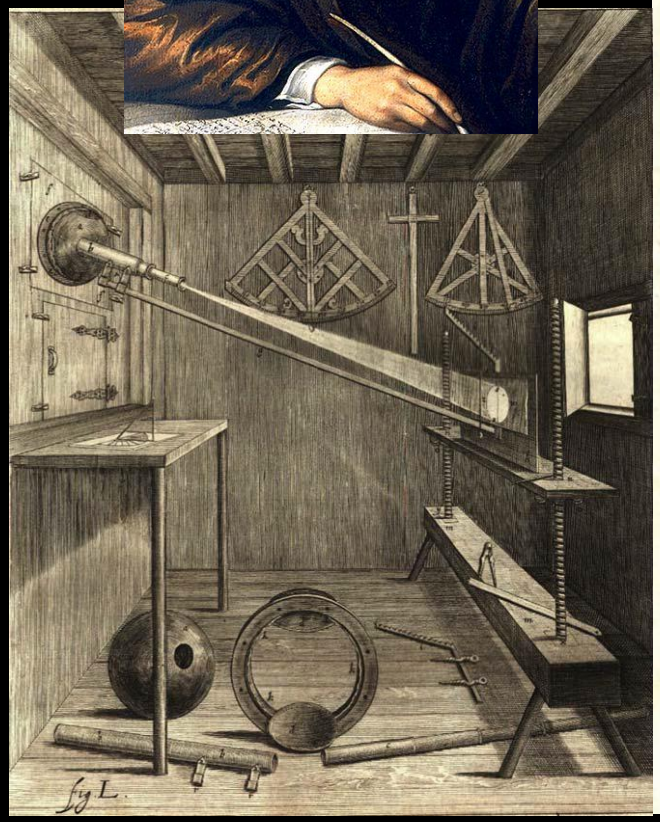
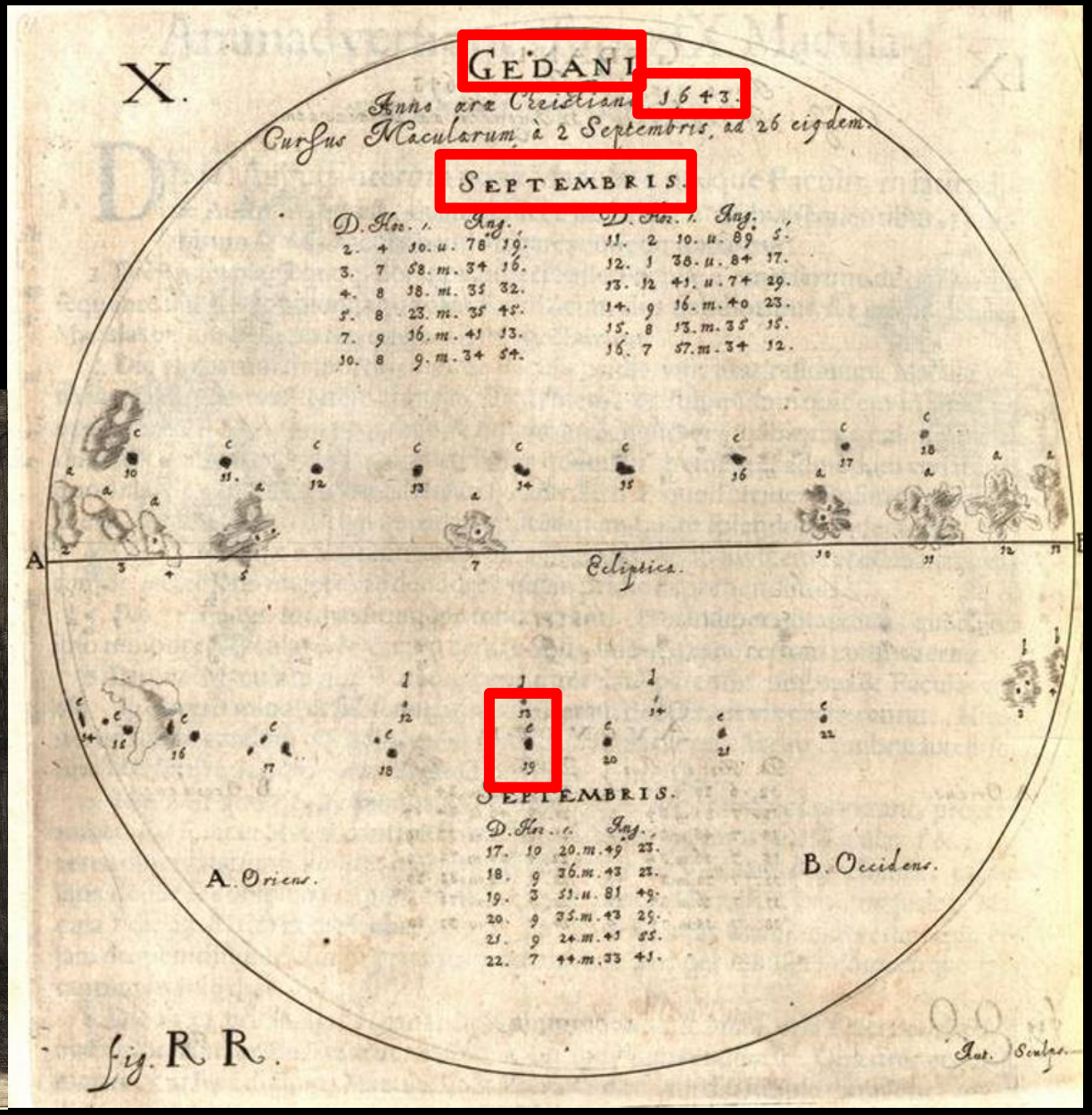
On improvements in the future version of the revised collection of sunspot group numbers

Víctor Carrasco

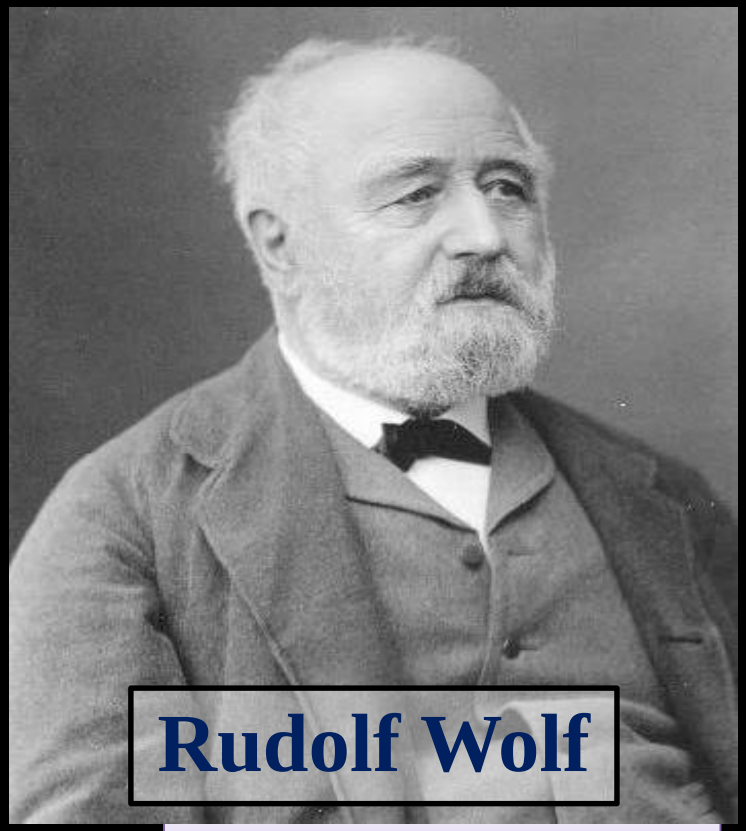
Today, 379 years ago, a famous Polish astronomer…





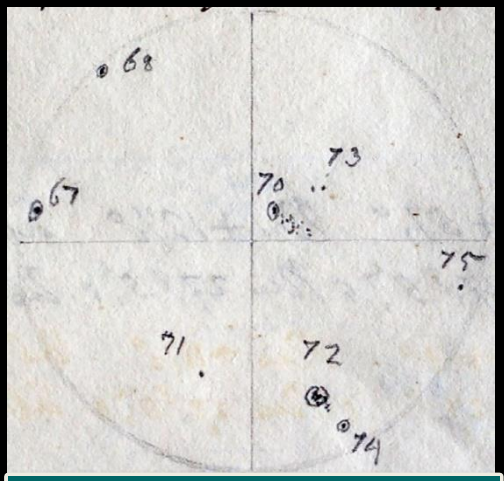
SUNSPOT NUMBER CONTEXT

RELATIVE SUNSPOT NUMBER



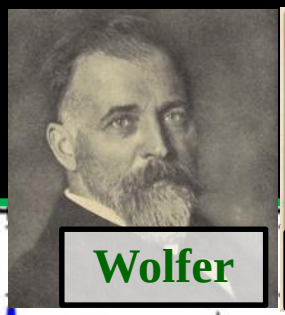
Rudolf Wolf

Staudacher
(1749-1799)

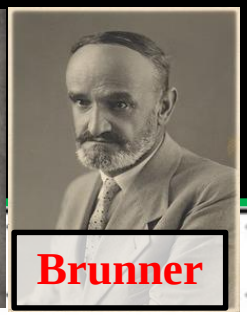


Schwabe
(1825–1867)

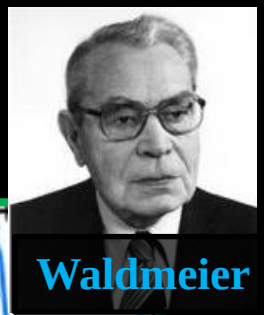
$R_Z = k(10G + S)$



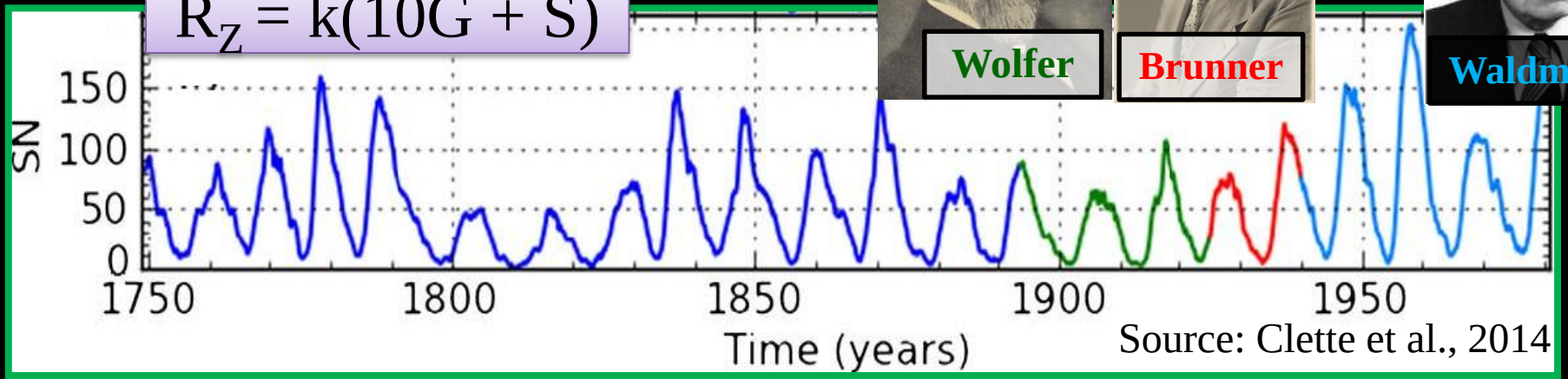
Wolfer



Brunner

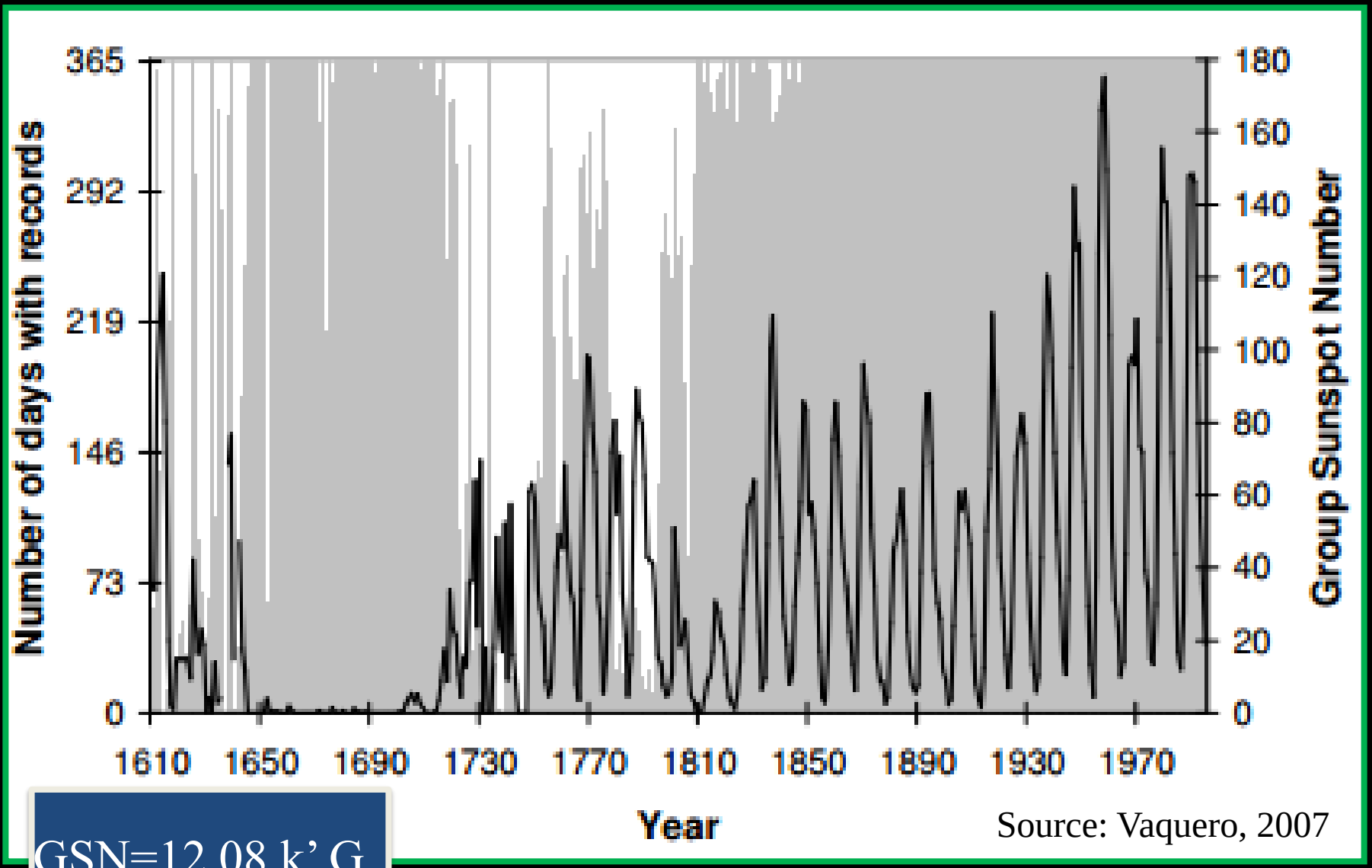


Waldmeier



Source: Clette et al., 2014

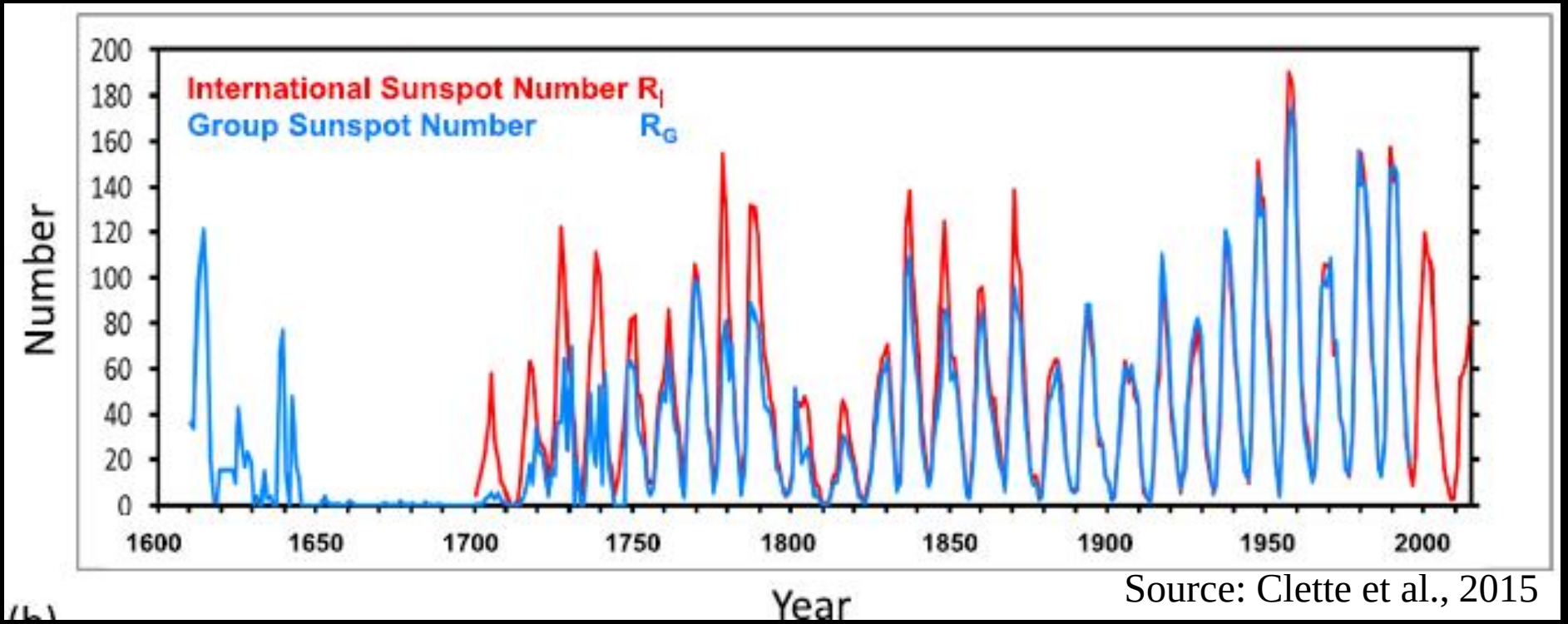
GROUP SUNSPOT NUMBER



GSN=12.08 k' G

Source: Vaquero, 2007

ISN vs GSN



Source: Clette et al., 2015

SUNSPOT NUMBER WORKSHOPS

2011

2012

2013

2014

UPDATED GROUP NUMBER DATABASE

Solar Phys (2016) 291:3061–3074
DOI 10.1007/s11207-016-0982-2

SUNSPOT NUMBER RECALIBRATION

A Revised Collection of Sunspot Group Numbers

J.M. Vaquero[1,2] · L. Svalgaard[3] · V.M.S. Carrasco[2,4] · F. Clette[5] · L. Lefèvre[5] · M.C. Gallego[2,4] · R. Arlt[6] · A.J.P. Aparicio[2,4] · J.-G. Richard[7] · R. Howe[8]

Received: 8 November 2015 / Accepted: 21 August 2016 / Published online: 14 September 2016

Abstract We describe a revised collection of the number of sunspot groups from 1610 to the present. This new collection is based on the work of Hoyt and Schatten (*Solar Phys.* **179**, 189, 1998). The main changes are the elimination of a considerable number of observations during the Maunder Minimum (hereafter, MM) and the inclusion of several long series of observations. Numerous minor changes are also described. Moreover, we have calculated the active-day percentage during the MM from this new collection as a reliable index of the solar activity. Thus, the level of solar activity obtained in this work is greater than the level obtained using the original Hoyt and Schatten data, although it remains compatible with a grand minimum of solar activity. The new collection is available in digital format.

Keywords Sunspots, statistics · Solar cycle, observations

Sunspot Number Recalibration
Guest Editors: F. Clette, E.W. Cliver, L. Lefèvre, J.M. Vaquero, and L. Svalgaard

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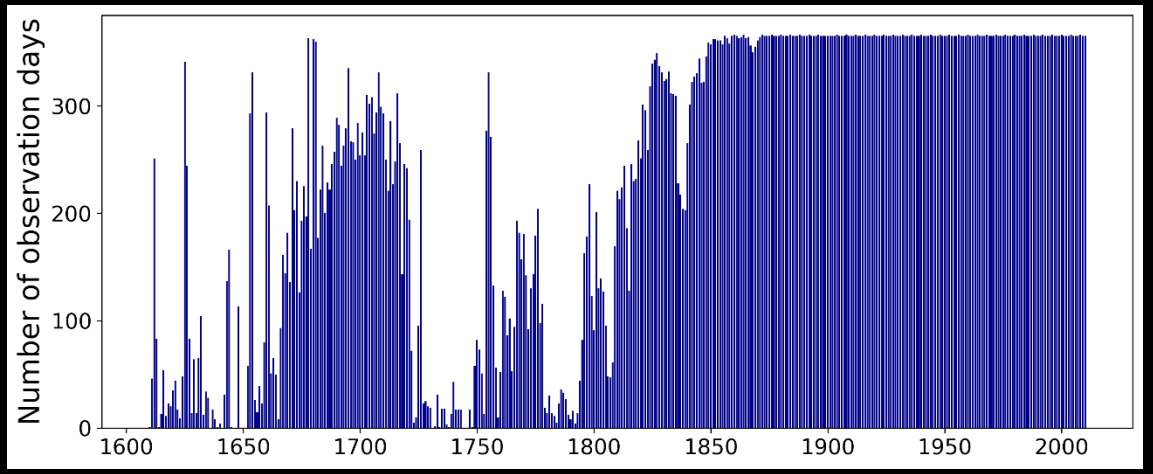
3 W.W. Hansen Experimental Physics Laboratory, Stanford University, Stanford, CA 94305, USA
4 Departamento de Física, Universidad de Extremadura, 06071 Badajoz, Spain
5 World Data Center SILSO, Royal Observatory of Belgium, 3 Avenue Circulaire, 1180 Brussels, Belgium
6 Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16, 14482 Potsdam, Germany
7 Independent Scholar, 6 rue Guesnault, 41100 Vendôme, France
8 AAVSO, Solar Section, 49 Bay State Road, Cambridge, MA 02138, USA

Springer

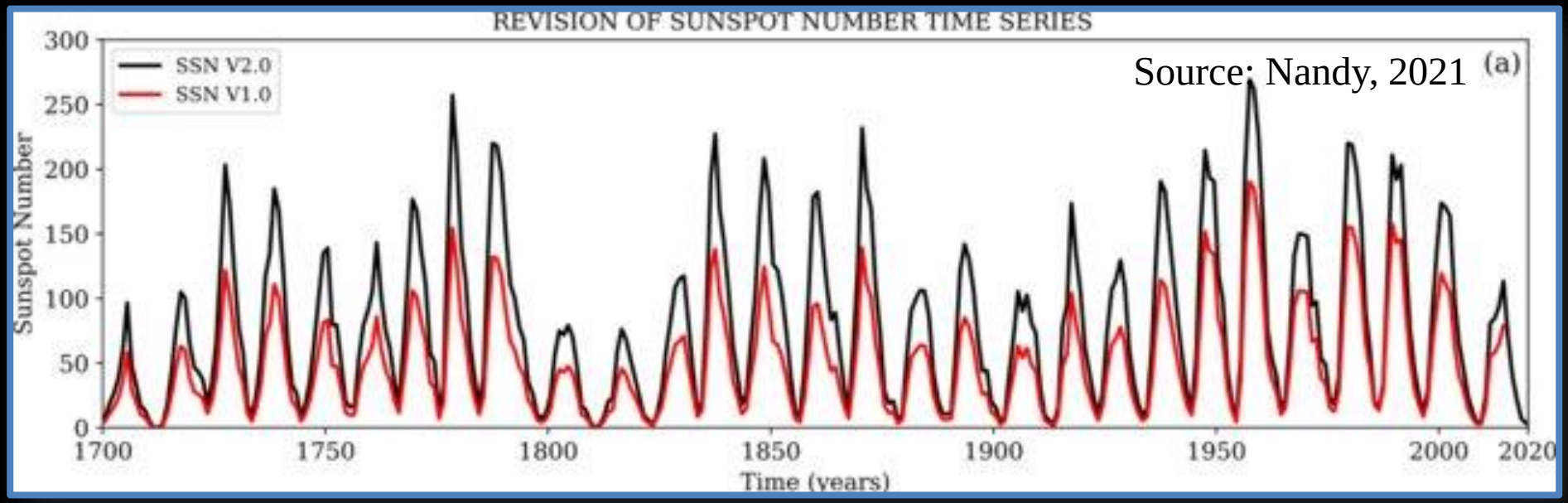


http://sidc.be/silso/

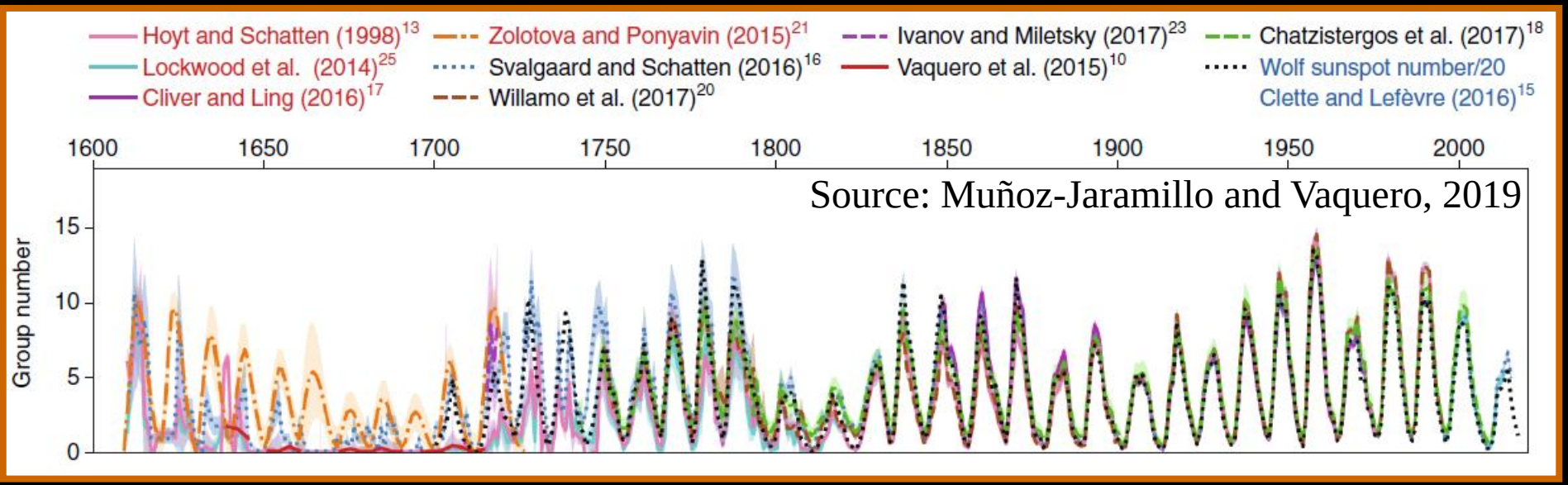
HISTORICAL ARCHIVE OF SUNSPOT OBSERVATIONS

http://haso.unex.es

NEW SUNSPOT NUMBER SERIES



Source: Nandy, 2021

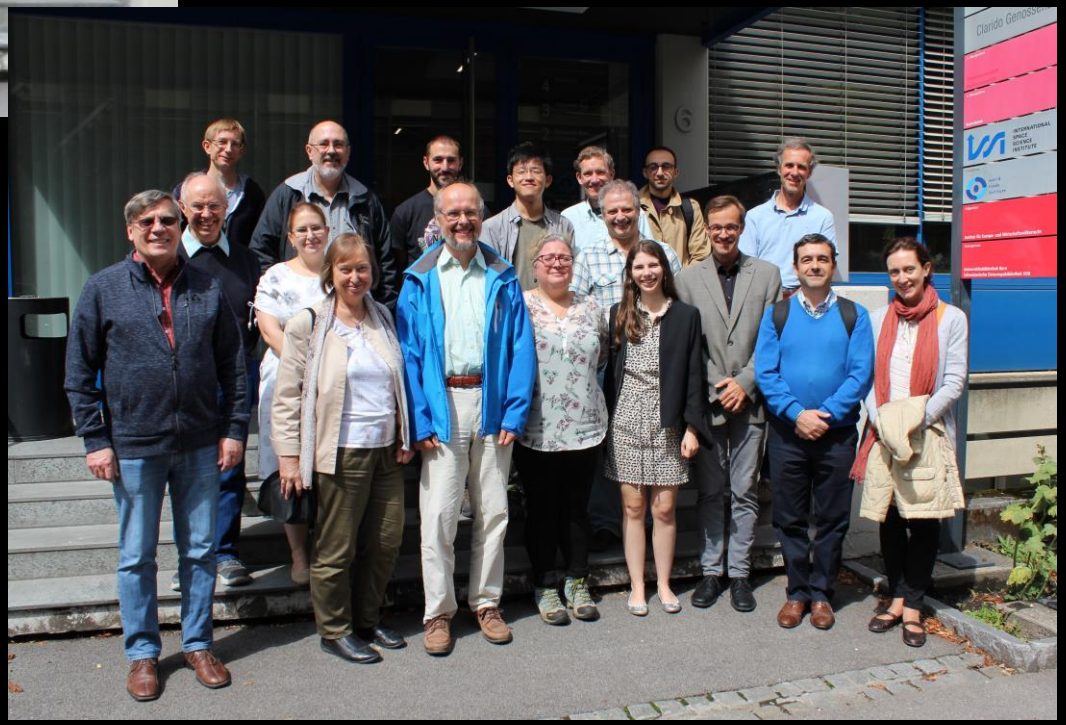


Source: Muñoz-Jaramillo and Vaquero, 2019

SUNSPOT NUMBER RECALIBRATION

2018

2019



FUTURE IMPROVEMENTS IN THE GROUP NUMBER DATABASE

FIRST TELESCOPIC RECORDS: ROSA URSINA

ROSA VRSINA

SIVE

SOL

EX ADMIRANDO FACVLARVM
& Macularum ſuarum Phœnomeno VARIVS,

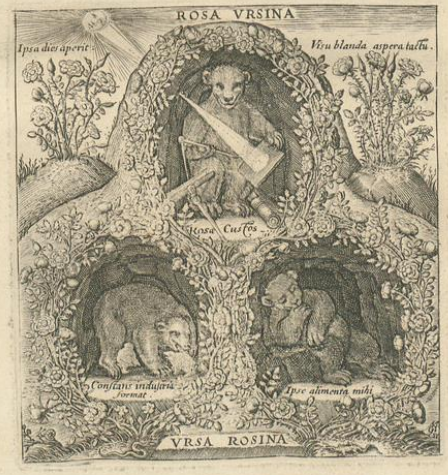
Colleg: Societ: IESU. NECNON Wratislav. Tit Marben. 1675

Circa centrum ſuum & axem fixum ab occaſu in ortum annua,
circaq. alium axem mobilem ab ortu in occaſum conuerſione
quaſi menſtrua, ſuper polos proprios, Libris quatuor
MOBILIS oſtenſus,

A

CHRISTOPHORO SCHEINER
GERMANO SVEVO, E SOCIETATE IESV.

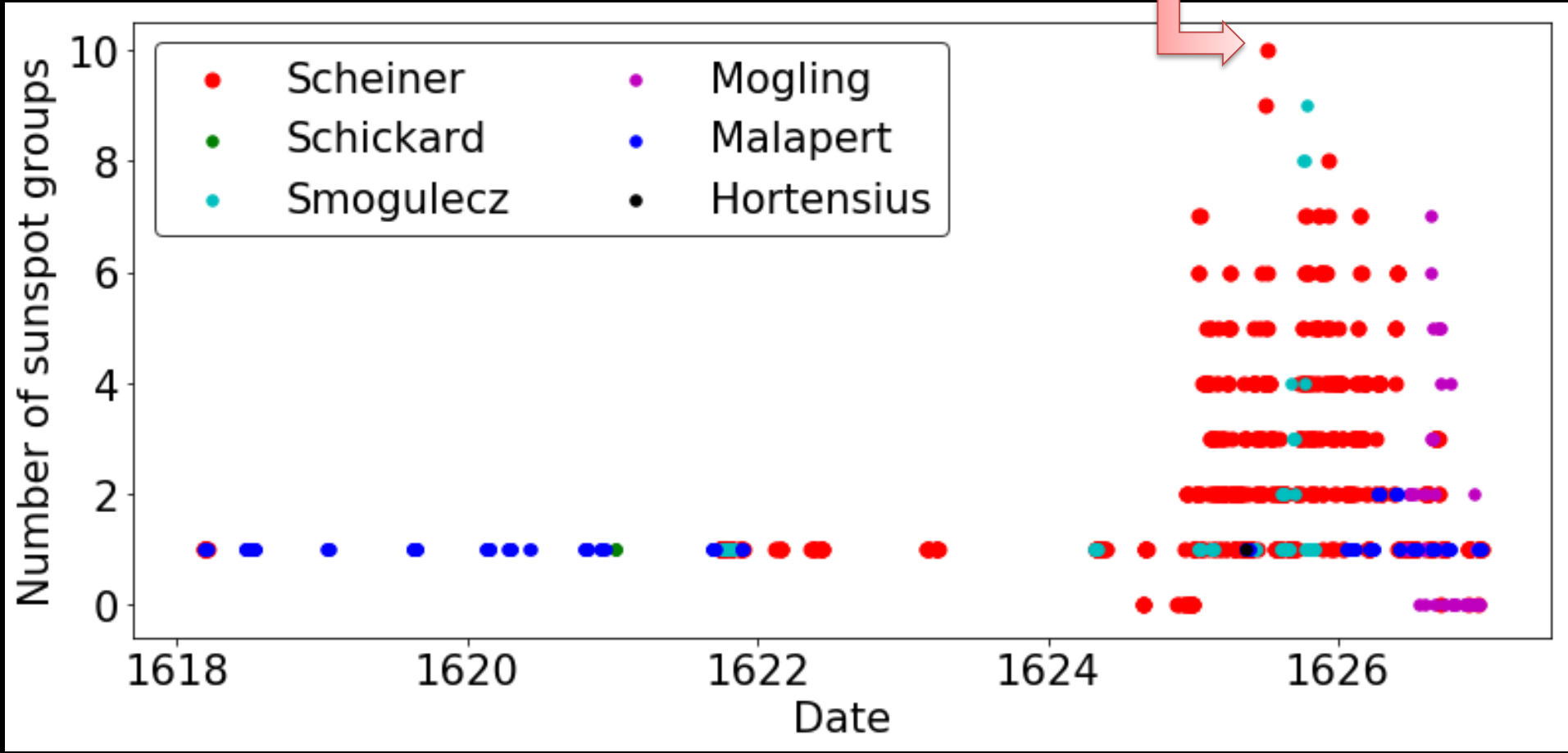
AD PAVLVM IORDANVM II.
VRSINVM BRACCIANI DVCEM.



BRACCIANI,
Apud Andream Phæum Typographum Ducalem.

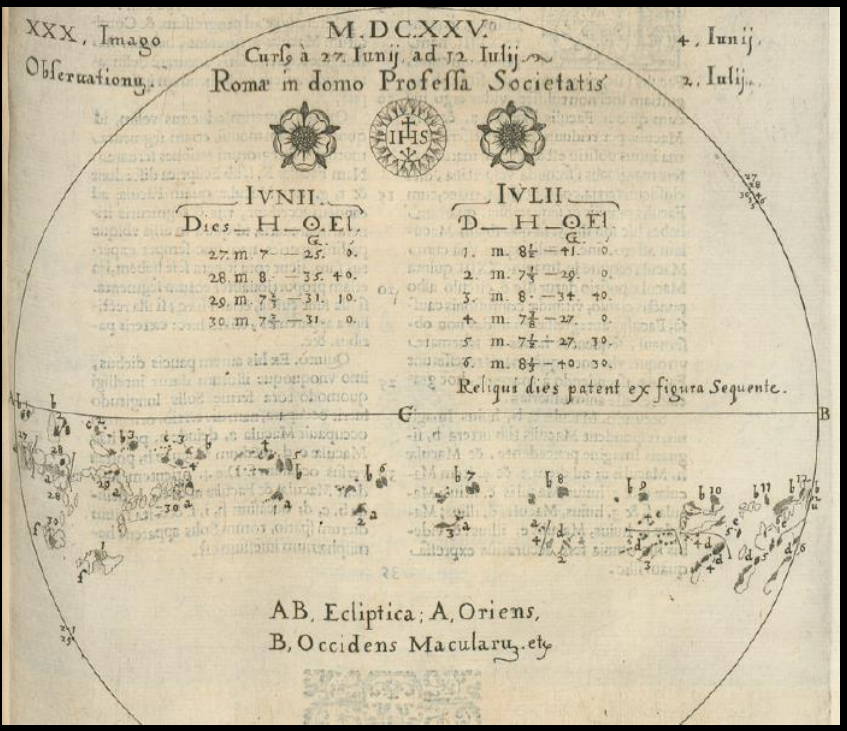
Impreſsio cœpta Anno 1626. finita vero 1630. Id. Iunij. Cum licentia Superiorum.

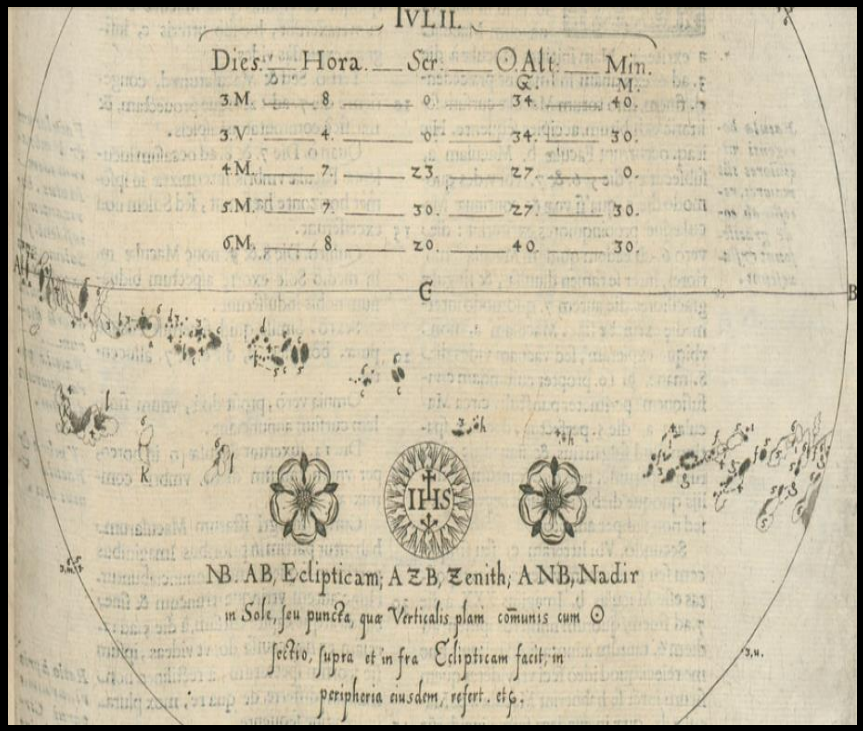
4 July 1625


Scheiner
Schickard
Smogulecz
Mogling
Malapert
Hortensius
Number of sunspot groups
0
2
4
6
8
10
1618
1620
1622
1624
1626
Date

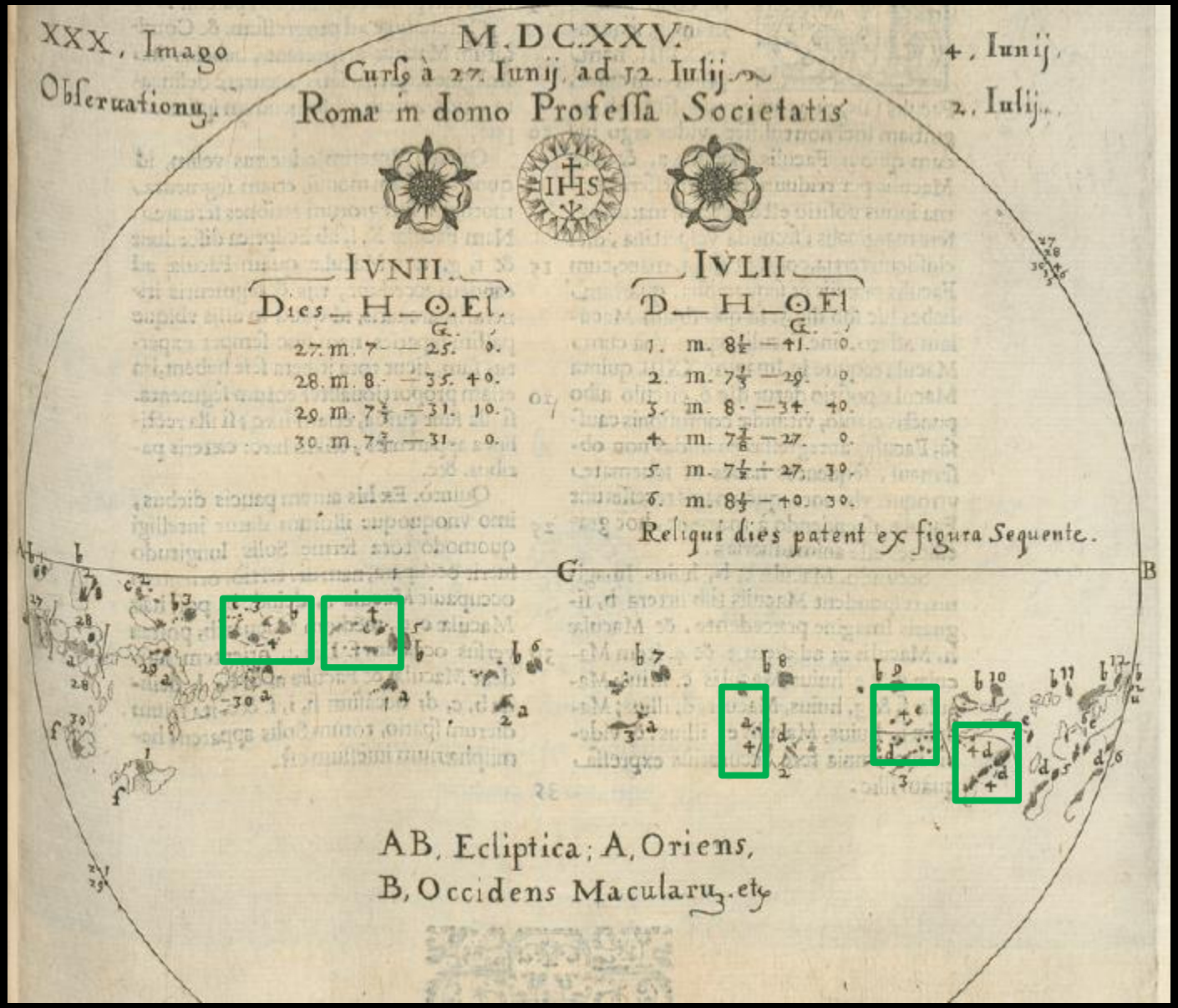
ROSA URSINA

4 July 1625

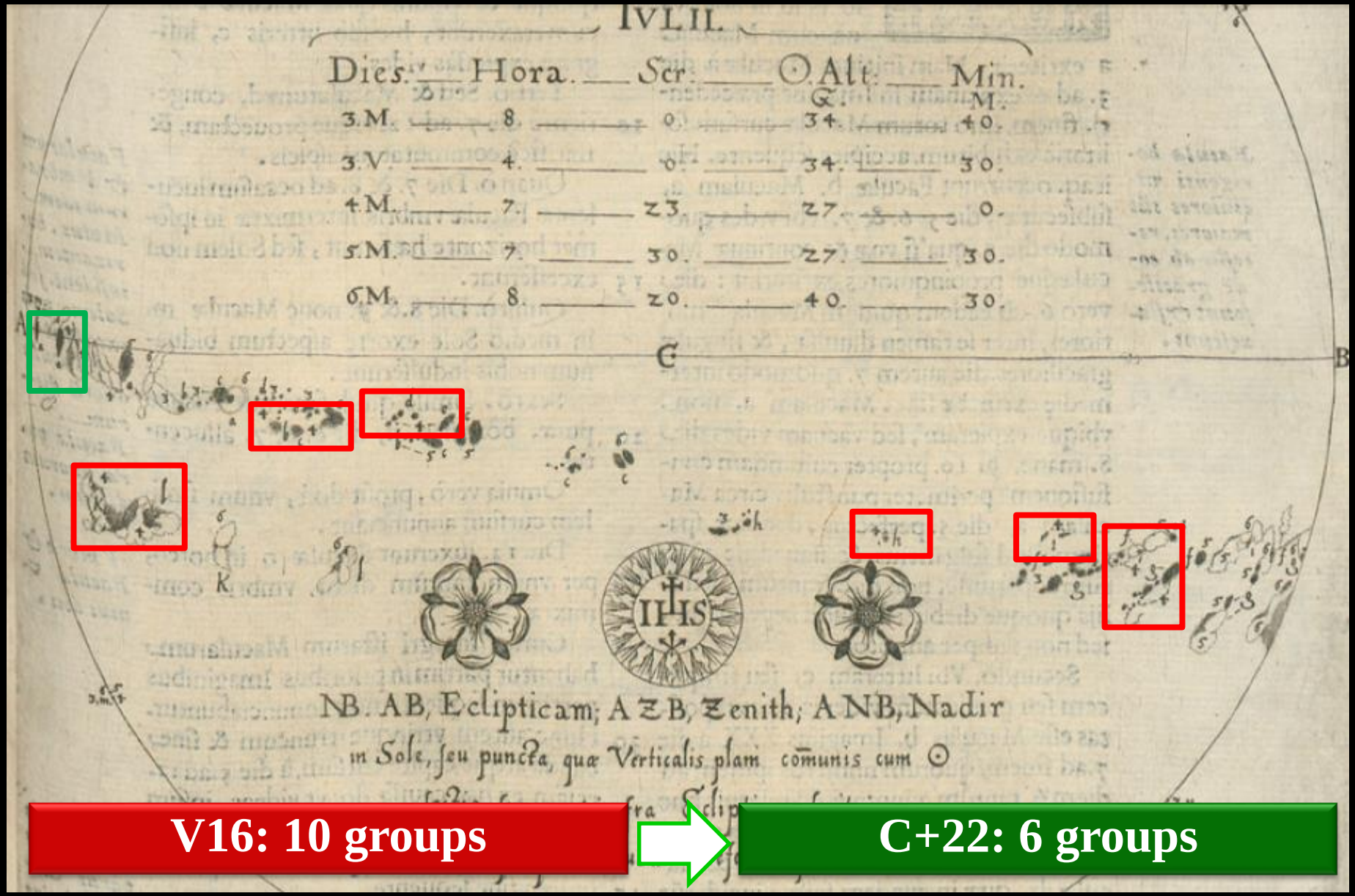




MISINTERPRETATION



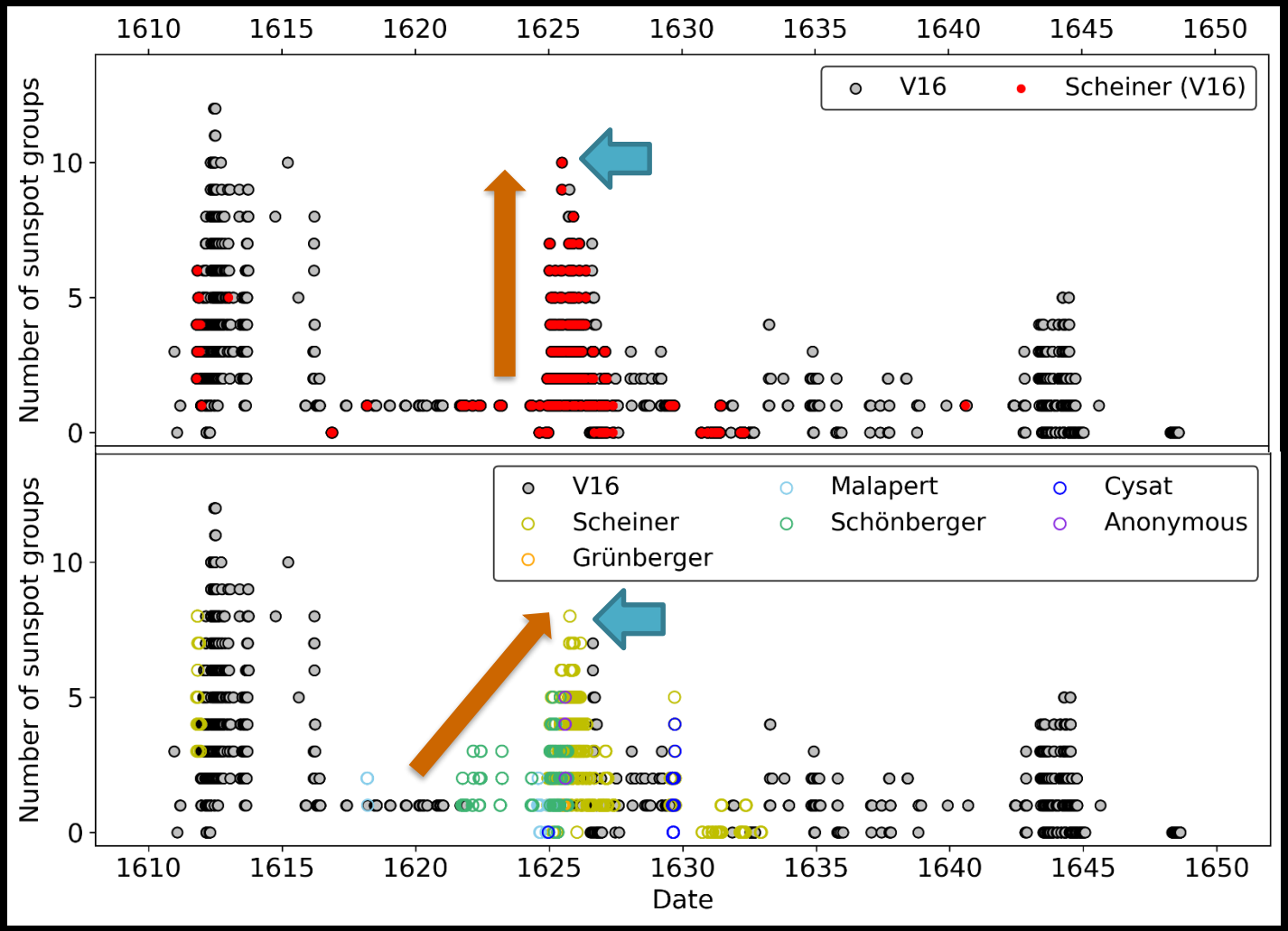
MISINTERPRETATION



V16: 10 groups

C+22: 6 groups

FIRST TELESCOPIC OBSERVATIONS



The Astrophysical Journal, 927:193 (11pp), 2022 March 10
https://doi.org/10.3847/1538-4357/ac52ee

Revisiting Christoph Scheiner's Sunspot Records: A New Perspective on Solar Activity of the Early Telescopic Era

V. M. S. Carrasco[1,2], A. Muñoz-Jaramillo[3], M. C. Gallego[1,2], and J. M. Vaquero[2,4]
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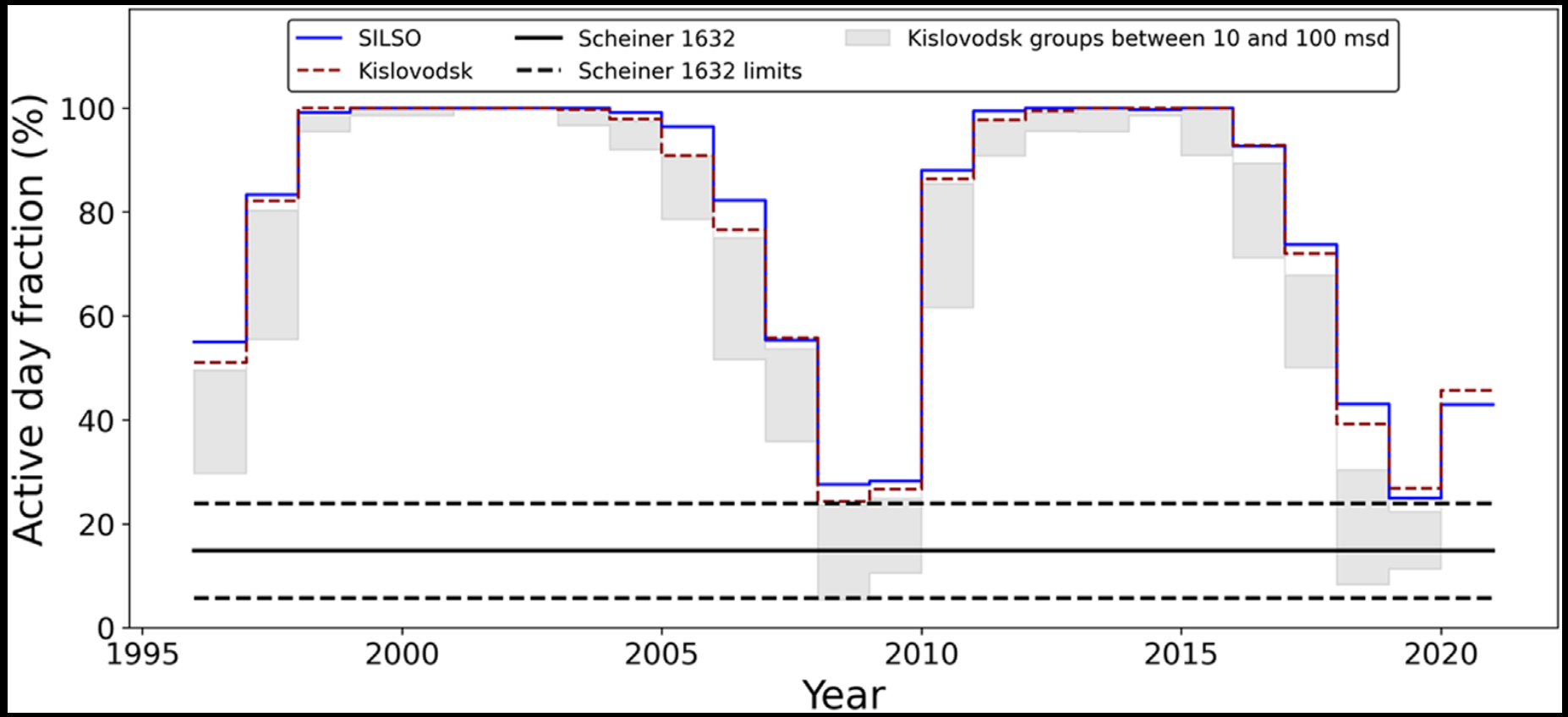
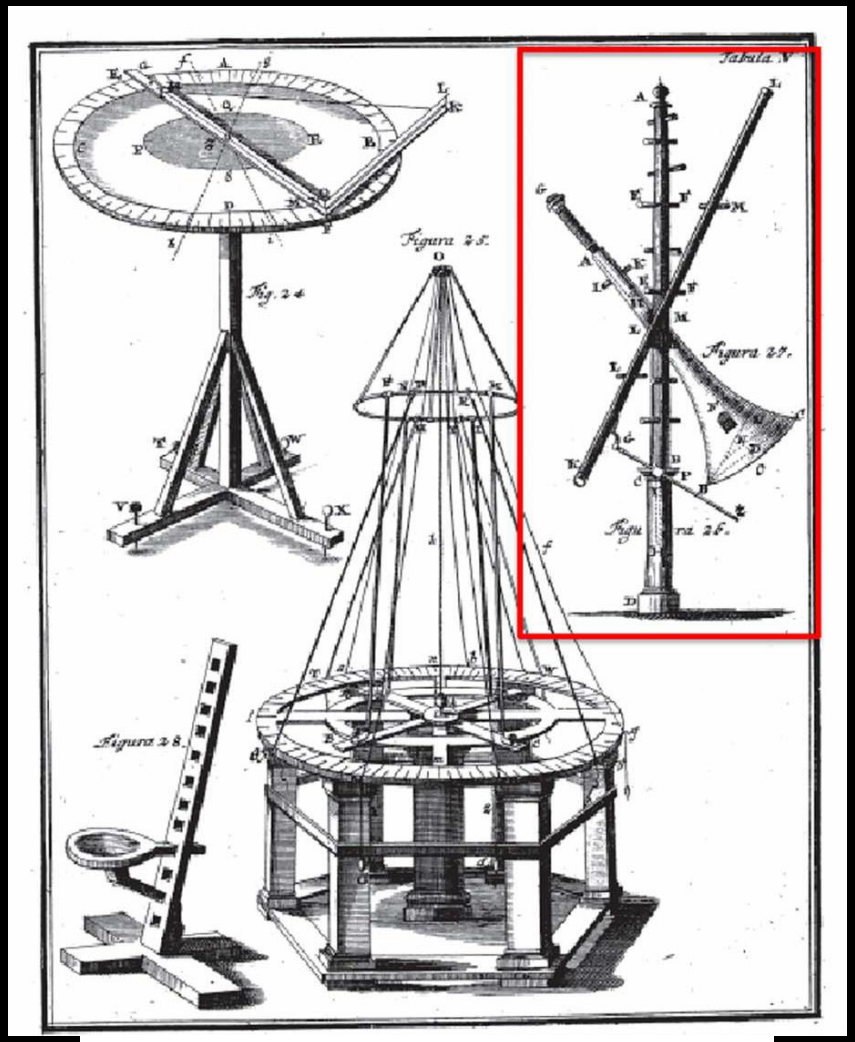
Received 2021 February 12; revised 2022 February 1; accepted 2022 February 5; published 2022 March 15

COMPARING WITH MODERN CYCLES

26 Feb – 13 Dec 1632 → **11 active days**
63 quiet days → **ADF=14,8%**
Range: 5,7-23,9%



MAUNDER MINIMUM: EIMMART



The Astrophysical Journal, 909:166 (12pp), 2021 March 10 https://doi.org/10.3847/1538-4357/abd949

Sunspot Observations at the Eimmart Observatory and in Its Neighborhood during the Late Maunder Minimum (1681–1718)

Hisashi Hayakawa[1,2,3,4], Chiaki Kuroyanagi[5], Víctor M. S. Carrasco[6,7], Shoma Uneme[1], Bruno P. Besser[8,9], Mitsuru Sôma[10], and Shinsuke Imada[1]
[1] Institute for Space-Earth Environmental Research, Nagoya University, 4648601, Nagoya, Japan; hisashi@nagoya-u.jp, hisashi.hayakawa@stfc.ac.uk
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[3] UK Solar System Data Centre, Space Physics and Operations Division, RAL Space, Science and Technology Facilities Council, Rutherford Appleton Laboratory, Harwell Oxford, OX11 0QX, Didcot, Oxfordshire, UK
[4] Nishina Centre, Riken, 3510198, Wako, Japan
[5] Graduate School of Arts and Sciences, University of Tokyo, 1538902, Tokyo, Japan
[6] Departamento de Física, Universidad de Extremadura, E-06006 Badajoz, Spain
[7] Instituto Universitario de Investigación del Agua, Cambio Climático y Sostenibilidad (IACYS), Universidad de Extremadura, E-06006 Badajoz, Spain
[8] Space Research Institute, Austrian Academy of Sciences, A-8042, Graz, Austria
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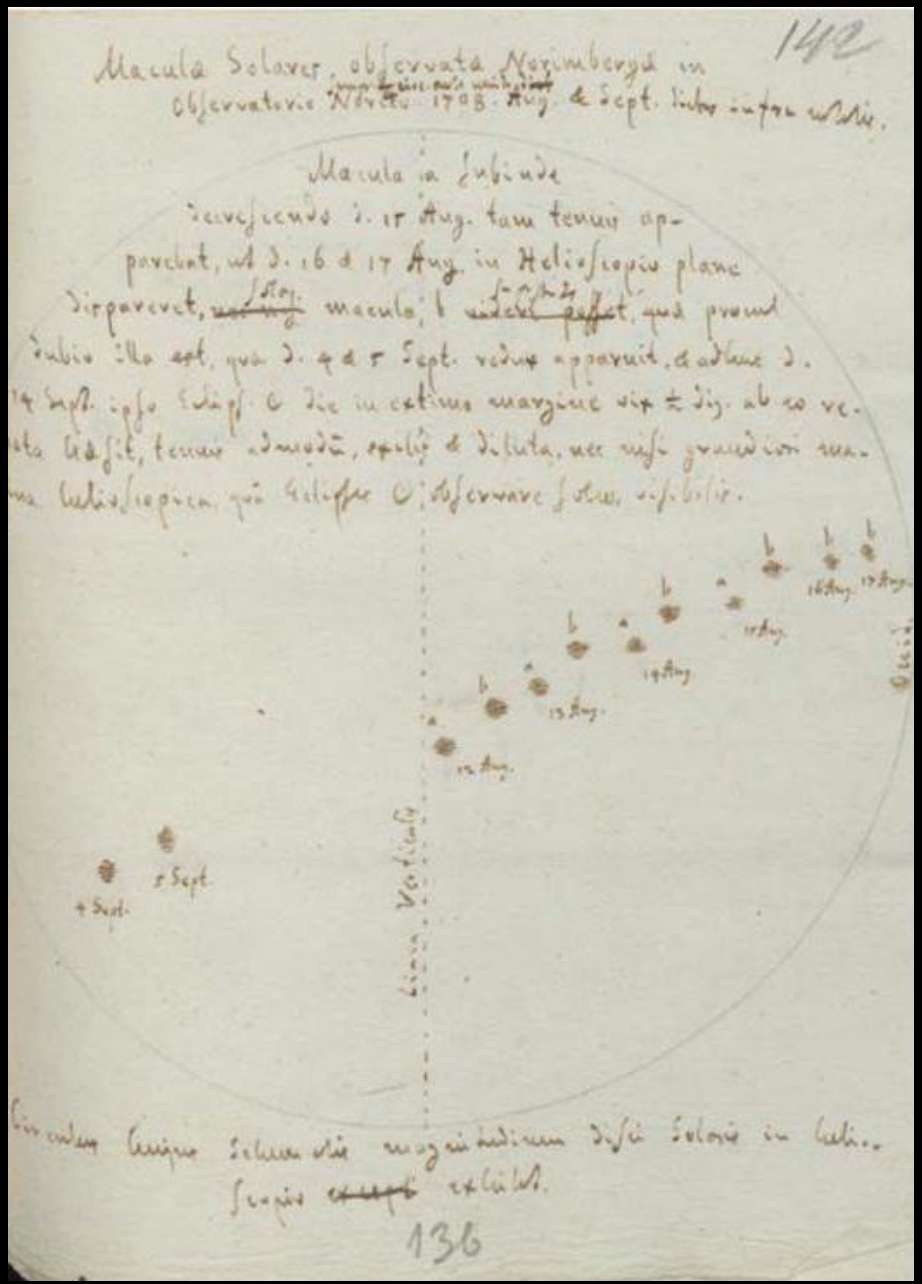
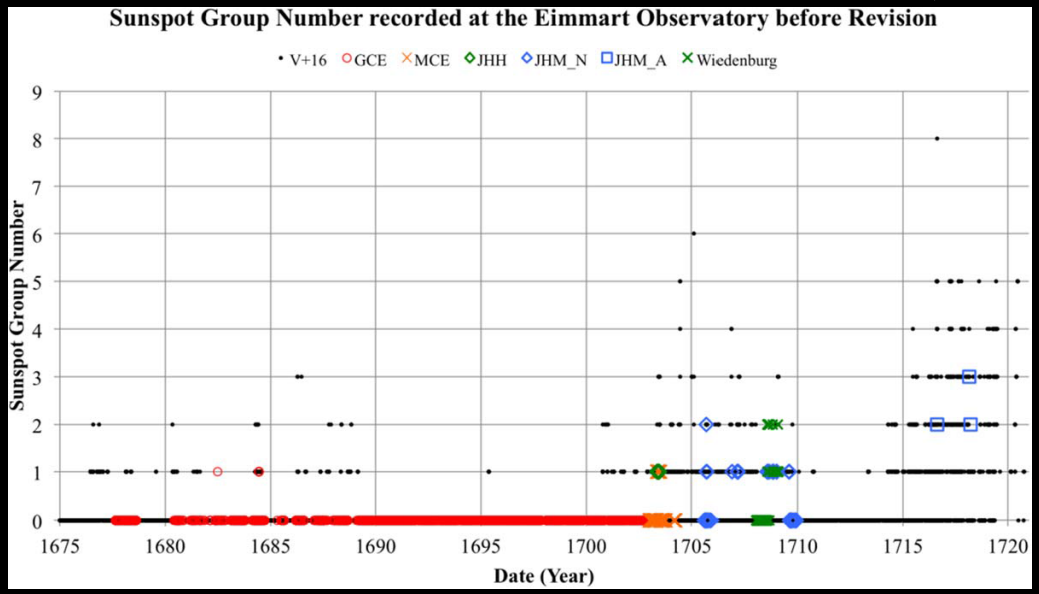
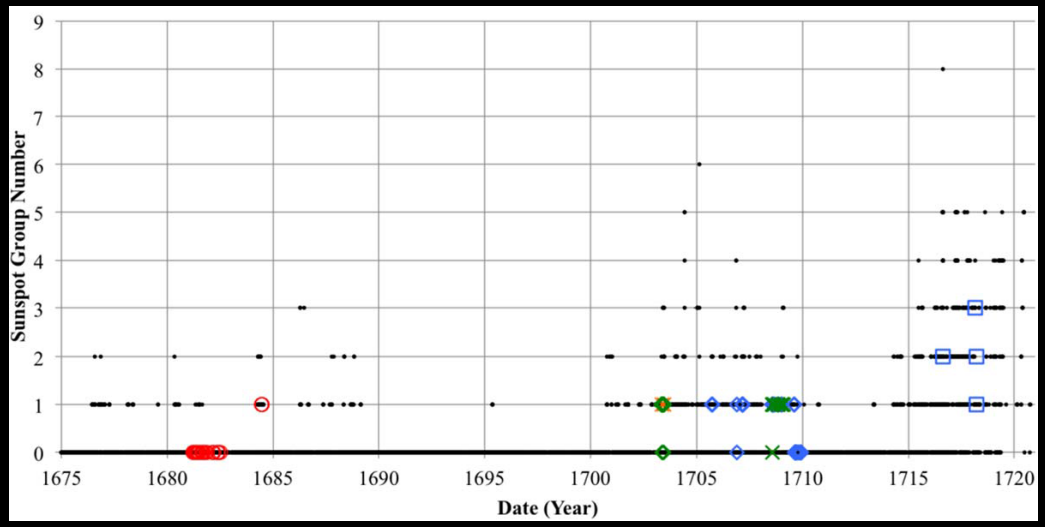
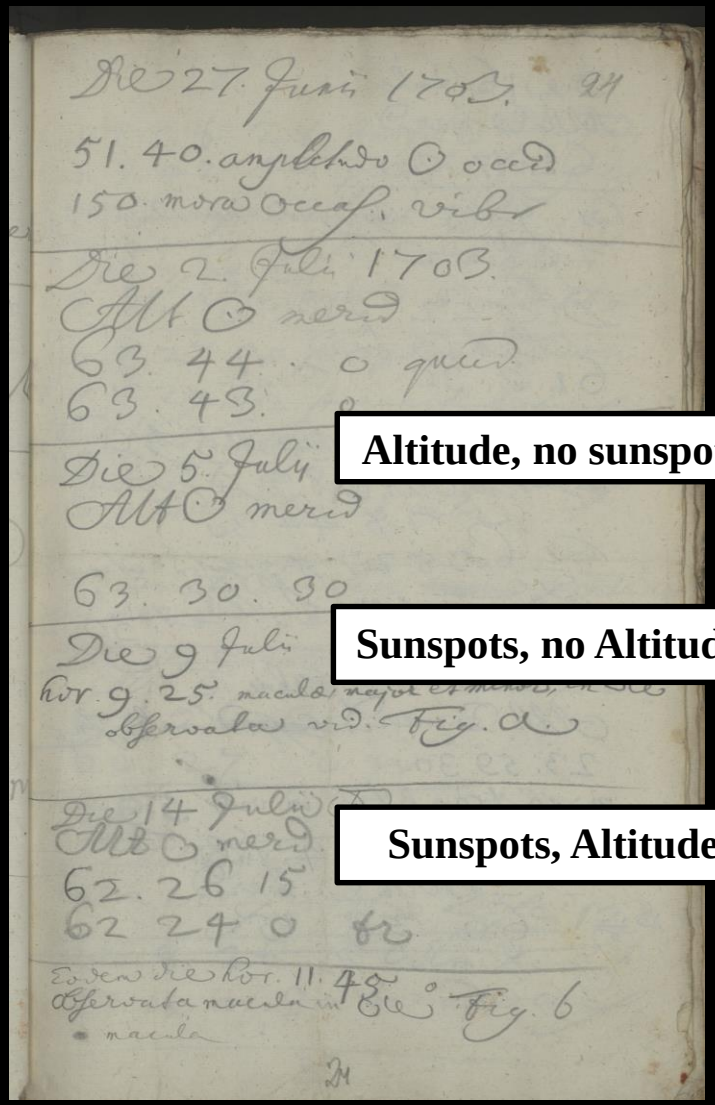
[10] National Astronomical Observatory of Japan, 1818588, Mitaka, Japan
Received 2020 December 17; revised 2021 January 5; accepted 2021 January 5; published 2021 March 15



EIMMART (1681 – 1718)







Altitude, no sunspots

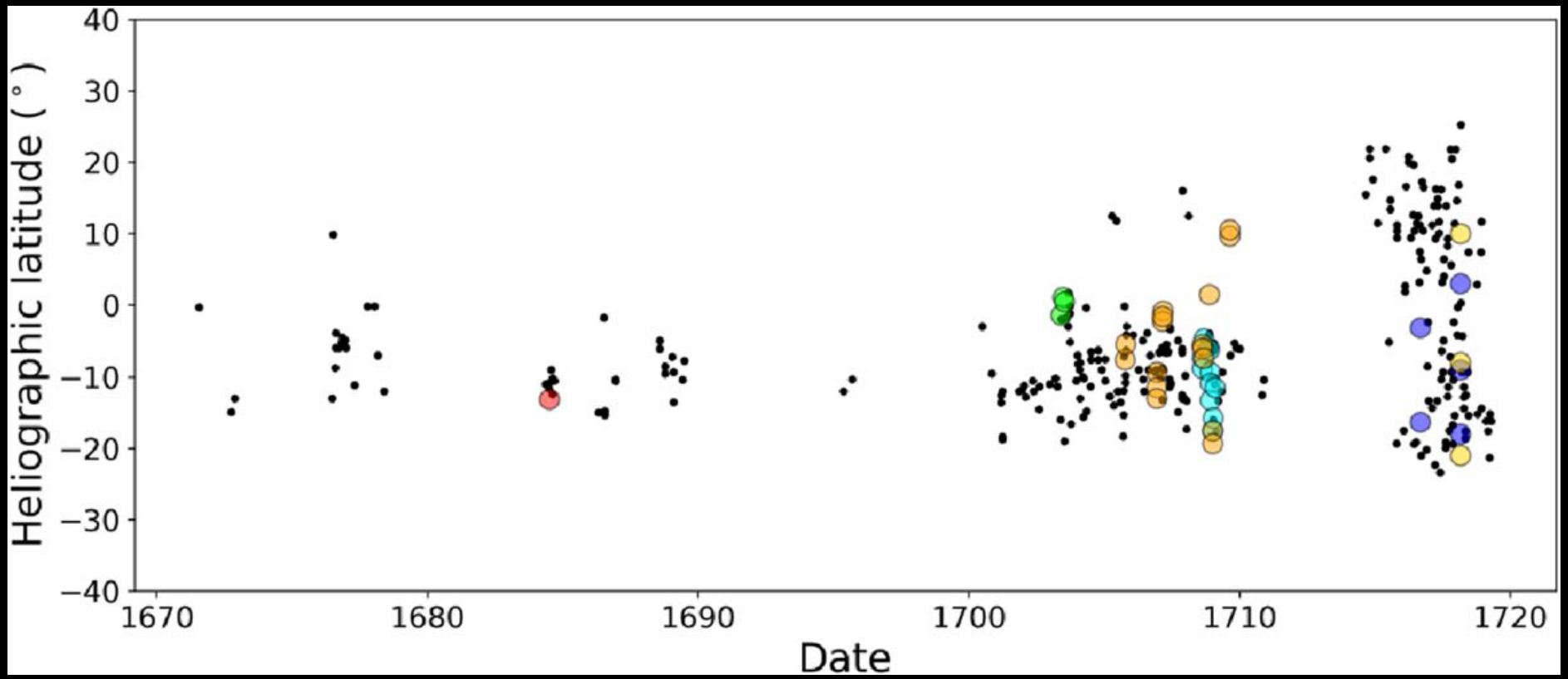
Sunspots, no Altitude

Sunspots, Altitude

Coverage for 1677-1709: 73,4% to 66,9%

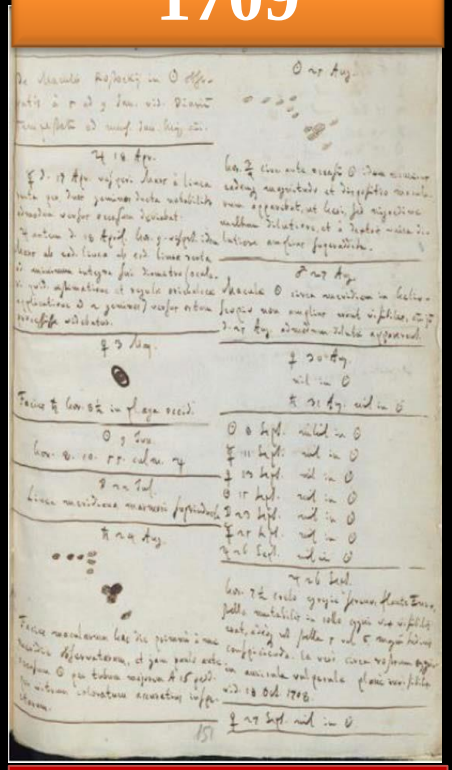
Coverage for 1685-1702: 71,4% to 61,5%

MAUNDER MINIMUM: EIMMART



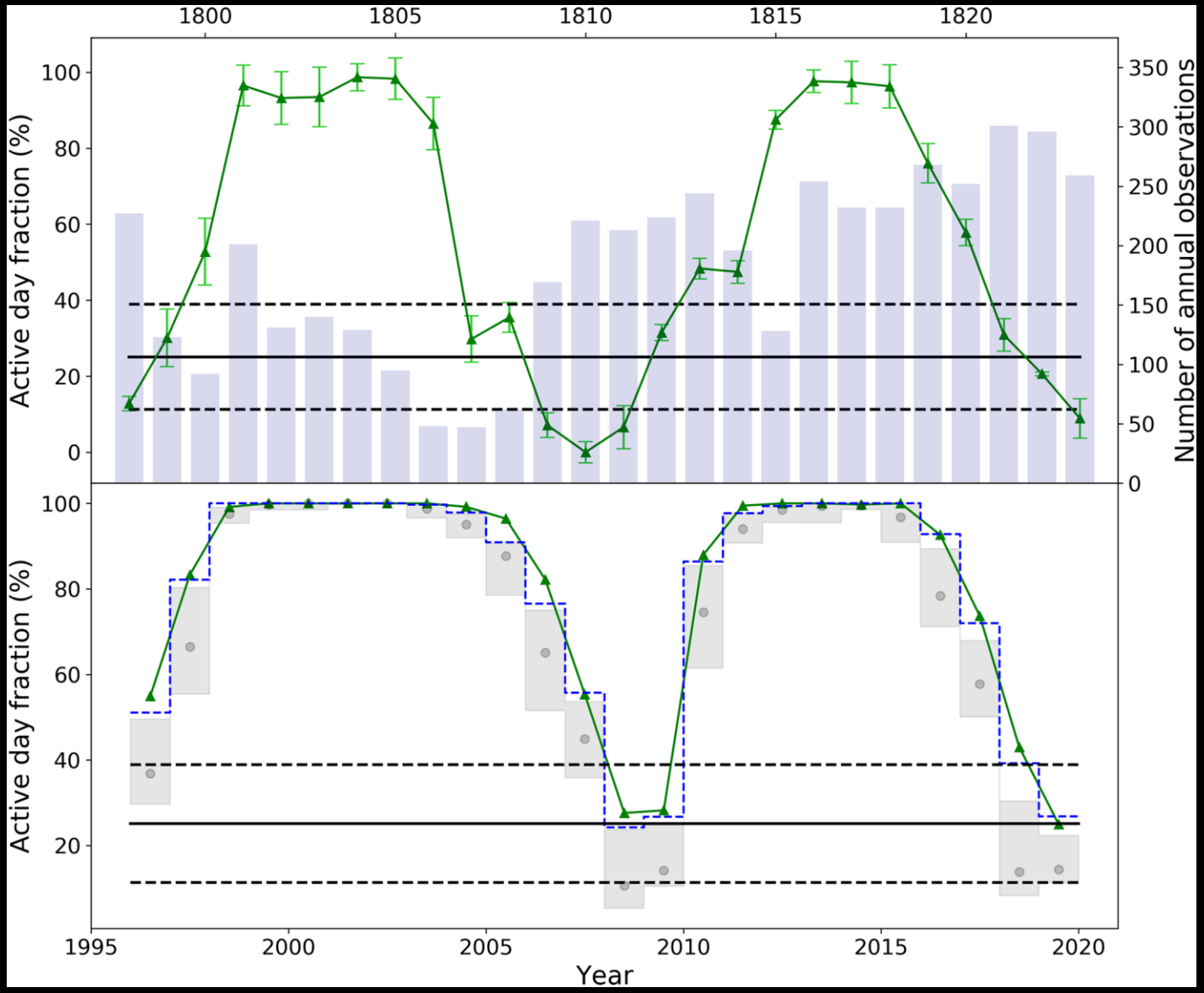
MAUNDER MINIMUM: EIMMART

1709



8 active days
24 quiet days

ADF=25,1%
Range:
11,3-38,9%



DALTON MINIMUM: TEVEL (1816-1836)

Tevel was one of the most active observers of the Dalton Minimum

The Astrophysical Journal, 922:58 (8pp), 2021 November 20 https://doi.org/10.3847/1538-4357/ac24a5

Number of Sunspot Groups and Individual Sunspots Recorded by Tevel for the Period 1816–1836 in the Dalton Minimum

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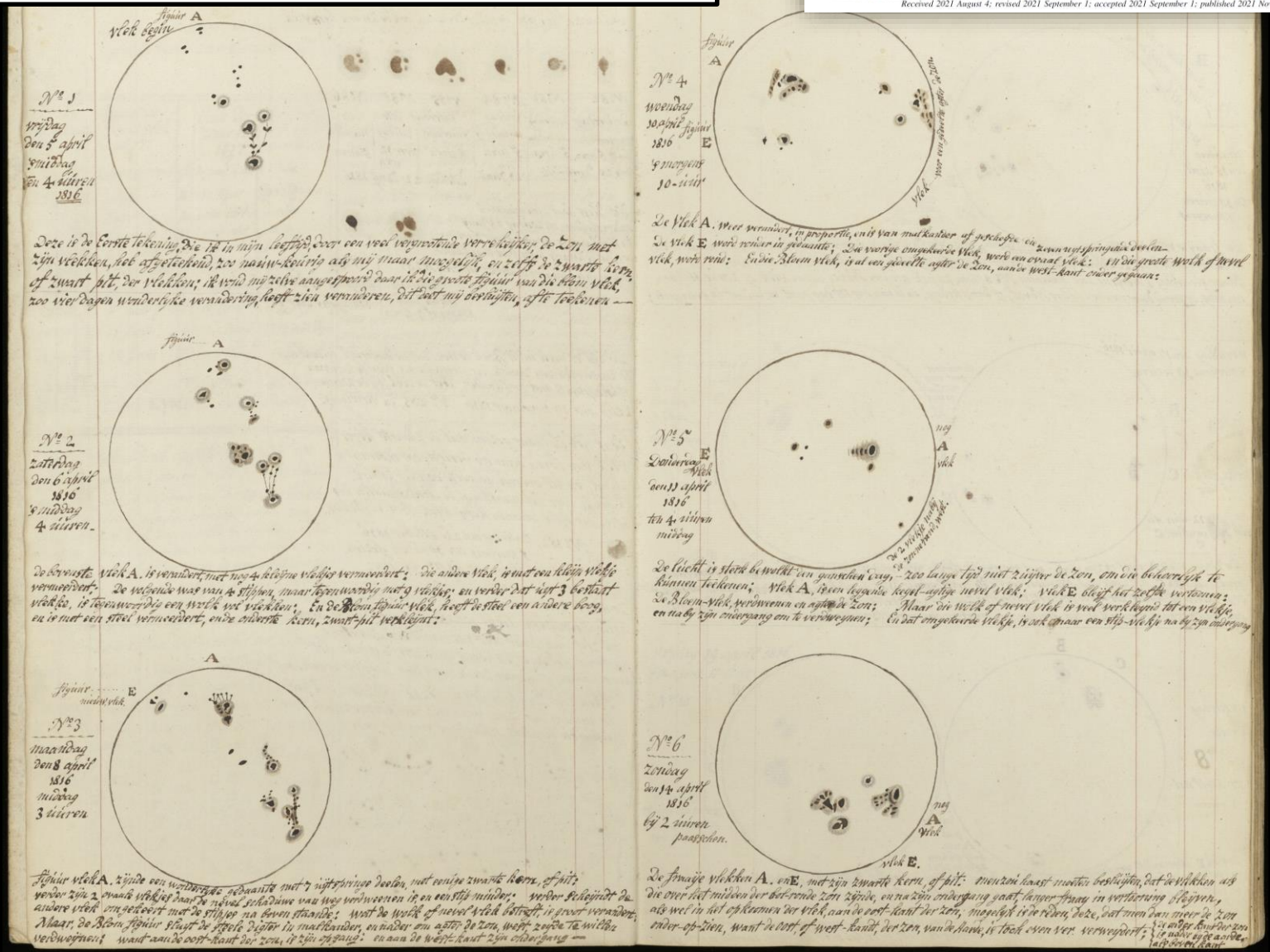
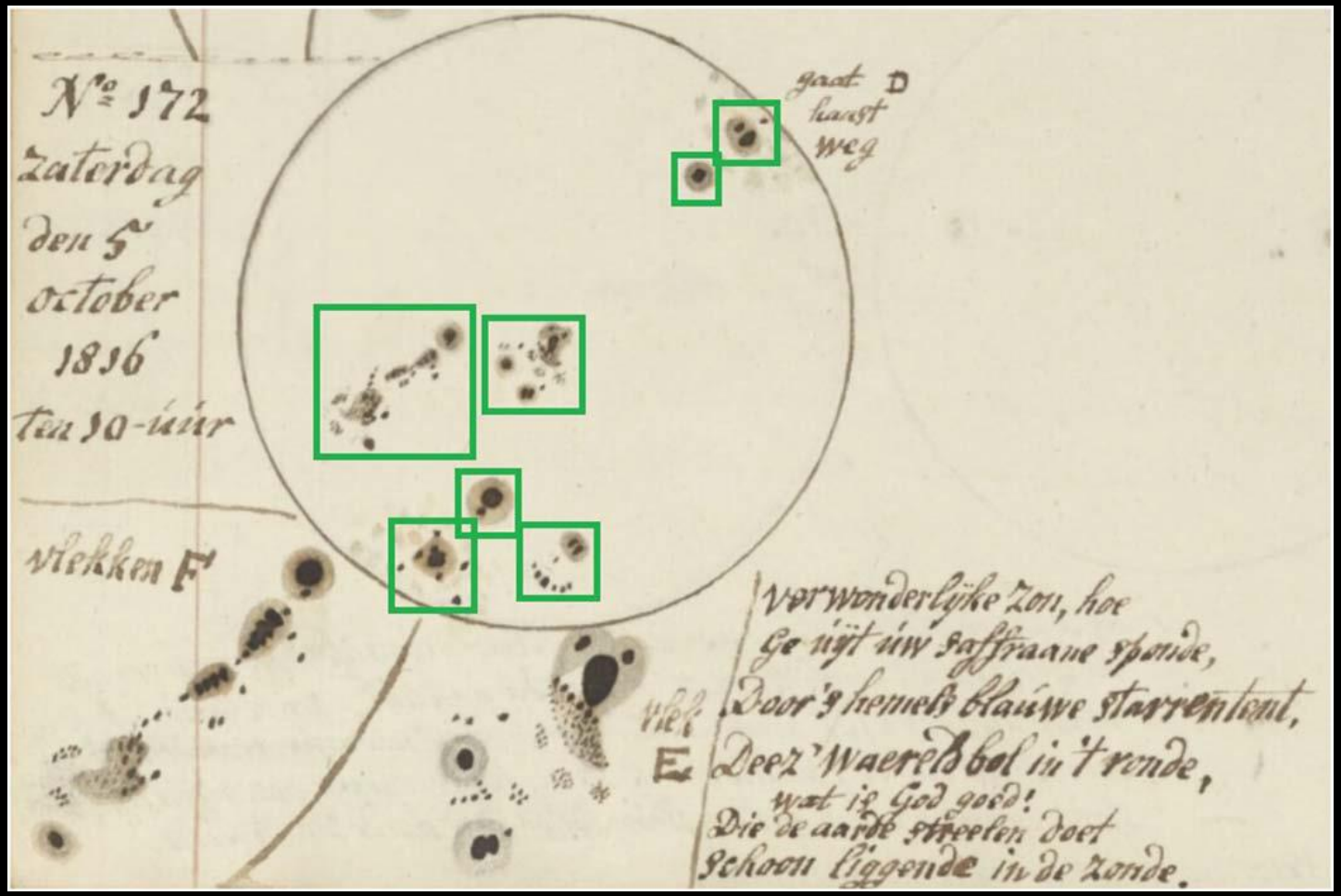
[2] Instituto Universitario de Investigación del Agua, Cambio Climático y Sostenibilidad (IACYS), Universidad de Extremadura, E-06006 Badajoz, Spain
Received 2021 August 4; revised 2021 September 1; accepted 2021 September 1; published 2021 November 19



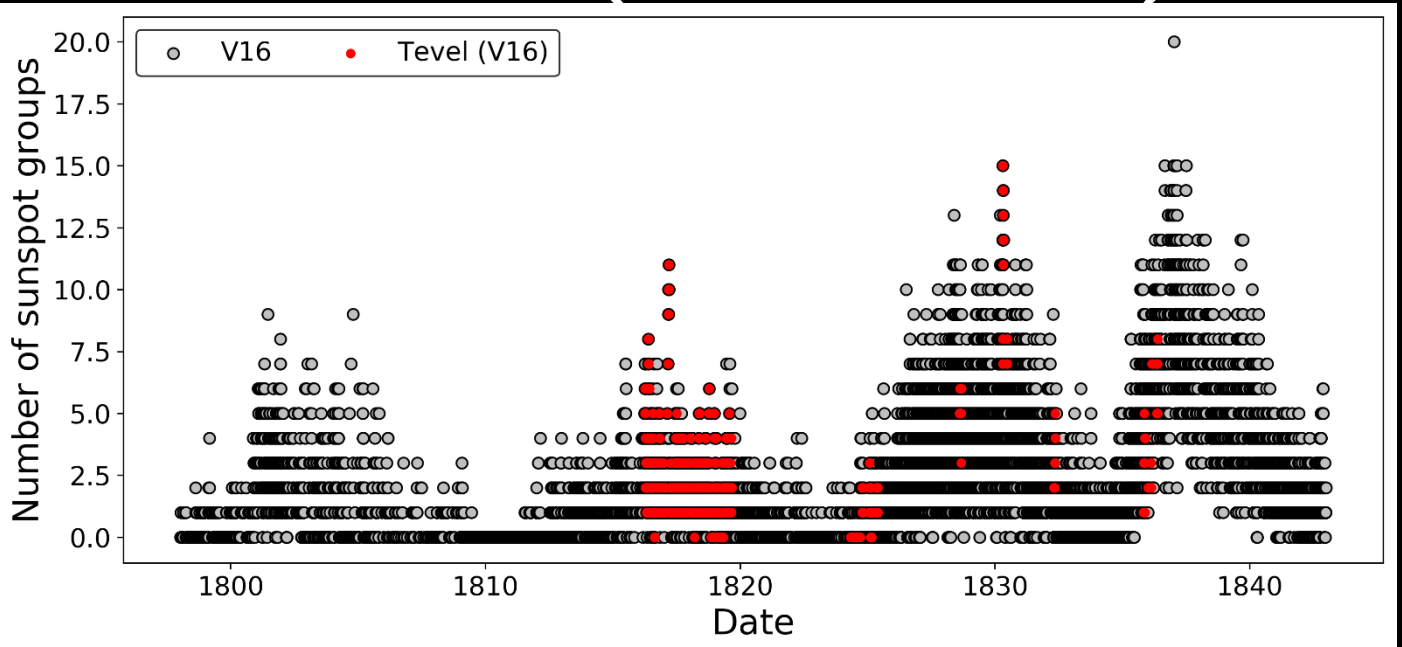
DALTON MINIMUM

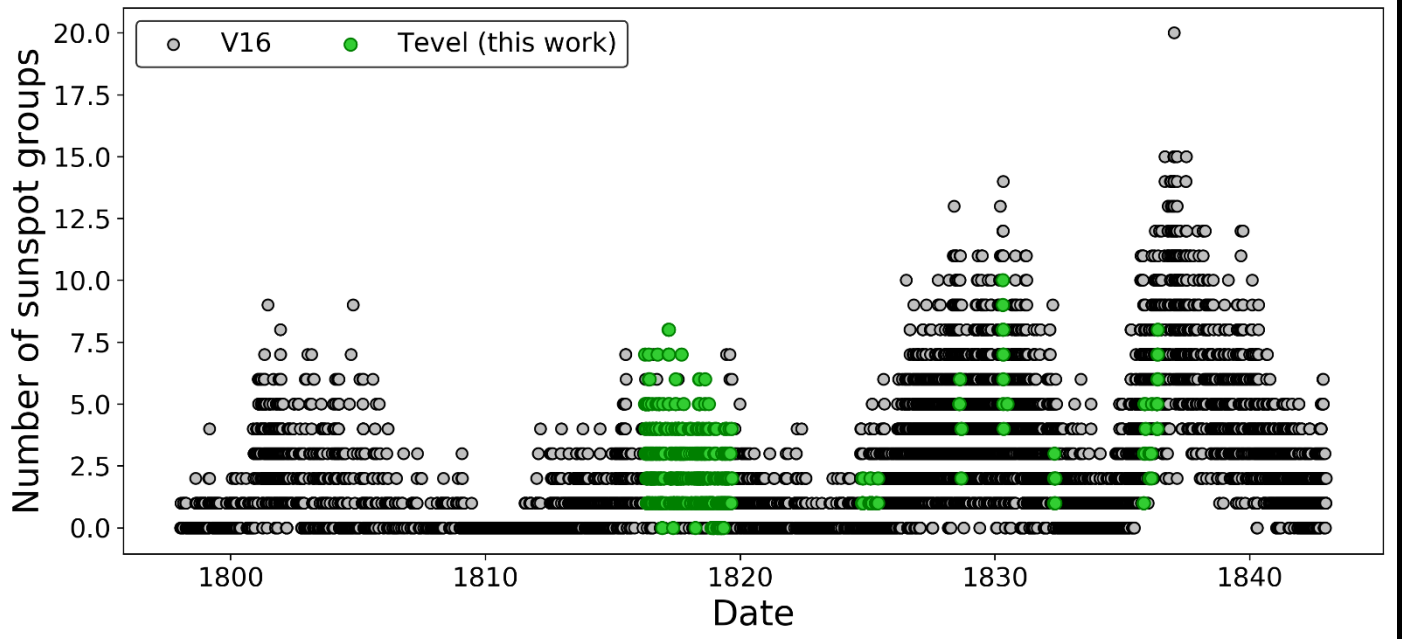
5 October 1816



V16: 3 groups → **C21: 7 groups**

TEVEL (1816 – 1836)





20TH CENTURY: SAC PEAK

SAC PEAK OBSERVATORY (1947-2004)

Solar Phys (2021) 296:3
https://doi.org/10.1007/s11207-020-01746-5

The Sunspot Drawing Collection of the National Solar Observatory at Sacramento Peak (1947–2004)

V.M.S. Carrasco[1,2] · **A.A. Pevtsov**[3] · **J.M. Nogales**[4] · **J.M. Vaquero**[2,5]

Received: 21 July 2020 / Accepted: 9 December 2020

Abstract A complete dataset of sunspot drawings recorded at Sacramento Peak Observatory (SPO) from late 1947 till mid-2004 has been digitized. We present the history of the observations and describe the data included in the drawings. We compare the sunspot number index calculated from the SPO data and the International Sunspot Number (S_Nv2), and we find that both series exhibit a similar behavior. The ratio of two sunspot numbers is relatively constant at about 1.2 – 1.3 during 1955–1995, with larger variations present at the beginning of the time series. This work represents the first step for the publication of the SPO sunspot catalogue in digital format. More information, such as positions and areas of sunspots, will be included in the next versions in order to provide the space weather and climate community a more complete sunspot catalogue with good quality observations.

Keywords Solar cycle · Observations · Sunspots · Statistics

1. Introduction

Sunspot drawings represent the earliest and the longest record of direct observations of solar activity (Muñoz-Jaramillo and Vaquero, 2019). The earliest drawings were taken by Harriot, Galileo, Scheiner, Fabricius, and others four centuries ago (Arlt and Vaquero, 2020). Despite its simplicity, this proxy of solar activity continues to be used till present. The strength

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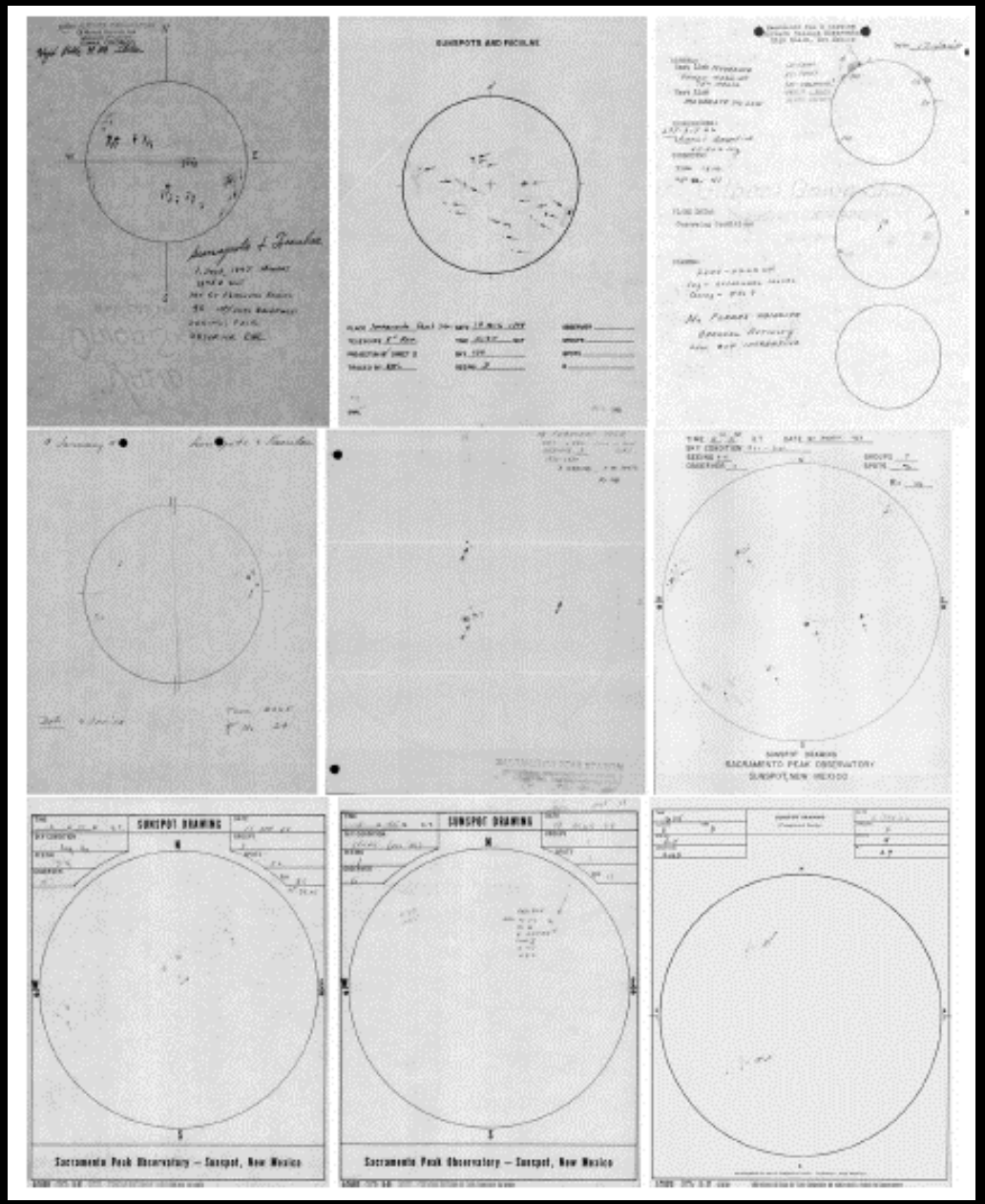
2 Instituto Universitario de Investigación del Agua, Cambio Climático y Sostenibilidad (IACYS), Universidad de Extremadura, 06006 Badajoz, Spain

3 National Solar Observatory, Boulder, CO 80303, USA

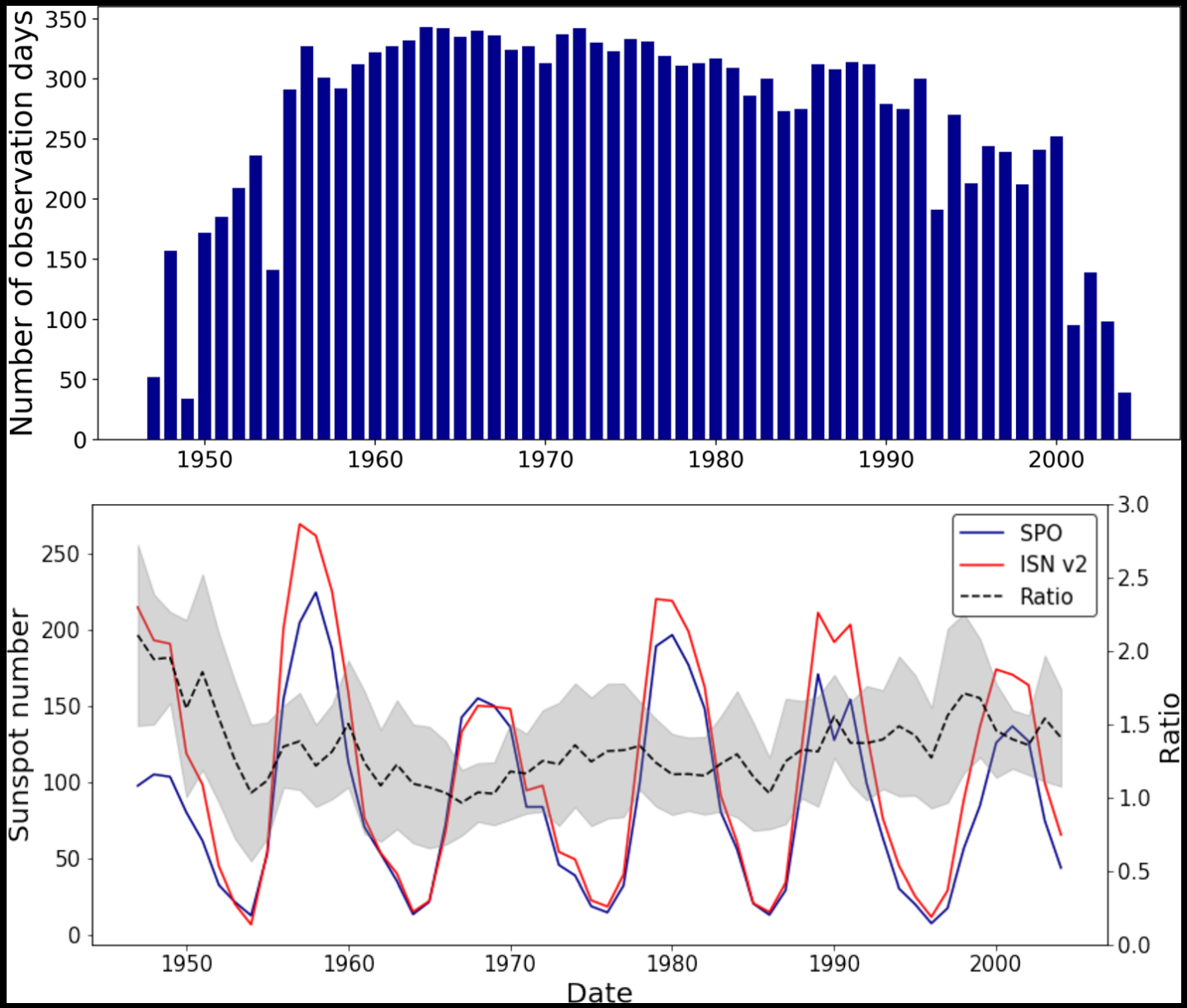
4 Departamento de Expresión Gráfica, Universidad de Extremadura, 06800 Mérida, Spain

5 Departamento de Física, Universidad de Extremadura, 06800 Mérida, Spain

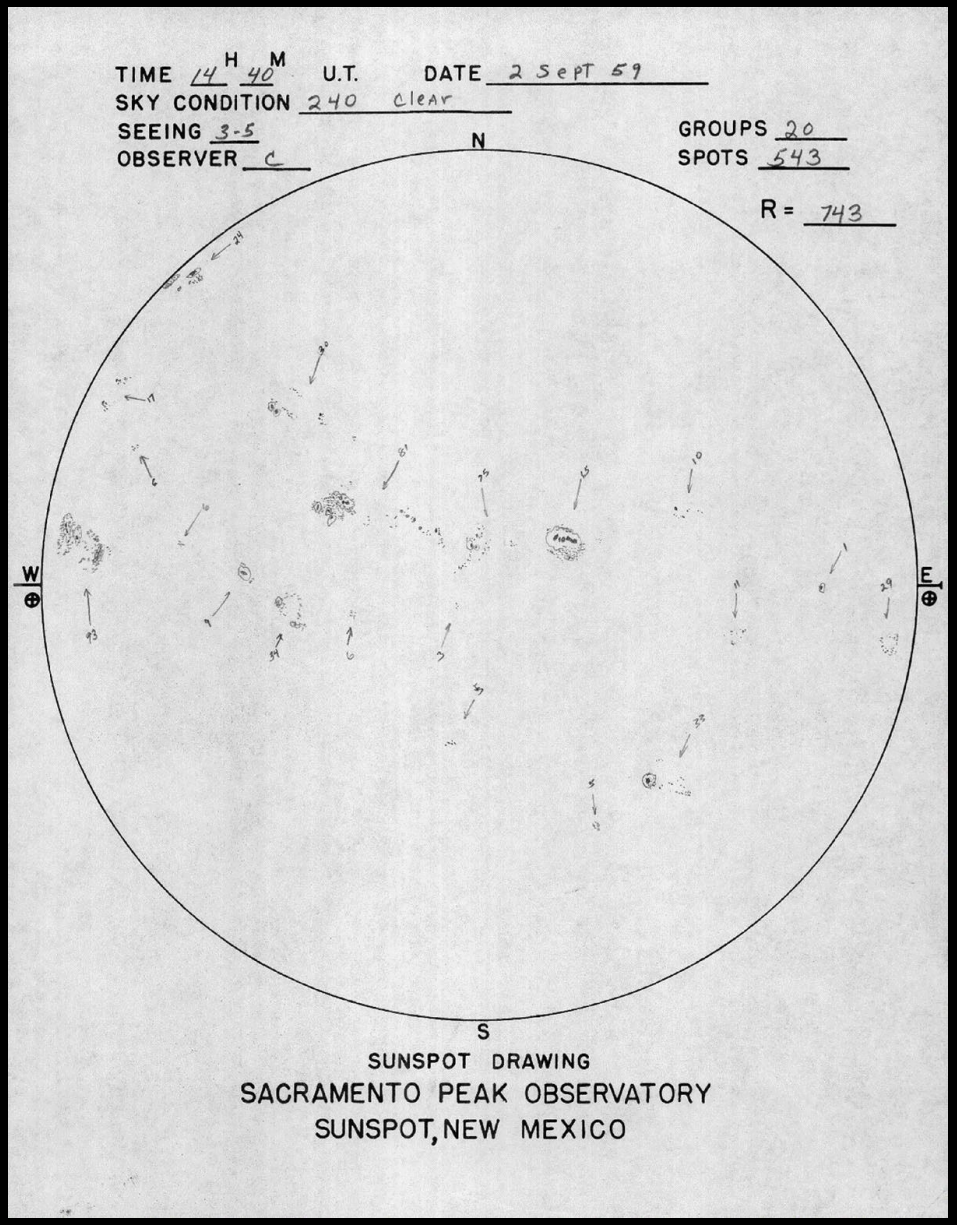
Published online: 05 January 2021

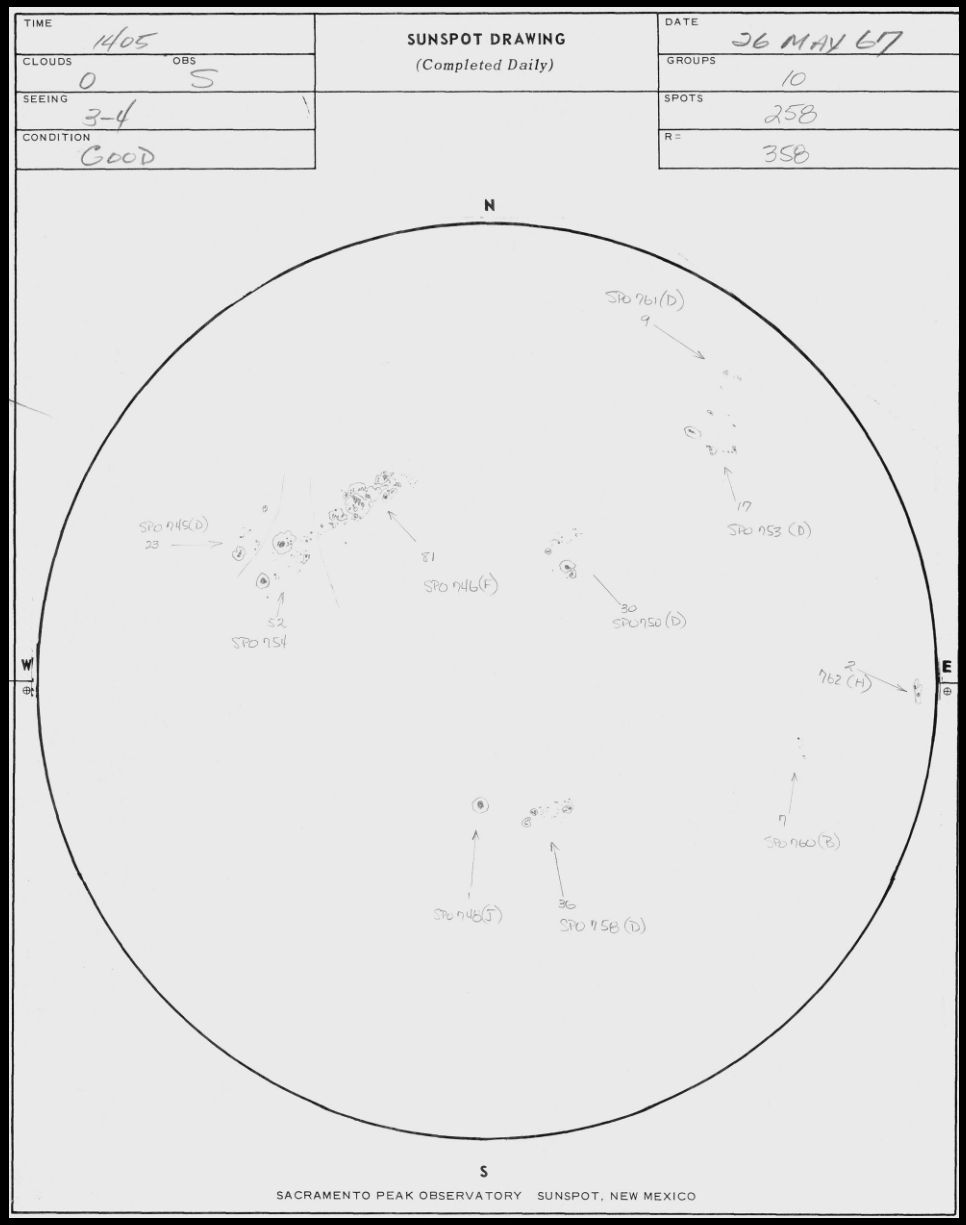


SAC PEAK OBSERVATORY (1947-2004)



SAC PEAK OBSERVATORY (1947-2004)





THANK YOU FOR YOUR ATTENTION

On improvements in the future version of the revised collection of sunspot group numbers

Víctor Carrasco