COMPARATIVE BETWEEN THE AREAS MEASURED WITH PHOTOGRAPHY AND BY PROJECTION OF THE SUN IMAGE ON A TEMPLATE

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The idea is to verify the reliability of the observations of the areas of sunspot groups with artisanal methods such as the projection of the image of the Sun in a template.

Introduction

The photographic observations allow great precision against the observations made by drawing the projection of the Sun on a template, but it may happen that there is no other possibility of performing those measurements due to lack of means, so they are sufficiently acceptable?

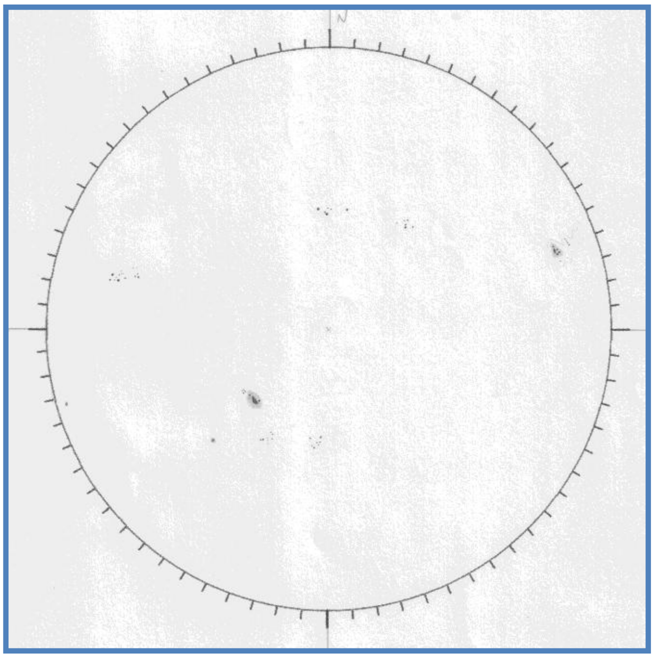
The observations were made with a refractor telescope of 77/1000 mm with a 20 mm eyepiece that allows me to project the entire disk of the Sun on a 16 cm template.

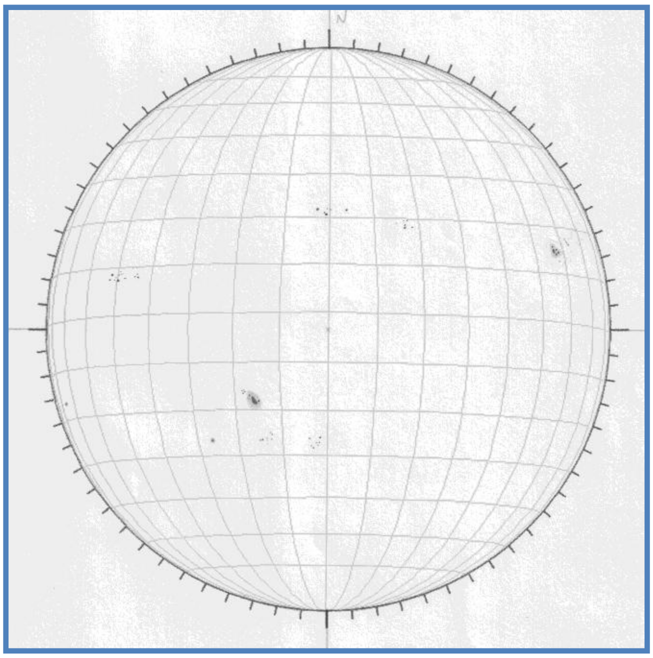
And the observations made with photography were made with the following instruments: Javier Ruiz Fernández worked with a Astrosolar + Equinox 120/900 mm and Nikon D40 camera and Juan Pedro Mesas Plaza does it with Baader K line + Newton Vixen SS 200/800 mm and the Olympus E300 camera.

The observations made with photography were taken from the database of the **Parhelio** website (http://www.parhelio.com).

Measurements

After drawing the Sun, the orientation process begins with the coordinates for the day and time of observation, then a grid with the meridians and solar parallels is added and it is then, with those guides and with the help of a rule when I take measurements of length and width of each of the sunspots to measure their area on paper. The main problems appear with groups that have small loose spots, such as groups of type A, B, C and D according to the classification of Zürich, since many of them are smaller than one millimeter, so they are oversized, since the maximum possible approximation is 0.5 mm, on the other hand, highly developed sunspot groups, such as groups of type E and F are so complex that, as a rule, I measure the area of the region and not that of sunspots only.





The observation corresponds to the day January 4, 2012, with solar parameters of: B0 = - 3.4 P = 0.6 L0 = 70 of the rotation 2118 (day 22 of rotation).

Then, the areas measured in millimeters on the spreadsheet replaced them in the equation that allows them to be passed to area measurements such as the millionth part of the observable hemisphere of the Sun.

$$A_i = 10^6 \cdot \frac{A_i'}{2 \cdot \pi \cdot R^2 \cdot \cos\left(\arcsin\left(\frac{r_i}{R}\right)\right)}$$

Ai = Is the area of a sunspot expressed in millionths of the observed solar disk.
A'i = Is the area of a spot measured in square millimeters on the spreadsheet.
R = Is the radius of the spreadsheet measured in millimeters.
ri = Is the distance from the center of the spot to the center of the spreadsheet measured in millimeters.misphere of the Sun:

To make the comparison I used the measurements of the areas of sunspots observed during 2011 by **Javier Ruíz Fernández**, by **Juan Pedro Mesas Plaza** and by me. The data used were taken from the database of the **Parhelio** website (http://www.parhelio.com) as I indicated above and from my own observations.

Both the observations made by **Javier** and those of **Juan Pedro** were made through photography and using the software **SOL** and **IRIS** together to reduce them, the procedure can be seen in detail on **Parhelio** website, at the following link: http://www.parhelio.com/docareas.html.

Data

The data taken are those of the attached table:

DATE	NOAA	JMP	JDR	DATE	NOAA	JRF	JDR	DATE	NOAA	JRF	JMP
16/04/2011	11190	449	645,34	17/01/2011	11147	250	141,62	16/04/2011	11190	449	449
	11191	109	109,19	20/01/2011	11147	217	292,19		11191	103	109
	11193	560	674,1	02/02/2011	11150	59	102,09		11193	452	560
16/05/2011	11208	48	23,6	08/02/2011	11153	228	955,69	16/05/2011	11208	52	48
	11214	187	183,25		11157	15	18,05		11214	158	187
28/07/2011	11260	563	829,65		11156	7	8,07	28/07/2011	11260	610	563
	11261	540	440,04	10/02/2011	11156	56	412,35		11261	389	540
02/08/2011	11260	439	186,51	28/02/2011	11164	455	806,99	03/08/3011	11260	312	421
	11261	757	1178,06		11165	13	53,65		11261	522	593
	11263	1190	1963,43	06/03/2011	11164	1237	1473		11263	1022	999
03/08/3011	11260	421	307,49		11167	15	80,05	28/09/2011	11306	63	93
	11261	593	1009,73	07/03/2011	11166n	18	27,47		11305	192	208
	11263	999	1512,18		11164	1192	1849,21		11302	1417	1326
28/09/2011	11306	93	34,82		11169	171	207,23		11304	17	56
	11305	208	55,31	11/03/2011	11166	1190	1248,39	29/09/2011	11302	1006	1326
	11302	1326	1436,57		11169	323	1086,02		11304	39	26
	11304	56	115,84	12/03/2011	11166	1051	1657		11301	21	26
29/09/2011	11302	1326	1541,01		11169	413	788,9		11305	209	260
	11304	26	7,87	18/03/2011	11173	41	161,85		11306	64	77
	11301	26	10,36	20/03/2011	11175	181	125,84	11/10/2011	11309	87	101
	11305	260	210,36	13/04/2011	11186	79	102,73		11312	329	366
	11306	77	31,09	16/04/2011	11190	449	645,34		11315	65	99
	11307	80	57,05		11191	103	109,19		11314	463	506
11/10/2011	11309	101	72,21		11193	452	674,1		11313	241	396
	11312	366	160,1	19/04/2011	11191	67	54,27	14/10/2011	11312	340	358
	11315	99	77,05		11193	611	1003,89		11315	13	21
	11314	506	242,1	07/05/2011	11203	141	31,86		11318	49	71
	11313	396	640,39		11204	156	7,37		11314	386	444
12/10/2011	11309	96	188,83	08/05/2011	11203	138	36,82		11319	222	383
	11312	374	423,89		11204	125	8,18		11313	95	105
	11314	505	199,19	15/05/2011	11208	79	67,41		11320	14	23
	11313	335	779,71		11214	98	79,64		11316	501	564
	11316	370	393,51	16/05/2011	11208	52	23,6		11317	116	121
	11317	115	121,58		11214	158	183,25	25/10/2011	11327	165	157
14/10/2011	11312	358	150,39	28/05/2011	11224	220	508,67		11324	118	276
	11315	21	16,36		11225	56	9,61		11325	132	163
	11318	71	56,52		11223	24	12,73		11330	740	786
	11314	444	329,67	01/06/2011	11225	24	6,47		11332	70	72
	11319	383	473,32		11229	38	80,48	24/11/2011	11357	43	67
	11313	105	80,7		11228	151	161,39		11353	16	23
	11320	23	75,19		11230	15	38,44		11355	138	167
	11316	564	221,24		11226	276	325,59		11356	416	550
	11317	121	34,82		11227	139	182,37		11358	168	159
15/10/2011	11312	335	283,24	02/06/2011	11226	244	362,11		11352	114	104
	11315	30	72,21		11227	123	167,86		11354	30	49
	11314	454	241,43		11225	16	6,71	26/12/2011	11383	12	37
	11319	451	603,66		11229	18	13,27		11384	528	754
	11313	73	51,37		11228	137	289,6		11386	362	376
	11320	19	11,8		11230	22	16,14				
	11316	477	262,95	03/06/2011	11226	253	369,85				
	11317	123	31,46		11227	21	33,07				
16/10/2011	11312	316	121,58		11225	16	7,2				
	11314	408	327,58		11229	13	6,7				
	11319	889	1509,15		11228	142	157,77				
	11322	75	102,73		11230	6,7	12				
	11316	443	130,34	05/06/2011	11226	147	130,78				
	11317	127	28,96		11227	59	118,4				
25/10/2011	11327	157	75,19		11228	80	104,72				
	11324	276	184,07	12/06/2011	11234	11	28,26				
	11325	163	76,8	14/06/2011	11234	60	76,57				

JRF = Javier Ruiz Fernández

JMP = Juan Pedro Mesas Plaza

JDR = Jorge Luis del Rosario García

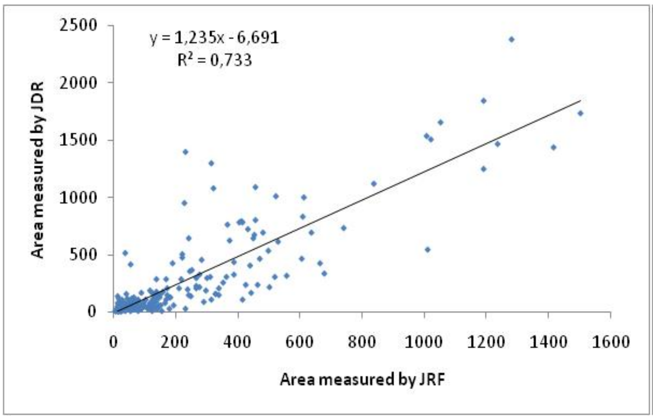
The table shows the dates of the observations, the numbering of the sunspots groups observed simultaneously by each pair of observers according to **NOAA** and the areas of the sunspot measured by each observer.

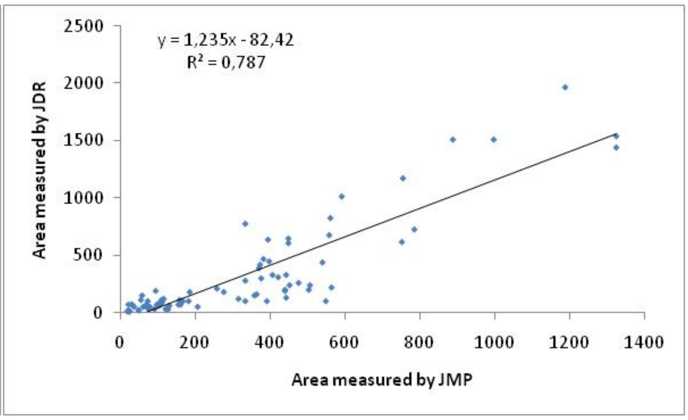
I have only been able to use the sunspot groups in which **Javier** and **Juan Pedro** coincided on the one hand, **Javier** and I on the other and finally **Juan Pedro** and I, hence three tables appear. For this reason, a large number of observations have also been lost, those where there was no coincidence.

Analysis

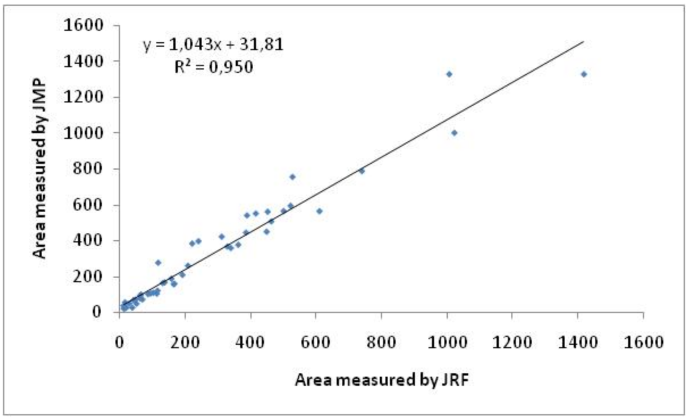
The next step was to make a correlation between the observations in pairs, that is, compare **Javier**'s observations with mine and those of **Juan Pedro** with mine.

The results are shown in the following graphs:





While the correlation between the photographic data of **Javier** and **Juan Pedro** is as seen in the following graph:



As expected, the slope of the graph for the comparison **JDR** vs **JRF** and for **JDR** vs **JMP** is almost identical, its value is ***m = 1,235*** and ***R2 = 0,7***, while the comparison between **JRF** and **JMP** gives a slope of ***m = 1.043*** and ***R2 = 0.95***. He commented that it was to be expected, since it is assumed that the observations of **Javier** and **Juan Pedro** should be similar since both were made with the same method and especially because the accuracy of the observations with photography is much greater, fact that is reflected in the graph, whose slope is close to **1**, "*what is not equal is probably due to the use of different instruments and techniques by astrophotographers*"(explanatory note of **Javier Ruíz Fernández**).

It is clear that the mistake made in my observations is great. But still, if we take average values, the relationship between my observations and the photographic observations would be as follows:

$$A_{template} = 1{,}235 \cdot (A_{photography} + 44{,}559)$$

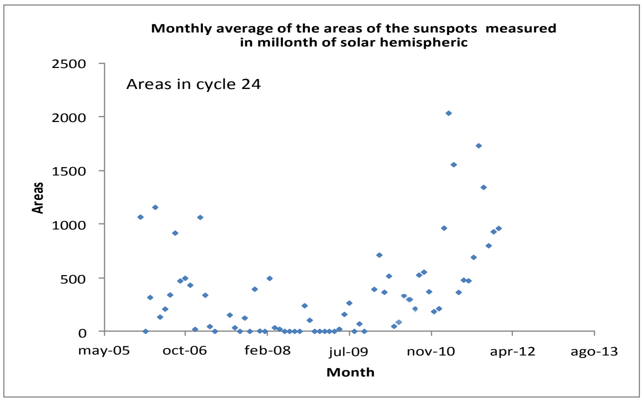
The areas observed by me are somewhat larger than those observed with photography, in fact, there is an error of about **2º** in the measurements, which can be translated into **1.8** mm in the template, "when we draw the sunspots we tend to make the larger drawing of what the real sunspot would be" (explanatory note by **Javier Ruíz Fernández**), this fact may favor this difference that is commented.

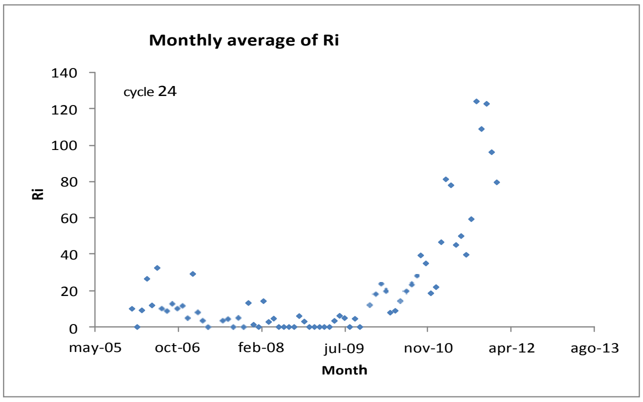
On the other hand, it is curious to see in the graphs how the spots are not as oversized as expected since these are below the line, this fact can be explained thinking that it is due to the excess of zeal that I put at the time of draw them so as not to deviate too much from reality and maybe, I'm falling short in the measure of their areas and on the other hand, I'm falling long in the measure of the areas of sunspot groups very developed since as I indicated previously I don’t measure the area of sunspots but that of entire sunspot group.

The areas measured that are closest to the photographic results are those of the sunspots that are passing through the central meridian or the areas of sunspots of type **G**, **H** or **J** according to the ***Zürich*** classification, since due to their size and form the mistakes made are minor.

Conclusion

Even so, and even if only on a personal basis, the areas of sunspots measured in this artisanal way are a good index for monitoring solar activity, as can be seen in the following graphs:





In both graphs we see that both distributions evolve marking the rise to the maximum of the solar cycle number 24 (according to ***Carrington***'s enumeration) of solar activity in a quite similar way.

Gratitude

I wanted to thank the corrections and contributions of **Javier Ruíz Fernández**, who have enriched this work.

Bibliography

- Compendium of practical astronomy, V2. Ed: Günter Dietmar Roth.
- Error of observation and their treatment. J. Topping. Ed: Chapman and Hall. Science paperback.