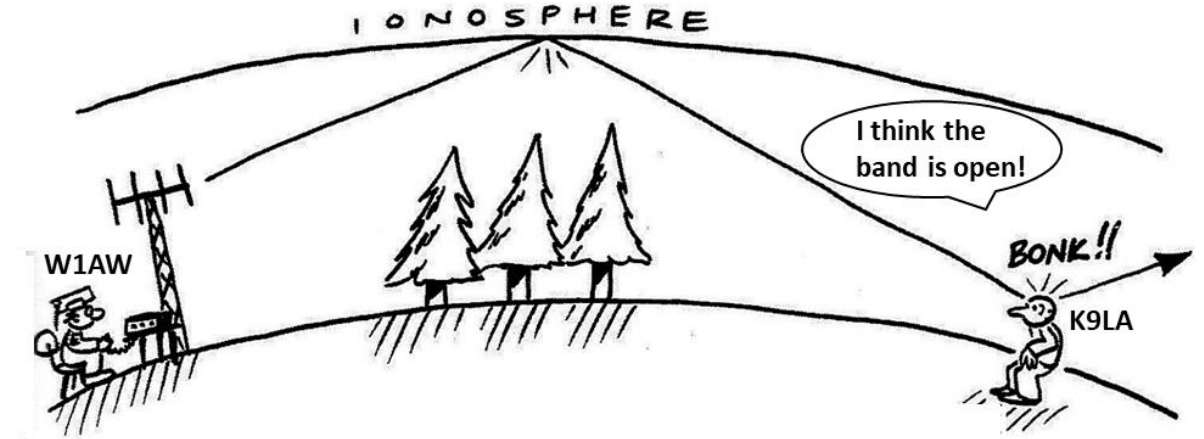


# Solar Cycle 25 Predictions

Carl Luetzelschwab K9LA

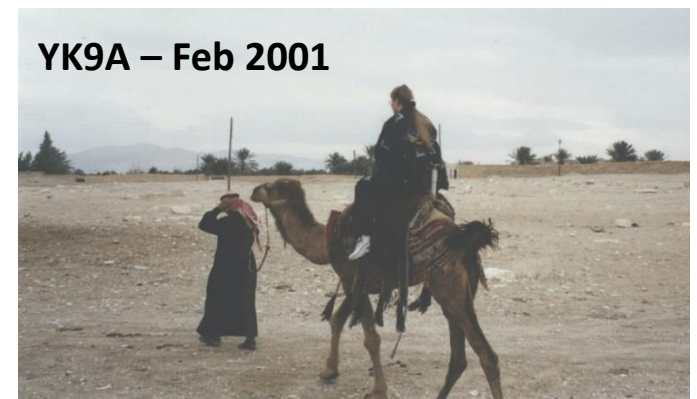
e-mail: [k9la@arrl.net](mailto:k9la@arrl.net)

website: <https://k9la.us>



# A Little About K9LA

- Novice in October 1961 (WN9AVT)
  - General in May 1962 (WA9AVT), Extra in 1977 (K9LA)
- Purdue grad – BSEE 1969 and MSEE 1972
- Worked for Motorola and Magnavox/Hughes/Raytheon
  - Retired in 2013
  - RF design engineer – mostly solid-state RF power amplifiers
  - Visited Tucson many times – met Tom K7DF
- Enjoy propagation, DXing, contesting, antennas and vintage equipment
- Wife is Vicky AE9YL
- ARRL Central Division Vice Director

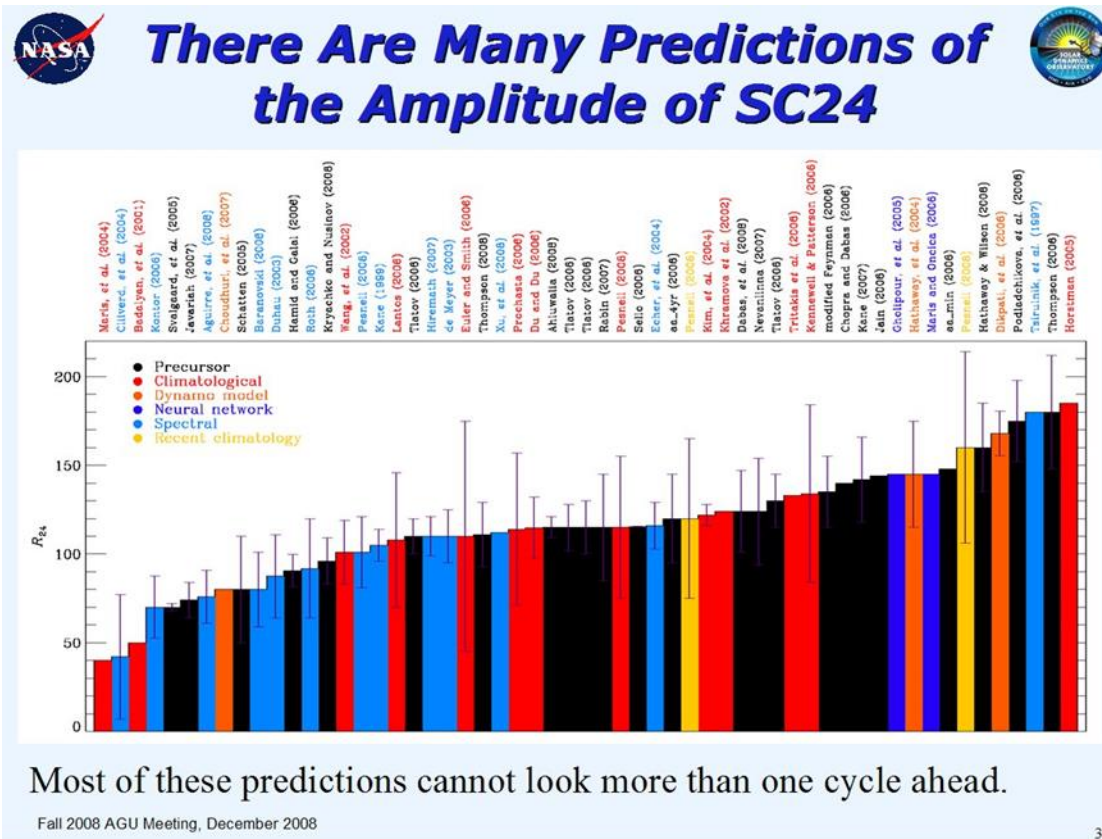


# Agenda

- A review of Cycle 24 predictions
- A review of Cycle 25 predictions
- How fast is Cycle 25 rising?
- A look at two of the many predictions

# *A Review of Cycle 24 Predictions*

# A Review of Cycle 24 Predictions



from W. Dean Pesnell, NASA (GSFC), 2008

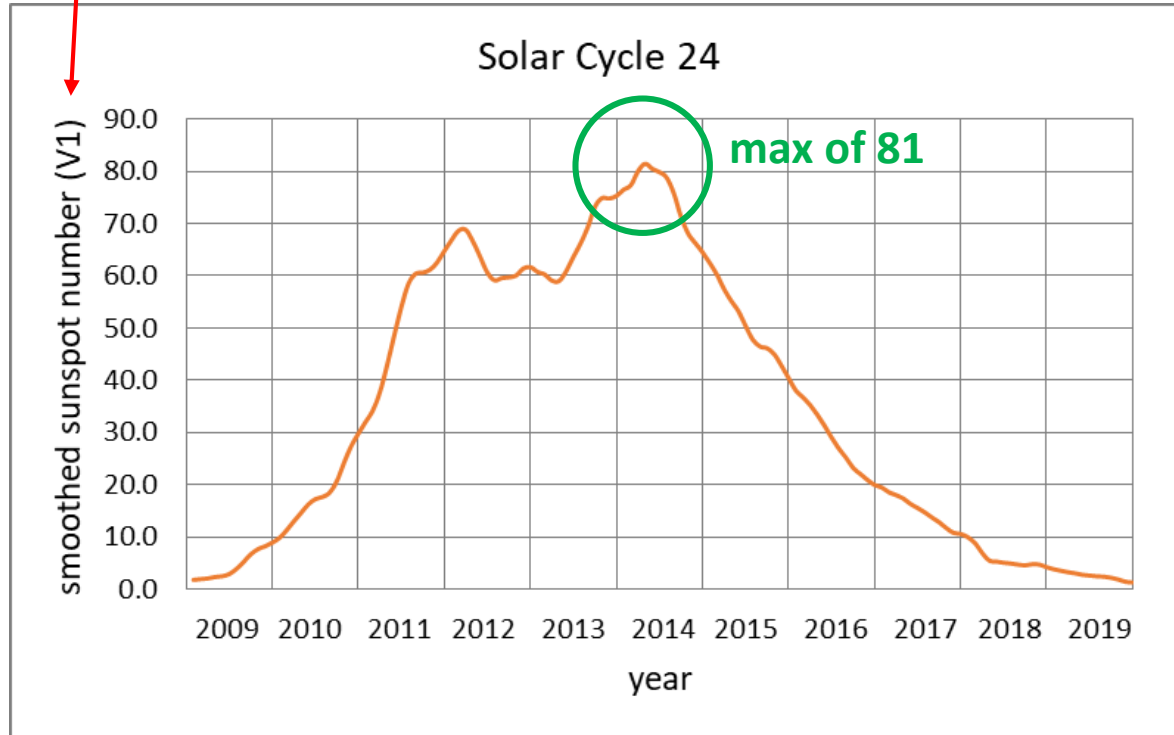
- A total of 57 predictions
- From 40 to 185 (V1 sunspot record) ← what is V1?
- Breakdown by method

method	quantity	range
Precursor	24	70 to 180
Climatological	13	40 to 185
Dynamo model	3	80 to 169
Neural network	2	both at 142
Spectral	13	42 to 180
Recent climatology	2	120 to 160

total 57

# What Cycle 24 Did

there's that V1 again



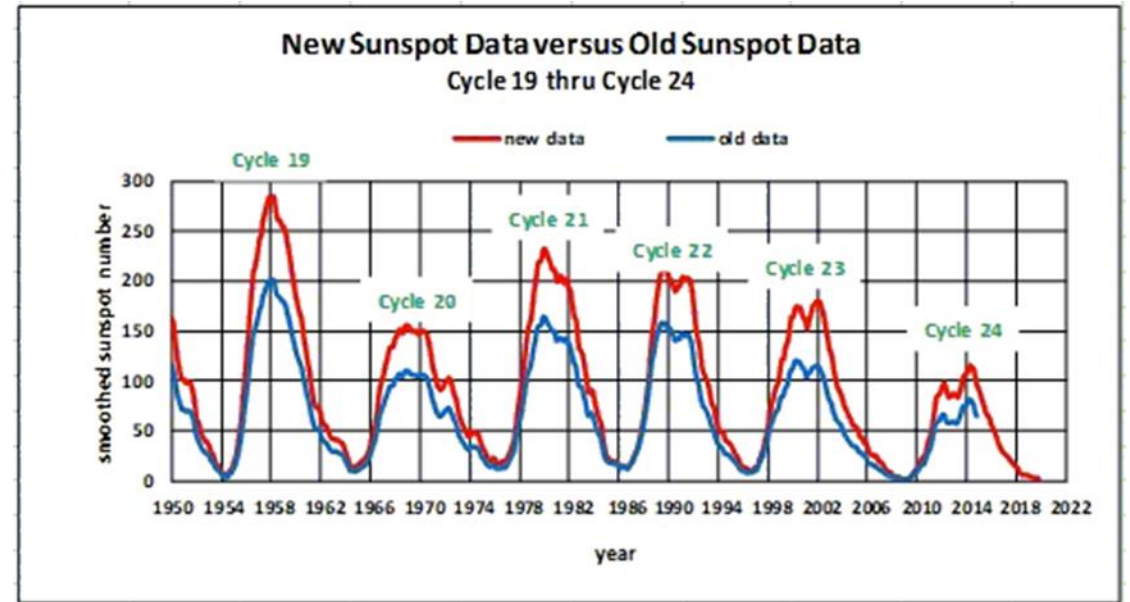
- 5 of the 6 methods had a big range of predictions
- There were 2 neural network predictions that had the same prediction
  - But they missed by quite a bit – 142 vs 81
- It tough to say that any method was better than the others

# Why So Many Predictions?

- To put it simply, we don't fully understand the nitty-gritty details of what generates the length and amplitude of a solar cycle
- We know it has to do with how plasma flows inside the sun how and magnetic fields move inside the sun
- But what drives these flows and movements?
- What about the gravitational tug by Venus, Jupiter and Saturn?
- What about the movement of the sun about the center of mass of the solar system?
- What about the wobble of the sun?

# Now to Answer “What Is V1?”

- Beginning in 2011, four workshops were held to review the old sunspot data
- Changes were deemed necessary to have a more accurate record of sunspot history
- Royal Observatory of Belgium began reporting the new sunspot numbers on July 1, 2015
- Biggest issue was transition from Rudolph Wolf to Alfred Wolfer

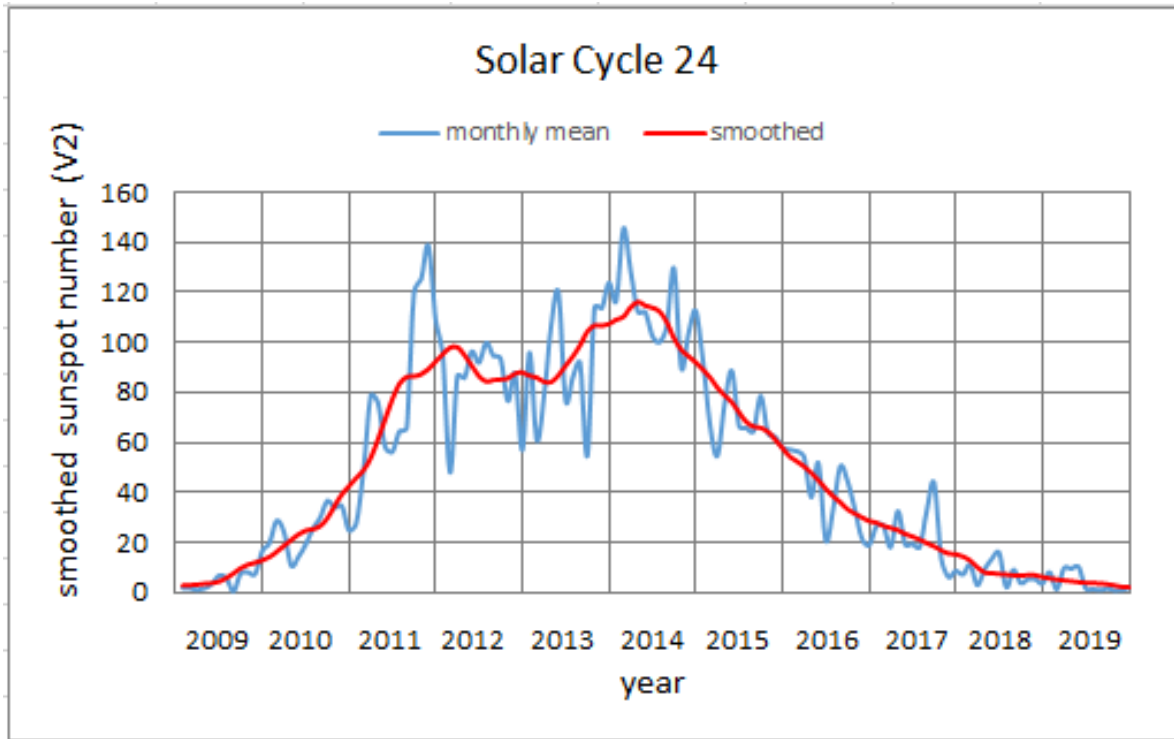


Old sunspot data is V1  
New sunspot data is V2

All data going forward will be V2



# And What's Monthly Mean and Smoothed?



- Here's Cycle 24 in terms of the monthly mean sunspot number (blue) and the smoothed sunspot number (red)
  - Daily data (not shown) is even more spiky than the monthly mean data
- Monthly mean data still too spiky
- Smoothed data is best to see what a cycle is doing
  - Smoothed data is 6 months behind monthly mean data because of the additional averaging

# *A Review of Cycle 25 Predictions*

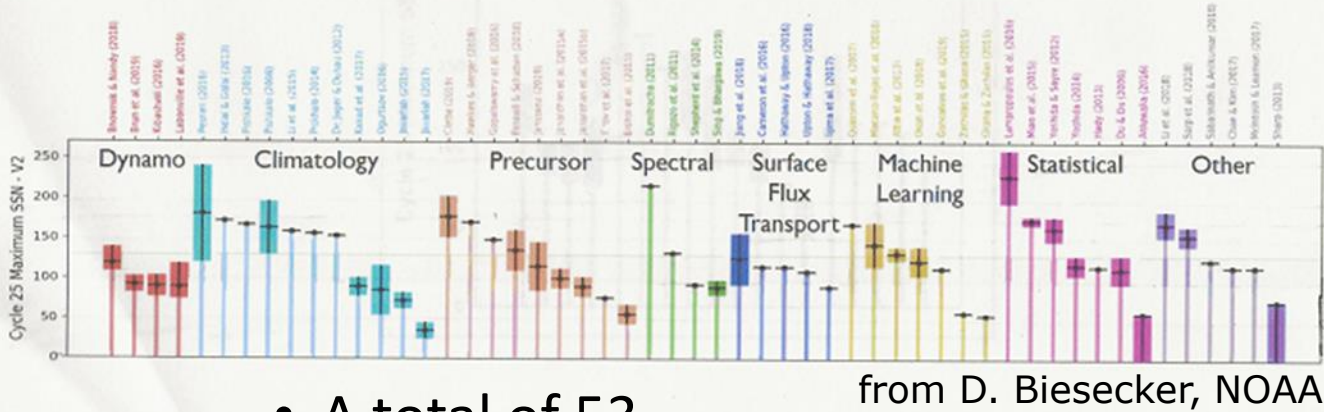
# A Review of Cycle 25 Predictions

• The categories of prediction

- Climatology (11)
- Machine Learning (8)

- Precursor (9)\*
- Spectral (4)
- Statistical (7)
- Solar dynamo (4)\*

- Surface flux transport (5)\*
- Other (6)



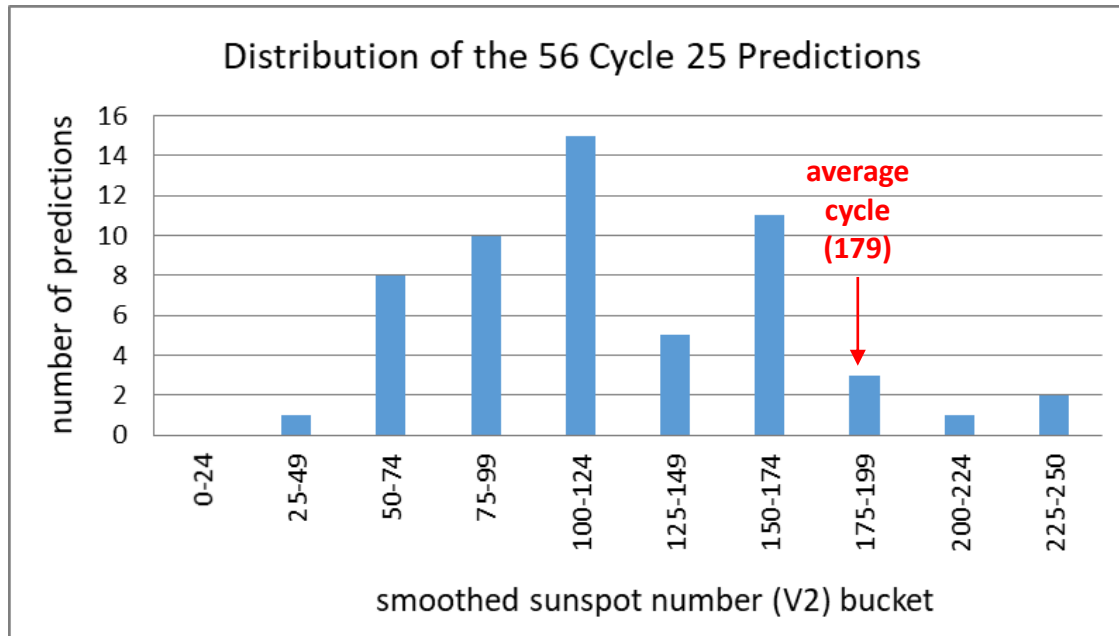
- A total of 53
- From 40 to 230 (V2 sunspot record)
  - 30 to 160 in terms of the V1 sunspot record
- Breakdown by methodology

method	quantity	range
Precursor	9	60-175
Climatology	11	40-180
Solar dynamo	4	90-120
Machine learning	7	50-170
Spectral	4	95-210
Statistical	7	50-230
Surface flux transport	5	100-130
Other	6	70-170

total 53

Again, with the wide range of data it is tough to say that any method may be better than the others

# Distribution of Cycle 25 Predictions



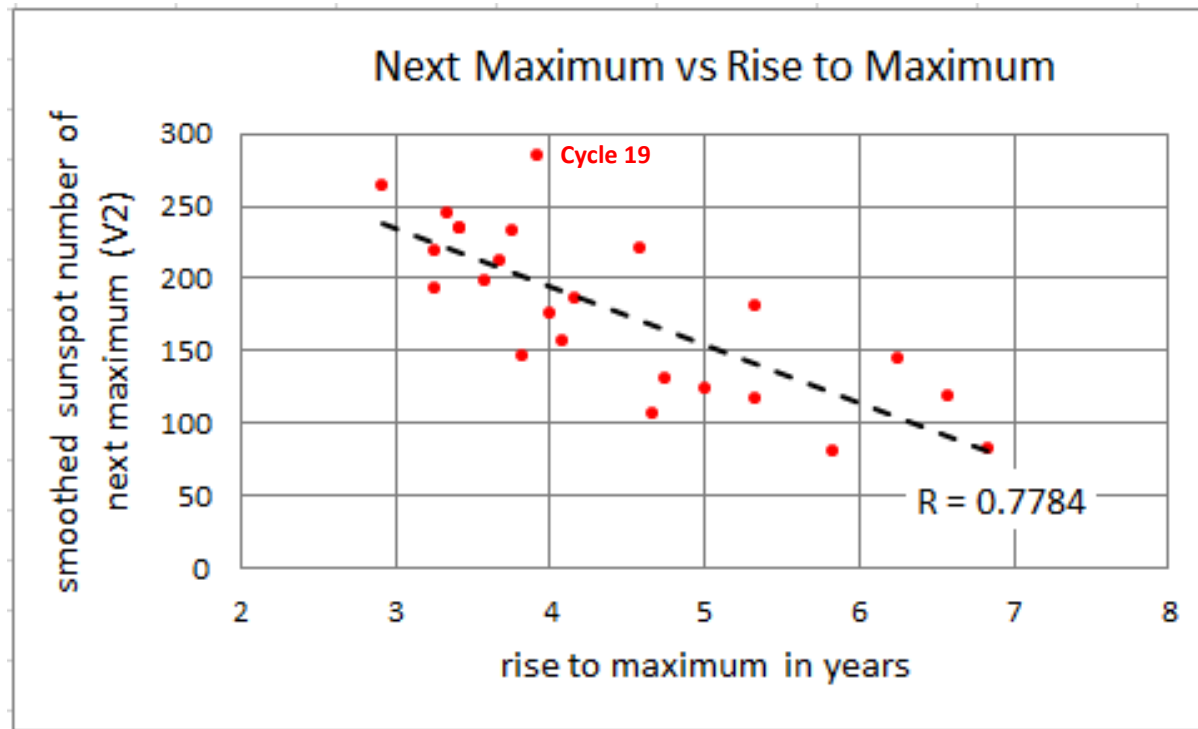
- 50 of the 56 (89%) are below average
- 3 are average
- 3 are above average

The 53 predictions from slide 11 plus the McIntosh, et al, prediction of 6/2020 and the Pease & Glenn prediction of 10/2016 and the Kitiashvili prediction of 1/2020

there are probably more predictions out there

*How Fast Is Cycle 25 Rising?*

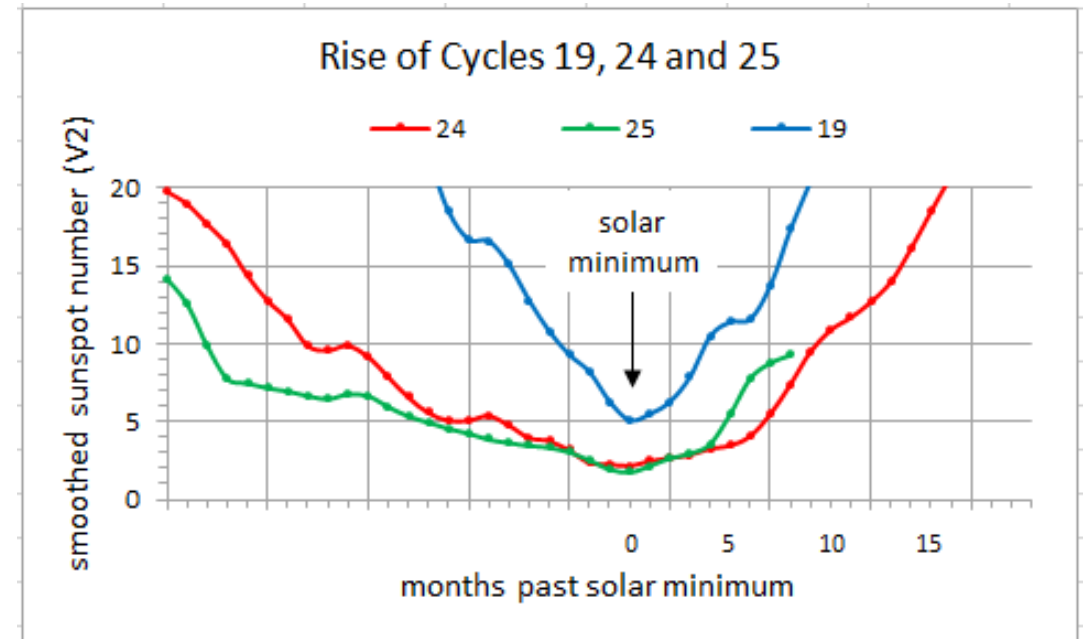
# Next Max versus Rise Time to Max



- Data for all 24 cycles
  - Only see 23 data points since Cycles 4 and 11 are the same data point
- Conclusion: Big cycles tend to rise faster than small cycles
- Decent correlation – but not perfect correlation
- How fast is Cycle 25 rising?

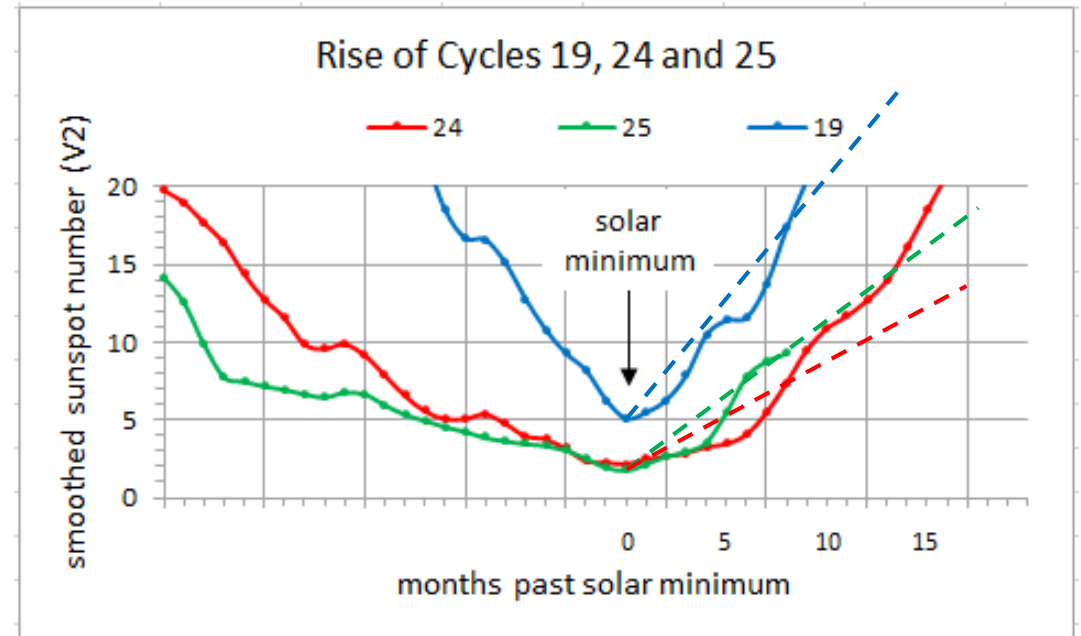
# We Have 8 Months of Cycle 25 Data

- Smoothed data thru August 2020 for Cycle 25
  - Remember smoothed data is 6 months behind monthly mean data
- Compare to Cycles 24 and 19
  - Cycle 24 is the smallest in our lifetime
  - Cycle 19 is the biggest in our lifetime (and in recorded history)



# Add Straight Lines to This Data

- Cycle 25 is not rising as fast as Cycle 19 after 8 months past solar minimum
- But it's still rising faster than Cycle 24
- I think it will take at least 6 to 12 more months of data before we have a decent clue as to where Cycle 25 is going

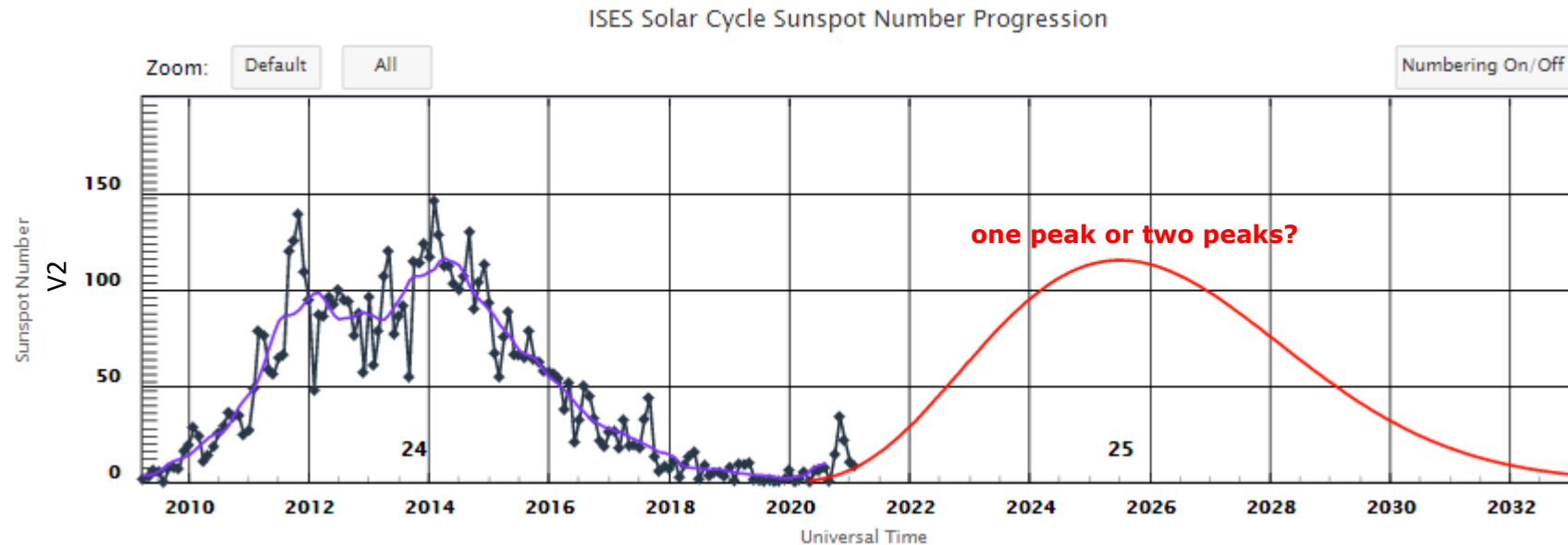


Caution - solar cycles do not rise in a straight line 😊



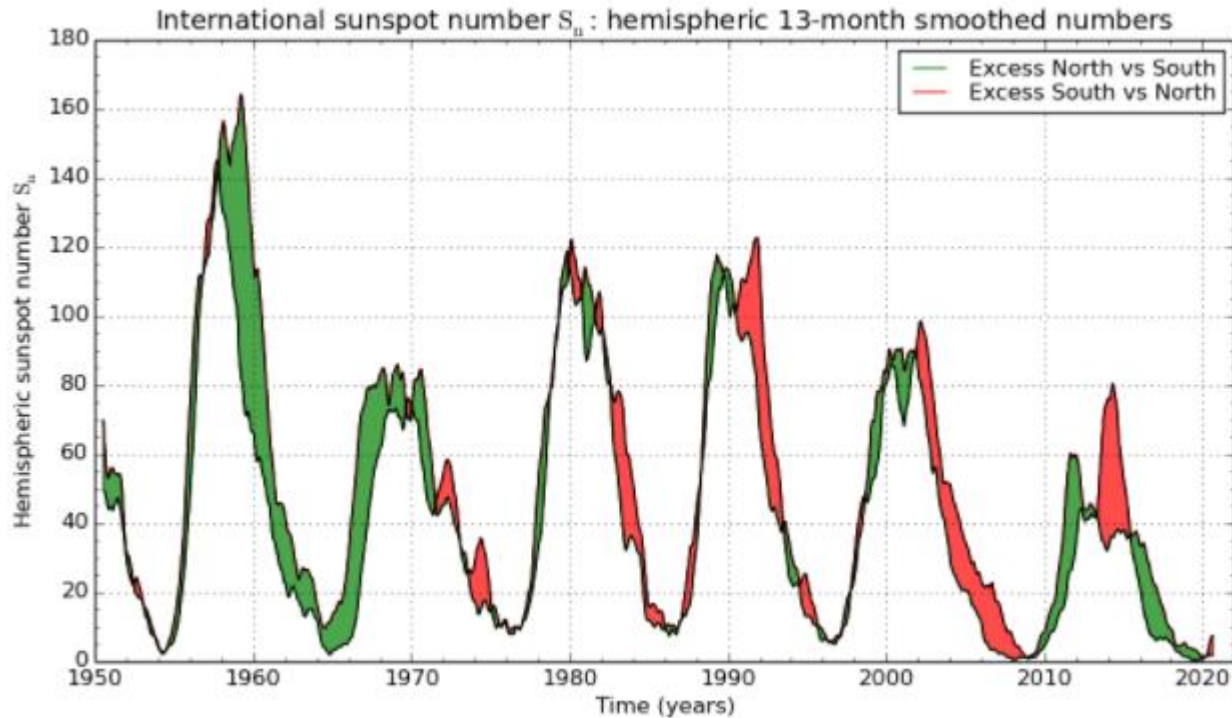
## *Let's Look at Two Predictions*

# Solar Cycle 25 Prediction Panel



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

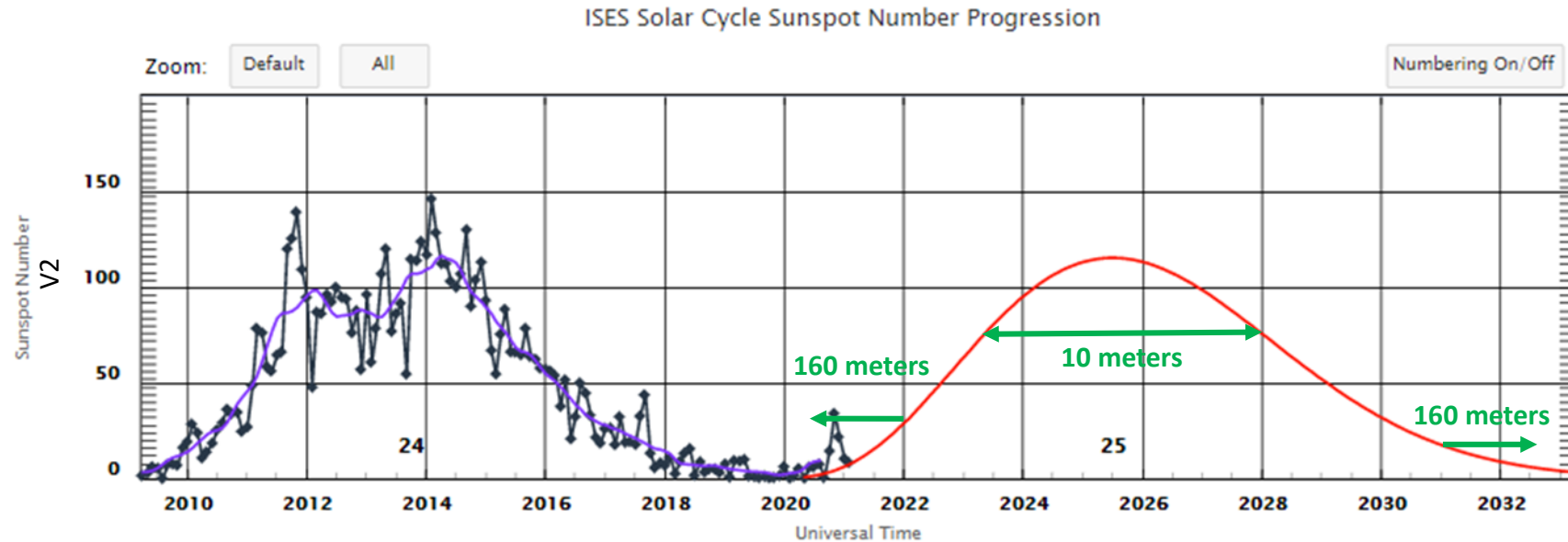
# One Or Two Peaks?



SILSO graphics (<http://sidc.be/silso>) Royal Observatory of Belgium 2021 March 1

- Two peaks are due to asymmetry of sunspots in the two solar hemispheres
- I don't think we understand this yet

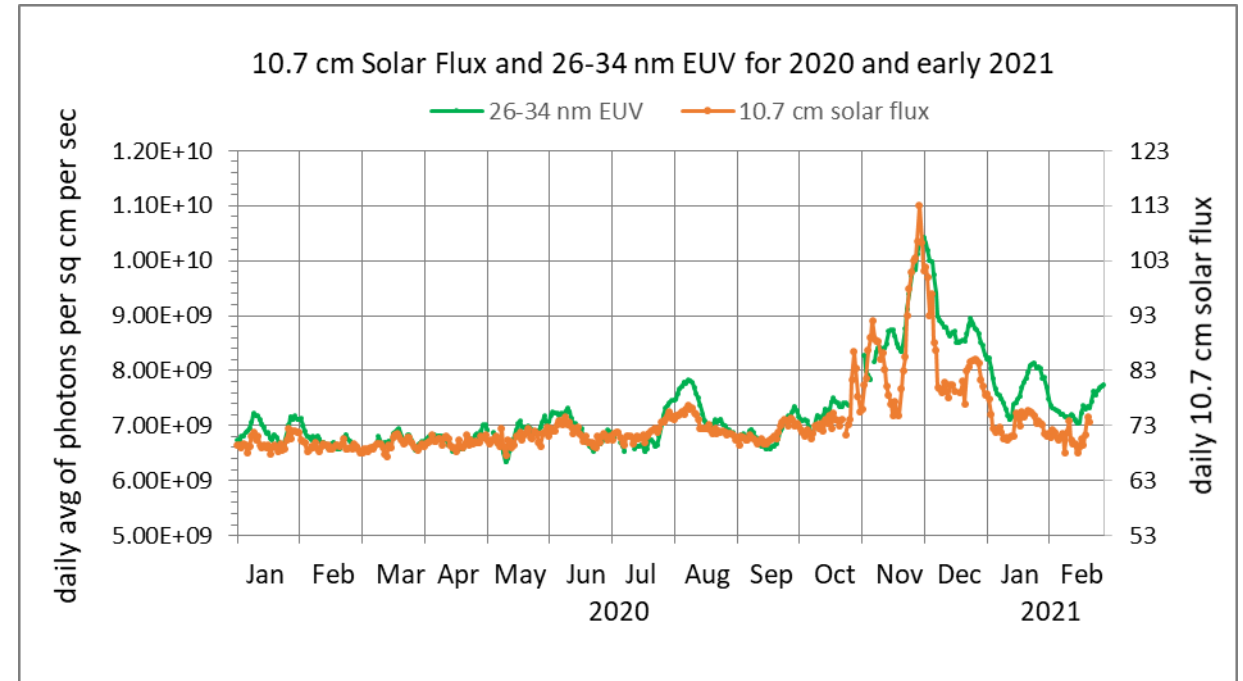
# When Will the Bands Be Good?



- Assumption: Cycle 25 will be similar to Cycle 24
- Very general assessment
  - 160m – now until 2022 (when CMEs/flares start up)
  - 10m – 2023 through 2027 (smoothed sunspot number above 70)
  - 160m – after 2031 (when coronal holes come to and end)

# Comment on the Last Slide

- To reiterate, if Cycle 25 is similar to Cycle 24, then 10m will be consistently good from 2023-2027
- This assumes the sun does not hiccup
- Late last year the sun hiccupped and we had some great propagation on the higher HF bands for CQ WW DX and ARRL 10 Meter contests
- We had a big spike EUV (shows up in sunspots and 10.7 cm solar flux – which are proxies for EUV)
- It looks like we're kind of back to solar minimum now



If you see the 10.7 cm solar flux spike up big, take a look at the higher HF bands

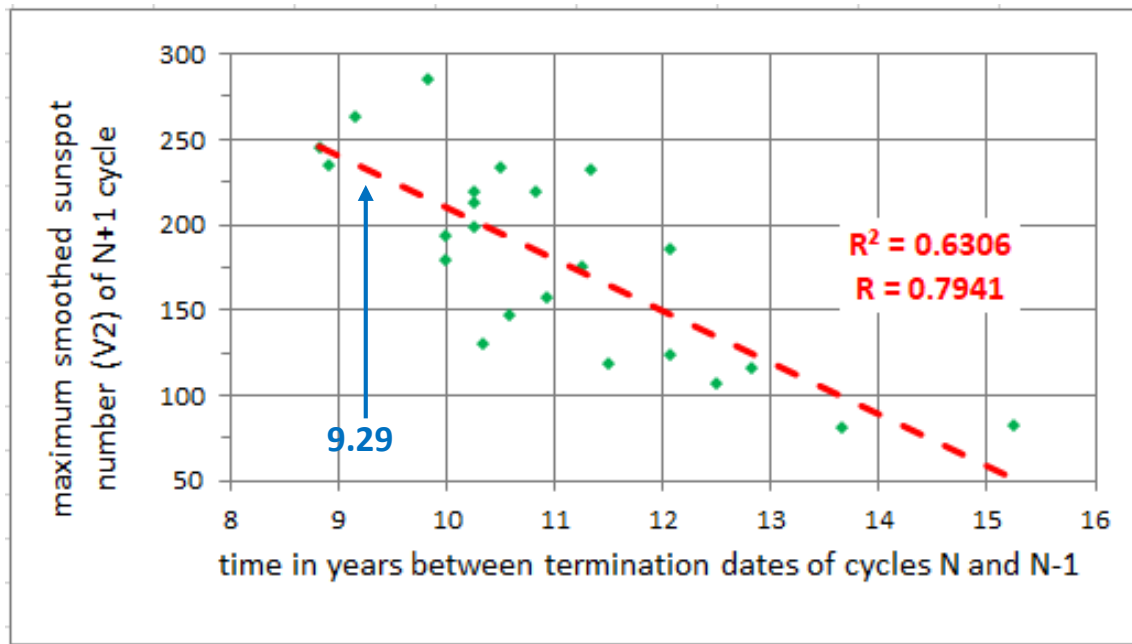
# One of the Big Predictions

- McIntosh, et al, in June 2020
- Received much publicity as it's significantly bigger than most predictions
  - Would be good for 10 meters and 6 meters!
- Based on time difference of termination dates ( $\Delta T$ ) of inferred magnetic activity bands

Cycle	Maximum Sunspot Number	Terminator Date	$\Delta T$
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	...	...

From McIntosh, et al, paper

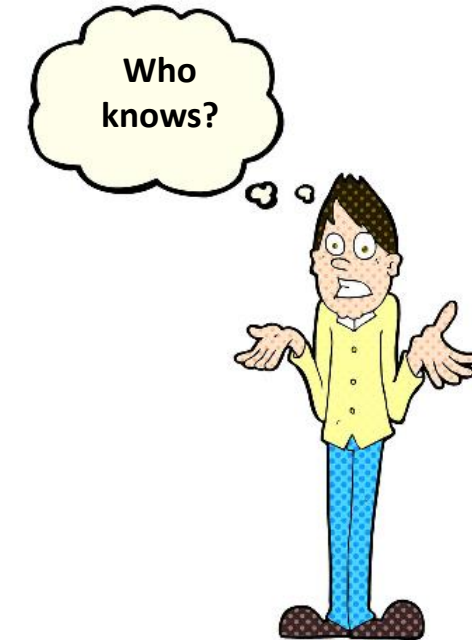
# The McIntosh, et al, Prediction



- Plot on left from termination dates on previous slide and maximum of next cycle
- McIntosh, et al, estimated Cycle 24 termination date of 2020.37
- Cycle 23 termination date was 2011.08
- Difference is 9.29 years – enter this on plot on left
  - About 229
- Caution - as far as I'm aware, Cycle 24 termination date has not yet occurred

# Which Prediction Will Be Most Accurate?

- I don't know
- With the range of the predictions so wide (40 to 230), someone is going to be correct
- Will they be correct for the right reason?
- It's unfortunate that solar cycles are so long – it can take a long time to ascertain whether a prediction is right or wrong
  - Even a prediction at solar min may take 4 years to validate since the average rise time of a cycle is about 4 years





# Summary

- We don't fully understand solar cycles
- Your guess is as good as mine for Cycle 25
- Although we're still near solar minimum, there's enough EUV to open 20 meters (and 17 meters to a lesser extent) worldwide during the day and early evening
- Low bands should be good
- 15 meters, 12 meters, 10 meters spotty for now
- My homebrew QRP (250 milliwatts) 10 meter DSB transceiver wants to see a big cycle!

