the standard deviation of the distribution)

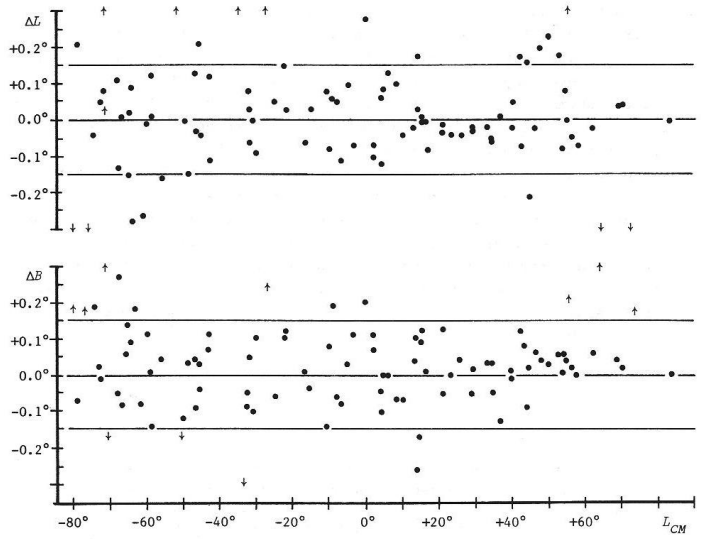

Fig.2 The heliographic coordinate differences between Greenwich and Debrecen measurements of single spots measured on Greenwich plates.
(The data are plotted as in Fig.1, concerning the arrows see the text. Cf. also Table 1.)

III. For comparison between Debrecen measurements on Greenwich and Debrecen heliograms the same 96 single spots were used as in the foregoing. The dispersion of the deviations are fairly similar to the ones shown in Figure 2; however, the scatter is a little larger. This stands to reason as the Greenwich and Debrecen observations on the same day were mostly taken with a great time difference, less than 20% occurred within one hour and even in 10% the time difference was more than 4 hours. Consequently, the general intrinsic proper motion of the spots could also have an effect on this comparison, notwithstanding that in nine cases we learned from additional Debrecen heliograms which one of the spots had indeed a considerable motion.

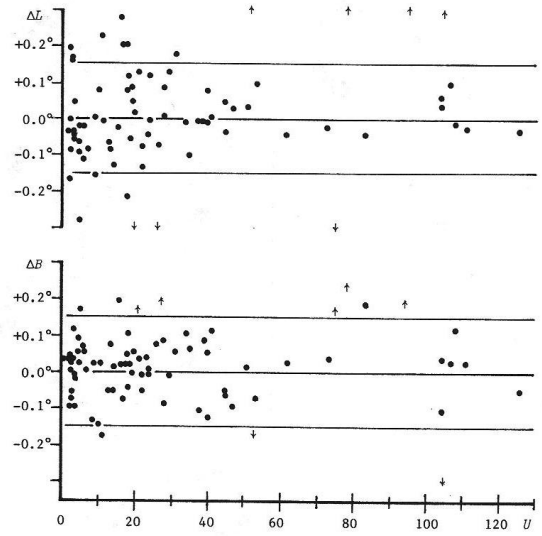

Fig.3 The heliographic coordiante differences ΔL and ΔB *versus* umbra areas of the U ≥ 2 single spots given in Figure 2.
(The U areas in 10^{-6} of the visible solar hemisphere.)

The main results of the comparisons (I-III) are summarized in Table 1. Disregarded here are those ten spots in statistical sample II which most probably could not be measured unambiguously and in sample III those two ephemeral one-day spots that were not visible on Debrecen plates, as well as the nine spots of rapid motion (out of them, four are the same which were also disregarded in sample II).

In spite of the fact that from a statistical point of view the distributions in Table 1 are only on the basis of a limited number of data, one thing is certain: there can not be any real objections relating to the accuracy of the Debrecen spot positions as compared to those of Greenwich. On the other hand, notwithstanding that the measurements are slight in number, it should be emphasized that the data sets tested are "true" statistical samples.

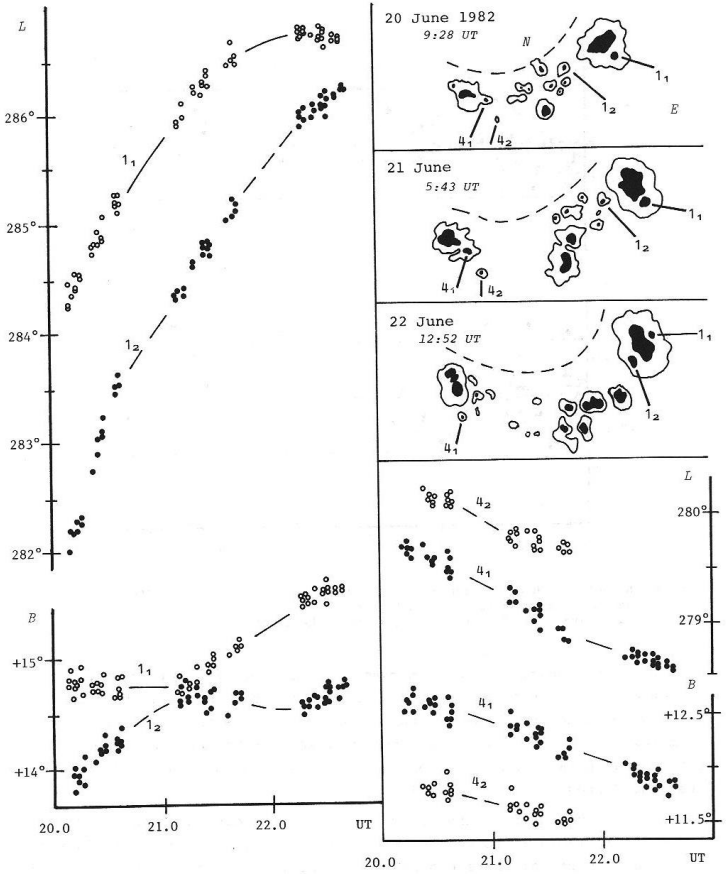

Fig.4 Heliographic coordinates *versus* time of four umbrae in a three-day period. The umbrae are members of a large sunspot group in Hale rgn.No 18430. In the drawings, only the SW part of the group is visible. (The diameter of the plotted circles is about 0.03°.)

3. ON THE ACCURACY OF OUR POSITION MEASUREMENTS

In order to show by simple means the probable errors in our data of positions, the results of some series of measurements, made on a number of heliograms taken over a daily observational period of several hours, are given in Figure 4, where each plot represents a single observation. These data form an unpublished part of an investigation on the development of sunspot groups {Á.Kovács and L.Dezső, Sunspot motion in Hale region No 18430, *Contr. Astr.Obs.Skalnaté Pleso, Vol.15*, Part 1, pp.103-110 = *Heliophys.Obs.Debrecen, Preprint No.9*, 1986}.

It is easy to see that all the heliographic coordinates given in Figure 4 lie within a 0.3°- wide zones. Thus, in general, we may estimate the probable error of the positions in both coordinates approximately as ±0.1°. If there are a sufficient number of observations, of course, then it is possible to reliably give a mean position in heliographic degree to two decimal places, as well. (This is the reason for our using, as a rule, the coordinates two decimal places as given in Figures 1-4.)

Consequently, on the basis of the foregoing (and of our other similar experience) it may be said that the heliographic coordinates in the *Debrecen Photoheliographic Results*, measured on a daily single heliogram, could not have generally an error larger than 0.2°.

The author thanks Lidia Gesztelyi and I.Nagy for measuring the 39 Greenwich plates.