The Future of Solar Cycle Forecasts

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Sunspot Number (V1) and Solar Cycles

Solar Cycle 1: Beginning of “adequate” data
Solar Cycle 10: Carrington Event
Solar Cycle 16: Similar to Solar Cycle 24
Solar Cycle 19: Largest cycle in record
Solar Cycle 23: My first predicted cycle

Data courtesy of the SIDC.
One of NASA’s mandates is to build spacecraft that operate in the hostile environment of space. Getting it right means understanding what can go wrong and then building and operating payloads that work.

Two areas of concern:
- Orbital decay
- Radiation exposure

The HST orbit decays at 1-2 km/year
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Two areas of concern:

• Orbital decay
• Radiation exposure
• Interesting science

The HST orbit decays at 1-2 km/year
105 predictions of the amplitude of Solar Cycle 24 from around the world, each convinced they would be correct!

Categories

Dynamo Models

Statistics of Sunspots (Climatology)

Lies, damned lies, and statistics

Recent Climatology

Prefacing Model

Improved Model

Predictive Model

Assimilate

Observations

Spectral

Precursor

Neural Net

Space Climate 6, Levi, Finland, April 2016
Solar Cycle 24 has had a below-average level of activity.

Data courtesy of the SIDC

Schatten 2005

Space Climate 6, Levi, Finland, April 2016
Box & Whiskers Diagram

Pesnell, Space Weather, 2016
Physical basis for solar and geomagnetic precursor techniques

Solar Dynamo

(a) polar fields
(b) rotation
(c) Solar Min
(d) active regions
(e) Solar Max
(f)
Polar fields from the Wilcox Solar Observatory have changed sign, indicating solar maximum conditions.

Space Climate 6, Levi, Finland, April 2016
Solar Cycle 25 is Coming!

SODA Index already indicates SC 25 will be similar to SC 24.

Space Climate 6, Levi, Finland, April 2016
Flux transport models have benefited from new data by getting a more complicated meridional velocity structure. Old info on left, new info has two cells in radius; others have multiple cells in latitude.

Space Climate 6, Levi, Finland, April 2016
After the enormous range of amplitude predictions for Solar Cycle 24, we start looking forward to Solar Cycle 25.

The polar magnetic field shows that Solar Cycle 25 will be at least as active as to Solar Cycle 24, and could be more active.

Published predictions of Solar Cycle 25 span from an average amplitude to small or absent. It appears that predictions of Solar Cycle 25 will again have a large spread of values.

But the biggest challenge will be …
It always takes awhile for the community to adopt a new calibration of a well-known data series.

**Please use the V2 Sunspot Number!**
Spotless Days

$R_{24} = 100 \pm 80$

$R_{24} = 165 \pm 115$

Pesnell (2012)
To begin working toward a consensus prediction for Solar Cycle 25, we are holding a short workshop as part of the SDO 2016 Meeting in Burlington, VT.

Meeting is October 17-21, the prediction workshop is Friday.

Chance to review methods and results of SC24
Five-year Forecast

- Gradual decrease in the sunspot number toward solar minimum
- Partly spotty with a chance of flares and CMEs
- Coronal holes $\Rightarrow$ High-speed solar wind streams $\Rightarrow$ radiation belts
- Cooling of thermosphere $\Rightarrow$ reduced satellite drag
- Higher cosmic ray fluxes $\Rightarrow$ increased radiation
AR 12192 (October-November 2014) was the largest active region since 1990. Six X-class flares and no large CMEs!
Abstract

Solar activity forecasts range from minutes to decades. The long-term forecasts are needed for spacecraft planning and electrical grid construction. One example is the accurate orbits needed to avoid collisions in the increasingly crowded orbits near the Earth. That makes predicting the drag on satellites in low-Earth orbits one of the most important uses of these forecasts. Solar activity comes from the Sun’s magnetic field, which is generated by the solar dynamo. A true understanding of the solar dynamo would allow us to predict when and where flares will occur as well as the level of solar activity years into the future. We have anticipated the level of activity in upcoming cycles since the 11-year sunspot cycle was identified in 1843. The last four sunspots cycles have had many published predictions using a wide variety of methods. But all of the cycles had a wide range of predicted amplitudes. I will talk about the current state of solar cycle predictions, the skill of the predictions of Solar Cycle 24, and anticipate how those predictions could be made more accurate in the future.