Cycle 25 Predictions and Progress

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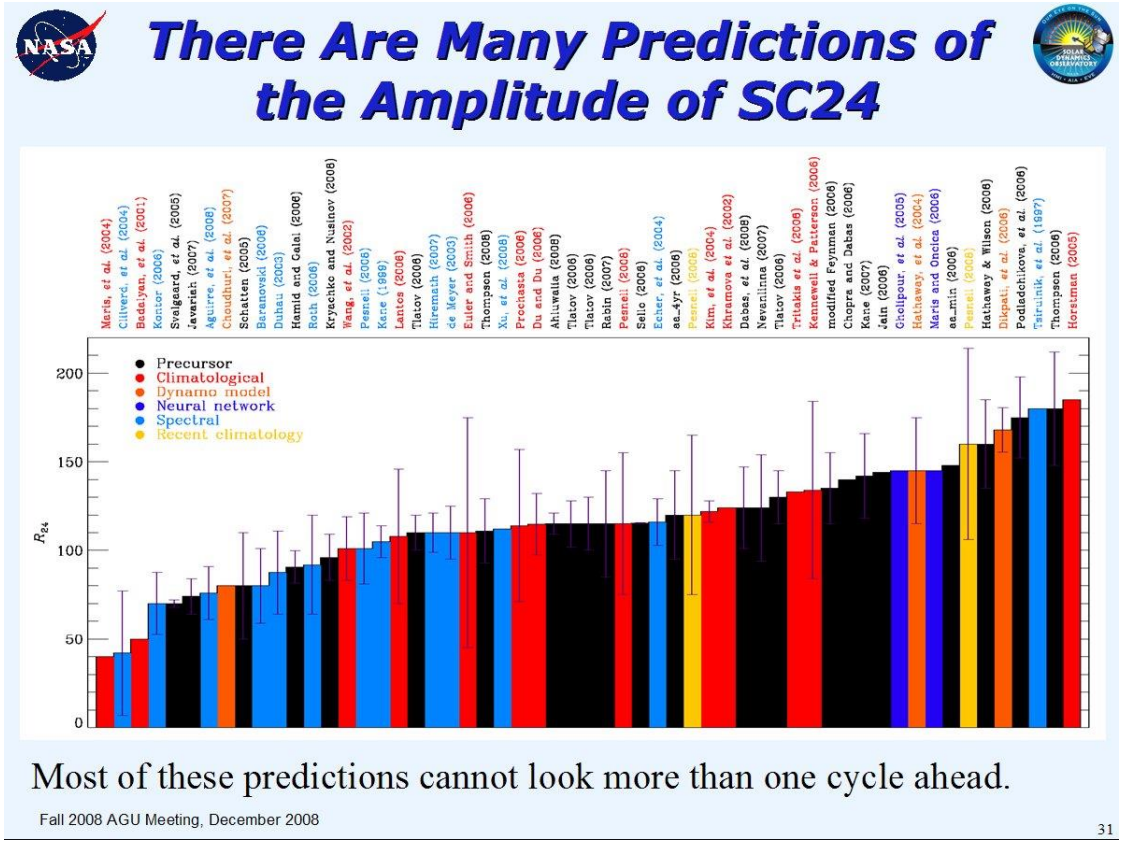
Topics

- Review of Cycle 24
- Current solar minimum
- Cycle 25 predictions
- Early Cycle 25 progress

Review of Cycle 24

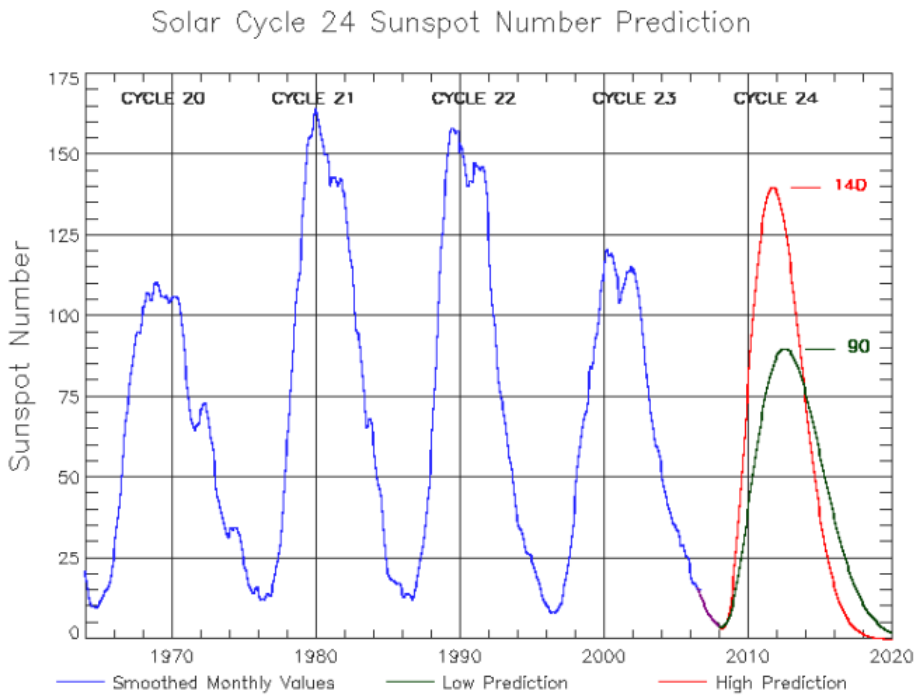
History – Cycle 24 Predictions



from W. Dean Pesnell, NASA (GSFC)

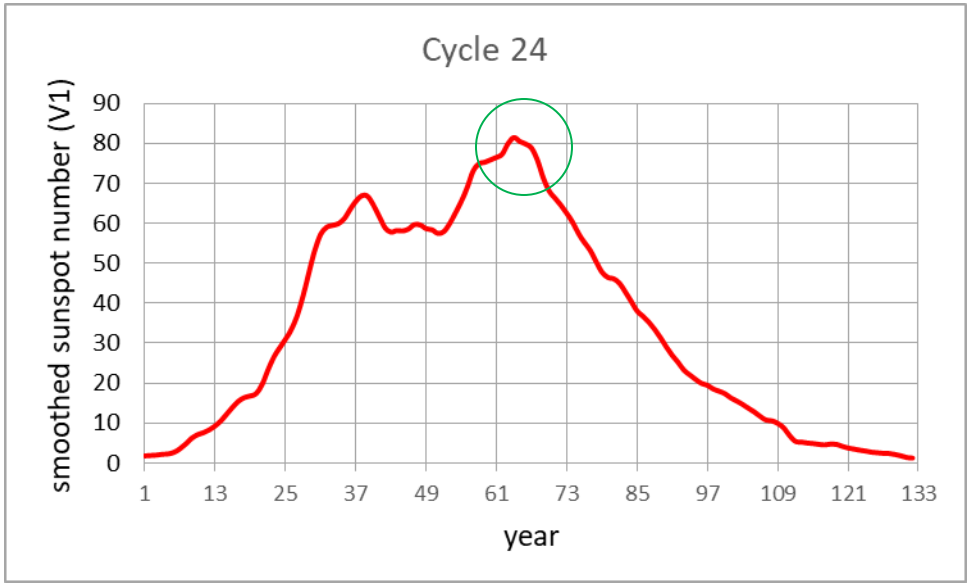
- A total of 57
- From 40 to 185
  - V1 sunspot record
- Someone was bound to be right!
- Why so many?
  - We don't fully understand the sunspot process

Solar Cycle 24 Prediction Panel
NOAA/NASA



- Two predictions issued initially
- As solar minimum lengthened, consensus was for a low cycle
  - We'll see why on slide 10

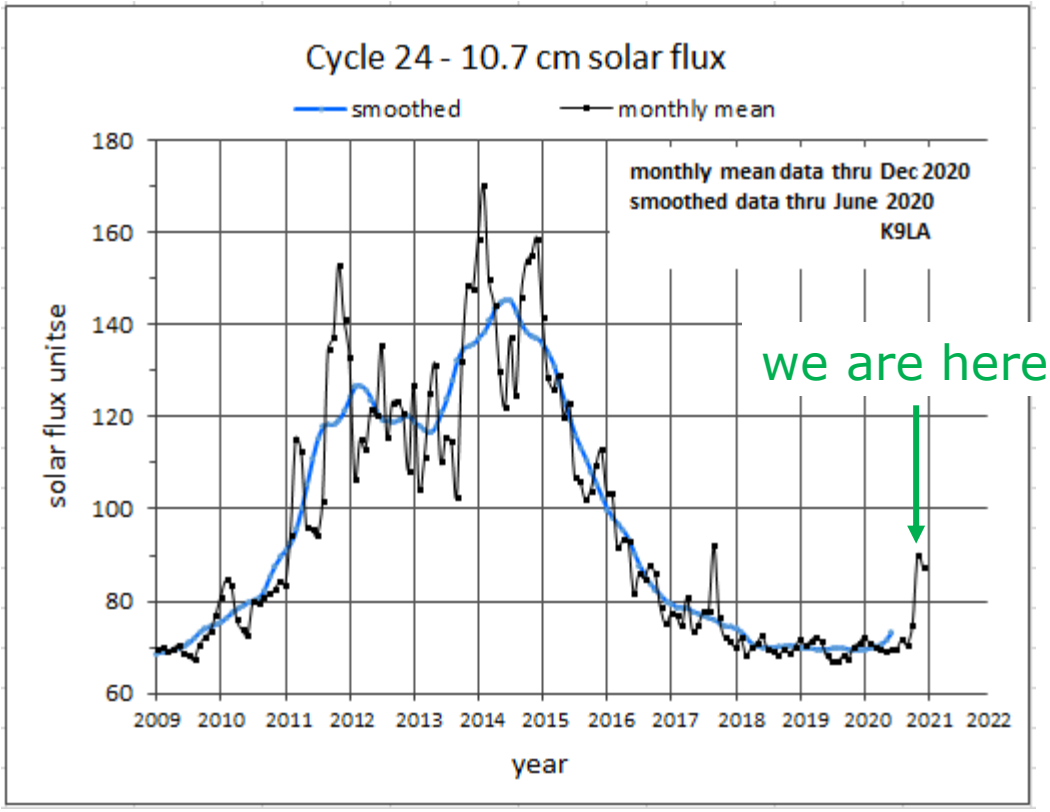
What Cycle 24 Actually Did



A handful of the predictions were ‘correct’

Why two peaks? Solar hemisphere asymmetry

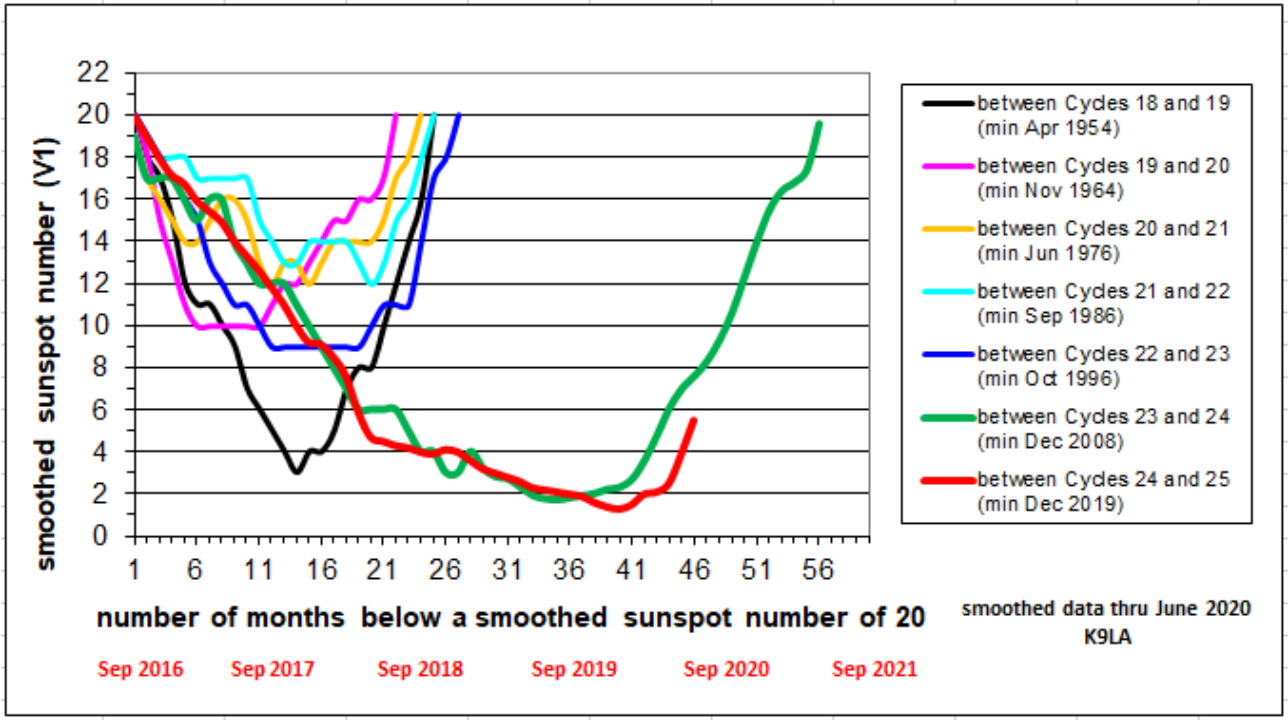
Cycle 24 Update



- Cycle 24 is over!
  - Last sunspot in July 2020
- Cycle 25 has started up
  - The blue 'smoothed' line shows this
- 10.7 cm solar flux doesn't have a V1 vs V2 problem
  - But it does change the correlation between the sunspot number and the 10.7 cm solar flux

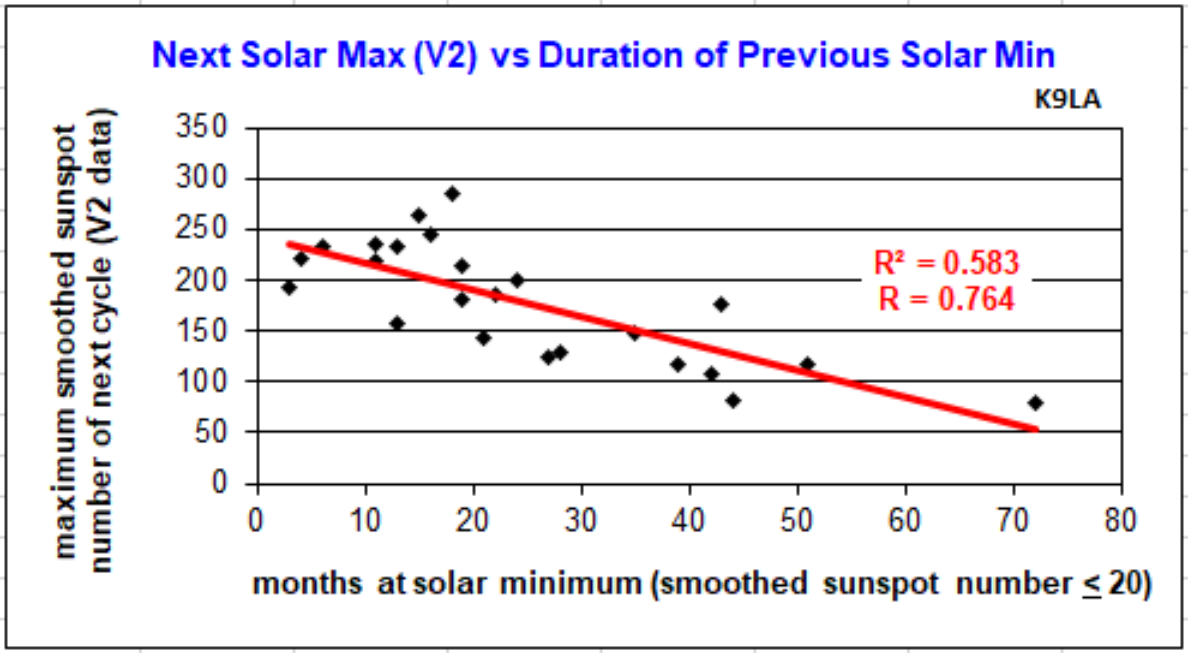
Current Solar Minimum

The Current Solar Minimum



- Duration of recent solar min will likely be about the same as the last solar min
- Now let's look at the correlation between the duration of solar min and the amplitude of the next cycle

Duration of Solar Min vs Next Max



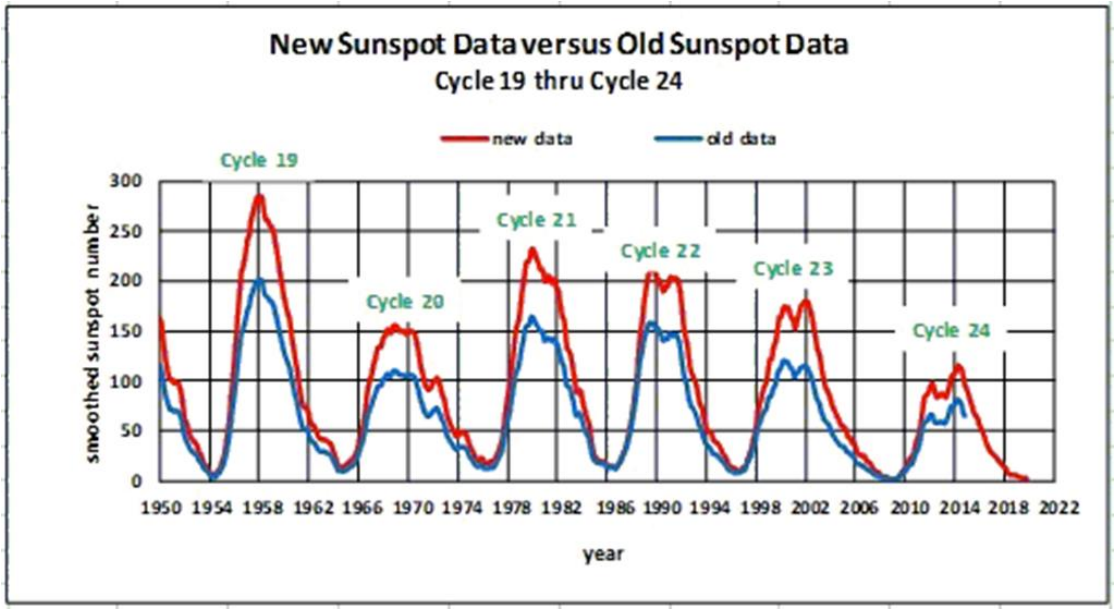
- Decent correlation
- The longer the duration of the solar minimum period, the smaller the next cycle

Cycle 25 Predictions

The NEW Sunspot Numbers

- In 1849 Rudolf Wolf devised the sunspot number
  - Wolf number = k x (10 x g + s) where g is number of sunspot groups, s is total number of sunspots, k includes telescope considerations, viewing conditions, observer bias
- His successor Alfred Wolfer applied a 'k' of 0.6 to make his counts agree with Wolf (in other words, Wolfer counted more sunspots)
  - This has been carried through forever
- Concern about the old sunspot numbers began in the early 1990s
- Four sunspot workshops held beginning in 2011
- Result was a new sunspot data set – named V2
  - Removed 0.6 factor, corrected other less-major issues
- Royal Observatory of Belgium began reporting the new sunspot numbers on July 1, 2015
- Beware of early Cycle 25 predictions – most V2, few V1

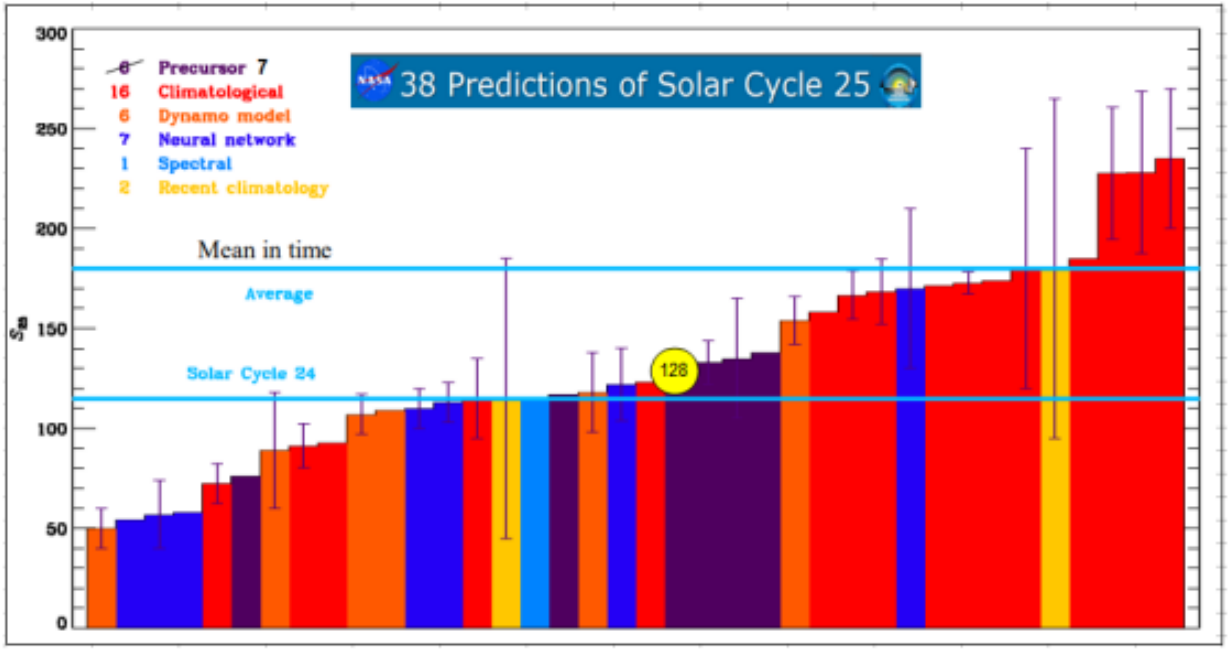
V1 vs V2 Sunspot Data



One of my anchor points for sunspot cycles was always 201 for Cycle 19 – not anymore!

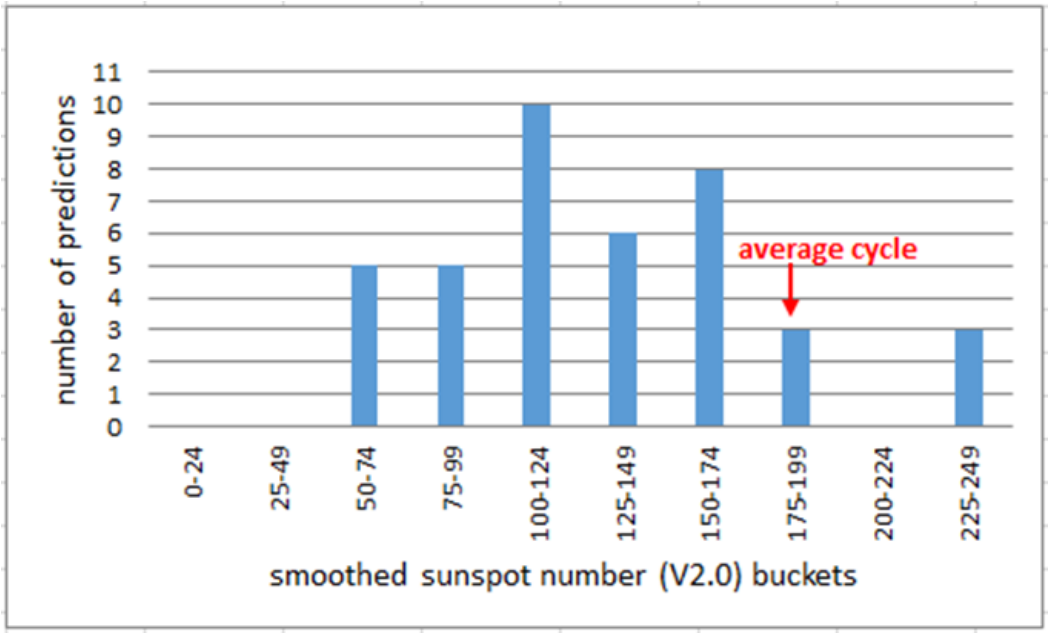
- Be aware of which data set is used
- Model of F2 region in our propagation predictions used V1 data
- Biggest difference is at solar maximum
  - V2 data about 1 band optimistic
  - IRI 2016 automatically applies factor to V2 data

Cycle 25 Predictions



- From W. Dean Pesnell, Sun Climate, Tucson, Jan 2020
- Soon after this was shown, I became aware of 2 more predictions – for a total of 40

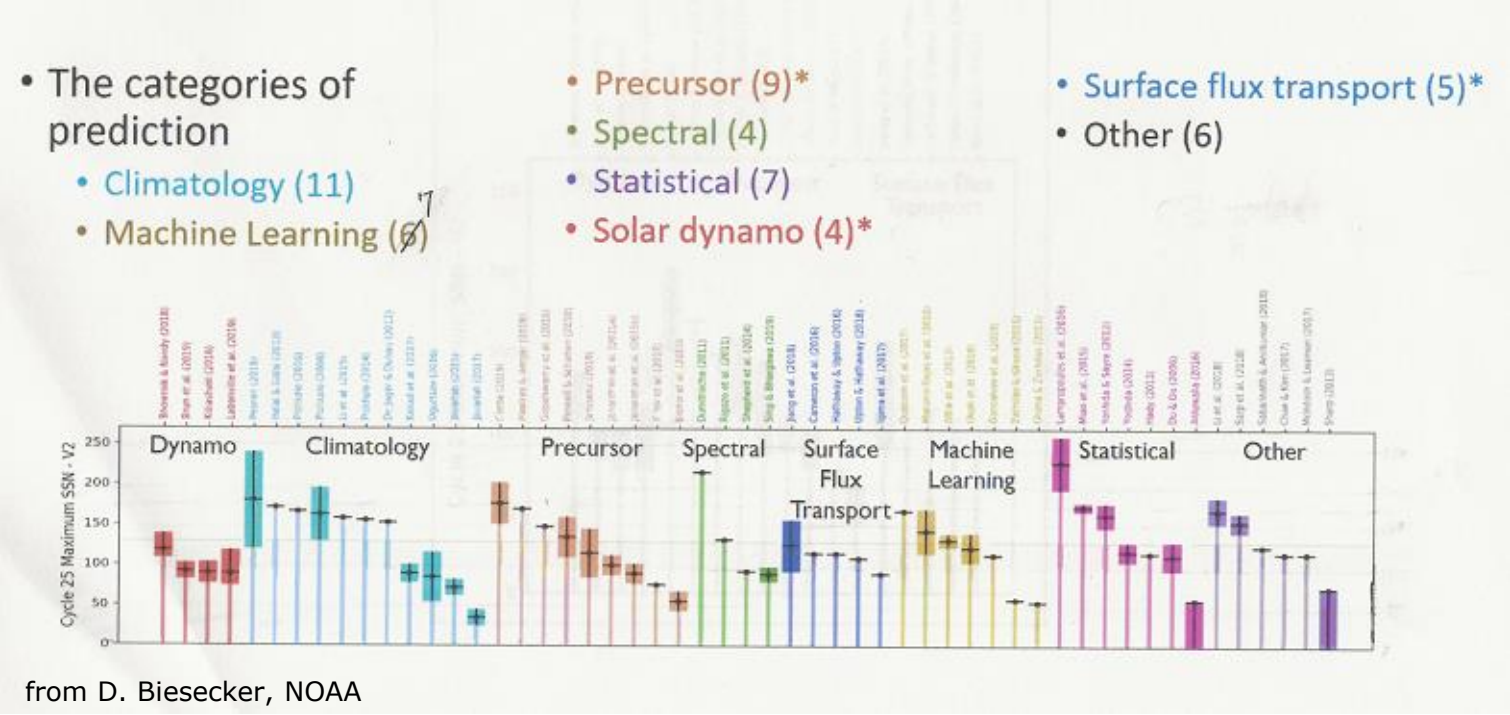
Distribution of Cycle 25 Predictions



- 34 of 40 (85%) are for a below-average cycle
  - (average is 179 in terms of V2 data set)
- 3 are for an average cycle
- 3 are for a big cycle (one is Dr. McIntosh, et al)

Even More Cycle 25 Predictions

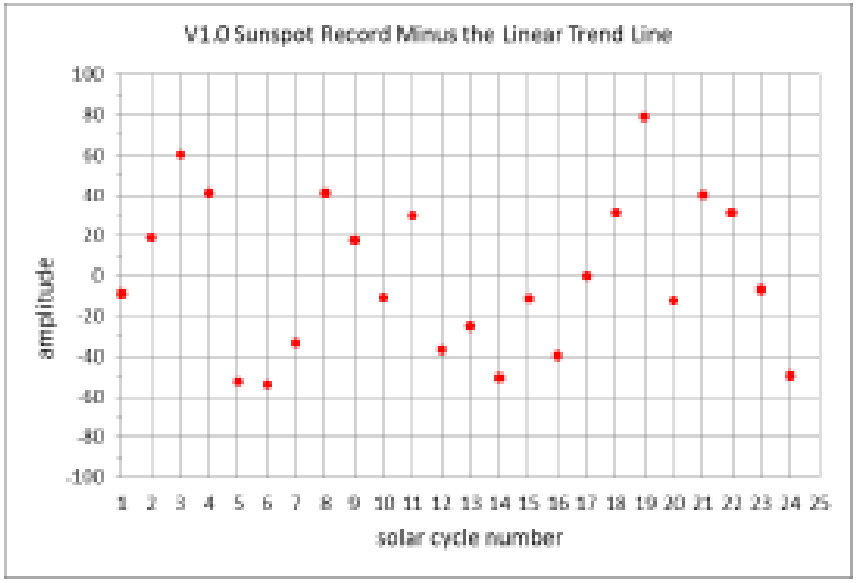
- I recently found more predictions for Cycle 25
- 50 of the 53 are at or below an average cycle
- Distribution not changed much



from D. Biesecker, NOAA

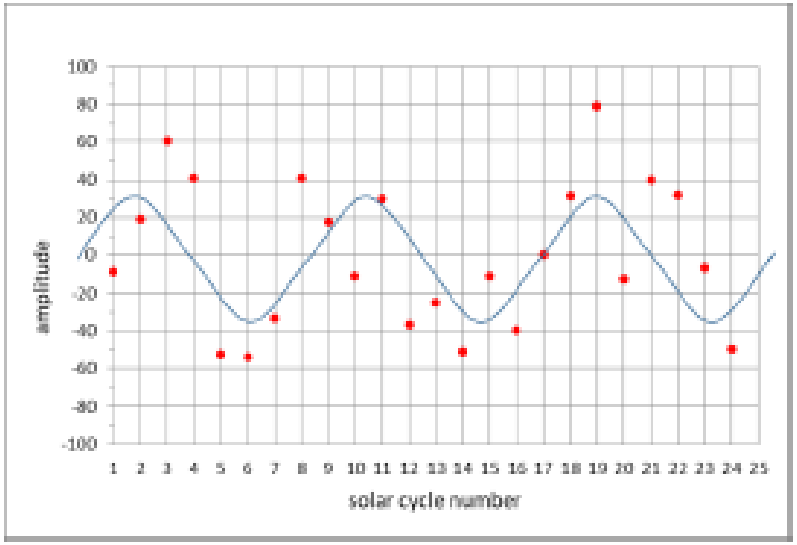
One of the Lowest Predictions

- J. Javaraiah in 2017 – about half the size of Cycle 24
- Fundamental basis is Gleissberg cycle
  - Schwabe 11 yrs, Hale 22 yrs, Gleissberg 80-100 yrs, other longer ones
- He fit linear trend line to all 24 cycles and then subtracted this trend line from V1 sunspot data



- Now data is centered about zero
- Next he fit a cosine function to this data

One of the Lowest Predictions

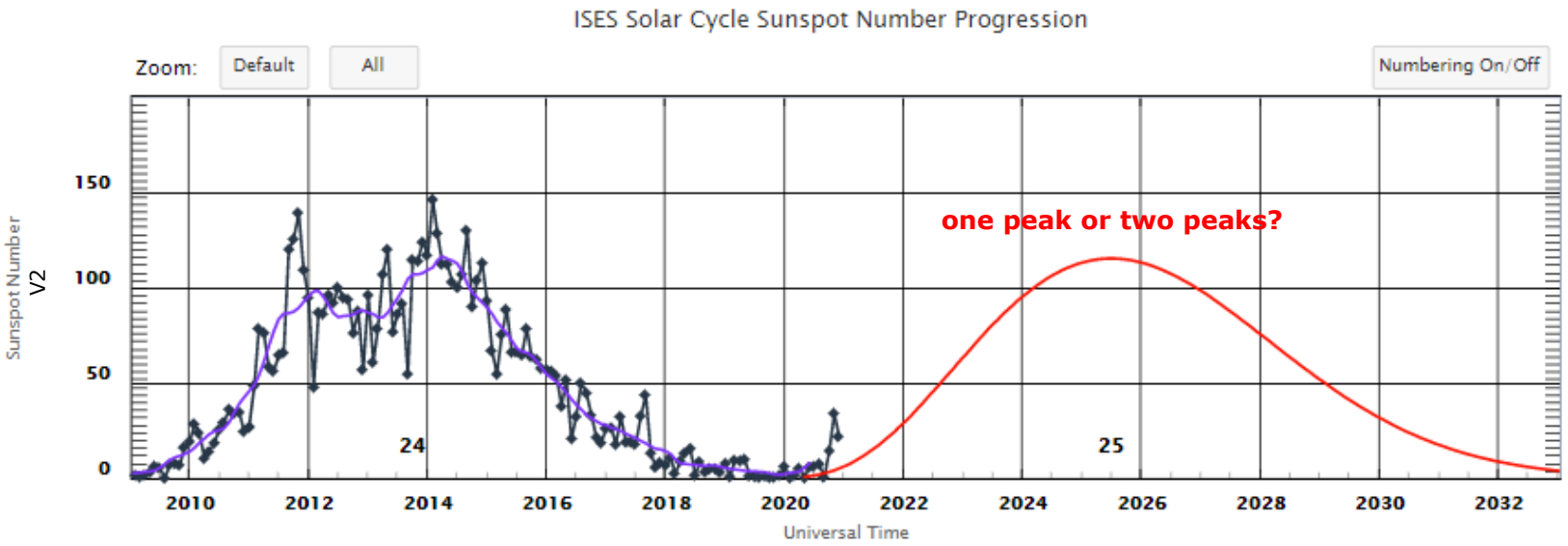


- Fit not very good
- Looked at two other factors
  - Gnevyshev-Ohl rule
    - Odd numbered cycle bigger than previous even numbered cycle – not always true, though
    - 23 should have been bigger than 22
  - Orbital angular momentum of the Sun about the center of mass of the solar system

- Resulted in a V1 prediction of 35 +/- 5
- Equivalent to a V2 prediction of 50 +/- 7

The NOAA/NASA Prediction

- similar to Cycle 24 -



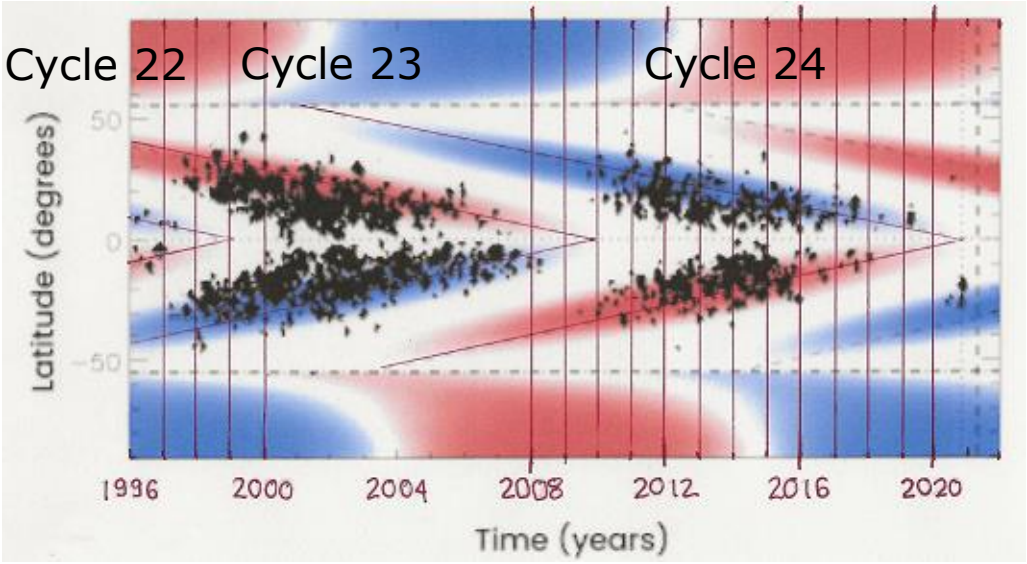
- Predicted maximum of 115 in mid 2025
  - About the same as Cycle 24
- https://www.swpc.noaa.gov/products/solar-cycle-progression

Another ‘Sim to’ Prediction

- Last night (January 22) I attended the Zoom meeting of the Foothills Amateur Radio Society
  - southern San Francisco Peninsula area in California
- Guest speaker was Dr. Leif Svalgaard
  - Solar scientist at Stanford University
  - Prolific writer and speaker
  - https://www.leif.org/research/
- His prediction is for Cycle 25 to be slightly bigger than Cycle 24
- This prediction is based on the magnitude of the sun’s polar fields at solar minimum

A High Prediction

- From Dr. Scott McIntosh, et al
- Basis is inferred magnetic activity bands

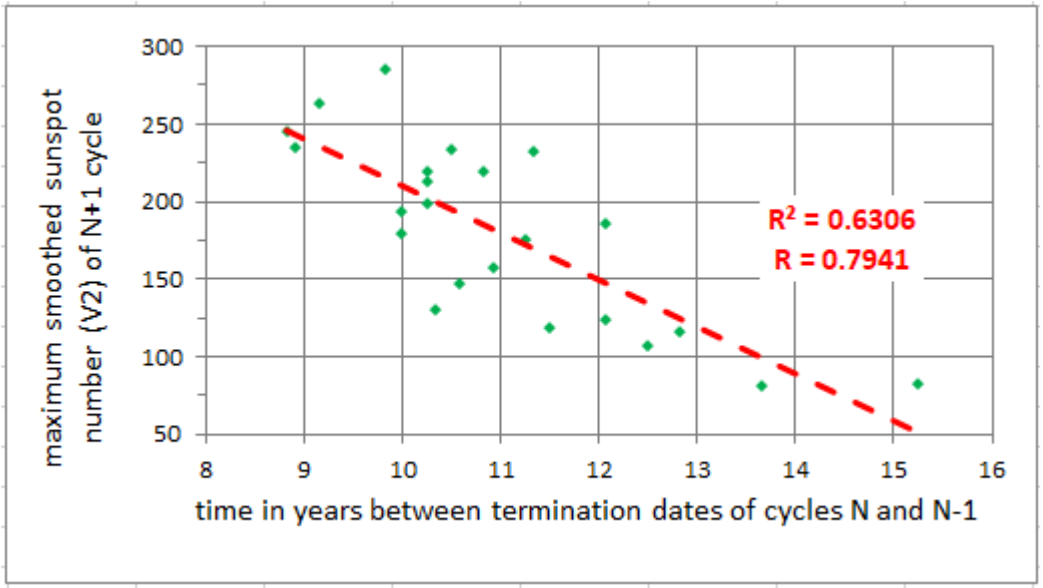


termination dates

Cycle	Maximum Sunspot Number	Terminator Date	ΔT
0	...	1757.92	...
1	144	1767.92	10.00
2	193	1777.08	9.16
3	264	1786.00	8.92
4	235	1801.25	15.25
5	082	1814.92	13.66
6	081	1826.42	11.50
7	119	1835.25	8.83
8	245	1846.08	10.83
9	220	1858.17	12.08
10	186	1868.67	10.50
11	234	1880.75	12.08
12	124	1891.33	10.58
13	147	1903.83	12.50
14	107	1915.08	11.25
15	176	1925.42	10.33
16	130	1935.67	10.25
17	199	1945.92	10.25
18	219	1955.75	9.83
19	285	1966.67	10.92
20	157	1978.00	11.33
21	233	1988.25	10.25
22	213	1998.25	10.00
23	180	2011.08	12.83
24	116	...	...

- Thin red lines intersect at termination dates of magnetic activity
- Prediction is based on time difference between termination dates per the tabular data

A High Prediction

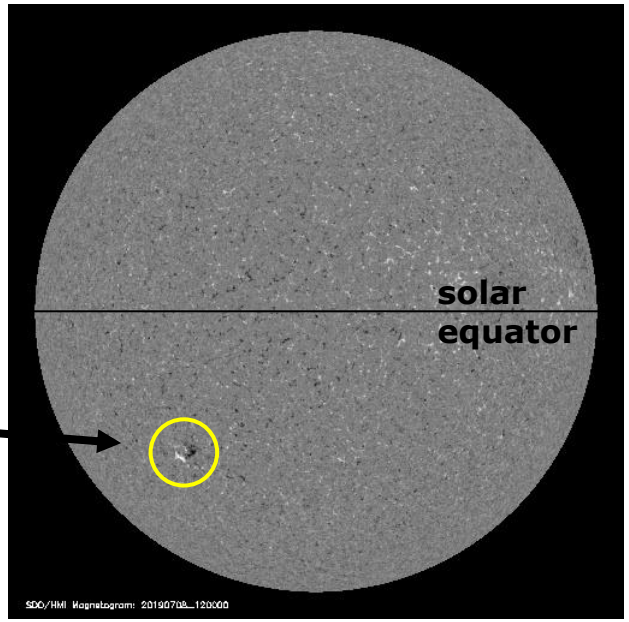


- Trend line from tabular data on last slide and maximum smoothed sunspot of next cycle
- Estimate for Cycle 24 termination date is 2020.37
- Not confirmed yet (as far as I'm aware)

- Trend says a longer number of years between termination dates gives a smaller cycle – similar to the concept on slide 10
- 2020.37 (estimate) – 2011.08 (from table) = 9.29 years
  - Enter 9.29 in plot above
  - Max Cycle 25 = 230
- Prediction depends on accuracy of termination dates

Cycle 25 Sunspots

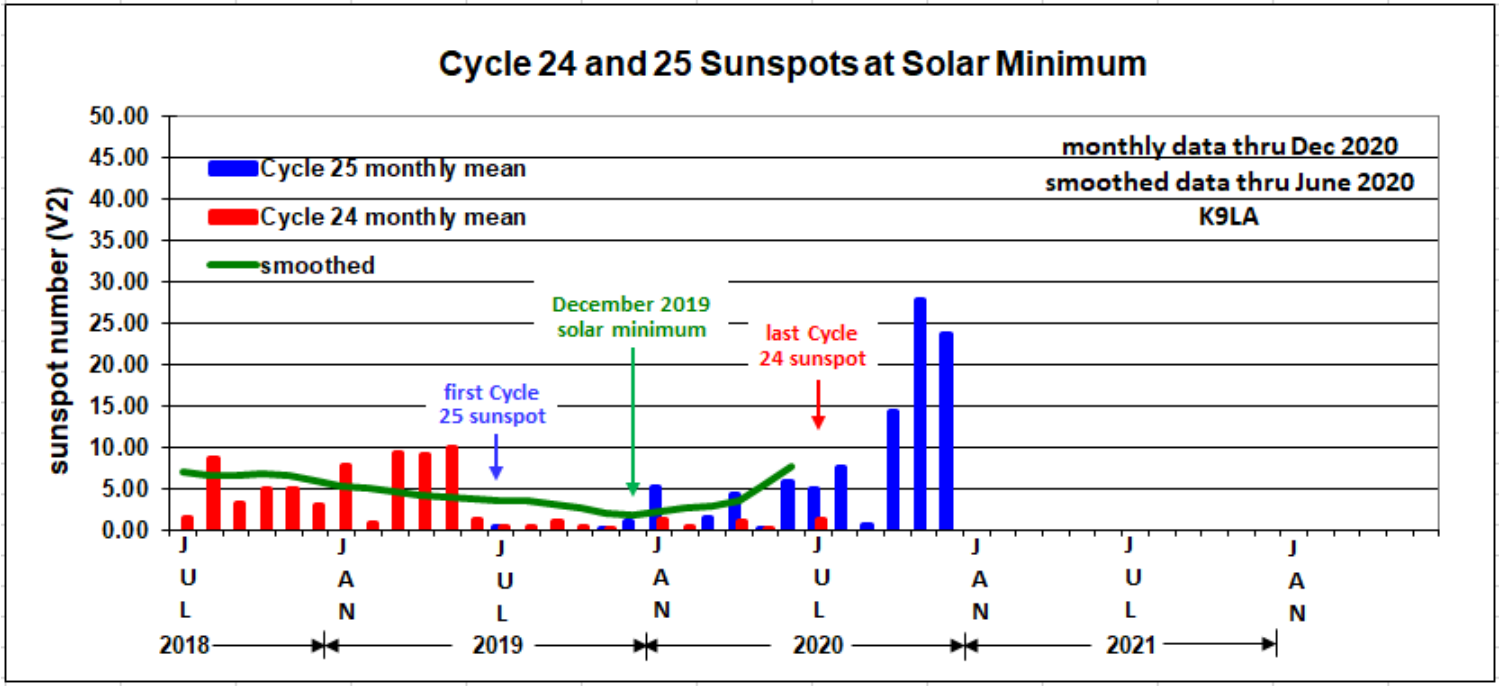
- Dec 2016, Nov 2018, May 2019, early July 2019
  - All were small and of short duration – no AR (Active Region) numbers assigned
- A longer duration Cycle 25 sunspot on July 8, 2019
  - Assigned AR2744
  - The first 'official' Cycle 25 sunspot



Cycle 25 came alive!

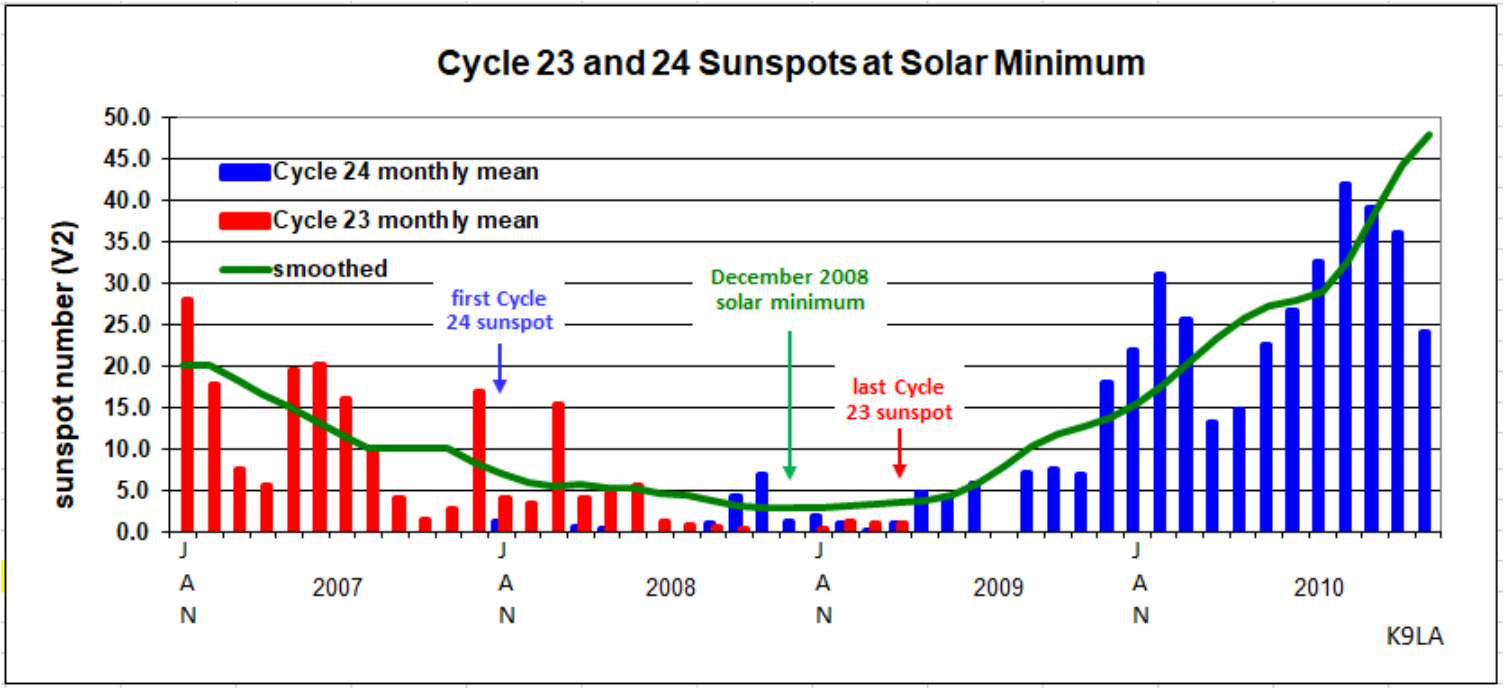
Early Cycle 25 Progress

Cycle 24/25 Sunspots



- Cycle 25 off to a good start
- January monthly mean data will be down
  - 12-day stretch of zero sunspots
- Is this a concern?

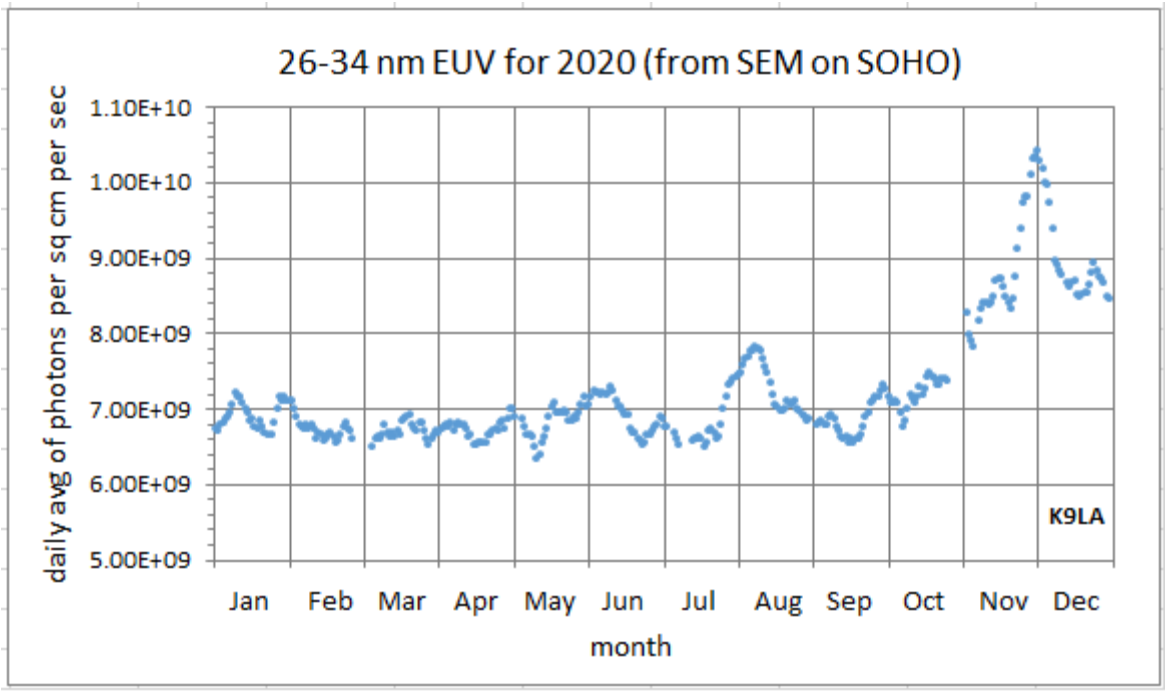
Cycle 23/24 Sunspots



- Cycle 24 had one zero-sunspot month
- Cycle 19 had two months with very low monthly means
  - Less than 0.5
- What we're seeing with Cycle 25 appears to be normal

Cycle 25 in EUV

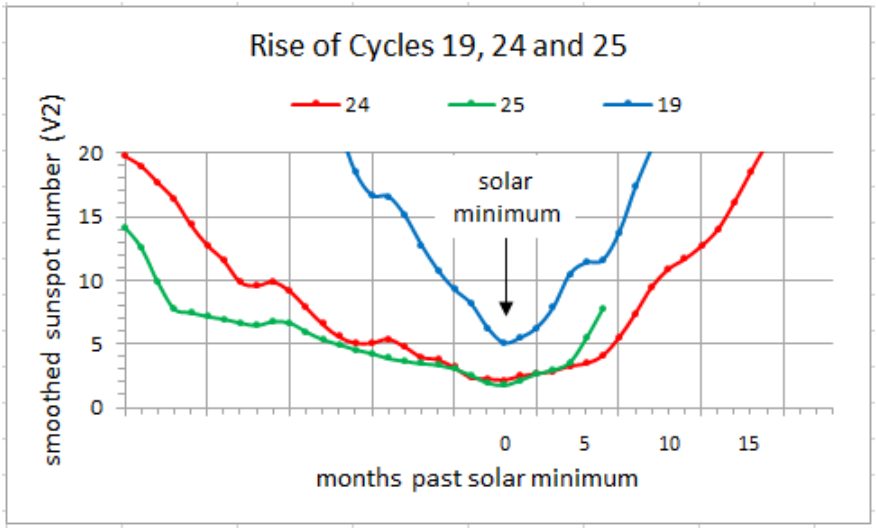
- Remember that sunspots and 10.7 cm solar flux are proxies for the true F2 ionizing radiation – which is EUV (~ 10-100 nm)
- 26-34 nm is responsible for about 60% of the F2 region
  - He II spectral line at 30.4 nm is dominant



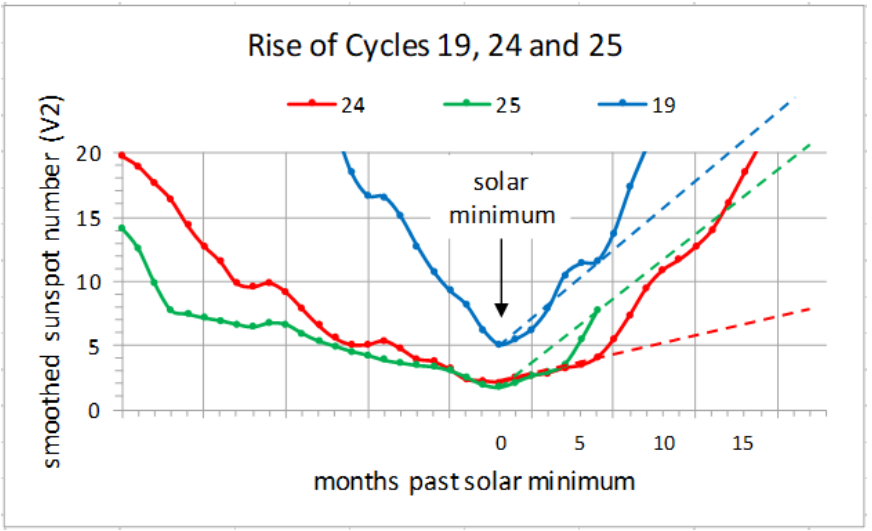
- Easy to see why we had good propagation on the higher bands toward the end of the year
- Shows up in sunspots and 10.7 cm solar flux, too

Ascent Rate of Cycle 25

raw data



with slopes after 6 months



- Big cycle rises faster than a small cycle
- Cycle 25 not too bad – so far
- Keep your fingers crossed
- Still too early to tell where Cycle 25 is headed

Summary

- Solar minimum occurred in December 2019
- Cycle 25 is on the rise
- Most believe Cycle 25 will be small
- A few predict a big Cycle 25
- I'm rooting for a big Cycle 25 as my homebrew 10m QRP transceiver (250 milliwatts PEP) needs sunspots!
- **Be sure to watch Frank W3LPL's presentation at 2 PM – he'll talk about what to expect with respect to propagation during the rise of Solar Cycle 25**