

# Annual Report on Sunspot Counting Program

2022

Vol. 10

Universidad de Extremadura, Spain



This *Annual Report on Sunspot Counting Program 2022* has been compiled by A. J. P. Aparicio, I. Tovar, N. Bravo-Paredes, V. M. S. Carrasco, and J. M. Vaquero.

## Introduction

This program was born in late 2012 at the University of Extremadura (Badajoz,  $38^{\circ}53'$  N  $6^{\circ}58'$  W) in order to further extend our research in the reconstruction of past solar activity (see, for example, Vaquero, 2007). Since 1st January 2013, our sunspot counts have been submitted to the Royal Observatory of Belgium (ROB) as a contribution to the international effort of maintaining and updating the International Sunspot Number. For this purpose, we use a small apochromatic refractor –80 mm of objective diameter and 550 mm of focal length– to project a 150 mm diameter image onto a template. Then, a drawing is done so we obtain our sunspot counts from it. Moreover, solar observations from secondary stations are carried out some days when the main station (in Badajoz) fails. One of these stations is in Badajoz too (in a different part of the city) and is equipped with a refractor –90 mm of objective diameter and 900 mm of focal length–, and the other one is in Valencia de las Torres ( $38^{\circ}24'$  N  $6^{\circ}00'$  W) and is equipped with a smaller refractor –70 mm of objective diameter and 700 mm of focal length–.

In this report, we provide a complete set of data obtained throughout the year 2022, with four tables including our data. Moreover, the reference sunspot number index is compared with our results.

We hope that this publication is useful to the scientific community studying the sunspot number: the longest solar index series derived from direct observation of the Sun.

## Data

Table 1 lists all the observations made in 2022. A few days reflect more than one observation. In such cases, we follow the ROB criteria to choose the best drawing of each day, that is, we choose the observation presenting (in order of priority):

- Highest number of groups
- Highest Wolf number
- Highest Quality
- Smallest time-difference with respect to 12:00 UT (solar culmination)
- Early-in-the-morning counts are best

The drawing quality is represented as an integer number between 1 and 5, according to the following rule (USSPS code):

- 1 = very poor
- 2 = poor
- 3 = fair
- 4 = good
- 5 = exceptional

Note that when the main and the secondary stations record a solar observation for the same day, that from the main station is chosen as the best observation of the day.

Tables 2 and 3 list daily, monthly, and yearly values of the number of groups and spots, respectively, over 2022. From the group count  $G$  and the sunspot count  $S$ , we define the UEx sunspot number (or UEx Wolf number) as follows:  $SN_{UEx} = 10G + S$ . Additionally, we define the UEx group number as:  $GN_{UEx} = G$ . These definitions are in agreement with the classical ones and their updates (Clette *et al.*, 2014, 2015, 2016). Thus, Table 4 lists daily, monthly, and yearly values of  $SN_{UEx}$ , while Figure 1 displays the evolution of the time series of the above two indices.

Table 1. Data on sunspot counting over 2022, including month, day, time (UT), observer, quality, number of groups ( $G$ ), number of spots ( $S$ ), and UEx sunspot number ( $SN_{UEx}$ ). One asterisk in the last column indicates that the solar observation was registered at the secondary station in Badajoz and two asterisks correspond to the secondary station in Valencia de las Torres.

Month	Day	Time (UT)	Observer	Quality	$G$	$S$	$SN_{UEx}$	Station
1	3	11:40	N. Bravo-Paredes	3	1	2	12	
1	7	11:05	N. Bravo-Paredes	4	3	29	59	
1	10	10:40	N. Bravo-Paredes	4	5	17	67	
1	12	10:55	N. Bravo-Paredes	3	6	32	92	
1	13	11:10	N. Bravo-Paredes	3	7	23	93	
1	14	12:40	I. Tovar	3	6	10	70	
1	17	11:32	I. Tovar	4	4	12	52	
1	18	11:35	I. Tovar	4	4	15	55	
1	19	11:52	I. Tovar	3	4	12	52	
1	20	12:09	I. Tovar	3	2	2	22	
1	21	12:03	I. Tovar	3	2	2	22	
1	23	11:00	V.M.S. Carrasco	3	1	1	11	*
1	25	11:51	I. Tovar	4	4	15	55	
1	26	11:57	I. Tovar	4	5	20	70	
1	31	11:20	N. Bravo-Paredes	1	4	22	62	
2	1	11:25	N. Bravo-Paredes	2	5	30	80	
2	2	12:10	I. Tovar	3	4	24	64	
2	7	10:35	I. Tovar	3	3	29	59	
2	8	11:45	N. Bravo-Paredes	3	4	34	74	
2	9	12:00	I. Tovar	4	3	21	51	
2	11	12:15	I. Tovar	3	3	10	40	
2	14	12:05	I. Tovar	3	3	12	42	
2	15	11:50	N. Bravo-Paredes	2	5	14	64	
2	16	12:15	I. Tovar	2	5	18	68	
2	17	11:00	N. Bravo-Paredes	1	7	20	90	
2	21	11:35	N. Bravo-Paredes	2	3	8	38	
2	22	11:25	N. Bravo-Paredes	3	2	8	28	
2	25	12:25	I. Tovar	1	2	2	22	

3	2	11:55	I. Tovar	3	5	10	60	
3	3	12:15	I. Tovar	3	4	19	59	
3	7	12:09	I. Tovar	1	4	13	53	
3	10	9:35	N. Bravo-Paredes	3	4	35	75	
3	28	11:30	I. Tovar	1	5	26	76	
3	30	10:40	I. Tovar	4	5	25	75	
3	31	10:30	N. Bravo-Paredes	3	6	51	111	
4	1	10:45	I. Tovar	2	6	27	87	
4	4	10:49	I. Tovar	1	3	8	38	
4	6	10:45	I. Tovar	3	2	12	32	
4	7	11:20	N. Bravo-Paredes	1	2	7	27	
4	13	17:20	J.M. Vaquero	2	3	5	35	**
4	14	16:30	J.M. Vaquero	2	3	6	36	**
4	15	18:00	J.M. Vaquero	2	3	6	36	**
4	16	16:30	J.M. Vaquero	2	6	13	73	**
4	17	10:15	J.M. Vaquero	2	6	18	78	**
4	18	10:25	J.M. Vaquero	1	6	14	74	**
4	20	11:00	I. Tovar	3	5	26	76	
4	24	15:30	J.M. Vaquero	3	6	27	87	
4	25	11:00	I. Tovar	3	6	23	83	
4	27	10:04	I. Tovar	3	7	14	84	
4	28	10:25	N. Bravo-Paredes	2	8	25	105	
4	29	10:10	N. Bravo-Paredes	2	10	15	115	
4	30	12:40	J.M. Vaquero	1	3	10	40	**
5	1	17:10	J.M. Vaquero	2	2	5	25	**
5	3	7:35	N. Bravo-Paredes	3	5	23	73	
5	4	10:35	I. Tovar	3	4	13	53	
5	5	11:25	N. Bravo-Paredes	1	4	21	61	
5	6	11:30	I. Tovar	3	3	16	46	
5	9	10:45	I. Tovar	3	3	16	46	
5	10	10:45	N. Bravo-Paredes	2	2	24	44	
5	11	8:35	I. Tovar	3	5	34	84	
5	13	9:25	I. Tovar	3	4	33	73	
5	16	9:24	I. Tovar	3	5	32	82	
5	17	8:10	N. Bravo-Paredes	2	7	51	121	
5	18	8:30	I. Tovar	3	6	33	93	
5	19	8:50	N. Bravo-Paredes	2	8	37	117	
5	23	11:25	I. Tovar	2	4	21	61	
5	24	9:10	N. Bravo-Paredes	2	5	22	72	
5	25	10:45	I. Tovar	3	5	15	65	
5	26	10:25	N. Bravo-Paredes	3	6	19	79	
5	27	9:15	N. Bravo-Paredes	4	5	9	59	
5	31	8:00	N. Bravo-Paredes	3	6	17	77	
6	3	9:30	I. Tovar	2	4	8	48	
6	6	11:50	I. Tovar	2	1	1	11	

6	7	9:00	N. Bravo-Paredes	4	2	3	23	
6	8	10:30	I. Tovar	3	0	0	0	
6	9	8:40	N. Bravo-Paredes	3	1	11	21	
6	10	9:00	N. Bravo-Paredes	3	4	15	55	
6	13	9:30	N. Bravo-Paredes	2	8	23	103	
6	14	8:30	N. Bravo-Paredes	1	7	41	111	
6	15	9:00	N. Bravo-Paredes	1	8	60	140	
6	17	11:00	N. Bravo-Paredes	1	8	47	127	
6	21	9:50	N. Bravo-Paredes	1	5	32	82	
6	23	9:20	N. Bravo-Paredes	3	4	23	63	
6	27	10:20	I. Tovar	3	4	9	49	
6	28	11:20	I. Tovar	3	4	9	49	
6	29	11:05	I. Tovar	4	2	6	26	
7	1	10:20	I. Tovar	3	2	4	24	
7	4	10:50	I. Tovar	2	4	10	50	
7	5	8:35	N. Bravo-Paredes	2	5	13	63	
7	6	10:10	I. Tovar	4	6	20	80	
7	7	9:05	I. Tovar	3	6	22	82	
7	8	8:45	I. Tovar	3	5	20	70	
7	11	8:35	I. Tovar	3	6	30	90	
7	12	8:45	N. Bravo-Paredes	1	5	50	100	
7	14	9:10	I. Tovar	2	4	47	87	
7	19	8:25	N. Bravo-Paredes	2	6	31	91	
7	20	9:08	I. Tovar	3	7	34	104	
7	21	9:00	I. Tovar	2	7	20	90	
7	22	9:00	I. Tovar	2	7	20	90	
7	25	8:50	I. Tovar	2	5	10	60	
7	26	8:25	I. Tovar	3	6	17	77	
7	27	9:00	I. Tovar	3	4	8	48	
7	28	9:05	I. Tovar	2	3	3	33	
7	29	9:10	I. Tovar	2	2	7	27	
8	1	17:30	J.M. Vaquero	3	1	12	22	**
8	3	17:45	J.M. Vaquero	3	2	14	34	**
8	4	18:45	J.M. Vaquero	2	5	15	65	**
8	6	18:30	J.M. Vaquero	2	5	19	69	**
8	14	18:15	J.M. Vaquero	2	6	37	97	**
8	15	18:00	J.M. Vaquero	3	6	54	114	**
8	16	17:45	J.M. Vaquero	2	9	35	125	**
8	20	18:30	J.M. Vaquero	2	7	13	83	**
8	21	18:00	J.M. Vaquero	3	6	12	72	**
8	22	18:00	J.M. Vaquero	2	5	15	65	**
8	25	18:15	J.M. Vaquero	2	5	22	72	**
8	26	17:45	J.M. Vaquero	2	5	32	82	**
8	27	17:45	J.M. Vaquero	2	5	33	83	**
8	28	9:15	J.M. Vaquero	3	5	30	80	**

8	31	16:40	J.M. Vaquero	3	2	23	43	**
9	4	17:15	J.M. Vaquero	4	4	30	70	**
9	5	9:45	I. Tovar	2	3	6	36	
9	8	17:30	J.M. Vaquero	3	6	29	89	**
9	9	17:15	J.M. Vaquero	3	7	37	107	**
9	10	16:45	J.M. Vaquero	3	8	34	114	**
9	11	9:00	J.M. Vaquero	3	8	39	119	**
9	13	9:00	N. Bravo-Paredes	2	4	36	76	
9	15	10:30	N. Bravo-Paredes	3	6	31	91	
9	16	8:40	N. Bravo-Paredes	2	4	26	66	
9	20	10:15	N. Bravo-Paredes	2	3	23	53	
9	21	10:50	I. Tovar	2	3	17	47	
9	22	10:00	N. Bravo-Paredes	2	5	39	89	
9	23	8:35	N. Bravo-Paredes	2	6	44	104	
9	27	10:10	I. Tovar	3	5	35	85	
9	28	9:30	N. Bravo-Paredes	3	4	25	65	
10	4	10:00	N. Bravo-Paredes	1	7	72	142	
10	5	9:30	N. Bravo-Paredes	1	7	89	159	
10	6	10:00	N. Bravo-Paredes	2	8	76	156	
10	7	9:50	N. Bravo-Paredes	3	7	81	151	
10	10	10:45	N. Bravo-Paredes	1	5	57	107	
10	11	10:15	N. Bravo-Paredes	1	4	47	87	
10	12	16:45	J.M. Vaquero	3	6	20	80	**
10	13	10:20	N. Bravo-Paredes	2	4	15	55	
10	14	10:00	N. Bravo-Paredes	2	7	12	82	
10	17	10:30	N. Bravo-Paredes	1	4	20	60	
10	18	11:00	N. Bravo-Paredes	1	3	8	38	
10	25	10:00	N. Bravo-Paredes	3	6	18	78	
10	27	11:45	N. Bravo-Paredes	1	4	22	62	
10	29	-	J.M. Vaquero	2	5	17	67	
10	31	16:30	J.M. Vaquero	3	3	10	40	**
11	1	12:30	J.M. Vaquero	2	6	15	75	**
11	9	11:10	I. Tovar	3	5	24	74	
11	10	12:00	I. Tovar	2	3	22	52	
11	11	12:45	I. Tovar	2	3	22	52	
11	18	10:50	N. Bravo-Paredes	4	4	11	51	
11	25	12:13	I. Tovar	3	5	10	60	
11	27	9:25	J.M. Vaquero	3	4	14	54	
11	28	12:33	I. Tovar	3	2	6	26	
11	29	11:35	I. Tovar	2	1	5	15	
12	1	11:25	I. Tovar	3	3	7	37	
12	2	12:00	N. Bravo-Paredes	3	4	19	59	
12	16	11:35	I. Tovar	2	7	42	112	
12	19	15:15	I. Tovar	1	4	20	60	
12	26	15:40	J.M. Vaquero	3	8	27	107	

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12	31	12:45	J.M. Vaquero	2	6	26	86
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Total number of observations: 164

Total number of days recorded: 164



Table 2. Daily, monthly, and yearly values of number of groups in 2022.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		5		6	2		2	1			6	3
2		4	5									4
3	1		4		5	4		2				
4				3	4		4	5	4	7		
5					4		5		3	7		
6				2	3	1	6	5		8		
7	3	3	4	2		2	6			7		
8		4				0	5		6			
9		3			3	1			7		5	
10	5		4		2	4			8	5	3	
11		3			5		6		8	4	3	
12	6						5			6		
13	7			3	4	8			4	4		
14	6	3		3		7	4	6		7		
15		5		3		8		6	6			
16		5		6	5			9	4			7
17	4	7		6	7	8				4		
18	4			6	6					3	4	
19	4				8		6					4
20	2			5			7	7	3			
21	2	3				5	7	6	3			
22		2					7	5	5			
23	1				4	4			6			
24				6	5							
25	4	2		6	5		5	5		6	5	
26	5				6		6	5				8
27				7	5	4	4	5	5	4	4	
28			5	8		4	3	5	4		2	
29				10		2	2			5	1	
30			5	3								
31	4		6		6			2		3		6
Monthly mean	3.9	3.8	4.7	5.0	4.7	4.1	5.0	4.9	5.1	5.3	3.7	5.3
Yearly mean	4.6											

Table 3. Daily, monthly, and yearly values of number of spots in 2022.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		30		27	5		4	12			15	7
2		24	10									19
3	2		19		23	8		14				
4				8	13		10	15	30	72		
5					21		13		6	89		
6				12	16	1	20	19		76		
7	29	29	13	7		3	22			81		
8		34				0	20		29			
9		21			16	11			37		24	
10	17		35		24	15			34	57	22	
11		10			34		30		39	47	22	
12	32						50			20		
13	23			5	33	23			36	15		
14	10	12		6		41	47	37		12		
15		14		6		60		54	31			
16		18		13	32			35	26			42
17	12	20		18	51	47				20		
18	15			14	33					8	11	
19	12				37		31					20
20	2			26			34	13	23			
21	2	8				32	20	12	17			
22		8					20	15	39			
23	1				21	23			44			
24				27	22							
25	15	2		23	15		10	22		18	10	
26	20				19		17	32				27
27				14	9	9	8	33	35	22	14	
28			26	25		9	3	30	25		6	
29				15		6	7			17	5	
30			25	10								
31	22		51		17			23		10		26
Monthly mean	14.3	17.7	25.6	15.1	23.2	19.2	20.3	24.4	30.1	37.6	14.3	23.5
Yearly mean	22.1											

Table 4. Daily, monthly, and yearly values of  $SN_{UEx}$  in 2022.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		80		87	25		24	22			75	37
2		64	60									59
3	12		59		73	48		34				
4				38	53		50	65	70	142		
5					61		63		36	159		
6				32	46	11	80	69		156		
7	59	59	53	27		23	82			151		
8		74				0	70		89			
9		51			46	21			107		74	
10	67		75		44	55			114	107	52	
11		40			84		90		119	87	52	
12	92						100			80		
13	93			35	73	103			76	55		
14	70	42		36		111	87	97		82		
15		64		36		140		114	91			
16		68		73	82			125	66			112
17	52	90		78	121	127				60		
18	55			74	93					38	51	
19	52				117		91					60
20	22			76			104	83	53			
21	22	38				82	90	72	47			
22		28					90	65	89			
23	11				61	63			104			
24				87	72							
25	55	22		83	65		60	72		78	60	
26	70				79		77	82				107
27				84	59	49	48	83	85	62	54	
28			76	105		49	33	80	65		26	
29				115		26	27			67	15	
30			75	40								
31	62		111		77			43		40		86
Monthly mean	52.9	55.4	72.7	65.1	70.1	60.5	70.3	73.7	80.7	90.9	51.0	76.8
Yearly mean	68.5											
Days recorded	15	13	7	17	19	15	18	15	15	15	9	6
Total days recorded	164											

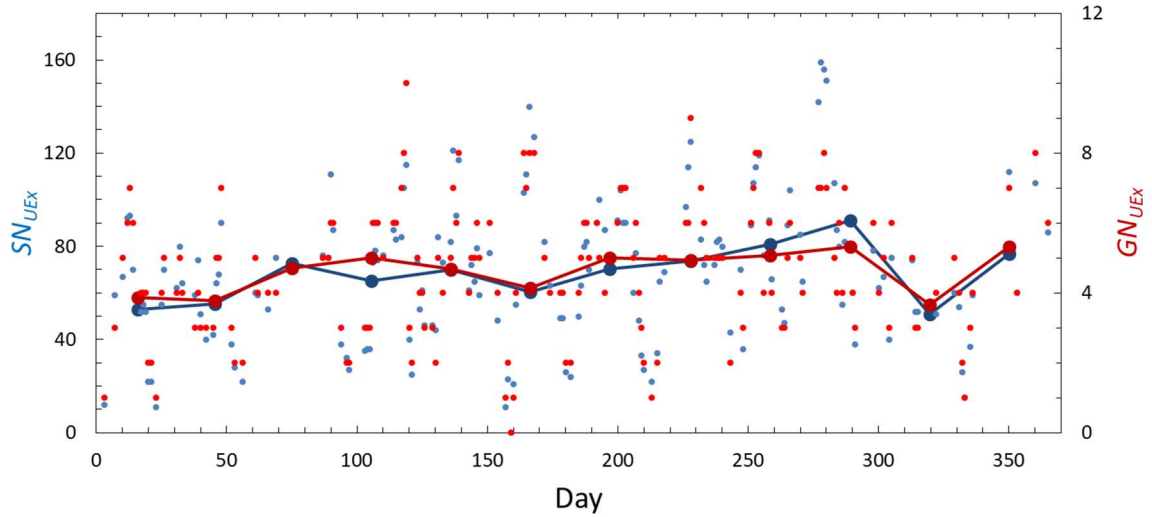


Figure 1. Daily (small dots) and monthly (big dots and lines) UEx sunspot number ( $SN_{UEX}$ ) (blue) and UEx group number ( $GN_{UEX}$ ) (red) in 2022.

### Relationship with the reference sunspot number index

We have compared  $SN_{UEX}$  with the sunspot number ( $S_N$ , version 2.0) provided by the World Data Center SILSO, Royal Observatory of Belgium, Brussels (see Figure 2).

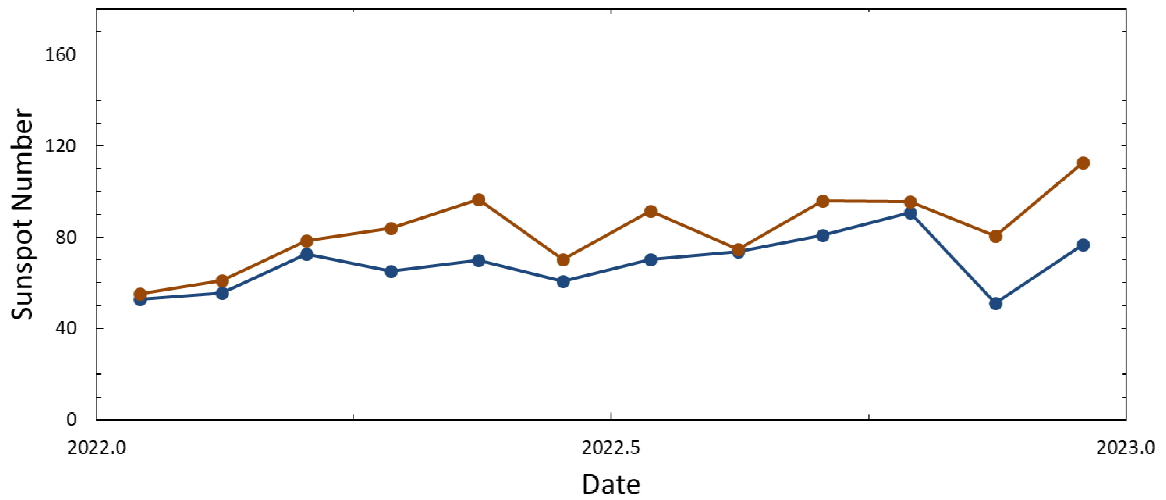


Figure 2. Monthly  $SN_{UEX}$  (blue) and sunspot number ( $S_N$ ) (brown) in 2022.

Figure 3 shows a scatter plot of daily  $SN_{UEX}$  versus  $S_N$ . The corresponding linear fit equation is:

$$SN_{UEX} = (0.77 \pm 0.03) S_N + (4.18 \pm 3.14) \quad (r = 0.866; p\text{-value} < 0.001)$$

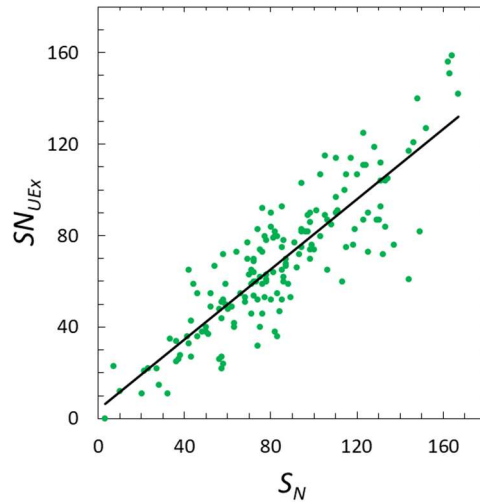


Figure 3. Scatter plot of daily  $SN_{UEX}$  versus  $S_N$  in 2022.

### Acknowledgements

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