

Cycle 24, Solar Minimum and Cycle 25

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Agenda

- Current status of Cycle 24
 - Not much to say!
- Propagation at solar minimum
 - What to expect on the bands
- Predictions for Cycle 25
 - There are many of them
 - Why most predict a small Cycle 25
 - A brief look at the recent "big cycle" prediction by McIntosh, et al

Solar Cycle 24 Progress



- We are at solar minimum
- Official solar minimum (numerical minimum of the smoothed sunspot number) likely to have occurred in early 2020

Only one way to go – UP!

Recent Solar Minimums



- We became
 accustomed to
 short solar
 minimums –
 about 2 years
- Min between
 Cycles 23 and 24
 (green) changed
 that!

Current minimum (in red) even longer than the last minimum

Cycle 24 and 25 Sunspots



First <u>official</u> sunspot of Cycle 25 was in July 2019

- Solar cycles overlap
- Starting to see an increasing number of Cycle 25 sunspots
- No Cycle 25 sunspots in July (as of July 15)

What To Expect at Solar Minimum

- The following assumes CW/SSB
- 160m, 80m, 60m, 40m and 30m should be open worldwide at night and around sunrise/sunset
- 20m (and 17m to a lesser degree) should be open worldwide during the day and early evening
- Occasional openings for North America on 15m, 12m and 10m mostly of a north-south nature to Caribbean, South America and Central America
- 6m openings to the south possible
 - Sporadic E link to TEP (trans-equatorial propagation)

What to Expect at Solar Minimum - more

- Don't forget Sporadic E on 6m and 10m during the summer (and December)
 - Bi-modal occurrence pattern allows NA to JA and two times during the day for NA to EU
 - We've had many great openings so far this summer
- Take advantage of the digital modes
 - More opportunities
 - They have an SNR advantage over CW and SSB
 - This can show up as detecting signals deeper in the noise or allowing some above-the-MUF propagation



Sporadic E - late morning and early evening local time

Some Ionospheric Physics

- Why is 20m open when the sunspot number is zero and the 10.7 cm solar flux is around 65-66?
- Sunspots and 10.7 cm solar flux are <u>proxies</u> for the true F2 region ionizing radiation – which is radiation at EUV (extreme ultraviolet) wavelengths (roughly 10-100 nm)
- At solar minimum there is still enough EUV from the Sun to refract low angle 20m RF (and low angle 17m RF to a lesser degree)

Some Ionospheric Physics - continued

- Our model of the ionosphere for prediction purposes is a monthly median model we do not have a daily model
- Being a <u>monthly median</u> model (kind of like an average over the month), we don't capture short-term events that may enhance propagation
- Watch for enhanced propagation right when the K index spikes up
 - Great example is the 2018 California QSO party on 10m to the Midwest
 - Nothing on Saturday
 - K index spiked up on Sunday 10m opened between W6 and Midwest

Predictions for Cycle 25 (in ascending order)

	minimum date	maximum date	maximum (V2.0)	author(s)	prediction date
1			50 +/-7 (converted from V1.0)	Javaraiah	2017
		2022-2023	57 +/-17	Covas, et al	2019
			71 (converted from V1.0)	Javaraiah	2014
			78	Upton and Hathaway	2017
5			85 +/-5	Bisoi and Janardhan	2019
	2020.5 +/- 0.12	2027.2 +/1 1.0	89 +29/-14	Labonville, et al	2019
	2019-2020	2024 +/- 1	90 +/-15	Kitiashvili	2016
			94 (converted from V1.0)	Shepherd, Zharkov, Zharkova	2014
		2024	excess of 100	Bhowmik and Nandy	2018
10		2024 +/- 0.6	103 +/-25	Singh and Bhargawa	2017
	2020.9		110	Upton and Hathaway	2018
	April 2020 +/- 6 months	July 2025 +/- 8 months	115	NOAA/NASA Solar Cycle 25 Prediction Panel	2019
			117	Hawkes and Berger	2018
			117 +/-15	Petrovay	2019
15		2025.2 +/- 1.5	120 +/-39	Pesnell and Schatten	2018
			121.5 +/-32.9	Miao, et al	2020
			124 +/-31	Jiang, et al	2018
		2022	130 (converted from V1.0)	Attia, et al	2013
	2019.4	2024.8	130	Petrovay	2018
20			134	Bisoi, Janardhan, Ananthakrishnan	2020
			136	Svalgaard	2017
			136 +/-48	Pesnell and Shatten	2018
		2023.2 +/- 1.1	154 +/-12	Sarp, et al	2018
			169 (converted from V1.0)	Helal and Galal	2012
25	2019.9	2023.8	175 (154-202)	Li, et al	2015
		2023.4	188 (converted from V1.0)	Rigozo, et al	2011
			229 +/-25 (68% confidence)	McIntosh, et al	2020

 I'm aware of 27 predictions so far

- There will probably be more
- Low of 50 +/-7
- High of 229 +/- 25 at 68% confidence
 - 229 +/- 76 at 95% confidence

Range of predictions says we don't fully understand the sunspot process yet

Distribution of Predictions



There is much more consensus among solar scientists on Cycle 25

- Cycle 24 initially had two predictions – one low, one high – until the duration of solar minimum became so long
- Cycle 24 had a maximum of 116 for its second peak
- Cycle 25 expected to be similar to Cycle 24
- Most predictions for Cycle 25 are in the 100-124 bucket

What Does a Long Solar Minimum Tell Us?



My definition of solar minimum – when the smoothed sunspot number is below 20

- Per the plot, the longer the solar minimum period, the smaller the next cycle
- Not perfect correlation, but an R of 0.762 (square root of 0.5815) is a strong correlation
- Suggests Cycle 25 is going to be another small one
- What about the prediction of a big Cycle 25?

The McIntosh Prediction (#27 on the list on slide 10)

- McIntosh, et al, looked at the <u>length of the magnetic cycle</u> (T) for all recorded history
 - A short T = a big next cycle ———
- They believe the end of the magnetic cycle for Cycle 24 will be early 2020
 - $\Delta T = 9.29$ years from end of Cycle 23
- Based on their correlation, their prediction is for a big Cycle 25



There is a contradiction between the graph on the previous slide and the above graph - we'll know which one is right in several years!

Confusion with Sunspot Numbers

- Beginning in 2011, four workshops were held to review old sunspot data
- Biggest issue was a scale factor of 0.6 that was applied in 1894 by A. Wolfer to make his measurements agree with R. Wolf's earlier measurements
- This scale factor, plus other lesser issues, were addressed by the workshops



- New V2 sunspot data (back to 1794) is higher than the old V1 sunspot data
- Royal Observatory of Belgium began reporting new V2 data on July 1, 2015

Our Propagation Predictions

- Correlated to the old V1 smoothed sunspot numbers
- The new V2 smoothed sunspot numbers are higher
- Thus using the V2 numbers will give more optimistic predictions
- By how much?
 - Most difference around solar max about 1 band
 - Least difference around solar min
- For predictions, multiply the V2 number by 0.7 and use that in your prediction software

Summary

- We're at solar minimum longest in our lifetimes
- Still good DX opportunities at solar minimum be on the right band at the right time and watch for short-term enhancements
- A big question is "how long will we be at solar min?"
- All I can say is "Cycle 25 is alive" hopefully it will start its ascent soon
- Cycle 25 predictions are all over the map maybe we'll figure this out someday ⁽²⁾
- Take advantage of more opportunities with the digital modes
- Know which version of sunspot data you're working with

Some Web Sites

- Space Weather
 - <u>https://spaceweather.com/</u>
 - <u>https://www.swpc.noaa.gov/</u>
 - <u>http://www.spaceweatherwoman.com/</u>
- Propagation information
 - <u>https://k9la.us/</u> (a shameless plug for my web site)
- A discussion of Cycle 25 predictions (my Monthly Feature for August 2020)
 - https://k9la.us/Aug20_Cycle_25_Predictions.pdf
- Reference books
 - NM7M (SK) The Little Pistol's Guide to HF Propagation
 - Available at https://k9la.us/NM7M_The_Little_Pistol_s_Guide_to_HF_Propagation.pdf
 - The NEW Short Wave Propagation Handbook
 - Available from CQ updated edition in process