# Re-examination of the Daily Number of Sunspot Groups for the Royal Greenwich Observatory (1874 – 1885)

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# The International Sunspot Number (R<sub>1</sub>)

The International (or Wolf, or Zürich) Sunspot Number, R<sub>1</sub>, is defined as follows:

 $R_{I} = k(10 \times G + S)$ ,

where G is the number of sunspot groups;S is the number of individual spots; andk is the observer's personal correction factor.

# The Group Sunspot Number (R<sub>G</sub>)

Hoyt and Schatten (1998a,b) defined a sunspot index called the Group Sunspot Number, *R<sub>G</sub>*, defined as follows:

$$R_G = (12.08/N)\Sigma k_i'G_{i,j}$$

where G<sub>i</sub> is the number of sunspot groups recorded by the *i*-th observer;

k<sub>i</sub>' is the *i*-th observer's correction factor;

N is the number of observers used to form the daily value;

# The Group Sunspot Number (R<sub>G</sub>)

and

12.08 is a normalisation number chosen to make the mean value of  $R_G$  equal to the mean value of  $R_I$  for the interval 1874 – 1976, during which the RGO was acquiring and publishing solar data.

## The Importance of the RGO Observations in Calculating Group Sunspot Numbers

12.08 is a normalisation number chosen to make the mean value of  $R_G$  equal to the mean value of  $R_I$  for the interval 1874 – 1976, during which the RGO was acquiring and publishing solar data.

The symbol  $k_i'$  represents the *i*-th observer's correction factor, which is required to place each observer on the same scale as the RGO.

The correction factor for the primary RGO "standard observer" is defined to be 1.000.

### The Importance of the RGO Observations in Calculating Group Sunspot Numbers

A correction factor for each individual observer is formed by dividing the total number of sunspot groups seen by the RGO "standard observer" by the total number of sunspot groups seen by the comparison observer.

The ratio is limited to those days for which both observers saw one or more sunspots. This ratio is k'.

## The Importance of the RGO Observations in Calculating Group Sunspot Numbers

- The quality of the comparison is defined as being equal to the number of inter-comparison days divided by the quantity |(1 k')|.
- Thus a high-quality secondary observer is one for whom many comparisons can be made with the primary observer (RGO) and whose measurements are most similar to those by the primary RGO observer.
- If the value of k' for a secondary observer (or any higher-order observer) is less than 0.6 or greater than 1.4, that observer is not used for any inter-comparisons.

# **The RGO Printed Publications**

- The RGO published the measured positions and areas of individual sunspots or distinct groups of sunspots in a series of printed publications that constitute the *Greenwich Photo-heliographic Results (GPR) 1874 – 1976*:
- Greenwich Observations (1874 1955)
- Royal Greenwich Observatory Bulletins (1956 1961)
- Royal Observatory Annals (1962 1976)

# **The RGO Printed Publications**

The RGO printed publications are divided into three main sections:

- "<u>Measures</u> of the Positions and Areas of Sun Spots and Faculae on Photographs Taken at [List of the Relevant Solar Observatories] With the Deduced Heliographic Longitudes and Latitudes." [Footnotes give the duration and type of each group.]
- "<u>Ledgers</u> of Areas and Positions of Groups of Sun Spots Deduced From the Measurement of the Solar Photographs for Each Day in the Year [e.g., 1884]."
- "<u>Total</u> Projected <u>Areas</u> of Sun Spots and Faculae for Each Day in the Year [e.g., 1884]."

### **The RGO Printed Publications: Measures**

- The <u>Greenwich Civil Time</u> at which the Photograph was taken is expressed by the Day of the Year and decimals of a day, reckoning from Midnight, January 1<sup>d</sup> 0<sup>h</sup>. For convenience of reference, the Month and Day of the Month (Civil Reckoning) are added.
- The areas of Spots and Faculae are expressed in Millionths of the Sun's visible Hemisphere. [These values have been corrected for foreshortening.]

### The RGO Printed Publications: Ledgers

The <u>Greenwich Civil Time</u> at which the photograph was taken is expressed by the month, day of the month (civil reckoning), and decimal of a day, reckoned from Greenwich Mean Midnight.

The Projected Area of the Umbrae and Whole Spots is the area as it is measured on the photograph, uncorrected for the effect of foreshortening, and expressed in millionths of the Sun's apparent disk.

### The RGO Printed Publications: Ledgers

Dates for which the decimal [part] of the day is not given indicate days for which no photographic record is at present available [1907]. In these cases the means have been taken of the areas and positions of the spot-groups as measured on the day immediately preceding, and that immediately following the day for which the photograph is lacking. These interpolated values are enclosed in brackets, but are used in taking the final means for each spot-group.

## The RGO Printed Publications: <u>Total</u> Projected <u>Areas</u> (1874 – 1877)

The Projected Area is the area as it is measured on the photograph, uncorrected for foreshortening, and expressed in millionths of the Sun's apparent disk.

The <u>Greenwich Civil Time</u> is expressed by the month, day of the month (civil reckoning), and decimal [part] of a day, reckoned from Greenwich Mean Midnight. <u>The decimal [part] of the day has not</u> <u>been given for days when neither spots nor faculae</u> <u>were observed on the photographs.</u>

## The RGO Printed Publications: <u>Total</u> Projected <u>Areas</u> (1874 – 1877)

The dates for which no photographic record is at present available are indicated by the words "No photograph". As these are numerous in the present table [1874 – 1877], no attempt has been made to supply approximate numbers for them by interpolation from the days immediately before and after those for which photographs are lacking.

## The RGO Printed Publications: <u>Total</u> Projected <u>Areas</u> (1878 – 1885)

Dates for which the areas are given in brackets indicate days for which no photographic record is at present available [1878 – 1885]. In these cases the areas have been obtained by interpolation from the measures of photographs taken on days immediately preceding and following the day for which the photograph is lacking. These interpolated values have been used in taking the mean daily areas for each rotation and for each year, given in the last section of this volume [Section 4].

### Supplementary Results: 1874 – 1885 (Published 1907)

### 1874 то 1885 BEING SUPPLEMENTARY RESULTS FROM PHOTOGRAPHS OF THE SUN TAKEN AT GREENWICH, AT HARVARD COLLEGE, U.S.A., AT MELBOURNE, IN INDIA, AND IN MAURITIUS IN THE YEARS 1874 то 1885: AND MEASURED AND REDUCED AT THE ROYAL OBSERVATORY, GREENWICH, UNDER THE DIRECTION OF SIR W. H. M. CHRISTIE, K.C.B., M.A., D.Sc., F.R.S., ASTRONOMER-ROYAL. (APPENDIX TO THE GREENWICH OBSERVATIONS, 1905.) EDINBURGH: PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE

BY NEILL & CO., LIMITED, BELLEVUL

## **Measures Section: April 1874**

		for	· smr	in's	HELIOG	RAPHIC	SPO	TS.	FACULÆ.
Greenwich Civil Time.	Measurers.	No. of Group, and Letter Spot.	Distance from Centre in tel of Sun's Radius.	Position Angle from St Axis.	Longitude.	Latitude.	Area of UMBRA for each Spot (and for Day).	Area of WHOLE for each Spot (and for Day).	Area for each Group (and for Day).
1874. 106 <sup>.</sup> 485 Apr. 17	јв, в	82 Centre	0.388	° 61·2	。 113 <sup>.</sup> 3 (133 <sup>.</sup> 2)	+ 5 <sup>.8</sup> (- 5 <sup>.3</sup> )	0 (0)	113 (113)	(0)
107·506 Apr. 18	JB, B	82 Centre	0.510	26.7	114 <b>·3</b> (119·7)	+ 5.6 (-5.2)	0 (0)	60 (60)	(0)
116.556 Apr. 27	JB, B	83 Centre	0.899	101.2	296·0 (0·1)	-12.4 (-4.4)	0 (0)	17I (17I)	(0)
117 <sup>.</sup> 574 Apr. 28	м, м	83 Centre	0.766	102.6	297°0 (346°7)	-12.4 (-4.3)	4 <sup>I</sup> (4 <sup>I</sup> )	22 I (22 I)	(0)
118.663 Apr. 29	м, м	83 Centre	0.294	105.8	296·6 (332·3)	-12.6	33 (33)	189 (189)	(0)
119'577 Apr. 30	ЈВ, В	83 84 Centre	0.428 0.284	112°1 316•8	296·3 331·5 (320·2)	-13.0 + 7.9 (-4.1)	40 0 (40)	205 24 (229)	(0)

# **Ledgers Section: April 1874**



## **Total Areas Section: April 1874**

Greenwich		Projected Areas.						
Civil	Time.	Umbræ.	Whole Spots.	Faculæ.				
187	74. d		14					
Apr.	17.5	0	208	0				
	18.5	0	117	0				
	19	No	photo	graph.				
	20	0	0	0				
	2 I	0	0	0				
	22	0	0	0				
	23	0	0	0				
	24	No	photo	graph.				
	25	No	photo	graph.				
	26	No	photo	graph.				
	27.6	0	150	0				
and the second	28.6	53	285	0				
	29.7	53	306	. 0				
	30.0	72	415	0				
	-	a series and	a farmer and a start	1 martine the state				

### Errata Section: 1874 – 1877

MEASURES OF POSITIONS AND AREA OF SUN SPOTS AND FACULÆ ON PHOTOGRAPHS TAKEN IN THE YEARS, 1874-1877.

Photographs taken on the following additional dates show neither Spots nor Faculæ :---

1874, April 20, 21, 22, 23. June 8, 9. October 26, 27, 29. December 3. 1875, January 28. February 15, 16. 1876, March 3. September 12, 20. November 24, 27, 30. December 1, 2, 7, 12, 14. 1877, May 30. June 12, 17, 18, 19, 20, 21, 22. July 6, 7, 13, 24, 25, 26, 29. August 9, 12, 16, 17, 18, 20, 21. September 22. October 2, 3, 8, 9, 11, 12, 15, 16, 18, 20. November 20. December 28.

### Interpretation of the RGO Results: Number of Sunspot Groups (2012 Talk)

Date	Group No.	Measures	Ledgers	Total Areas	H&S	W&W
1874 Apr 17	82	1	1	[1]	1	1
1874 Apr 18	82	1	1	[1]	1	1
1874 Apr 19	No entry	No entry	No entry	No photo	-99	-99
1874 Apr 20	No entry	No entry	No entry	U=0,W=0,F=0	-99	0
1874 Apr 21	No entry	No entry	No entry	U=0,W=0,F=0	-99	0
1874 Apr 22	No entry	No entry	No entry	U=0,W=0,F=0	0	0
1874 Apr 23	No entry	No entry	No entry	U=0,W=0,F=0	0	0
1874 Apr 24	No entry	No entry	No entry	No photo	0	-99
1874 Apr 25	No entry	No entry	No entry	No photo	-99	-99
1874 Apr 26	No entry	No entry	No entry	No photo	-99	-99
1874 Apr 27	83	1	1	[1]	1	1
1874 Apr 28	83	1	1	[1]	1	1
1874 Apr 29	83	1	1	[1]	1	1

RGO Publications Used in the Present Investigation (1874 – 1885)

- Greenwich Photo-heliographic Results 1874 1885 (1907). Includes Supplementary Results, and Errata and Additions.
- Publication of the Solar Physics Committee 1878 1881 (1891). Includes Additional Results.
- 3. Greenwich Photo-heliographic Results 1882.
- 4. Greenwich Photo-heliographic Results 1883.
- 5. Greenwich Photo-heliographic Results 1884.
- 6. Greenwich Photo-heliographic Results 1885.

### Supplementary Results: 1874 – 1885 (Published 1907)



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### Additional Publication by the Solar Physics Committee (1891)



## Greenwich Photo-heliographic Results 1882, 1883, 1884, 1885

### Solar Observatories Contributing to the Greenwich Photoheliographic Results (1874 Apr 17 – 1885 Dec 31)

Solar Observatory	New Code	Number of Photographs (Days)
Dehra Dun, Uttar Pradesh, India	DHRA	1127
Royal Greenwich Observatory, London, UK	GREN	1988
Harvard College Observatory, Cambridge, MA, USA	HARV	112
Royal Alfred Observatory, Pamplemousses, Mauritius	MAUR	172
Melbourne Observatory, Victoria, Australia	MELB	161
Photograph Acquired but Observatory Unknown	UNKN	61
No Photograph Acquired	NONE	656
TOTAL		4277

Solar Image for 1905 Nov 3 (probably from Greenwich). Boundary Contours of Groups are Delineated. Groups are not Numbered.



Solar Image for 1918 Feb 26 from the Cape. Boundary Contours of Groups are Delineated and Numbered. Groups are also Numbered. Note Group No. 861k.



### **Greenwich Photo-heliographic Results 1918**

### Positions and Areas of Sun Spots and Faculae for Each Day in the Year 1918

Column 2 (in the printed results) is defined as follows:

Number of Spot Group in order of appearance and in continuation of the Group-numbers given in previous years.

Groups seen on one day only are distinguished by the number of the [Carrington] Rotation during which they were observed and by a letter given in the order of their appearance.

The presence of 861k on the contact print for 1918 February 26 implies that 11 distinct groups existed for just one day during Carrington Rotation 861.

# Number of RGO Solar Photographs Available (2012 Talk)

Year	No. of Photographs	Days	Coverage (%)	Year	No. of Photographs	Days	Coverage (%)
1874	141	259	54	1885	359	365	98
1875	263	365	72	1886	363	365	99
1876	271	366	74	1887	361	365	99
1877	235	365	64	1888	359	366	98
1878	347	365	95	1889	360	365	99
1879	318	365	87	1890	361	365	99
1880	341	366	93	1891	363	365	99
1881	348	365	95	1892	362	366	99
1882	343	365	94	1893	362	365	99
1883	340	365	93	1894	364	365	100
1884	315	366	86	1895	364	365	100

### Number of Days Per Calendar Month for which No Photograph was Acquired

Year						Mo	nth						Total
	J	F	Μ	А	Μ	J	J	А	S	0	Ν	D	
1874	_	-	_	4	15	12	10	11	13	16	15	22	118
1875	20	6	1	3	6	6	5	7	7	11	11	19	102
1876	13	9	3	3	4	6	6	6	9	11	10	15	95
1877	7	13	12	11	10	8	9	13	13	12	8	14	130
1878	6	3	2	0	3	0	2	2	0	0	0	0	18
1879	1	2	0	4	4	5	6	8	4	5	5	3	47
1880	3	1	0	2	0	2	5	3	1	1	1	6	25
1881	2	1	1	1	0	4	4	3	1	0	0	0	17
1882	5	2	0	1	0	2	3	6	3	0	0	0	22
1883	3	0	1	1	1	0	7	4	3	0	1	4	25
1884	3	4	3	2	2	8	16	3	5	2	2	1	51
1885	2	0	0	0	2	1	0	1	0	0	0	0	6
Total	65	41	23	32	47	54	73	67	59	58	53	84	656

### Number of Occurrences Per Calendar Month of a Sunspot Group Being Seen on Just a Single Day

Year						Mor	nth						Total
	J	F	Μ	А	Μ	J	J	А	S	0	Ν	D	
1874	_	_	—	0	0	0	0	0	0	0	0	0	0
1875	1	0	1	0	1	1	1	1	1	0	0	0	7
1876	0	0	0	3	0	0	0	0	0	0	1	0	4
1877	0	0	0	0	0	0	0	0	1	0	0	0	1
1878	0	2	0	1	0	1	1	0	0	0	0	0	5
1879	0	0	0	1	0	0	0	0	0	0	1	0	2
1880	4	1	0	1	3	1	1	3	1	8	8	0	31
1881	2	5	6	6	8	2	5	5	2	3	9	5	58
1882	2	9	6	4	6	7	2	3	2	1	4	6	52
1883	8	6	1	4	9	7	4	2	3	4	4	4	56
1884	7	2	9	6	4	1	2	3	4	5	4	2	49
1885	3	3	4	5	5	3	4	6	3	2	2	6	46
Total	27	28	27	31	36	23	20	23	17	23	33	23	311

### Format of the New Dataset: Part 1 (LHS)

Date YYYY-MM-DD	Obser. Code	No. Groups (Measures)	No Groups (Ledgers)	Total Areas (Projected)	No. Groups (WWW)	No. Groups (H&S)
1874–04–17	GREN	1	1	U=0, W=208,F=0	1	1
1874–04–18	GREN	1	1	U=0,W=117,F=0	1	1
1874–04–19	NONE	-99	-99	No photograph	-99	-99
1874–04–20	UNKN	0	-99	U=0,W=0,F=0	0	-99
1874–04–21	UNKN	0	-99	U=0,W=0,F=0	0	-99
1874–04–22	UNKN	0	-99	U=0,W=0,F=0	0	0
1874–04–23	UNKN	0	-99	U=0,W=0,F=0	0	0
1874–04–24	NONE	-99	-99	No photograph	-99	0
1874–04–25	NONE	-99	-99	No photograph	-99	-99
1874–04–26	NONE	-99	-99	No photograph	-99	-99
1874–04–27	GREN	1	1	U=0,W=150,F=0	1	1
1874–04–28	GREN	1	1	U=53,W=285,F=0	1	1
1874–04–29	GREN	1	1	U=53,W=306,F=0	1	1
1874–04–30	GREN	2	2	U=72,W=415,F=0	2	2

### Errata Section: 1874 – 1877

MEASURES OF POSITIONS AND AREA OF SUN SPOTS AND FACULÆ ON PHOTOGRAPHS TAKEN IN THE YEARS, 1874-1877.

Photographs taken on the following additional dates show neither Spots nor Faculæ :---

1874, April 20, 21, 22, 23. June 8, 9. October 26, 27, 29. December 3. 1875, January 28. February 15, 16. 1876, March 3. September 12, 20. November 24, 27, 30. December 1, 2, 7, 12, 14. 1877, May 30. June 12, 17, 18, 19, 20, 21, 22. July 6, 7, 13, 24, 25, 26, 29. August 9, 12, 16, 17, 18, 20, 21. September 22. October 2, 3, 8, 9, 11, 12, 15, 16, 18, 20. November 20. December 28.

### Format of the New Dataset: Part 2 (RHS)

Date YYYY-MM-DD	Sunspot Numbers	Comments
1874–04–17	82	
1874–04–18	82	
1874–04–19	(No photograph)	
1874–04–20	(No spots)	Photographs taken on these days at an unknown
1874–04–21	(No spots)	observatory show neither Spots nor Faculae; see page xxii of the Errata and Additions in the <i>Greenwich Photo</i> -
1874–04–22	(No spots)	heliographic Results 1874–1885 (Royal Observatory,
1874–04–23	(No spots)	Supplementary Results (1907) in the dataset.]
1874–04–24	(No photograph)	
1874–04–25	(No photograph)	
1874–04–26	(No photograph)	
1874–04–27	83	
1874–04–28	83	
1874–04–29	83	
1874–04–30	83, 84	

### Format of the New Dataset: Part 1 (LHS)

Date YYYY-MM-DD	Obsr. Code	No. Groups (Measures)	No Groups (Ledgers)	Total Areas (Projected)	No. Groups (WWW)	No. Groups (H&S)
1884–07–19	DHRA	5	5	U=39,W=296,F=1470	5	5
1884–07–20	DHRA	5	5	U=44,W=296,F=1439	5	5
1884–07–21	NONE	-99	NP	No photograph	-99	3
1884–07–22	NONE	-99	NP	No photograph	-99	3
1884–07–23	NONE	-99	NP	No photograph	-99	3
1884–07–24	GREN	3	3	U=111,W=702,F=581	3	3
1884–07–25	GREN	3	3	U=125,W=684,F=613	3	3
1884–07–26	DHRA	5	5	U=125,W=856,F=1142	5	5
1884–07–27	DHRA	5	5	U=96,W=742,F=1138	5	5
1884–07–28	NONE	-99	NP	No photograph	-99	2
1884–07–29	NONE	-99	NP	No photograph	-99	2
1884-07-30	NONE	-99	NP	No photograph	-99	2
1884–07–31	DHRA	5	5	U=154,W=1269,F=1128	5	5

### Format of the New Dataset: Part 2 (RHS)

Date YYYY-MM-DD	Sunspot Numbers	Comments				
1884–07–19	1427, 1434, 1435, 1436, 1437					
1884–07–20	1434, <mark>1436, 1437, 1438</mark> , 1439					
1884–07–21	(No photograph)	Since 1436, 1437 and 1438 still exist on				
1884–07–22	(No photograph)	1874–07–24, Hoyt and Schatten assume the Sunspot Group Number is <b>3</b> .				
1884–07–23	(No photograph)	This is clearly just a lower limit.				
1884–07–24	1436, 1437, 1438					
1884–07–25	1436, 1437, 1438					
1884–07–26	1436, 1437, 1438, 1440, 1441					
1884–07–27	1436, 1438, <mark>1440</mark> , <mark>1441</mark> , 1442					
1884–07–28	(No photograph)	Since 1440 and 1441 still exist on 1874–				
1884–07–29	(No photograph)	07–31, Hoyt and Schatten assume the Sunspot Group Number is <b>2</b> .				
1884–07–30	(No photograph)	This is clearly just a lower limit.				
1884–07–31	<mark>1440, 1441</mark> , 1443, 1444, 1445					

## Extracted from RGO Ledgers: Group 149\* (1875 March)

Date Greenwich	Projected Area of		Area for Group.		Mean Long.	Mean Lat.	Long. from
Civil Time.	Umbra.	Whole Spot.	Umbra.	Whole Spot.	of Group.	of Group.	Central Meridian.
Mar. 10.528	15	135	20	182	67.4	-6.8	-69.0
Mar. 11.597	36	245	31	213	67.1	-7.0	-55.2
Mar. 12.680	12	120	8	79	66.7	-7.8	-41.3
Mar. 13.060	26	176	16	108	67.4	-7.1	-35.6
Mar. 14.644	0	27	0	14	66.9	-7.8	-15.2
Mar. 15.584	0	0	0	0			
Mar. 16.127	0	20	0	10	66.0	-9.8	+3.5
Means			11	87	66.92	-7.72	

Footnote: March 10 – 16. One spot, regular in shape. It has divided into two parts by March 12, and is not seen on March 15. (No explanation is given)

## Extracted from RGO Ledgers: Group 174 (1875 September/October)

Date Greenwich	Proje Area	cted a of	Area Gro	a for oup.	Mean Long.	Mean Lat.	Long. from	
Civil Time.	Umbra.	Whole Spot.	Umbra.	Whole Spot.	of Group.	of Group.	Central Meridian.	
Sept. 29.467	0	46	0	28	1.3	-15.2	+27.1	
Sept. 30.471	0	19	0	14	3.8	-15.8	+42.8	
Oct. 1.065	0	0	0	0				
Oct. 2.423	0	12	0	20	4.9	-14.9	+69.7	
Means		•••	0	16	3.33	-15.30		

Footnote: September 29 – October 2. One small spot. The photograph on October 1 is too dense for the group to be seen. (An explanation is given)

## Extracted from RGO Ledgers: Group 365 (1880 September)

Date Greenwich	Proje Area	cted a of	Area Gro	a for oup.	Mean Long.	Mean Lat.	Long. from Central Meridian.	
Civil Time.	Umbra.	Whole Spot.	Umbra.	Whole Spot.	of Group.	of Group.		
Sept. 20.483	0	25	0	18	53.3	+23.7	-45.4	
Sept. 21.214	0	0	0	0				
Sept. 22.530	0	0	0	0				
Sept. 23.285	0	0	0	0				
Sept. 24.412	0	0	0	0				
Sept. 25.436	0	8	0	5	57.7	+22.3	+24.4	
Sept. 26.300	0	22	0	14	57.3	+21.4	+35.4	
Means			0	5	56.10	+22.47		

Footnote: September 20 – 26. A small faint spot, not seen from September 21 to 24. (No explanation is given) Number of Daily Occurrences Per Calendar Month of a Sunspot Group Not Being Seen on One or More Days Within a Longer Sequence of Days of Continual Observation (No Reason Given)

Year	Month								Total				
	J	F	Μ	А	Μ	J	J	А	S	0	Ν	D	
1874	_	_	—	0	0	0	0	0	0	0	0	0	0
1875	0	0	1	0	0	0	0	0	0	0	0	0	1
1876	0	0	0	0	0	0	0	0	0	0	0	0	0
1877	0	0	0	0	0	0	0	0	0	0	0	0	0
1878	0	0	0	0	0	0	0	0	0	0	0	0	0
1879	0	0	0	0	0	0	0	0	0	0	0	0	0
1880	0	0	0	0	0	1	0	0	11	4	5	0	21
1881	0	0	2	10	1	1	2	1	0	1	2	3	23
1882	0	1	3	1	0	0	3	0	0	2	1	0	11
1883	0	0	0	0	0	0	0	0	0	1	0	1	2
1884	0	0	0	0	0	0	0	0	1	2	0	1	4
1885	0	0	6	1	1	0	0	0	0	0	3	1	12
Total	0	1	12	12	2	2	5	1	12	10	11	6	74

### Number of Days Per Calendar Month With Measured Data (Photographs) (WWW) and With "Interpolated Data" Included (H&S)



### Monthly Means and Standard Errors (1874 – 1885) (WWW) and (H&S) [Top: No. of Days With No Photograph]



# The Group Sunspot Number (R<sub>G</sub>)

Hoyt and Schatten (1998a,b) defined a sunspot index called the Group Sunspot Number,  $R_G$ , defined as follows:

 $R_{G} = (12.08/N)\Sigma k_{i}'G_{i}$ 

where  $G_i$  is the number of sunspot groups recorded by the *i*th observer. Thus far, we have only discussed  $G_{RGO}$  for the restricted interval 1874 April 17 – 1885 December 31;

 $k_i'$  is the *i*-th observer's correction factor ( $k_{RGO}' = 1.000$ );

*N* is the number of observers used to form the daily value;

## The Group Sunspot Number (R<sub>G</sub>)

### and

**12.08** is a normalisation number chosen to make the mean value of  $R_G$  equal to the mean value of  $R_I$  for the interval 1874 April 17 – 1976 December 31, during which the RGO was acquiring and publishing solar data.

### Observations of Sunspots by Robert Main at the Radcliffe Observatory, Oxford, in the Years 1874 and 1875 (Observer 334 in the Hoyt and Schatten List)



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### Observation of Sunspots by Robert Main on 1874 Nov. 19(d) 22h 30m



### Observations of Sunspots by Robert Main on 1874 Dec. 17(d) at 0h 0m and at 23h 15m



### Observations of Sunspots by Robert Main During the Interval 1875 May 9(d) 23h 30m – May 22(d) 1h 0m

Day and Hour, 1875.	No. of Group.	Remarks.
d. h. m. May 9 23 30 to 22 I 0		The surface of the sun was minutely scrutinised on May 9, 23 <sup>h</sup> 30 <sup>m</sup> ; 10, 23 <sup>h</sup> 30 <sup>m</sup> ; 11, 23 <sup>h</sup> ; 12, 23 <sup>h</sup> ; 13, 23 <sup>h</sup> ; 14, 23 <sup>h</sup> 30 <sup>m</sup> ; 16, 23 <sup>h</sup> ; 20, 23 <sup>h</sup> ; 22, 1 <sup>h</sup> , and in each case no spots whatever could be seen; but on May 14, 23 <sup>h</sup> 30 <sup>m</sup> , I noticed some bright faculæ near the north and south points of the sun. The circumstances were generally favourable, except on May 20, 23 <sup>h</sup> , when thin cloud covered the sky.

# Conclusions

Hoyt and Schatten (1998a,b) undertook a truly massive research project in attempting to introduce a new sunspot index called the Group Sunspot Number,  $R_G$ , using sunspot observations from 463 observers.

This project was ingenious in the sense that it sought to reduce all observations to a common scale, related to observations by a "standard" (RGO) observer.

# Conclusions

However, some serious reservations must be expressed about the treatment of days for which no photograph is available.

In particular, the authors believe that it would be better to assume "no data" on days for which no photograph is available, rather than introduce some form of "interpolation" based on photographs on adjoining days.

# Conclusions

Careful examination of the original RGO publications and their associated errata and additions has revealed that some revisions are necessary to the Hoyt and Schatten determination of the number of sunspot groups for the RGO, even when photographs do exist.

In addition, when making comparisons with the sunspot observations made by Robert Main, Radcliffe Observatory, Oxford, 1874 – 1875, to determine  $k_i'$  for this particular observer, there appears to have been some confusion between astronomical and civil dates.