Cycle 25 Update
. . . and more . . .

Cycle 25 is very alive!

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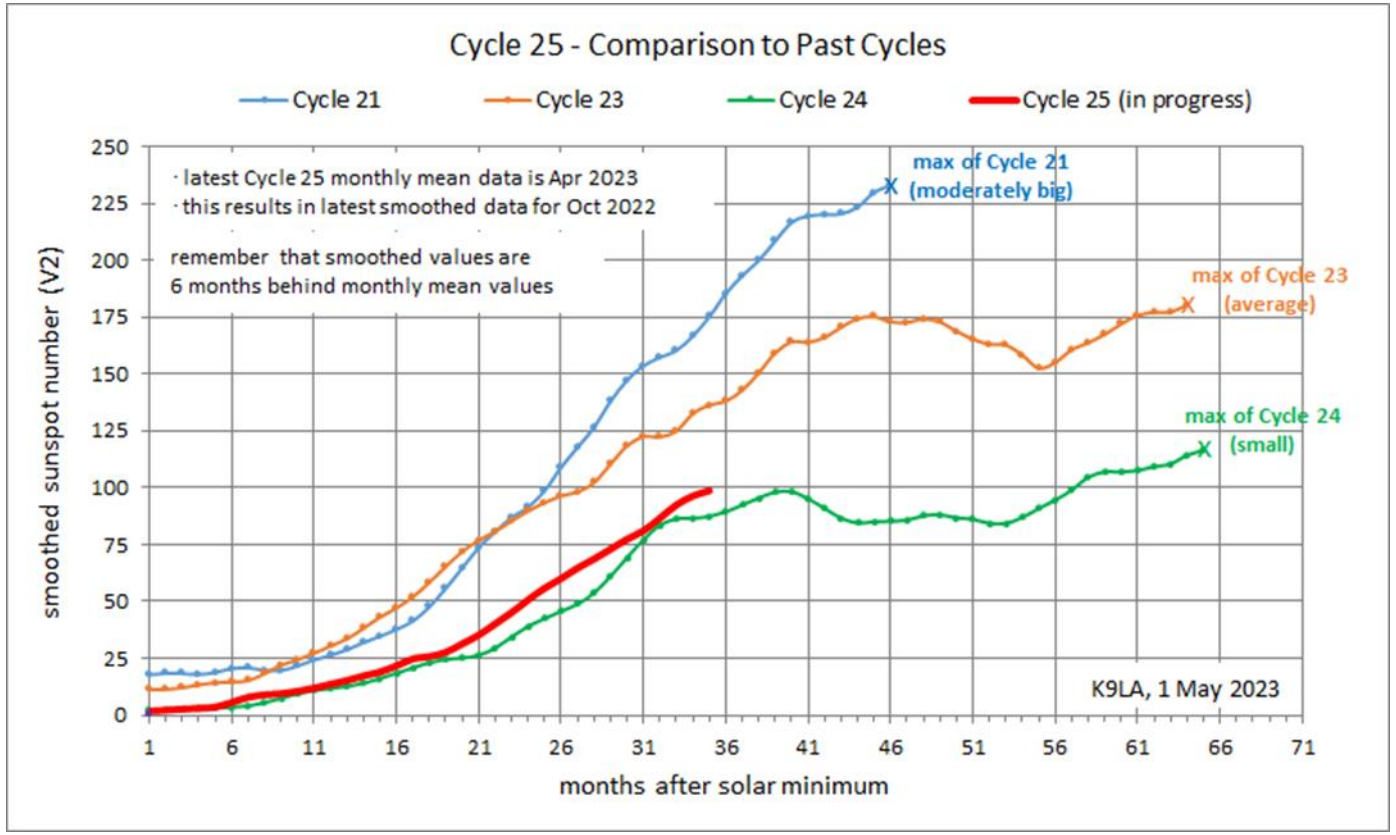
My May 2023 Presentation to Your Club

Agenda (May 2023)

- Our Atmosphere
- The Sun
- The Ionosphere
- HF Propagation
- Solar Cycles
- Space Weather
- Cycle 25

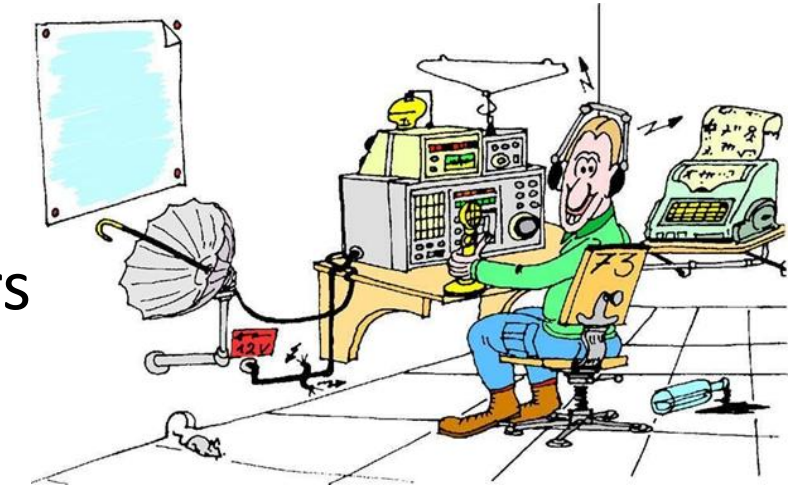


35 months of data since solar minimum in Dec 2019

What We'll Cover Tonight

Mostly from the Boulder ARC Presentation in August 2024

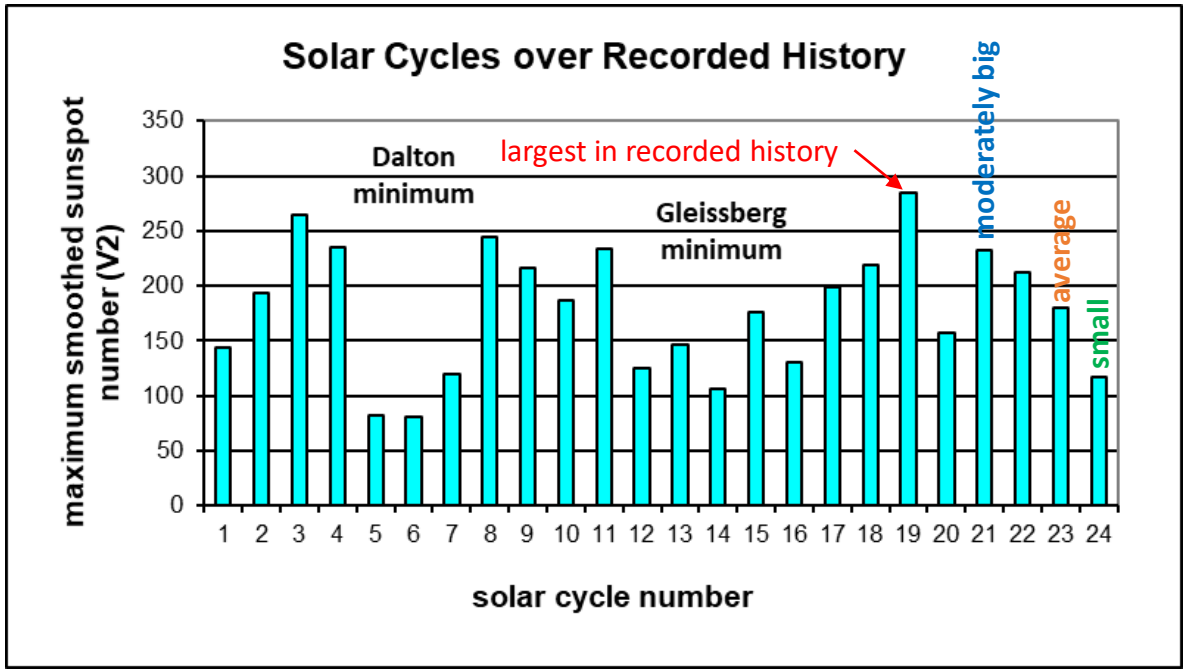
- Cycle 25
- General knowledge
- An interesting early May 2024
- Guidelines for the next several years
- Summary



Cycle 25

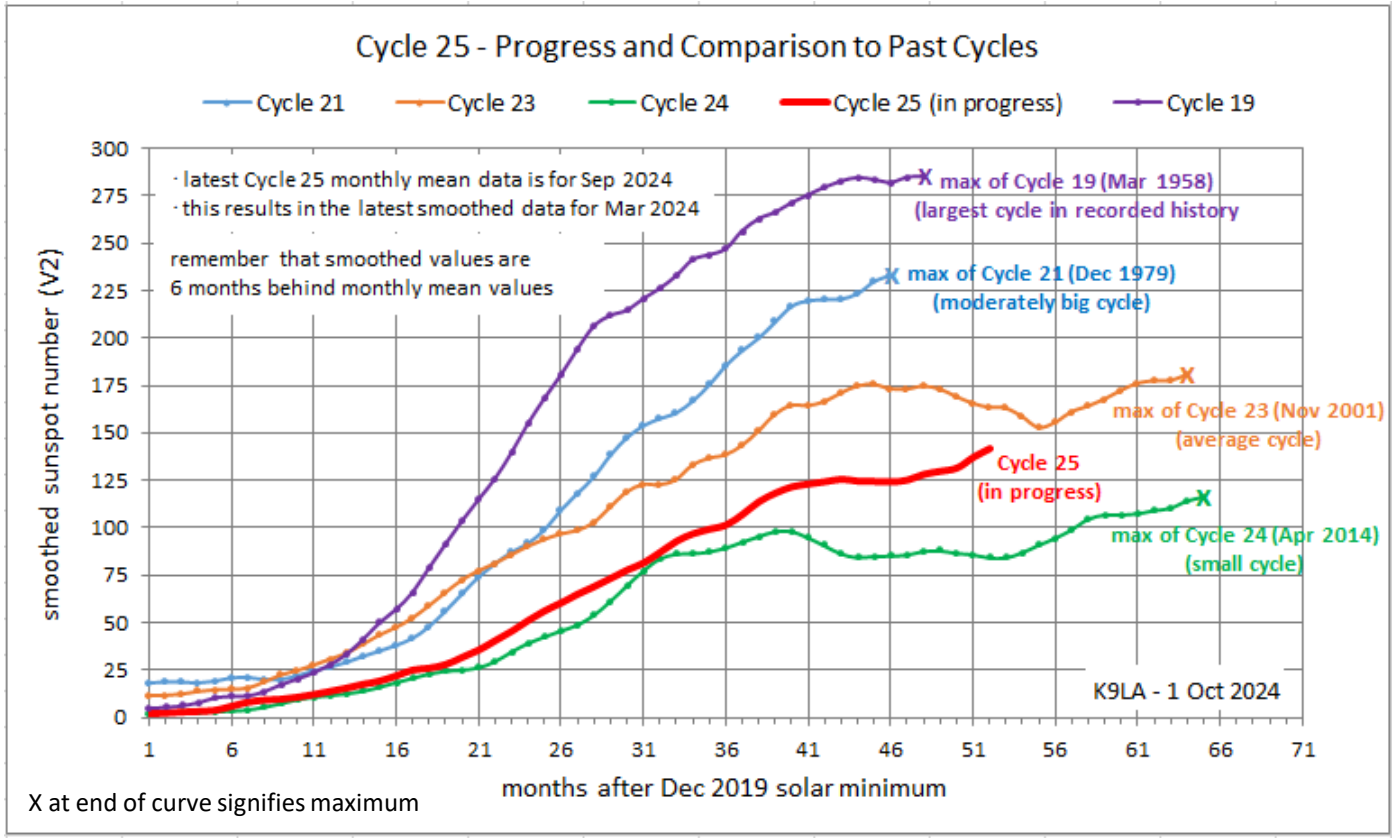
All Previous 24 Solar Cycles

- Cycle 1 began in 1755
  - Maunder Minimum (few sunspots) occurred from 1645-1715
- We've gone through 3 periods of big solar cycles
- We've gone through 2 periods of small solar cycles
- Cycle 24 appears to have ushered us into a third period of small solar cycles



Will Cycle 25 keep us in a third period of small solar cycles?

The Latest Cycle 25 Data

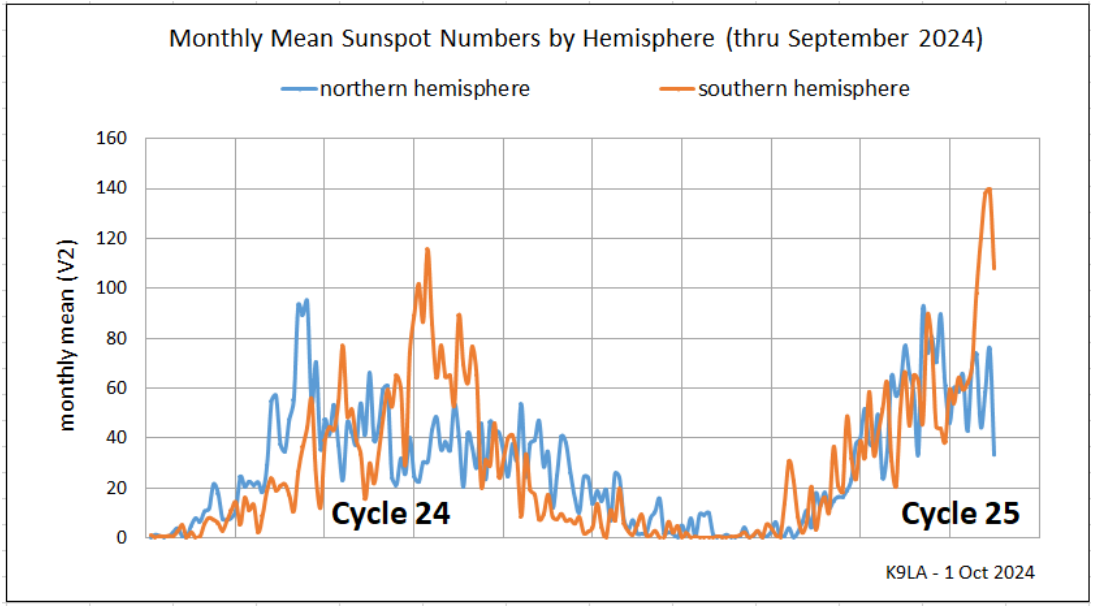


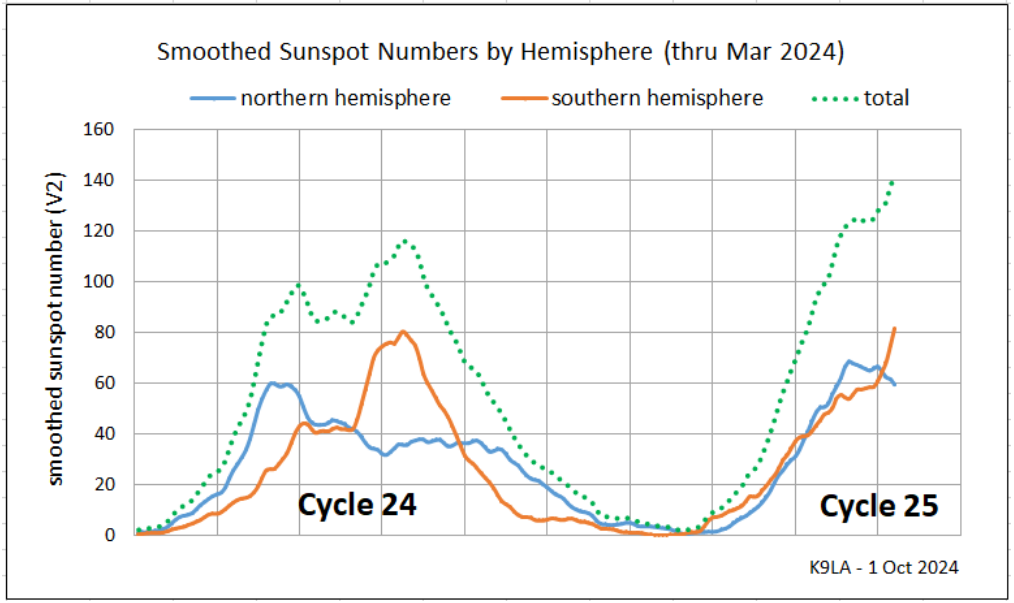
Bigger cycles rise faster

Bigger cycles generally start higher

- 52 months of data since solar min in Dec 2019
- Cycle 25 has surpassed Cycle 24
- Will it make it up to an average cycle like Cycle 23?
  - We shall see

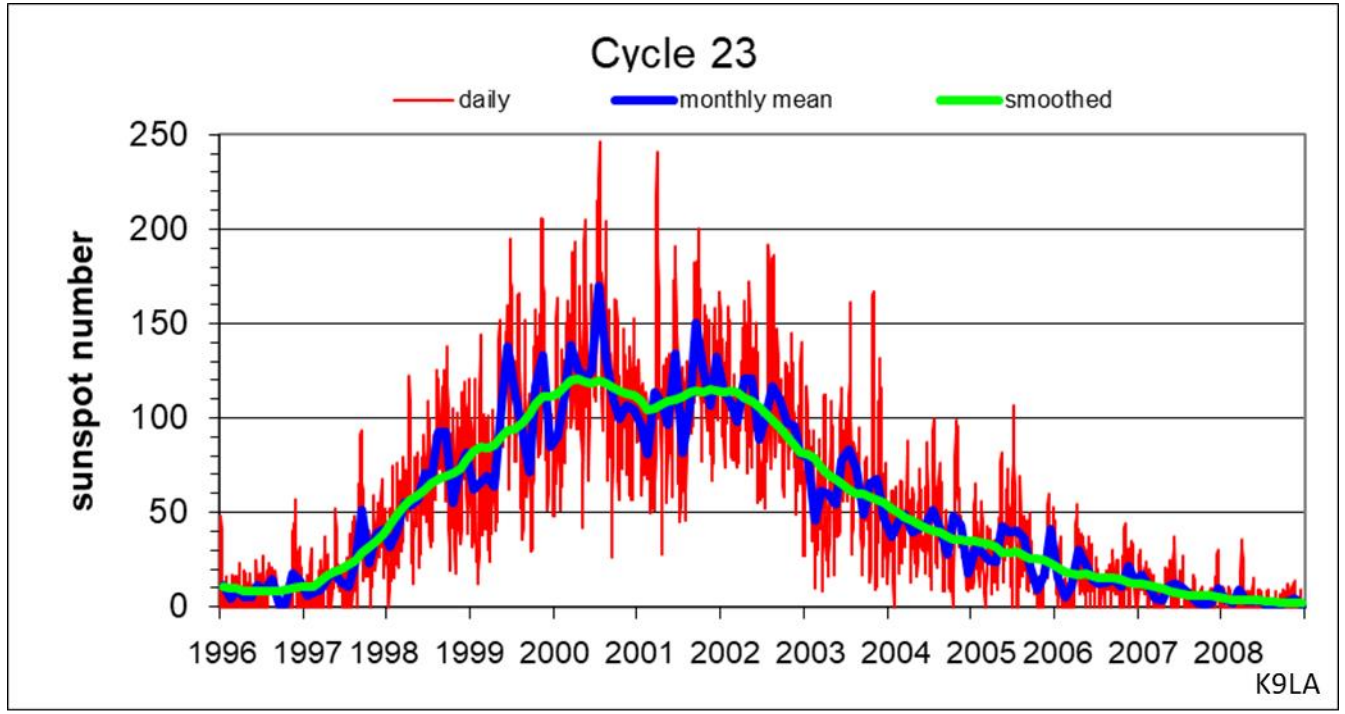
Cycle 25 – One Peak or Two Peaks?





- Cycle 24 (and Cycles 22 and 23) had two peaks
- My earlier guess has been that Cycle 25 would only see one peak due to the two solar hemispheres working together
- Right now the southern solar hemisphere is more active
- We may see two peaks

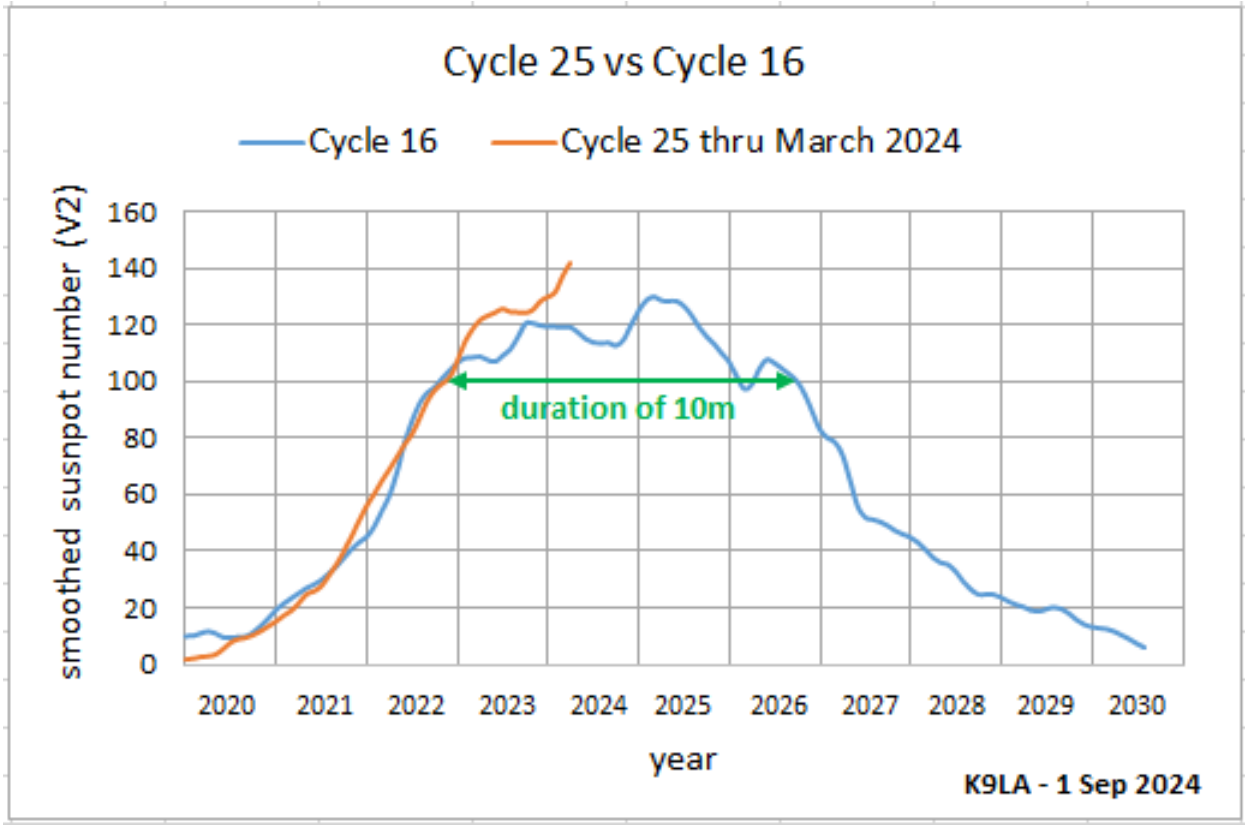
What Is a Smoothed Sunspot Number?



- Daily sunspot number (red) very spiky
- Monthly mean sunspot number (blue) still spiky
- Smoothed sunspot number (green) takes out the spikes
- Similar results for 10.7 cm solar flux

- **Smoothed sunspot numbers are used for two reasons**
  - **Best way to see what a solar cycle is doing – it's the official measure of a solar cycle**
  - **Best correlation between sunspots and what the ionosphere is doing**

The Coming Years

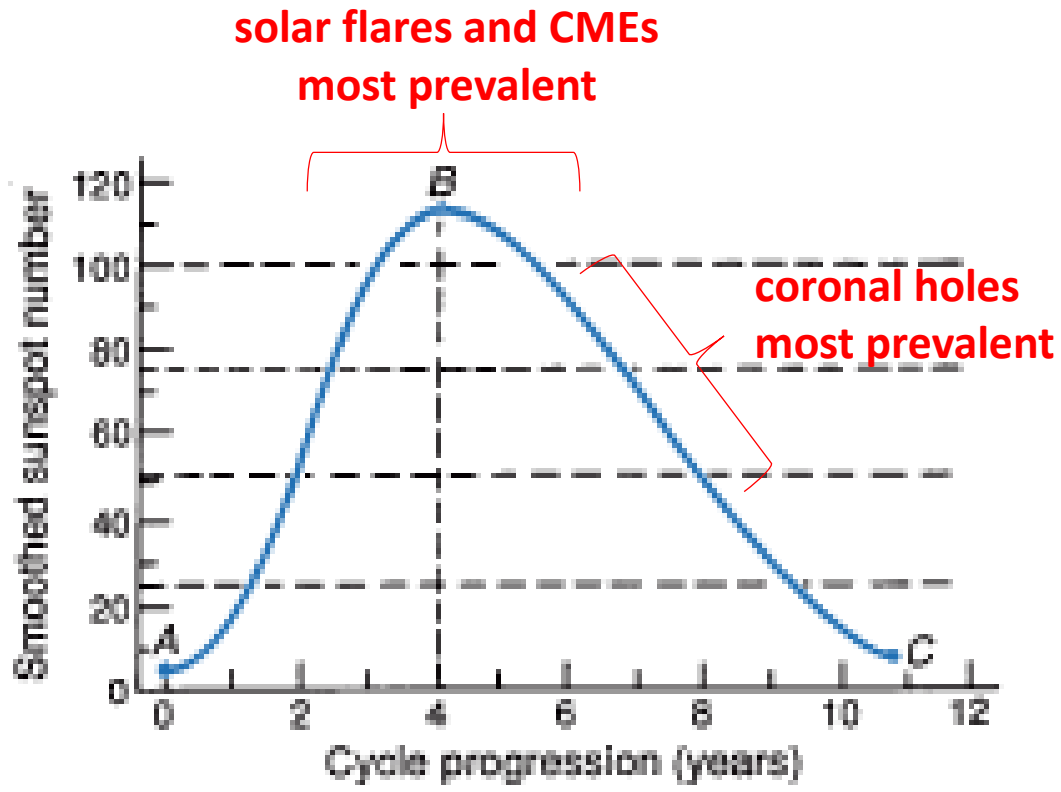


- Cycle 25 is similar to Cycle 16
- 10m needs a smoothed sunspot number of 100 (smoothed solar flux of 120) for consistent day-to-day worldwide propagation
- We're well past that
- Should be good until 2027

Interesting question - did Cycle 16 have four peaks?

General Knowledge

A Typical Solar Cycle

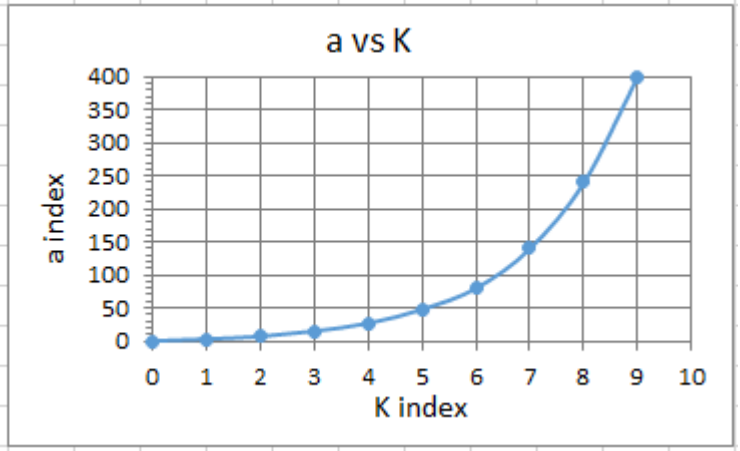


- Average length (A to B to C) is 11 years
  - Schwabe cycle
- Average rise (A to B) is 4 years
- Average decline (B to C) is 7 years
- Other cycles
  - Hale cycle ~ 22 years
  - Gleissberg cycle ~ 88-90 years
  - De Vries cycle ~ 205 years
  - Halstatt cycle ~ 2300 years

K and A Indices

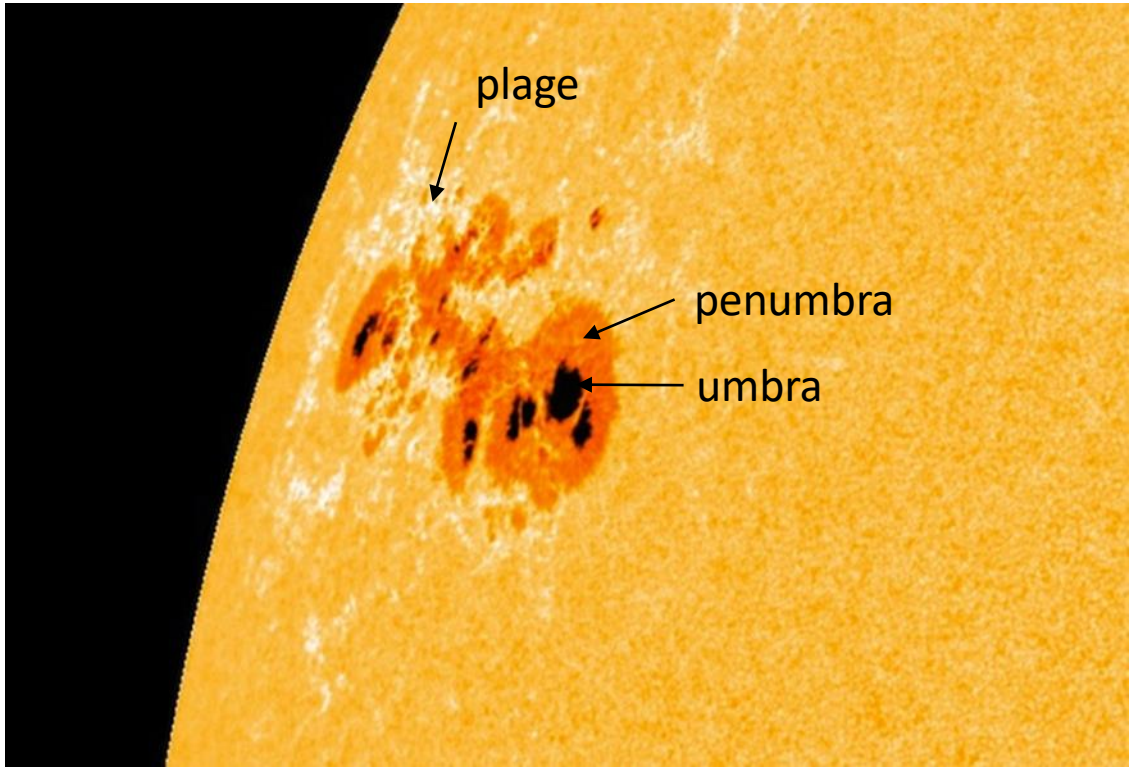
- The K index is a logarithmic 3-hour index – it is reported every 3 hours
  - It is the maximum deviation of the Earth's magnetic field in the eight 3-hour periods – 00-03z, 03-06z, 06-09z, 09-12z, 12-15z, 15-18z, 18-21z, 21-00z
  - K goes from 0 (quiet magnetic field) to 9 (extremely disturbed magnetic field)
- The A index is a linear daily index – it's the average of the eight K indices
  - A goes from 0 (quiet magnetic field) to 400 (extremely disturbed magnetic field)

K	a
0	0
1	3
2	7
3	15
4	27
5	48
6	80
7	140
8	240
9	400



- When the K and A indices are high, ionization in the F_2 region can be significantly reduced
- When the K index is $\leq$ 3 (A index $\leq$ 15), the F_2 region is considered to be undisturbed and all is well

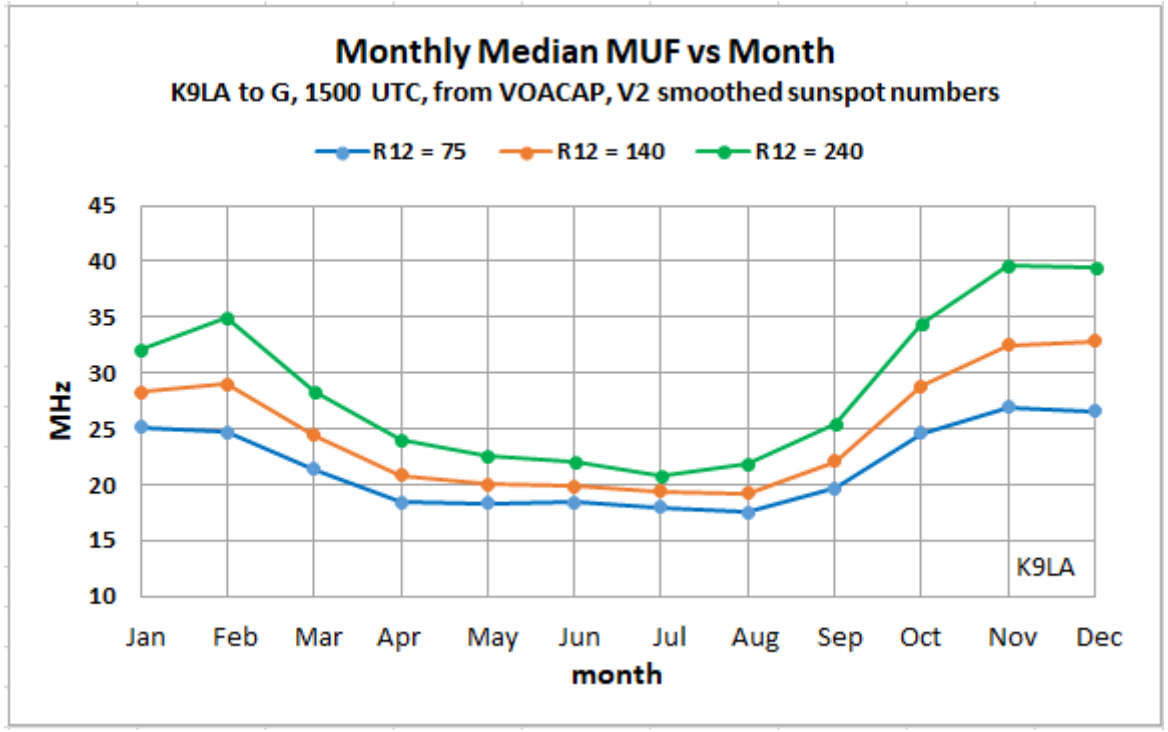
Why Are Sunspots Important?



The white area around a sunspot is called a plage (French for 'beach')

- Plage areas emit EUV (extreme ultra-violet) radiation
- EUV radiation ionizes the atmosphere at F_2 region altitudes
  - Sunspots themselves do not ionize anything - nor does 10.7 cm solar flux
- F_2 region is responsible for most of our long distance QSOs
  - And most QSOs at night

MUF vs Month – Northern Hemisphere

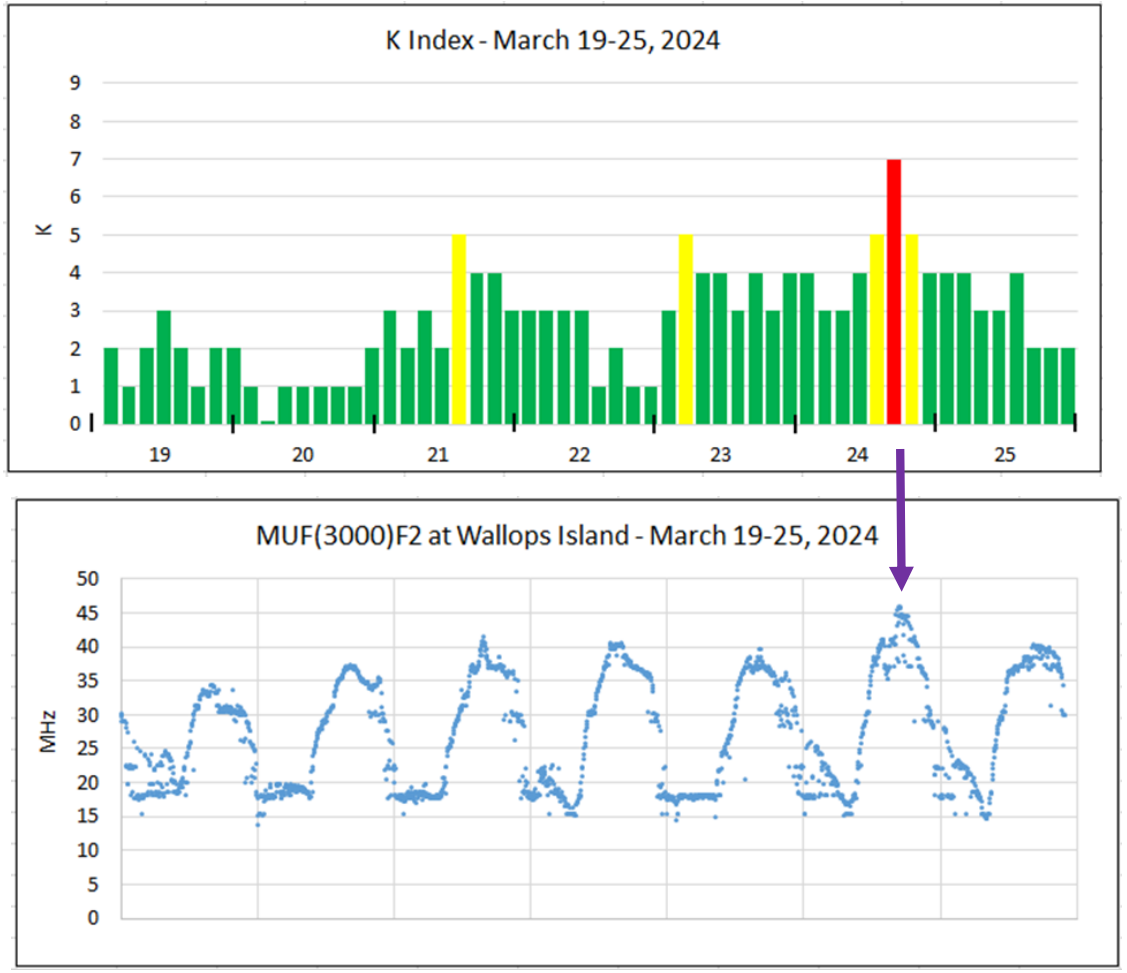


Sporadic-E helps in the summer – if it occurs!

- Lowest daytime MUFs are in the summer
  - IARU, Field Day, lots of state QSO parties
- Highest daytime MUFs are in the fall/winter
  - Major DX contests
- This is due to a change in the composition of the atmosphere throughout the year

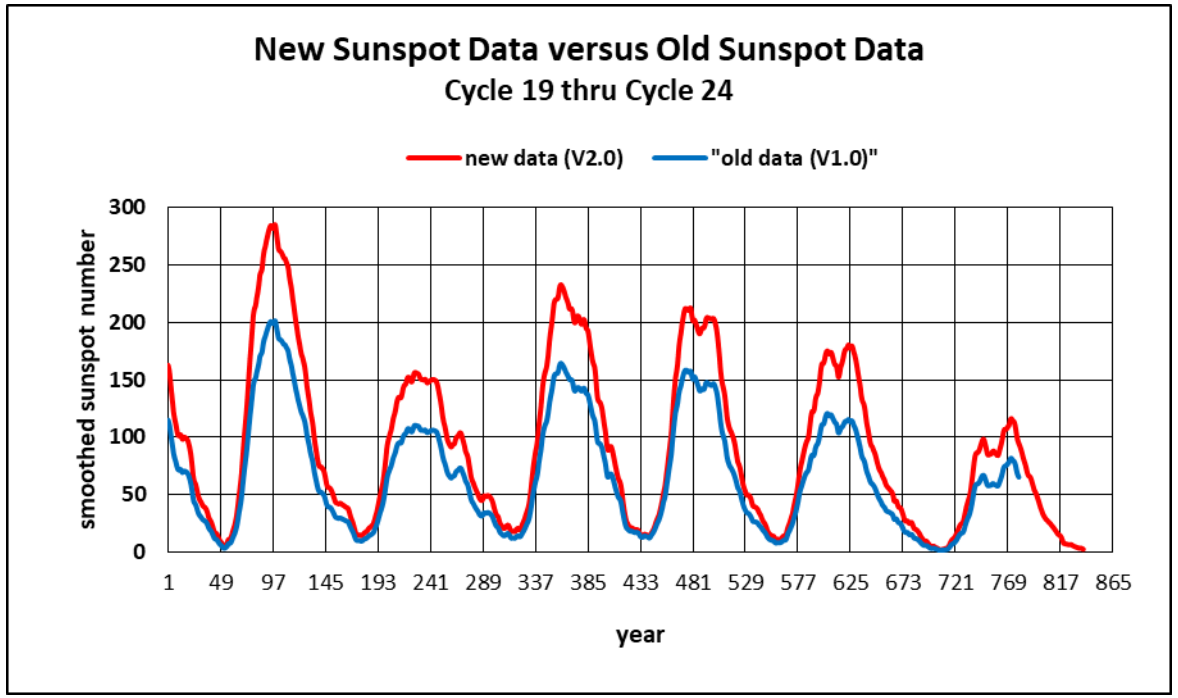
Short-Term Enhancements

- Check the higher HF bands and 6m when there is a moderate spike in the K index
- We had one of these on Sunday March 24, 2024
- Note what happened to the MUF on March 24
- Fall months are good to keep an eye on, too



V1 and V2 Sunspot Record

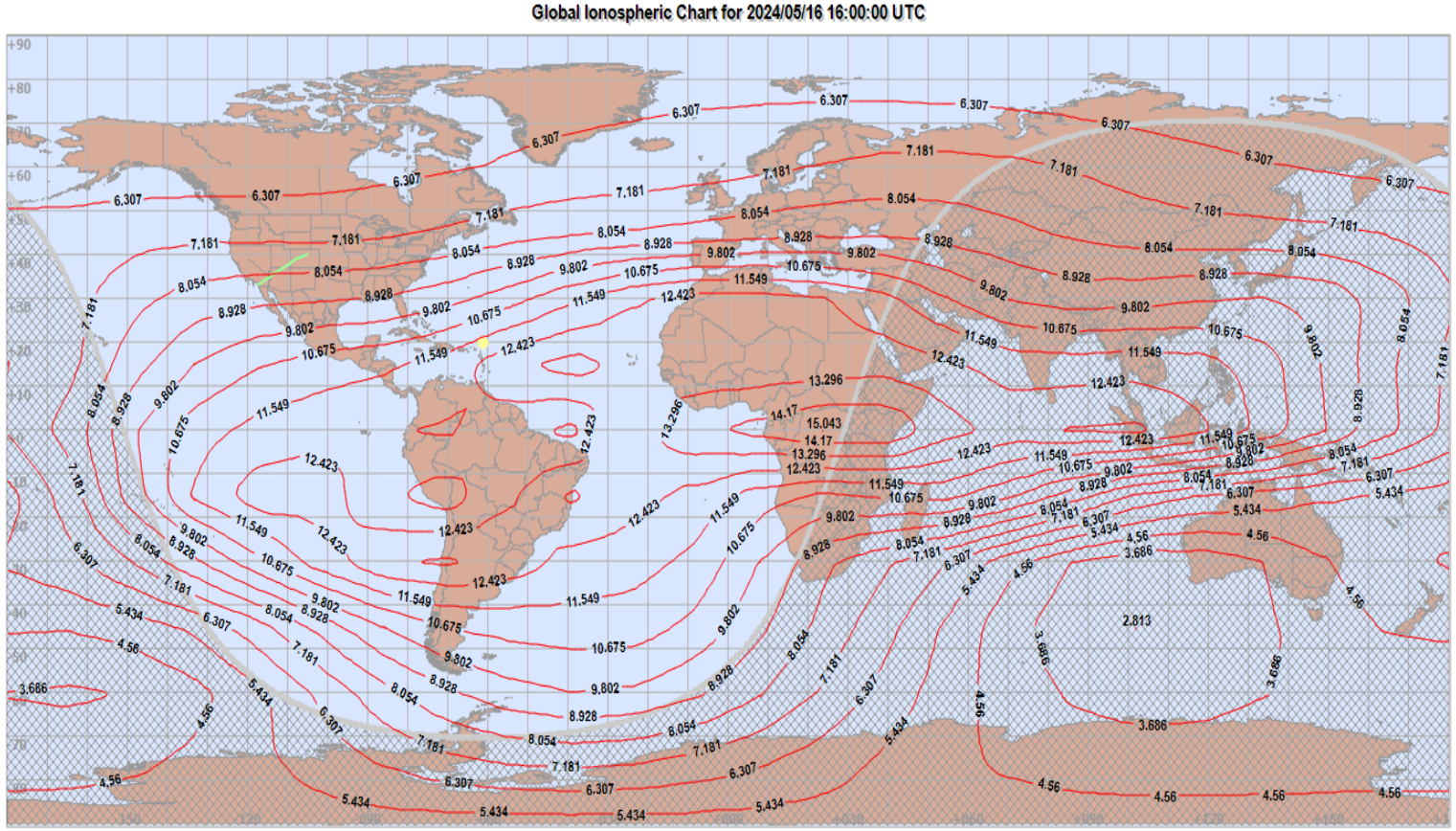
- In the mid 1990s, concern arose about the accuracy of the sunspot record
- Four Workshops were held to review the old data (2011, 2012, 2013, 2014)
- The end result of these Workshops generated a new sunspot record that is considered to be more accurate than the old one
- V1 is old version, V2 is new version
- Biggest issue was when Adolph Wolfer took over from Rudolph Wolf in 1876
- Wolfer had to multiply his count by 0.6 to agree with Wolf



- After much analysis, the 0.6 factor was backed out, and that makes the V2 values higher than the V1 values
- V2 record also goes back to 1755
- Note – our propagation predictions are based on the V1 sunspot numbers

Worldwide Ionosphere

- Equatorial region is the most robust area of the ionosphere – highest MUFs
- Farther north or south results in lower MUFs
- This results in an advantage for hams in the southern states



- Red lines are values of critical frequency of the F_2 region (related to the amount of ionization)
- Highest values are in the equatorial region

The Advantage of the Digital Modes

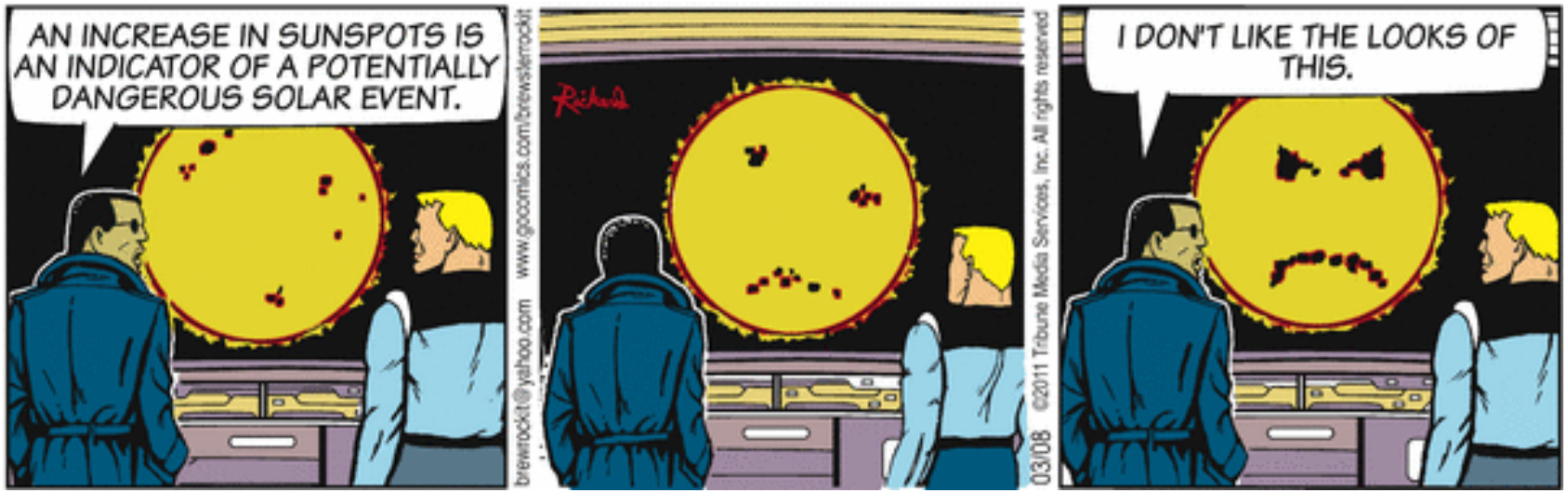
Weak-Signal S/N Limits

fastest data transfer at the top, slowest at the bottom

Mode	(B = 2500 Hz)
SSB	~+10 dB
MSK144	- 8
CW, “ear-and-brain”	-15
FT8	-21
JT4	-23
JT65	-25
JT9	-27
QRA64	-27
WSPR	-31

- Data suggests that the digital modes can detect signals well below the noise
- Note that the reference bandwidth is 2500 Hz
- The digital modes use narrow filters (commensurate with the bandwidth of the specific mode) to decode the signal
- Narrower bandwidth = less noise = can detect weaker signals

An Interesting Early May 2024



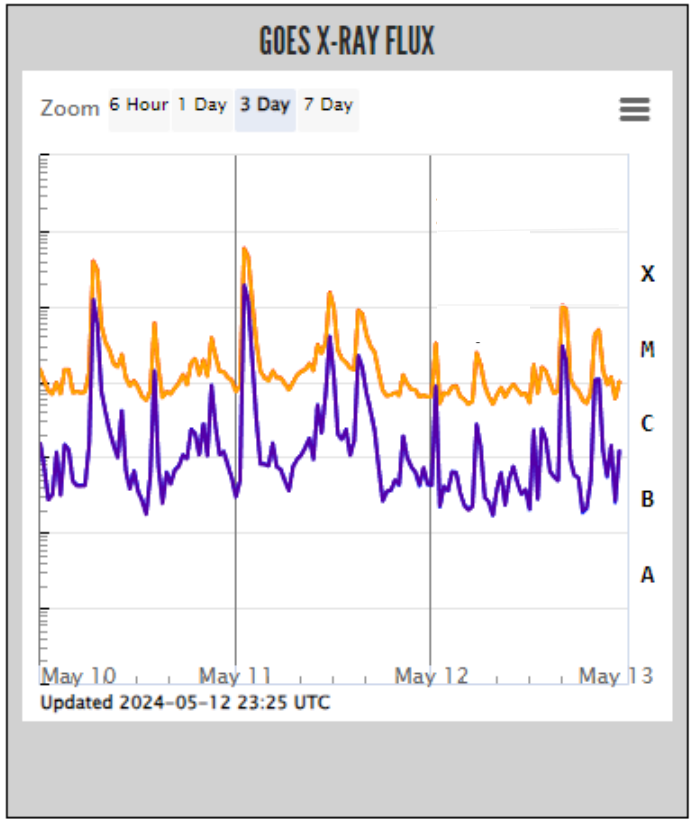
Early May 2024

- We had some interesting (not necessarily good) propagation in early May (10^{th}, 11^{th}, 12^{th})
- Started with two big sunspots
  - AR3663 (northern solar hemisphere)
  - AR3664 (southern solar hemisphere)

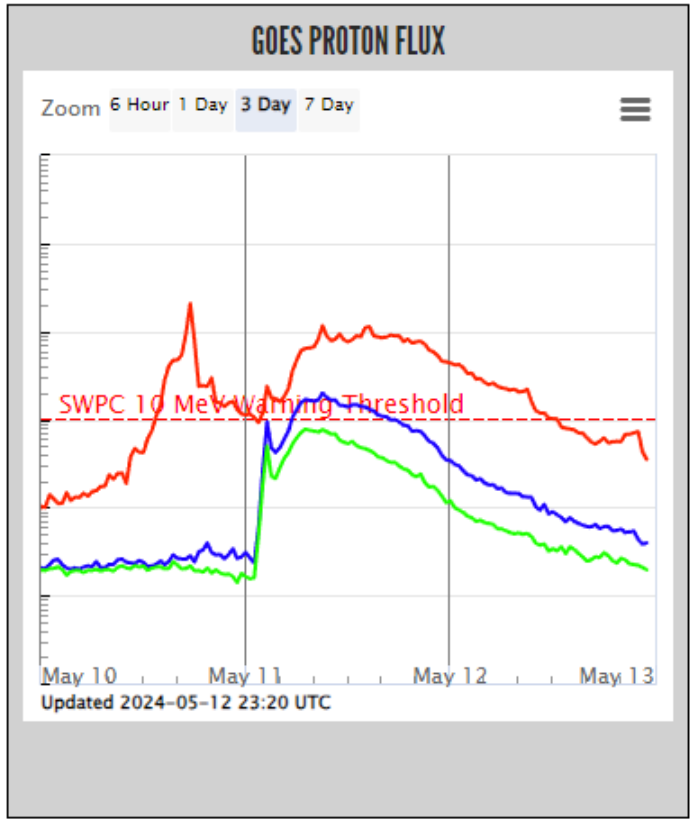
AR is Active Region

- Many solar flares from both regions
- Several CMEs (Coronal Mass Ejections) from AR3664
- Resulted in all <u>three</u> categories of disturbances to propagation
  - **Radio blackout** due to big solar flare – signals go away (the least impact of the 3)
  - **Solar radiation storm** due to big solar flare/CME – affects paths across the polar caps
  - **Geomagnetic storm** due to CME – degrades the F_2 region (the worst of the 3)

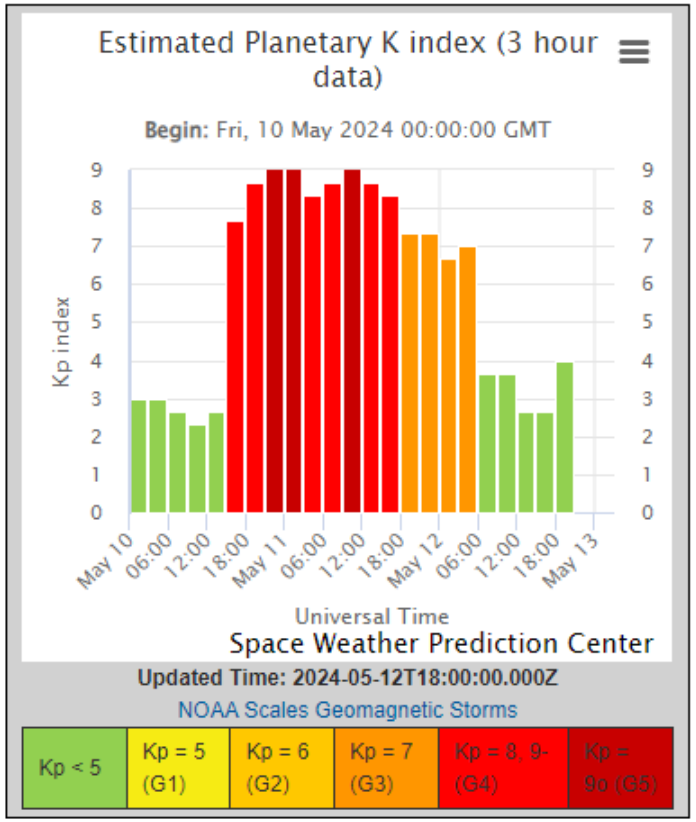
The Data at https://www.swpc.noaa.gov/



x-ray radiation from solar flares – can cause a radio blackout – short duration



Protons in the solar atmosphere can be accelerated by solar flares/CMEs – can cause a solar radiation storm – can last a day or two



elevated K indices from CMEs – can cause a geomagnetic storm – can last several days

Guidelines for the Next Several Years

What Allows a Successful QSO?

- Depends on D region absorption and F_2 region ionization

- 160m, 80m – <u>D region absorption is critical</u>
  - Amount of F_2 region ionization is usually high enough
  - These bands are best around solar <u>minimum</u>
  - Good at night for DX contacts – summer thunderstorms don't help ☹
  - Keep an eye on sunrise and sunset – in my experience, sunrise on the east end of a path is better than sunset on the west end of a path
  - General consensus seems to be that 160m isn't as good as it used to be
    - Something is going on that we don't understand

What Allows a Successful QSO – con't

- 15m, 12m, 10m, 6m – amount of ionization is critical
  - D region absorption is minimal
  - These band are best around solar maximum
  - Great worldwide propagation during the fall/winter months
  - Lower daytime MUFs during the summer months – sporadic-E can help mitigate this ☺
- 40m, 30m, 20m, 17m - transition bands
  - These bands are transitioning from D region absorption being critical to the amount of F_2 region ionization being critical
  - Generally good over a solar cycle
  - 40m, 30m - nighttime
  - 20m, 17m - daytime

Summary

- Will Cycle 25 get up to an average cycle?
  - IMHO, no - I think Cycle 25 will be a small-ish cycle
  - If we're in this third period of small cycles, Cycle 26 could be small
- We have to take the good (lots of sunspots to open 15m/12m/10m) with the bad (solar flares and CMEs that screw up the F_2 region)
- The digital modes offer an advantage over CW and SSB
- Take advantage of the summer E_s season on 10m and 6m
  - If it occurs !
- There are tools on the internet to determine what the bands are doing right now
  - dxmaps.com, PSKreporter, WSPRnet, RBN, etc

Solar and Propagation References

- Propagation chapters of the ARRL Handbook and ARRL Antenna Book
- Here to There: Radio Wave Propagation
  - https://home.arrl.org/action/Shop/Store
- The Little Pistol's Guide to HF Propagation – Bob NM7M (SK)
  - https://k9la.us/NM7M_The_Little_Pistol_s_Guide_to_HF_Propagation.pdf
- The CQ Shortwave Propagation Handbook – 4th Edition
  - Not available since CQ closed its doors
- Radio Propagation Explained – GØKYA
  - https://www.amazon.com/Radio-Propagation-Explained-Steve-Nichols/dp/1910193283
- Ham SCI – https://hamsci.org/ and https://hamsci.org/seqp-faqs
- K9LA web site – https://k9la.us/