# Discussion of Paper

## THE MAUNDER MINIMUM IS NOT AS GRAND AS IT SEEMED TO BE

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# The Paper

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## THE MAUNDER MINIMUM IS NOT AS GRAND AS IT SEEMED TO BE

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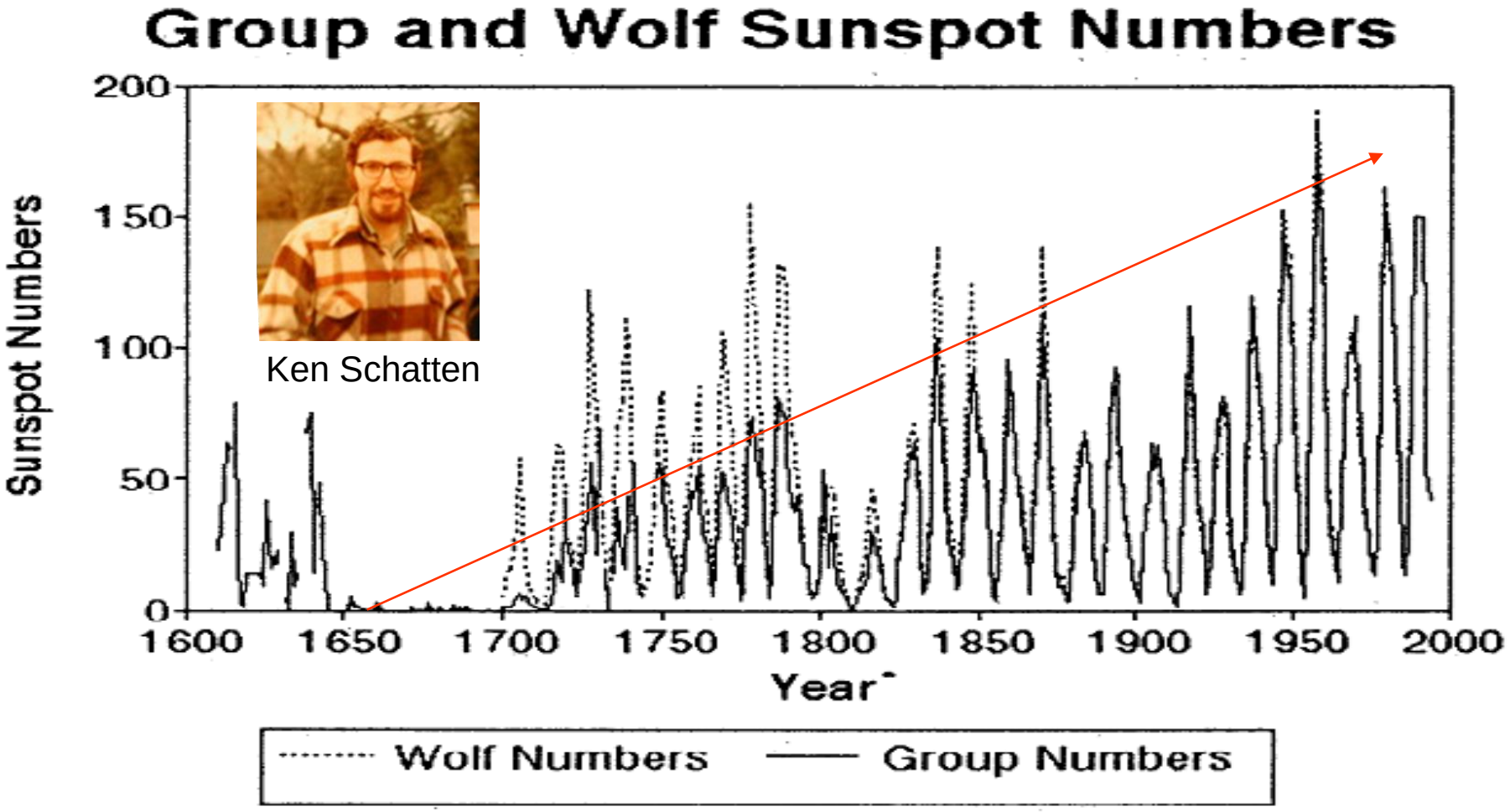
### ABSTRACT

The Maunder Minimum (MM), which occurred between 1645 and 1715, is mainly known as an almost spotless period on the Sun. We analyze the nominal number of sunspot groups for each observer individually. Comparing the sunspot drawings and textual reports, we conclude that the latter underestimate the number of sunspots. We also argue that the different points of view of observers in the seventeenth century on the origin of sunspots resulted in the underestimation of sunspot groups or even gaps in observational reports. We demonstrate that Jean Picard and Giovanni Domenico Cassini of the Paris Observatory did not report any sunspots, while other observers reported on the occurrence of spots. Moreover, compared with other observers, La Hire underestimated the solar activity. The MM looks like an ordinary secular minimum with a depressed 11 yr solar cyclicity.

*Key words:* Sun: activity – sunspots

# Unfortunately Two Data Series






Ken Schatten

**Hoyt & Schatten, GRL *21*, 1994**

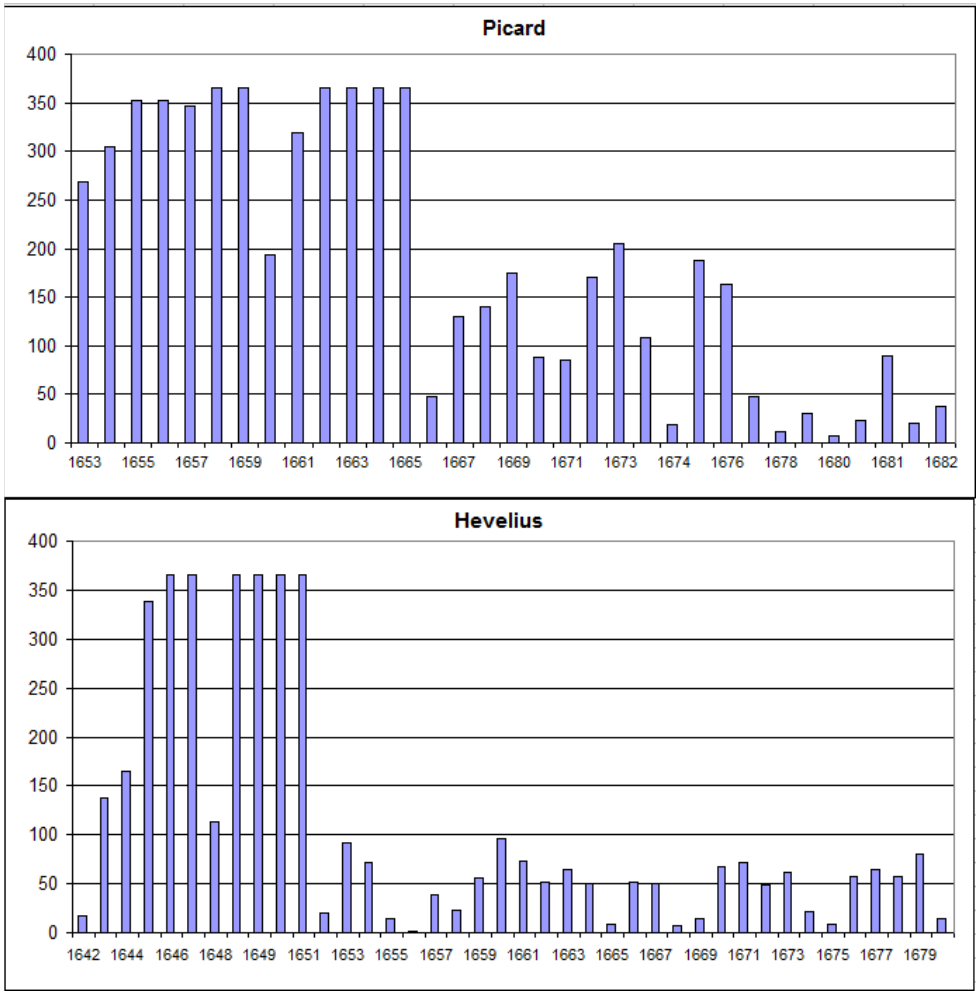
# How Well was the Maunder Minimum Observed?

NUMBER OF SUNSPOT GROUPS FOR THE YEAR: 1658
AS OBSERVED BY: PICARD/KEILL, PARIS

H&S

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 0 | -99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | -99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 0 | -99 | 0 | -99 | 0 | -99 | 0 | 0 | -99 | 0 | -99 | 0 |
| means: | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

It is not credible that for many years there were not a single day without observations




Number of days per year with ‘observations’

# Perhaps a More Realistic Assessment

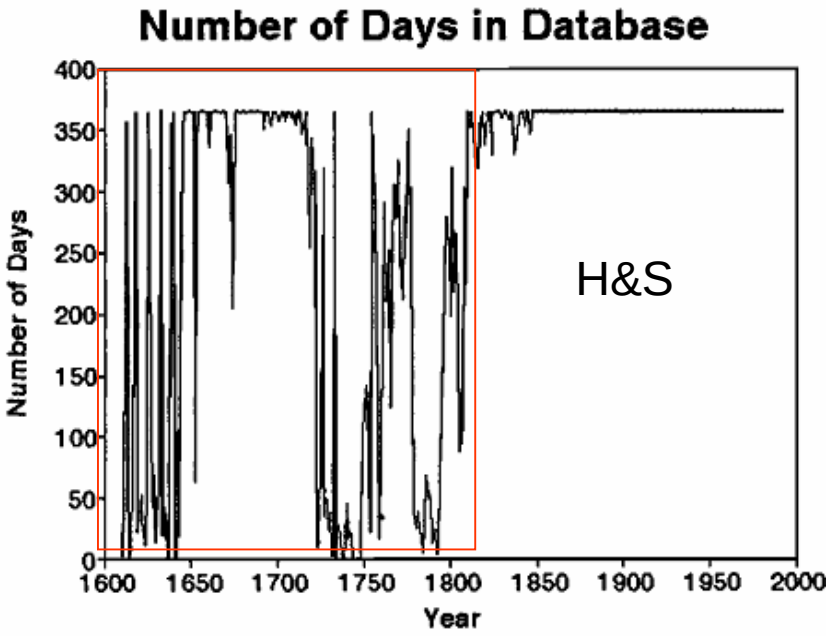
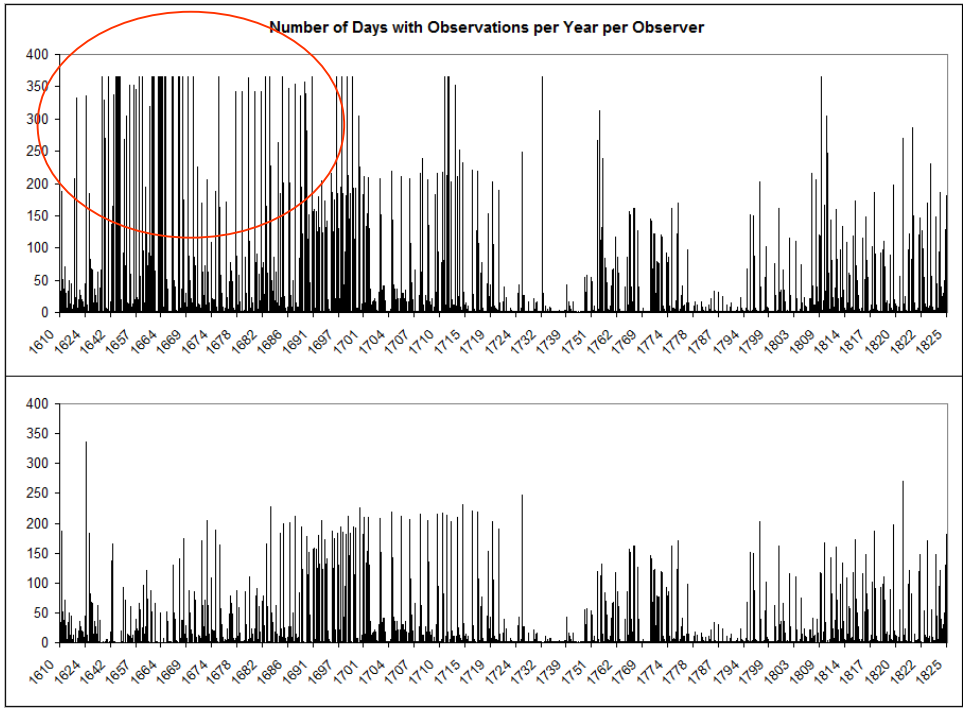
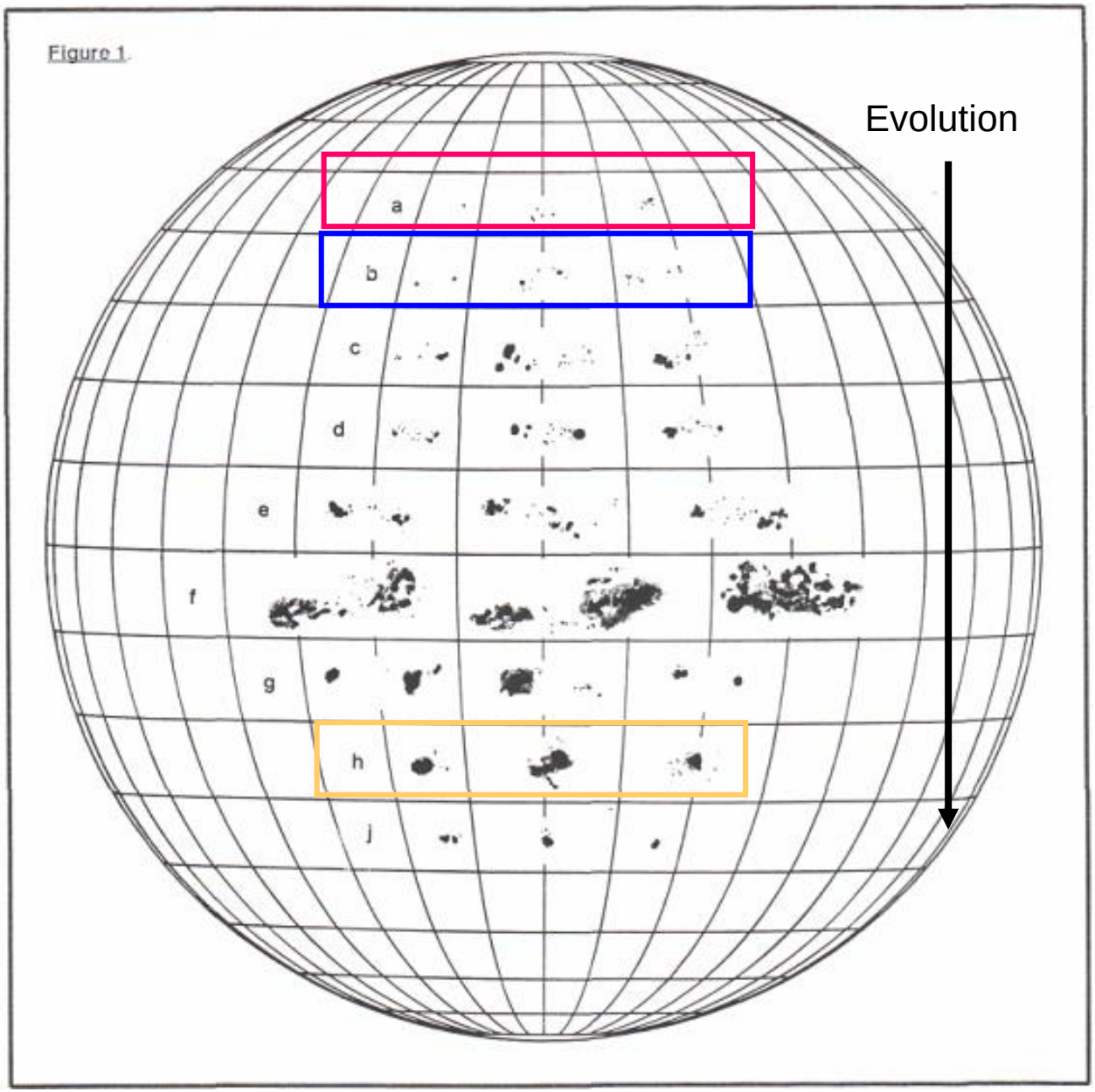



**Figure 3.** The number of days each year for we which have observations or interpolated values. If more than 5% of the days are observed in a year, a good yearly mean can usually be found. Most years meet this criteria. Note that the Sun was well observed during the Maunder Minimum.




1610 1700 1825




# The Zürich Classification

a: no penumbra, no bipolar structure

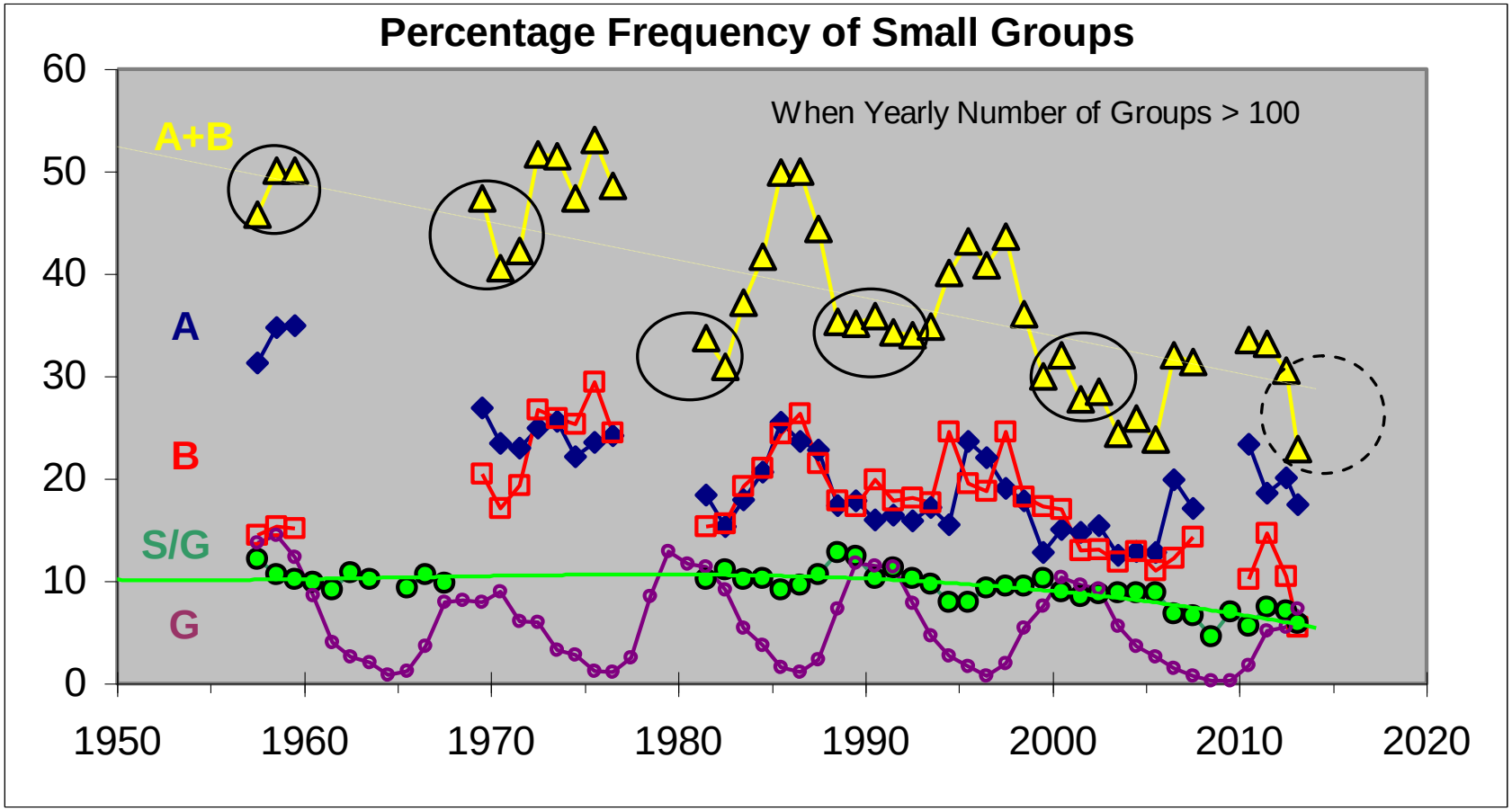
b: no penumbra, but clear bipolar structure

h: with penumbra, but no clear bipolar structure

But **large** spots

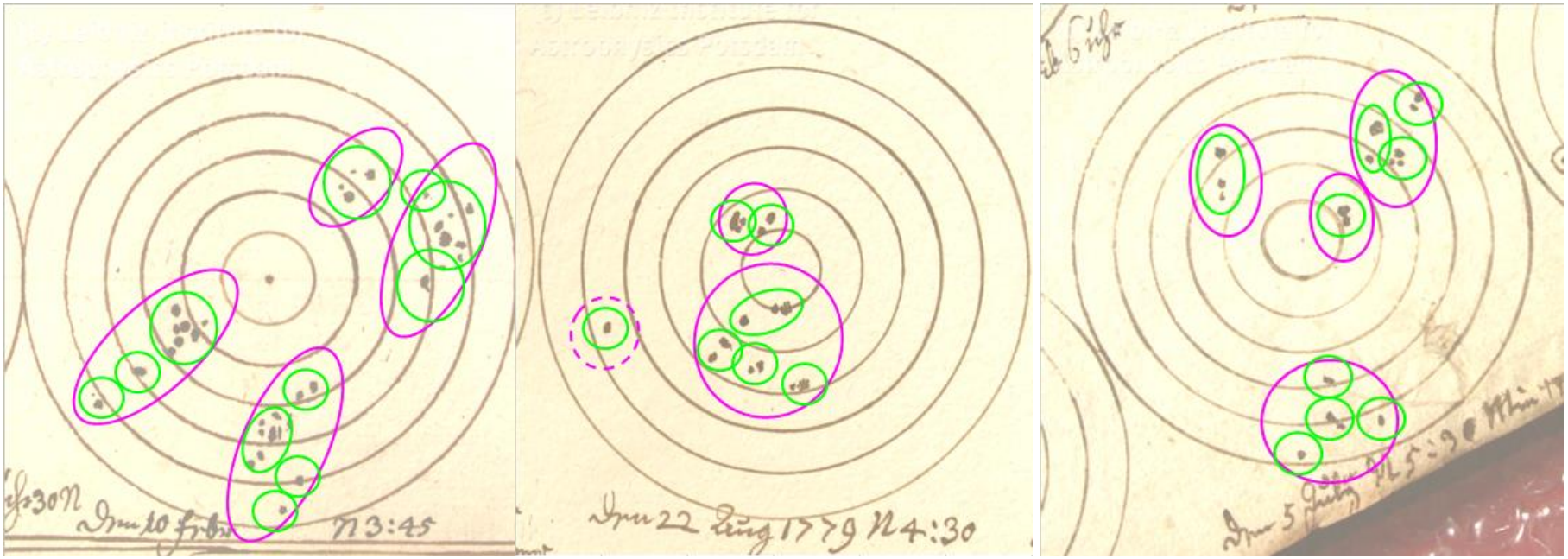
Pore: A feature in the photosphere, 1 to 3 arc seconds in extent, usually not much darker than the dark spaces between photospheric granules. It is distinguished from a sunspot by its short lifetime, 10 to 100 minutes.

# Occurrence of Small Spot Groups [Zürich Class A and B]



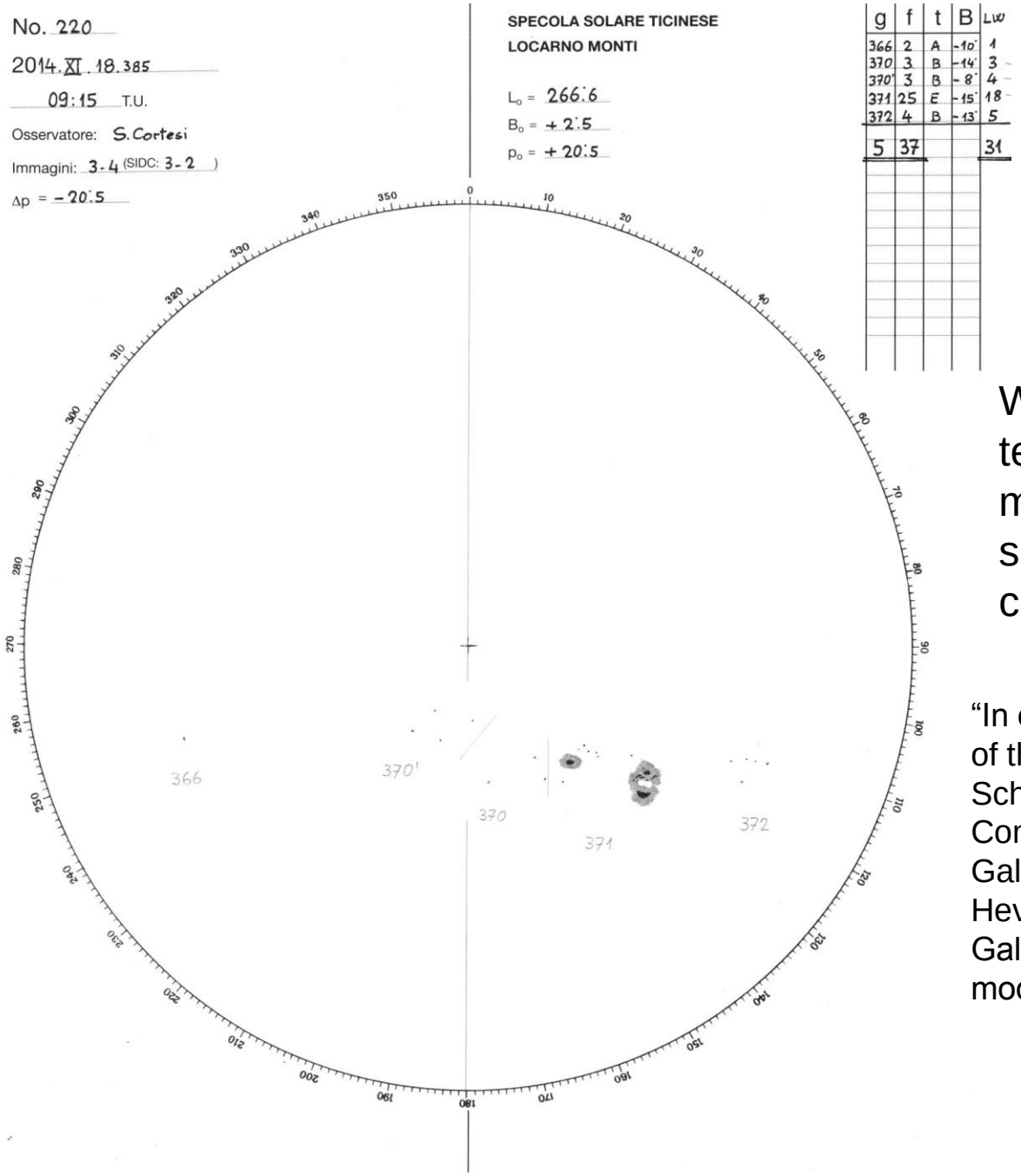

Data from Waldmeier, McIntosh, and Locarno

# Staudach's Drawings 1749-1799



Pink Ovals show the Grouping proposed by R. Wolf [and used by H&S]. Green ovals show my recent recount. On average I count 24% more groups than Wolf did.

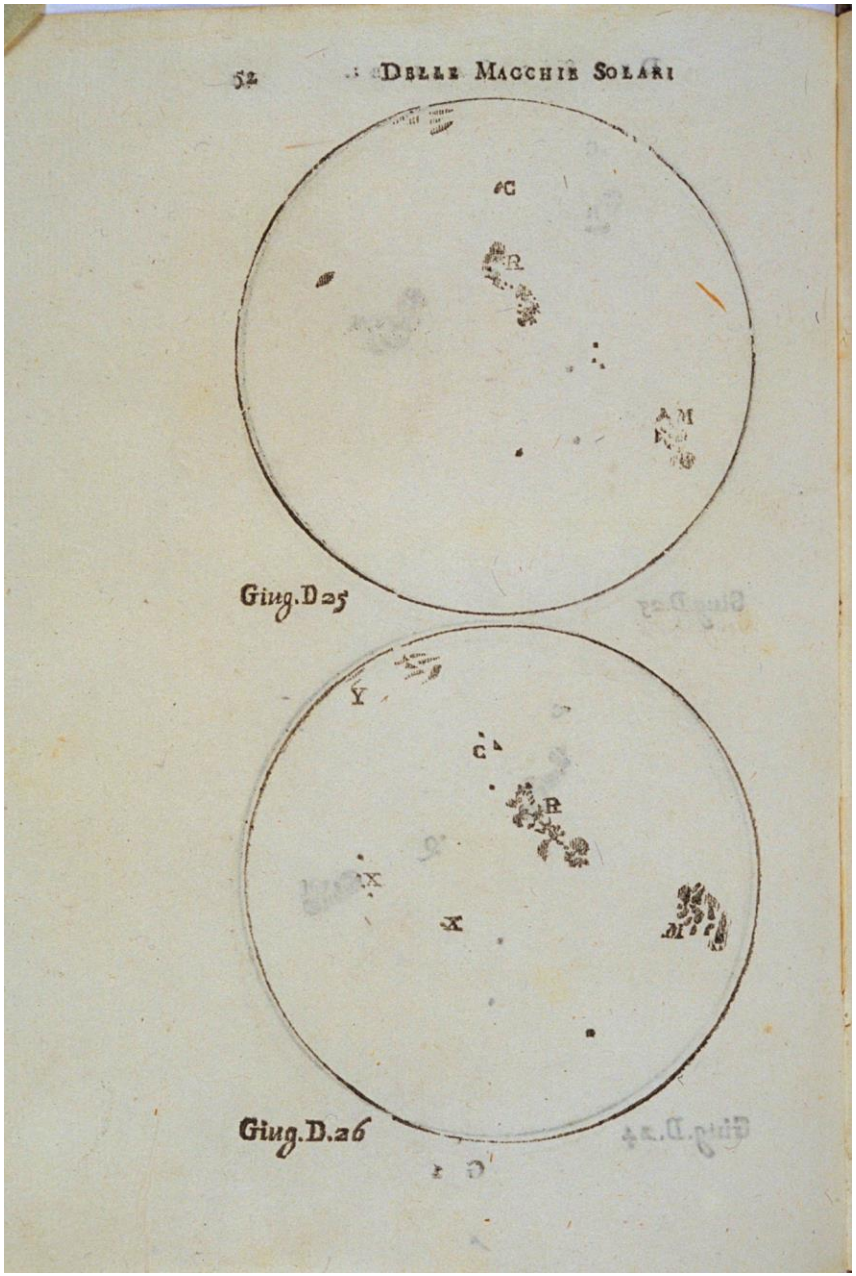
The observers in Locarno generally agree with me, except that they occasionally propose even more groups than I.




# Modern Image

With small non-acromatic telescope it is doubtful that more than 1 group with 2 spots would have been counted.

“In our work, we analyze the database of the nominal NSGs by Hoyt & Schatten (1998) from 1610 to 1720. Comparing the sunspot drawings by Galilei, Scheiner, Gassendi, and Hevelius, we conclude that only Galilei’s drawings are similar to the modern sunspot observations.”




# Galileo

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Galileo's drawings of sunspots (from the Istoria e Dimostrazioni, Florence 1613)

# Suggested Solar Activity Record



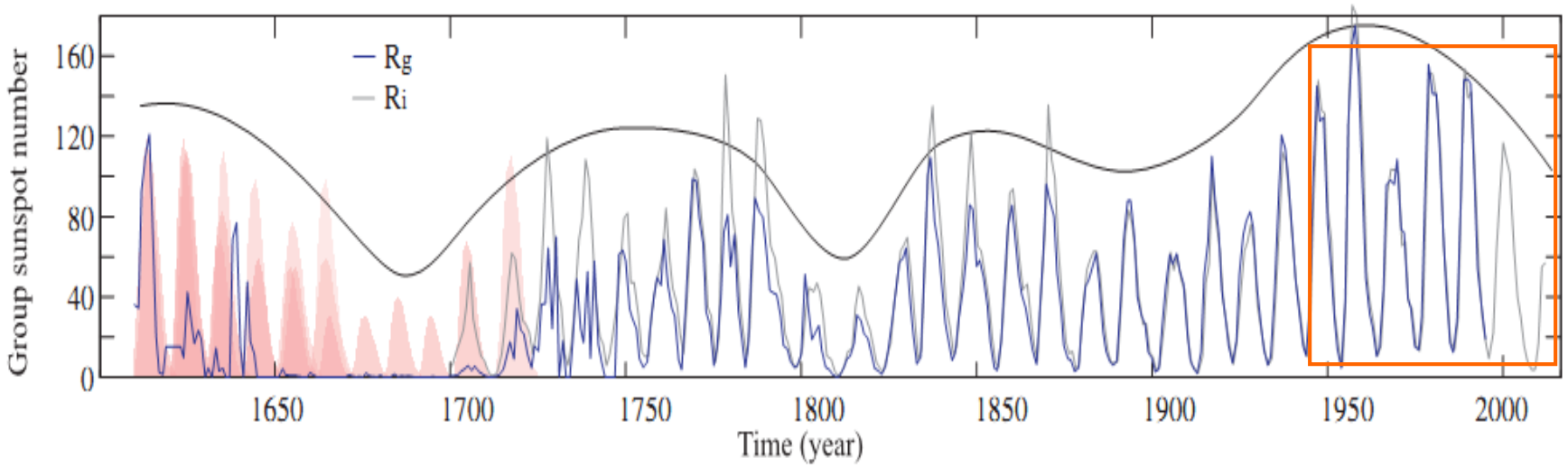


**Figure 13.** Group sunspot number $R_g$ is shown in blue, the international sunspot number $R_i$ in gray. Light red defines the supposed amplitude of solar cycles. The black line is the secular cycle.

Red box shows overcount due to weighting of sunspots