

# Annual Report on Sunspot Counting Program

2014

Vol. 2

Universidad de Extremadura, Spain



This *Annual Report on Sunspot Counting Program 2014* was compiled by A.J.P. Aparicio and J.M. Vaquero.

## Introduction

This program was born in late 2012 at the University of Extremadura 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 have used a small apochromatic refractor –80mm of objective diameter and 550mm of focal length– to project a 150mm diameter image onto a template.

In this report, we provide a complete set of data obtained throughout the year 2014, with four Tables showing our data. Moreover, the reference sunspot 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 along this year. A few days reflect two observations. In those cases, we follow the ROB criteria for the chosen drawing of each day. Here are the criteria:

- 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

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

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

Tables 2 and 3 list daily, monthly and yearly values of the number of groups and spots along 2014. From group count  $G$  and sunspot count  $S$ , we define UEx sunspot number (or UEx Wolf number) as follows:  $SN_{\text{UEx}} = 10G + S$ . Additionally, we define UEx group sunspot number as:  $GSN_{\text{UEx}} = 12.08G$ . These definitions are in agreement with the classical ones (Clette et al., 2014).

Table 4 lists daily, monthly and yearly values of  $SN_{UEX}$ , while Figure 1 shows the temporal evolution of these indexes.

Table 1. Data on sunspot counting along 2014, including day, month, time (U.T.), observer, quality, number of groups (G), number of spots (S) and Wolf number ( $SN_{UEX}$ ).

Day	Month	Time (U.T.)	Observer	Quality	G	S	$SN_{UEX}$
5	1	14:00	JM Vaquero	2	7	45	115
8	1	13:10	AJP Aparicio	2	4	62	102
9	1	10:25	AJP Aparicio	3	4	79	119
10	1	14:35	AJP Aparicio	2	5	29	79
11	1	13:45	JM Vaquero	3	8	37	117
13	1	11:00	AJP Aparicio	4	8	26	106
14	1	13:30	AJP Aparicio	2	6	23	83
16	1	10:25	AJP Aparicio	3	6	10	70
19	1	13:20	JM Vaquero	4	8	18	98
20	1	14:10	AJP Aparicio	4	10	37	137
22	1	11:35	AJP Aparicio	4	10	44	144
23	1	10:10	AJP Aparicio	4	9	37	127
25	1	16:55	JM Vaquero	3	7	21	91
26	1	13:45	JM Vaquero	1	4	11	51
28	1	9:20	AJP Aparicio	3	5	23	73
29	1	13:15	AJP Aparicio	4	5	31	81
30	1	13:45	JM Vaquero	2	5	30	80
1	2	16:25	JM Vaquero	2	3	43	73
2	2	13:35	JM Vaquero	2	4	54	94
10	2	10:45	AJP Aparicio	4	8	47	127
13	2	12:00	AJP Aparicio	4	7	59	129
16	2	17:20	JM Vaquero	2	3	35	65
17	2	11:15	N Bravo	3	6	31	91
19	2	11:15	MJ Trinidad	3	5	21	71
21	2	10:20	AJP Aparicio	4	5	44	94
23	2	11:15	AJP Aparicio	5	6	62	122
24	2	11:05	AJP Aparicio	4	6	46	106
26	2	10:15	AJP Aparicio	3	11	51	161
5	3	10:30	AJP Aparicio	4	9	36	126
6	3	11:20	AJP Aparicio	3	6	16	76
7	3	10:30	AJP Aparicio	4	7	30	100
8	3	12:20	JM Vaquero	3	6	18	78
10	3	10:20	AJP Aparicio	5	5	42	92
11	3	9:50	AJP Aparicio	5	5	50	100
12	3	10:00	AJP Aparicio	4	5	47	97

13	3	9:50	AJP Aparicio	4	6	36	96
14	3	10:10	AJP Aparicio	3	6	33	93
15	3	17:41	JM Vaquero	3	7	18	88
17	3	9:50	AJP Aparicio	4	7	27	97
18	3	10:10	AJP Aparicio	3	7	18	88
18	3	12:30	L Bautista	3	6	17	77
19	3	10:15	AJP Aparicio	4	8	31	111
20	3	12:20	AJP Aparicio	2	7	40	110
22	3	13:00	AJP Aparicio	3	9	28	118
23	3	12:00	AJP Aparicio	4	7	32	102
26	3	10:00	AJP Aparicio	4	5	36	86
27	3	10:30	AJP Aparicio	3	7	31	101
3	4	15:30	AJP Aparicio	4	8	38	118
6	4	18:20	JM Vaquero	2	7	23	93
7	4	15:20	AJP Aparicio	3	9	33	123
8	4	10:40	AJP Aparicio	3	9	24	114
8	4	13:15	L Bautista	4	6	15	75
10	4	9:10	AJP Aparicio	4	3	6	36
11	4	9:00	AJP Aparicio	5	4	11	51
15	4	16:25	JM Vaquero	3	9	45	135
22	4	8:40	AJP Aparicio	3	7	43	113
22	4	11:20	L Bautista	3	6	16	76
24	4	8:55	AJP Aparicio	4	5	13	63
25	4	10:30	AJP Aparicio	3	4	6	46
27	4	11:35	AJP Aparicio	1	4	5	45
28	4	8:35	AJP Aparicio	4	5	21	71
29	4	8:25	AJP Aparicio	4	5	18	68
29	4	11:25	L Bautista	4	5	13	63
30	4	8:40	AJP Aparicio	4	5	25	75
1	5	15:40	JM Vaquero	2	3	21	51
5	5	8:45	AJP Aparicio	4	8	45	125
6	5	8:45	AJP Aparicio	2	9	29	119
8	5	8:55	AJP Aparicio	4	7	22	92
9	5	8:45	AJP Aparicio	5	9	27	117
10	5	10:30	AJP Aparicio	3	8	19	99
11	5	10:10	AJP Aparicio	4	9	31	121
12	5	9:00	AJP Aparicio	4	8	51	131
13	5	8:50	AJP Aparicio	3	7	33	103
13	5	11:30	L Bautista	4	8	21	101
14	5	8:40	AJP Aparicio	5	9	60	150
15	5	10:15	AJP Aparicio	3	7	39	109
16	5	9:15	AJP Aparicio	4	9	25	115
25	5	18:00	AJP Aparicio	3	6	31	91
26	5	12:15	JM Vaquero	2	5	19	69
27	5	10:05	AJP Aparicio	4	4	15	55

28	5	15:30	AJP Aparicio	3	4	7	47
29	5	8:25	AJP Aparicio	4	3	6	36
30	5	10:25	JM Vaquero	2	4	10	50
31	5	11:25	AJP Aparicio	2	2	4	24
1	6	10:45	AJP Aparicio	4	4	9	49
2	6	8:35	AJP Aparicio	4	4	12	52
3	6	8:35	AJP Aparicio	4	4	13	53
4	6	8:35	AJP Aparicio	4	4	9	49
5	6	9:10	AJP Aparicio	3	4	16	56
6	6	8:30	AJP Aparicio	2	4	28	68
7	6	9:30	AJP Aparicio	4	6	38	98
8	6	11:00	AJP Aparicio	3	5	50	100
9	6	8:45	AJP Aparicio	3	6	56	116
10	6	18:30	AJP Aparicio	3	6	57	117
11	6	8:15	AJP Aparicio	3	8	60	140
12	6	8:50	AJP Aparicio	4	11	51	161
13	6	8:05	AJP Aparicio	4	10	59	159
14	6	16:15	JM Vaquero	2	6	25	85
15	6	12:40	JM Vaquero	2	4	18	58
16	6	8:50	AJP Aparicio	4	5	18	68
17	6	17:40	AJP Aparicio	3	8	26	106
18	6	9:20	AJP Aparicio	3	8	21	101
19	6	10:00	AJP Aparicio	3	6	9	69
20	6	8:15	AJP Aparicio	5	6	19	79
21	6	10:40	AJP Aparicio	3	7	13	83
22	6	10:00	AJP Aparicio	3	7	12	82
23	6	8:20	AJP Aparicio	4	6	9	69
24	6	10:50	AJP Aparicio	3	3	4	34
25	6	8:15	AJP Aparicio	4	3	15	45
26	6	8:50	AJP Aparicio	4	4	13	53
27	6	8:00	AJP Aparicio	4	4	7	47
28	6	10:00	AJP Aparicio	3	3	4	34
30	6	11:20	AJP Aparicio	3	8	25	105
3	7	11:45	AJP Aparicio	3	7	48	118
4	7	8:10	AJP Aparicio	5	9	89	179
5	7	9:15	AJP Aparicio	4	10	66	166
7	7	18:20	AJP Aparicio	4	14	77	217
8	7	8:45	AJP Aparicio	4	10	66	166
9	7	8:25	AJP Aparicio	4	9	64	154
10	7	8:10	AJP Aparicio	4	9	64	154
11	7	8:20	AJP Aparicio	4	9	49	139
12	7	10:10	AJP Aparicio	3	6	29	89
13	7	10:30	AJP Aparicio	3	5	13	63
14	7	8:05	AJP Aparicio	4	4	12	52
15	7	8:20	AJP Aparicio	4	1	1	11

16	7	8:00	AJP Aparicio	4	0	0	0
17	7	8:40	AJP Aparicio	4	0	0	0
18	7	8:15	AJP Aparicio	2	1	3	13
21	7	8:25	AJP Aparicio	4	1	4	14
22	7	8:25	AJP Aparicio	4	3	9	39
23	7	8:30	AJP Aparicio	4	4	8	48
24	7	8:20	AJP Aparicio	4	5	11	61
25	7	8:50	AJP Aparicio	4	3	12	42
9	8	9:55	JM Vaquero	3	4	20	60
10	8	18:50	JM Vaquero	2	3	13	43
11	8	8:30	AJP Aparicio	4	4	14	54
12	8	8:40	AJP Aparicio	4	5	17	67
14	8	9:10	AJP Aparicio	4	2	16	36
15	8	10:40	AJP Aparicio	3	5	33	83
18	8	8:50	AJP Aparicio	4	6	30	90
19	8	9:30	AJP Aparicio	3	6	20	80
20	8	8:40	AJP Aparicio	4	6	23	83
21	8	9:00	AJP Aparicio	3	6	28	88
22	8	11:50	AJP Aparicio	2	6	31	91
25	8	8:45	AJP Aparicio	4	5	34	84
26	8	8:45	AJP Aparicio	4	5	29	79
27	8	10:30	AJP Aparicio	3	5	14	64
28	8	8:40	AJP Aparicio	4	5	12	62
29	8	8:55	AJP Aparicio	4	5	12	62
30	8	16:50	AJP Aparicio	4	5	23	73
31	8	9:50	AJP Aparicio	4	4	23	63
1	9	8:45	AJP Aparicio	4	5	29	79
2	9	8:50	AJP Aparicio	4	5	32	82
3	9	9:15	AJP Aparicio	4	5	27	77
4	9	9:00	AJP Aparicio	3	6	27	87
5	9	8:50	AJP Aparicio	4	6	23	83
9	9	9:05	AJP Aparicio	3	8	53	133
10	9	9:10	AJP Aparicio	3	7	55	125
11	9	9:10	AJP Aparicio	3	9	55	145
12	9	9:10	AJP Aparicio	3	5	35	85
14	9	10:35	AJP Aparicio	3	5	19	69
17	9	12:20	AJP Aparicio	3	7	21	91
18	9	8:15	JM Vaquero	2	5	16	66
23	9	11:20	JM Vaquero	3	7	27	97
24	9	12:15	AJP Aparicio	3	5	20	70
25	9	9:25	AJP Aparicio	4	8	42	122
26	9	10:15	AJP Aparicio	4	6	51	111
27	9	15:55	JM Vaquero	3	6	74	134
28	9	11:00	AJP Aparicio	3	8	91	171
29	9	9:50	AJP Aparicio	4	9	69	159

30	9	9:45	AJP Aparicio	2	8	37	117
1	10	9:10	AJP Aparicio	4	7	42	112
2	10	10:30	N Bravo	4	7	32	102
3	10	9:40	AJP Aparicio	4	7	18	88
6	10	9:15	AJP Aparicio	4	4	14	54
7	10	10:50	AJP Aparicio	3	6	14	74
7	10	11:30	L Bautista	3	6	10	70
14	10	9:45	AJP Aparicio	3	5	16	66
14	10	11:20	L Bautista	2	3	8	38
17	10	9:55	AJP Aparicio	4	4	5	45
18	10	11:30	AJP Aparicio	4	3	14	44
19	10	10:30	AJP Aparicio	3	4	24	64
20	10	11:20	AJP Aparicio	4	5	64	114
21	10	9:35	AJP Aparicio	3	4	65	105
21	10	11:30	L Bautista	3	4	50	90
22	10	10:15	AJP Aparicio	4	5	74	124
23	10	9:55	AJP Aparicio	4	5	71	121
24	10	10:15	AJP Aparicio	4	6	74	134
27	10	10:10	AJP Aparicio	5	5	62	112
29	10	10:20	AJP Aparicio	4	6	30	90
30	10	10:15	AJP Aparicio	4	9	14	104
31	10	10:40	AJP Aparicio	3	7	8	78
2	11	17:00	JM Vaquero	2	6	17	77
4	11	11:40	AJP Aparicio	3	8	20	100
4	11	12:45	L Bautista	3	8	16	96
5	11	10:30	AJP Aparicio	4	8	38	118
6	11	9:30	N Bravo	3	5	27	77
6	11	10:15	AJP Aparicio	3	5	37	87
9	11	13:00	JM Vaquero	2	5	27	77
10	11	9:15	L Paniagua/D Duarte	2	3	9	39
10	11	10:20	AJP Aparicio	3	4	30	70
11	11	10:45	R Valero/E Polo	2	3	14	44
12	11	10:30	AJP Aparicio	4	4	34	74
17	11	12:10	AJP Aparicio	2	7	22	92
18	11	11:15	AJP Aparicio	3	4	25	65
21	11	11:15	AJP Aparicio	3	5	31	81
23	11	10:40	AJP Aparicio	2	4	32	72
24	11	12:10	JM Vaquero	3	6	33	93
26	11	12:20	L Bautista	3	7	23	93
1	12	9:30	L Paniagua/D Duarte	4	7	23	93
1	12	11:40	AJP Aparicio	4	9	50	140
2	12	10:20	R Valero/D Duarte	3	6	17	77
2	12	11:00	AJP Aparicio	3	6	25	85
4	12	12:30	L Valadés/A Flores	3	3	8	38
4	12	13:00	AJP Aparicio	2	3	12	42



5	12	13:15	AJP Aparicio	3	5	9	59
6	12	13:30	JM Vaquero	2	3	6	36
7	12	13:50	JM Vaquero	2	3	10	40
8	12	12:05	JM Vaquero	3	3	13	43
10	12	12:30	L Bautista	3	5	19	69
10	12	14:05	AJP Aparicio	4	5	28	78
11	12	11:50	AJP Aparicio	3	7	30	100
11	12	12:15	A Flores/L Valadés	3	6	12	72
15	12	9:25	L Paniagua/D Duarte	3	9	17	107
15	12	11:35	AJP Aparicio	4	9	56	146
16	12	11:15	AJP Aparicio	5	9	81	171
21	12	13:05	JM Vaquero	3	8	48	128
22	12	13:40	JM Vaquero	4	9	45	135
23	12	12:50	JM Vaquero	3	8	21	101
25	12	13:20	JM Vaquero	3	7	20	90
26	12	12:20	JM Vaquero	3	5	14	64
28	12	13:45	JM Vaquero	2	7	17	87
30	12	13:45	JM Vaquero	2	7	24	94

Total number of observations: 233

Total number of days with a record: 216

Table 2. Daily, monthly and yearly values of number of groups ( $G$ ) in 2014.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		3			3	4			5	7		9
2		4				4			5	7	6	6
3				8		4	7		5	7		
4						4	9		6		8	3
5	7		9		8	4	10		6		8	5
6			6	7	9	4				4	5	3
7			7	9		6	14			6		3
8	4		6	9	7	5	10					3
9	4				9	6	9	4	8		5	
10	5	8	5	3	8	6	9	3	7		4	5
11	8		5	4	9	8	9	4	9		3	7
12			5		8	11	6	5	5		4	
13	8	7	6		8	10	5					
14	6		6		9	6	4	2	5	5		
15			7	9	7	4	1	5				9
16	6	3			9	5	0					9
17		6	7			8	0		7	4	7	
18			7			8	1	6	5	3	4	
19	8	5	8			6		6		4		
20	10		7			6		6		5		
21		5				7	1	6		4	5	8
22	10		9	7		7	3	6		5		9
23	9	6	7			6	4		7	5	4	8
24		6		5		3	5		5	6	6	
25	7			4	6	3	3	5	8			7
26	4	11	5		5	4		5	6		7	5
27			7	4	4	4		5	6	5		
28	5			5	4	3		5	8			7
29	5			5	3			5	9	6		
30	5			5	4	8		5	8	9		7
31					2			4		7		
Monthly mean	6.5	5.8	6.6	6.0	6.4	5.7	5.5	4.8	6.5	5.5	5.4	6.3
Yearly mean	5.9											

Table 3. Daily, monthly and yearly values of number of spots (*S*) in 2014.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		43			21	9			29	42		50
2		54				12			32	32	17	25
3				38		13	48		27	18		
4						9	89		27		20	12
5	45		36		45	16	66		23		38	9
6			16	23	29	28				14	37	6
7			30	33		38	77			14		10
8	62		18	24	22	50	66					13
9	79				27	56	64	20	53		27	
10	29	47	42	6	19	57	64	13	55		30	28
11	37		50	11	31	60	49	14	55		14	30
12			47		51	51	29	17	35		34	
13	26	59	36		21	59	13					
14	23		33		60	25	12	16	19	16		
15			18	45	39	18	1	33				56
16	10	35			25	18	0					81
17		31	27			26	0		21	5	22	
18			18			21	3	30	16	14	25	
19	18	21	31			9		20		24		
20	37		40			19		23		64		
21		44				13	4	28		65	31	48
22	44		28	43		12	9	31		74		45
23	37	62	32			9	8		27	71	32	21
24		46		13		4	11		20	74	33	
25	21			6	31	15	12	34	42			20
26	11	51	36		19	13		29	51		23	14
27			31	5	15	7		14	74	62		
28	23			21	7	4		12	91			17
29	31			18	6			12	69	30		
30	30			25	10	25		23	37	14		24
31					4			23		8		
Monthly mean	33.1	44.8	31.6	22.2	25.4	24.0	31.3	21.8	40.2	35.6	27.4	28.3
Yearly mean	30.5											

Table 4. Daily, monthly and yearly values of Wolf number ( $SN_{UEX}$ ) in 2014.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		73			51	49			79	112		140
2		94				52			82	102	77	85
3				118		53	118		77	88		
4						49	179		87		100	42
5	115		126		125	56	166		83		118	59
6			76	93	119	68				54	87	36
7			100	123		98	217			74		40
8	102		78	114	92	100	166					43
9	119				117	116	154	60	133		77	
10	79	127	92	36	99	117	154	43	125		70	78
11	117		100	51	121	140	139	54	145		44	100
12			97		131	161	89	67	85		74	
13	106	129	96		101	159	63					
14	83		93		150	85	52	36	69	66		
15			88	135	109	58	11	83				146
16	70	65			115	68	0					171
17		91	97			106	0		91	45	92	
18			88			101	13	90	66	44	65	
19	98	71	111			69		80		64		
20	137		110			79		83		114		
21		94				83	14	88		105	81	128
22	144		118	113		82	39	91		124		135
23	127	122	102			69	48		97	121	72	101
24		106		63		34	61		70	134	93	
25	91			46	91	45	42	84	122			90
26	51	161	86		69	53		79	111		93	64
27			101	45	55	47		64	134	112		
28	73			71	47	34		62	171			87
29	81			68	36			62	159	90		
30	80			75	50	105		73	117	104		94
31					24			63		78		
Monthly mean	98.4	103.0	97.7	82.2	89.6	80.6	86.3	70.1	105.2	90.6	81.6	91.1
Yearly mean	89.7											
Observed days	17	11	18	14	19	29	20	18	20	18	14	18
Total observed days	216											

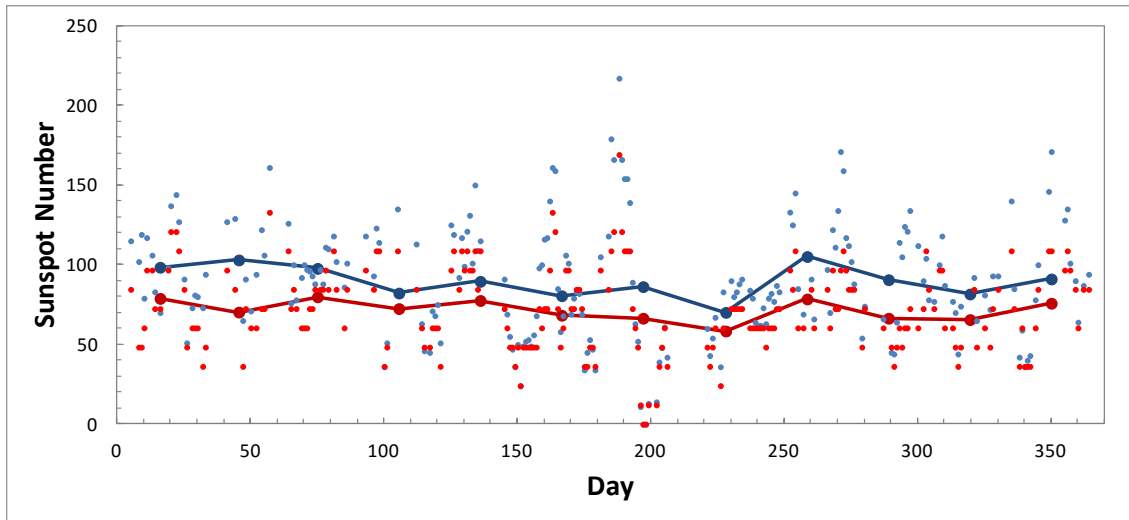


Figure 1. Daily (small dots) and monthly (big dots and lines)  $SN_{UEX}$  (blue) and  $GSN_{UEX}$  (red) values in 2014.

### Relationship with the reference sunspot 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).

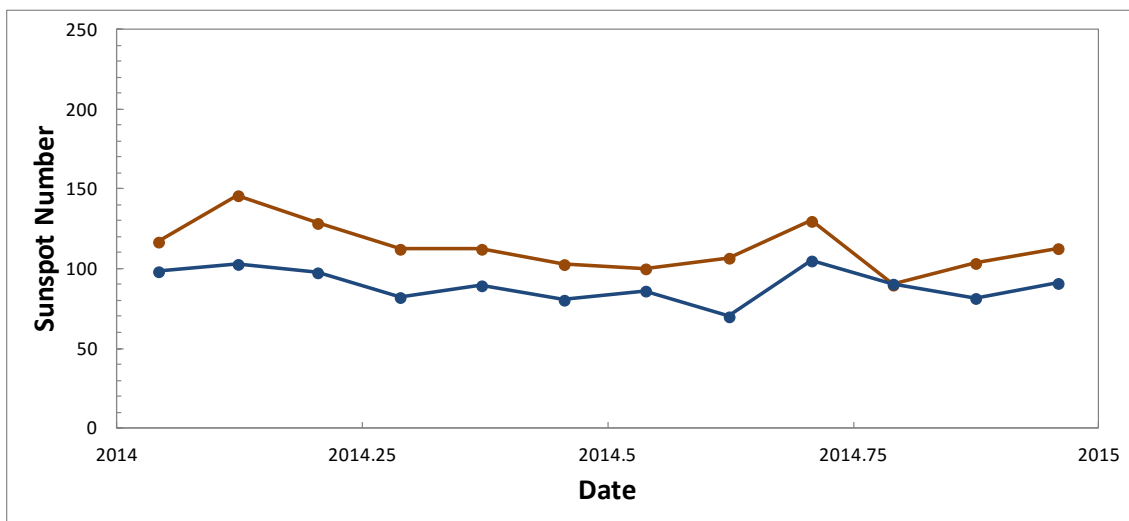


Figure 2. Monthly  $SN_{UEX}$  (blue) and  $S_N$  (brown) values in 2014.

Figure 3 shows a scatter plot of daily  $SN_{UEX}$  versus  $S_N$  values for those values corresponding to 2014. Here is the linear fit equation:

$$SN_{UEX} = (0.85 \pm 0.03) S_N + (-3.5 \pm 2.9) \quad (r = 0.916; p\text{-value} < 0.001)$$

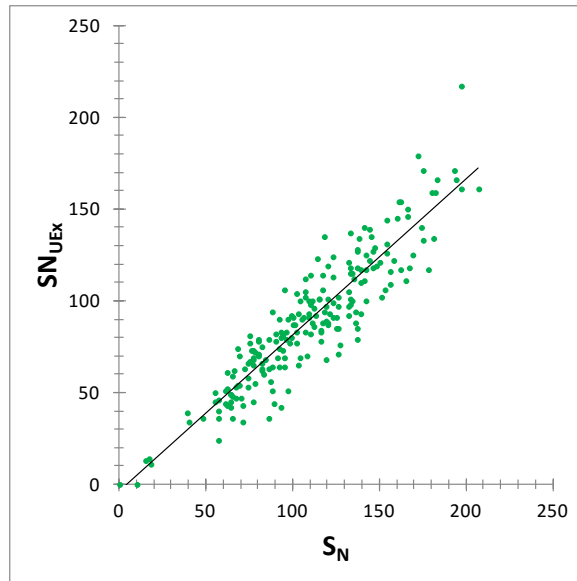


Figure 3. Scatter plot of daily  $SN_{UEX}$  versus  $S_N$  values in 2014.

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### References

- Clette, F., Svalgaard, L., Vaquero, J.M., Cliver, E.W.: 2014, *Space Sci. Rev.* **186**, 35. DOI: 10.1007/s11214-014-0074-2.
- SILSO, World Data Center - Sunspot Number and Long-term Solar Observations, Royal Observatory of Belgium, on-line Sunspot Number catalogue: <http://www.sidc.be/silso/>, '2014'.
- Vaquero, J.M.: 2007, *Adv. Space Res.* **40**, 929.