

# *The Sun, the Ionosphere, Space Weather and Cycle 25*

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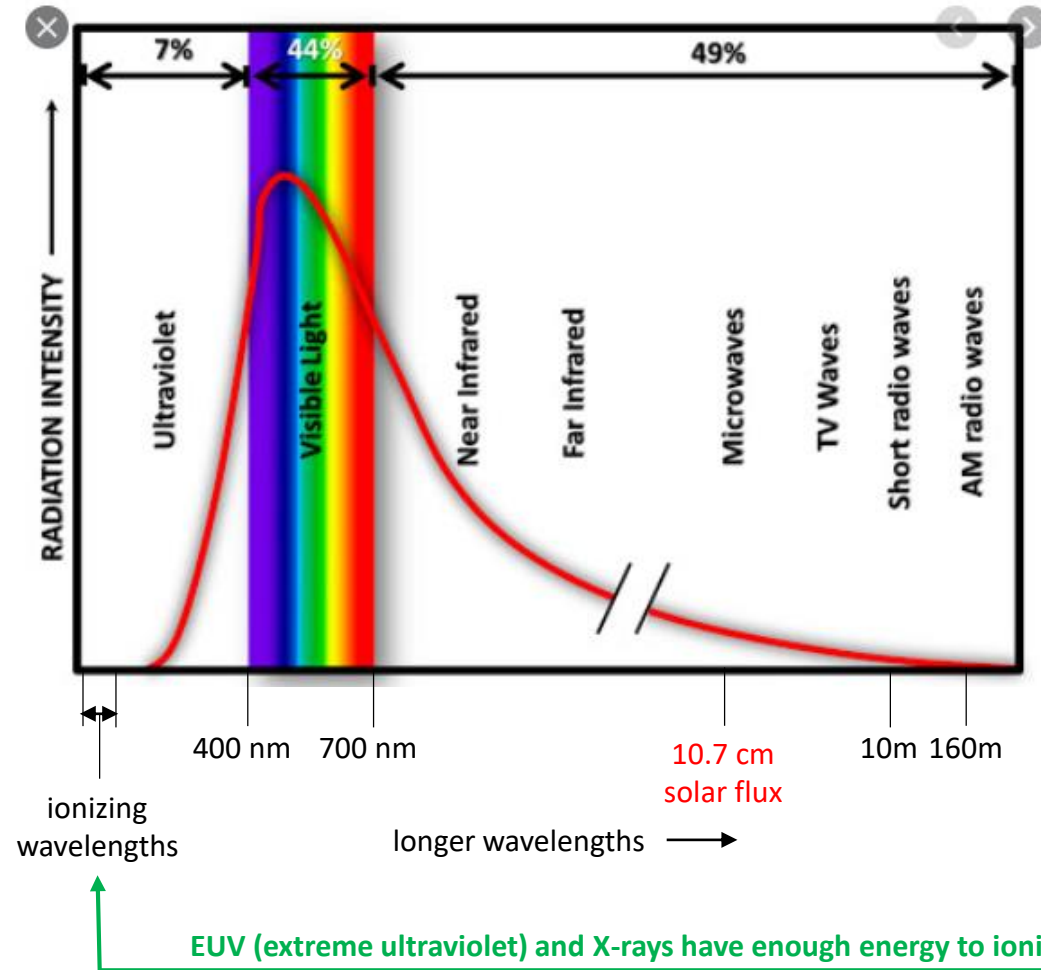
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# Agenda

- The sun and the ionosphere
- Solar cycles
- Space weather
- Cycle 25

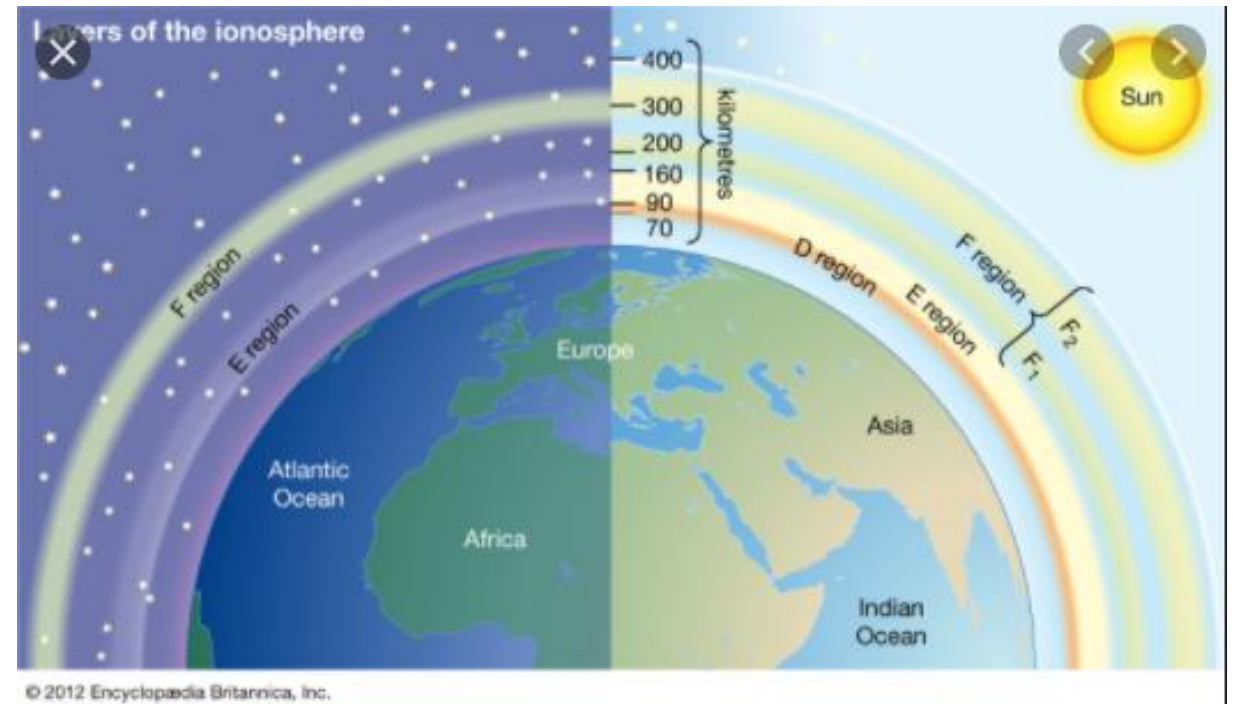
# Solar Radiation



- The sun emits electromagnetic radiation at many wavelengths
- Most intense radiation is at visible light wavelengths (400-700 nm)
- Energy of a photon is inversely proportional to its wavelength
  - Shortest wavelengths are highest in energy
- The important range of radiation for our Amateur Radio HF endeavors is very short wavelengths (ionizing wavelengths)

# Regions (Layers) of the Ionosphere

- Ionizing radiation creates regions of ionization in the atmosphere
  - Dependent on wavelength of radiation and number of neutral atmospheric constituents vs altitude
- EUV (extreme ultraviolet) between 10-100 nm results in the F<sub>2</sub> region
  - EUV is the true ionizing radiation of the F<sub>2</sub> region
- X-rays between 1-10 nm result in the E region
- Shorter X-rays between 0.1-1 nm and the Lyman- $\alpha$  spectral line of hydrogen result in the D region



Free electrons (electrons stripped from a neutral atmospheric constituent in the ionization process) are what is important for skywave propagation

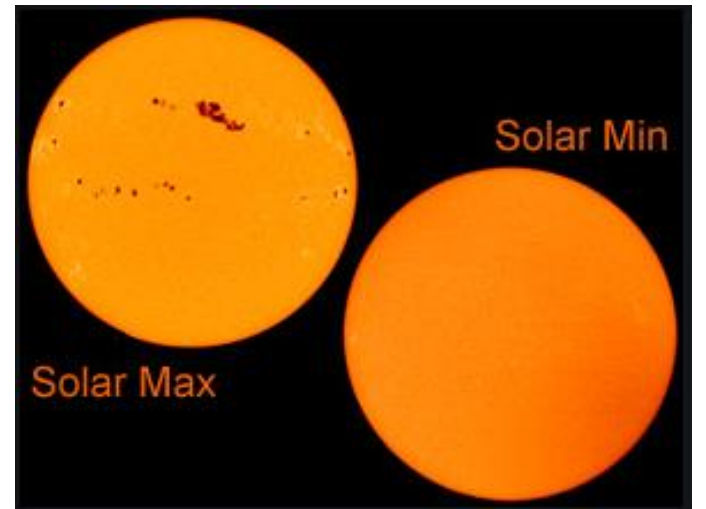
# General Characteristics of the Regions

- F region (roughly 150-400 km)
  - Highest in altitude – gives the longest hops
  - Highest electron densities – best for the higher bands (15m, 12m, 10m)
  - F<sub>2</sub> region is the most important for our long distance QSOs
- E region (roughly 90-150 km)
  - Shorter hops due to lower altitude
  - Can block signals from getting to the F region
- D region (roughly 60-90 km)
  - A detriment to propagation due to absorption (loss)

# *Solar Cycles*

*determines which bands are open*

many sunspots

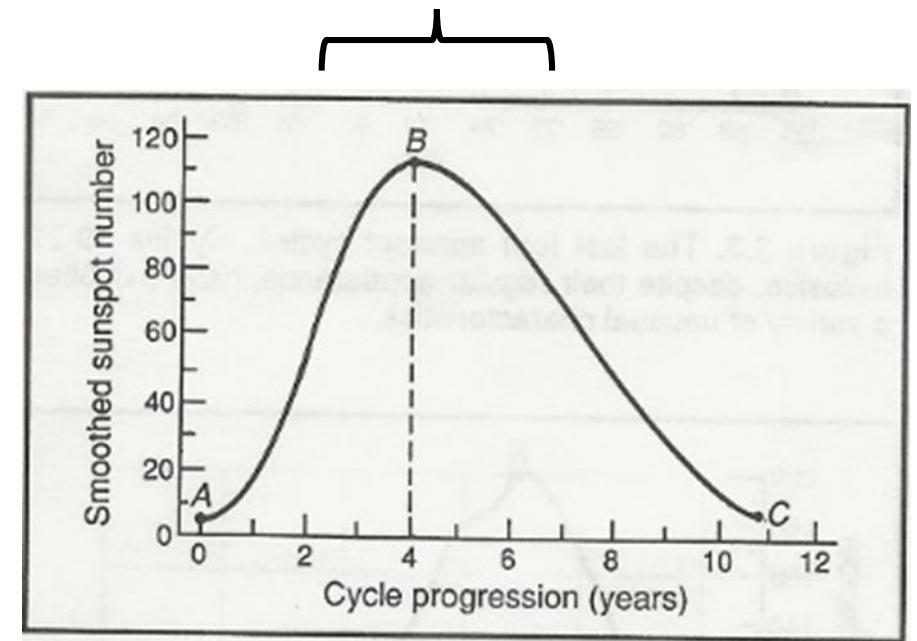


few or no sunspots

# Why Solar Cycles Are Important – High Bands

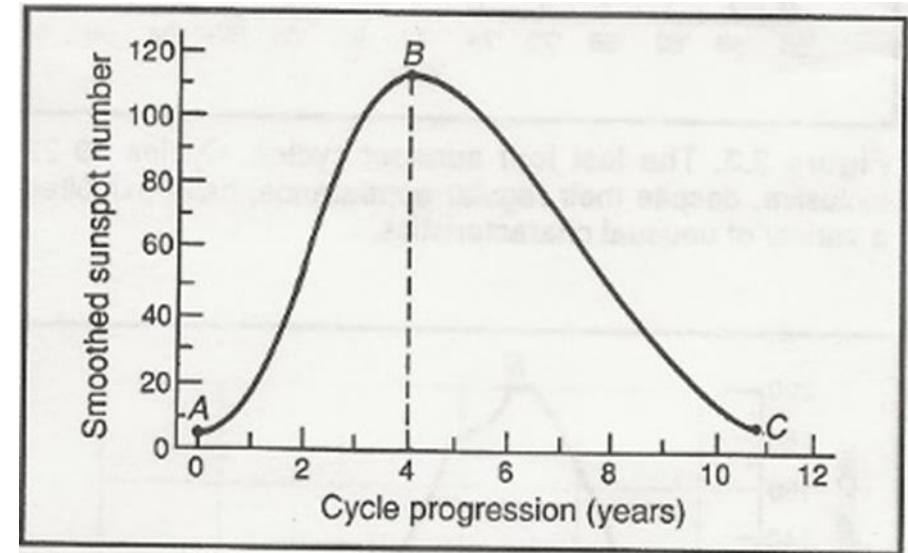
- They are important for 15m, 12m, 10m (and 6m)
  - The area around a sunspot emits EUV radiation to ionize the F<sub>2</sub> region
    - Remember that sunspots and 10.7 cm radiation are proxies for EUV
  - More sunspots = more EUV = more ionization (especially during the day) = best propagation on the higher HF bands

best propagation on  
15m, 12m, 10m, 6m



# Why Solar Cycles Are Important – Low Bands

- They are important on 160m, 80m, 60m, 40m
  - Less sunspots = less ionospheric absorption (especially at night) and less disturbances to propagation = best propagation on the low bands



best propagation on 160m, 80m, 60m, 40m



# *Space Weather*

*making sense of all those parameters*



# A Caveat - What We're Trying to Do

- We're trying to come up with simple statements about HF propagation that are derived from very complicated atmospheric/ionospheric processes
- This kind of works a lot of the time
- We have trouble predicting short-term events
  - The day-to-day variability of the ionosphere
    - Variability of the ionosphere depends on three factors: solar radiation, geomagnetic field activity, events in the lower atmosphere coupling up to the ionosphere
    - Our propagation predictions are not daily predictions – they are monthly median (50% probability) predictions – statistical in nature over a month's time frame
  - Short-term enhancements

# Lots of Websites With Data

- NØNBH banner (his website is <http://www.hamqsl.com/solar.html>)
  - at <https://www.qrz.com/> and many other places
- Dr. Tony Phillips
  - at <https://spaceweather.com/>
- Space Weather Prediction Center (SWPC)
  - at <https://www.swpc.noaa.gov/>
- VE3EN
  - at <https://www.solarham.net/>
- WX6SWW videos by Dr. Tamitha Skov
  - at <https://www.spaceweatherwoman.com/>
- Other general websites and many others that are more specific

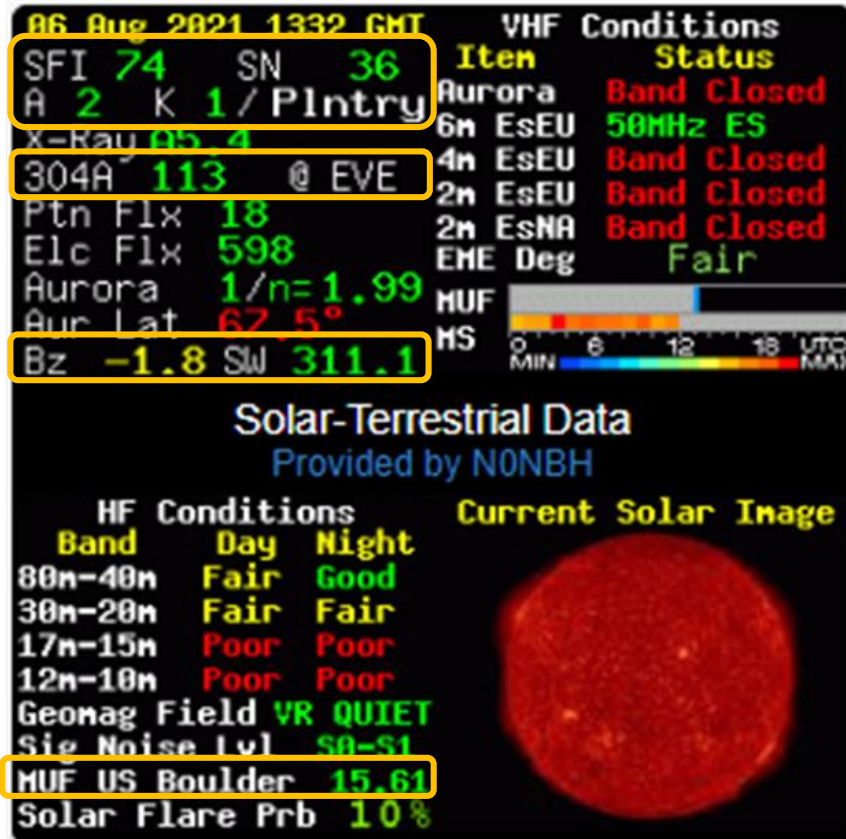
# What Parameters Are Important?

- These are the basic parameters that tell us if there's enough ionization to refract the signal back to Earth (they tell us if the MUF is high enough)
  - **SFI** – latest 10.7 cm solar flux index
  - **SN** – today's sunspot number
  - **304A** – EUV radiation at 304 Angstroms = 30.4 nm
  - **MUF US Boulder** – 3000 km MUF in MHz at Boulder – what the ionosphere is doing right now

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- These are the basic parameters that tell us if the Earth's magnetic field is disturbed (they tell us if the F<sub>2</sub> region might be screwed up)
  - **K** – 3-hour index
    - P<sub>lntry</sub> (K<sub>p</sub> and A<sub>p</sub>) is 'Planetary' and means it's from many stations, not a single station
  - **A** – average of the eight 3-hr K indices
  - **B<sub>z</sub>** – strength and direction of the IMF (Interplanetary Magnetic Field)
    - B<sub>z</sub> is perpendicular to the ecliptic – pretty much N-S
  - **SW** – solar wind speed

# All Those Parameters Are On the NØNBH Banner

Boulder 8:32 AM local



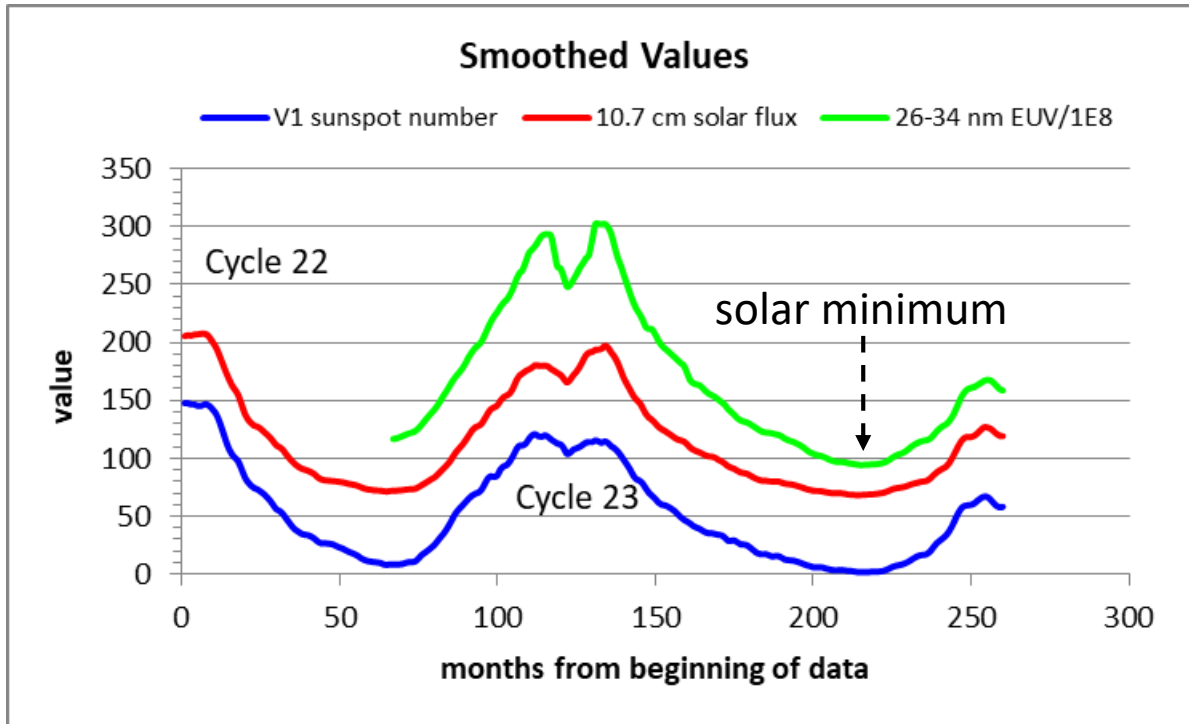
Range – solar min to big solar max

- SFI: 65 to 245
- SN: 0 to 286
- 304A: 90 to 400
- MUF US Boulder: daytime 20 MHz to 46 MHz

Range – quiet to disturbed (geomagnetic storm)

- K: 0 to 9
- A: 0 to 400
- B<sub>z</sub>: roughly +50 to -100
- SW: 300 to 2000

# SFI, SN, EUV



- SFI = 65, SN = 0, EUV = 90 is the baseline at solar min
- Values above those values can indicate when 15m, 12m, 10m and 6m are open

- Note that at solar minimum the 26-34 nm EUV is not zero
- It is around  $90E8$  photons per sq cm per second
- Electron production/loss calculations say that this is enough to keep 20m open at solar minimum during the day and early evening

# SFI, SN, EUV vs MUF

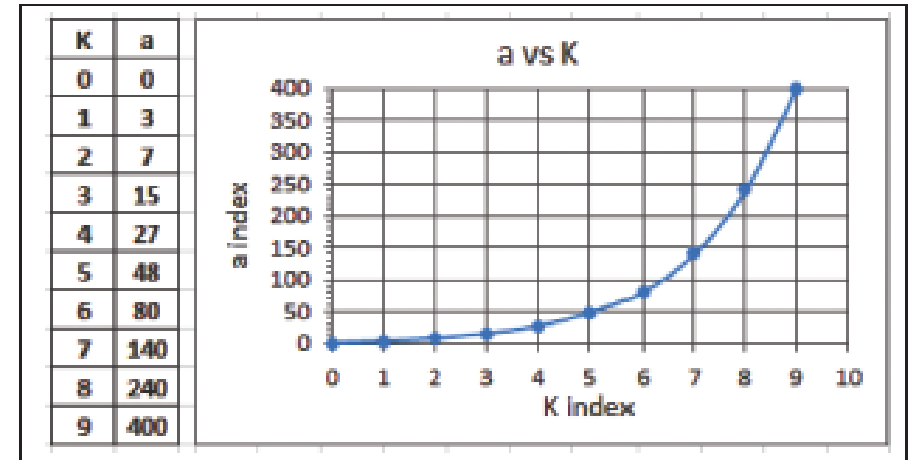
this chart indicates which bands may be open

	long-term EUV	long-term sunspot number (V2)	long term 10.7 cm solar flux	similar to . . .	monthly median (50% prob) MUF
<b>baseline</b>	90	0	65	solar minimum	20 MHz
	175	70	100	very small cycle (C6)	28 MHz
	215	115	130	small cycle (C24)	33 MHz
	285	179	170	average cycle (C23)	38 MHz
	325	215	195	moderate cycle (C22)	41 MHz
	400	286	245	big cycle (C19)	46 MHz

- Long-term means not for just a couple days – smoothed values are best
- Monthly median MUFs are for F<sub>2</sub> propagation in a fall/winter month in the afternoon on a mid-latitude path (there is a distribution about the median)

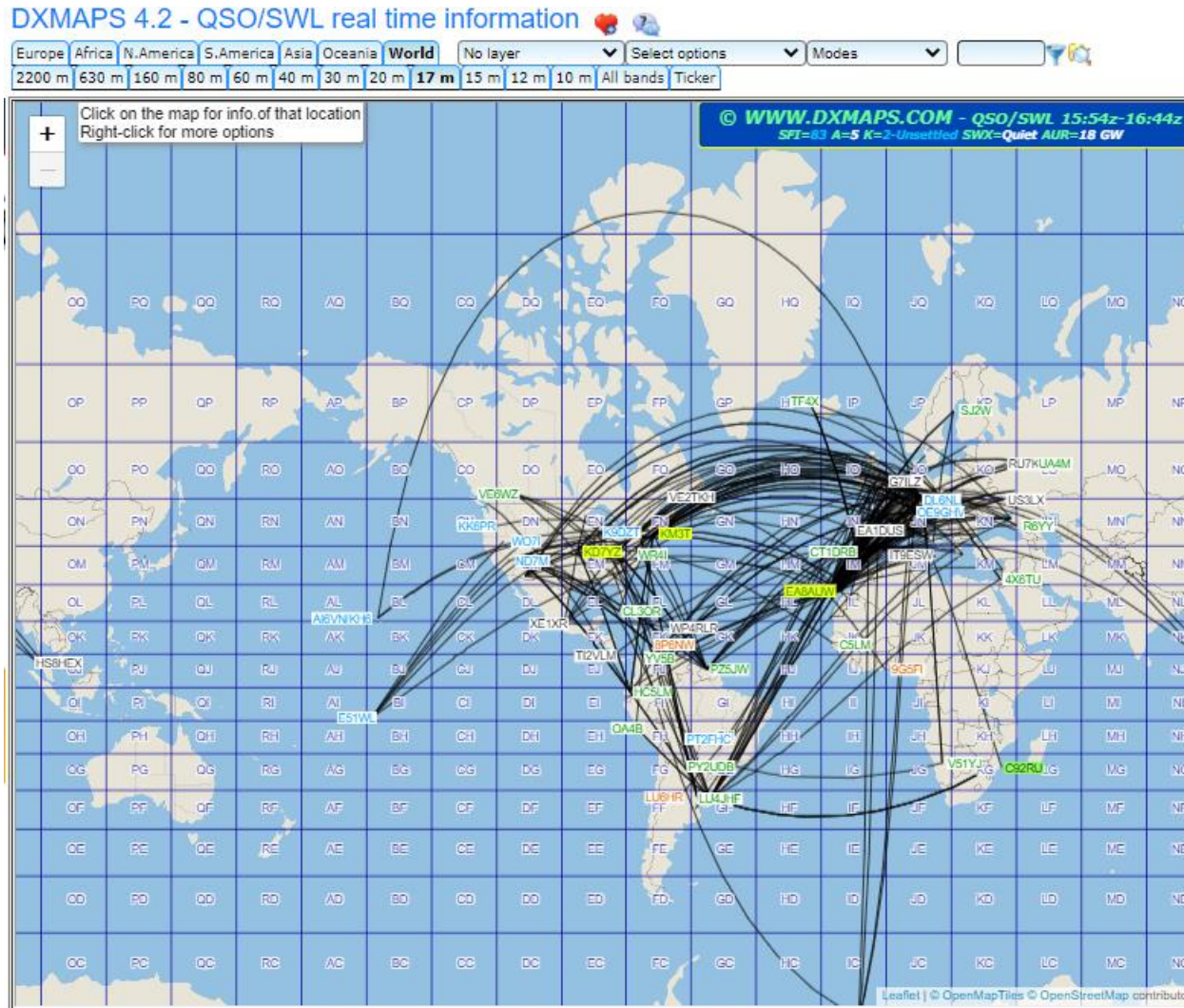
# K, A, B<sub>z</sub>, SW

- For an undisturbed F<sub>2</sub> region, we desire:
  - $K \leq 3$
  - $A \leq 15$
  - B<sub>z</sub> positive (a little negative is okay)
  - SW not too much greater than 400
- Although the SFI, SN, 304A parameters may indicate there's enough ionization, the above parameters may say the F<sub>2</sub> region is screwed up (the MUF is lower)





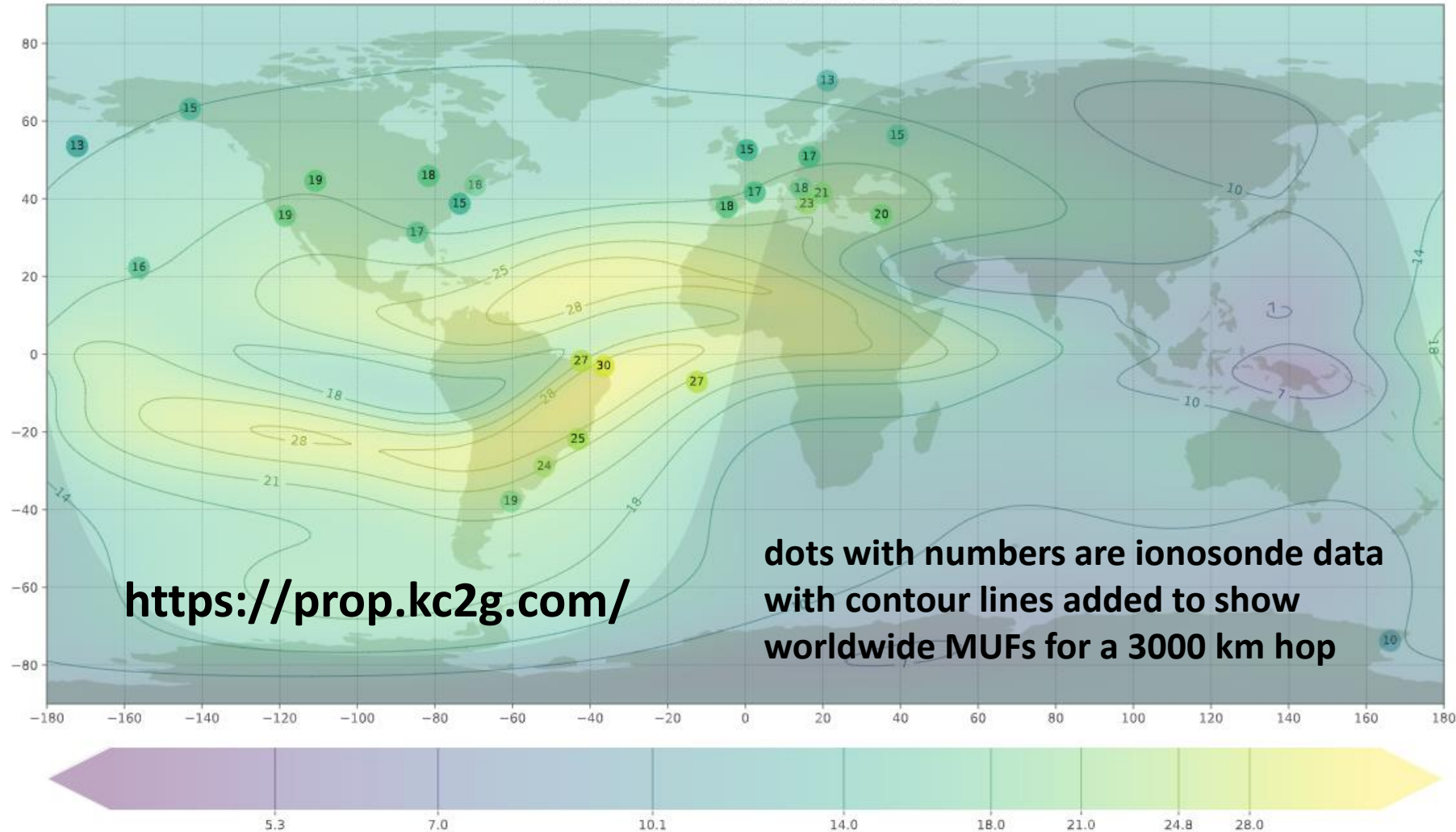
# Real-Time QSOs



- See who others are working
- Visit [dxmaps.com](http://dxmaps.com)
- Select view: World, NA, SA, etc
- Select band
- April 13, 2021 from 1554-1644 UTC on 17m
- Similar info
  - or PSKReporter
  - or WSPRnet
  - or Reverse Beacon Network
  - or IARU/NCDXF beacons

# Real-Time Ionosphere

mufd 2021-08-17 18:15 eSFI: 71.3, eSSN: 10.4



<https://prop.kc2g.com/>

**dots with numbers are ionosonde data  
with contour lines added to show  
worldwide MUFs for a 3000 km hop**

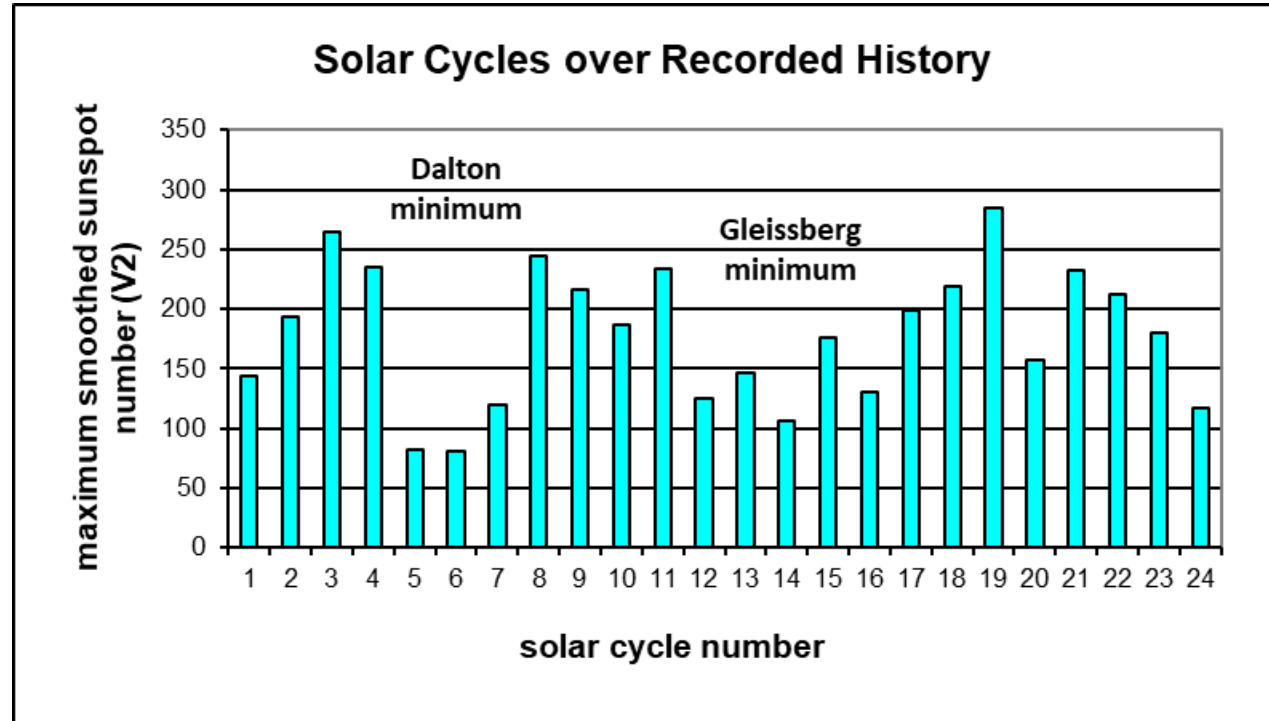
It would be nice to be able to add a great circle path from your QTH to a target QTH

# Cycle 25

*If you've only been licensed for several years, you may be asking "what's so great about 15m, 12m and 10m?" as most of the time there is only noise and not many signals on those bands*

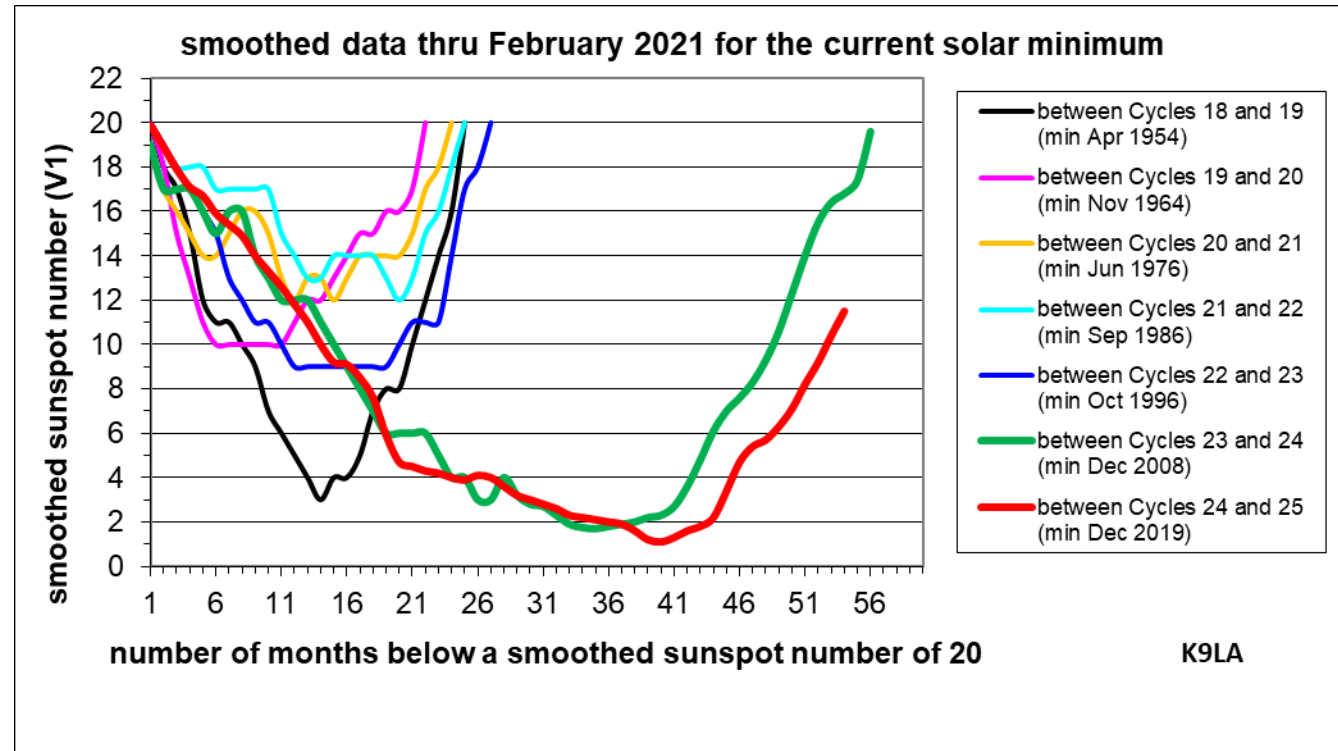
*All I can say is "wait a couple years and you'll be amazed what those bands can do around solar maximum with low power and modest antennas"*

# Previous 24 Solar Cycles



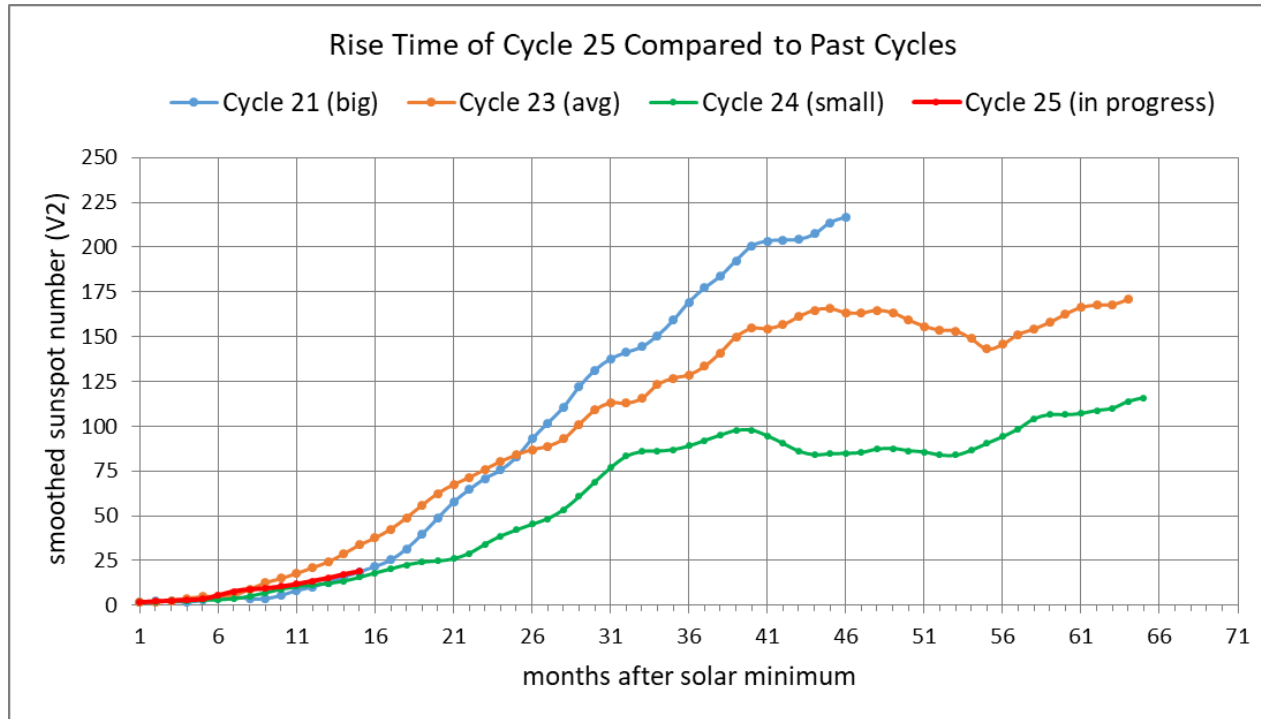
- We've been thru three periods of big cycles
- We've been thru two periods of small cycles
- We appear to be in a third period of small cycles
- Will Cycle 25 get us out of this third period of small cycles?

# Solar Minimums in Our Lifetimes



- Historical data suggests long minimum results in small next cycle
- Long minimum between Cycles 23-24 gave small Cycle 24
- Minimum between Cycles 24-25 is longer than previous minimum

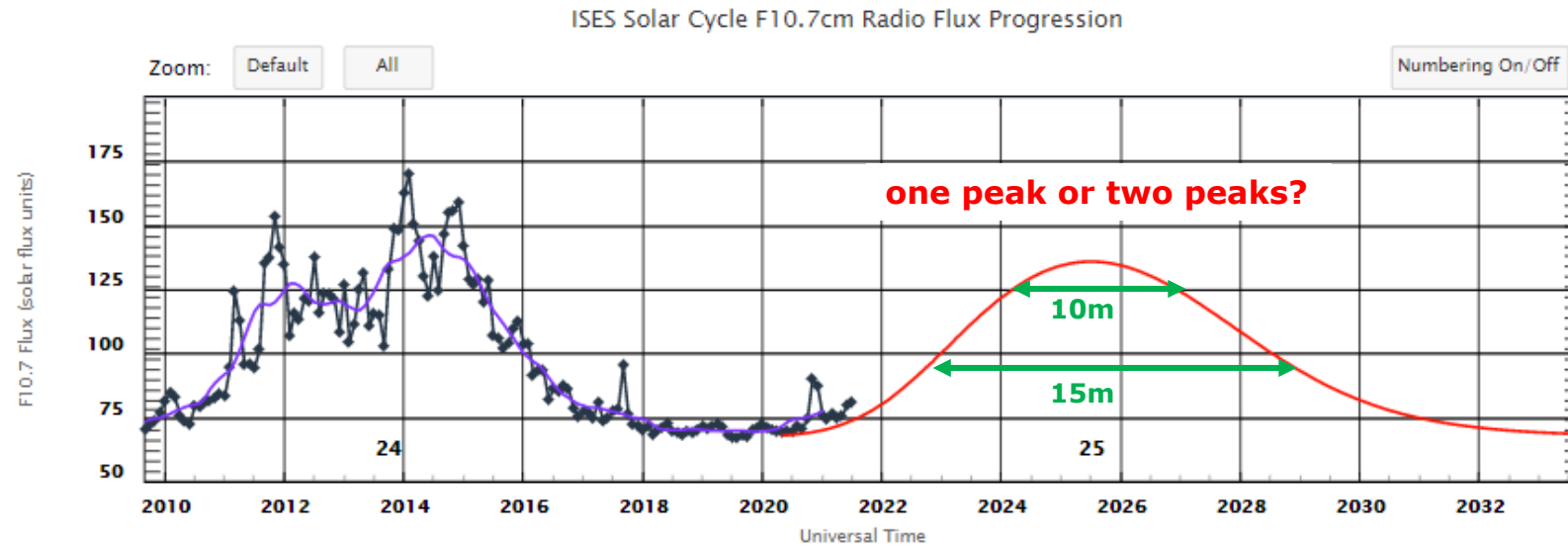
# The Rise of Cycle 25



Historical data says big cycles rise faster than small cycles

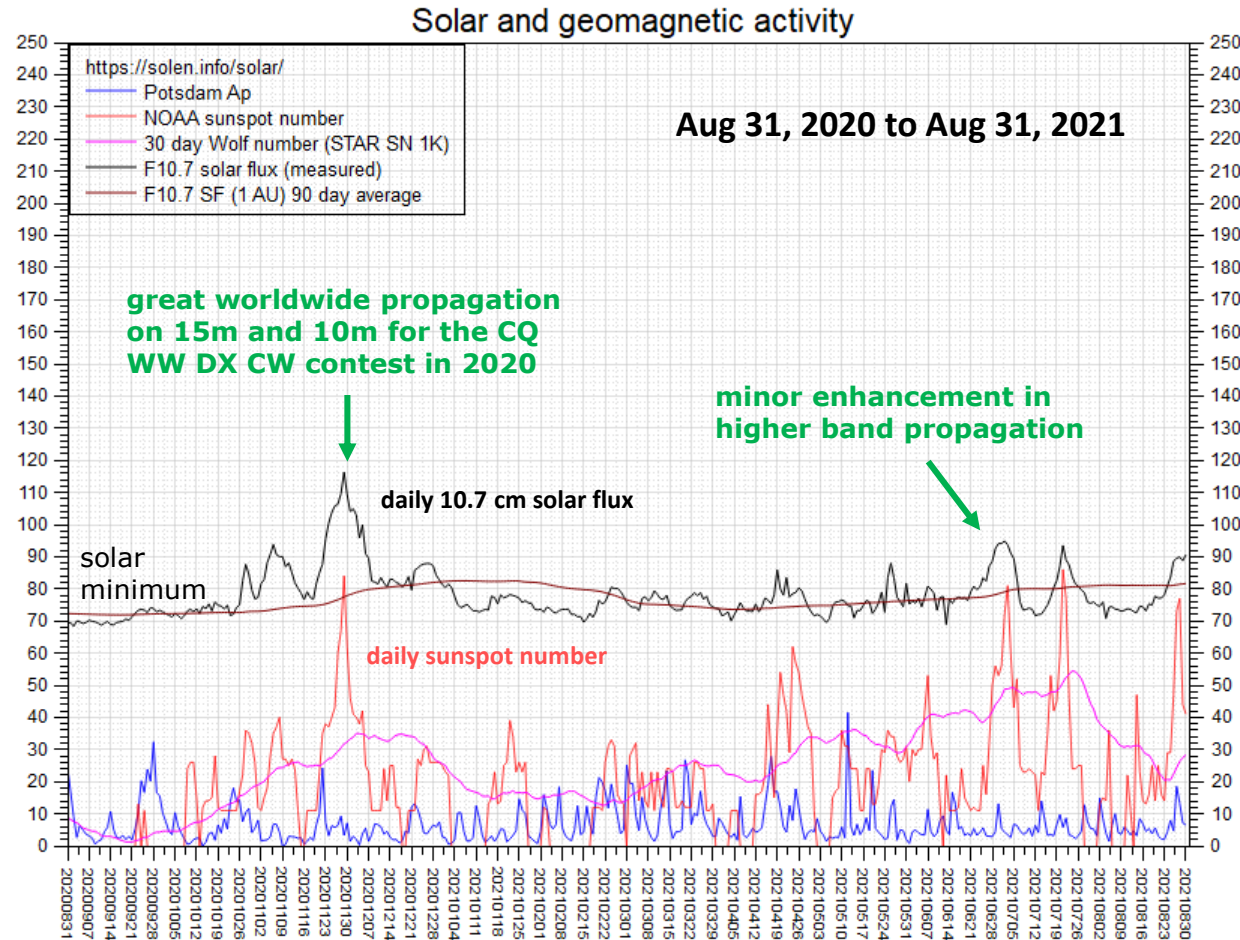
- Cycle 25 (red) is rising similar to Cycle 24 (small) and Cycle 21 (big)
- Next 6 to 12 months will likely tell us where Cycle 25 is headed

# What to Expect If Cycle 25 Is Similar to Cycle 24



- We still have a way to go before 15m/12m/10m open on a daily basis
- Watch for a big spike in SFI, SN, EUV or for a small spike in K
  - You may be rewarded with an enhanced opening
  - Great examples are late 2020 and the 2018 California QSO Party

# Big Spike in SFI and SN

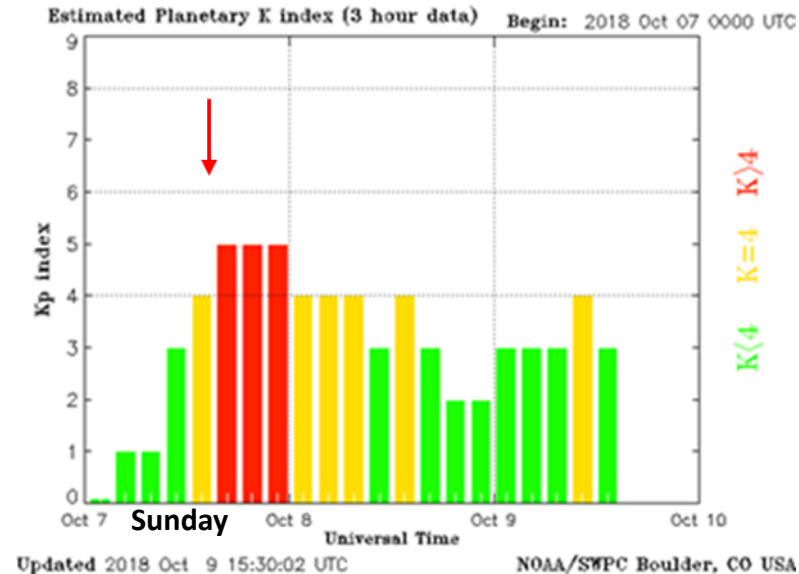
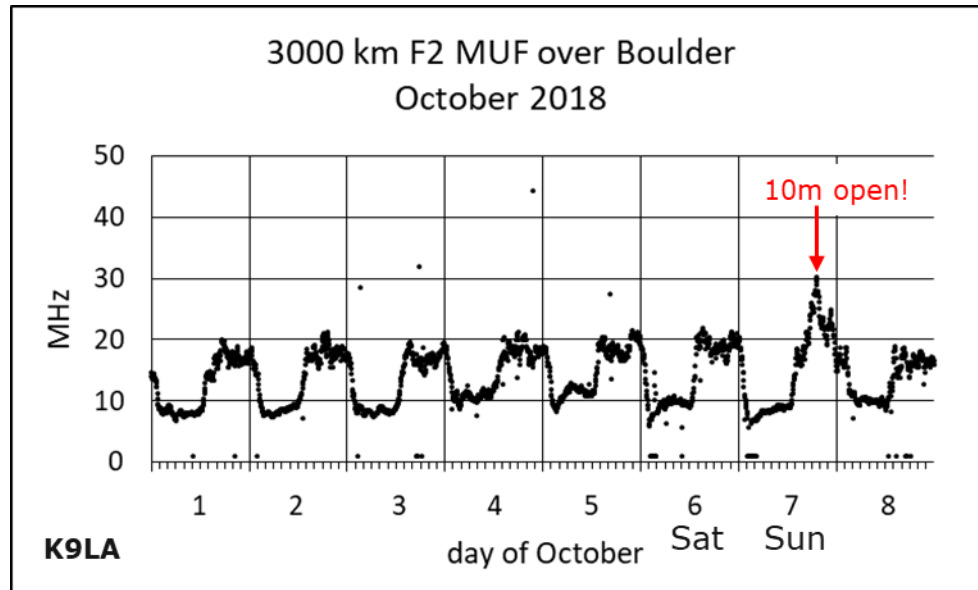


After the big spike late last year, things settled back down to solar minimum conditions



# Moderate Spike in the K Index

## October 2018 CA QSO Party



- Boulder ionosonde close to the midpoint of the W6-to-Midwest path
- I didn't hear any W6s on 10m on Saturday - MUF too low (only about 20 MHz)
- K index spiked up around midday on Sunday
- Lots of W6s on Sunday – MUF a bit greater than 30 MHz
- Watch for low/mid latitude enhancements when the K index spikes up

# Summary

- We still have a way to go until 15m, 12m and 10m are open on a daily basis
  - Start thinking about antennas for 15m,12m,10m
    - They are smaller at these higher frequencies
- Even if we have a small Cycle 25, there is the possibility for 6m F<sub>2</sub> propagation in the fall/winter months around solar maximum
  - Don't forget sporadic-E in the summer
  - Check the G3YLA sporadic-E prediction at <http://propquest.co.uk/map.php>
- Watch for short-term enhanced propagation on the higher bands
  - Check for big spikes in SFI and SN
  - Check for moderate spikes in the K index