An Update on Cycle 25

and some related topics

Cycle 25 is very awake!

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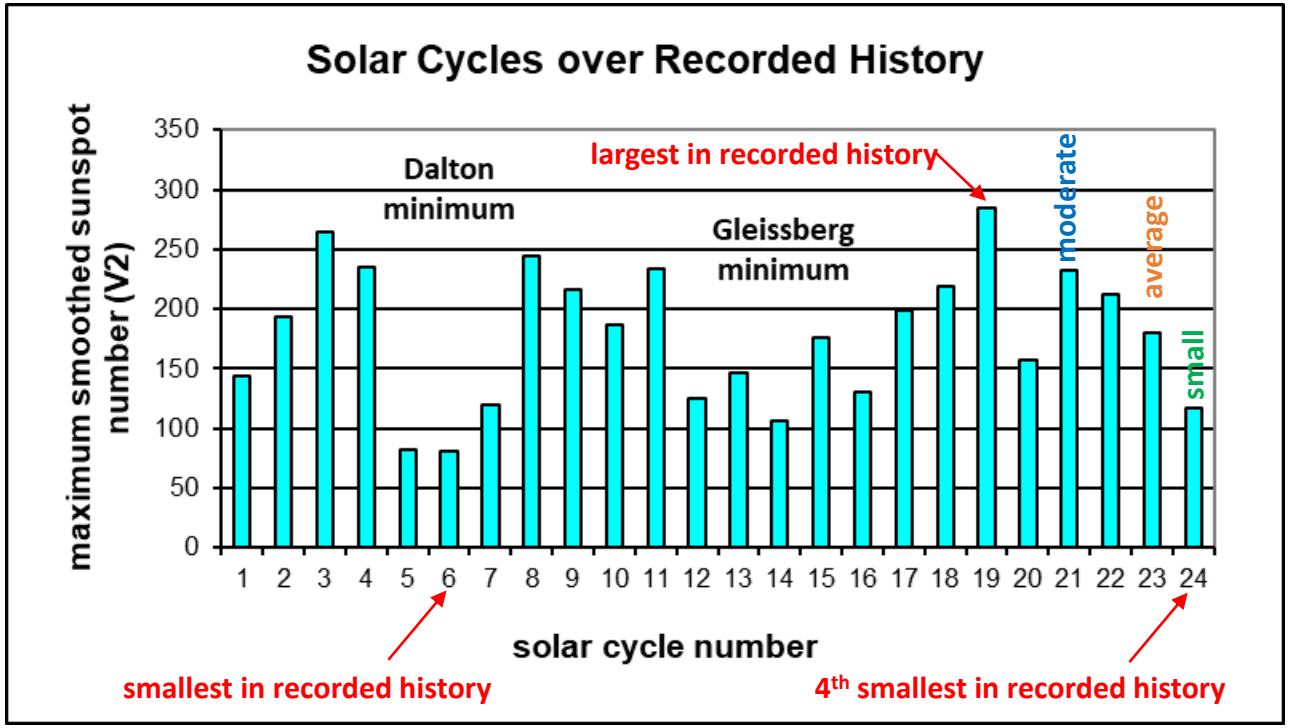
Agenda

- Previous 24 solar cycles
- Predictions of a solar cycle
- Latest data on Cycle 25
- Outlook for 160m and 6m
- Miscellaneous

Previous 24 Solar Cycles

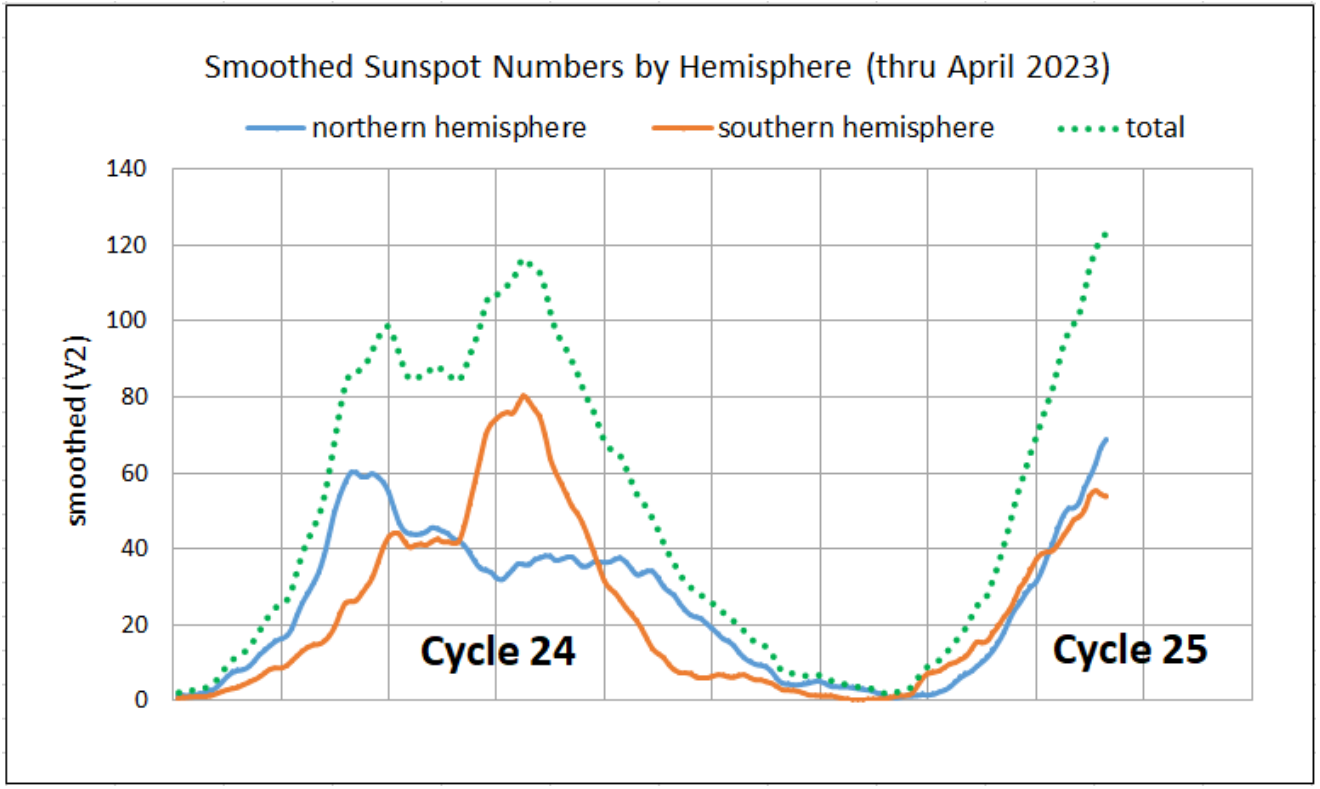
A Look at All Previous Cycles

- Cycle 1 began in 1755
  - Maunder Minimum occurred from 1645-1715 with few sunspots
- We've gone through 3 periods of big solar cycles and 2 periods of small solar cycles
- Cycle 24 was the smallest in our lifetimes
  - 4th smallest in recorded history
  - We appear to be in a third period of small solar cycles
- We have 270 years of sunspot data
  - Solar cycles have probably gone on for hundreds, thousands and millions of years – we have a pretty small sample size



Will Cycle 25 get us out of this third period of small solar cycles?

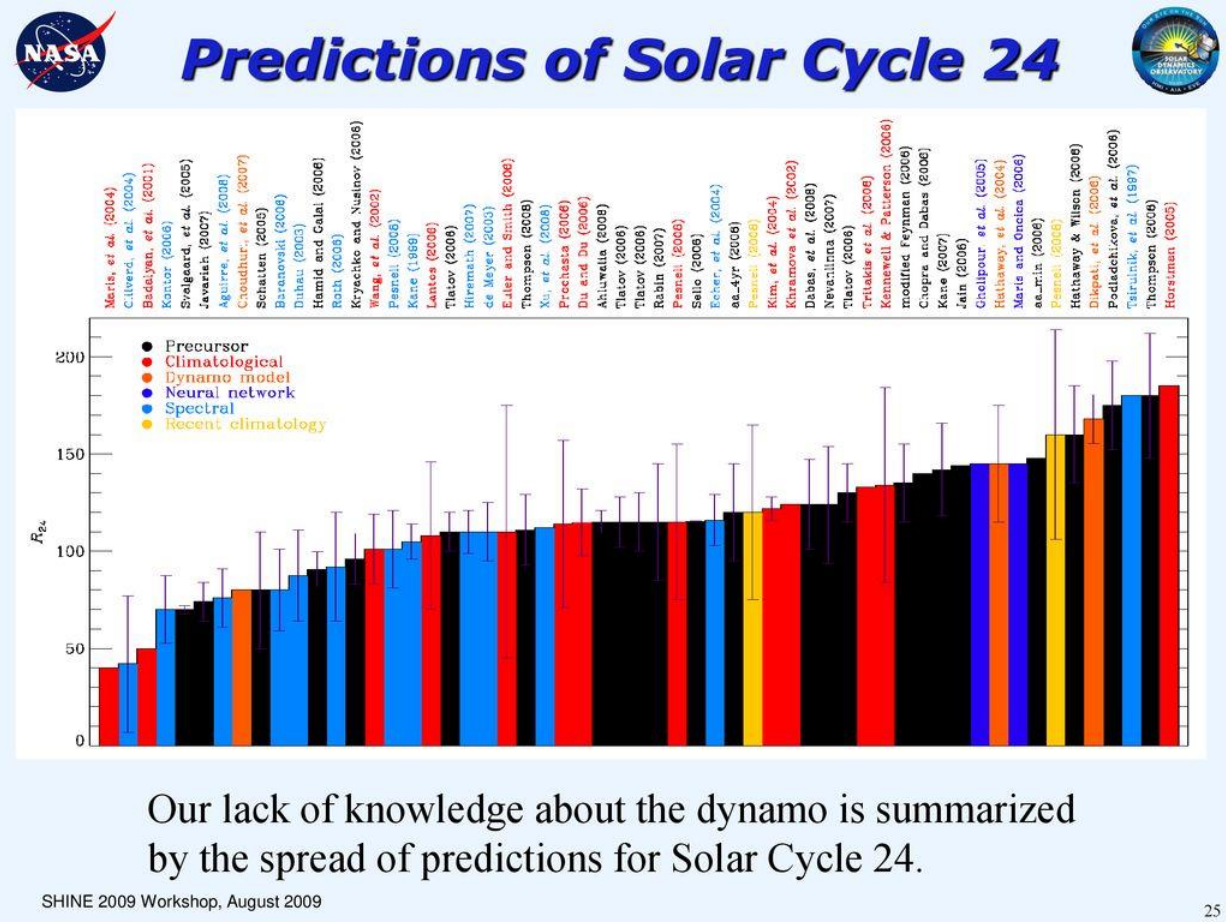
Cycle 25 – One Peak or Two Peaks?



- Best guess so far is one peak due to the two solar hemispheres working together – but watch the southern hemisphere in the coming months
- Cycle 25 is slightly bigger than Cycle 24 – will it get up to an 'average' cycle?

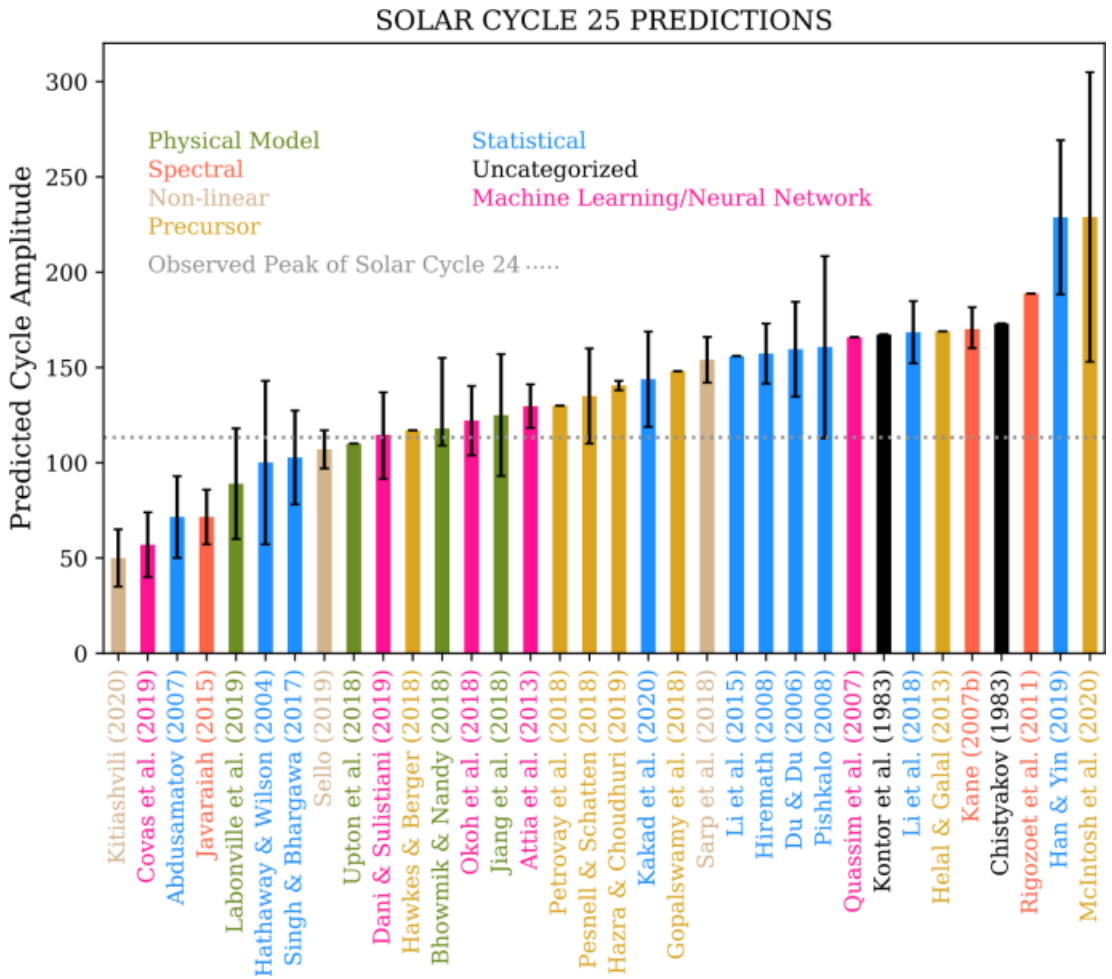
Predictions of a Solar Cycle

Predictions for Cycle 24



- Over 55 predictions
  - From very small to very big
- Why?
  - We don't fully understand the solar cycle process
  - We have the general idea, but not the details
- Thus we have different methods to predict a solar cycle
- What did we learn from Cycle 24?

Predictions for Cycle 25



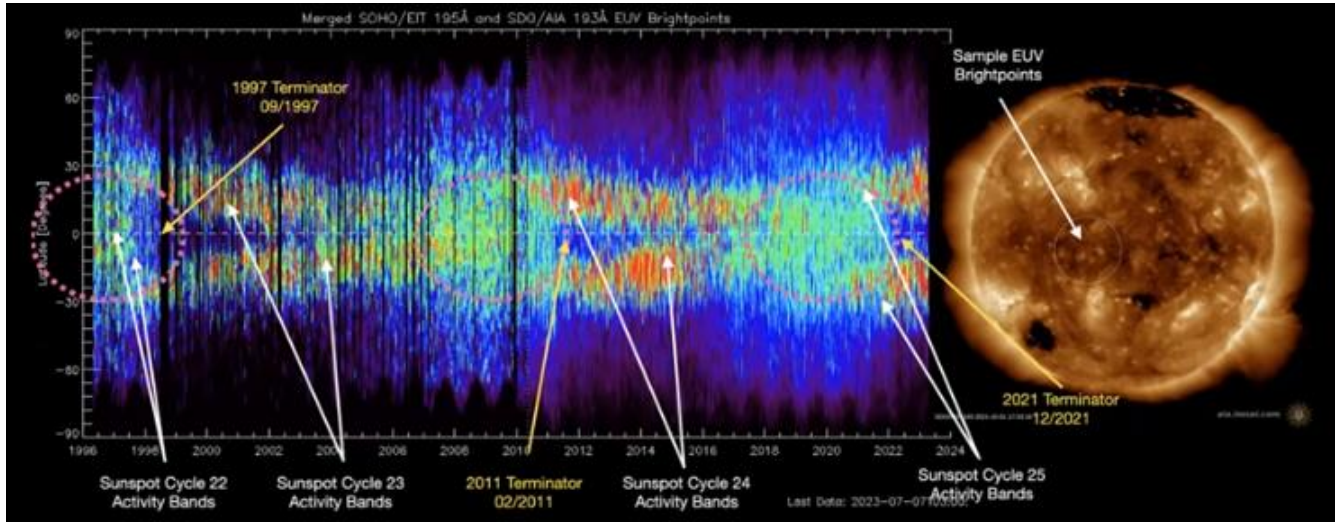
- We didn't learn enough
- This chart shows 35 predictions – but there are over 55 now
  - Again, from very small to very big
- NOAA/NASA predicted a small cycle
- Dr. Scott McIntosh and colleagues predicted a big cycle

Prediction for a Big Cycle 25

- Dr. Scott McIntosh and colleagues predicted a big cycle in June 2020
  - It ran against the NOAA/NASA consensus of a small cycle
- This prediction has received much publicity
- Dr. McIntosh has given many updates of their Cycle 25 prediction to the Front Range 6 Meter group – next update is December 13, 2023
- If the prediction comes true, it would be similar to Cycles 21 and 22
  - Excellent worldwide propagation on the higher HF bands
    - 15m, 12m, 10m
  - Lots of worldwide 6m propagation via the F_2 region around solar maximum, too
- **But . . .**

. . . They Revised Their Prediction

- In August 2021, Dr. McIntosh and colleagues downsized their prediction to a slightly above average cycle
  - The terminator event for Cycle 24 was much later than expected
- New prediction is similar to Cycle 23
  - Still lots of worldwide propagation on the higher HF bands
  - Decent worldwide propagation via the F_2 region on 6m

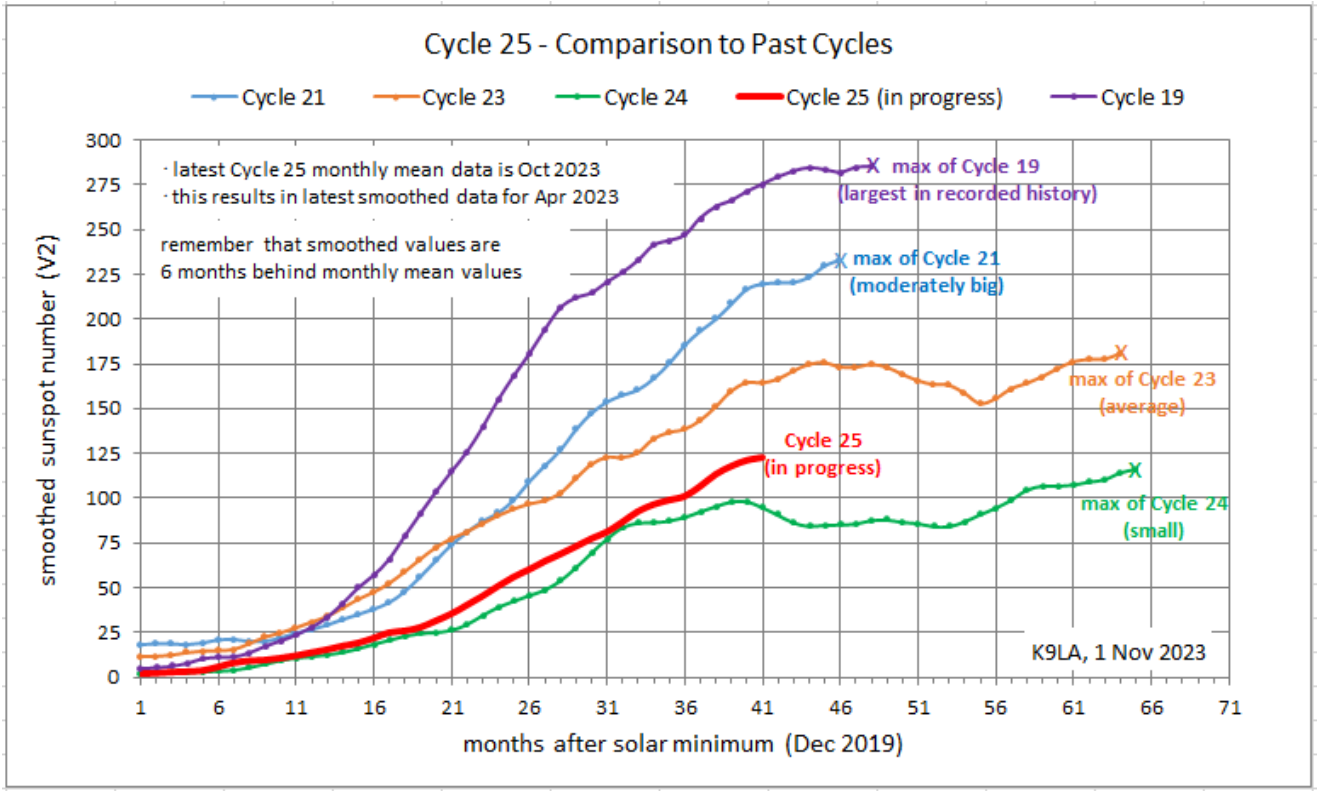


Terminator Cycle 22 – 09/1997
Terminator Cycle 23 – 02/2011 > 13yrs 5mo – small Cycle 24
Terminator Cycle 24 – 12/2021 > 10yrs 10mo – average Cycle 25

We'll gladly take a cycle similar to Cycle 23 over another Cycle 24!

Latest Data on Cycle 25

Latest Cycle 25 Data



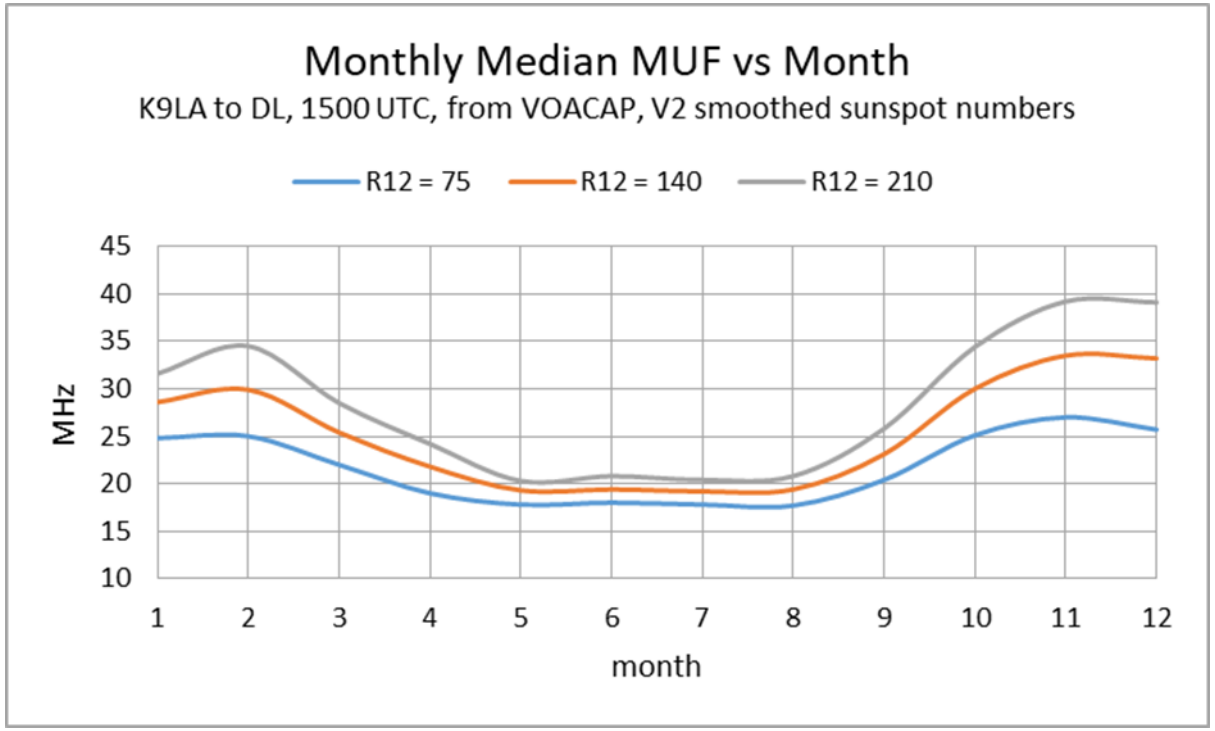
7 Sep 2023 prediction by Upton and Hathaway (134 +/-8)

JGR Space Physics
https://doi.org/10.1029/2023JA031681

- For now, Cycle 25 is doing a bit better than the small Cycle 24
- Perhaps it will get up to an 'average' cycle
- FYI – November has not been spectacular for sunspots – so far

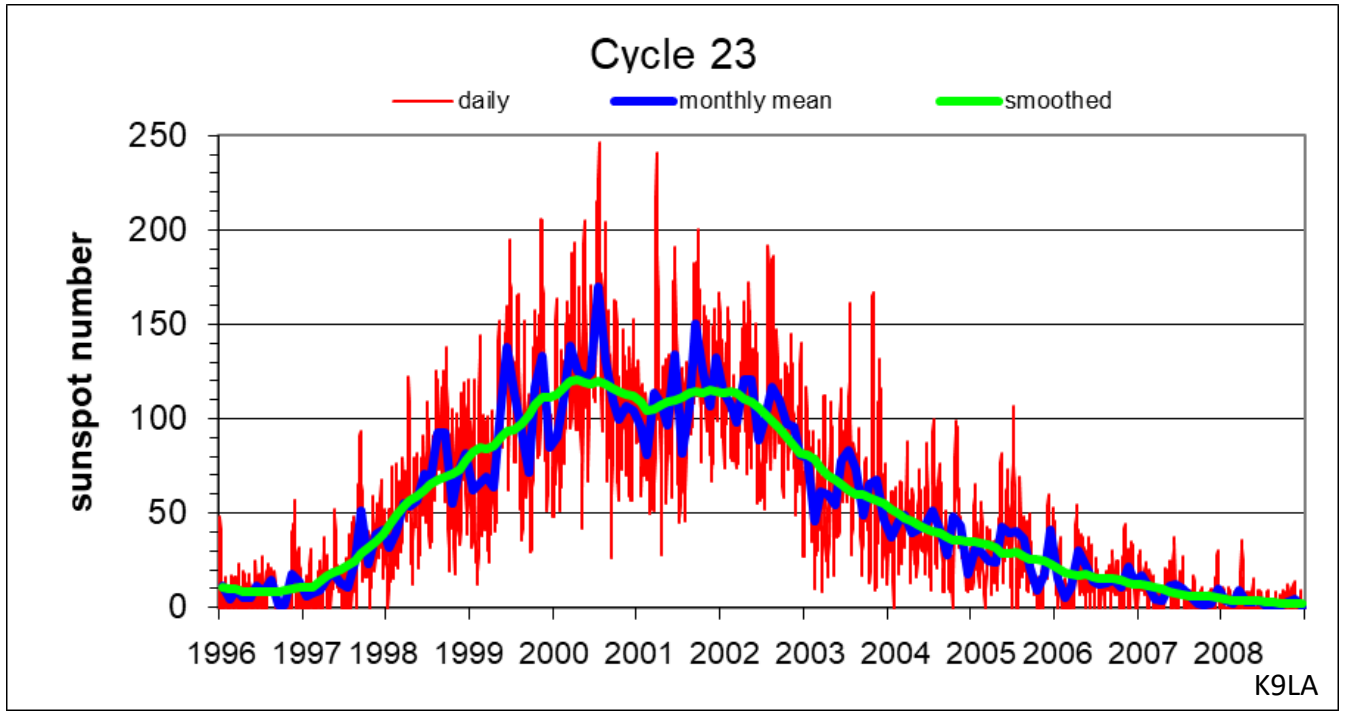
Propagation Right Now

- We're out of the F_2 region 'summer slump'
- In the northern hemisphere, lower daytime F_2 region MUFs than in fall/winter
- Caused by a change in the composition of the atmosphere
  - Decreased O/N_2 ratio in the summer
  - Increased O/N_2 ratio in the winter
- During summer, watch for E_s
  - Wasn't much of a season
    - Has the pattern of Es shifted?
  - Major E_s season is over



- Atomic oxygen (O) conducive to F_2 region electron production
- Molecular nitrogen (N_2) conducive to F_2 region electron loss

Daily, Monthly Mean and Smoothed

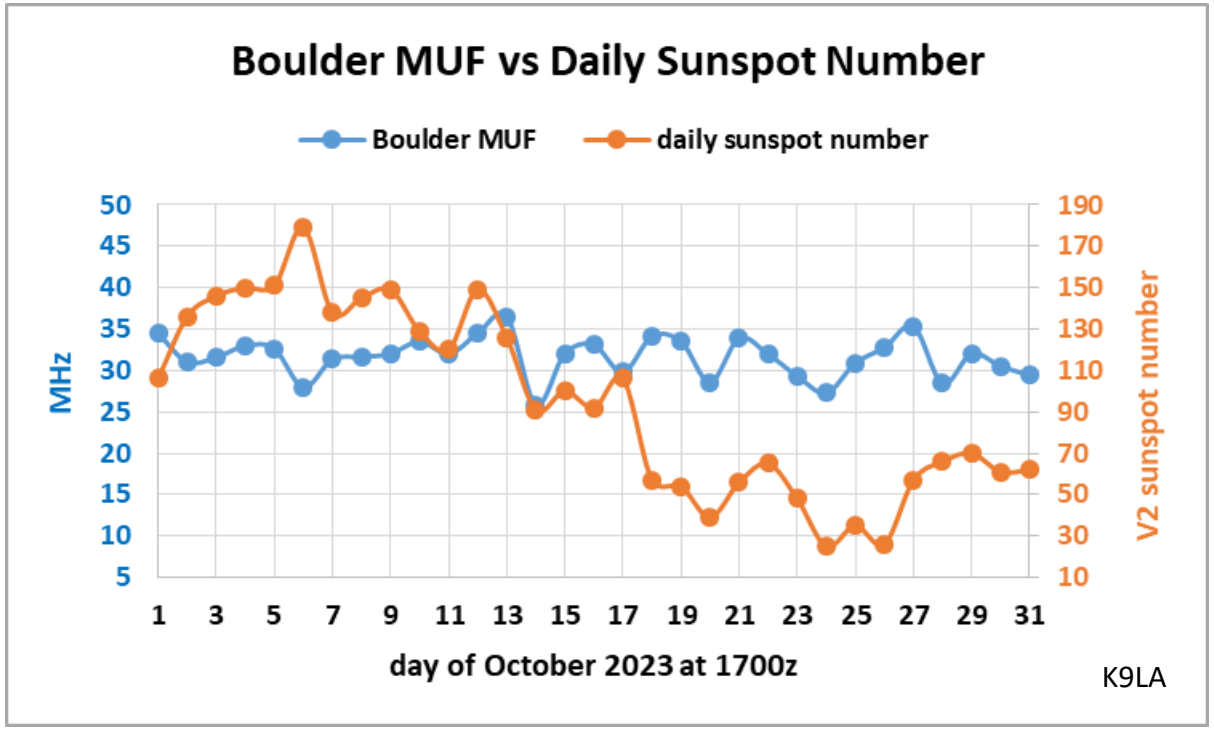


- Daily data (red) very spiky
- Monthly mean (blue) still spiky
- Smoothed (green) takes out the spikes
- Similar results for 10.7 cm solar flux

- Smoothed values are used for two reasons
  - Best way to see what a solar cycle is doing
  - Best correlation between sunspots and what the ionosphere is doing

We Don’t Have Daily Propagation Predictions

- Note what the daily sunspot number (orange curve) did during October 2023
  - It decreased from around 150 to around 50
- What did the daily MUF (blue curve) over the Boulder ionosonde do?
  - It remained pretty much constant around 30 MHz
- What this means – plugging in today’s sunspot number may not give you an accurate picture of what propagation is doing today
  - Our predictions are statistical over a month’s time frame using a smoothed sunspot number



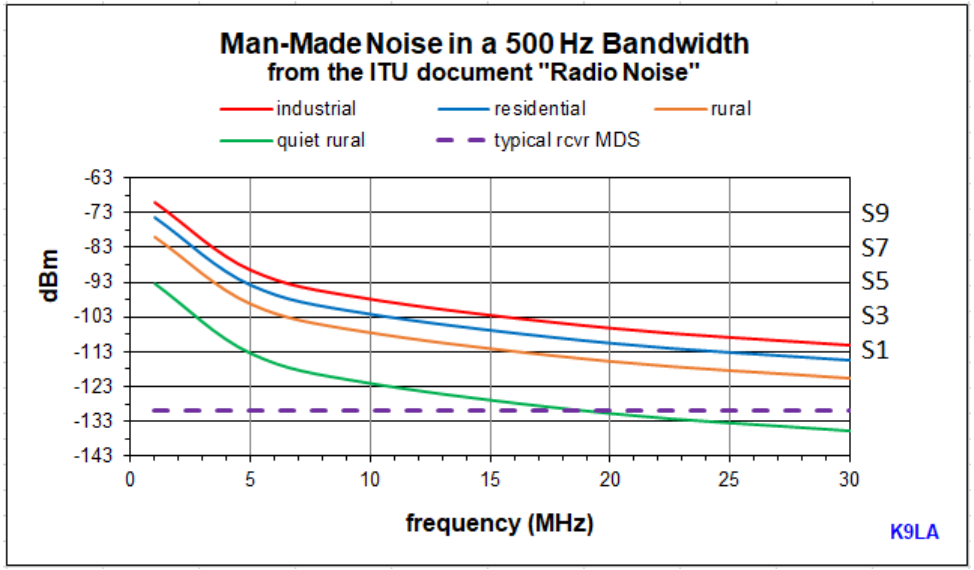
Outlook for 160m and 6m

160m

- I think there is a general consensus that topband (and 80m to a lesser extent) isn't as good as it used to be
- What could be the problem?
- Two issues to consider
  - Increase in man-made noise due to all the electrical devices in our lives
  - Climate change due to more CO_2 in the atmosphere
- Let's look at both

Increase in Man-Made Noise

- Data from circa 1970 shows the following man-made noise levels



- On 160m in a CW bandwidth, the man-made noise level with a short monopole in a residential area is around S8
- About S6 on 80m
- About S2 on 20m

- Recent data (see citation below) indicates the noise in a residential area has increased by about 9 dB on 160m and by about 4 dB on 20m
- Noise in a rural area increased by about 6 dB on 160m and by about 1 dB on 20m

Measurement Methodology and Results of Measurements of the Man-Made Noise Floor on HF in the Netherlands; Fockens, Zwamborn, Leferink; IEEE Transactions on EMC; Vol 61, No 2, April 2019

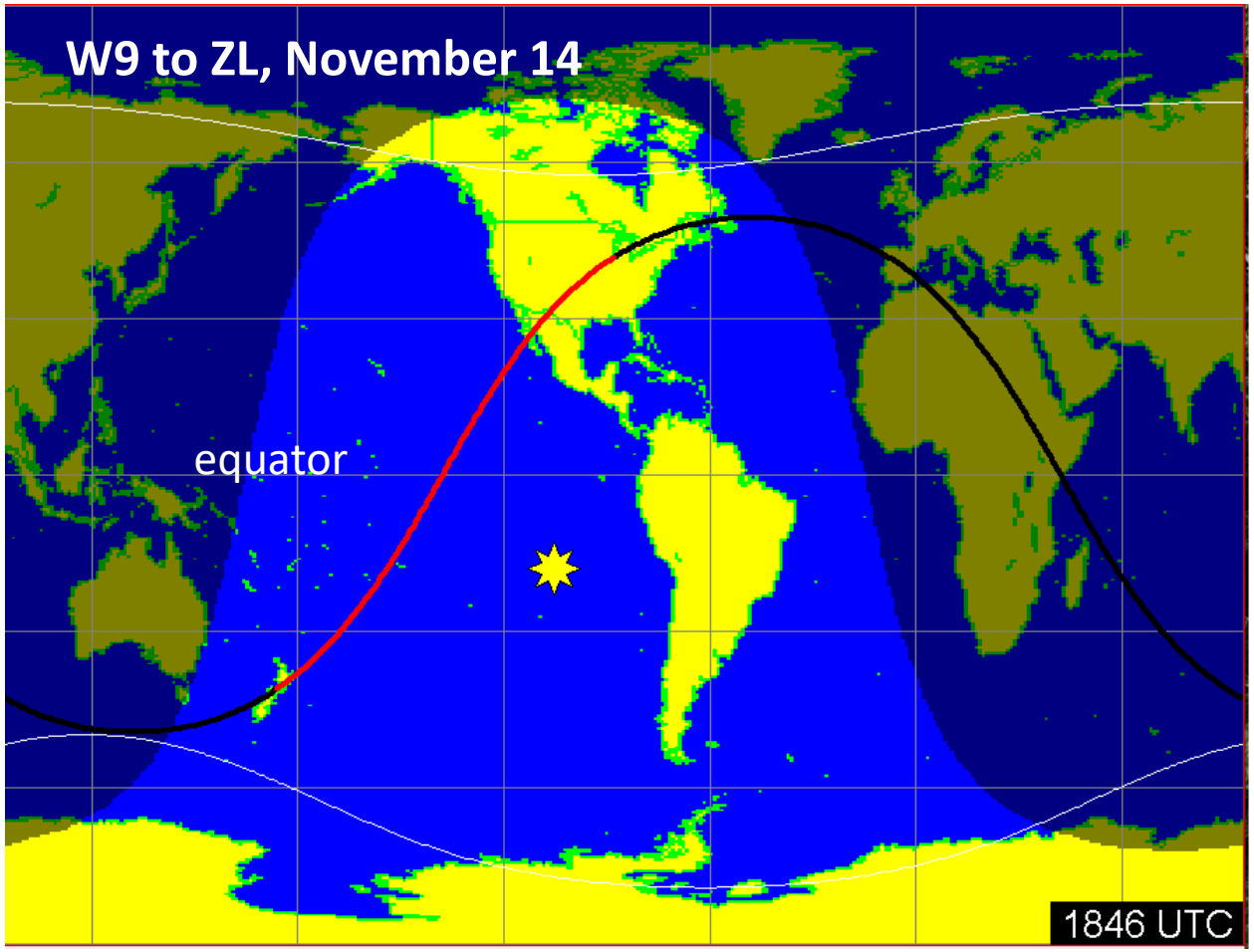
Climate Change

- A 2008 research paper (see citation below) simulated the change in the ionosphere due to CO_2 increasing from 365 parts per million by volume at 30 km in 2000 to 730 parts per million by volume in 2100 (as projected by the IPCC in 2007)
- Simulations indicated that the electron density in the lower E region (where absorption occurs at night) increases by 20% over 100 years
  - 2% in a decade
  - 6% in three decades
- Amount of absorption is proportional to the electron density
  - 2% more absorption over a decade
  - 6% more absorption in three decades
  - Doesn't sound like much, but . . .

Model simulations of global change in the ionosphere; Qian, Solomon, Roble, Kane; Geophysical Research Papers; Vol 35, L07811;doi:10.1029/2007GL033156; 2008

6m

- Max of Cycle 24 was a smoothed sunspot number of 116
  - We had 6m F2 propagation
- Cycle 25 is above a smoothed sunspot number of 125
  - And it may go a bit higher
  - We should expect 6m F2 propagation
  - Don’t confuse this with TEP
- Most likely in the fall and winter months (where we are now)
- Most likely on paths that stay at low latitudes
  - Robust equatorial ionosphere



Miscellaneous

The FT8 Advantage – S/N

Weak-Signal S/N Limits

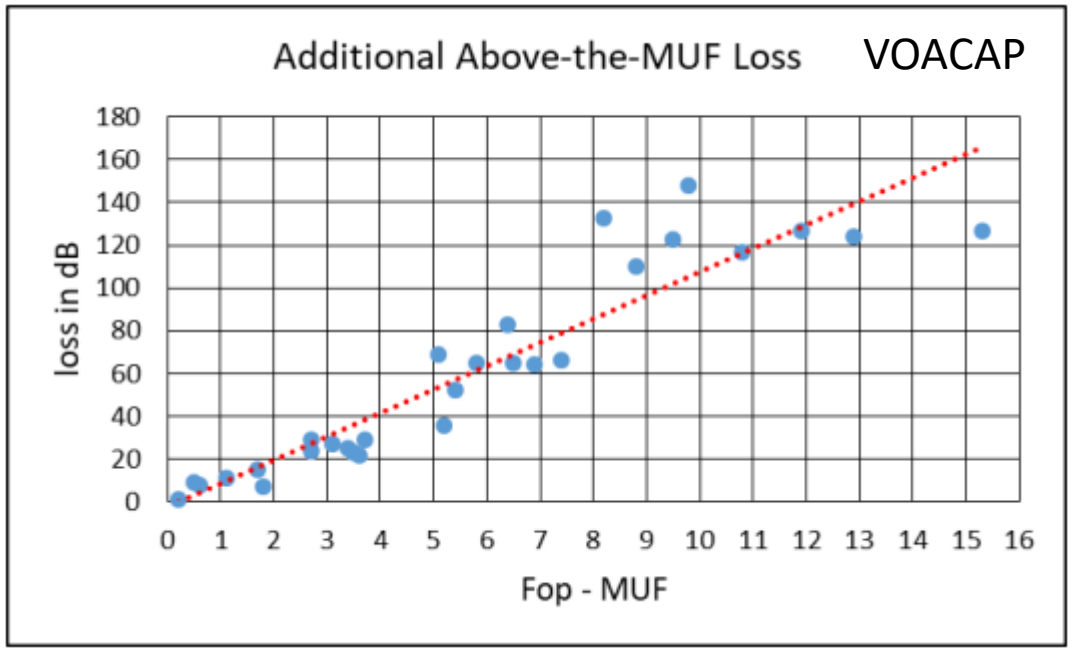
fastest data transfer at the top, slowest at the bottom

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

- For SSB, you need a +10 dB signal-to-noise ratio (S/N)
  - Signal 10 dB above the noise in a 2500 Hz bandwidth
- For FT8, you need a -21 dB SNR
  - Signal 21 dB below the noise in a 2500 Hz bandwidth
- WSPR is the most sensitive, needing a -31 dB SNR
  - Signal 31 dB below the noise in a 2500 Hz bandwidth
  - But it's the slowest of the digital modes for completing a QSO

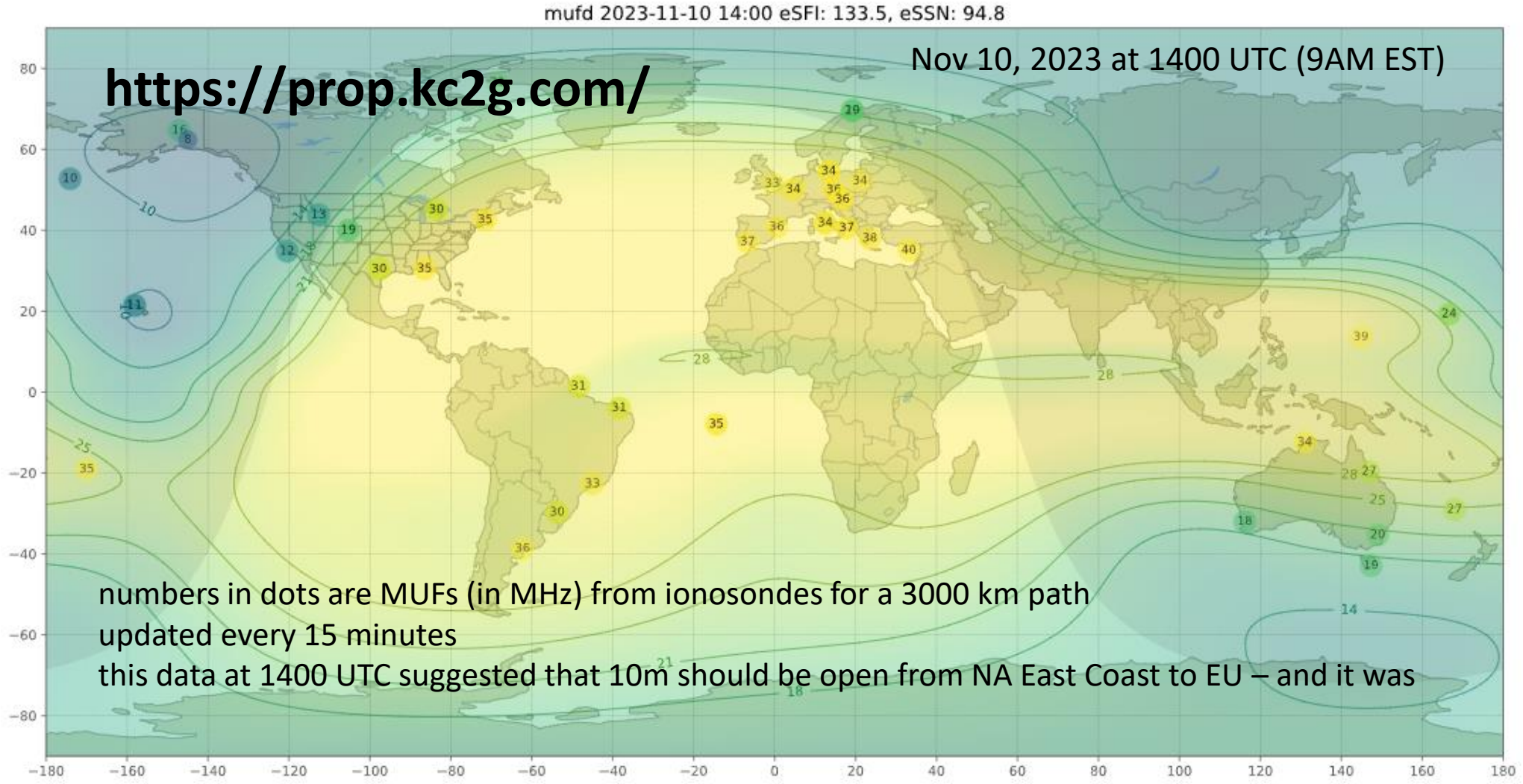
The FT8 Advantage – MUF

- VOACAP has an above-the-MUF algorithm in it
- The MUF is for pure refraction
- If you're operating above the MUF, VOACAP calculates how many dB of additional loss may occur due to 'scatter'
- The S/N advantage of the digital modes translates to being able to operate at frequencies higher than the MUF



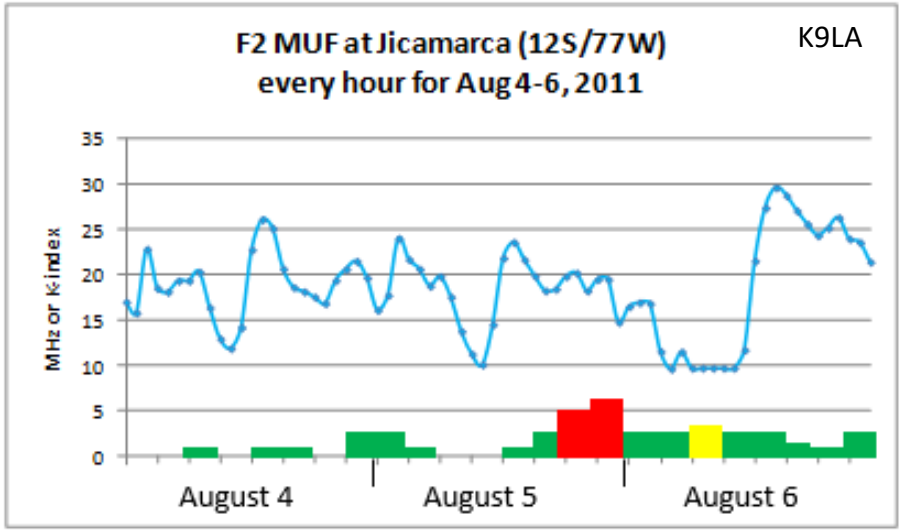
Eyeballing the above plot and looking at the last slide says the more robust digital modes may allow you to operate up to 4 MHz higher than the MUF

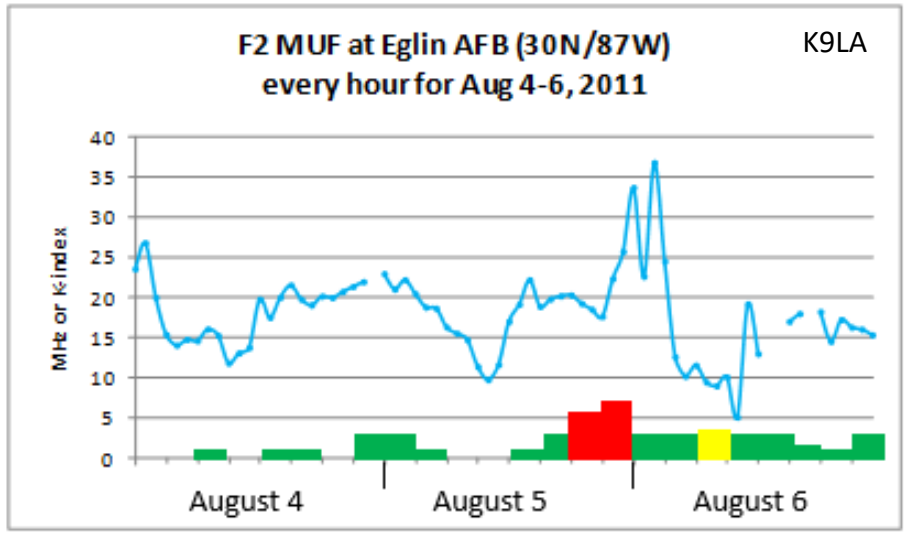
Worldwide View of Propagation



Disturbances to Propagation

- GEOMAGNETIC STORMS
  - Due to coronal mass ejection (CME) or coronal hole (CH) – elevates the K index
  - Can reduce the high-latitude MUF – higher bands might not be available for several days
  - Can give a short-term enhancement on low and middle latitude paths
  - Can offer VHF contacts via aurora
  - Worst of the three disturbances
    - Duration and worldwide

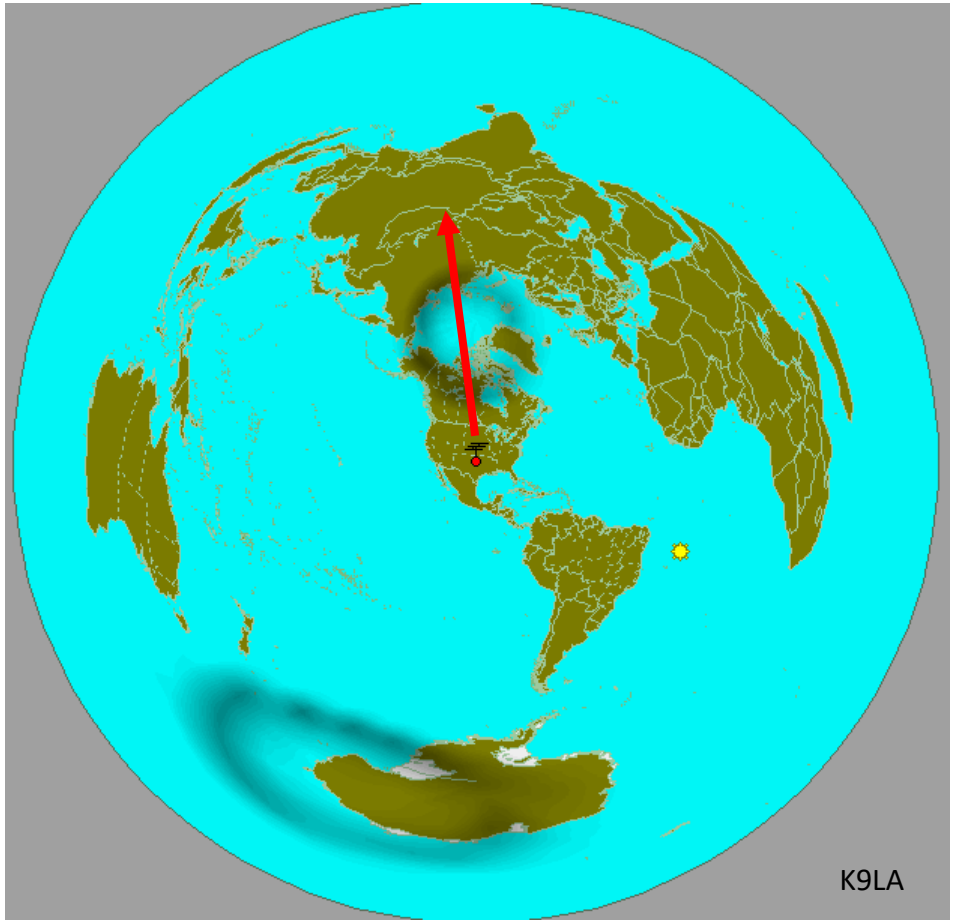




Disturbances to Propagation – continued

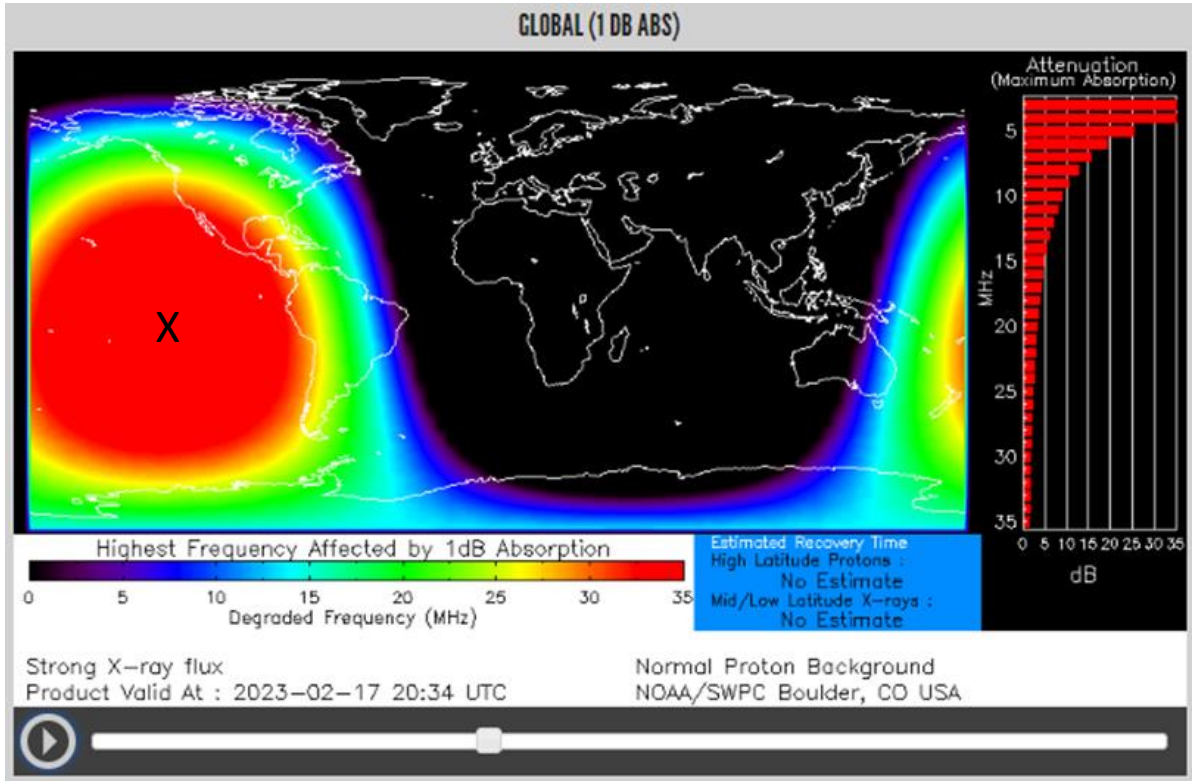
- SOLAR RADIATION STORMS
  - Due to relativistic protons from a big solar flare
  - Causes increased absorption in the polar cap – degrades over-the-pole paths
- Polar cap is that area inside the auroral zone

W5 to Russia



Disturbances to Propagation – continued

- RADIO BLACKOUTS
  - Due to X-ray radiation from a big solar flare
  - Causes increased absorption on the daylight side of Earth – more loss
- Note that the effect diminishes as you move away from the overhead point
- Note that the effect diminishes as frequency increases



X is where the flare was overhead

https://www.swpc.noaa.gov/products/d-region-absorption-predictions-d-rap

References for Propagation

- 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
  - https://store.cq-amateur-radio.com/shop/the-cq-shortwave-propagation-handbook-4th-edition-cd/
- Radio Propagation Explained – GØKYA
  - https://www.amazon.com/Radio-Propagation-Explained-Steve-Nichols/dp/1910193283
- K9LA web site – https://k9la.us/

Summary

- Cycle 25 is still ascending
  - We might be close to solar maximum
  - Or it may go a bit higher

- Man-made noise appears to be more critical than climate change on 160m
  - 160m will likely be tougher

- We had 6m propagation via the F2 region around Cycle 24 solar max, so we should expect 6m F2 propagation around Cycle 25 solar max
  - Best opportunities are during the fall and winter months and on low latitude paths
  - Read Jim K6MIO's papers at https://www.qsl.net/wa3mej/Articles/Propagation/6M%20Prop/K6MIO/

- Get on the higher HF bands now – 15m/12m/10m
  - They are offering excellent worldwide propagation
  - A modest station can do wonders – 100 Watts and a simple antenna