Solar Cycle 25 Update and Propagation in 2026

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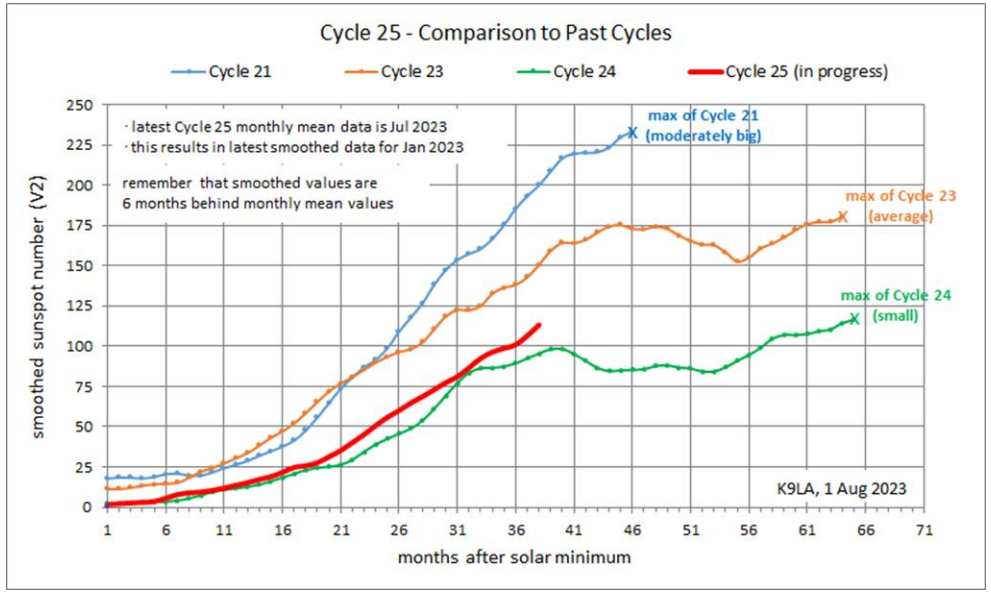
My Last Presentation to the Emerald ARS

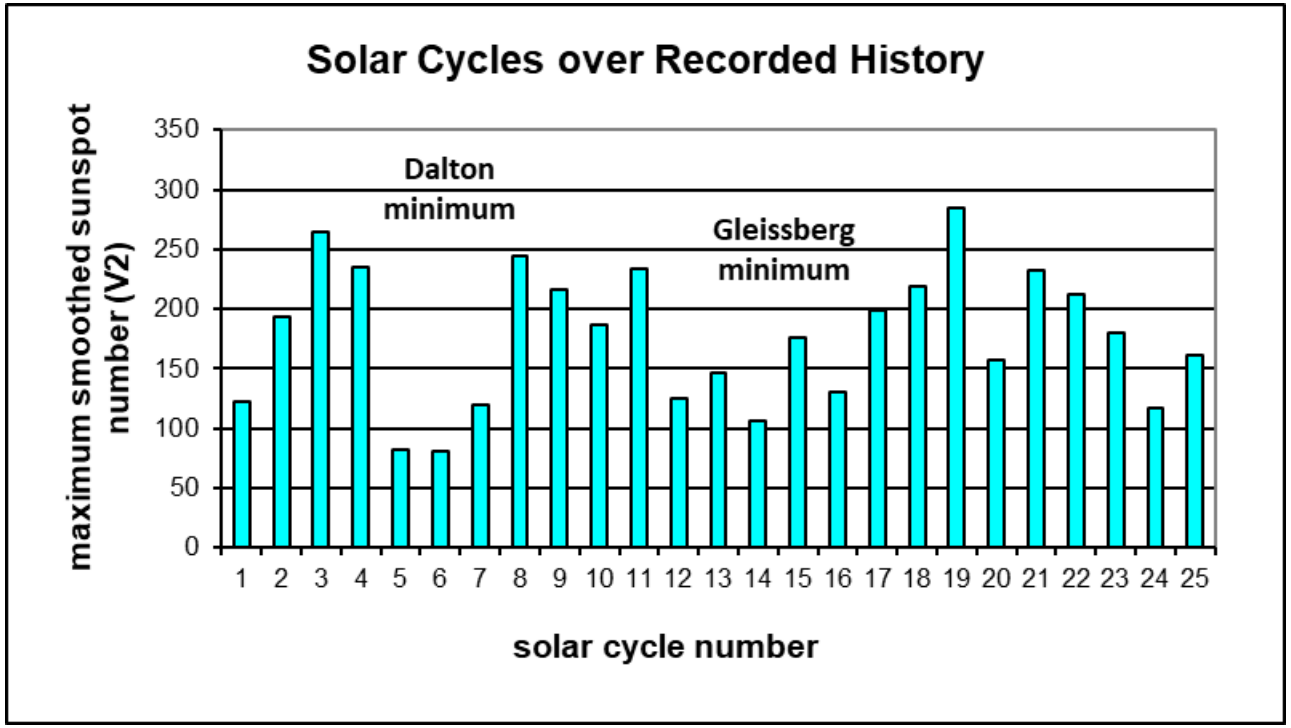
- August 2023
- Three years of data on Cycle 25
- Cycle 25 (red data) was looking like Cycle 24 (green data)



Agenda Tonight

- Historical solar cycle data
- Cycle 25 update
- Expected propagation in 2026
- Man-made and atmospheric noise
- Space weather and the ionosphere

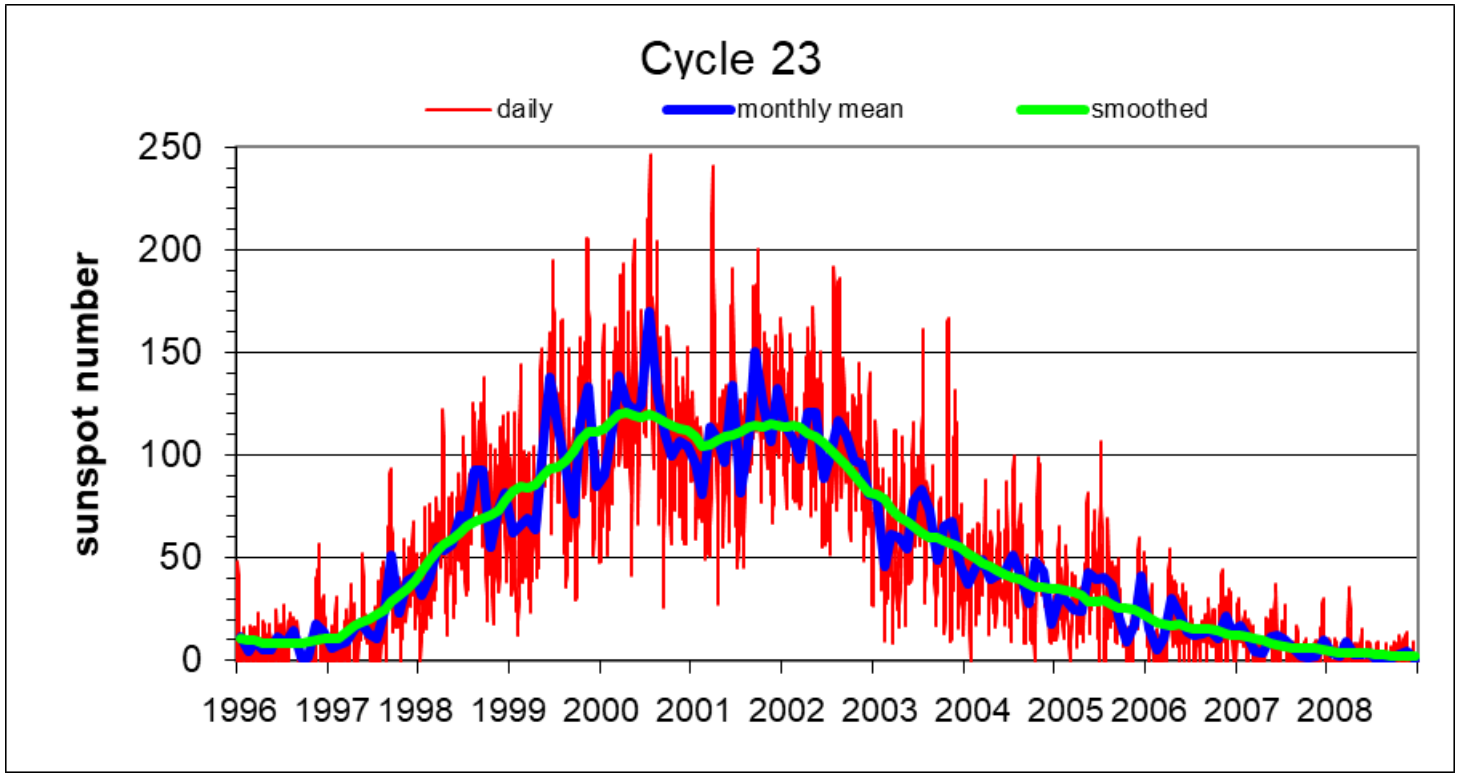
Historical Solar Cycle Data



note the cyclic nature of the data

- Cycle 1 began in 1755
- Average of all twenty-five cycles is 177
  - Includes Cycle 25
- Cycle 24
  - Smallest in our lifetimes
  - 4th smallest in recorded history
- Did Cycle 24 usher us into the third period of small solar cycles?
  - May need to see Cycle 26 to answer this question

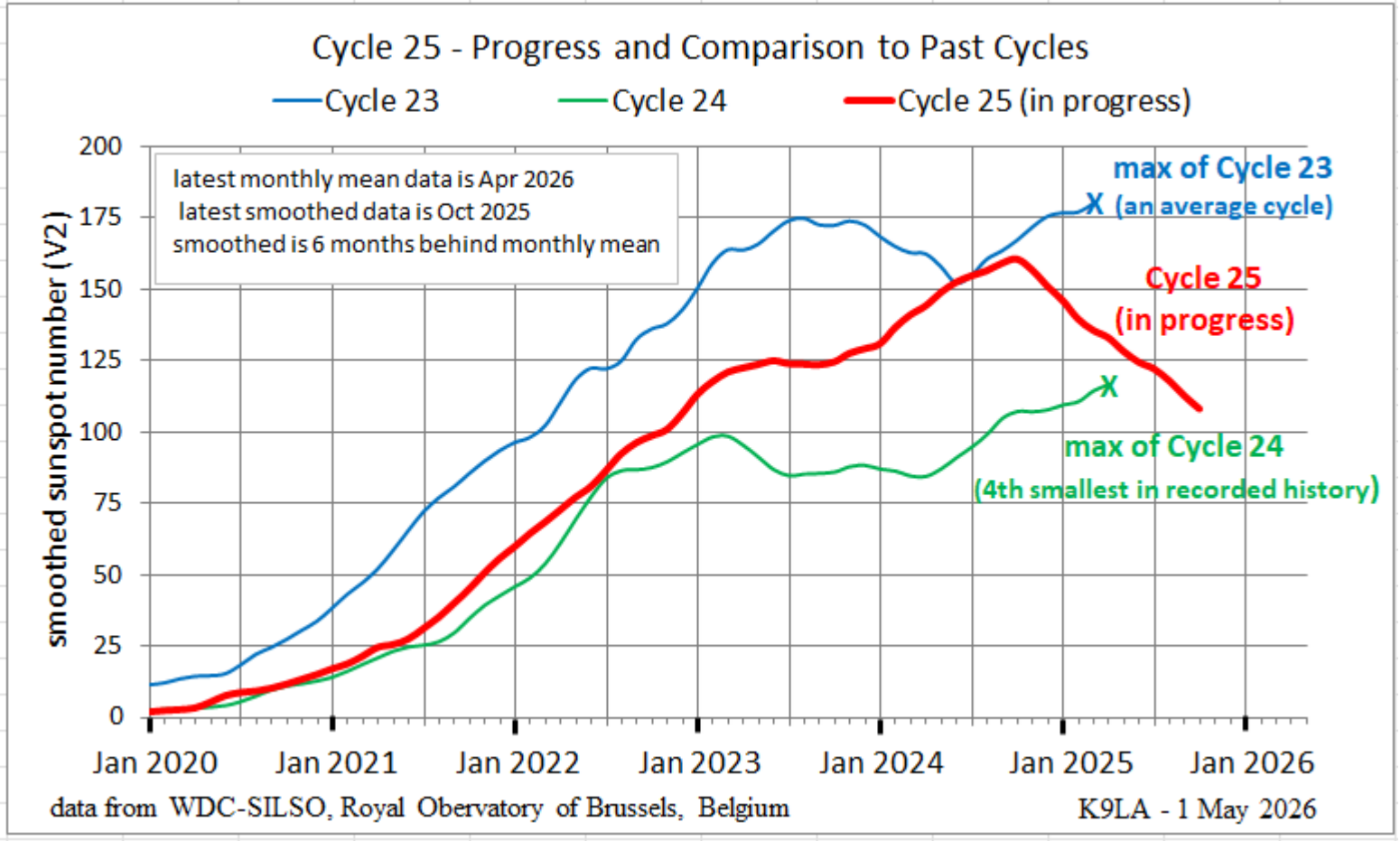
What Is a Smoothed Sunspot Number?



- Daily (red) – very spiky
- Monthly mean (blue) – still spiky
- Smoothed (green) – very smooth
- Similar results with 10.7 cm solar flux and EUV

- Smoothed is the official measurement of a solar cycle
- Smoothed gives the best correlation to the state of the ionosphere
  - Through monthly median ionospheric parameters (half the days of the month)

Cycle 25 Update



- The peak of Cycle 25 likely occurred in October 2024 at 161
- Second peak highly unlikely
- I'm confident that we are in the decline of Cycle 25

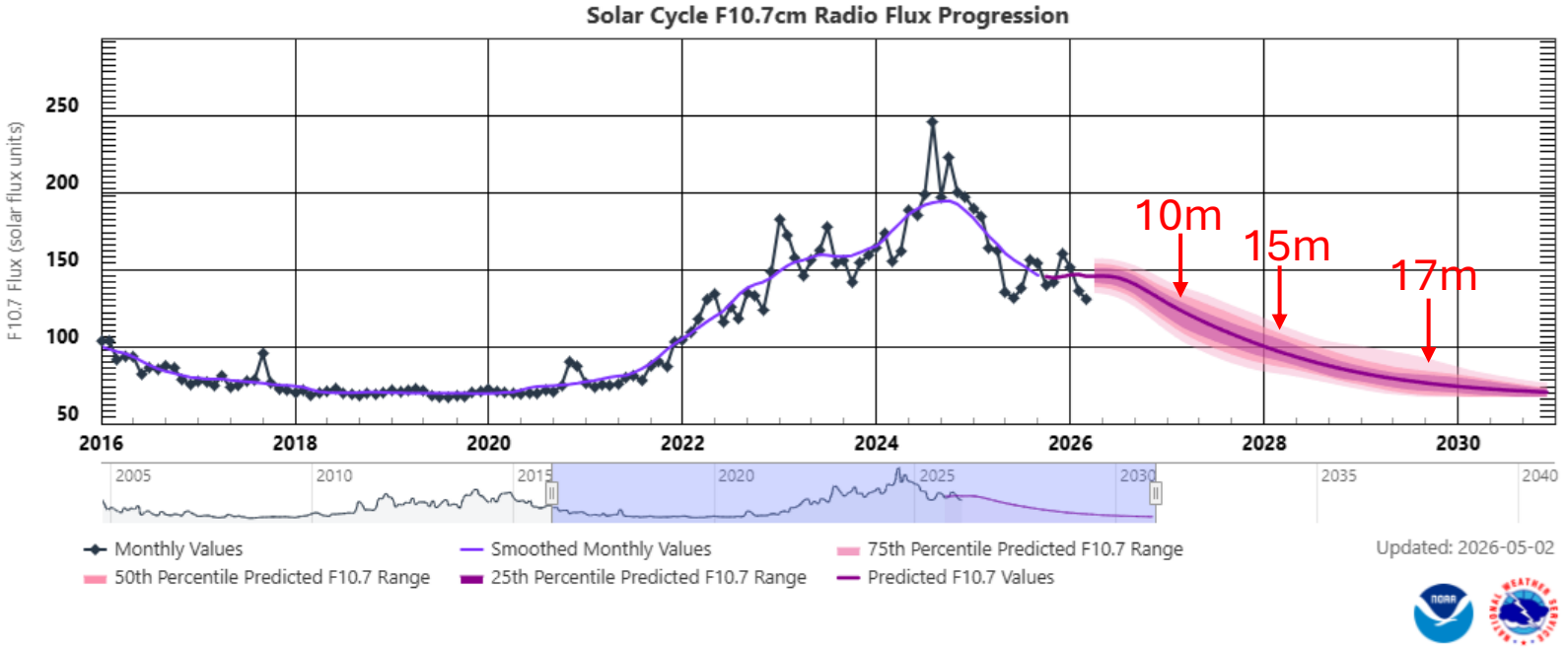
Propagation for 2026 – The Higher Bands

- 17m, 15m, 12m, 10m, 6m

- These bands are best for our long-distance QSOs via the F_2 region
  - F_2 region ionized by extreme ultra-violet (EUV) radiation from the Sun
  - Sunspots and 10.7 cm solar flux are proxies for EUV
- These bands are best around solar maximum (+/- couple years)

- For 17m, need long-term 10.7 cm solar flux $\geq$ 75
- For 15m, need long-term 10.7 cm solar flux $\geq$ 95
- For 10m, need long-term 10.7 cm solar flux $\geq$ 125
- For 6m, need long-term 10.7 cm solar flux $\geq$ 200

Decline of Cycle 25 from NOAA



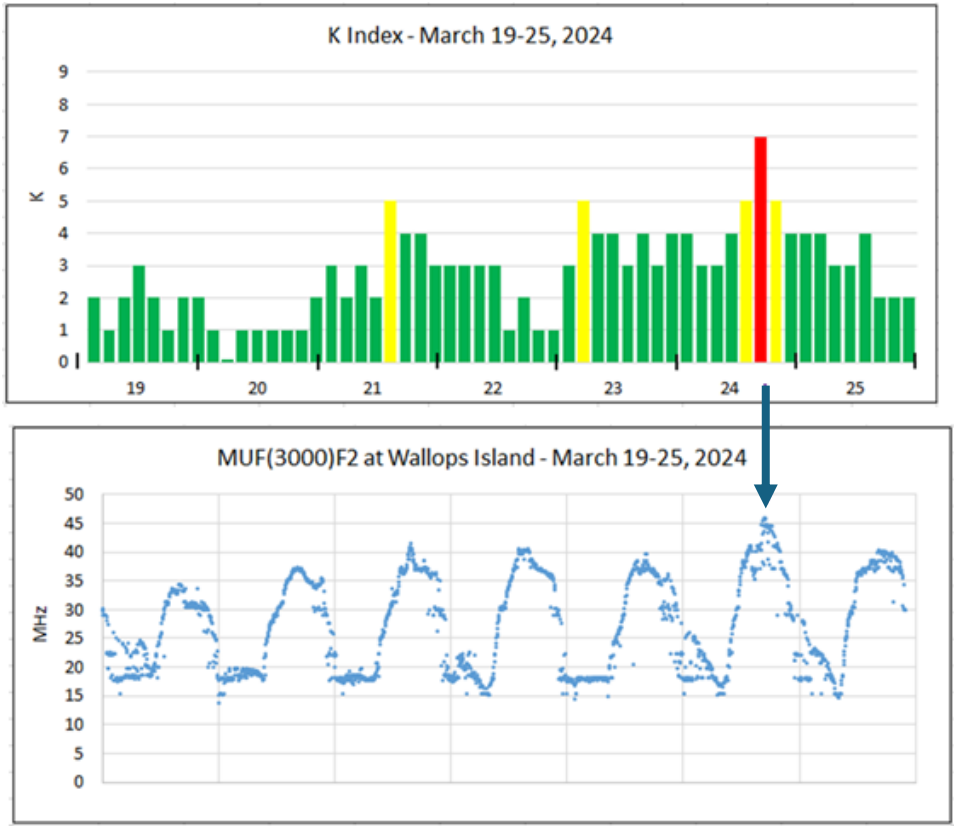
max smoothed solar flux

- Cycle 19 - 245
- Cycle 21 - 210
- Cycle 22 – 200
- Cycle 23 - 165
- Cycle 24 - 130
- Cycle 25 - 155

- 17m – decent to late 2029
- 15m – decent to early 2028
- 10m – decent to early 2027
- 6m – not much hope

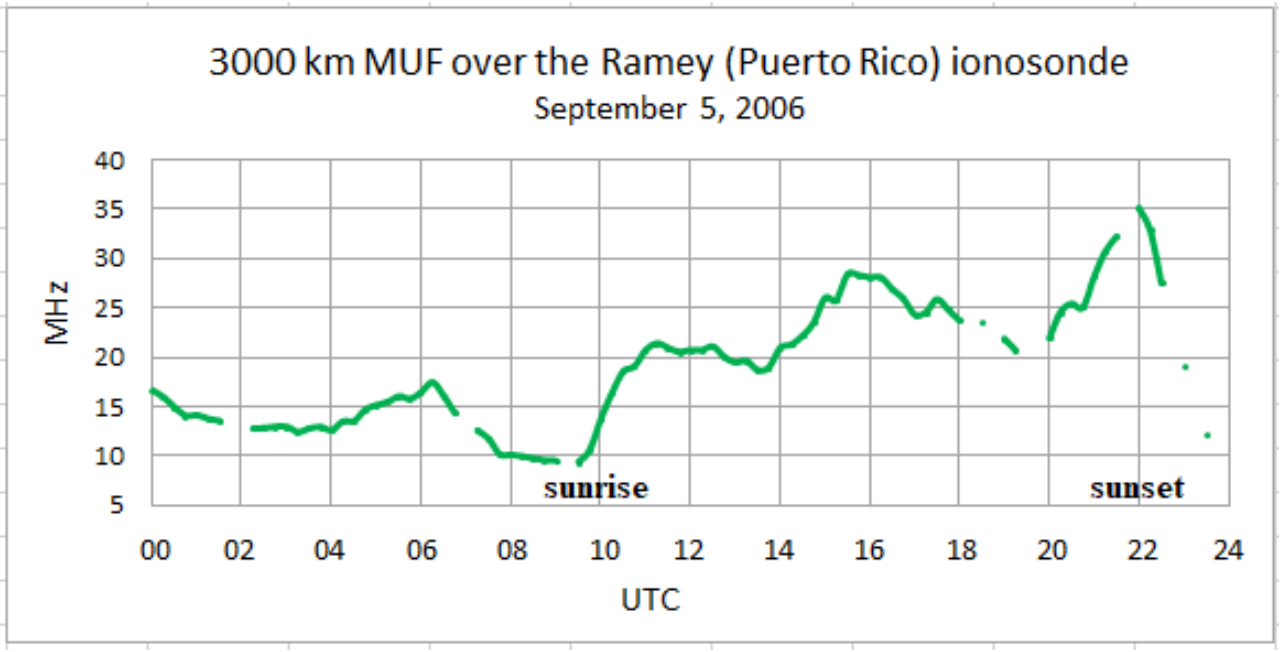
- But watch for
  - Short-term F_2 region enhancements – next two slides
  - Sporadic-E – slide 11
  - Low-latitude F_2 region paths in the fall and winter – slide 12

F_2 Region Enhancement from a Moderate Spike in the K Index



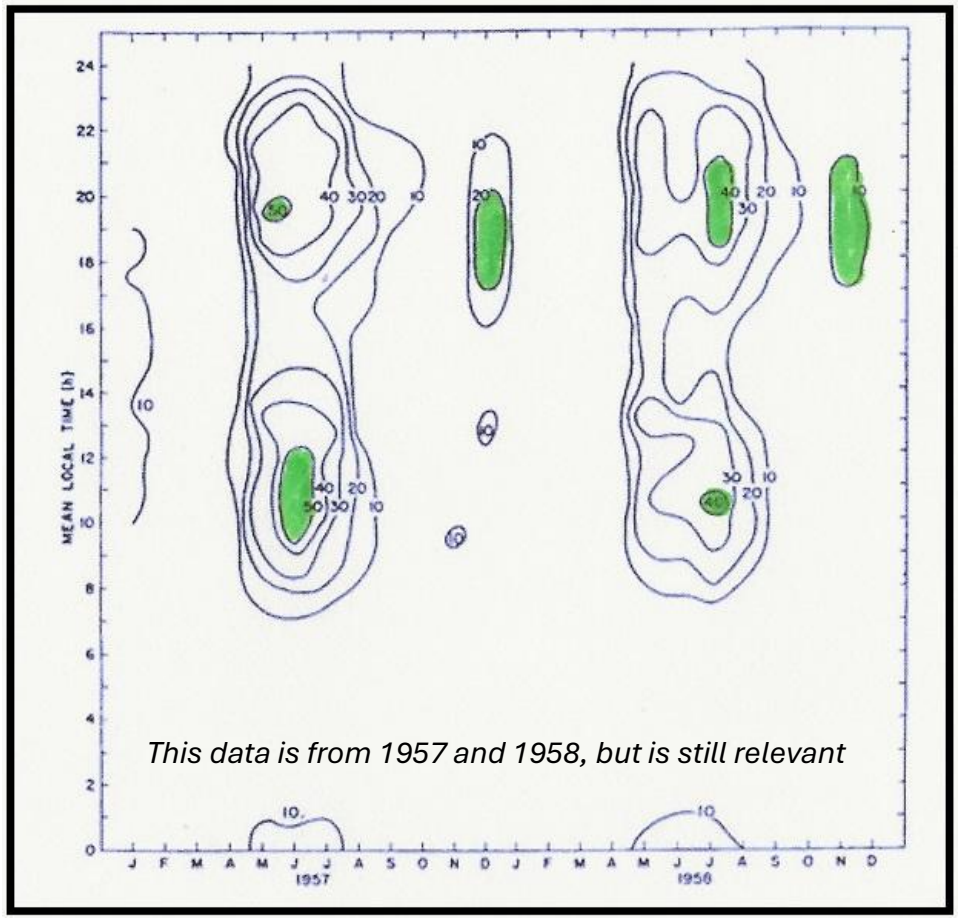
- It is short-term
  - Need to be in the right place (band) at the right time (when the K index spikes up)
- Most prevalent at low and mid latitudes
- Monitor the trend in the K index

F_2 Region Enhancement from a Traveling Ionospheric Disturbance (TID)



- Cyclic in nature
- It can be from an event in the lower atmosphere or from an event in the auroral zone
- I'm not aware of any website that easily shows this

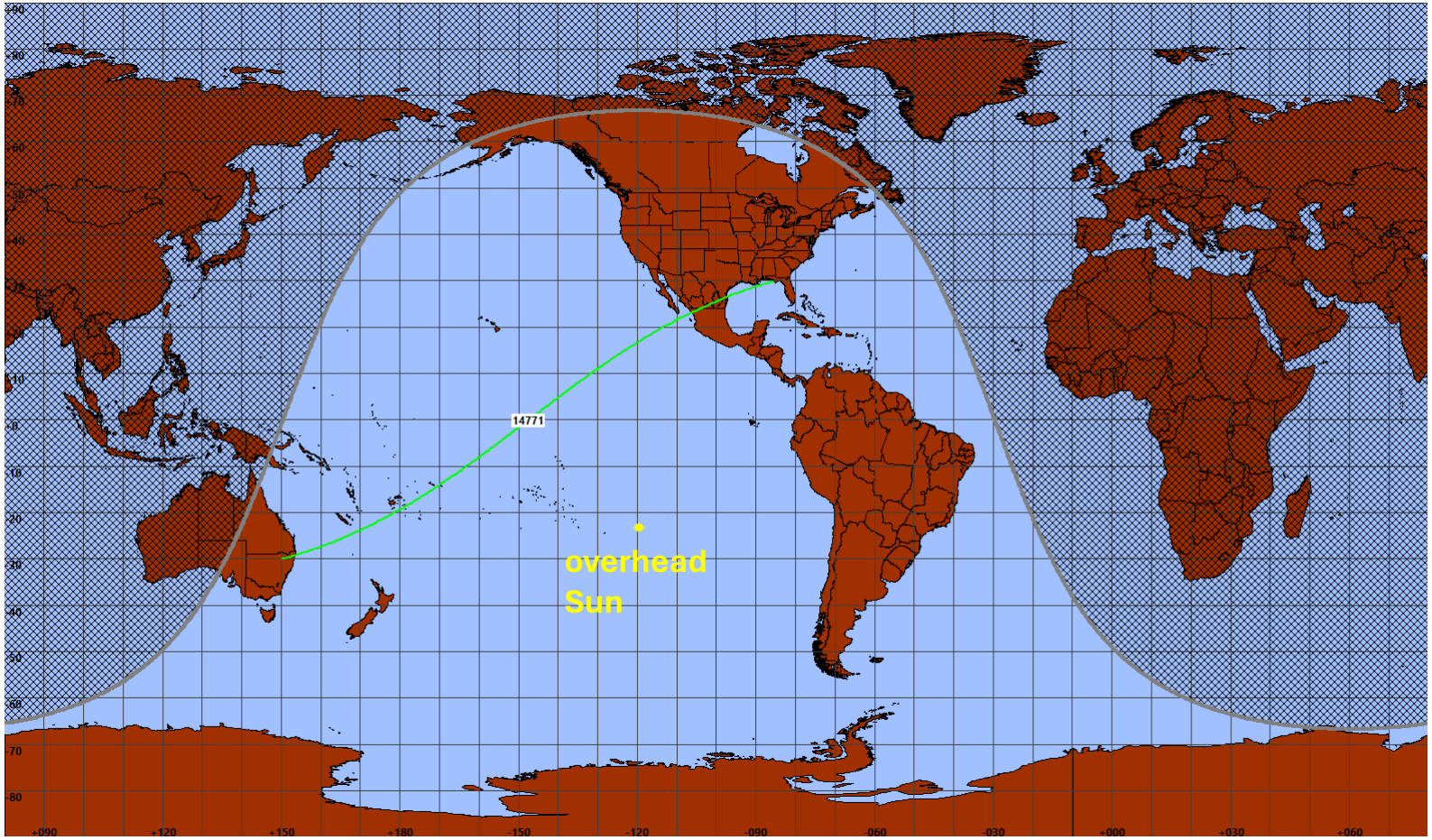
Sporadic-E



Tells us how many days of 6-meter sporadic-E are expected per month at a given local time

- Best in summer
  - Late morning and early evening
- Lesser probability in December
  - Early evening
- Caveat - sporadic-E can occur outside of these ‘peak’ times
- Bi-modal summer probabilities can offer long multi-hop QSOs
- Several hams are studying sporadic-E in relation to tropospheric events
  - Jim G3YLA
  - Joe K1YOW
  - Probably others

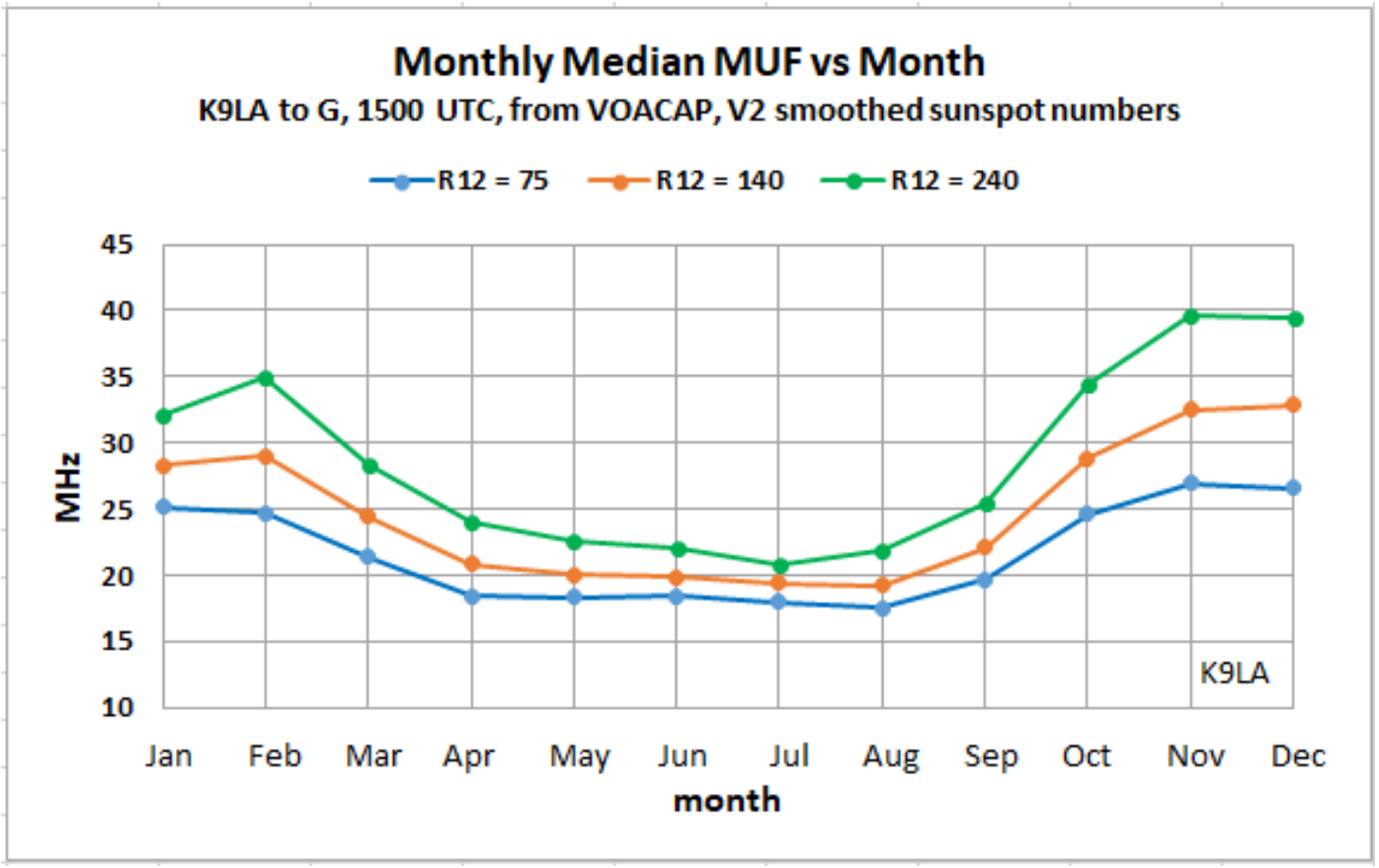
Low-Latitude F_2 Region Paths in the Fall and Winter



- Example
  - Southern USA to Australia
- Path stays in the robust equatorial ionosphere
  - Less than 30° north and 30° south latitudes

The Summer Decrease in F_2 Propagation

during the daytime in the northern hemisphere



- This happens every year
- Due to a change in the composition of the atmosphere
- MUF around 20 MHz in the summer months
- Hopefully, sporadic-E will be available for 10m and 6m in the summer months

Propagation for 2026 – The Lower Bands

- 160m, 80m, 60m

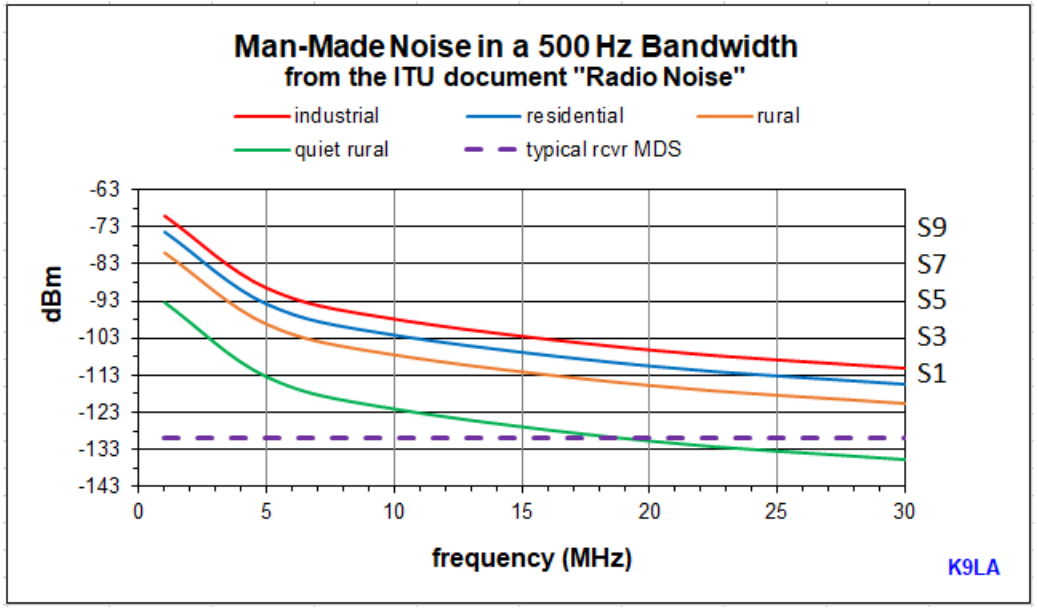
- Enough ionization even at solar minimum (10.7 cm solar flux around 65)
- Best in the winter months around solar minimum (+/- couple years)

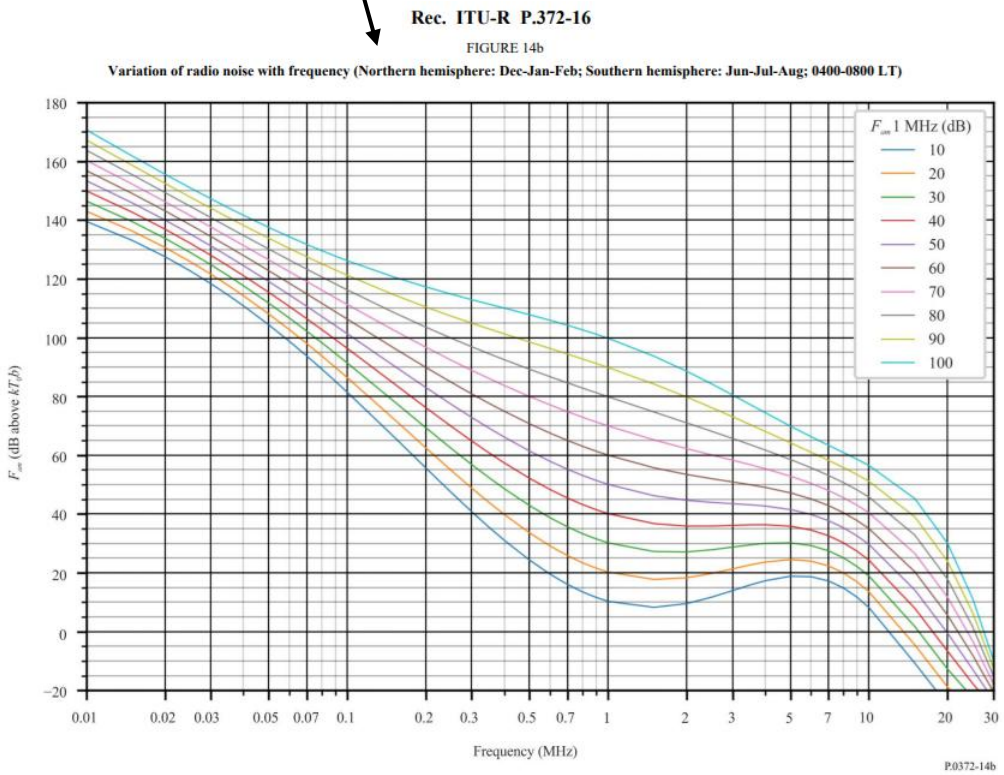
- Need low ionospheric absorption to be heard or to be decoded due to man-made and atmospheric noise levels
  - Absorption is inversely proportional to the square of the frequency

- These bands should be improving as Cycle 25 declines
- But man-made noise has increased – next slide

- Receive antennas are beneficial to mitigate noise

Man-Made and Atmospheric Noise





- *Data for the man-made noise plot is from the 1970s*
- *We have more man-made noise now due to more electronic devices*
  - *Lower bands are most affected*
  - *Up to 10 dB worse on 160m in a residential noise environment*

Propagation for 2026 – The Middle Bands

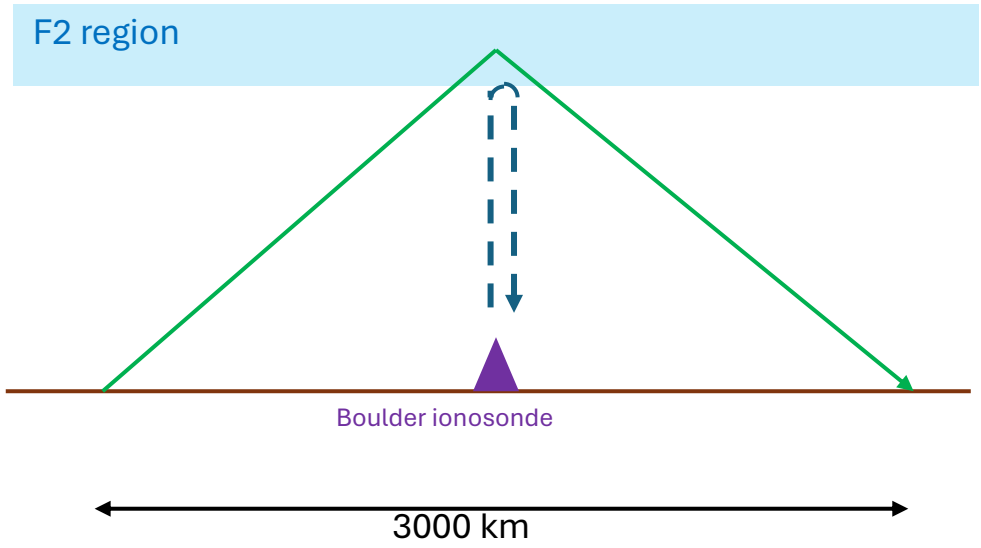
- 40m, 30m, 20m

- Can tolerate some ionospheric absorption
- Do not need a lot of F_2 region ionization
- Should be good throughout a solar cycle

- 40m and 20m are great for POTA operations (and Field Day)

Measuring the Ionosphere

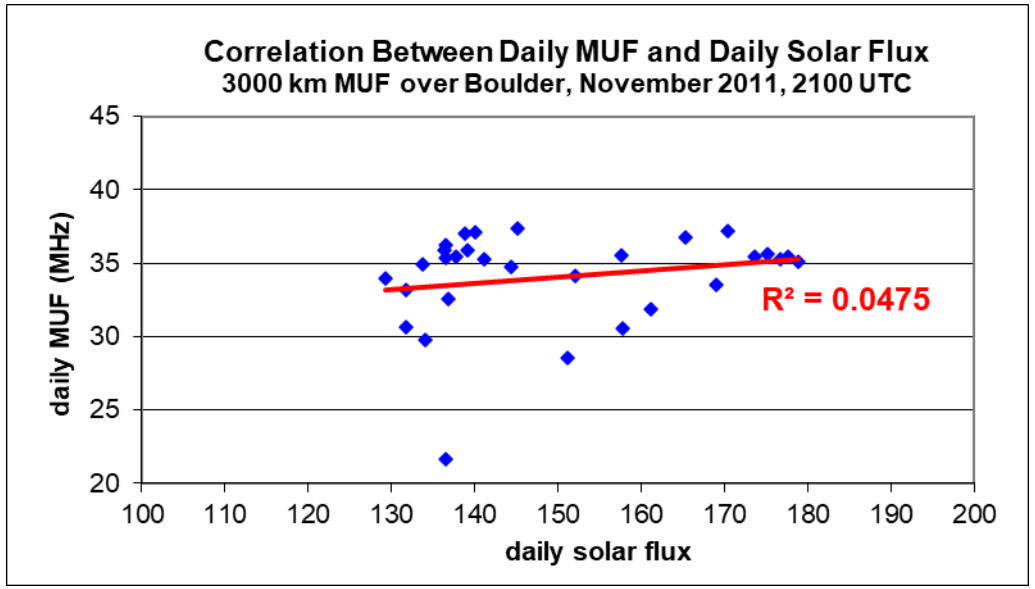
- Ionosondes are used (unfortunately more are going non-public)
  - They send pulses straight up while increasing the frequency
  - They measure the highest frequency that is returned to Earth at vertical incidence (the dashed line in the image below)



- From this data, we can calculate the highest frequency that returns to Earth at a given distance at a lower elevation angle
- This is the MUF (maximum useable frequency) for the specific path
  - Varies versus month, time of day, disturbances (elevated K index is worst) and where we are in a solar cycle

Space Weather

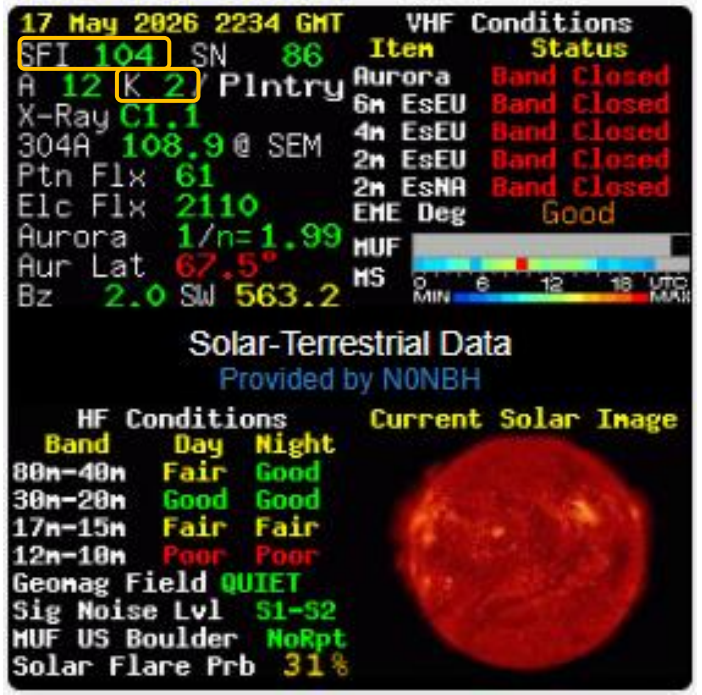
- Do we have daily propagation predictions?
  - Lots of space weather data available
  - Let's look at the daily 10.7 cm solar flux vs the daily MUF



- Correlation is not good
  - For a given solar flux value, the daily MUF could be off by at least one band
- Similar results with the daily sunspot number or the daily EUV
- A solar index is just 1 of the 3 factors that determines what the ionosphere is doing
- From slide 5, the smoothed sunspot number correlates very well to monthly median MUF and signal strength – ***we don't have daily predictions***

What We Generally Desire

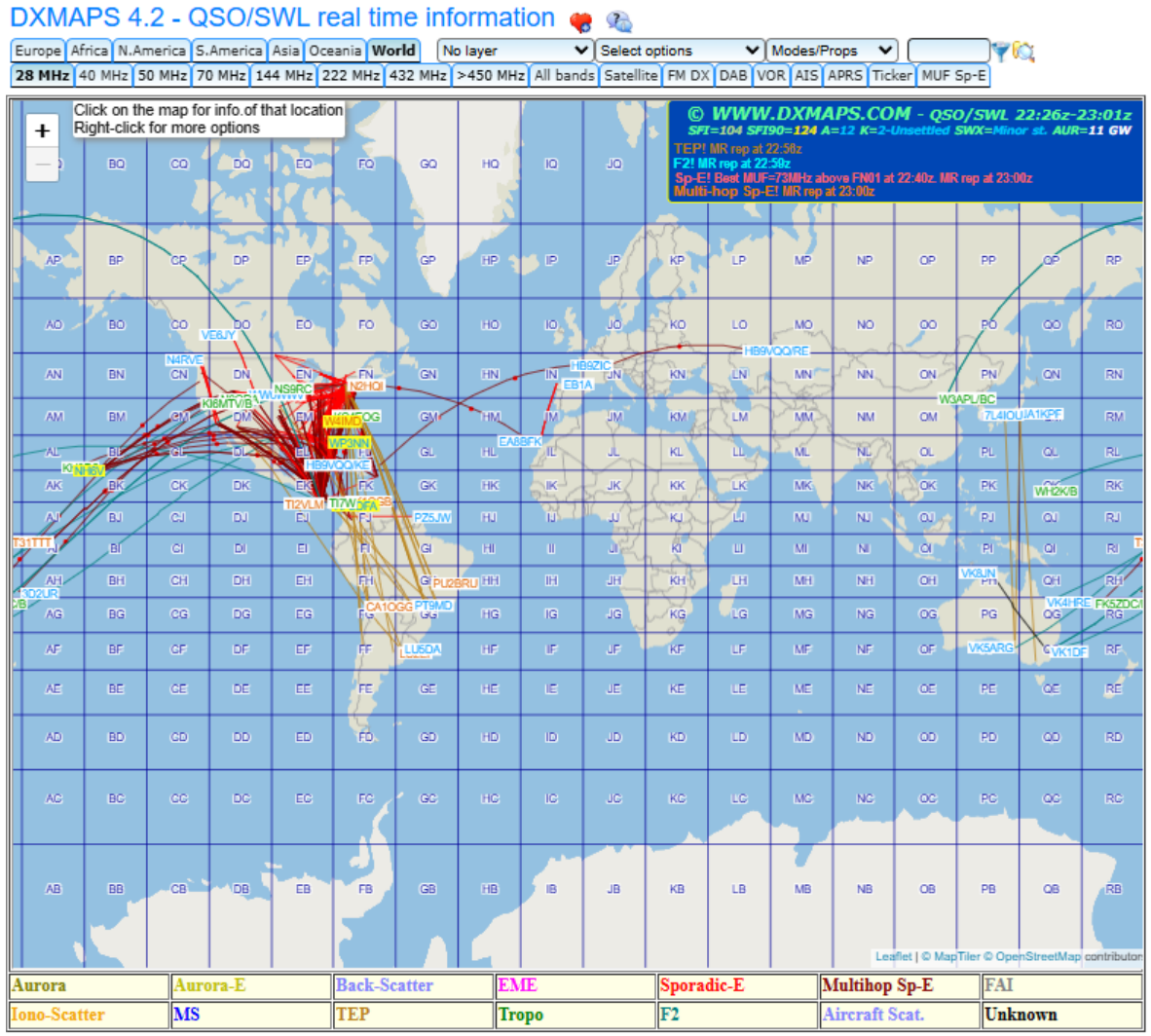
- For a general picture of the ionosphere today, monitor 10.7 cm solar flux and the K index
- 10.7 cm solar flux
  - Range is 65 to 300
  - Use band data on slide 7
- K index
  - 3-hr parameter, eight values per day, range is 0 (quiet) to 9 (disturbed)
  - For HF enthusiasts, desire K $\leq$ 3
  - For VHF enthusiasts, desire K $\geq$ 6 for propagation via aurora



from **qrz.com**

See next slide for a way to assess what a band is doing right now

dxmaps.com



- Sunday afternoon
  - 3:26 – 4:01 PM PDT
- 10m
- World view

- Red paths are sporadic-E
- Light brown paths are TEP to extreme southern South America
- Green paths are F_2
  - Thanks to the robust equatorial ionosphere

References and Websites

- References
  - The propagation chapters of the ARRL **Antenna Book** and **Handbook**
  - **Here to There: Radio Wave Propagation** by the ARRL
  - **The Little Pistols Guide to HF Propagation** by NM7M (SK)
    - Out of print, but it's on my website
  - **Radio Propagation Explained** by GØKYA (RSGB)
  - **The CQ Shortwave Propagation Handbook – 4th Editio**n (out of print due to CQ's demise)
  - Many others, including those specific to the low bands and 6-meters
- Websites
  - To see what a band is doing right now – **dxmaps.com, psk.reporter**, **wsprnet.org**
  - To see the current solar flux and K index – **qrz.com** (NØNBH banner on slide 19)
  - Worldwide MUF map - **prop.kc2g.com/**
  - More sites – **spaceweather.com**, **swpc.noaa.gov**, **solarham.com** and others

Summary

- Cycle 25 is likely in its decline
- We still should have good propagation on the higher bands this fall and winter
  - Some enhanced F_2 on 6m and hopefully good sporadic-E in the summer
- Simple antennas on the higher bands can work wonders with modest power (100 Watts)
- We have more made-made noise nowadays
  - Especially hurts the lower bands
- Space weather can give us an idea of how propagation is
- For a real-time assessment of a band
  - dxmaps.com, psk.reporter, wsprnet.org