

# Sunspots with Ancient Telescopes for the New Solar Cycle 25

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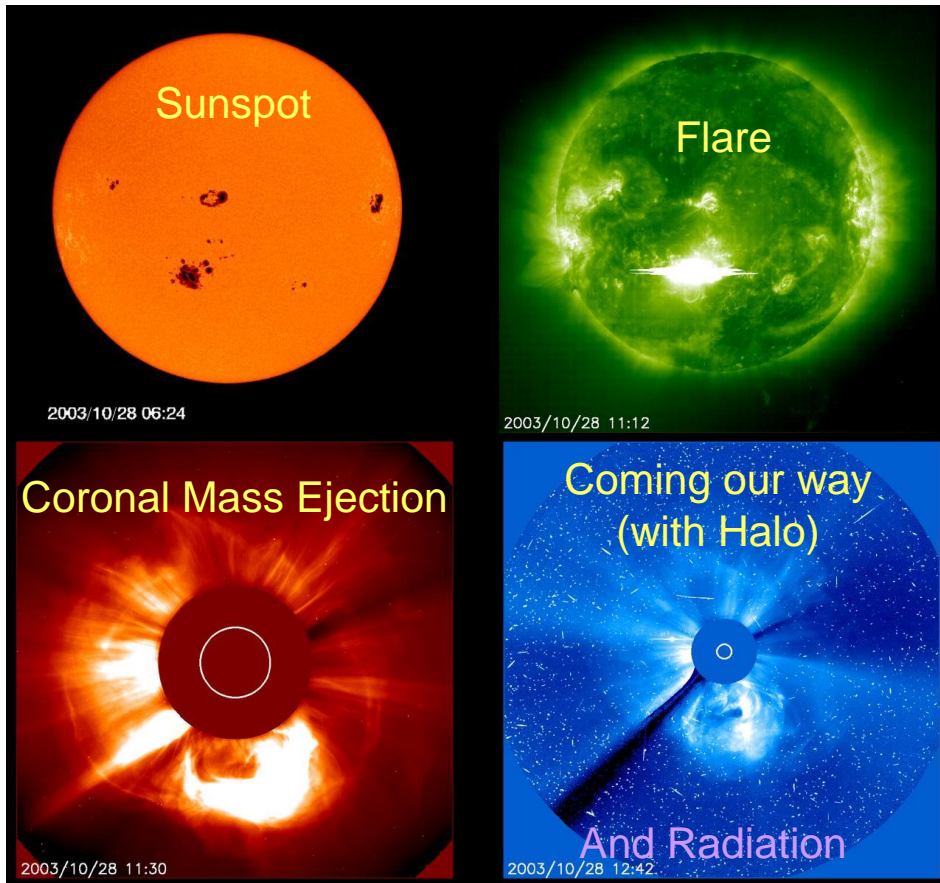
Ken Spencer  
Sea Cliff, New York, USA

Walter Stephani  
Ahrensburg, Germany



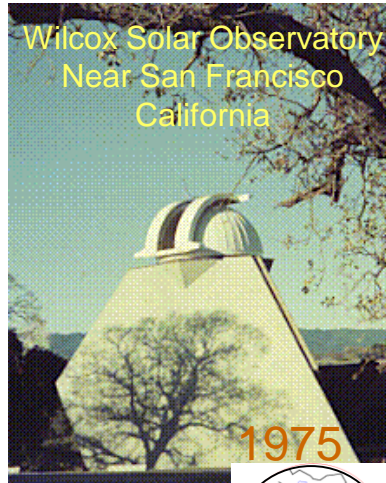
# Solar Storms and Consequences

The energy stored in Sunspot Active Regions can be released explosively causing dangerous radiation and plasma hurled into space. If Earth-directed, this 'debris' from the explosions can have damaging and disturbing effects on our technological infrastructure

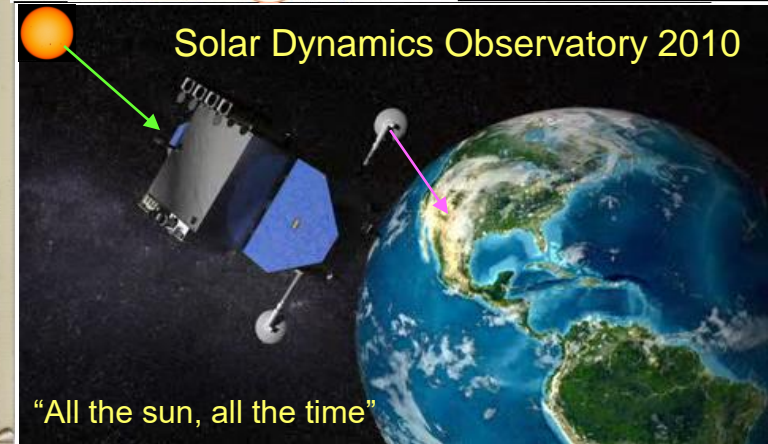
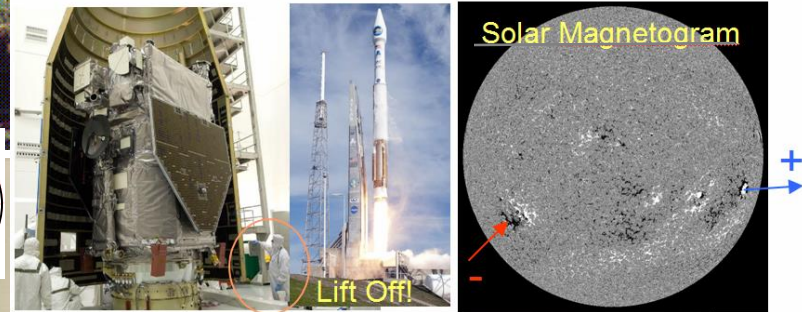


# Where Does the Magnetized Solar Wind Come From?

To find out we build Solar Magnetic Field Observatories !

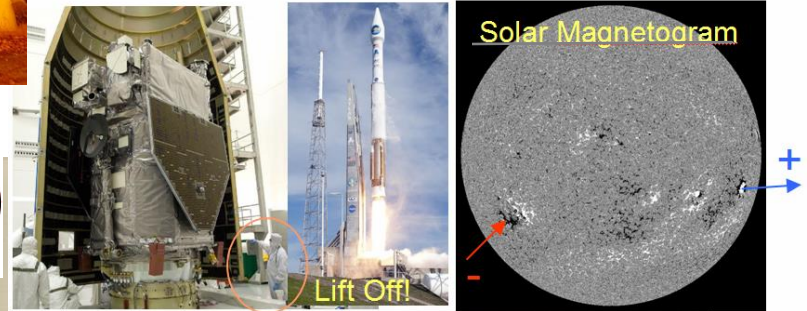


So, we go to sunny California to study the Magnetic Sun



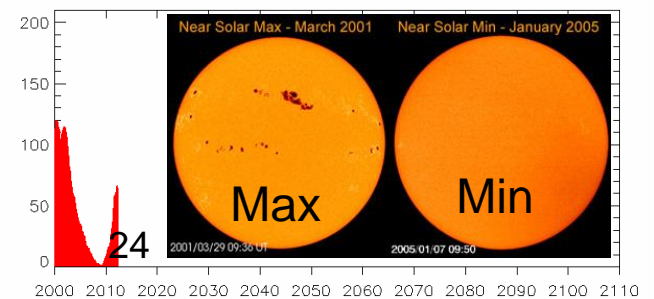
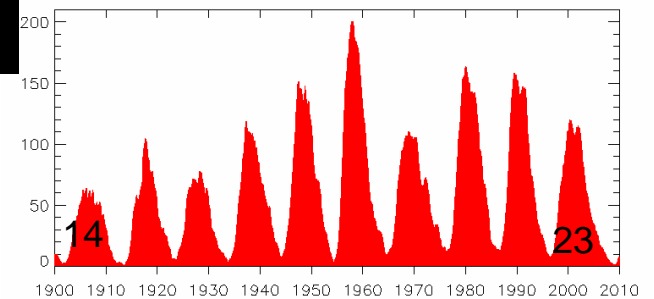
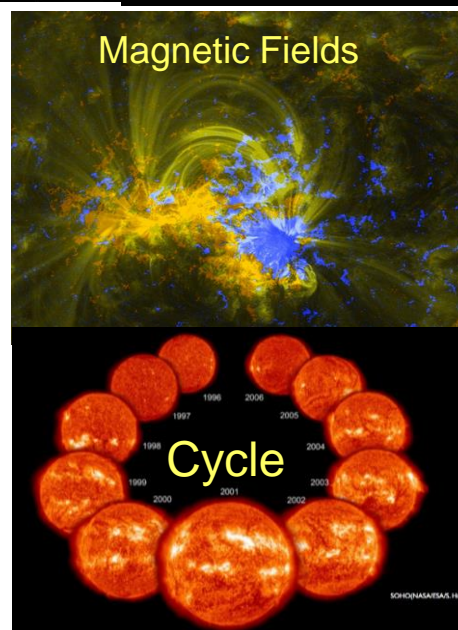
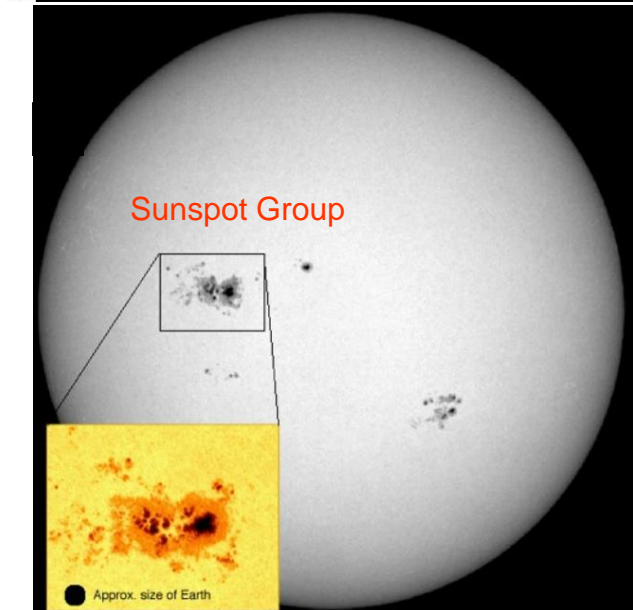
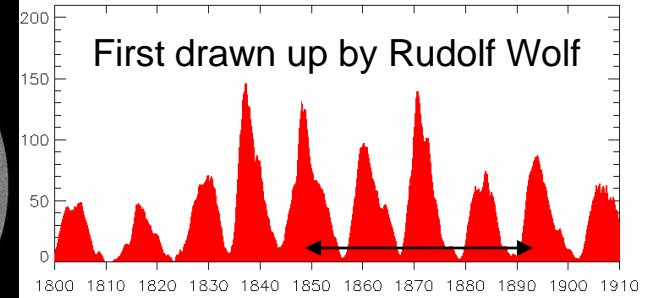
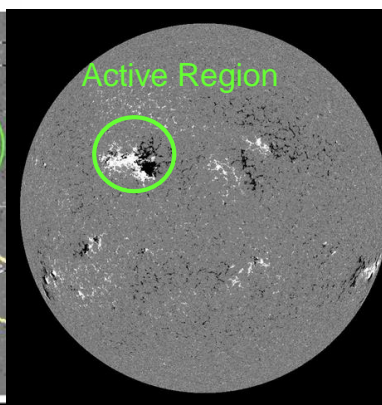
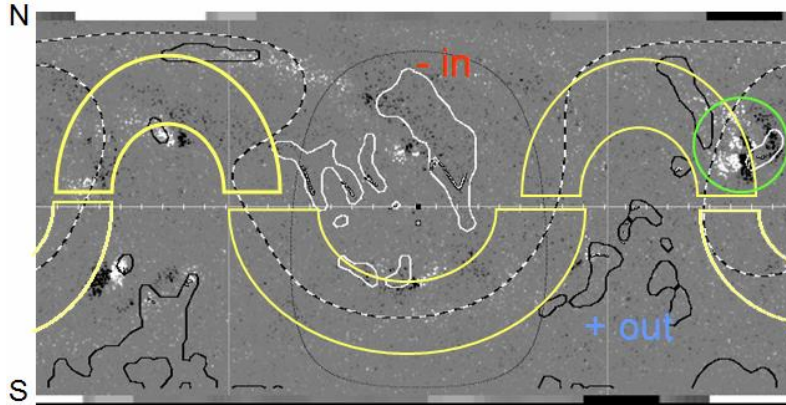
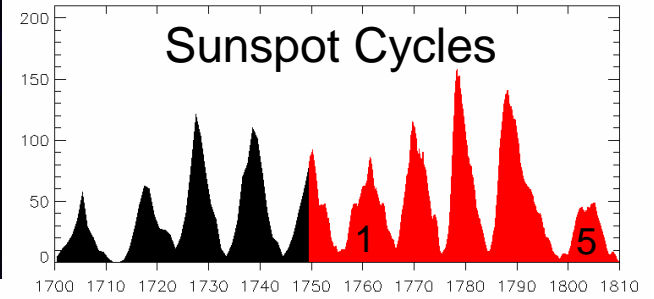
# Where Does the Magnetized Solar Wind Come From?

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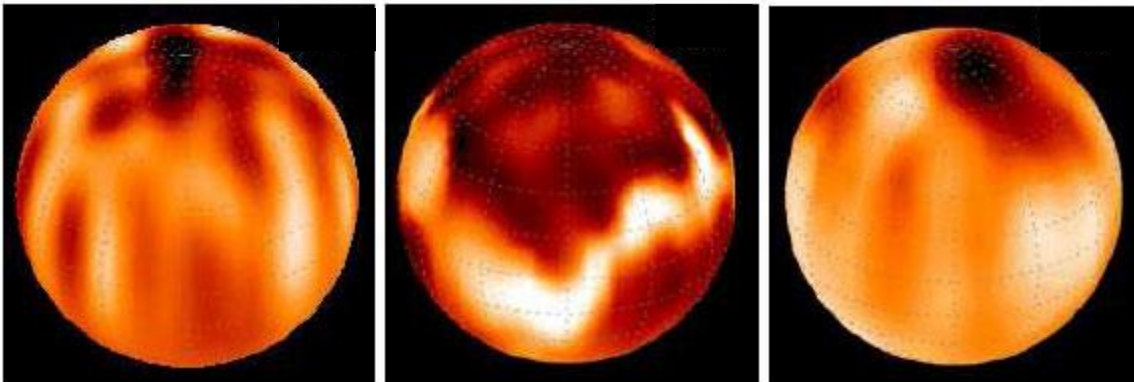
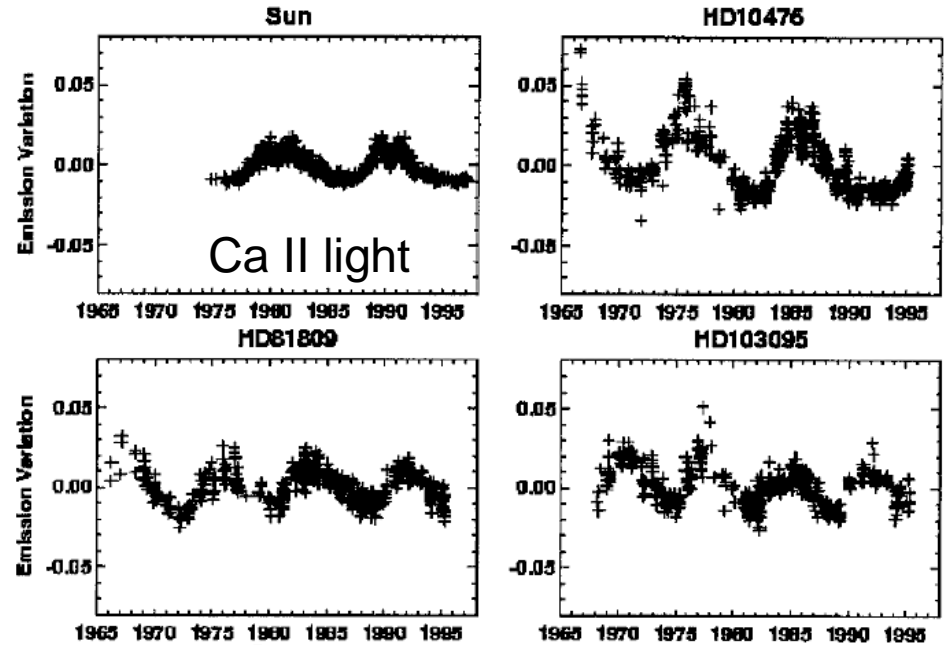
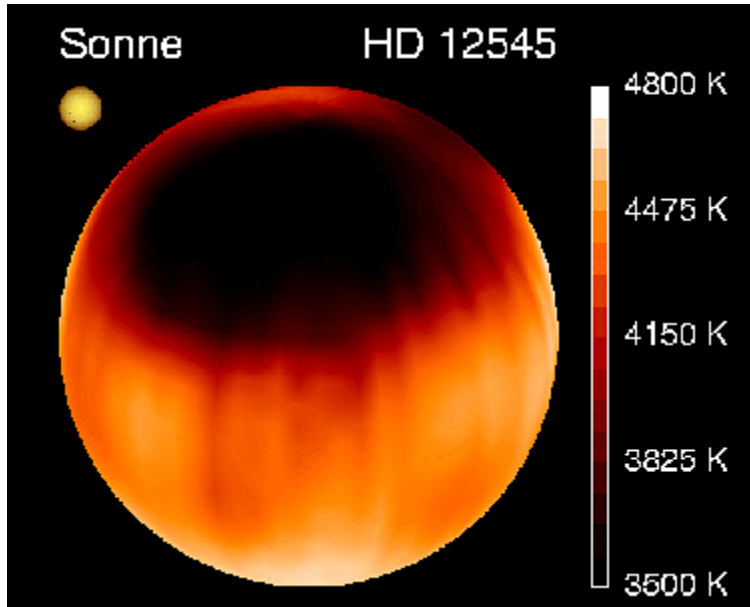
# The 11-yr Solar Cycle

An 'Active Region' = Lots of Magnetic Fields

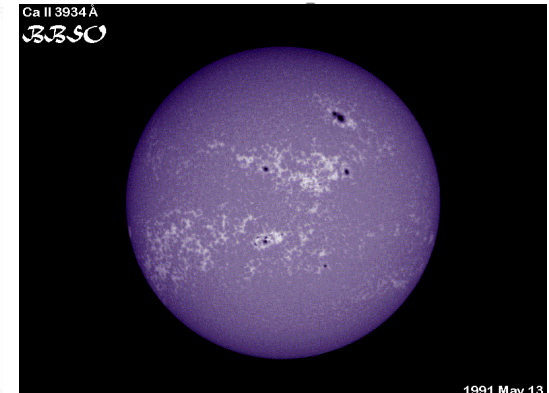


# Stars have Spots too

Largest starspot known



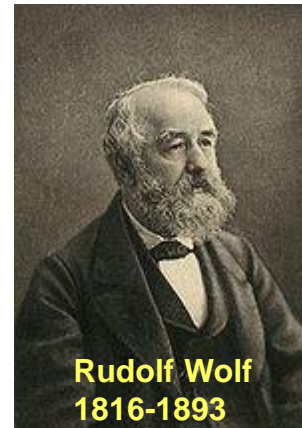
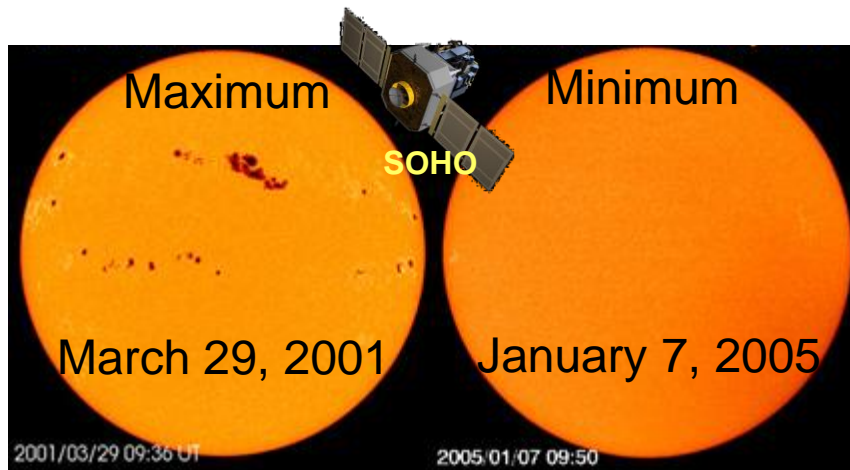
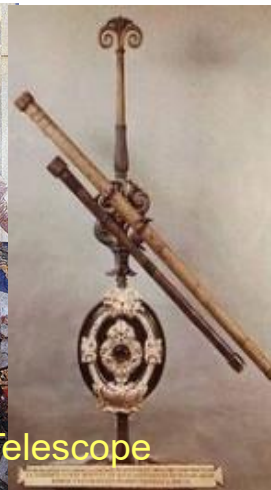
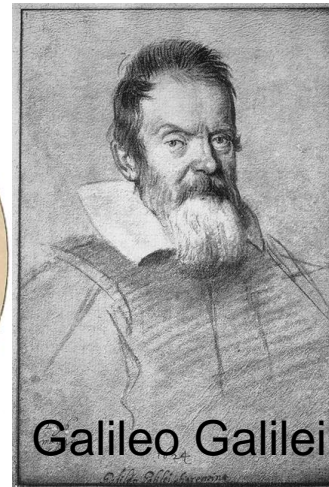
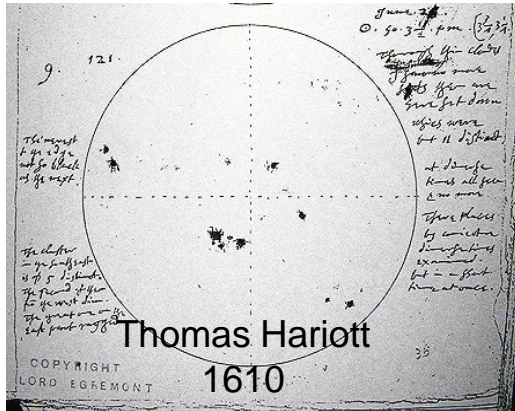
Some other stars



Sun in Ca II light 393 nm

# Centuries of Sunspot Observing

We have observed sunspots with telescopes for 400 years



Sunspots observed by Spacecraft

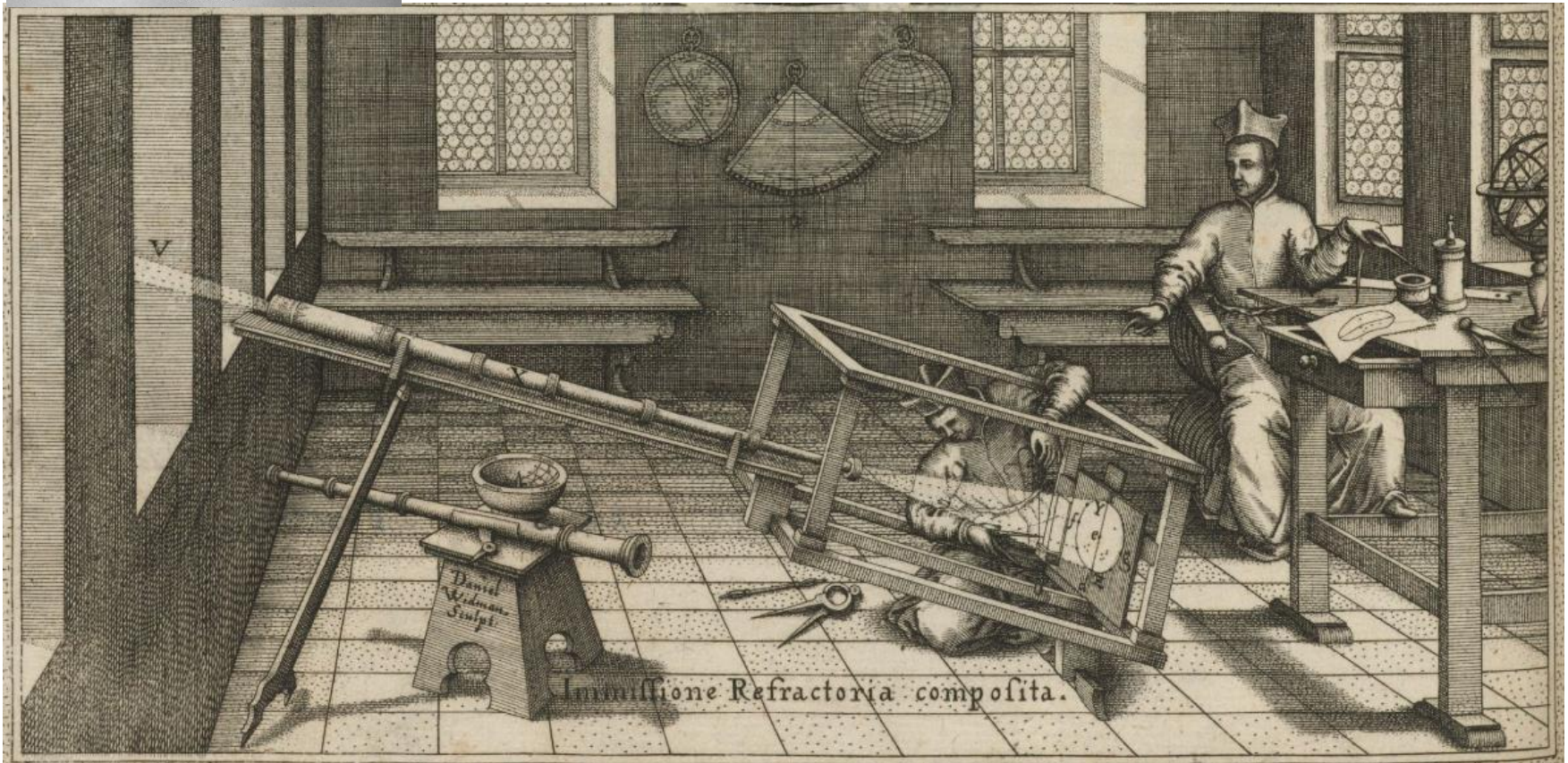
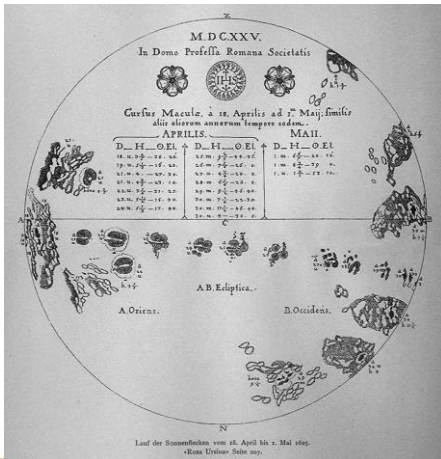
'Compiler' of Sunspot Number

Still used today

The sunspot number is always determined using small telescopes

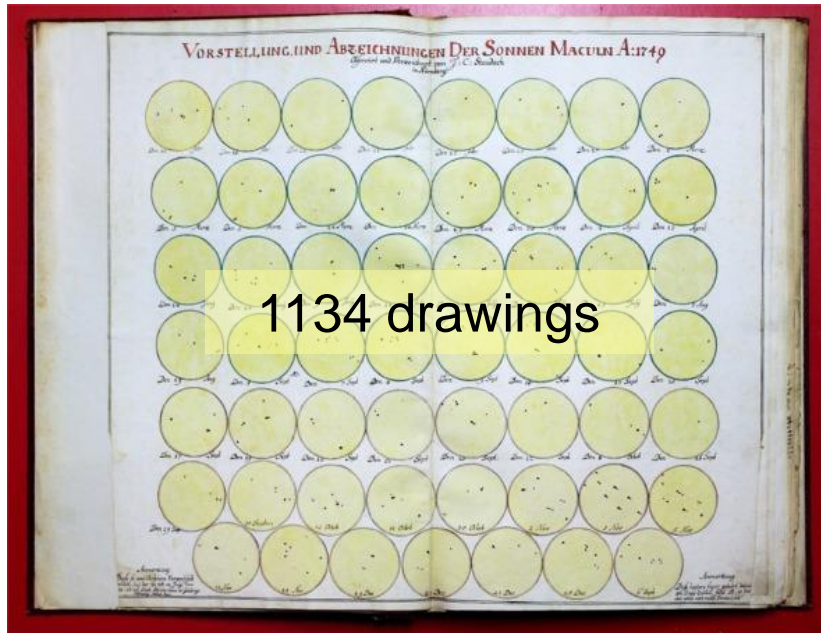
# Christoph Scheiner Rosa Ursina, Anno 1630

Helioscope: Projecting the Solar Image

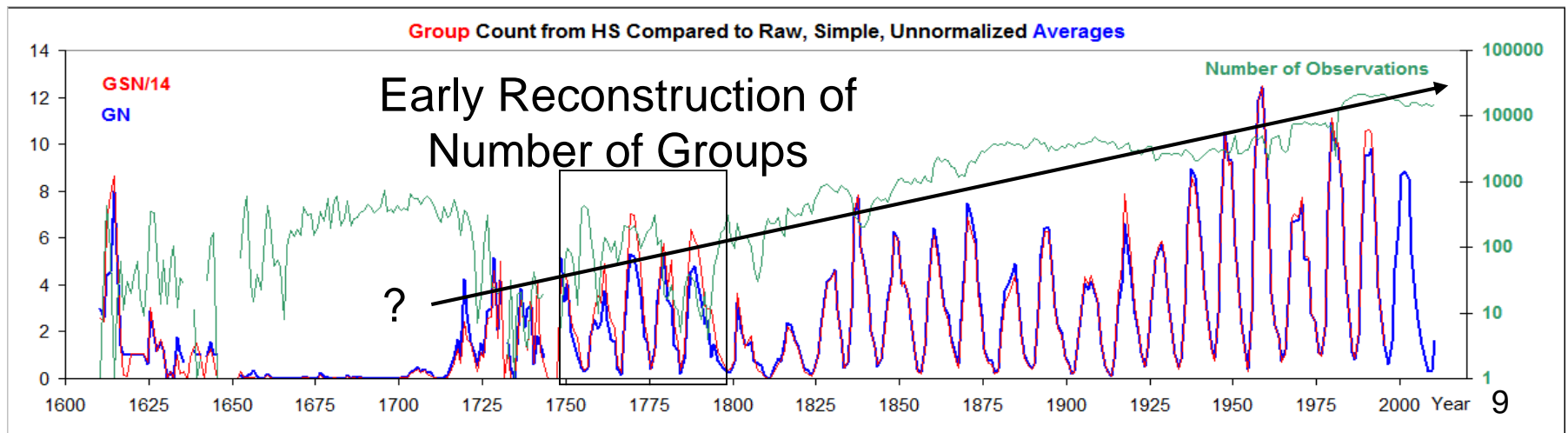




# Our Knowledge of Sunspots in the 18<sup>th</sup> Century is Based on J.C. Staudach's Drawings 1749-1799



13<sup>th</sup> & 15<sup>th</sup> February 1760



# The Project

- Find telescopes (from the 18th century or build replicas) with similar characteristics as Staudach's
- Find people willing to observe, i.e. make drawings of what they see (high precision of positions not needed)
- Make systematic observations over some time (many months) perhaps at least one drawing per week, better daily
- If we can find several people, they can share the load (and also make it possible to assess the 'error bar')
- Scan the drawings and communicate them to me (leif@leif.org).  
Website: <https://leif.org/research>
- I'll process the drawings and produce a scientific paper with the observers as co-authors publishing the result
- Benefits: Exposure of ATS (Antique Telescope Society) and providing an important calibration point for the Sunspot Series (real science)
- First observation 14 January, 2016

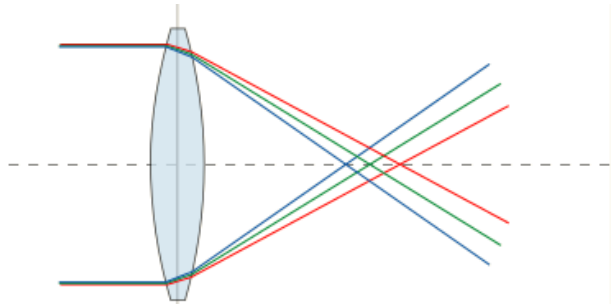
# Optical Flaws in Early Telescopes



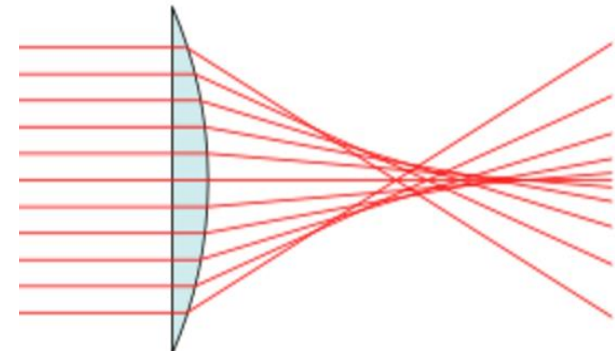
Amateurs could not afford achromatic telescopes with composite lenses

(Cost a years salary)

*Chromatic aberration*



*Spherical aberration*



No. 52

2016. III. 11. 333

08:00 T.U.

Osservatore: M. CAGNOTI

Immagini: 2-3 (SIDC: 3-4)

$\Delta p = +23.9$

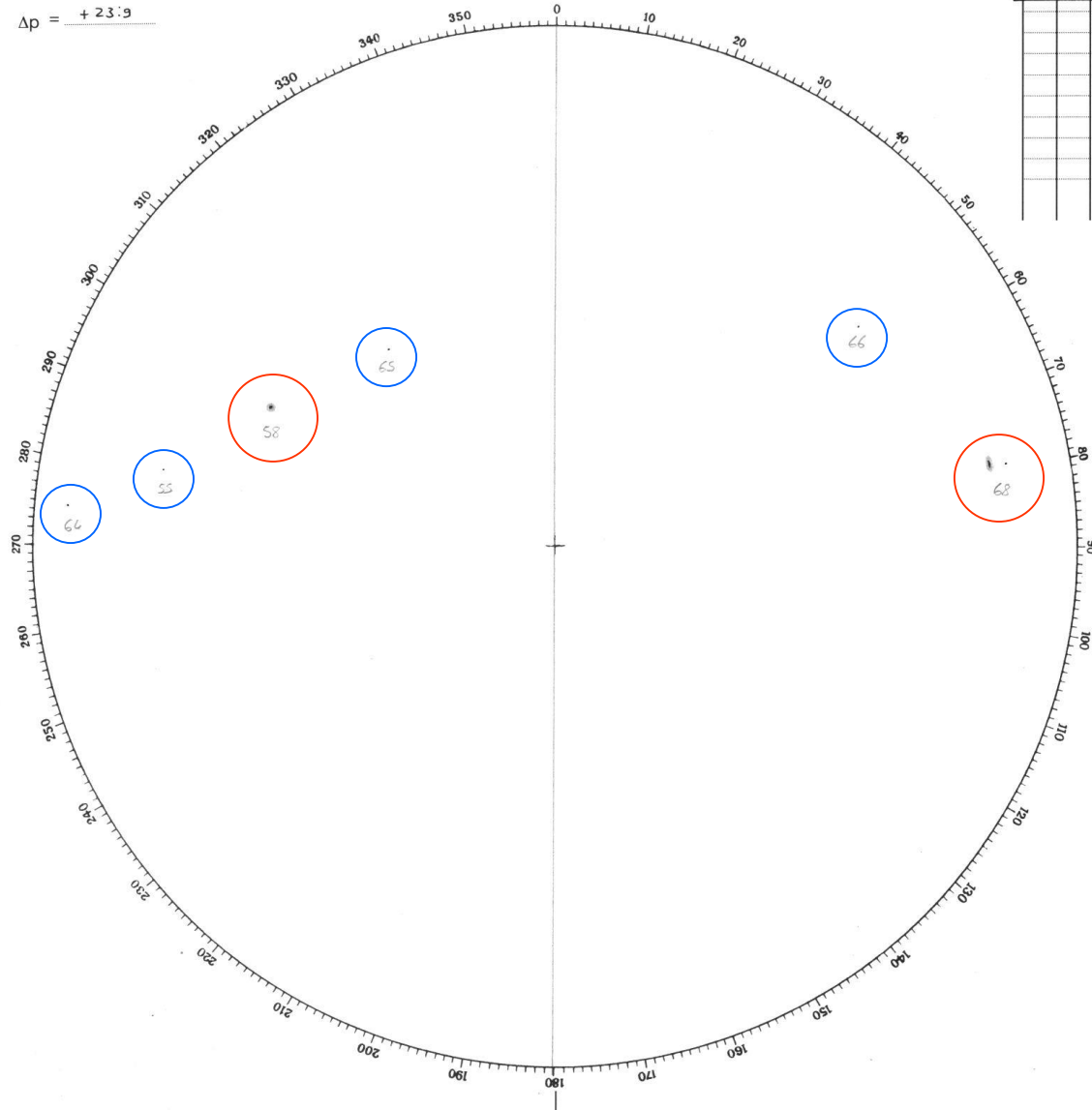
SPECOLA SOLARE TICINESE  
LOCARNO MONTI

$L_0 = 68.1$

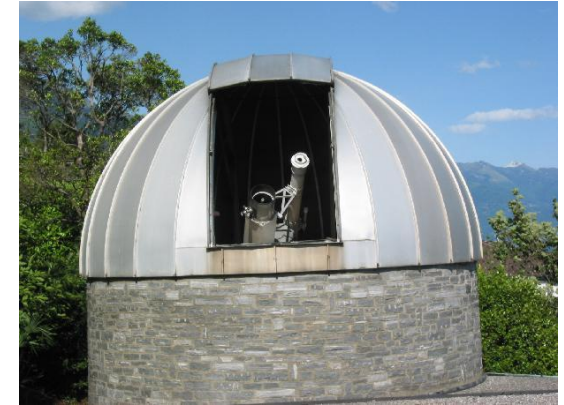
$B_0 = -7.2$

$p_0 = -23.9$

g	f	t	B	$\Delta W$
55	1	A	+4	1
58	3	2	+5	1
64	1	A	+2	1
65	1	A	+15	1
66	1	A	+19	1
68	4	C	+5	2
6	11			7

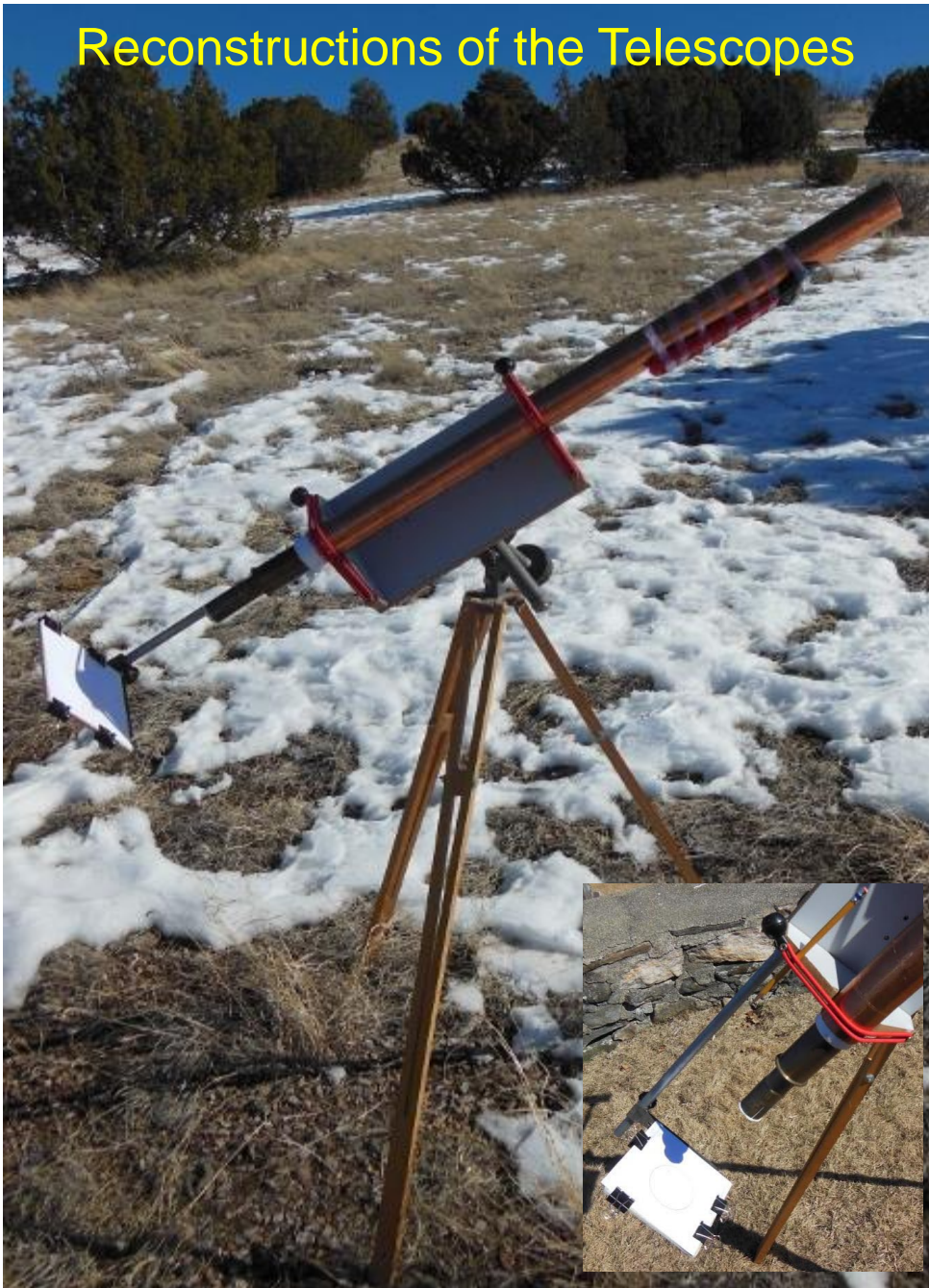


# Locarno 2016-03-11

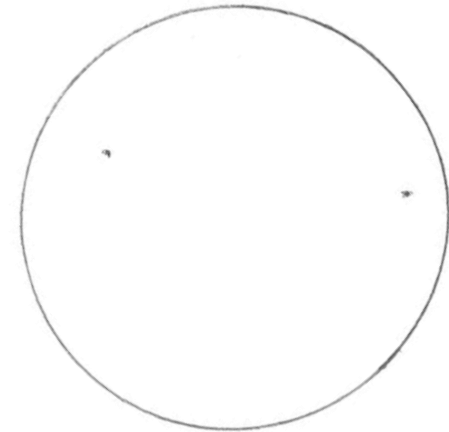


Briggs, and  
(importantly)  
Staudach simply  
could not see the  
tiny groups (in blue  
circles) with their  
inferior telescopes

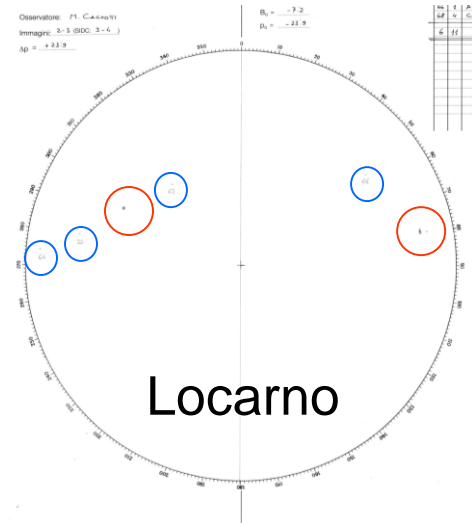
# Reconstructions of the Telescopes



# John W. Briggs, Magdalena, NM

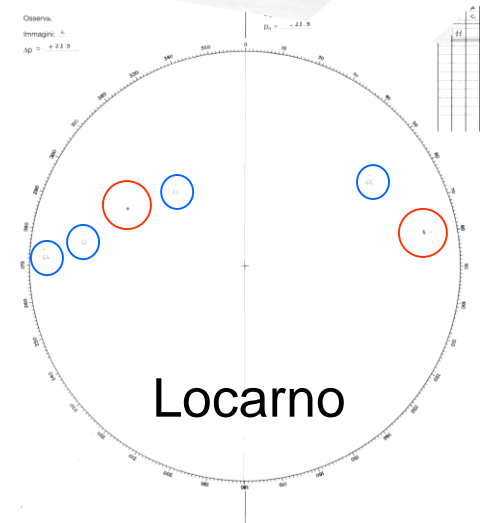


2016-03-11



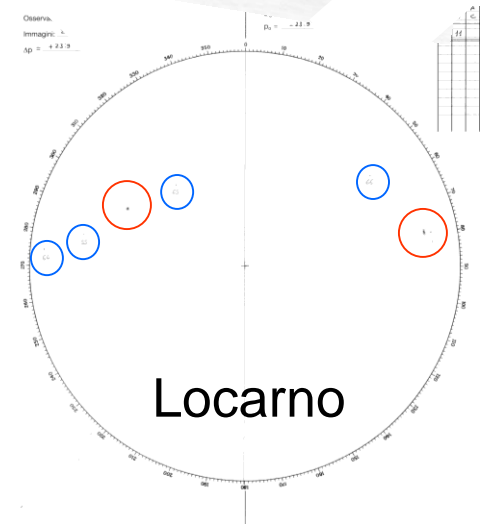


# Ken Spencer, Sea Cliff, NY

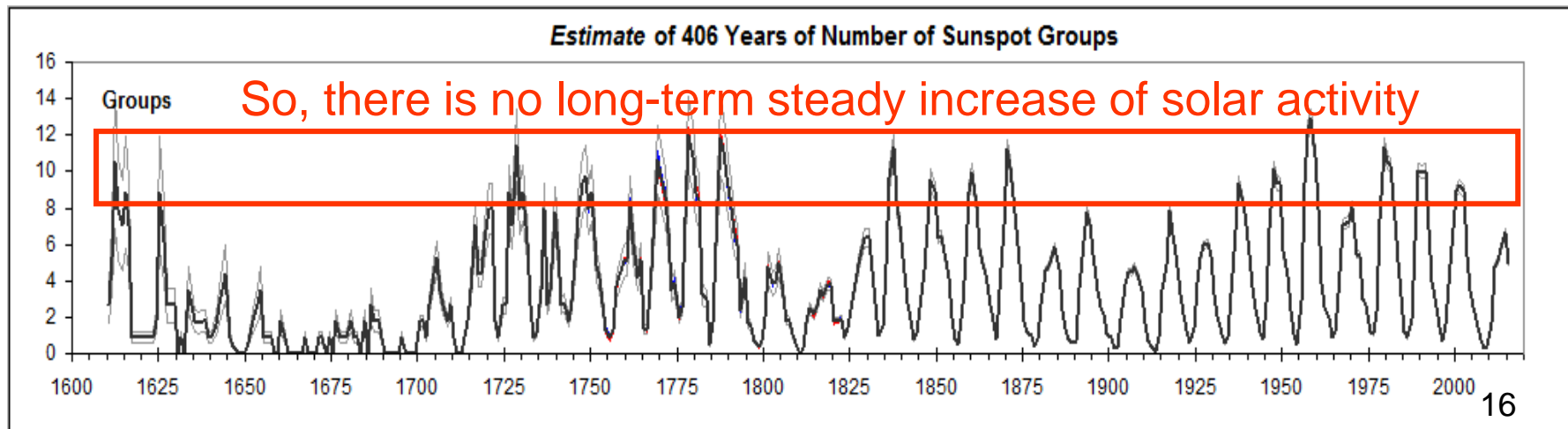
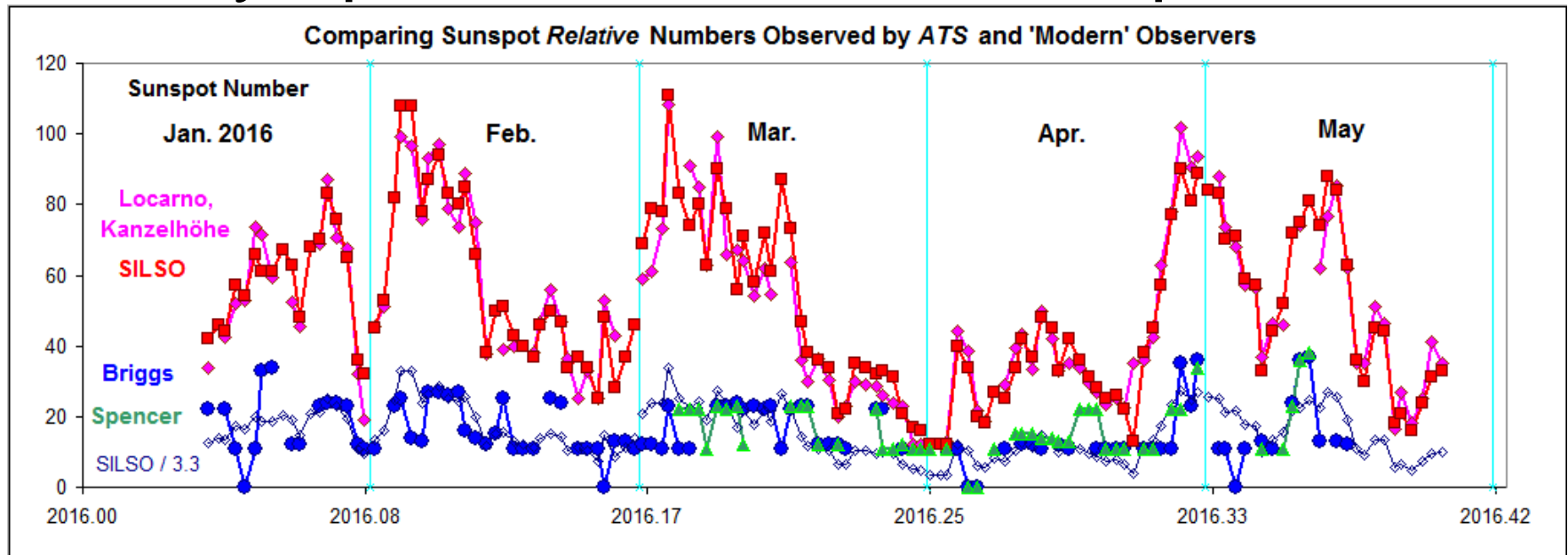




# Walter Stephani, Germany

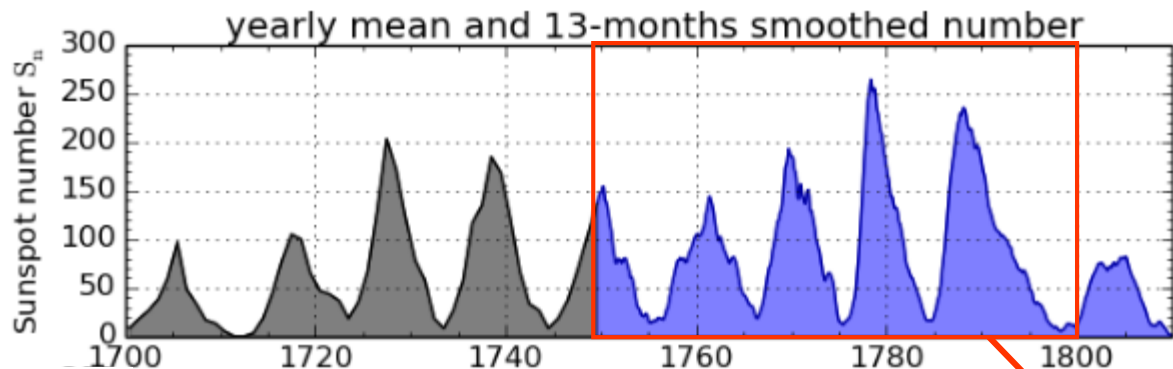


# Modern Observers See Three Times as Many Spots as The Old Telescopes Show

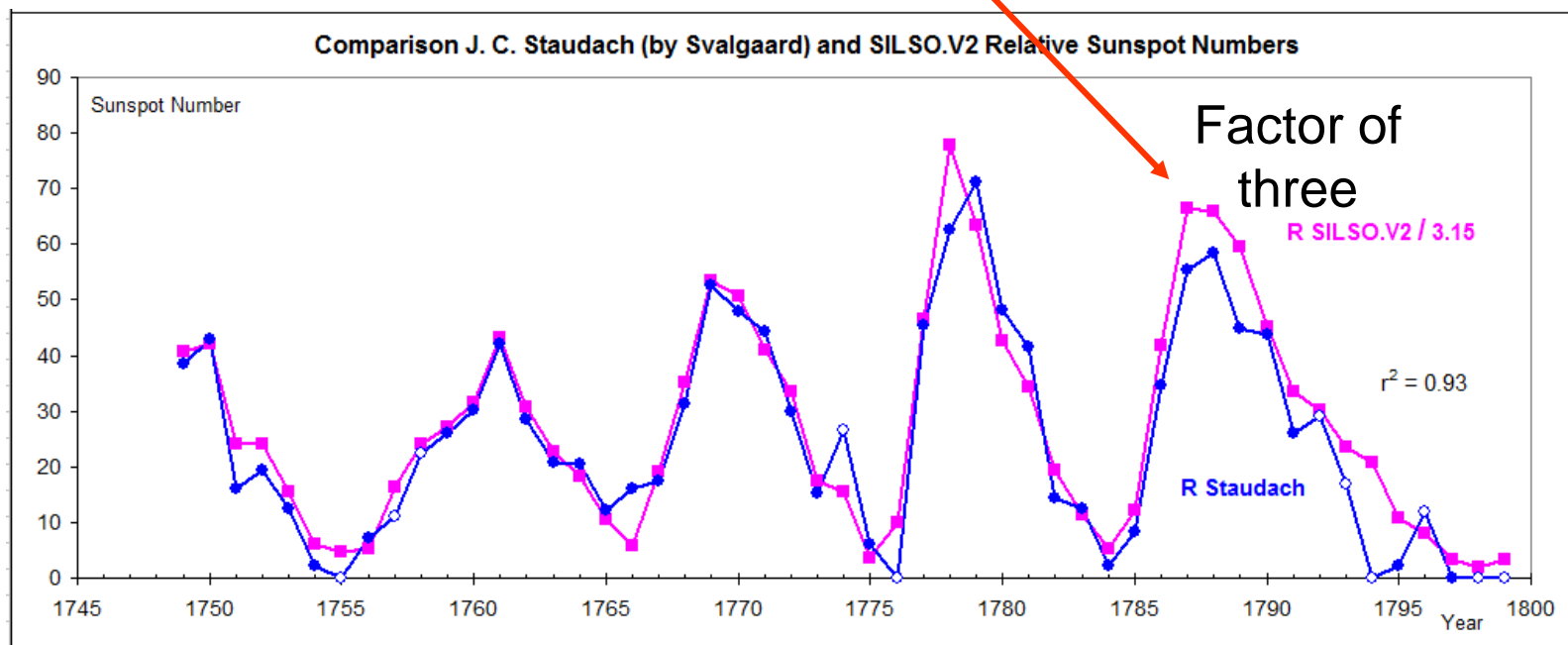




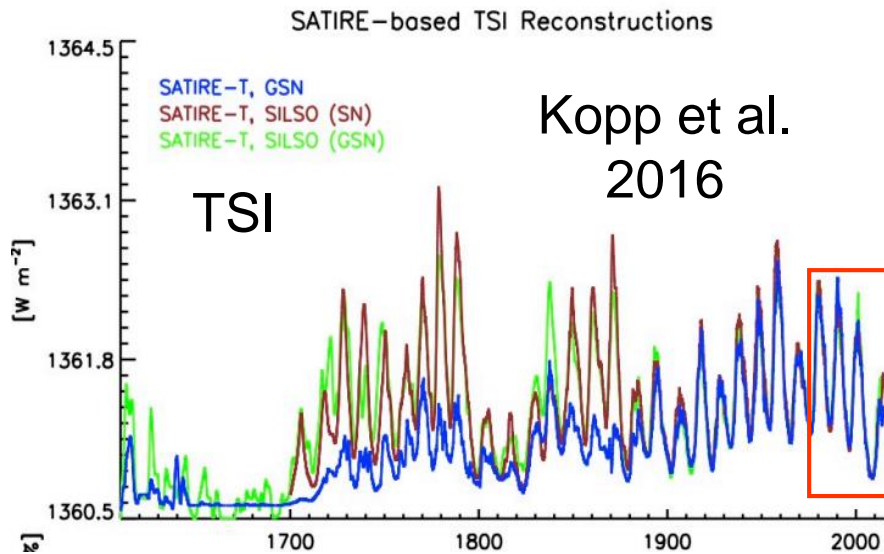
# Our Project has Confirmed the 'New Sunspot Number Series'



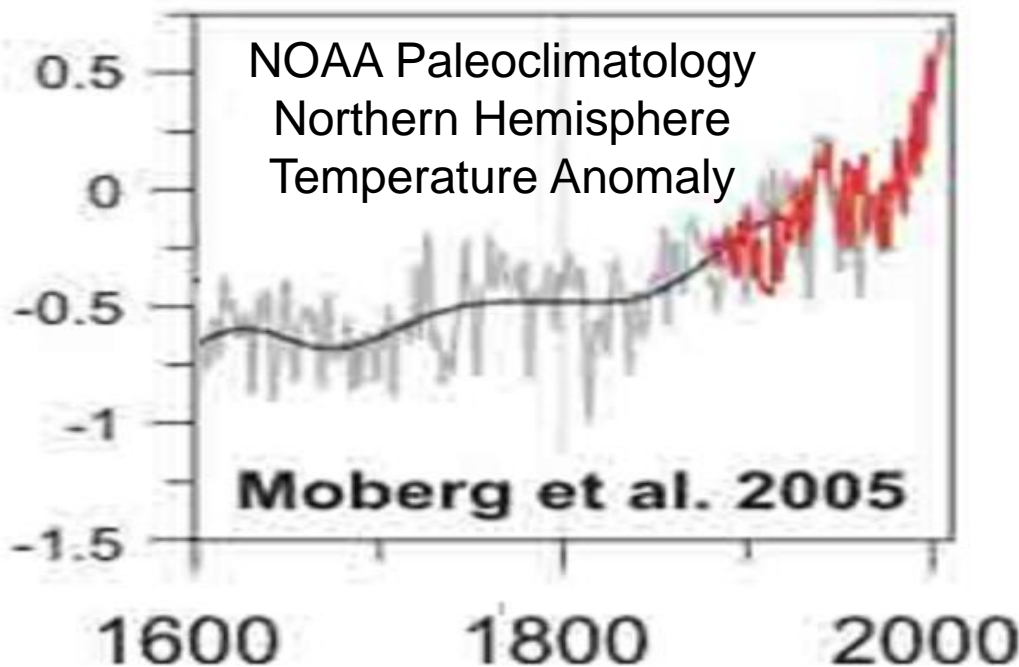
A recent revision (Clette et al. 2014) of the Sunspot Number is nicely validated by our observations



# Why Is This Important?



1. The Total Solar Irradiance (output of heat) in the past before satellite measurements is reconstructed from the sunspot numbers and is used as input to climate models
2. Predictions of future solar activity, damaging solar storms, and our general understanding of the sun rely on knowledge about its past behavior



# Science Highlights from Solar Physics Division Meeting 2016

The Sun is a magnetic star. Its magnetic field affects Earth, by causing space weather that affects our technology. Understanding its formation and effects gives rise to some of the most challenging scientific problems of our time. *We present four different exciting advances in the search to understand the consequences and origin of the Sun's magnetic field.*

First, an exciting new result about the origins of hard-to-predict “Stealth CMEs” that can launch from the Sun and impact Earth without an obvious signature at the surface.

Next new insights into the formation of sunspots, produced via strikingly beautiful simulations of the flows inside the star.

*Third, understanding the long-term evolution of the Sun's magnetic field drove one team of scientists to recreate 18th century telescopes in the modern era.*

Finally, in the 21st century the titanic four-meter-diameter solar telescope DKIST is nearing completion and will enable new observation of solar magnetism at the very finest scales.

Boulder, June 2016

# Conclusions

- Observations with telescopes suffering from the same spherical and chromatic aberrations as we think Staudach's 'sky tube' did, validate the factor of about three that we previously found was needed to normalize the 18<sup>th</sup> century amateur observations to the modern scale, and hence that there has been no steady increase of solar activity
- When sunspots disappeared at the end of the previous sunspot cycle, my observers got bored and stopped observing
- Now that a new cycle (#25) has started it is time to begin again !