What Happened to Those Sunspots and What Can We Expect

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Chair of Solar Cycle 24 Prediction Panel
Outline

• Reminder of how this cycle behaved
  • But first, the prediction
• They did what to the sunspot number?
  • What is SWPC doing about it
• What’s left in Cycle 24?
• What are the early indicators for Cycle 25?
Solar Cycle 24
Predicted solar max. of 90 to occur in May 2013
Solar Cycle 24

October 2009

SUNSPOT NUMBER

DATE

Solar Cycle 24
Solar Cycle 24

March 2011

Graph showing the sunspot number over time from 2008 to 2020.
Solar Cycle 24

July 2011

Graph showing the Sunspot Number from 2008 to 2020, with a peak in 2014.
Solar Cycle 24

July 2012
Solar Cycle 24
Solar Cycle 24

![Graph showing sunspot number varying over time, with peaks around 2014]
Solar Cycle 24
Solar Cycle 24

February 2015

[Graph showing the Sunspot Number from 2008 to 2020, with a peak around 2014]
The 24 Solar Cycles...recalculated

- Cycle 24 peak 81.9 in April 2014 (forecasted 90)
- The average peak is 112.7
  Min:Max [48.7:201.3]
- Cycle 24 4th smallest
- No, the cycle 24 peak was 116.4 (42% higher)
- The new average peak is 179.4 (59% larger)
  Min:Max [81.2:285]
What did they do?

• For the full story see Clette et al. 2014
• Rudolph Wolf created the first modern count stitching together observations from 1749-1893
  • He tried to mimic early observers
  • Artificially lowering his count
  • In 1893, Wolfer took over and determined the 0.6 scaling required to keep modern count consistent with Wolf
• In 1947 Waldmeier started applying weights according to sunspot size
• In 1980, Zurich was discontinued and Locarno became the standard reference station
  • Numerous issues have been identified with the Locarno station

![Graph of ratio old/new SSN]
What is SWPC doing?

- In July 2015 the Solar Influences Data Center started publishing daily sunspot numbers ‘uncorrected’
- But, we’d already published predictions for the solar cycle
- Users had experience using corrected numbers
  - May 2015 was 58.8
  - Uncorrected was 88.8
- SWPC continues to correct sunspot number by 0.6
  - Will remove this correction at the next solar minimum
  - No one will notice
- Plenty of time to ensure users understand before Cycle 25 gets going
• The probability of a flare occurring is correlated with the SSN
  • Rate of flares as a function of size varies in intensity and slope with SSN.
• The properties of observed CMEs also are correlated with phase in the solar cycle
When will Cycle 24 End?


From analysis of solar cycle 24 GOES X-ray data from Dec 2008 – May 2014

Predicted end of solar cycle 24: September 2020

X-ray Background Can be Used to Predict the Date of Solar Cycle Maximum and Length of Solar Cycle
- Cycle 25 is visible at higher latitudes in both hemispheres
- Cycle 25 appears at Solar Max of Cycle 24 with new cycle spots appearing in late 2019
- Two year hemispheric phase shift is still in place
- Anticipate that Cycle 25 is (much) weaker than Cycle 24 (S. McIntosh, not D. Biesecker)
Historically, geomagnetic precursors have proven to be the best predictors of solar cycle.

- Polar field precursors (e.g. SOlar Dynamo Amplitude)

\[
SODA = 60 + 146 \left[ \left( \frac{B_{pol}}{1.28} \right)^2 + \left( \frac{F10.7 - 60}{146} \right)^2 \right]^{1/2}
\]

Schatten and Pesnell (1993)
Solar Polar Field Strength

- Polar field strength already almost equal to last solar minimum peak
  - Though northern hemisphere is lagging
- Cycle 25 at least as large as Cycle 24
  - Keep an eye on this space
  - D. Biesecker, not S. McIntosh

![Solar Polar Field Strength vs. Time](http://wso.stanford.edu/gifs/Polar.gif)
Livingston and Penn (2009) showed sunspot magnetic field was getting weaker

- If field drops below ~1500 Gauss, sunspots can’t form

- Is this a solar cycle effect?

Will We Even Have a Cycle 25?
Summary

• Solar Cycle 24 forecast was pretty good
  • In my ever so humble opinion
• Solar Cycle 24 probably has 3-4 years still to run
• It’s much too early to predict solar cycle 25, but early indications are
  • There will be a solar cycle 25
  • It will be at least as strong as cycle 24.