Cycle 25 and Propagation

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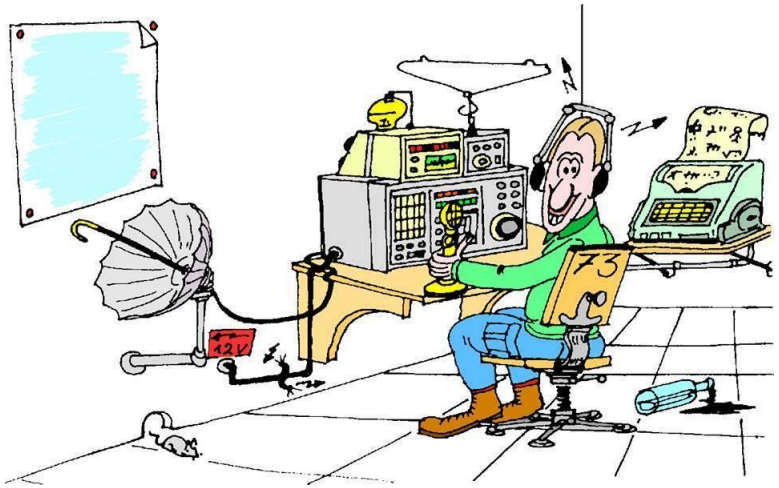
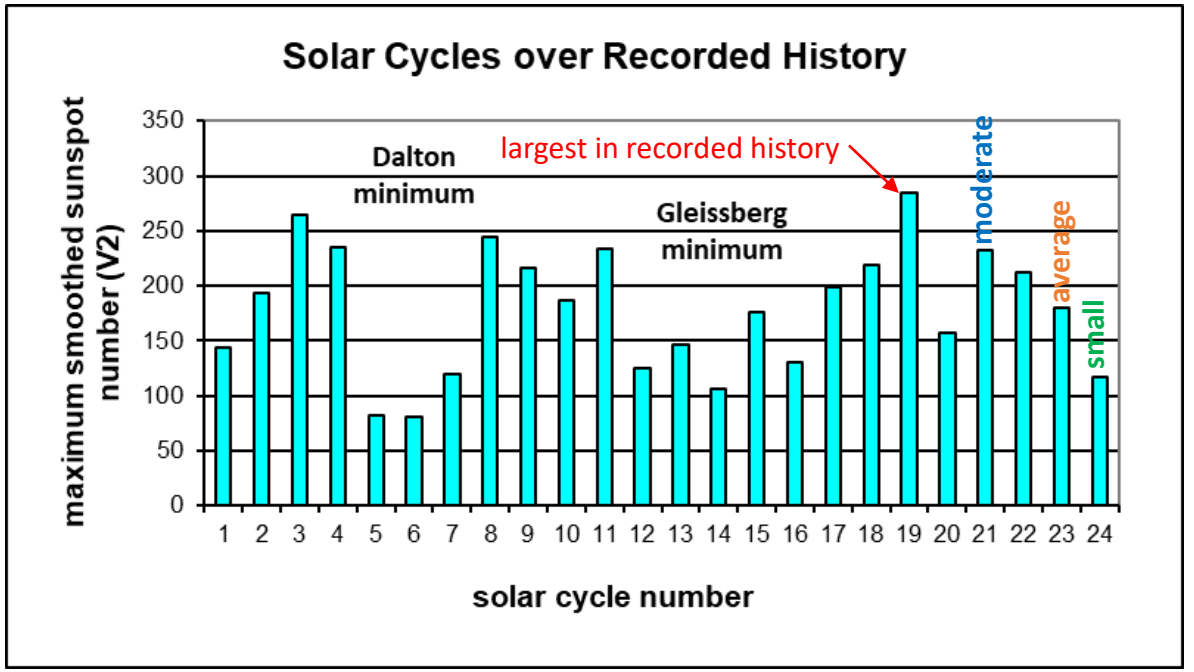


What We'll Cover

- Previous 24 solar cycles
- Review of Dr. Scott McIntosh's prediction for a big Cycle 25
- Latest data on Cycle 25
- What to expect for the next year
  - Higher bands
  - Lower bands
  - 6m
- A brief review of space weather and propagation

All Previous 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 and 2 periods of small solar cycles
  - We appear to be in a third period of small solar cycles
- Cycle 24 was the smallest in our lifetimes
  - 4th smallest in recorded history



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

Solar Cycle Predictions

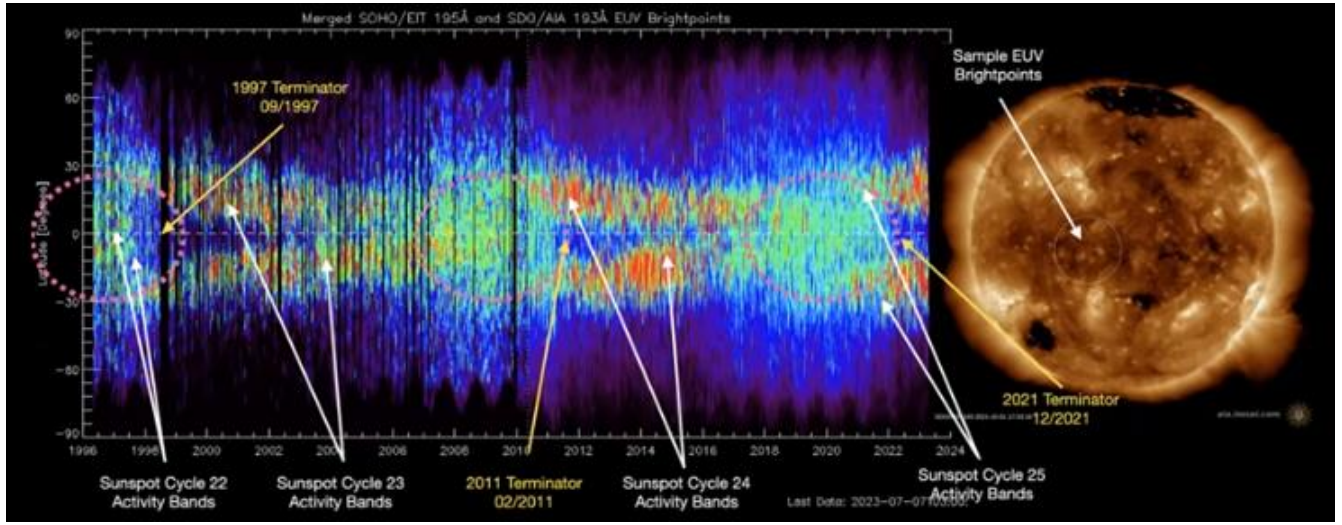
- I'm aware of more than 50 predictions for Cycle 25
  - From a small cycle (NOAA/NASA consensus) to a big cycle
  - Why so many?
- Because we don't fully understand the sunspot cycle process
  - We know it has to do with how magnetic fields move inside the Sun and how plasma flows inside the Sun – but the nitty-gritty details are not yet fully clear
- Thus many methods are used to make a prediction
  - Precursor appears to give the best results now
  - Dynamo is the future – the physics of the Sun

Prediction For A Big Cycle

- Dr. Scott McIntosh and colleagues (NCAR) 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 Dec 13
- 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 in the fall and winter months around solar maximum, too
- **But . . .**

. . . They Revised Their Prediction

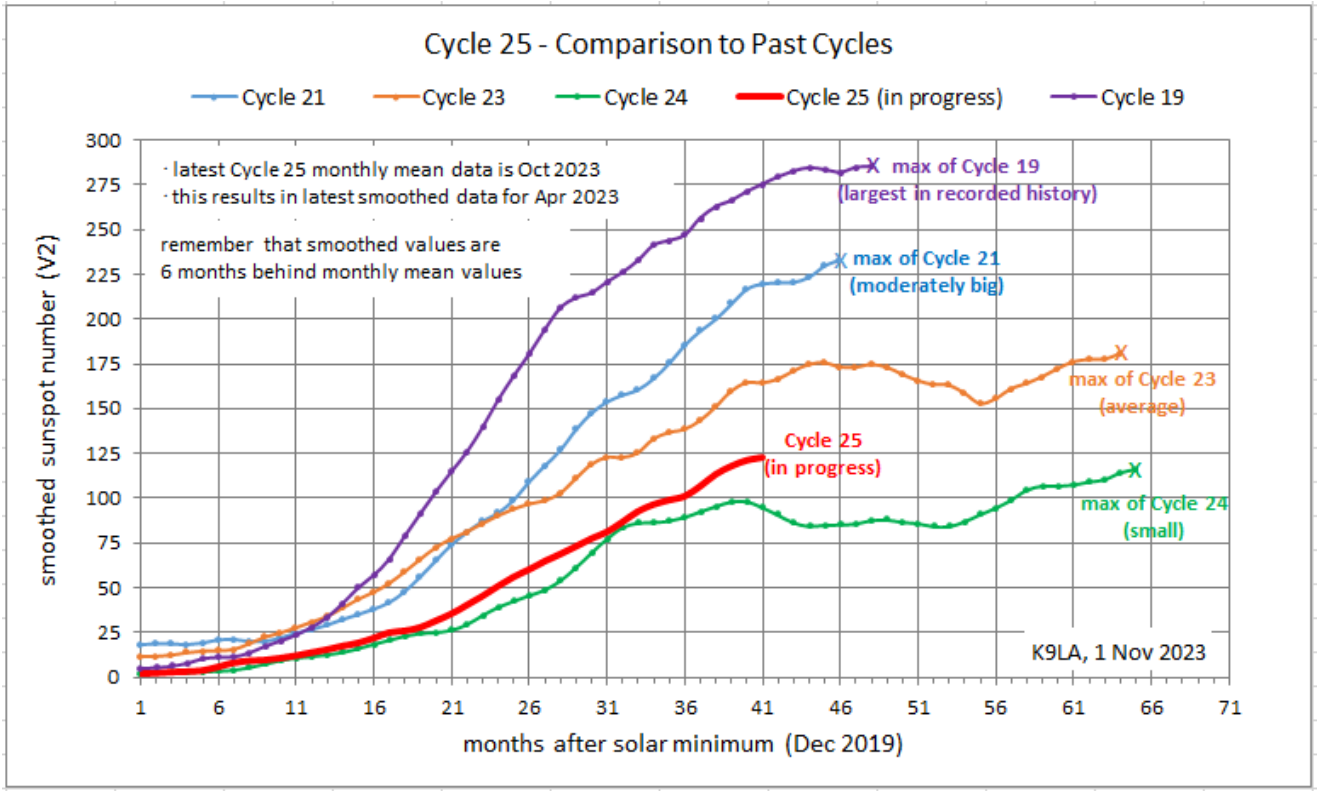
- In August 2021, Dr. McIntosh and colleagues downsized their prediction to a slightly above average cycle
  - The terminator event for Cycle 24 was much later than expected
- New prediction is similar to Cycle 23 (average cycle)
  - Still lots of worldwide propagation on the higher HF bands
  - Decent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

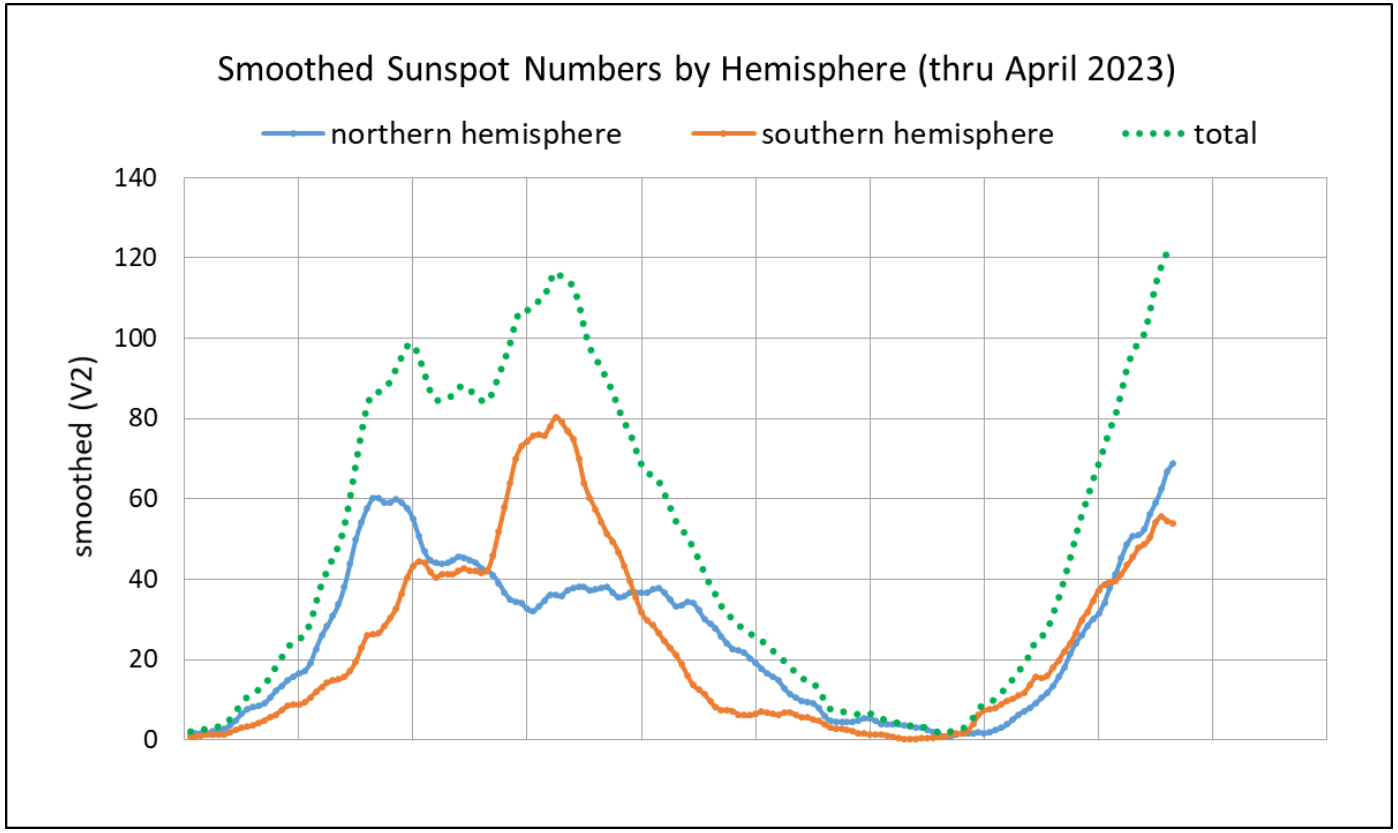
We'll gladly take a cycle similar to Cycle 23!

Here's The Latest Cycle 25 Data



- Cycle 25 is doing better than the small Cycle 24
- Will it make it up to an average cycle (like Cycle 23)?

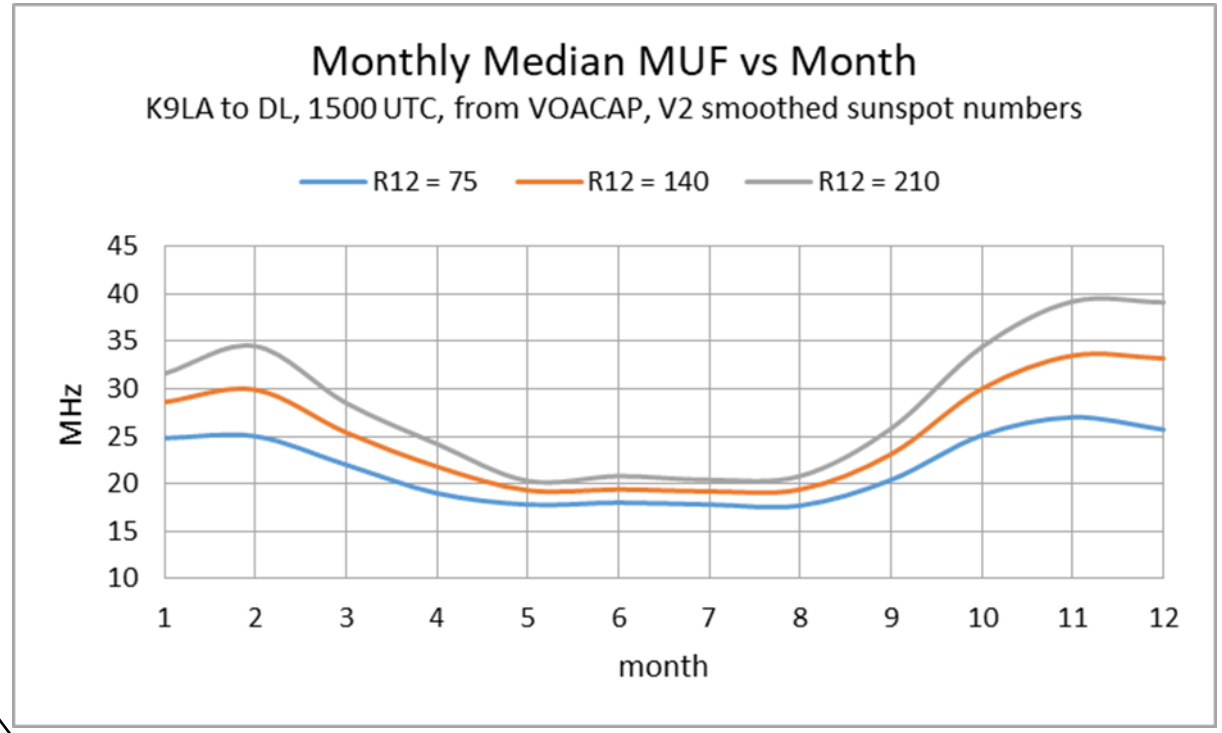
Cycle 25 – One Peak or Two Peaks?



- Cycle 24 (and 22 and 23) had two peaks
- Best guess right now is one peak for Cycle 25 due to the two solar hemispheres working together
  - But keep an eye on the southern hemisphere to see if the downturn continues

Propagation Right Now

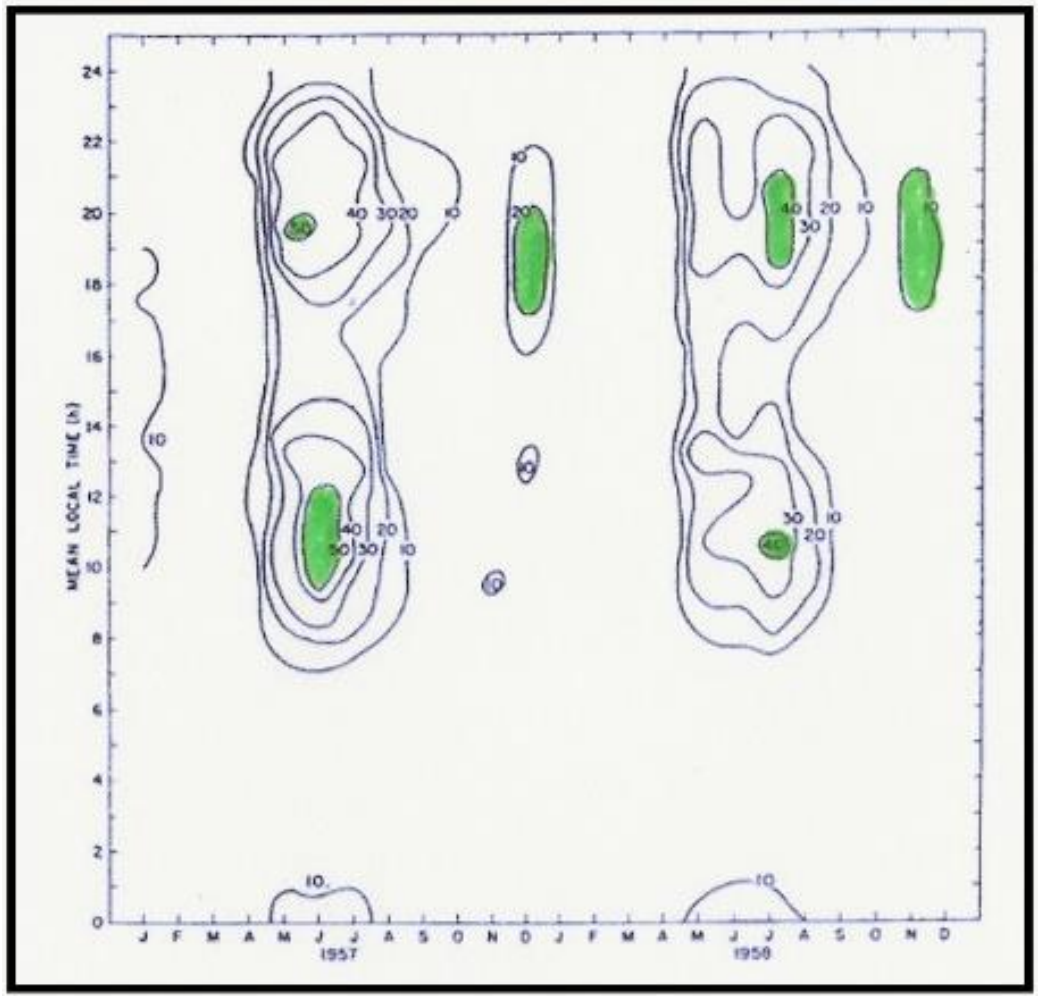
- We're out of the F_2 region 'summer slump'
- In the northern hemisphere, lower daytime F_2 region MUFs in summer than in fall/winter
- Caused by a change in the composition of the atmosphere
  - Decreased O/N_2 ratio in the summer
  - Increased O/N_2 ratio in the winter
- During the summer, watch for E_s
  - Wasn't much of a season
  - Keep an eye out in December
    - See next slide



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

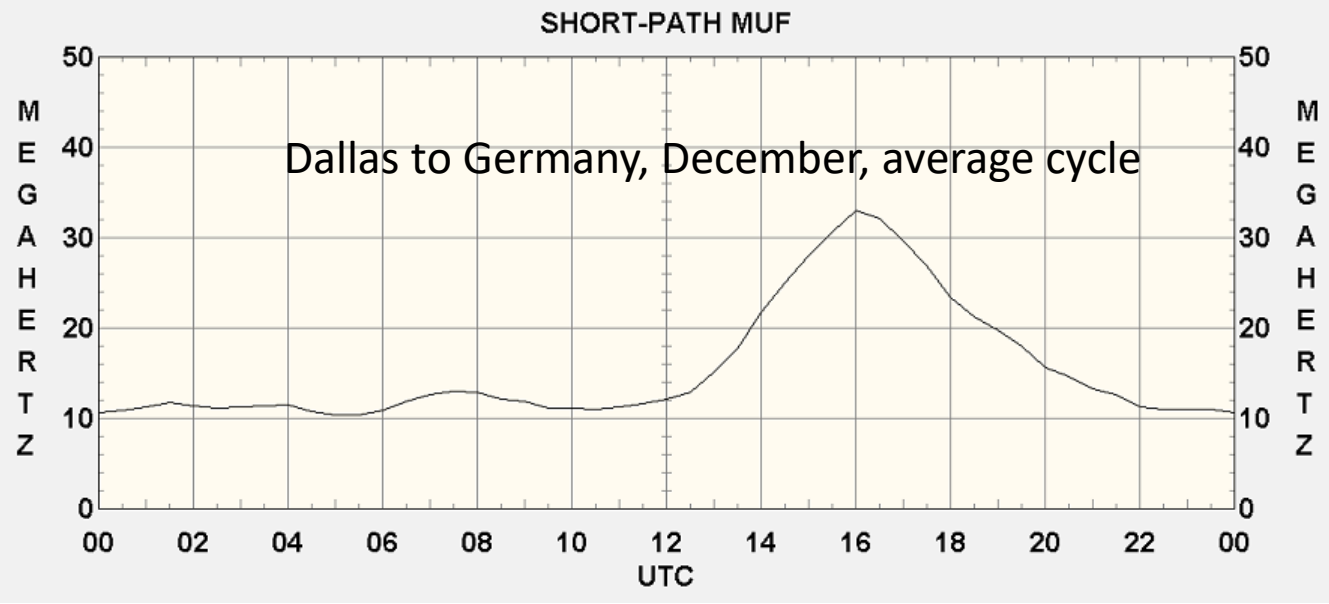
Probability of E_s on 50 MHz

- June, July and August are best
  - Late morning and early evening
  - But keep an eye on May and September
- December
  - Early evening
- Old data, but still relevant



6m F_2 Propagation

What's the best time for 6m F_2 propagation in December?



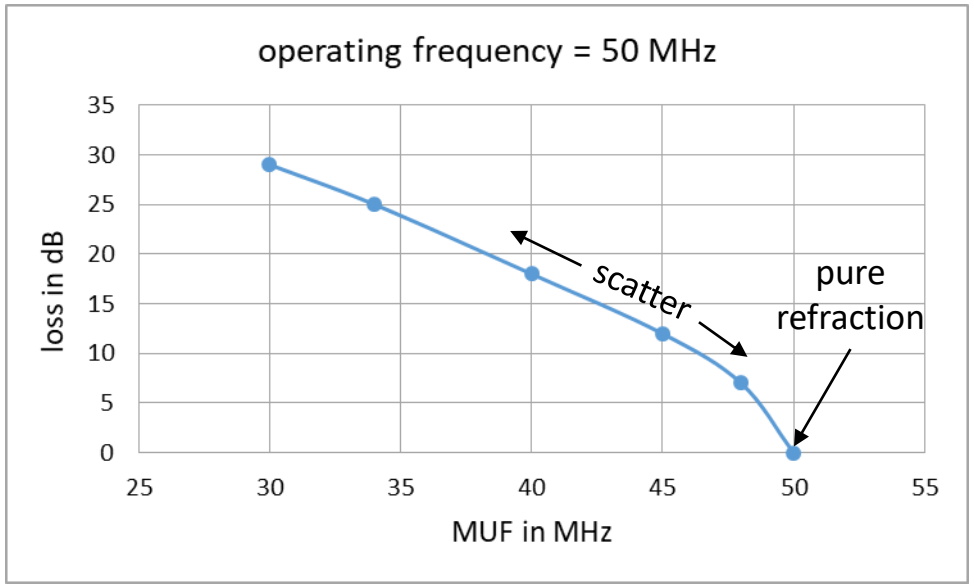
- Best around 1600 UTC
- Monthly median MUF (half the days of the month) is ~34 MHz
  - On a couple days, MUF is ~40 MHz
- Enhancements
  - F_2 region scatter mechanism at the expense of more loss
    - Known as above-the-MUF propagation (slide 12)
  - Non-homogeneous F_2 region
    - Spotlight propagation
  - Moderate spike in the K index (slide 13)

Above-the-MUF Propagation

- VOACAP has an above-the-MUF algorithm in it
  - Report ITU-R P.2011 - *Propagation at frequencies above the basic MUF*

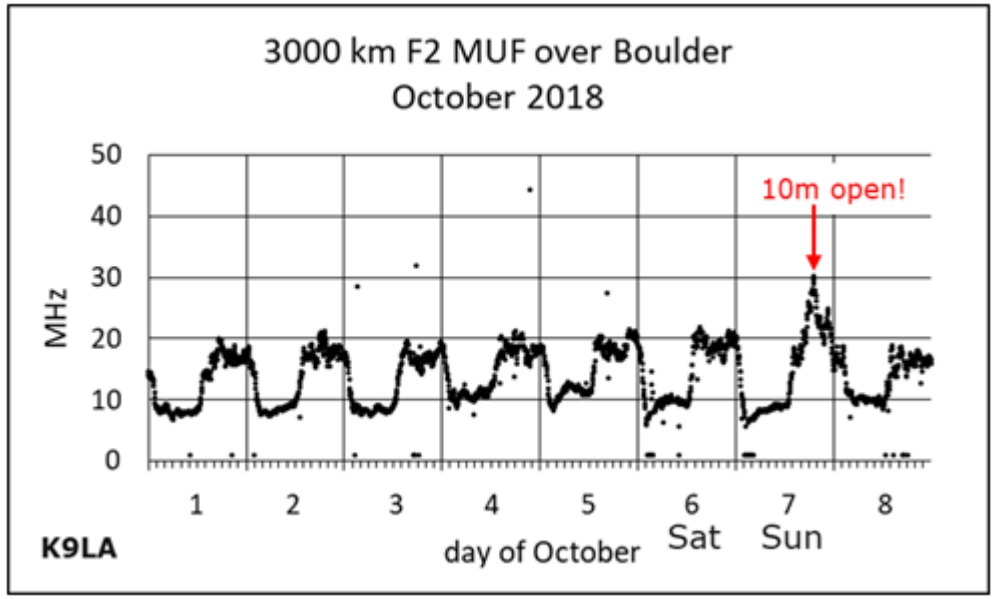
For F2-modes (up to a range of 7 000 km), when $f > f_b$

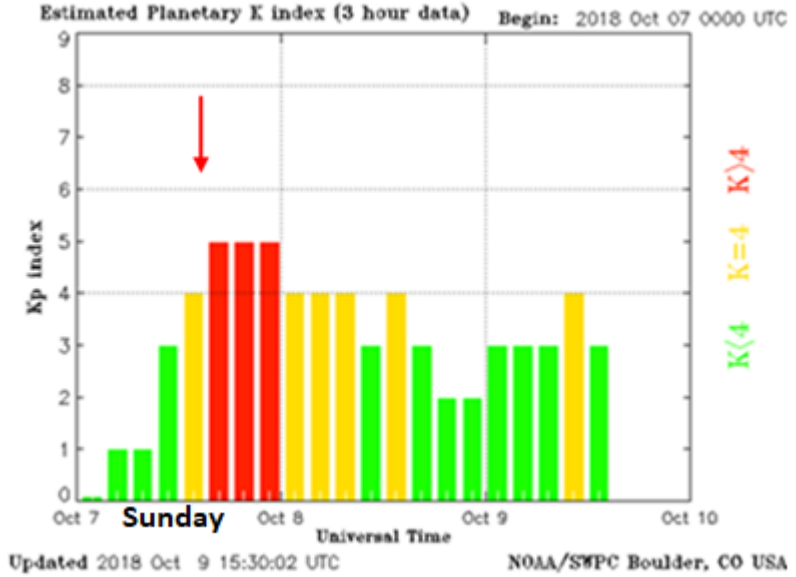
$$L_m = 36\left[\frac{f}{f_b} - 1\right]^{1/2} \text{ dB, or 62 dB whichever is the smaller.}$$



- *It also helps that ionospheric absorption at 50 MHz is minimal*
  - There's also an equation for the E region – thus the E region MUF doesn't have to be 50 MHz for a readable signal
  - FT8 will give you more opportunities

Moderate Spike in the K Index





- California QSO party – October 2018
- No W6s on 10m at K9LA on Saturday – MUF only around 20 MHz
- Many W6s on 10m at K9LA on Sunday – MUF up to 30 MHz
- Boulder ionosonde is about the midpoint of the path from W6 to K9LA

Propagation This Fall/Winter

- The higher bands (15m, 12m, 10m) should be excellent for worldwide F_2 propagation
  - Just like last fall/winter – and Cycle 25 will be higher than in the fall/winter of 2022
- I expect we'll have some F_2 propagation on 6m
  - Just like we did around the maximum of Cycle 24 in the fall/winter
  - Not much, but it should be there if you're in the right place at the right time
- The lower bands (160m, 75/80m, 60m, 40m) should be decent at night
  - More big solar flares and CMEs are a detriment as we approach solar max
  - And more people migrate to the higher bands because of stronger signals
  - General consensus is that 160m is not as good as it should be

Space Weather and Propagation

- Lots of data on the internet – two general categories
- Solar indices – indication of the amount of ionization (MUF)
  - SN – sunspot number
  - SFI – 10.7 cm solar flux index
  - EUV – extreme ultra-violet radiation
- Geomagnetic field indices – indication of a degradation to the MUF
  - K – 3-hour index (activity of Earth's magnetic field)
  - A – daily index (average of eight K indices)
  - Bz – component of interplanetary magnetic field that aligns with the Earth's magnetic field
  - SW – solar wind speed

IMHO, pay attention to the SFI and the K index

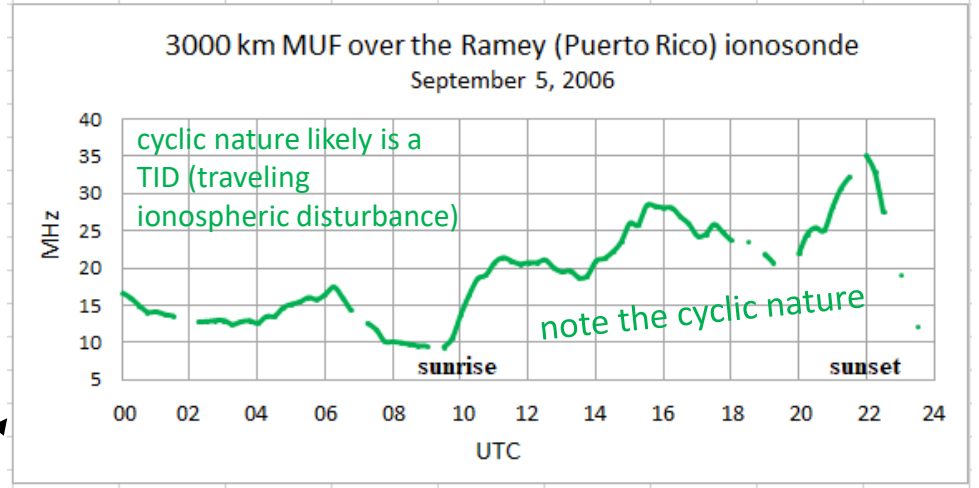
Applying the SFI and the K-Index

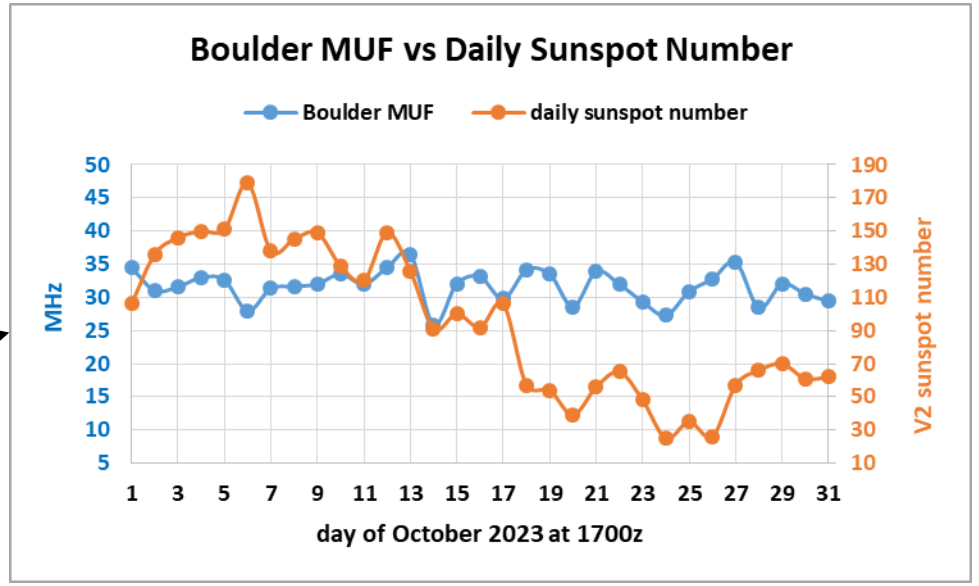
- For propagation on the higher bands (15m, 12m, 10m)
  - Best around solar maximum
  - Long-term SFI greater than 100 and K less than or equal to 3
- For propagation on the middle bands (30m, 20, 17m)
  - Good throughout a solar cycle
  - SFI not a big issue and K less than or equal to 3
- For propagation on the low bands (160m, 75/80m, 60m, 40m)
  - Best around solar minimum
  - Long-term SFI less than 80 and K less than or equal to 3
- For F2 propagation on 6m
  - Best in the fall/winter months around a big solar maximum
  - Long-term SFI greater than 200 and K less than or equal to 3

Do these numbers guarantee propagation?

No, They Don't ☹

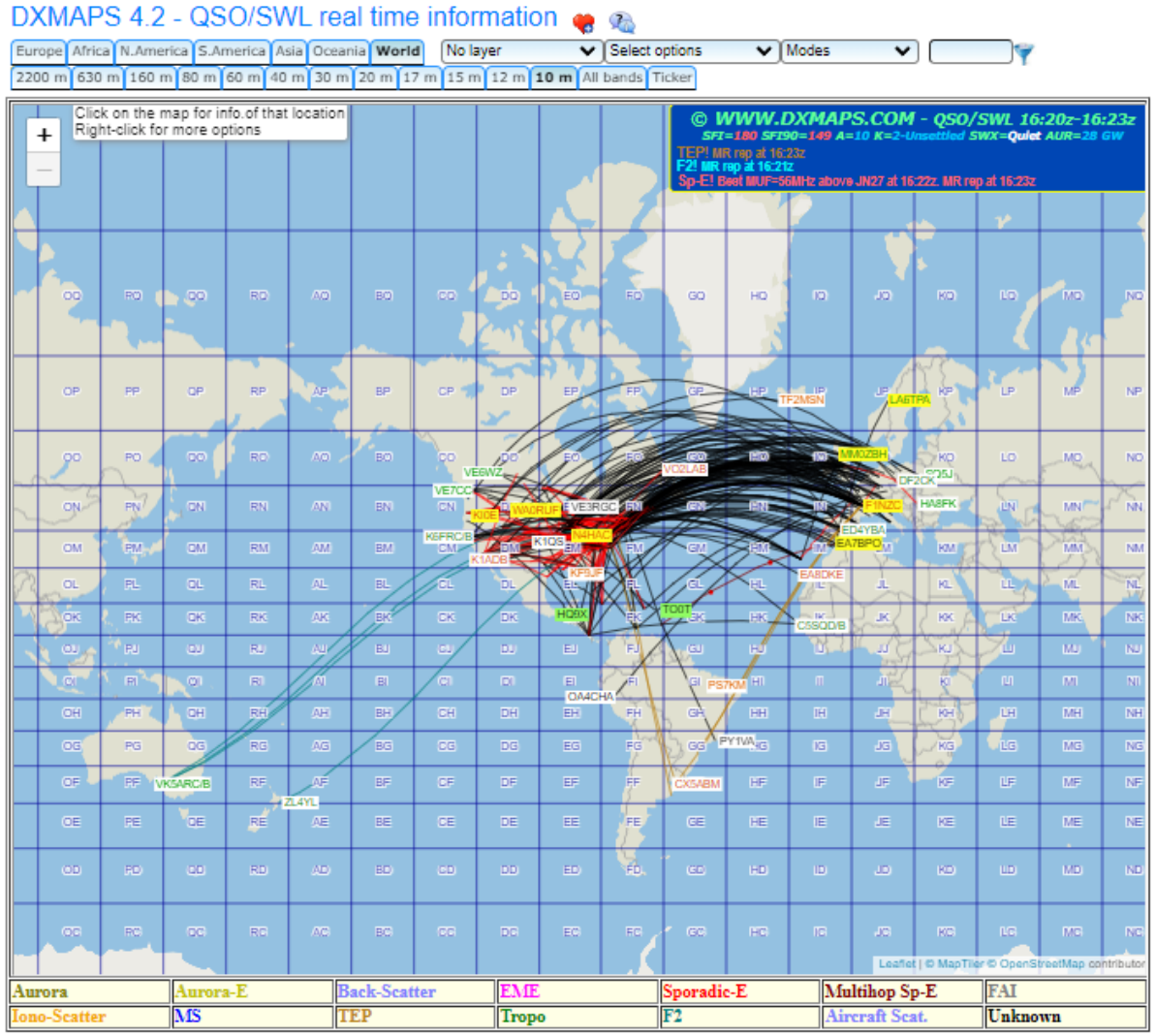
- What's the problem?
- Three sources of the day-to-day variation of the ionosphere
  - Solar activity – *we have a good understanding of this*
  - Geomagnetic field activity – *we have a decent understanding of this*
  - Events in the lower atmosphere that couple up to the ionosphere – *no parameters*
- What this means
  - We don't have daily predictions
  - Example
    - SN went from 150 to 50
    - MUF remained pretty much constant



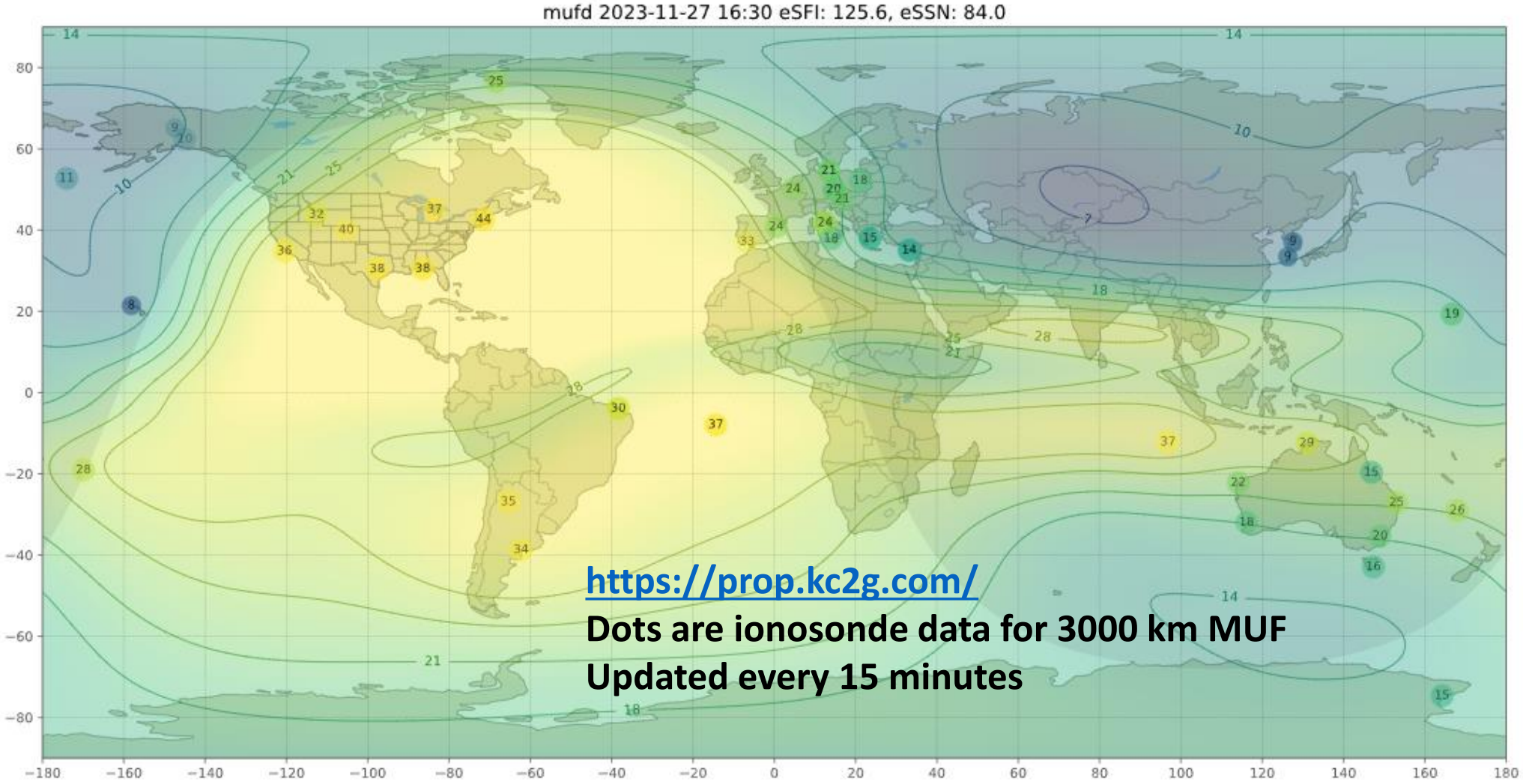


Real-Time Propagation

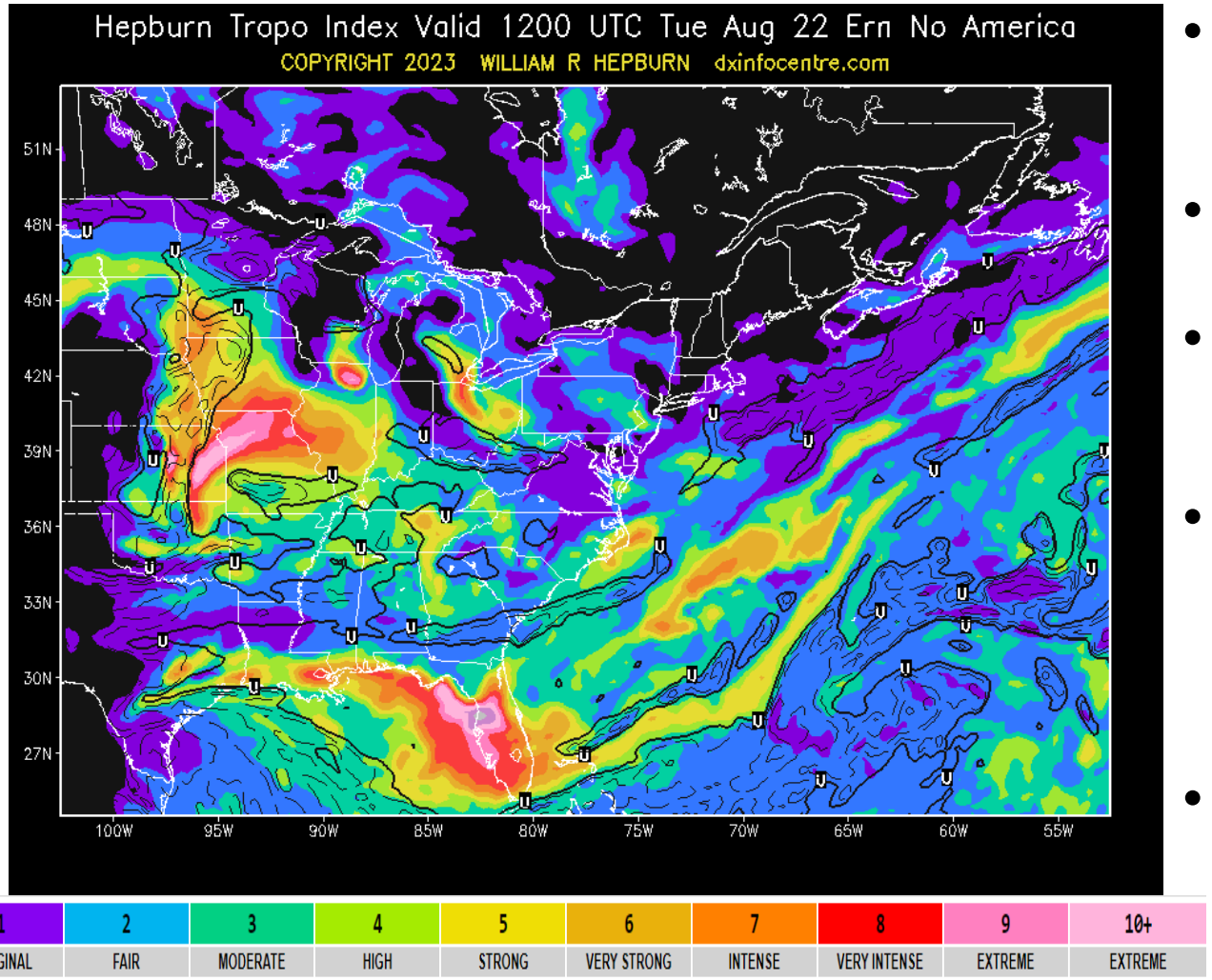
- Visit dxmaps.com
- Select view, select band
- Image today from 1620-1623 UTC (10:20-10:23 CST)
- Other methods
  - WSPRnet
  - PSKreporter
  - IARU/NCDXF beacons
  - Reverse Beacon Network
  - probably others out there



Worldwide F_2 MUF Data



Hepburn Tropospheric Forecast



- W9VHF here in Ft Wayne had fun in August 2023 (around the 22nd)
- Outstanding VHF/ UHF tropo conditions.
- Worked 41 grid squares on 432 MHz and 13 on 1296 MHz
- Best on 432 MHz was AC4TO in Florida and several 1296 MHz contacts in the 600 mile range
- 2 Meters sounded more like 20 Meters, with strong signals and long distance contacts

Summary

- Cycle 25 is still ascending – hopefully up to an average cycle
- Expect excellent worldwide 15m/12m/10m propagation now
  - Even some 6m F_2 propagation
- Get on the air and have fun!