3rd Sunspot Workshop

Tucson, Arizona

22-25 January 2013

Recent Work on Improving the Historical Sunspot Record

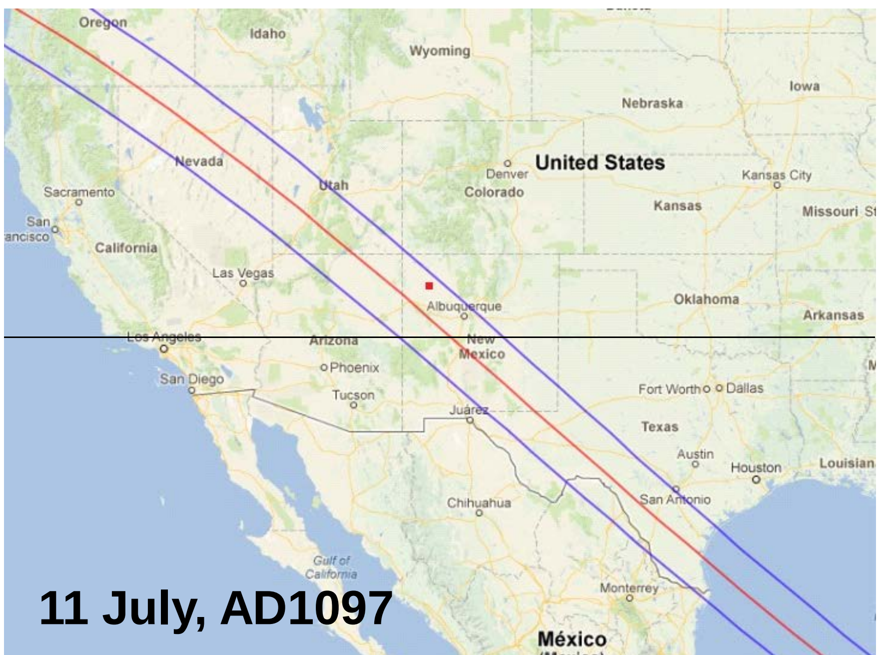
J. M. Vaquero

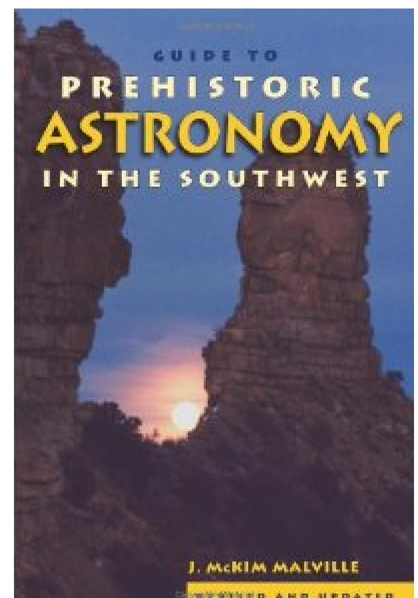
Centro Universitario de Mérida

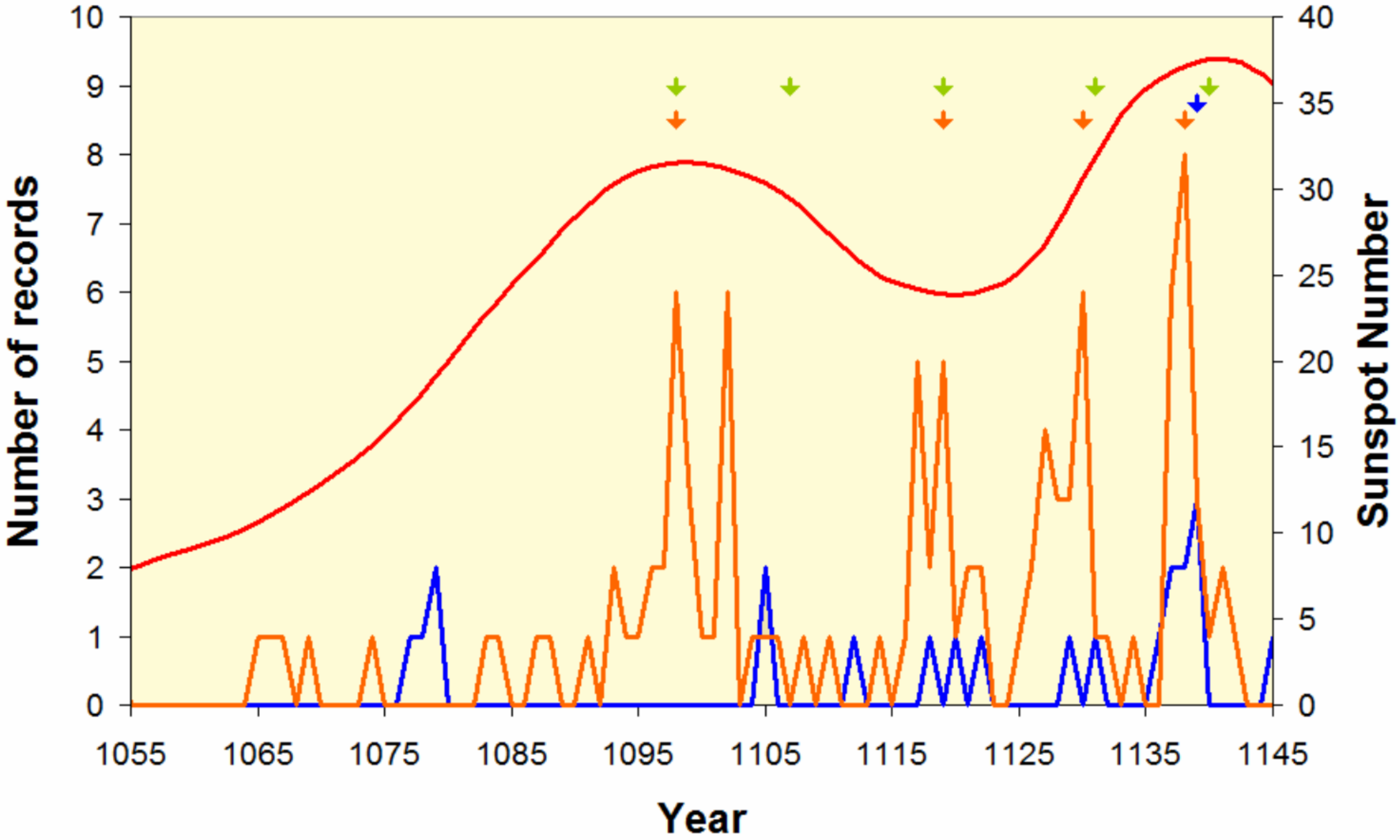
Universidad de Extremadura, Spain

First “drawing” of the solar corona

Vaquero & Malville (2013), in preparation


Oregon
Idaho
Wyoming
Iowa
Nebraska
Nevada
United States
Denver
Kansas City
Utah
Colorado
Sacramento
Kansas
San
ancisco
California
Las Vegas
Albuquerque
Oklahoma
Arkansas
Los Angeles
Arizona
New
Mexico
Phoenix
San Diego
Tucson
Fort Worth
Dallas
Juárez
Texas
Austin
Houston
San Antonio
Chihuahua
Gulf of
California
Monterrey
11 July, AD1097
México
(Mexico)


GUIDE TO
PREHISTORIC
ASTRONOMY
IN THE SOUTHWEST
J. McKIM MALVILLE
REVISED AND UPDATED



Different solar activity proxies during the period 1055–1145: annual number of naked-eye observations of sunspots, annual number of auroral nights. Arrows correspond to estimated maxima of solar cycle. Green arrows correspond to the estimated maxima of solar cycle using a high resolution 14C record from tree rings (courtesy of H. Miyahara). Both kinds of information suggest that the date of maximum of the solar cycle is close to AD1098. This fact is, therefore, a support for the hypothesis of the solar corona represented in the petroglyph of the "Piedra del Sol".

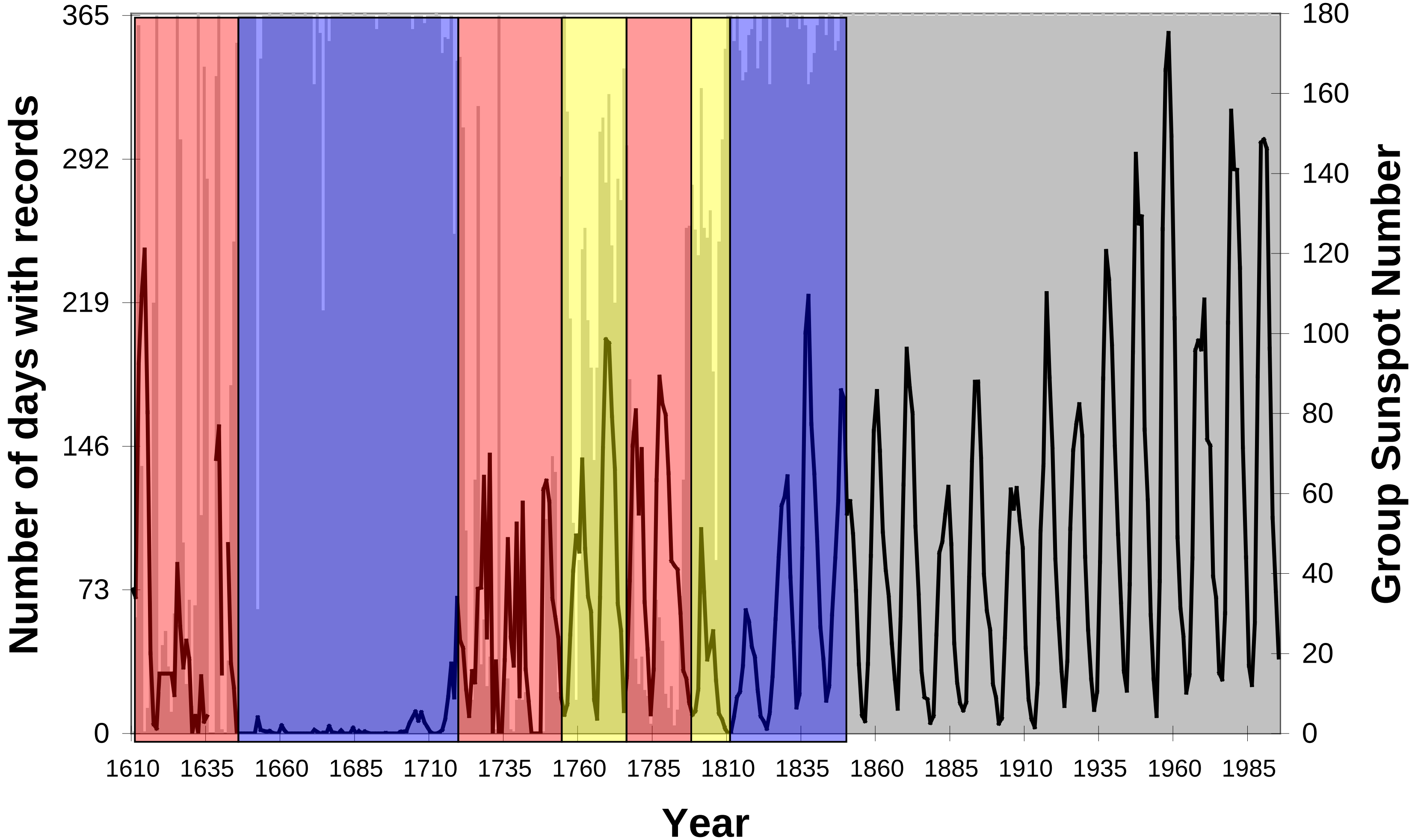
Outline

- Main changes in the Hoyt & Schatten Database
  - 17th century
  - 18th century
- Recovering old data
  - Great observers
  - Sunspot positions
  - Solar diameter
- Maunder Minimum: reading original sources

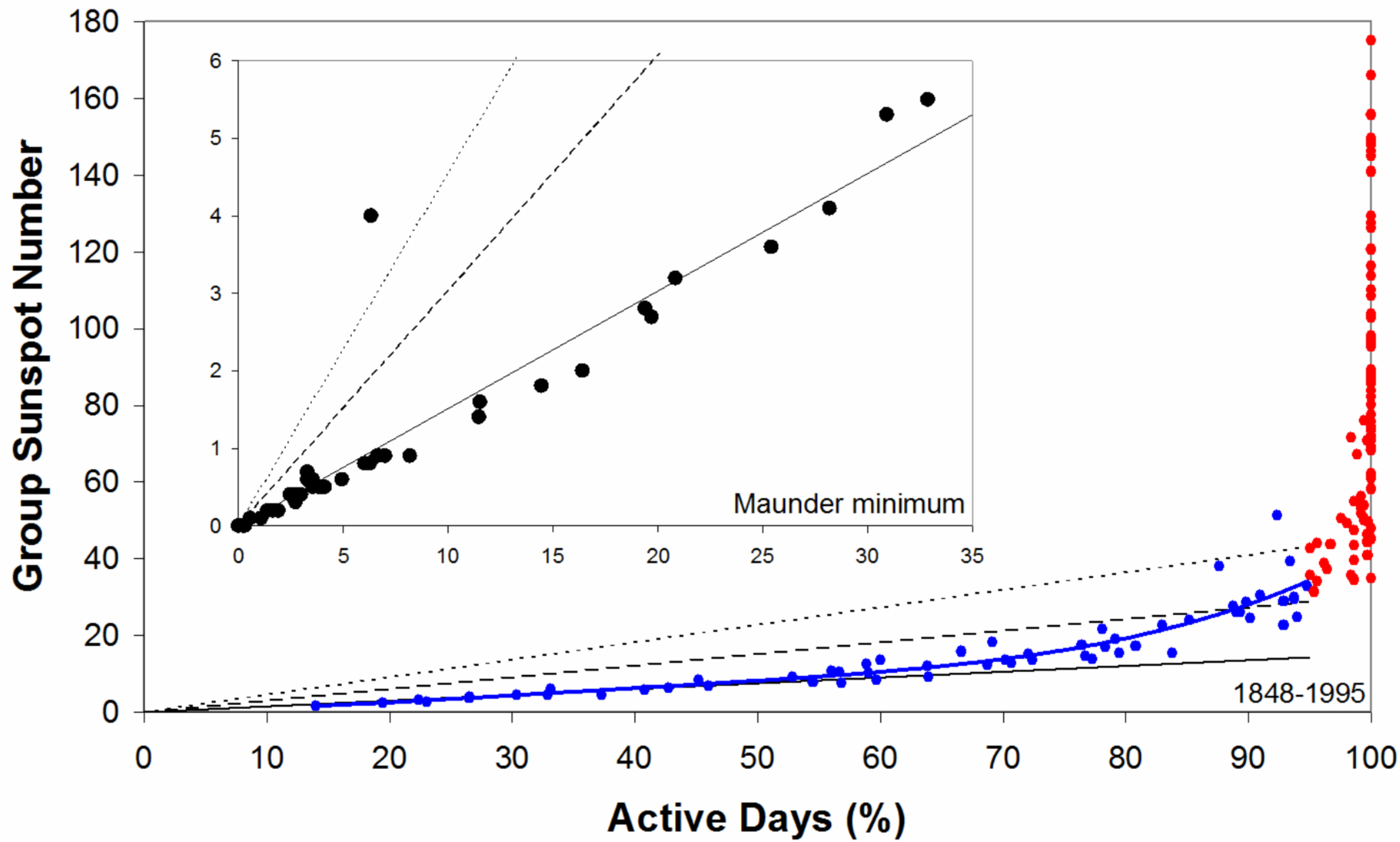
Main changes in the database compiled by Hoyt and Schatten

17th century

18th century

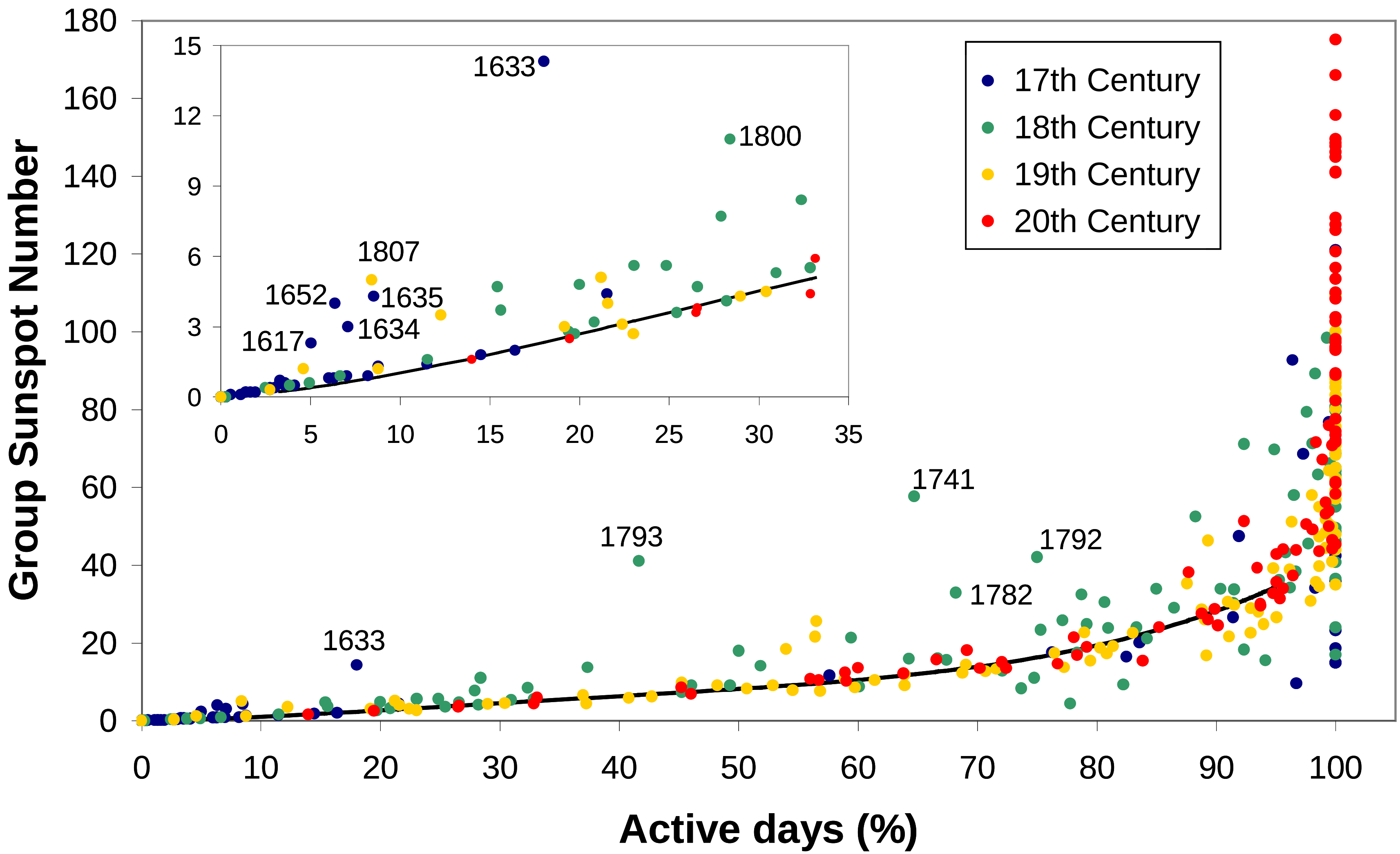


Vaquero (2007) *Adv. Spa. Res.* **40**, 929.



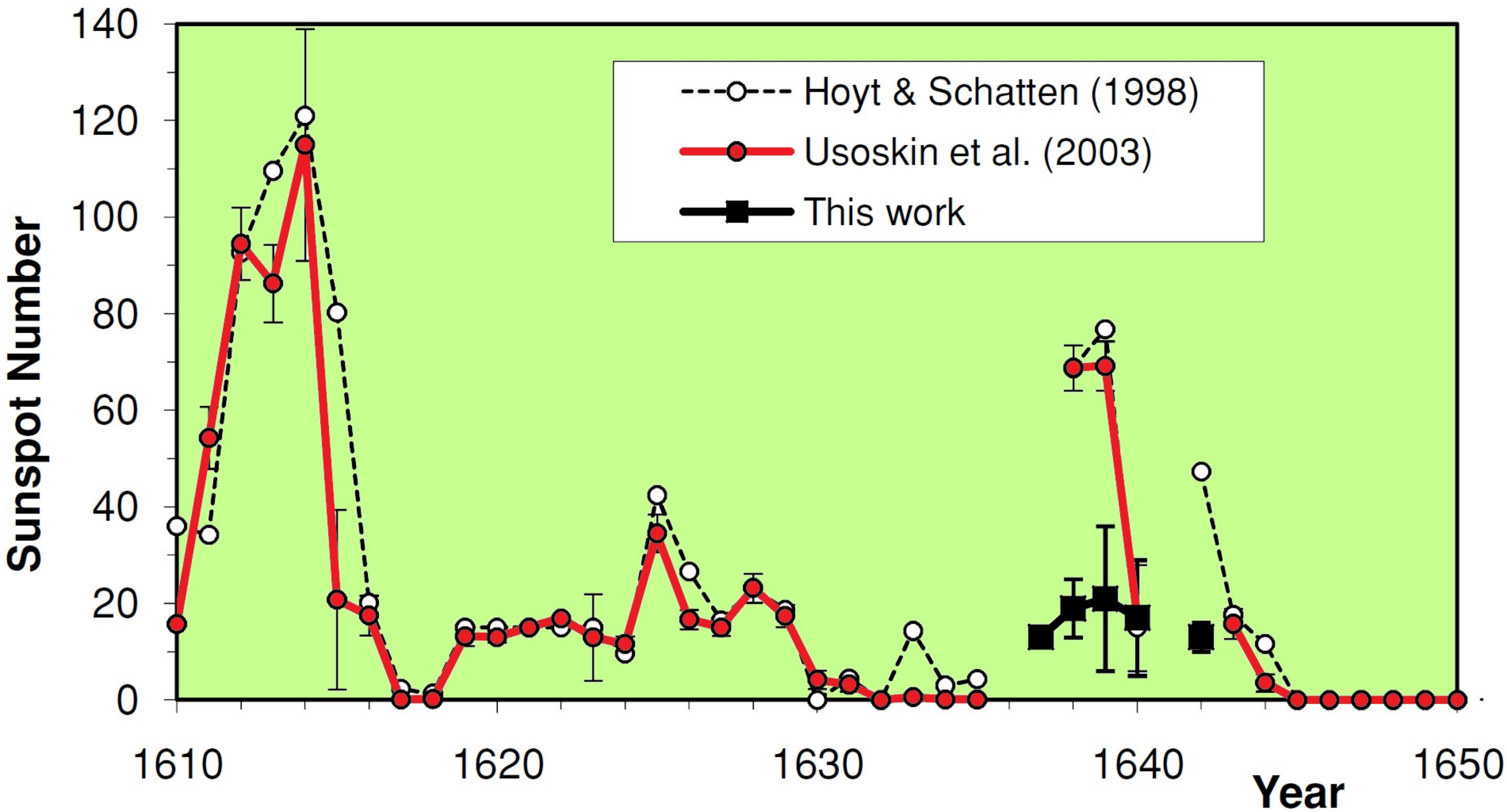
Vaquero et al. (2012) *Solar Phys.* **277**, 389

Relationship between GSN and AD for 1848–1995 from Hoyt & Schatten (1998). Polynomial fit (order 4) is shown for AD < 95% (blue line and points). Graphic inserted shows the same relationship during the Maunder minimum. Black lines represent the theoretical values for an average observer with 1 (continuous), 2 (dashed), and 3 (dotted) groups for each active day.

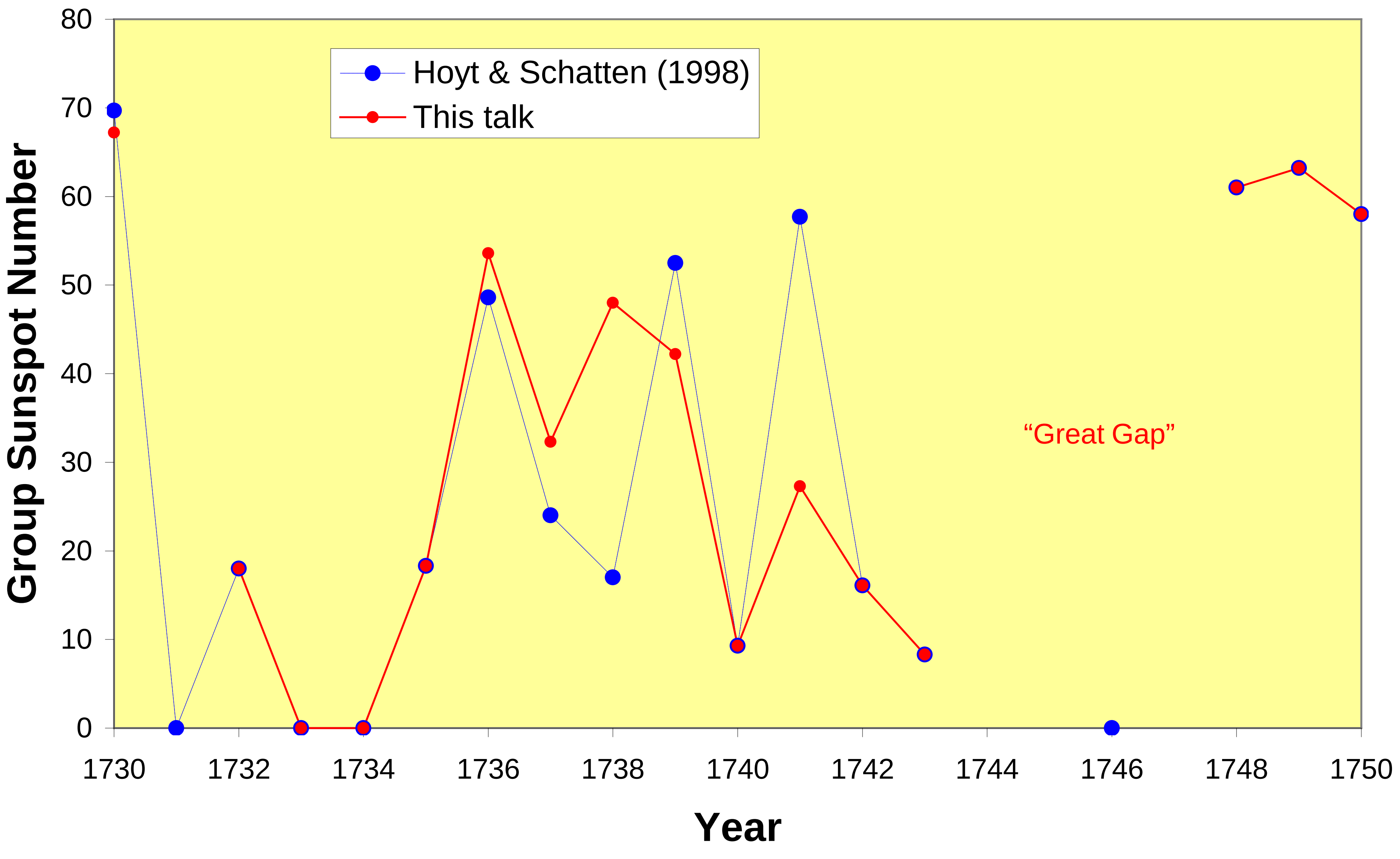


Vaquero et al. (2012) *Solar Phys.* **277**, 389

Relationship between GSN and AD for all available data from Hoyt & Schatten (1998). Black line is the polynomial fit of last Figure. The inset presents an enlarged version but restricted to values AD < 35%.



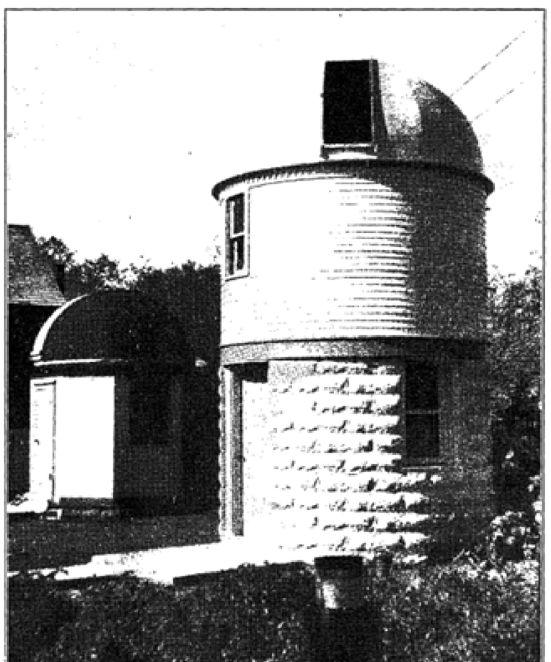
Vaquero et al. (2011) *ApJL* **731**, L24.

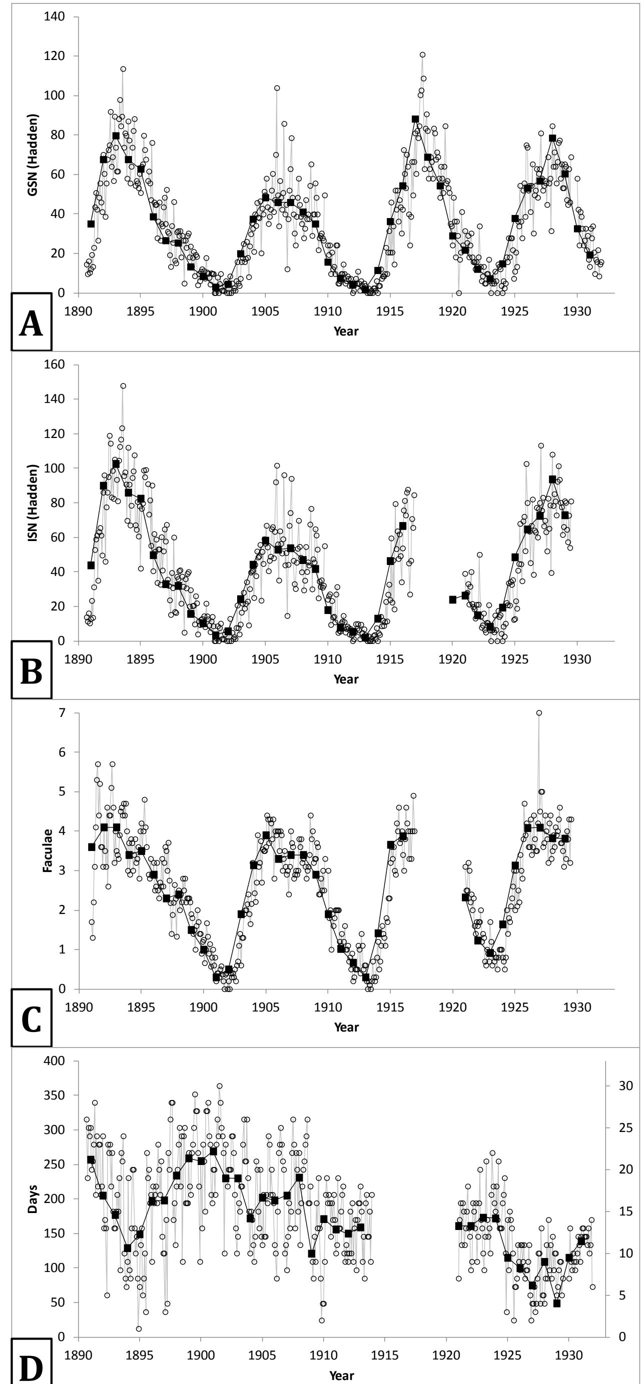


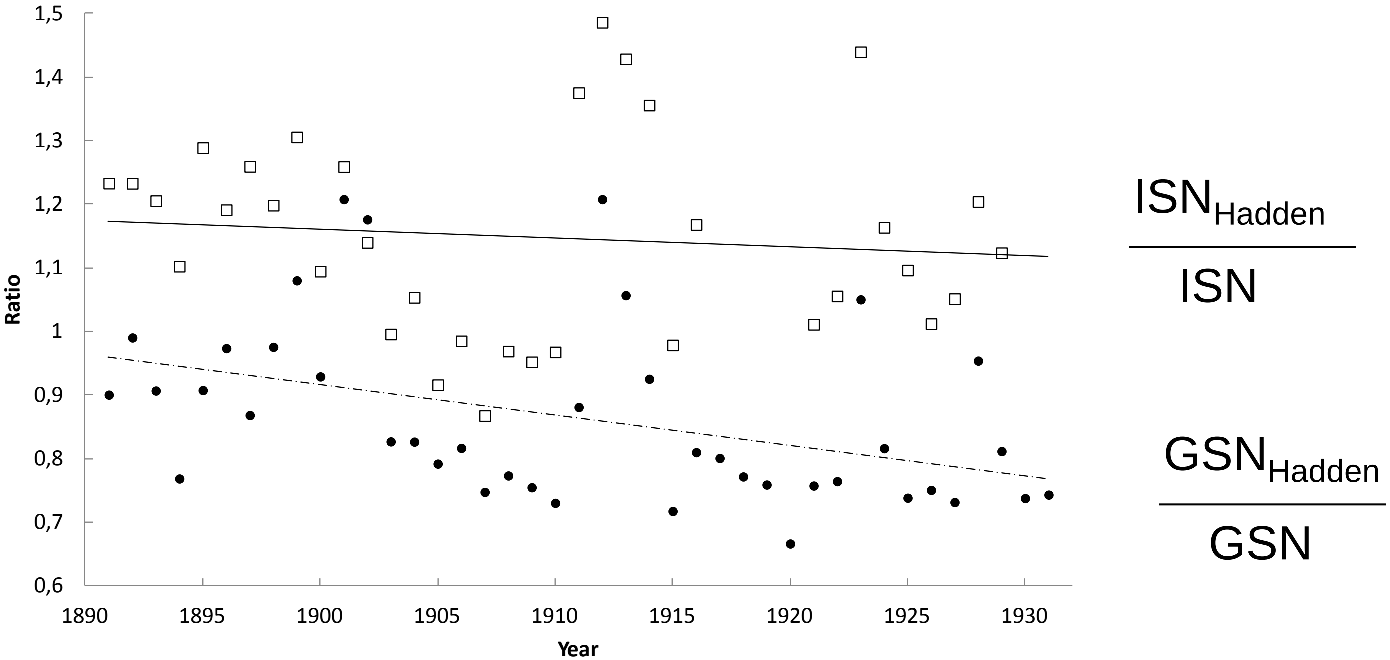
Vaquero & Trigo (2013), in progress

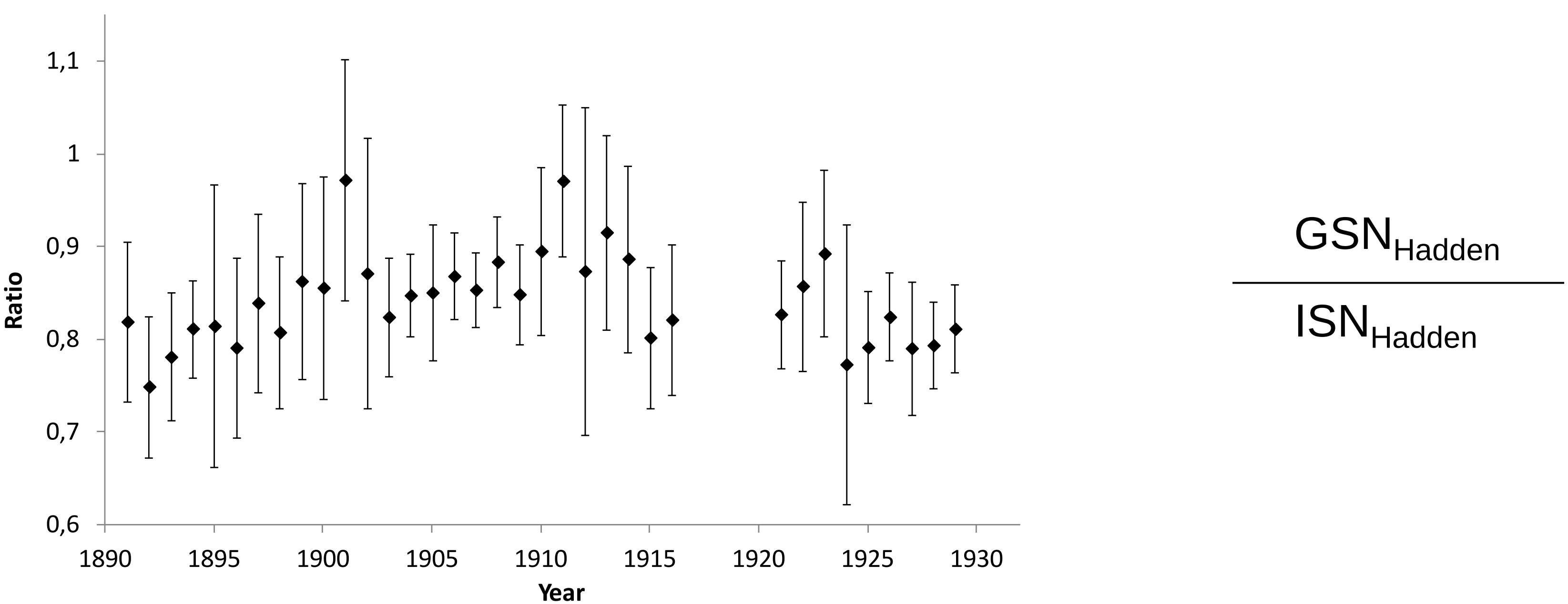
Important sunspot observers: the case of D.E. Hadden (Alta, Iowa)

Carrasco et al. (2013), in preparation




A
GSN (Hadden)
Year
B
ISN (Hadden)
Year
C
Faculae
Year
D
Days
Year


1,5
1,4
1,3
1,2
1,1
1
0,9
0,8
0,7
0,6
Ratio
1890
1895
1900
1905
1910
1915
1920
1925
1930
Year
ISNHadden
ISN
GSNHadden
GSN


1,1
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Ratio
1890
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1920
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1930
Year
GSNHadden
ISNHadden

Recovering old data on sunspot positions

Nogales & Vaquero (2013), in preparation

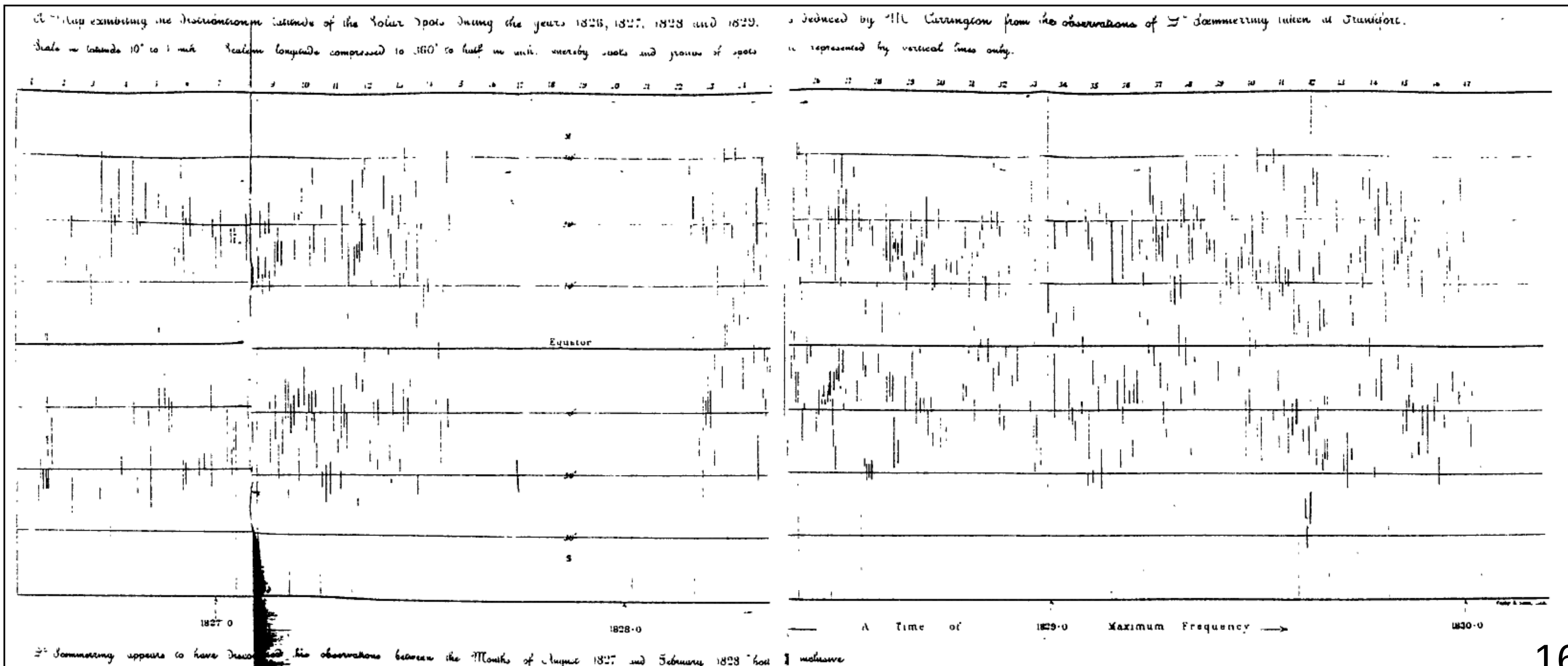
Casas & Vaquero (2013), in preparation

Carrasco et al. (2013), in preparation

On Dr. Sœmmerring's Observations of the Solar Spots in the Years 1826, 1827, 1828, and 1829. By R. C. Carrington, Esq.

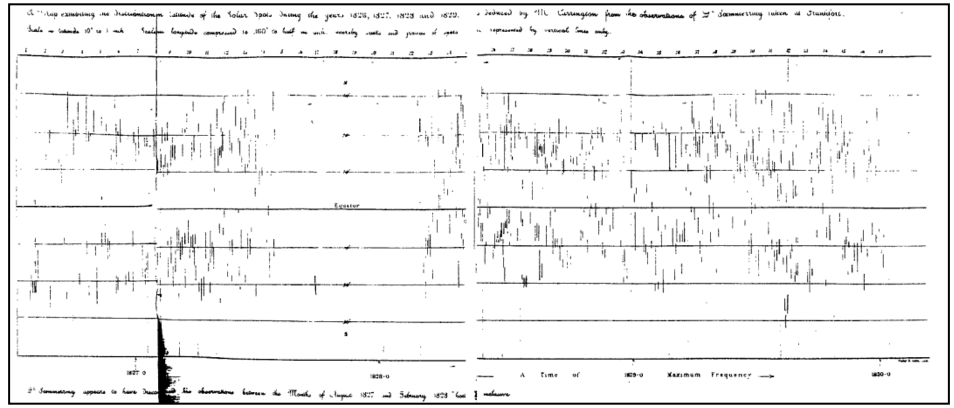
When I visited North Germany in the year 1856, one object which I had in view was to obtain personal information of the observations of the solar spots made by Dr. von Sœmmerring; as I thought it probable, from the account given of them by Professor Thilo, in a dissertation published in the year 1828, that records made by a man of Sœmmerring's eminence would exhibit a degree of accuracy which would repay the labour of reduction; and, when reduced, would put me in immediate possession of an ancient series which might enable me to obtain a more exact value of the time of rotation of the sun on its axis. I

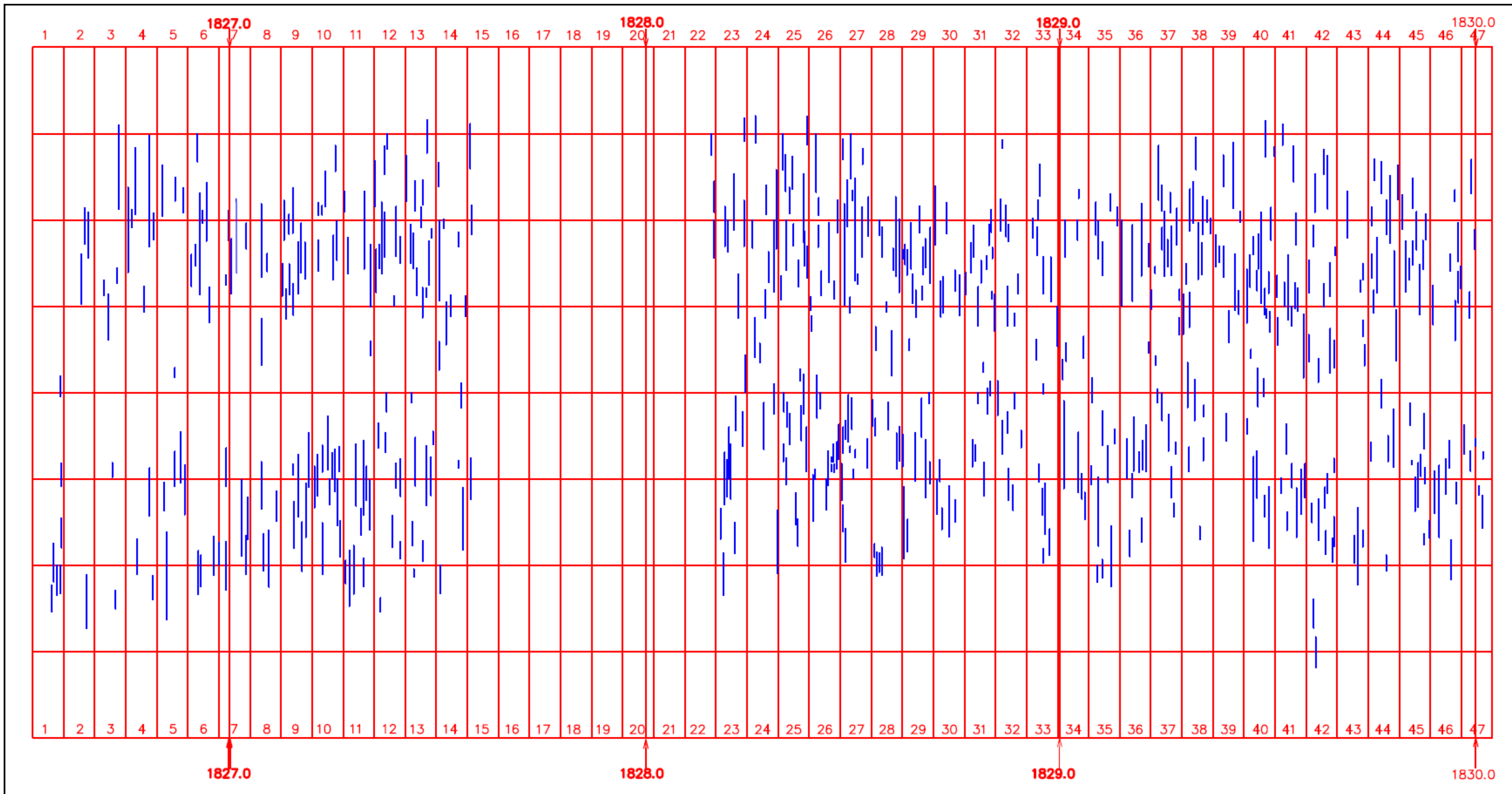
Carrington (1860)
MNRAS **20**, 71



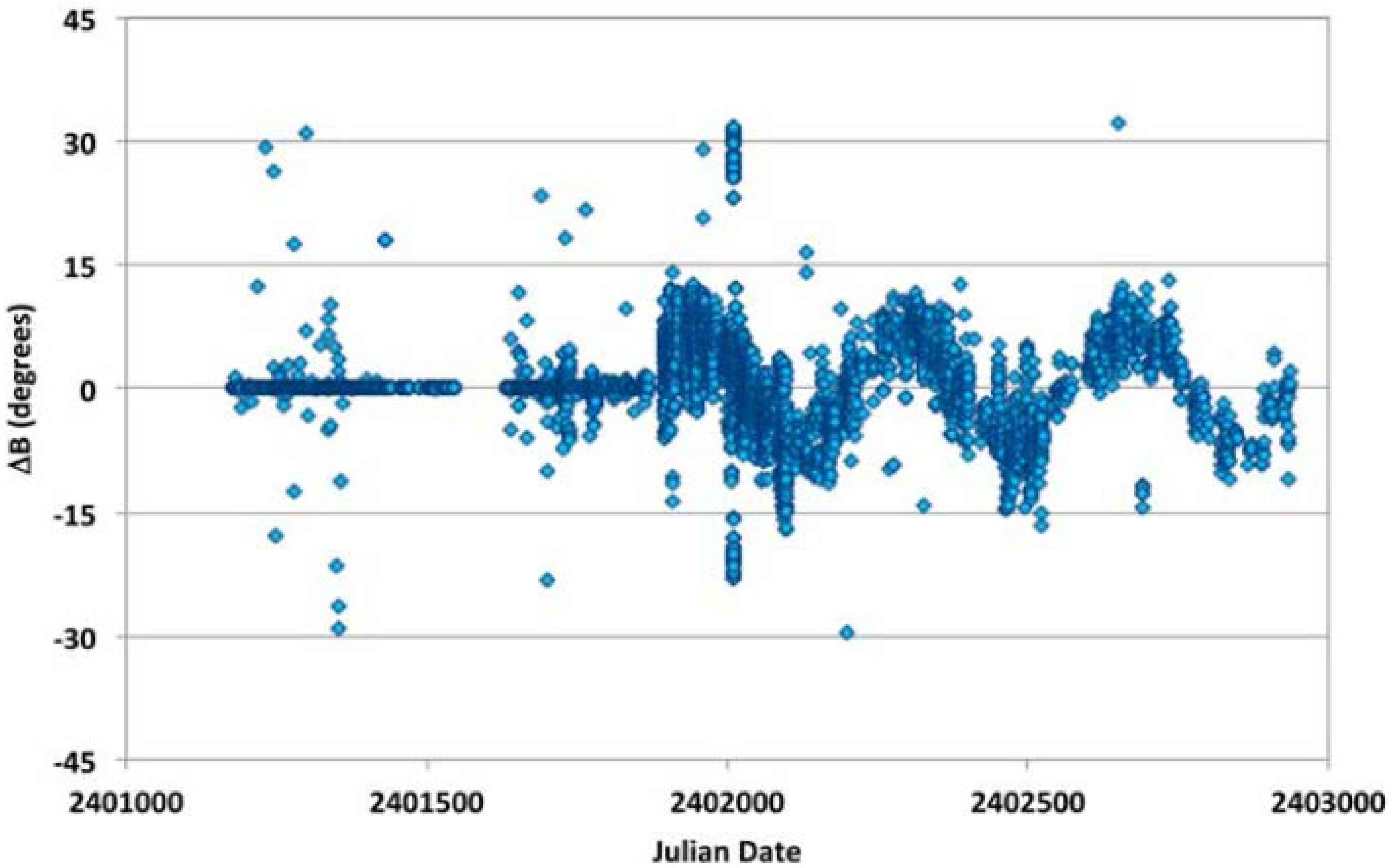
Nogales & Vaquero (2013),

in progress

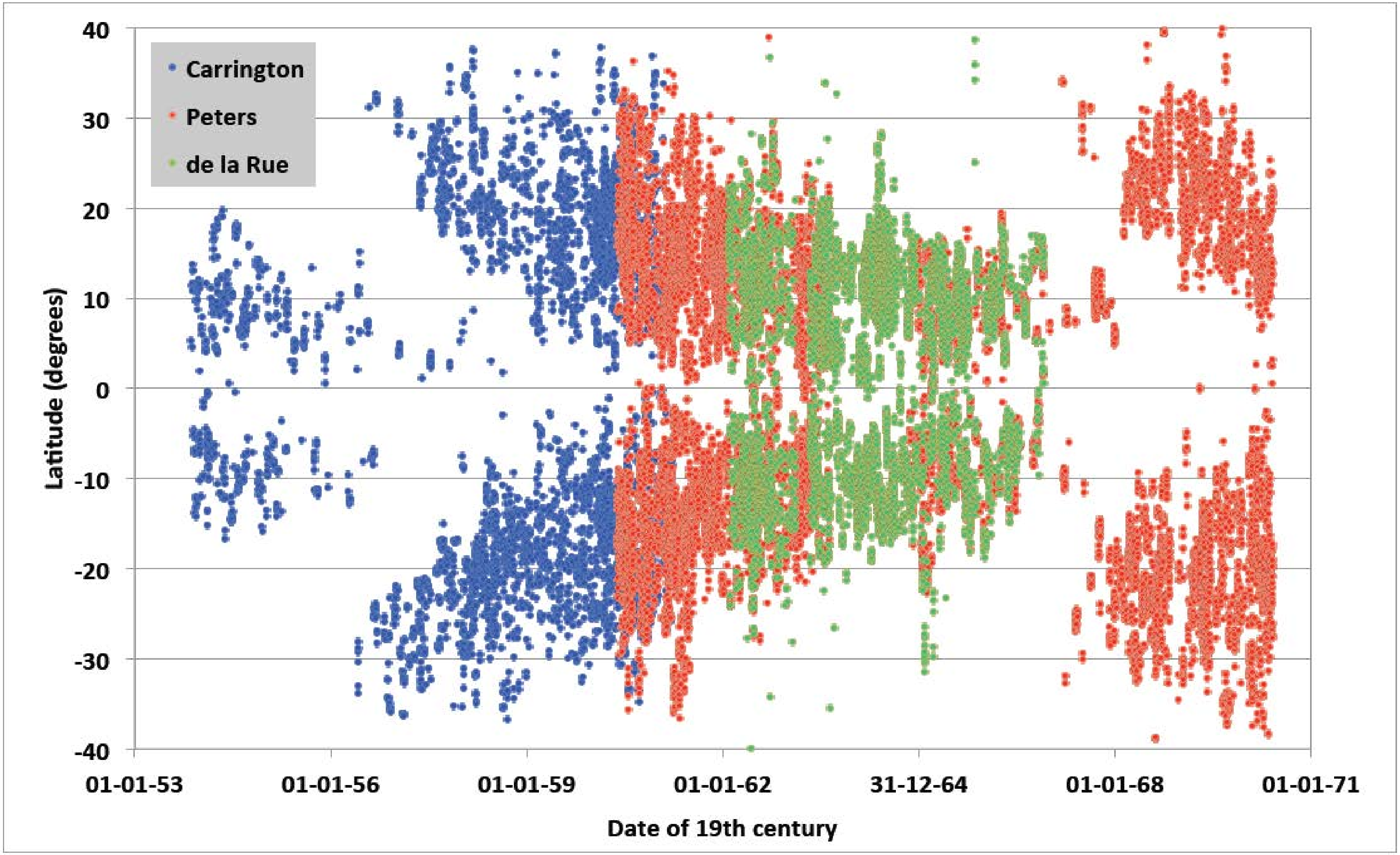




The sunspot catalogues of Carrington, Peters and de la Rue: quality control and machine-readable versions (Casas & Vaquero, in preparation)

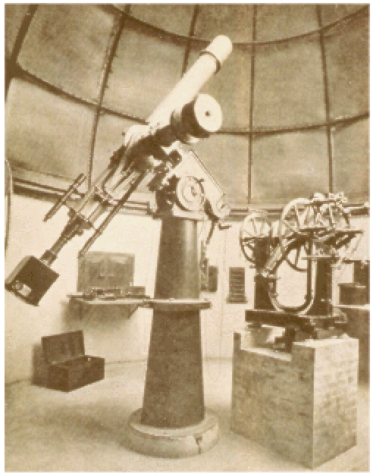


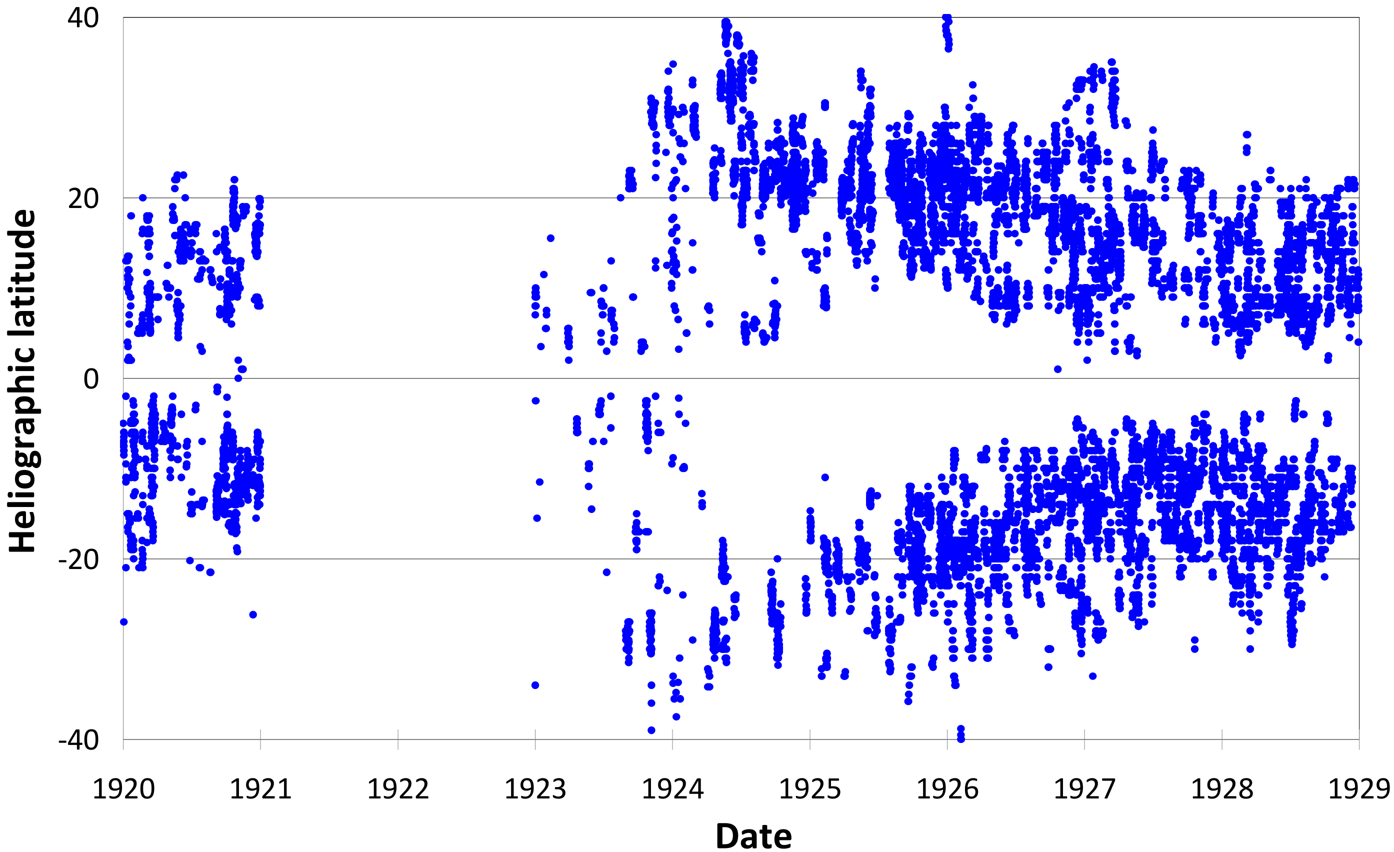
Difference between the latitude calculated by de la Rue and our study. A sinuosoidal behaviour is present from January 1^{st}, 1864 with a period of a year and an amplitude of 14.5 degrees.



Carrington
Peters
de la Rue
40
30
20
10
0
-10
-20
-30
-40
Latitude (degrees)
01-01-53
01-01-56
01-01-59
01-01-62
31-12-64
01-01-68
01-01-71
Date of 19th century

Astronomical Observatory of Universidad de Valencia (Spain)

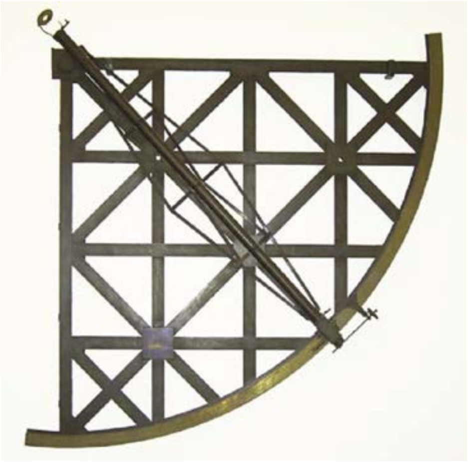




Carrasco et al. (2013), in preparation

Solar diameter in 18th century

Ruiz-Lorenzo et al. (2013), in preparation

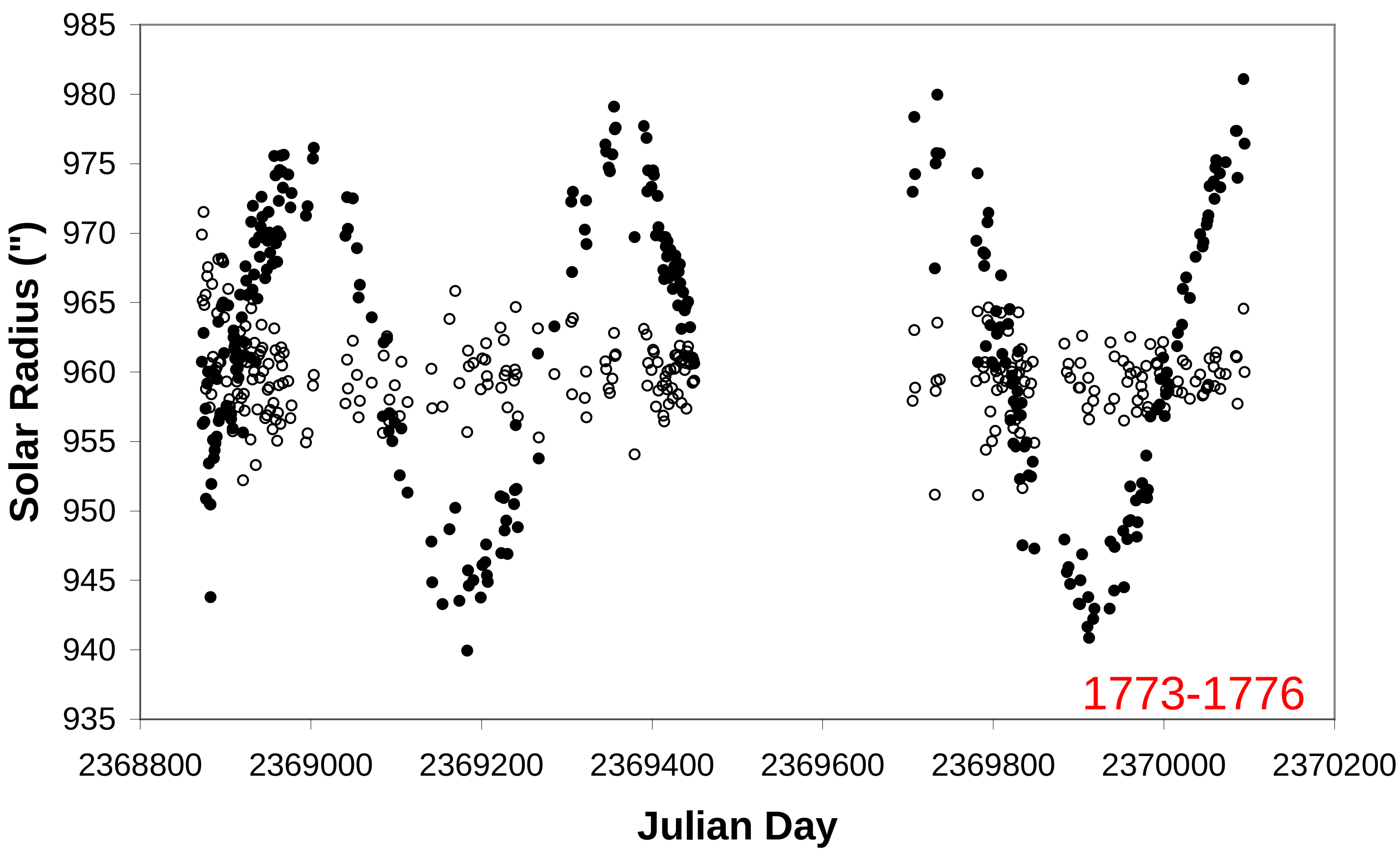


Mural quadrant by Bird (London)

Cadiz Observatory used the some instrument and methodology that Tobias Mayer used in Göttingen Observatory (Wittmann, 1980, 1998).

Table 1. Observations performed in Observatory of Cádiz (Spain) in late 18th Century.

Period	Number of obs.	Solar Radius (")
Jun-Dec 1776	68	959.61±1.61
1773-1776	310	959.84±2.90
1788-1790	391	964.55±5.48
1776-1790	701	962.46±5.09



This observations are comparable to the observations of Tobias Mayer in the same time, but the dispersion is higher.

The observations performed in June-December 1776 seem more reliable.

Maunder Minimum: consulting original sources

Vaquero et al. (2013), in preparation

JOHANNIS HEVELII

MACHINÆ COELESTIS

PARS POSTERIOR;

Rerum Uranicarum

OBSERVATIONES,

Tam Eclipsium Luminarium, quàm Occultationum Planetarum, & Fixarum,

Nec non

Altitudinum Meridianarum Solarium, Solstitiorum, & Æquinoctiorum;

Unà cum

Reliquorum Planetarum, Fixarumq; omnium hactenus cognitarum, Globisq; adscriptarum, æquè ac plurimarum hucusq; ignotarum

OBSERVATIS;

Pariter quoad

Distantias, Altitudines Meridianas, & Declinationes;

Additis

Innumeris aliis notatu dignissimis, atquè ad Astronomiam excolendam maximè spectantibus rebus,

Plurimorum annorum, summis vigiliis, indefessoque labore, ex ipso æthere haustas, permultisquè Iconibus, Auctoris manu, æri incisis, illustratas, & exornatas,

TRIBUS LIBRIS, exhibens.

Cum Gratiâ & Privilegio Sac. Regiæ Majest. Polon.

GEDANI.

In ædibus AUCTORIS, ejusq; Typis, & Sumptibus

Imprimebat

SIMON REINIGER.

ANNO M DC LXXIX.

JOHANNIS HEVELII

IN

Partem Posteriorem

MACHINÆ COELESTIS

PRÆFATIO

AD

LECTOREM.

QUintus jam effluxit annus, cùm Partem Machinæ meæ Cœlestis Priorem, Organographiam videlicet, quâ Organa nostra universa, hactenus ad Observationes Cœlestes à me adhibita, graphicè delineata, atq; accuratè descripta, in lucem ediderim. Nunc verò cùm DEUS O. M. vitam porrò, sanitatem, otiumq; (pro quibus omnibus ex toto corde Ipsi & ago & habeo gratias) sub tantâ negotiorum, & molestiarum mole, clementissimè mihi concesserit, Tuis quoq;, mi Astrophile, (citiùs enim ob varia impedimenta, immensumq; laborem typis exscribi haud potuit,) Partem

Quo anno Pars Prior Machinæ Cœlestis typis sit divulgata.

a Machinæ

JOHANNIS HEVELII MACHINÆ COELESTIS

LIBER TERTIUS, Rerum Uranicarum OBSERVATIONES, GEDANI,

Altitudines videlicet Solares, unà cum Solstitiis Æstivis & Brumalibus, tam Æquinoctiis Vernalibus, quàm Autumnalibus;

Nec non

Planetarum reliquorum omnium separatim, addito vero tempore ex Altitudinibus correcto,

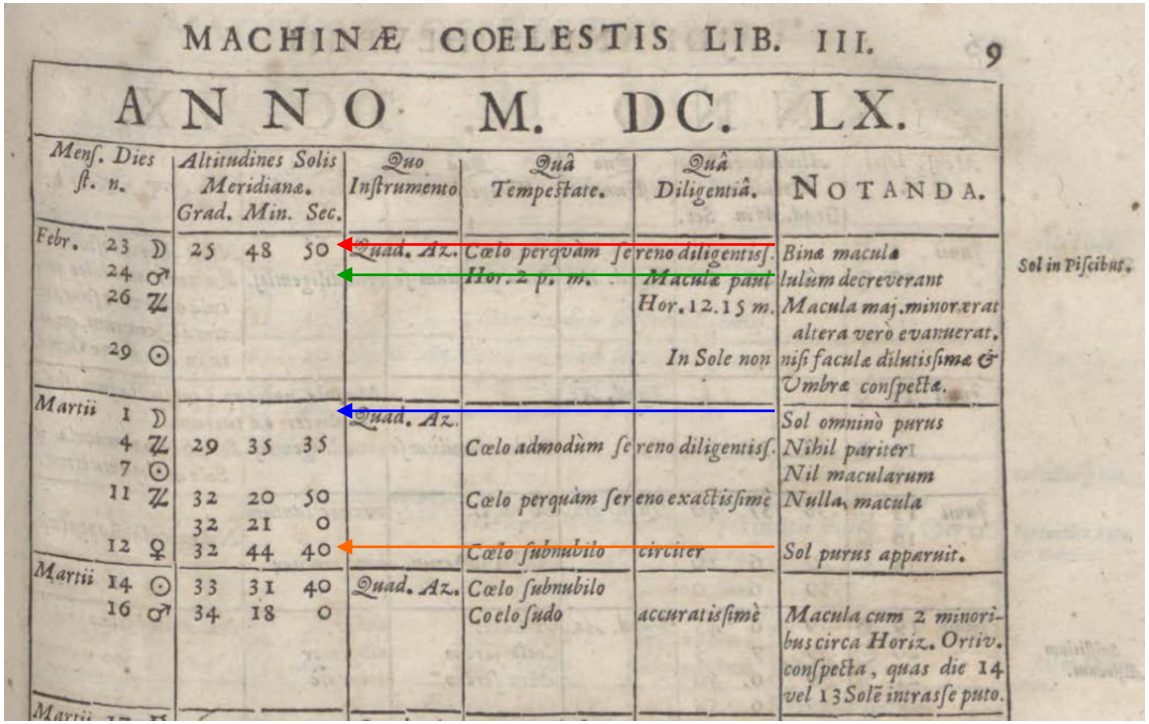
Plurimorum Annorum summis vigiliis, indefessoq; Labore, ex ipso Æthere, Majoribus Organis haustas, exhibens.

ANNO M. DC. LII.

Mens. Dies st. n.		Altitudines Solis Meridianæ. Grad.	Min.	Sec.	Quo Instrumento	Quâ Tempestate.	Quâ Diligentiâ.	NOTANDA.	
Octobr. 12	♄	27	56	10	Quad. Az.	Cœlo sereno			Sol in Librâ.
30	☿	21	35	0		Cœlo subnubilo			
Novemb. 1	♀	20	56	20		Cœlo sereno			
2	♄	20	37	40		Cœlo subnubilo	Vix satis dilig.		Sol in Scorpione.
Novemb. 4	☽	20	1	0	Quad. Az.	Cœlo nubilo			
26	♂	14	32	20		Cœlo subnubilo			
30	♀	13	51	45					Sol in Sagittario.
Decemb. 6	♀	13	3	30				Diam. ☉ obs. 34′ 0″	
Decemb. 7	♄	12	57	0	Quad. Az.	Cœlo perquam sereno			
8	☉	12	51	0		Cœlo subnubilo			
16	☽	12	18	7		Cœlo perquam sereno	diligentiss.	Diam. ☉ 34′ 30″	Diameter Solis.
17	♂	12	16	15		Cœlo admodum fœdo			
Decemb. 19	♃	12	13	30	Quad. Az.	Cœlo vix satis sereno			
20	♀	12	12	45		Aëre sereno		Diam. ☉ 34′ 0″	
21	♄	12	12	45		Aëre admodum sereno		Diam. ☉ 34 0	Solstitium Brumale in Capricorno.
27	♀	12	22	40				Diam. ☉ 33 35	

ANNO M. DC. LIII.

	Mens. Dies st. n.		Altitudines Meridianæ Solis. Grad.	Min.	Sec.	Quo Instrumento	Quâ Tempestate.	Quâ Diligentiâ.	NOTANDA.
Sol in Capricorno.	Januar. 16	♃	14	51	20	Quad. Az.			Diameter Solis 34′ 0″
	19	☉	15	28	0		Cœlo admodum sereno		
	25	♄	16	52	45				
	Februar. 5	☿	19	57	15				Macula exigua appar.
	Febr. 15	♄	23	13	30	Quad. Az.			
Sol in Piscibus.	24	☽	26	26	45				
	26	☿	27	12	10				
	27	♃	27	34	30		Cœlo subnubilo.		
	Martii 1	♄	28	19	20	Quad. Az.			Nil Macularum.
	9	☉	31	25	30		Cœlo perquam sereno		Nil Macularum.
			31	25	25				
	10	☽	31	49	30				
			31	49	25				
	Martii 13	♃	32	56	30	Quad. Az.			
Æquinoctium Vernale.	20	♃	35	45	0		Ob intercurrentes	nubes dubia	
	23	☉	36	56	0				
			36	56	10				Mac. in quad. Or. Solis
	Martii 24	☽	37	19	30	Quad. Az.		dubia	Macula Solis
	25	♂	37	42	25				Bina macula in Sole
			37	42	30				
Sol in Ariete.	Martii 27	♃	38	29	0	Quad. Az.			Jam penitus disparuerat
	29	♄	39	16	15		Cœlo perquàm sereno		Nil Macularum
	Aprilis 4	♀	41	34	0				
	6	☉	42	20	0				Nil Macularum.
	Aprilis 8	♂	43	5	30	Quad. Az.			Nihil prorsus apparet.
	11	♀	44	11	20				Nihil
	13	☉	44	55	0				Nihil
Sol in Tauro.	27	☉	49	39	30				
	Aprilis 28	☽	49	58	20	Quad. Az.			
	29	♂	50	17	0				
	30	☿	50	35	45				
	Maji 1	♃	50	53	40				
	Maji 3	♄	51	28	40	Quad. Az.			
	6	♂	52	19	45				
	9	♀	53	8	20		Cœlo subnubilo	dubia	
	10	♄	53	24	15				
Diameter Solis.	Maji 11	☉	53	39	0	Quad. Az.			Diamet. ☉ 32′ dilig.
	18	☉	55	20	45				
	19	☽	55	33	15			Diligenter.	Diamet. ☉ 32′
Sol in Geminis.	20	♂	55	46	0			Diam. ☉ 32′	Hucusq; nihil Macularum in Sole apparuit
	Maji 25	☉	56	43	0	Quad. Az.	Cœlo sereno		
	29	♃	57	22	30		Nubes interpella	runt	
	31	♄	57	40	0		Cœlo sereno	diligentissimè	
	Junii 1	☉	57	47	0				Diameter ☉ 32′
Diameter Solis.	Junii 2	☽	57	55	45	Quad. Az.			Diameter ☉ 32′
	18	☿	59	6	0				Diameter ☉ 32′
	19	♃	59	6	35		Cœlo quidem subnu	bilo; satis tam	en accurate
	20	♀	Nihil observat.				Ob turbidum Cœ	lum	
Solstitium Æstivum.	Junii 21	♄	Nihil observat.			Azim. 2°	ob pluviam		Altit. ob nubes haud observatum
	22	☉	59	7	0		Momentum autem	ipsum Merid.	
	27	♀	59	0	20			Diam. ☉ 32′	Huc usque nihil in Sole apparuit, nisi unica exigua macula
	28	♄	58	57	0		Cœlo sereno	Diligenter	



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ANNO M. DC. LX.

Menſ. Dies ſt. n.		Altitudines Solis Meridianæ. Grad.	Min.	Sec.	Quo Inſtrumento	Quâ Tempeſtate.	Quâ Diligentiâ.	NOTANDA.
Febr.	23 ☽	25	48	50	Quad. Az.	Cælo perqvàm ſ	ereno diligentisſ.	Binæ maculæ
	24 ♂					Hor. 2 p. m.	Maculæ pauˡ	lulùm decreverant
	26 ♃						Hor. 12.15 m.	Macula maj. minor erat altera verò evanuerat.
	29 ☉						In Sole non	niſi faculæ dilutiſsimæ & Umbræ conſpectæ.
Martii	1 ☽				Quad. Az.			Sol omninò purus
	4 ♃	29	35	35		Cælo admodùm ſe	reno diligentisſ.	Nihil pariter
	7 ☉							Nil macularum
	11 ♃	32	20	50		Cælo perquàm ſer	eno exactisſimè	Nulla macula
		32	21	0				
	12 ♀	32	44	40		Cælo ſubnubilo	circiter	Sol purus apparuit.
Martii	14 ☉	33	31	40	Quad. Az.	Cælo ſubnubilo		
	16 ♂	34	18	0		Coelo ſudo	accuratisſimè	Macula cum 2 minoribus circa Horiz. Ortiv. conſpecta, quas die 14 vel 13 Solē intraſſe puto.

Sol in Piſcibus.

Sunspot record with measurement of solar meridian altitude

Sunspot record without measurement of solar meridian altitude

No sunspot record with measurement of solar meridian altitude

No sunspot record without measurement of solar meridian altitude

Be careful!!!

Sunspot records are not associated with measurement of solar meridian altitude!!!

Year	AD	NAD	AD%
1653	11	11	50.00
1654	3	1	75.00
1655	n.a.	n.a.	n.a.
1656	n.a.	n.a.	n.a.
1657	4	2	66.67
1658	0	2	0.00
1659	0	47	0.00
1660	28	30	48.28
1661	2	16	11.11
1662	n.a.	n.a.	n.a.
1663	0	7	0.00
1664	n.a.	n.a.	n.a.
1665	n.a.	n.a.	n.a.
1666	n.a.	n.a.	n.a.
1667	n.a.	n.a.	n.a.
1668	n.a.	n.a.	n.a.
1669	n.a.	n.a.	n.a.
1670	n.a.	n.a.	n.a.
1671	2	3	40.00
1672	n.a.	n.a.	n.a.
1673	n.a.	n.a.	n.a.
1674	n.a.	n.a.	n.a.
1675	0	2	0.00
Total:	50	121	29.24
1653-1663:	48	116	29.27
1659-1661:	30	93	24.39

1659–1661: **AD%=24.39**, GSN≈3

1653–1663: **AD%=29.27**, GSN≈4

The estimations of GSN from Hevelius’ observations are 3-8 times greater that the values obtained by Hoyt and Schatten!!!

Year	H&S98
1653	0.9
1654	0.7
1655	0.5
1656	0.6
1657	0.2
1658	0
1659	0
1660	2
1661	0.8
1662	0
1663	0

1659–1661: **GSN=0.9**

1653–1663: **GSN=0.5**

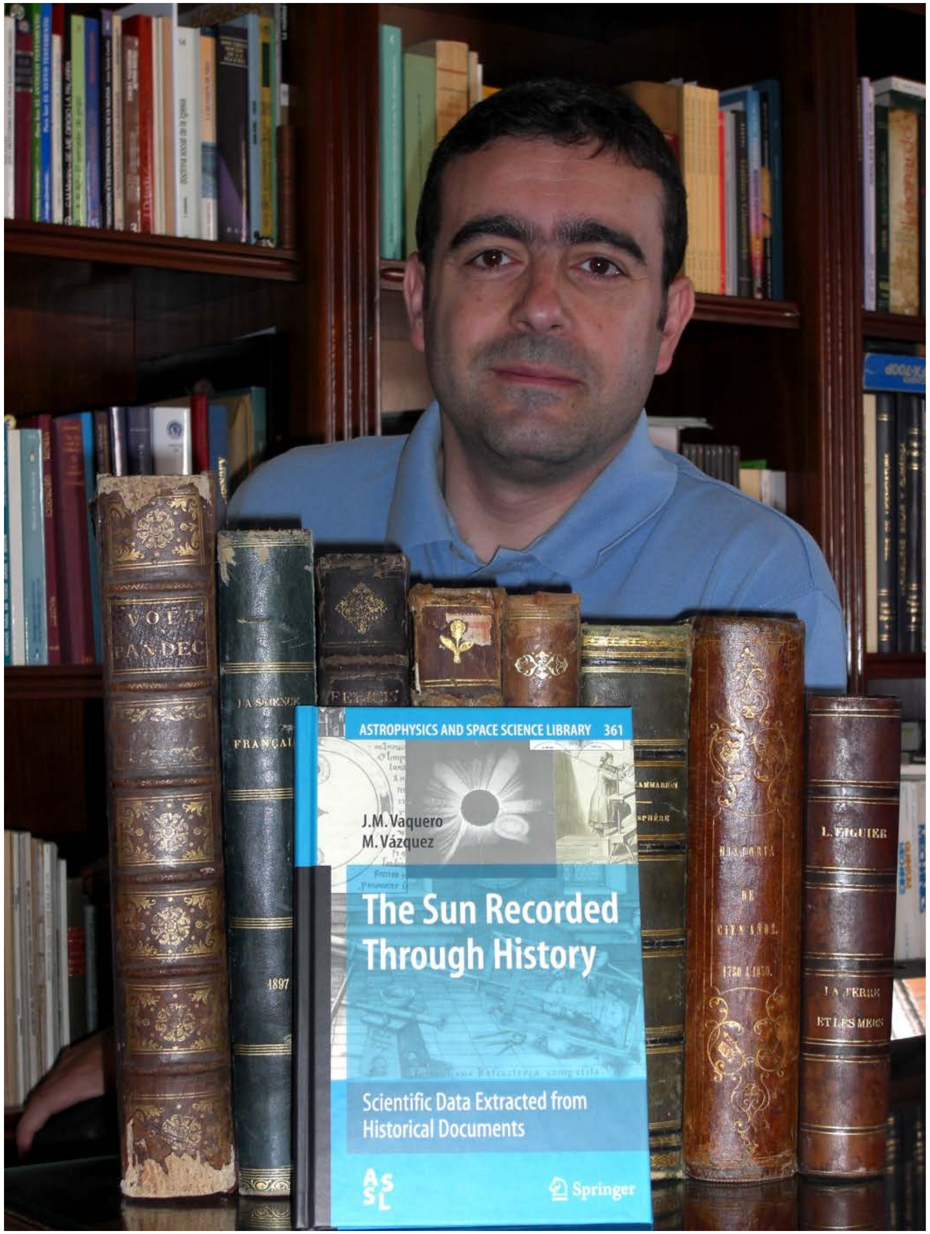
Some conclusions

- In last years, three mayor changes in H&S98 database have been proposed:
  - Onset of Maunder Minimum (Vaquero et al., 2011).
  - Solar Cycle #-1 (Vaquero et al., 2007; Vaquero & Trigo, 2013)
  - Lost solar cycle (Usoskin et al., 2009; Zolotova & Ponyavin, 2011).

- There are interesting lost solar information that are preserved in archives and libraries. This task is boring and unrecognized. We need a “Sunspot/Solar Historical Archive”.

- Maunder minimum was a period of very low sunspot numbers as Hoyt & Schatten stated. However, their values probably are understimated because they used astrometric observation records (including *camera obscura* records!)

Thank you very much!



Comments, suggestions, etc.:

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