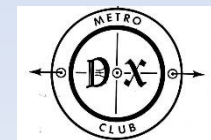


W9DXCC DXU/CTU 2024

Space Weather and Propagation

Carl Luetzelschwab K9LA
k9la@arrrl.net



The 64,000 Dollar Question

Does today's space weather tell us exactly what the ionosphere is doing today?

-- No --

It gives us a general idea of what's going on



W9DXCC
DXU/CTU 2024
K9LA

Agenda

- Examples of the 64,000 dollar question
- Why can't we determine what's exactly going on from today's space weather?
- Disturbances to propagation
- The important space weather parameters
- General correlations
- A quick look at Cycle 25



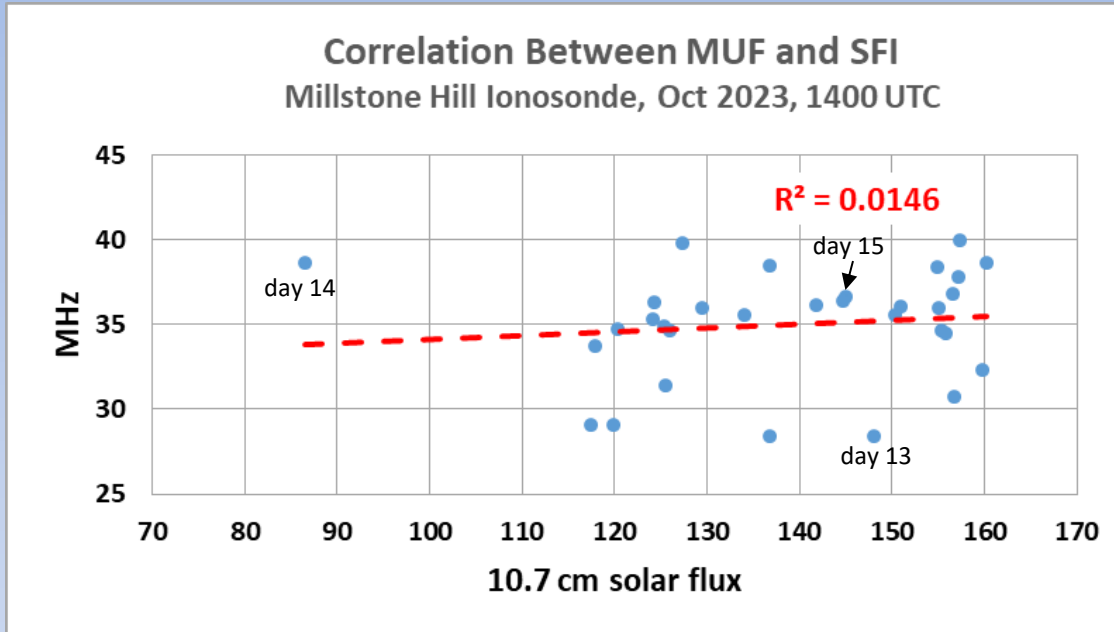
W9DXCC
DXU/CTU 2024
K9LA

Examples of the 64,000 Dollar Question



W9DXCC
DXU/CTU 2024
K9LA

Example #1



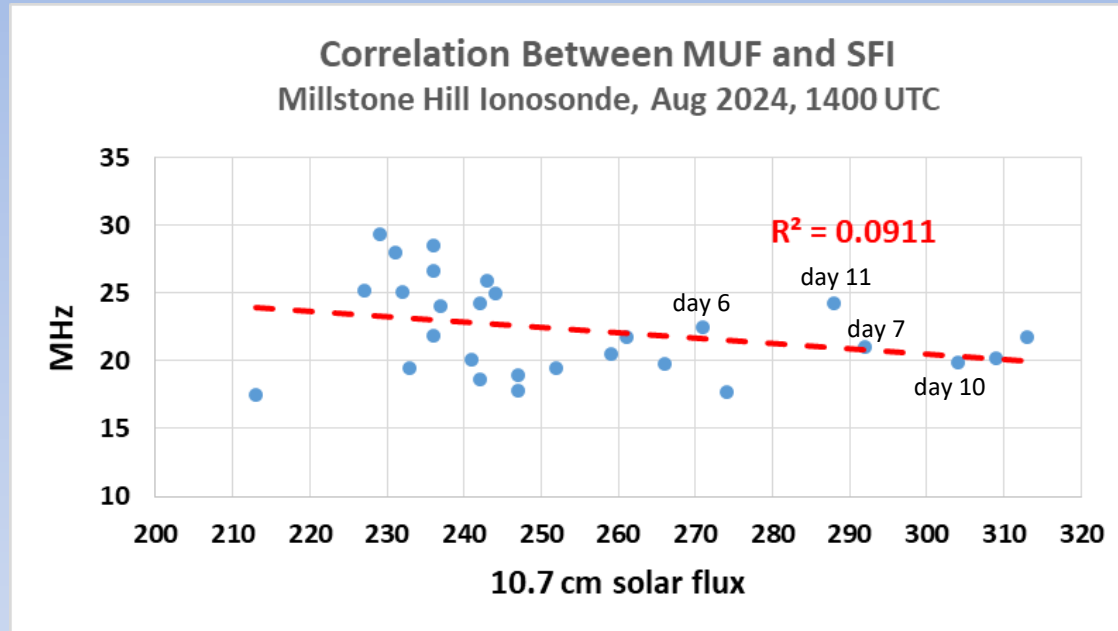
- MUF is maximum useable frequency
- For a flux of 137, MUF could be anywhere from 28 MHz to 38 MHz

day	solar flux	MUF in MHz	trend
14	86.5	38.7	flux up, MUF down
15	145	36.6	
13	148	28.4	flux down, MUF up
14	86.5	38.7	



W9DXCC
DXU/CTU 2024
K9LA

Example #2



day	solar flux	MUF in MHz	trend
6	271	22.4	flux up, MUF down
7	292	21	
10	304	19.9	flux down, MUF up
11	288	24.2	

The correlation between the daily flux and the daily MUF is poor - in the short-term, SFI can go up and the MUF can go down – and vice versa



W9DXCC
DXU/CTU 2024
K9LA

Why Can't We Determine What's Exactly Going On From Today's Space Weather?



W9DXCC
DXU/CTU 2024
K9LA

The Three Sources of F₂ Region Variability

- 1. Solar radiation
 - Best understood – contributes the least to variability
- 2. Geomagnetic field activity
 - Decent understanding with STORM
 - <https://www.swpc.noaa.gov/products/storm-time-empirical-ionospheric-correction>
- 3. Events in the lower atmosphere coupling up to the ionosphere
 - Least understood
 - No parameters (yet)

Understanding 2 of 3 isn't good enough to understand propagation in the short-term



Disturbances to Propagation



W9DXCC
DXU/CTU 2024
K9LA

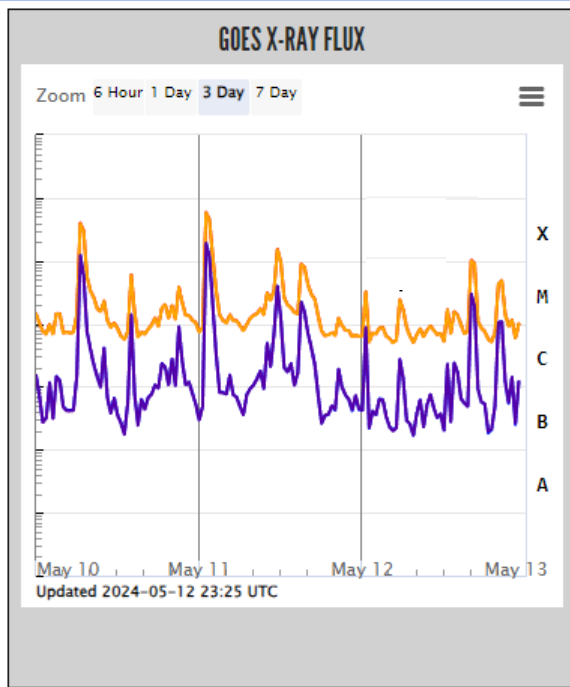
G, S, R

- **G** – Geomagnetic storm
 - Cause – Earth-directed CME or Coronal Hole
 - Effect – reduced F₂ region ionization
 - Duration – several days or more
- **S** – Solar radiation storm
 - Cause – concurrent big solar flare (M- and X-Class) and CME
 - Effect – degraded over-the-pole paths
 - Duration – a couple days
- **R** – Radio blackout
 - Cause – big solar flare
 - Effect – increased D region ionization on daylight side of Earth
 - Duration – an hour or so – lower frequencies affected most

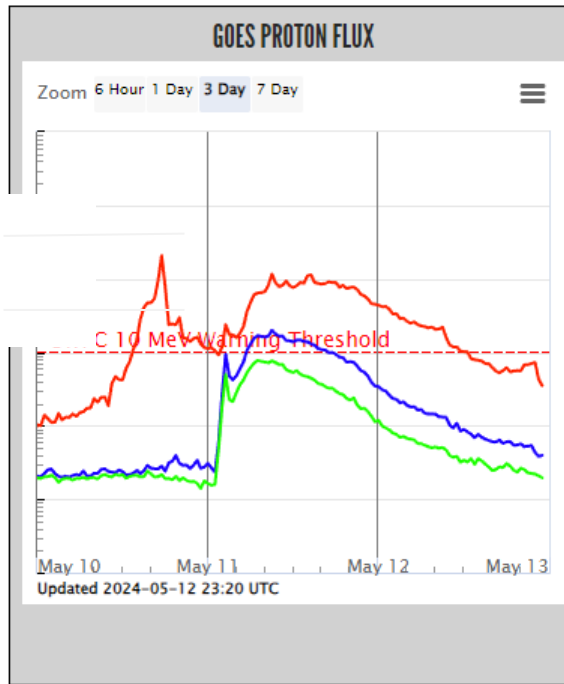


Something We Don't See Very Often

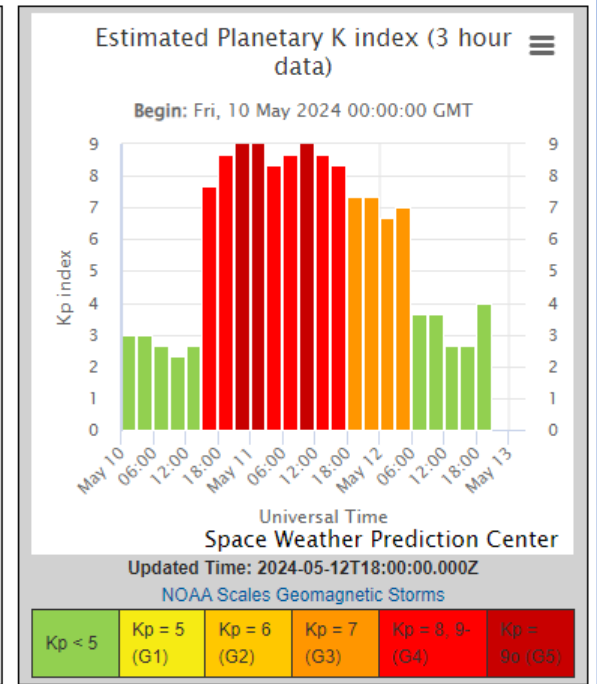
Early May 2024 – All Three Disturbances to Propagation



radio blackout from a big solar flare – an hour or so



solar radiation storm from a concurrent solar flare and CME – a couple days



geomagnetic storm from an Earth-directed CME (or Coronal Hole) – several days



W9DXCC
DXU/CTU 2024
K9LA

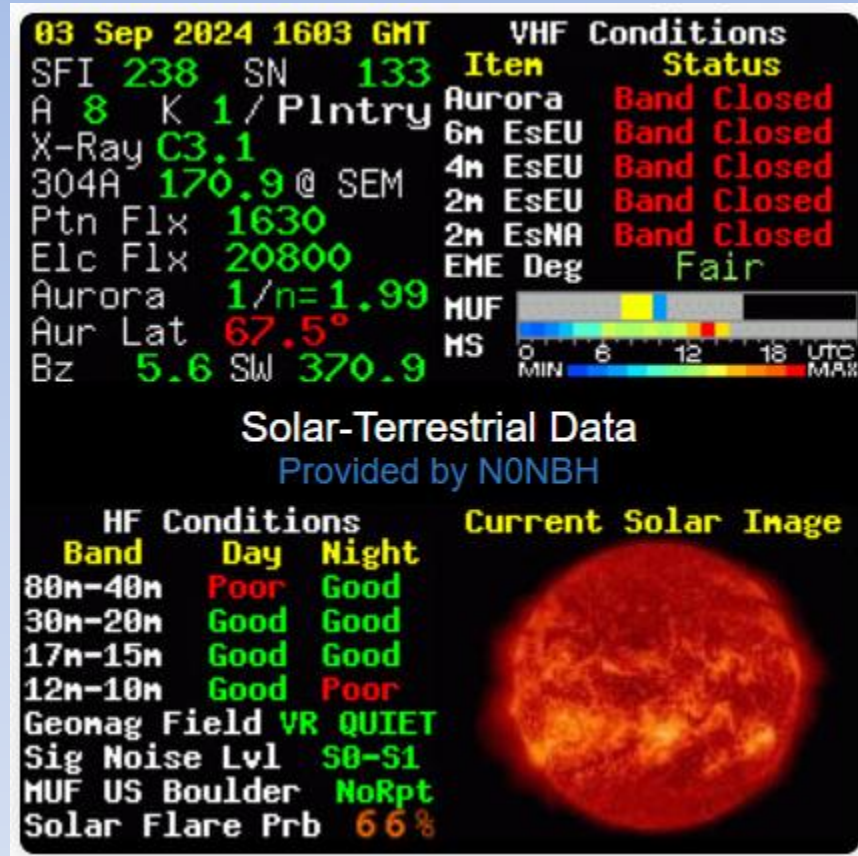
The Important Space Weather Parameters

-- at least the ones that I think are important --



W9DXCC
DXU/CTU 2024
K9LA

There's Lots of Data Available



NØNBH banner

- Image is from the home page at www.qrz.com
- Many other websites have even more data
- What we desire are parameters that correlate to the MUF and to the total path loss
 - MUF and loss determine if a QSO is possible



W9DXCC
DXU/CTU 2024
K9LA

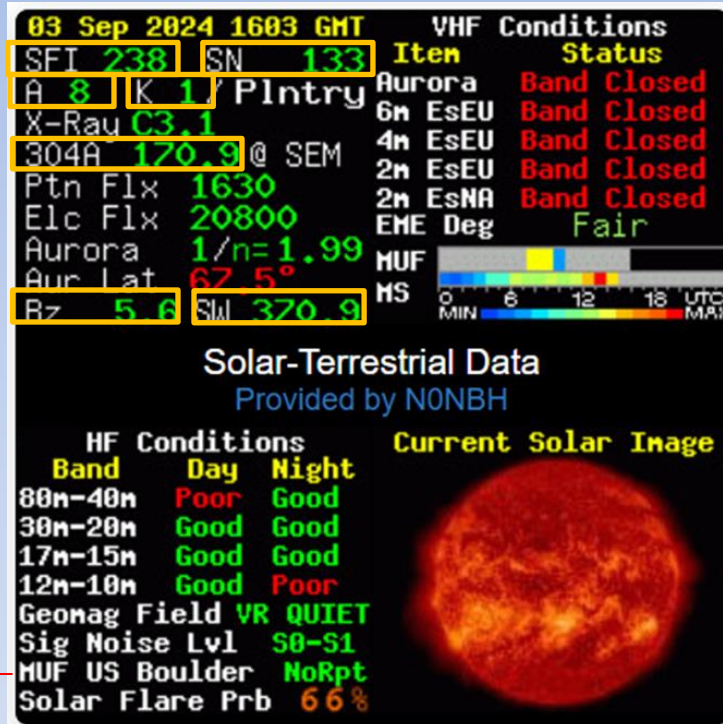
MUF Parameters

- We can divide the MUF parameters into two categories
 - Those that tell us how much the MUF should be (solar radiation)
 - Sunspot number, 10.7 cm solar flux, EUV
 - Those that tell us if there might be a degradation in the MUF (geomagnetic field)
 - K, A, B_Z, SW

Note that we can't do anything with events in the lower atmosphere

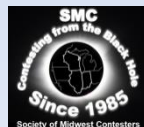


Details for the MUF Parameters



- SFI – daily 10.7 cm solar flux
- SN – daily sunspot number
- 304Å – daily EUV at 30.4 nm
- K – 3-hr index, logarithmic, 0 to 9
- A – daily index, average of eight 3-hr K indices, linear, 0 to 400
- B_z – component of the Sun’s magnetic field that is perpendicular to the ecliptic, aligns with Earth’s N-S magnetic field, large negative is bad
- SW – solar wind speed, quiet time is around 400 km/sec, higher could indicate elevated K

MUF US Boulder is a real-time measurement – if it’s reported



W9DXCC
DXU/CTU 2024
K9LA

Total Path Loss Parameters

- What makes up the total path loss?
 - free space path loss (spreading of the wave) – constant
 - Ionospheric absorption in the D region – it varies
 - Transmitter power, receiver sensitivity (may be limited by noise environment), antenna gains and ground reflections – can help overcome loss – constants
- Ionospheric absorption is the only one that varies in the short-term
 - We have models that tell us what it should be
 - But we have no daily measurements that tell us what the ionospheric absorption really is today



W9DXCC
DXU/CTU 2024
K9LA

MUF and Absorption on Our Bands

- Some physics
 - Refraction inversely proportional to frequency²
 - Absorption inversely proportional to frequency²
- 15m, 12m, 10m, 6m
 - MUF is critical, absorption is minimal
- 160m, 80/75m, 60m, 40m
 - MUF is usually high enough, absorption is critical
- 30m, 20m, 17m
 - Transition bands – generally good over a solar cycle



W9DXCC
DXU/CTU 2024
K9LA

General Correlations



W9DXCC
DXU/CTU 2024
K9LA

What We Desire for SFI and K

- 15m, 12m, 10m – best during the day near solar max
 - Long-term SFI (not just a couple days) ≥ 100 and $K \leq 3$
- 30m, 20m, 17m – good throughout a solar cycle
 - SFI generally not real critical and $K \leq 3$
- 160m, 75/80m, 60m, 40m – best at night near solar min
 - Long-term SFI ≤ 80 and $K \leq 3$
- 6m F₂ – best in fall/winter near big solar max
 - Long-term SFI ≥ 200 and $K \leq 3$
 - We will have some F₂ on 6m this fall and winter
 - More on this tomorrow



W9DXCC
DXU/CTU 2024
K9LA

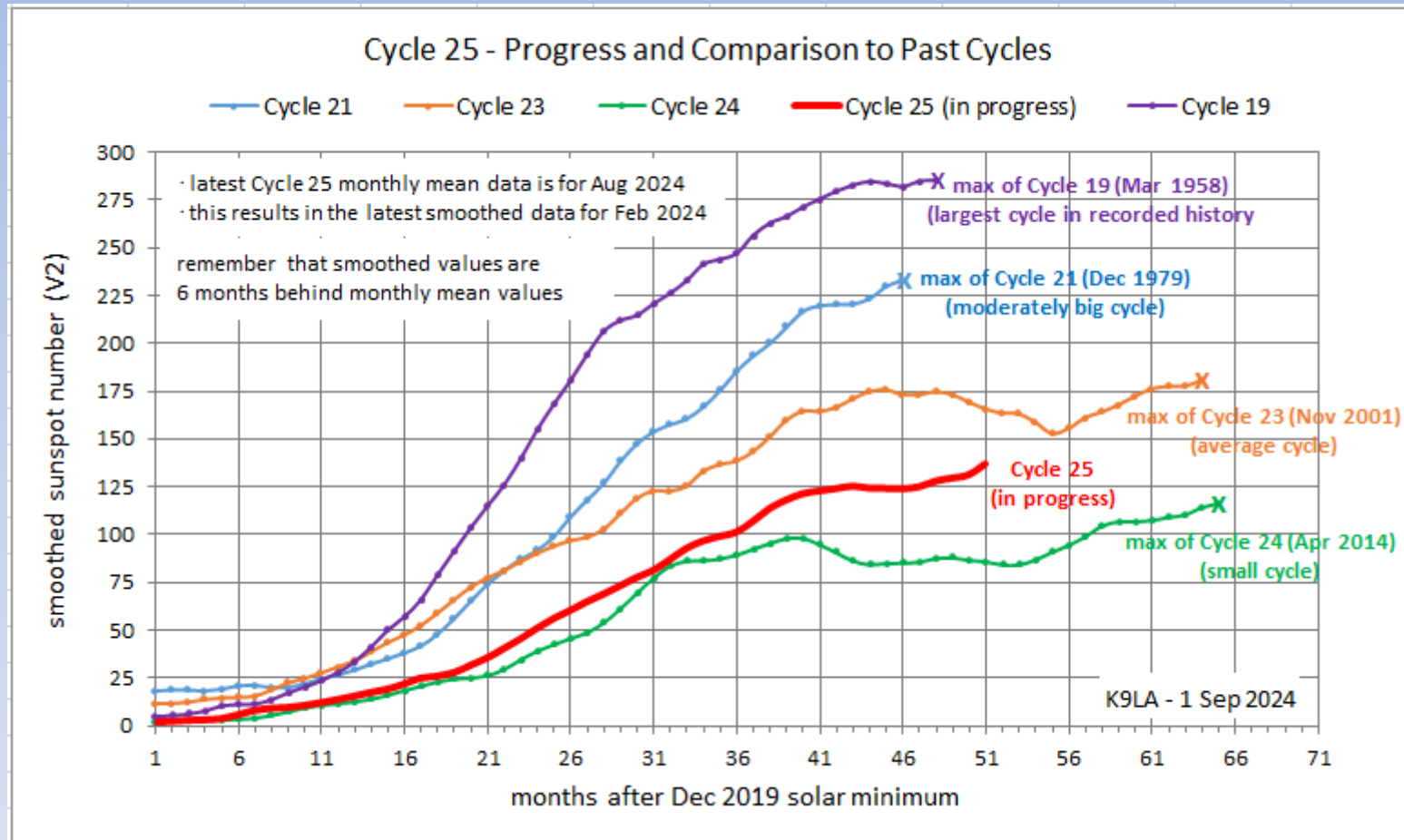
Caveats

- Radio blackout can cause band to go dead
 - Mitigation – QSY to a higher band (slide 10)
- Geomagnetic storm – lower MUFs
 - Mitigation – move down in frequency
- Solar radiation storm – over-the-pole degraded
 - Mitigation – try other way around (short path vs long path)
- Spike in the K index can enhance 10m and 6m F₂ propagation at low and mid latitudes
- If you're a VHF/UHF type, desire K > 5 for auroral propagation



W9DXCC
DXU/CTU 2024
K9LA

Quick Look at Cycle 25 – More Tomorrow



W9DXCC
DXU/CTU 2024
K9LA

Summary

- We don't fully understand the short-term ionosphere
 - We can't predict what's happening today
 - Neither can VOACAP or other predictions programs
- In the long-term, higher SFI = higher MUF
- Cycle 25 is strong enough for consistent worldwide propagation on 15m, 12m, 10m
 - Should continue until 2027 or so
- Get on the air and have fun!



W9DXCC
DXU/CTU 2024
K9LA