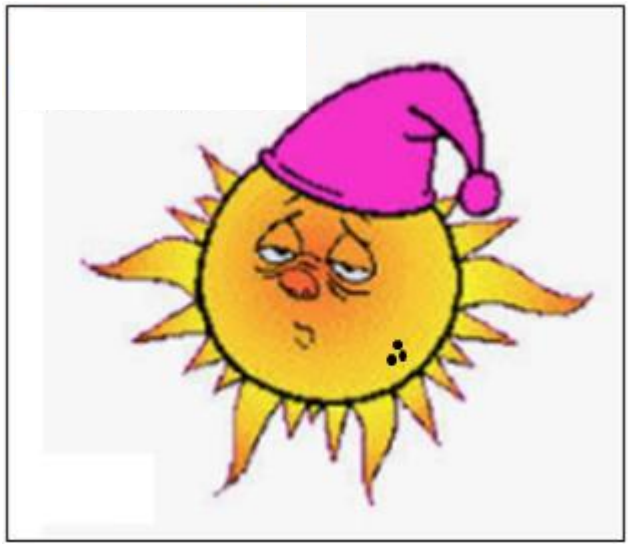
Get Ready for Fun on the Higher HF Bands



Cycle 25 is waking up

Carl Luetzelschwab K9LA

E-mail: k9la@arrl.net

Website: https://k9la.us

What We'll Cover

- The importance of solar cycles
- HF propagation fundamentals
- Space weather and propagation
- Cycle 25 update
- Antennas for the higher HF bands

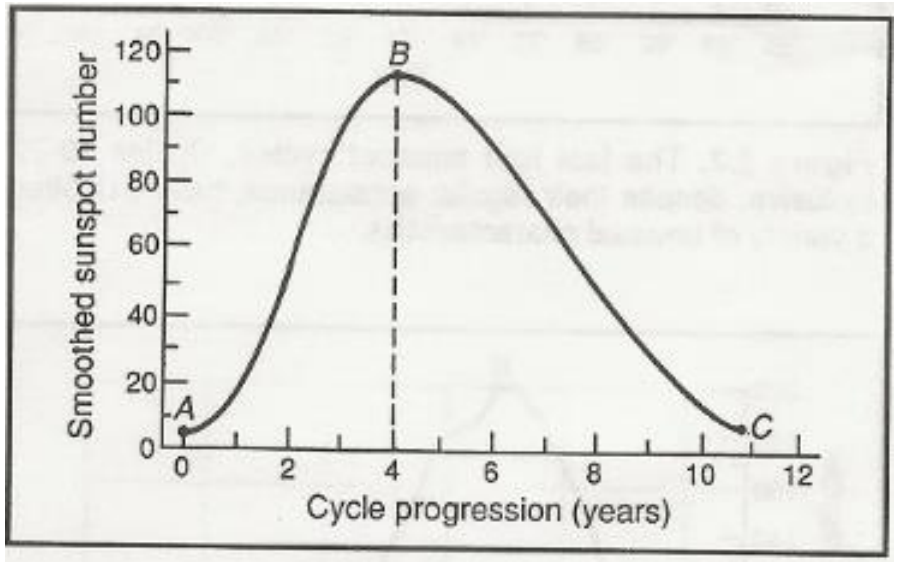
Future Presentations ?

- Modes of HF propagation
  - Short path vs long path
  - Multi-hop vs ducting/chordal hops
  - Non-great circle paths (also known as skewed paths)
  - Gray line propagation
  - Sporadic-E
  - Scatter propagation
- Disturbances to propagation (CMEs, coronal holes, solar flares)
- Propagation predictions
- VHF propagation
- More on antennas (receiving antennas, circular polarization, etc)

The Importance of Solar Cycles

What Is a Solar Cycle?

- Also known as a sunspot cycle
- It's the time period from a very low number of sunspots on the sun (solar minimum) through a maximum number of sunspots (solar maximum) and then back down to a very low number of sunspots
  - A to B to C in the plot on the right
- It's an approximate 11 year cycle
- On average
  - Rise time = 4 years
  - Descent time = 7 years

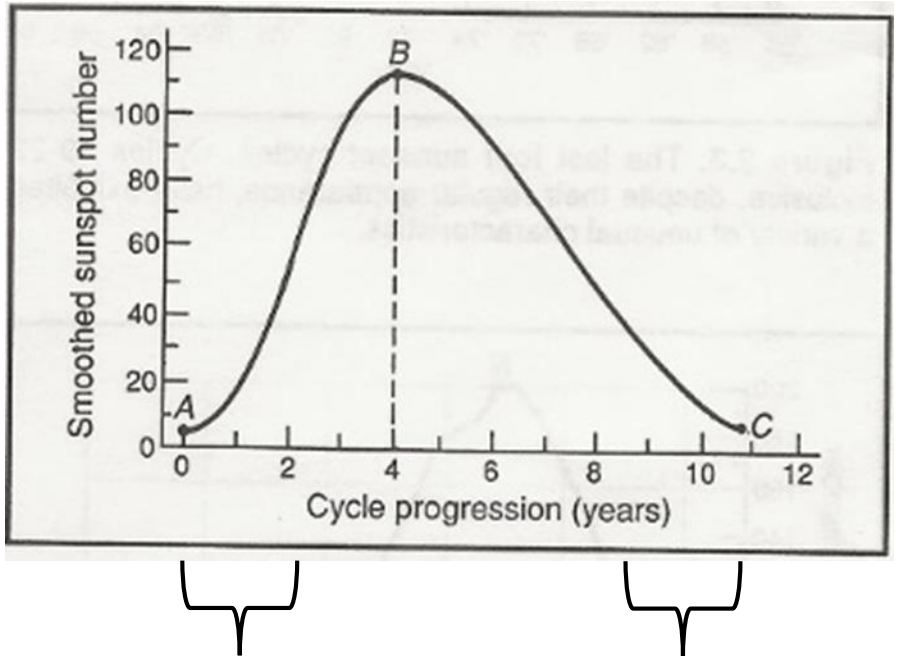


If you make a prediction at solar minimum, it could take about 4 years to validate

Why Are Solar Cycles Important?

- They are important for the higher HF bands
  - 15m, 12m, 10m (and 6m)
  - The area around sunspots emits EUV (extreme ultraviolet) radiation that ionizes the F2 region
    - The F2 region is responsible for most of our long-distance (DX) contacts on HF
  - More sunspots = more EUV = more ionization = a higher MUF (maximum useable frequency) = best propagation on the higher HF bands
- They are important for 160m and the lower HF bands
  - 160m, 80m, 60m, 40m
  - Few sunspots = less ionospheric absorption and less disturbances to propagation = best propagation on the lower bands

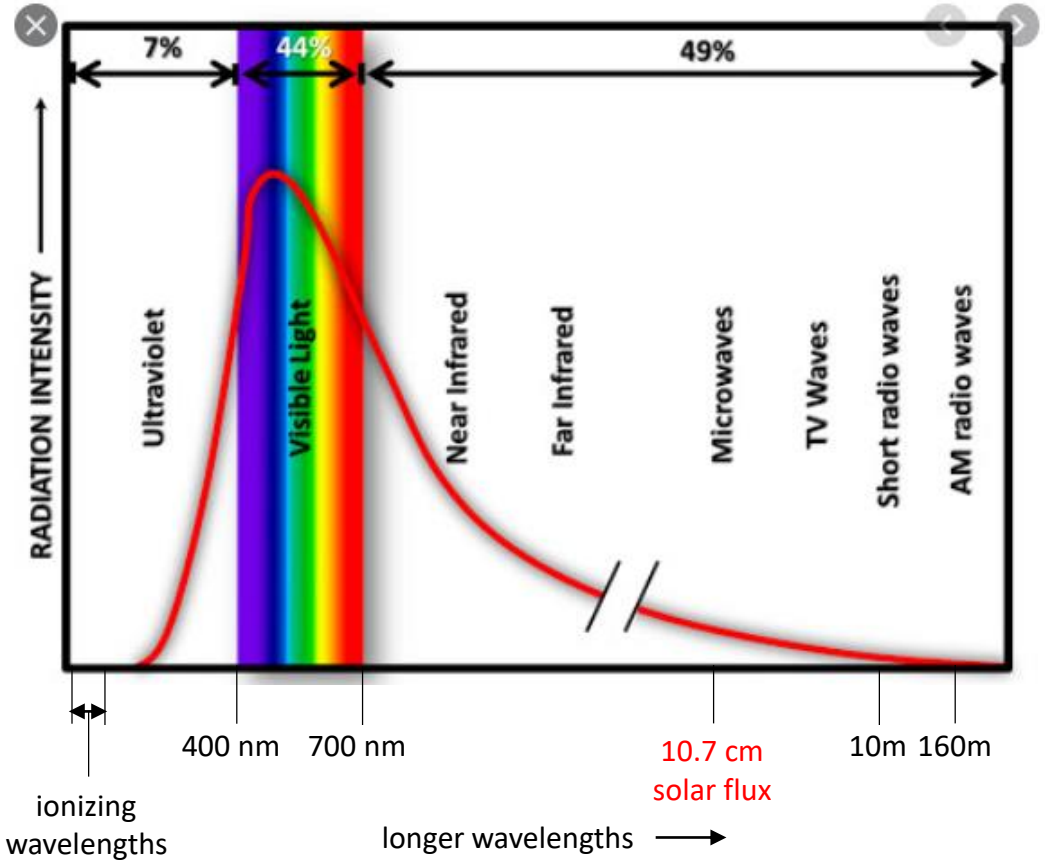
Best propagation on
15m, 12m, 10m, 6m



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

HF Propagation Fundamentals

Solar Radiation

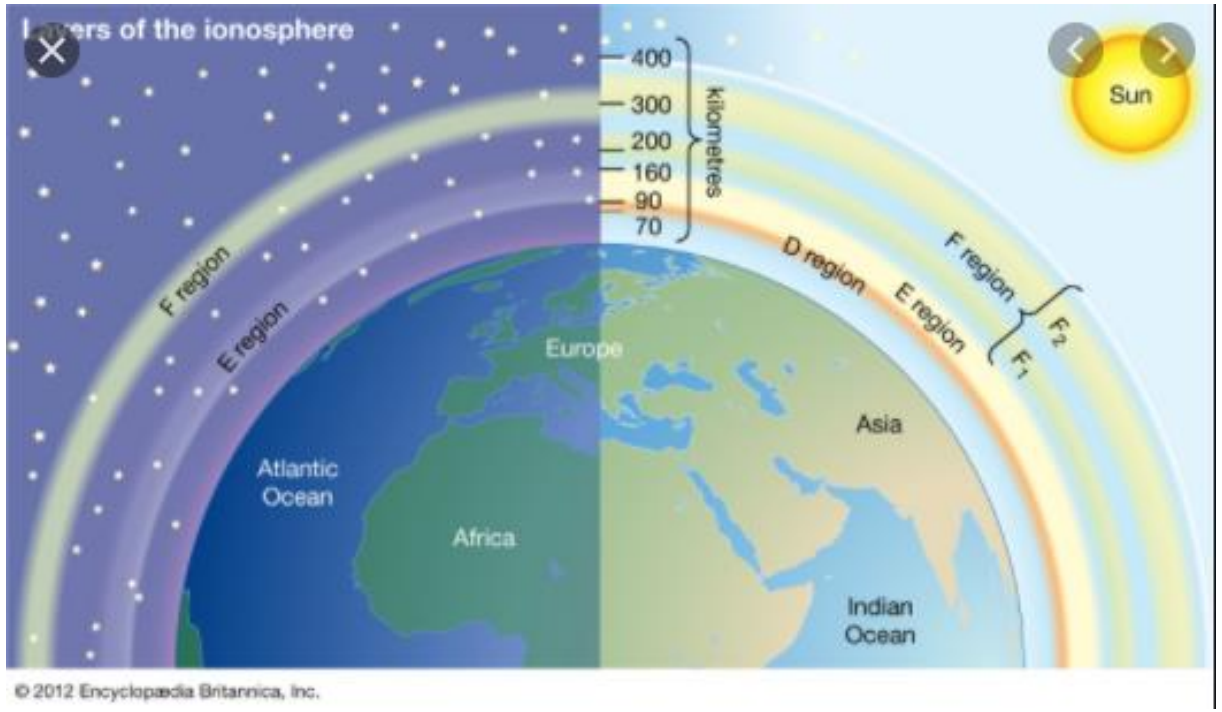


- The sun emits electromagnetic radiation at many wavelengths
- Most intense radiation is at visible light wavelengths (400-700 nm)
- Energy of a photon is inversely proportional to its wavelength
  - Shortest wavelengths are highest in energy
- The important range of radiation for our Amateur Radio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

EUV (extreme ultraviolet) and X-rays have enough energy to ionize an atom or molecule

Regions (Layers) of the Ionosphere

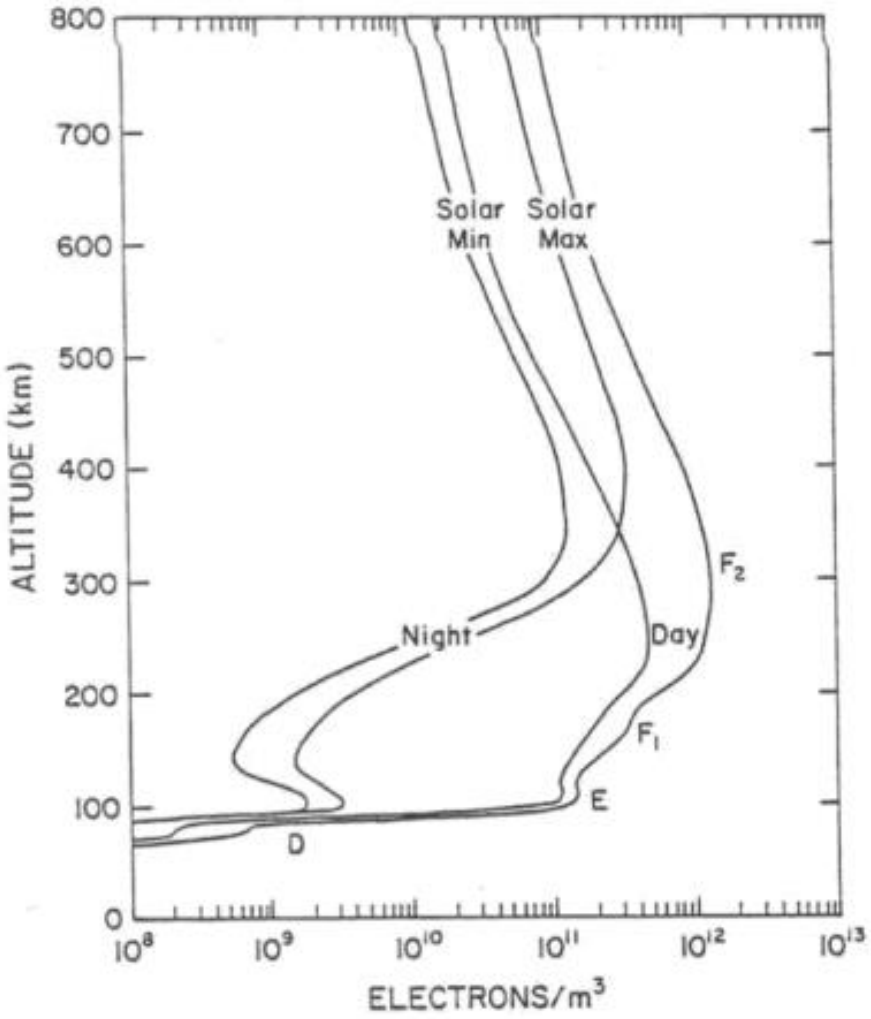
- Ionizing radiation creates regions of ionization in the atmosphere
  - Dependent on wavelength of radiation and number of neutral atmospheric constituents vs altitude
- EUV (extreme ultraviolet) results in the F_2 region
  - EUV is the true ionizing radiation of the F_2 region
- X-rays result in the E region
- Even shorter X-rays and the Lyman-α spectral line of hydrogen result in the D region



Free electrons (electrons stripped from a neutral atoms and/or molecules during the ionization process) are what is important for skywave propagation

Why We Should Call Them Regions

- The picture on the last slide suggests ‘layers’
  - For example, it appears that there is nothing in between the E layer and the F_1 layer
- But the ionosphere is really a continuous electron density profile as in the picture on the right

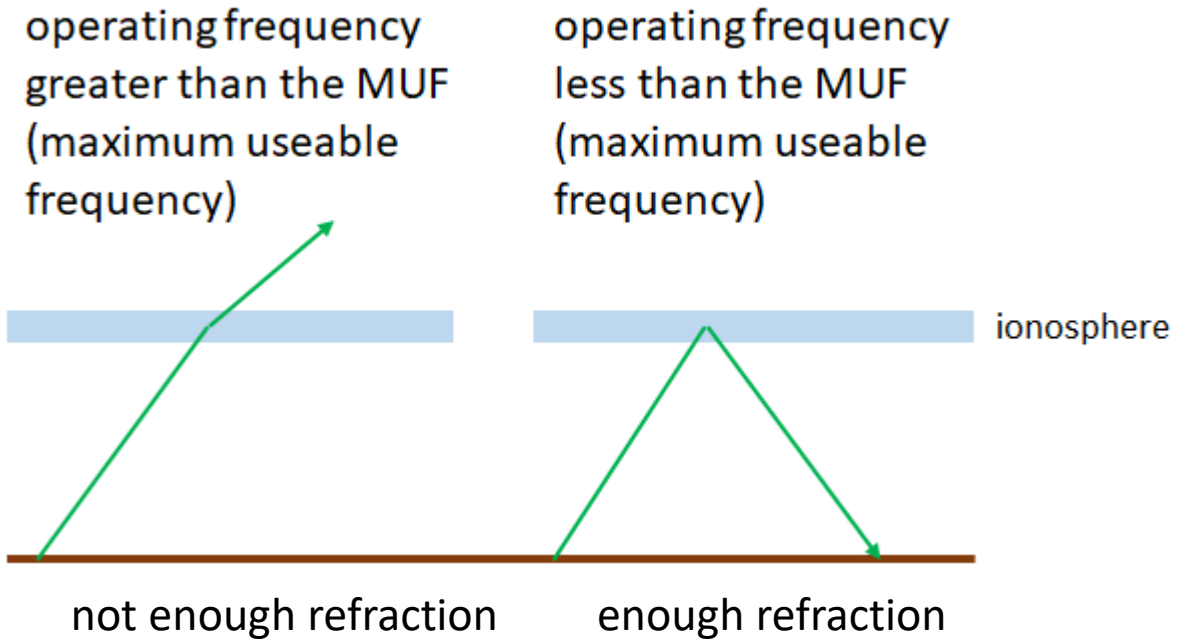


General Characteristics of the Regions

- F region (roughly 150-400 km)
  - F region splits into F_1 and F_2 region during the daytime
    - F1 is mostly an inflection point, not a major peak, in the electron density
  - Highest in altitude – gives the longest hops
  - F_2 region has the highest electron densities – best for the higher bands (15m, 12m, 10m)
  - F_2 region is the most important for our long distance QSOs
- E region (roughly 90-150 km) – peak around 105 km
  - Shorter hops due to lower altitude
  - Can block signals from getting to the F region
  - Sporadic-E in the summer really helps 10m and 6m
- D region (roughly 60-90 km) – inflection point
  - A detriment to propagation due to absorption (loss)

Ionosondes Measure the Ionosphere

- Ionosondes are for all intents and purposes radars looking straight up
- They measure maximum electron densities in the E, F_1 and F_2 regions
  - These are converted to a 'critical frequency' for each region
- Spherical geometry converts critical frequencies to oblique MUFs (maximum useable frequencies) at lower elevation angles
- The lower the elevation angle, the higher the MUF

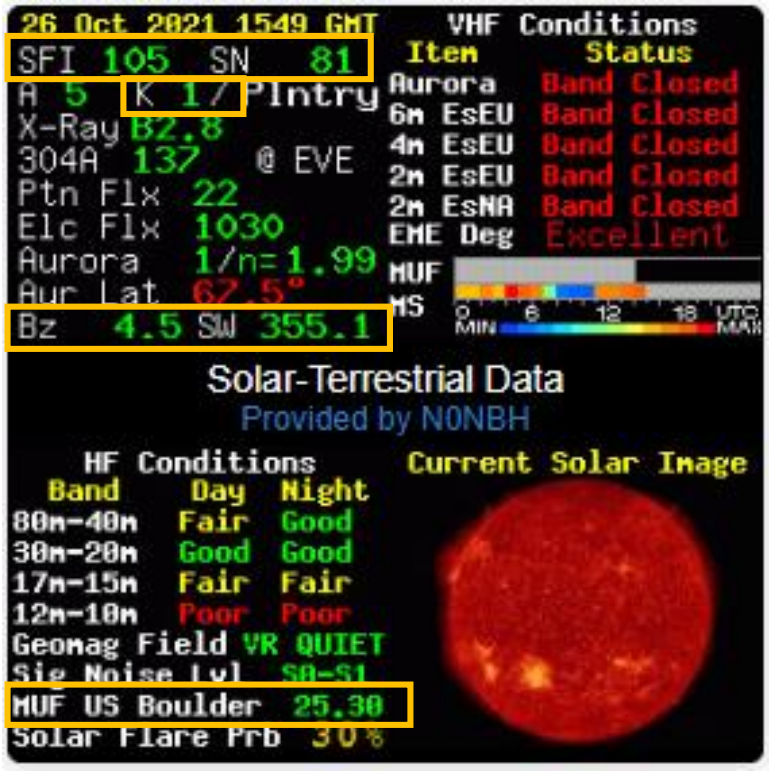


Space Weather and Propagation

Caution – we're going to make simple statements about very complicated processes

Parameters to Monitor – NØNBH Banner

- These parameters tell us which bands may be open (MUF may be high enough)
  - SFI – 10.7 cm solar flux – varies from 65 to over 245
  - SN – sunspot number – varies from 0 to over 286
    - SFI and SN are proxies for true ionizing radiation
  - Check ‘MUF US Boulder’ on the NØNBH banner
- These parameters tell us if the F_2 region of the ionosphere may be adversely impacted
  - K index – 3-hr measurement of the activity of the Earth’s magnetic field – varies from 0 to 9 (logarithmic scale)
  - Bz – magnitude and direction of IMF – varies from +50 to -100
  - SW – solar wind speed – varies from 300 to 2000 km/s



NØNBH banner at www.qrz.com

What We Generally Desire

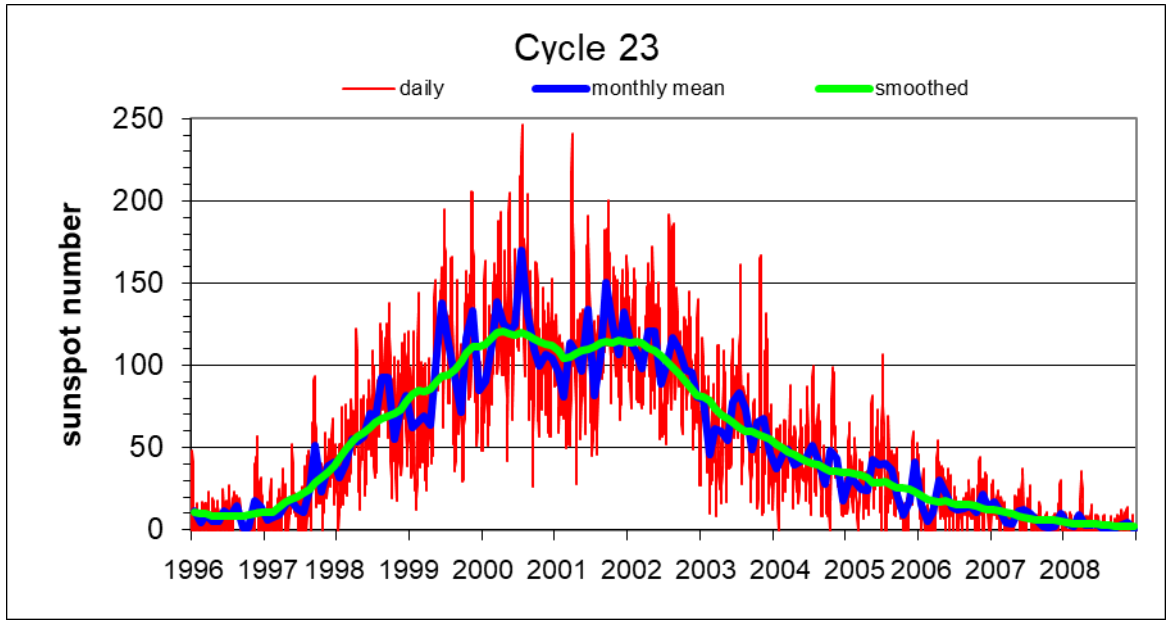
- High SFI and SN
  - The chart to the right gives an indication which bands may be open
- A high value of 'MUF US Boulder'
- K index < 3
- Bz positive or very slightly negative
- SW not too much greater than 400

Smoothed SFI	Smoothed SN	Similar to . . .	Monthly median MUF
65	0	Solar min	20 MHz
130	115	Cycle 24	33 MHz
170	179	Cycle 23	38 MHz
195	215	Cycle 22	41 MHz
245	286	Cycle 19	46 MHz

- Smoothed values are monthly means that are averaged over 12 months
- Monthly median MUF (50% probability) is for F_2 propagation in a fall/winter month in the afternoon on a mid-latitude path (there is a distribution about the median)

Why Smoothed Values?

Reason #1 – to better measure a solar cycle



similar results with 10.7 cm solar flux

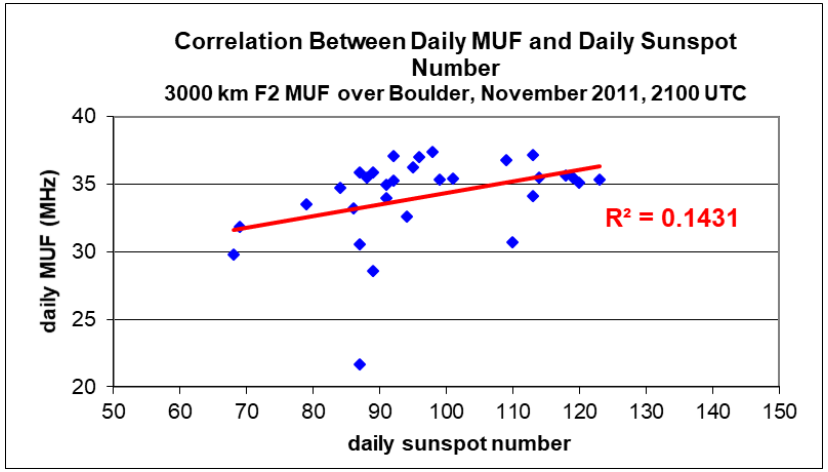
- Daily sunspot numbers (red) are very spiky – tough to see what a solar cycle is doing
- Monthly mean sunspot numbers (blue) better, but still somewhat spiky
- Smoothed sunspot numbers (green) result in a smoother curve

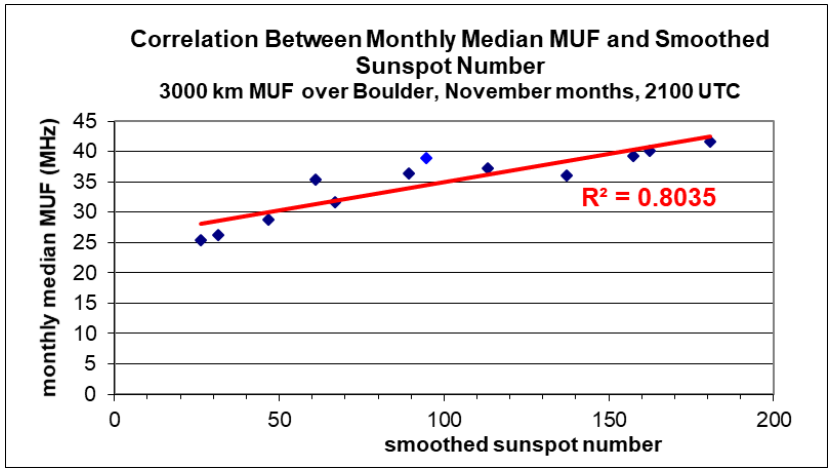
Why Smoothed Values?

Reason #2 – for propagation predictions

- Correlation between what the ionosphere is doing today and the daily sunspot number is poor
- Best correlation is between monthly median ionospheric parameters and the smoothed sunspot number

similar results with 10.7 cm solar flux

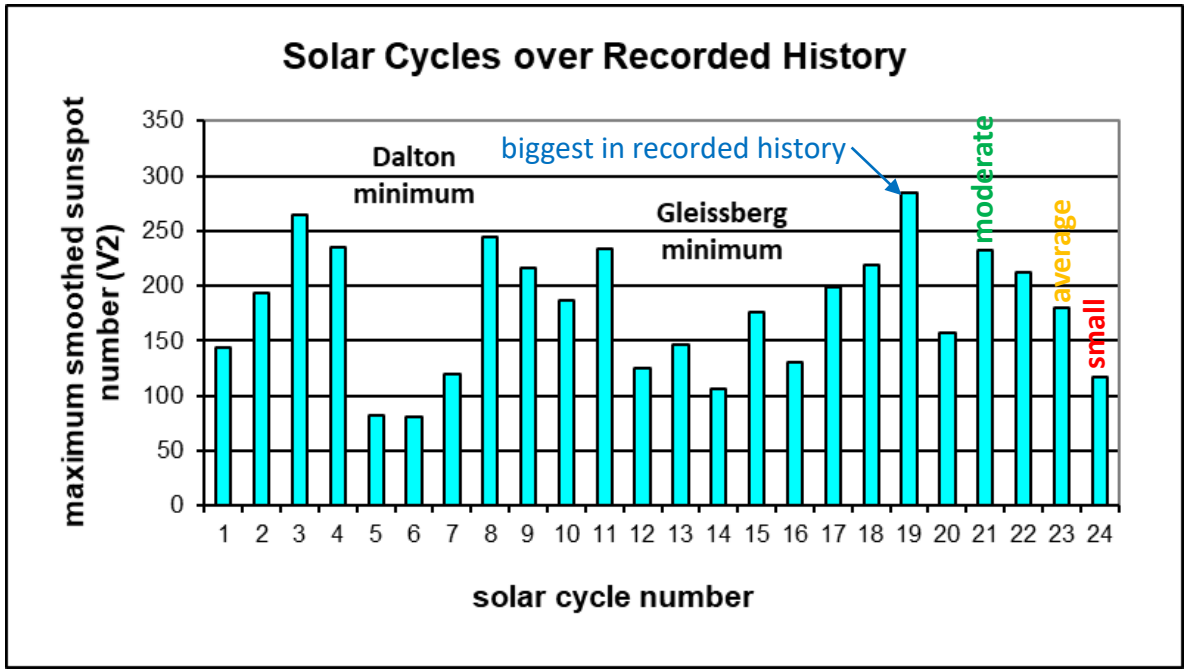




Cycle 25 Update

Recorded History

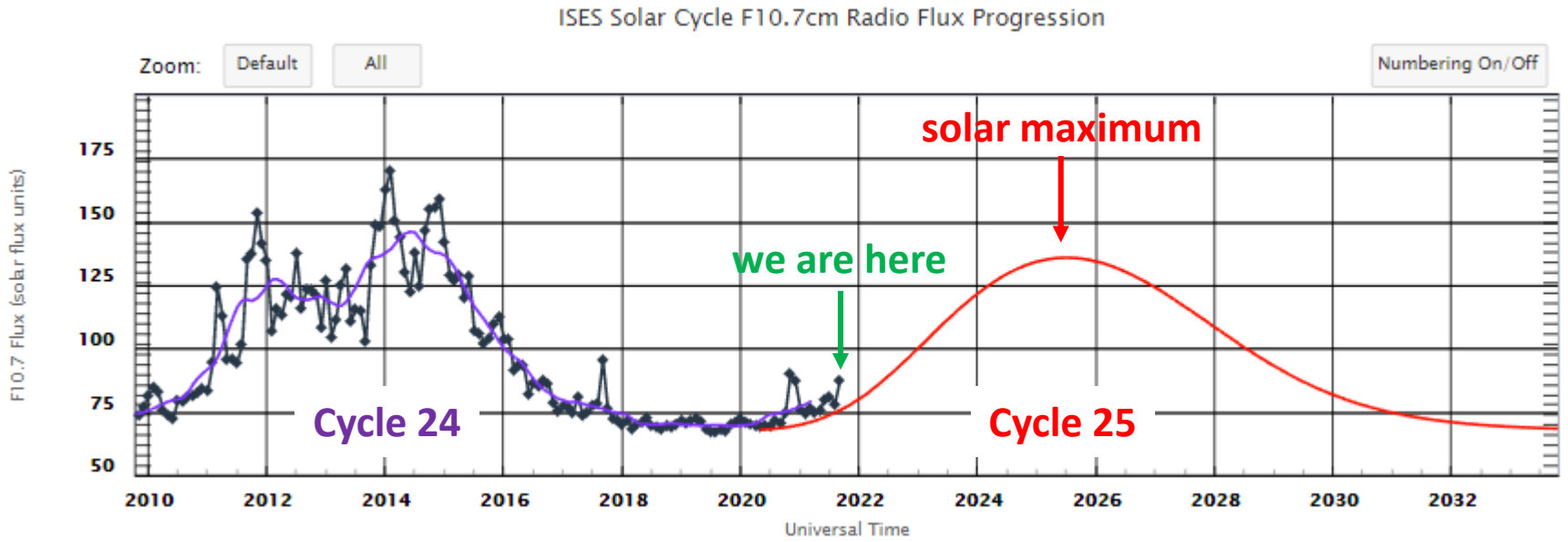
- Cycle 1 began in 1755
  - Maunder Minimum occurred from 1645-1715 with few sunspots
- We've gone through 3 periods of big solar cycles and 2 periods of small solar cycles
  - We appear to be in a third period of small solar cycles



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

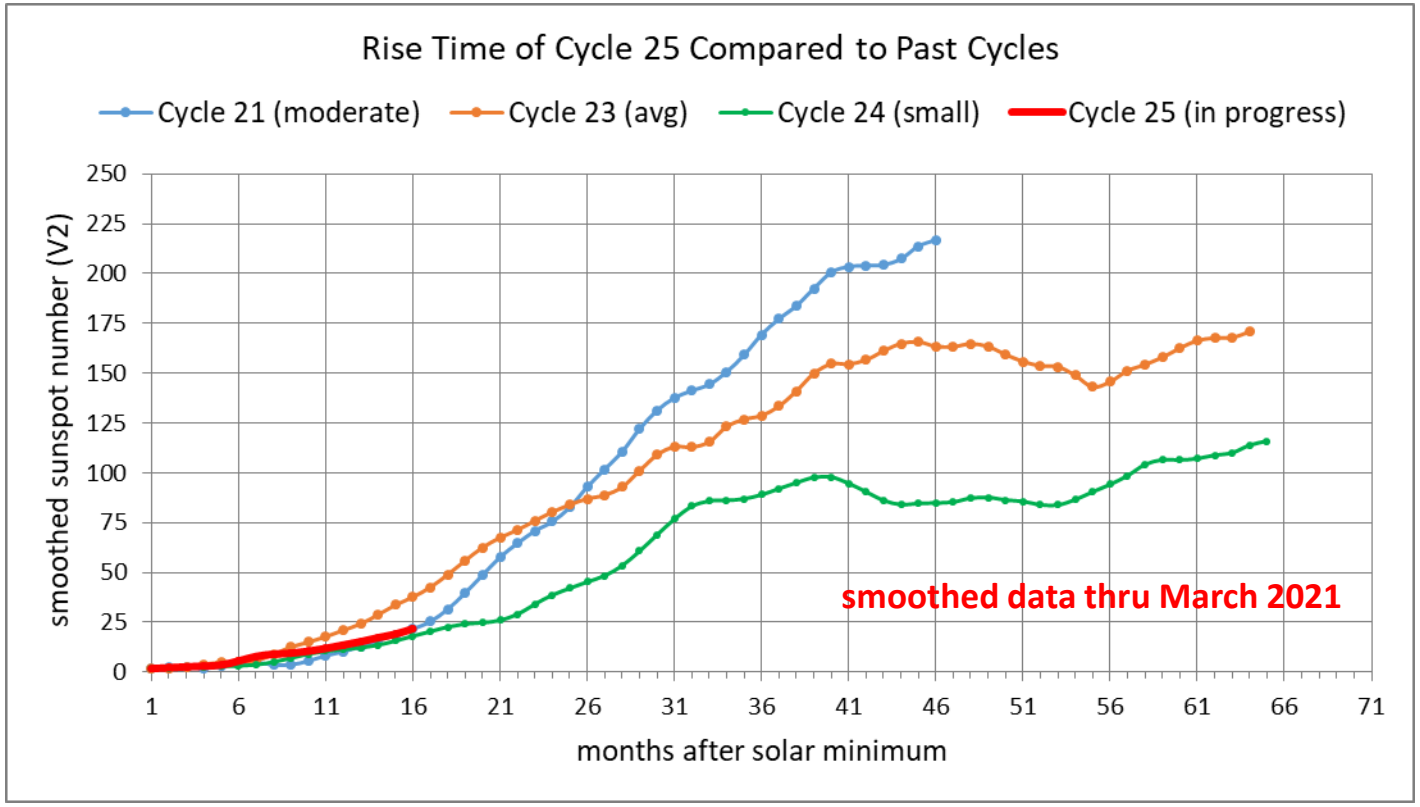
Prediction from NOAA/NASA

- Here's the prediction from the Solar Cycle 25 Prediction Panel



- This is one of <u>many</u> predictions (50 of 56 = 89%) that predicts a Cycle 25 similar to or smaller than Cycle 24
- Four predictions (4 of 56) are for an average cycle (similar to Cycle 23)
- Two predictions (2 of 56) are for a moderate cycle (similar to Cycle 21)

How Is Cycle 25 Doing?



Historical data indicates big solar cycles rise faster than small solar cycles

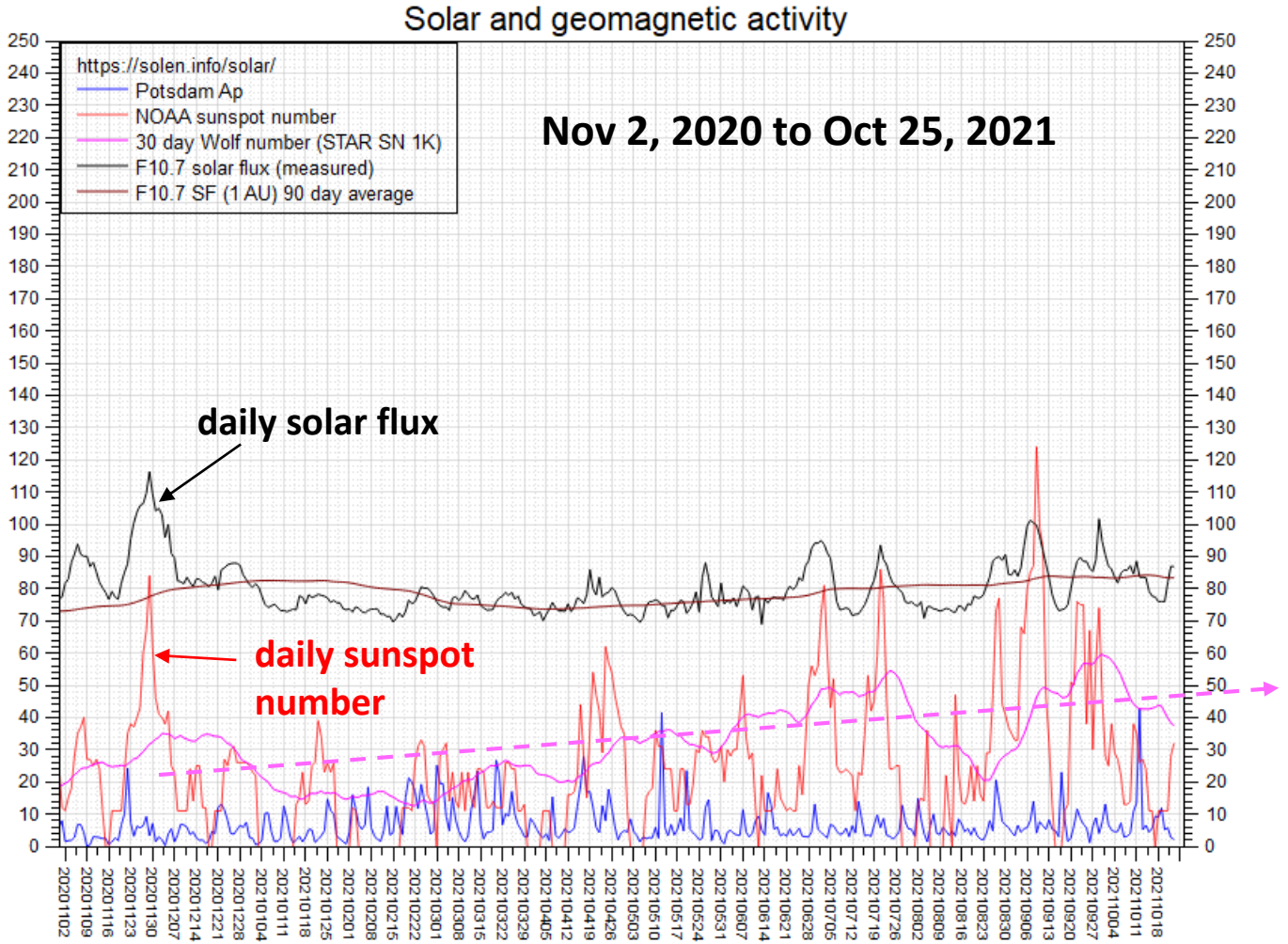
- Cycle 25 is starting its ascent – kind of slow right now
- Will it follow the moderately big Cycle 21 (blue), the small Cycle 24 (green) or end up somewhere in between (orange)?
- 6 to 12 more months of data may give us a better clue as to where it's headed

The Bands Right Now

- The higher bands are showing signs of life for three reasons
  - Cycle 25 is rising
  - We're moving into fall and winter in the northern hemisphere
  - DXpedition activity is finally picking up
    - DXpeditions can show us that the bands are open more than we think
- Digital modes offer more opportunities due to their signal-to-noise ratio advantage
  - FT8/FT4 offers more opportunities than CW, CW offers more than SSB
- The low bands (160m, 80m, 60m, 40m) are good at night around solar min
- 30m, 20m, 17m are generally good throughout a solar cycle

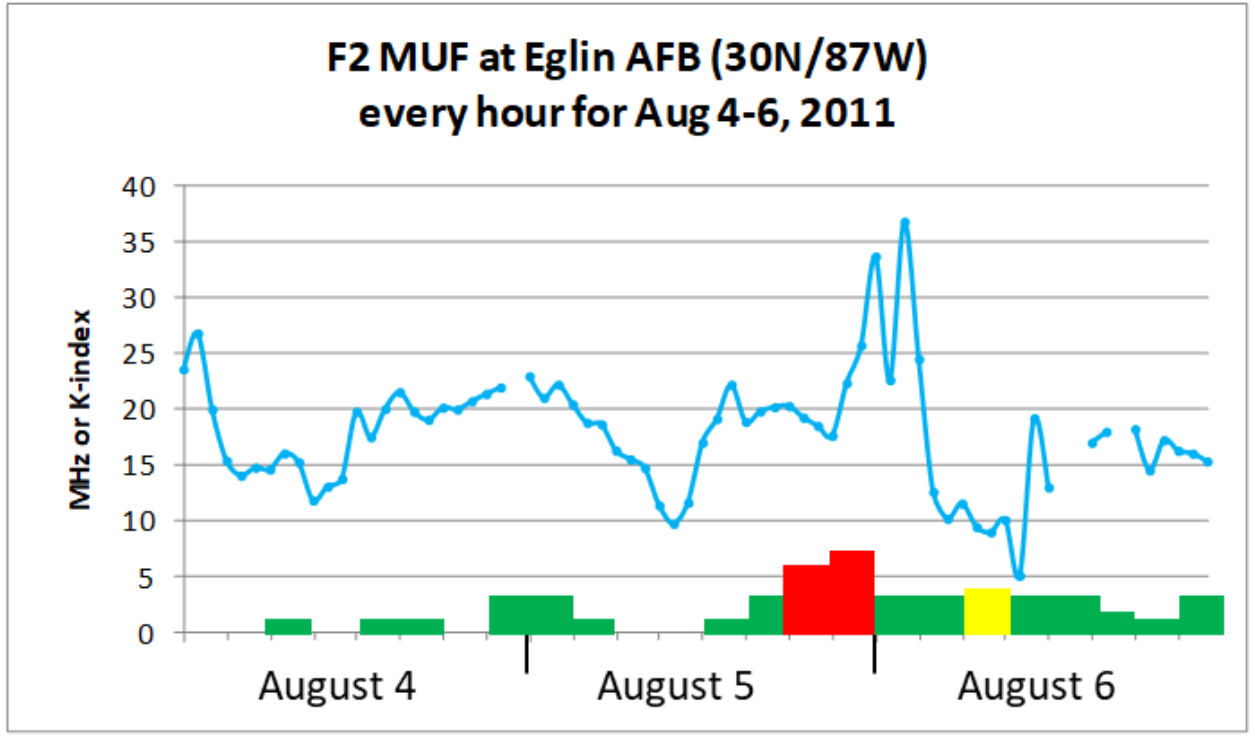
Big Spike in SFI/SN

- While waiting for Cycle 25 to get going in earnest, check the higher bands (15m, 12m, 10m) when there is a big spike in solar flux and sunspot number – like late last year
- Note the slow rise in the monthly mean sunspot number (the violet line) – Cycle 25 is alive !



Moderate Spike in the K Index

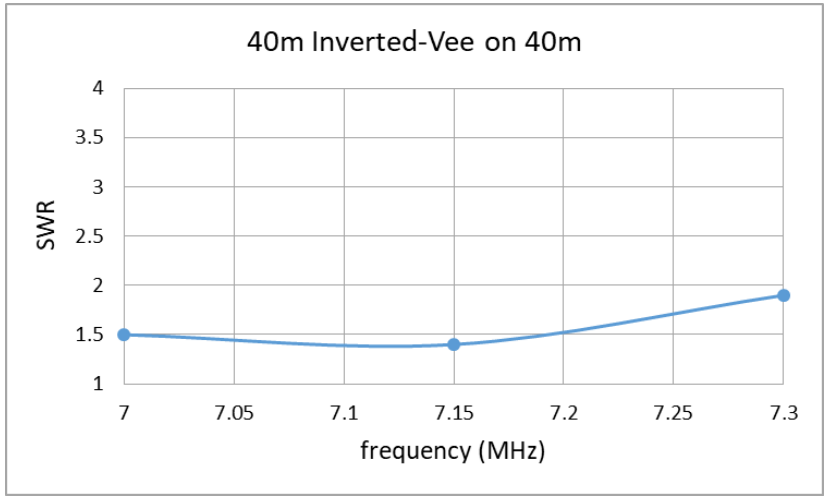
- While waiting for Cycle 25 to get going in earnest, also check the higher bands (15m, 12m, 10m) when there is a moderate spike in the K index
- Possible enhanced propagation on low and mid latitude paths

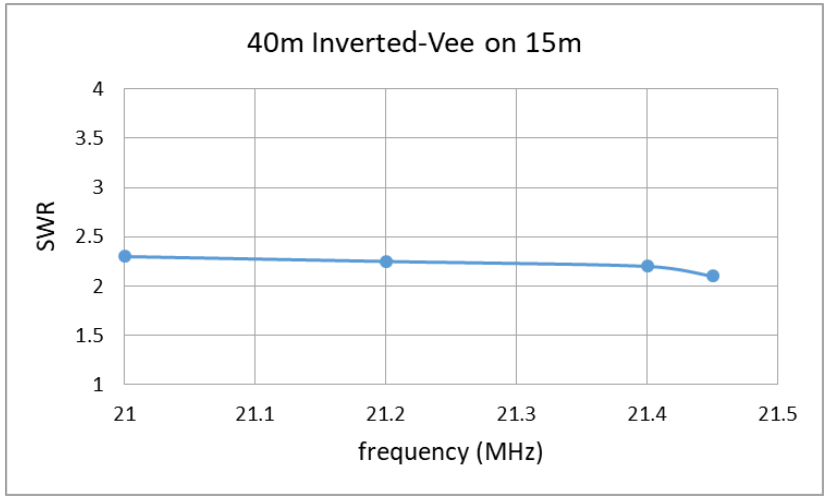


Antennas for the Higher HF Bands
(15m, 12m, 10m - and even 6m)

Antennas for 15m

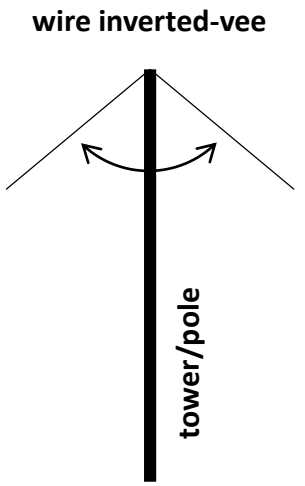
- Use your 40m dipole/inverted-vee
  - Works as a 3/2-wavelength antenna
    - A bit of gain in some directions
  - Lowest SWR on 15m may be above 21.450 MHz
    - Probably need to use a tuner – either your rig's internal tuner or an external tuner
- Vertical with four elevated radials
  - I have a Hustler 4BTV – gives decent results
- 15m dipole/inverted-vee
  - Overall length about 22 feet (11 ft each side)
  - Put it up at 20 feet
- 2-element Yagi

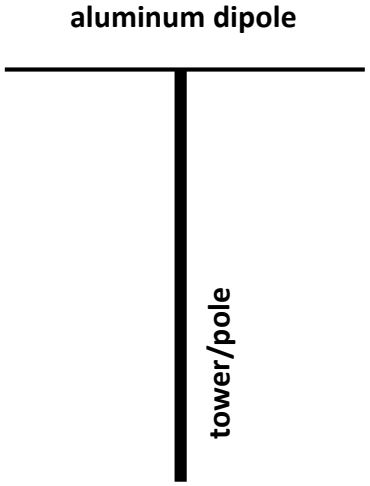




Antennas for 12m

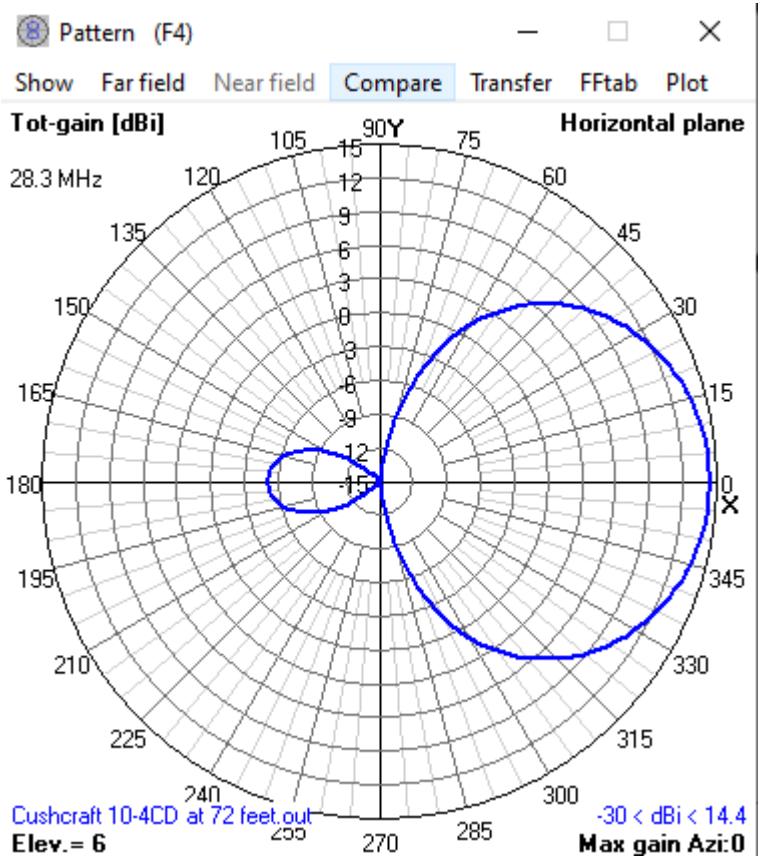
- Inverted-vee
  - Each side about 9.25 feet
  - Keep angle > 90 degrees
- Dipole made with aluminum tubing
  - About 18.5 feet from tip-to-tip
- 2-element Yagi
  - A bit smaller than a 15m Yagi
- 3-element Yagi
  - More gain
  - Better F/B ratio





Antennas for 10m

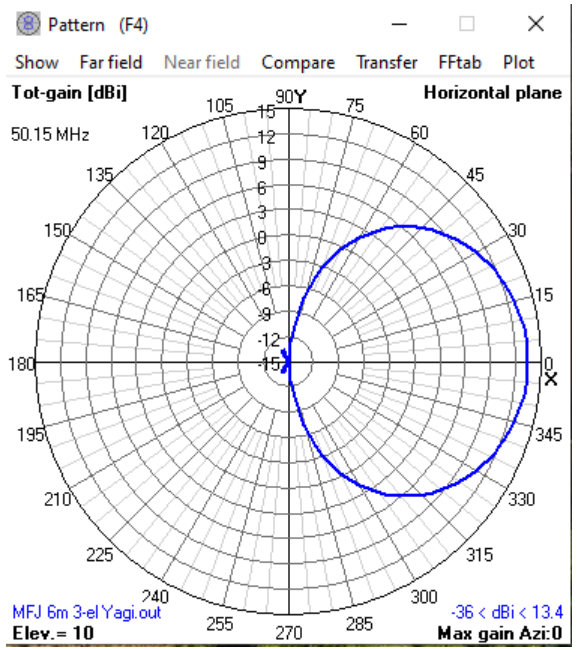
- Dipole (made of aluminum) is relatively small
  - About 16.5 feet tip-to-tip
  - It will give great results at 15-20 feet high
- Multi-element Yagis are quite reasonable
  - I have a 4-element Cushcraft 10m Yagi
    - 16 foot boom, elements about 17 feet tip-to-tip
    - Used it to work many stations with my homebrew QRP (250 milliwatts) 10m DSB transceiver during big Cycle 22



Antennas for 6m

- A multi-element Yagi is very doable – even for small property lots
  - Small and lightweight
- I have an MFJ-1762 3-element 6m Yagi
  - 9 foot elements, 6 foot boom, about 3 pounds
  - Great F/B – but what do you do when E_s is open in more than one direction?
- When E_s opens the band in multiple directions, just about any antenna will work that has a reasonable SWR on 6m
  - Very strong signals
  - I've used my 40m inverted-vee

MFJ-1762



Some References to Start With

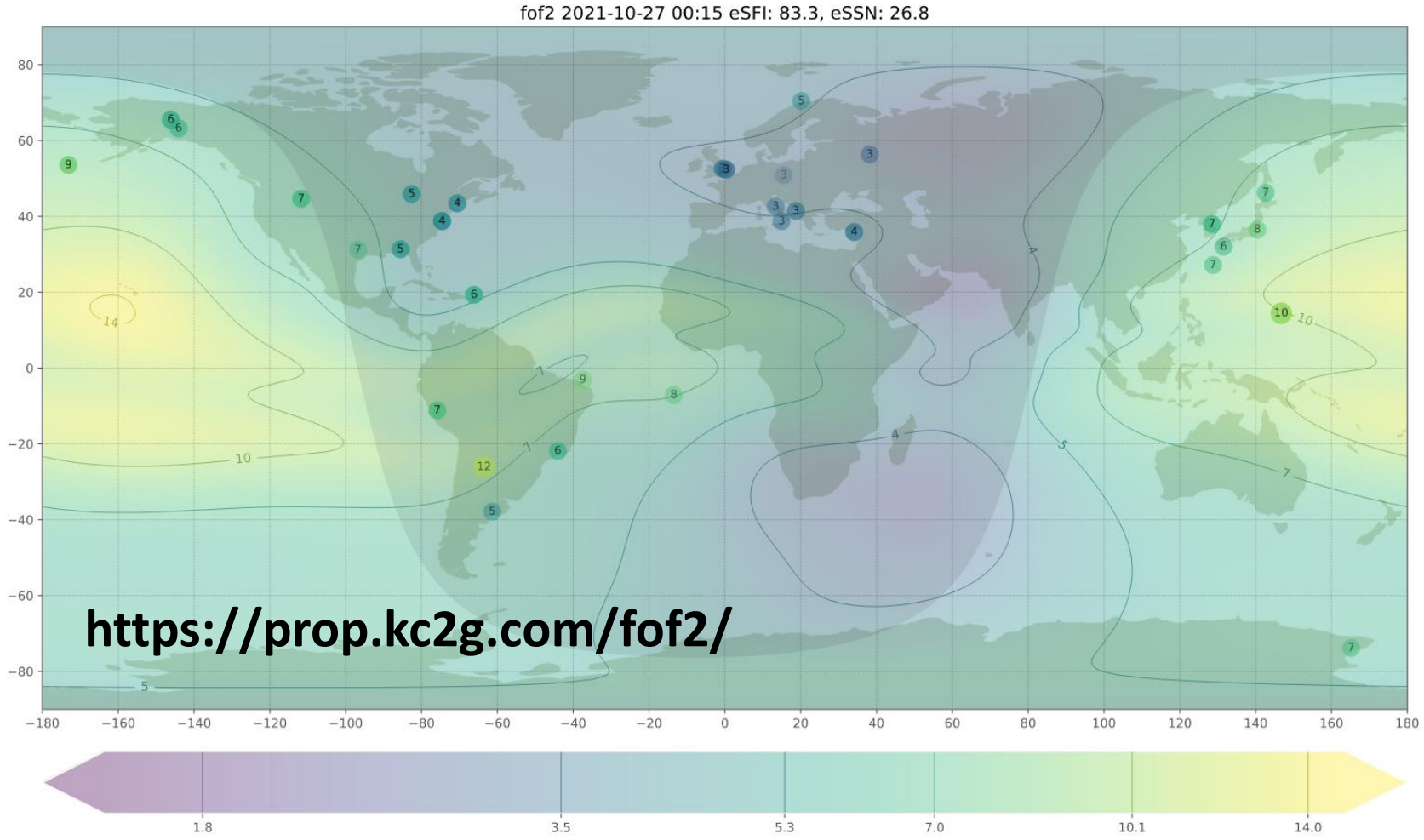
- Propagation
  - Propagation chapters of the ARRL Antenna Book and the ARRL Handbook
  - "The Little Pistol's Guide to HF Propagation" by Bob Brown NM7M (SK)
    - Available for free on my website at https://k9la.us - 15Mb file
  - The CQ Shortwave Propagation Handbook – 4th Edition (updated in 2021)
- Antennas
  - ARRL Antenna Book
  - Low-Band DXing (Fifth Edition) by ON4UN
- Solar info
  - Lots of data on the internet
  - https://spaceweather.com/, https://www.swpc.noaa.gov/, https://www.solarham.net/, NØNBH banner at https://www.qrz.com/, https://www.spaceweatherwoman.com/

Summary

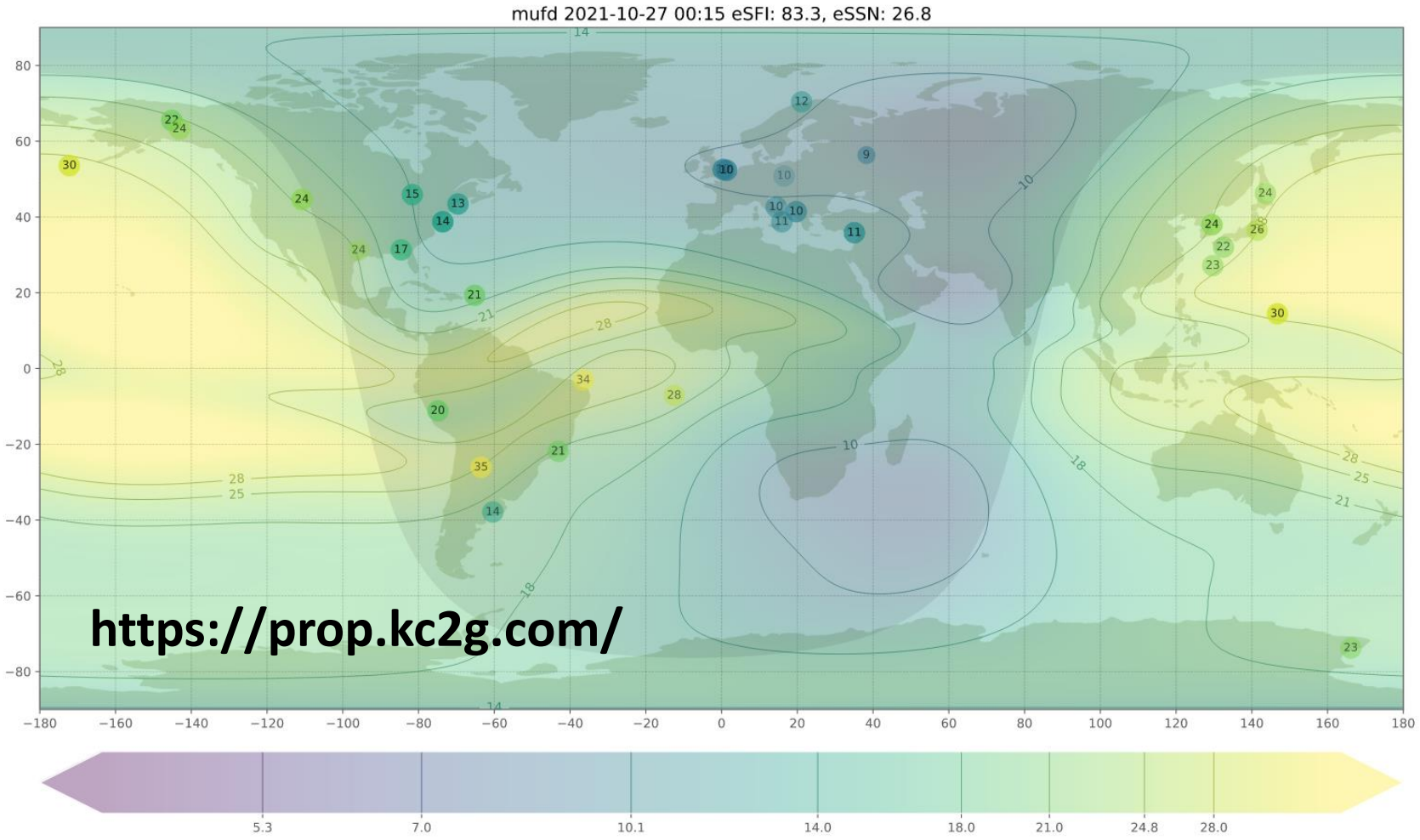
- Cycle 25 is beginning its ascent
- Most forecast a below average Cycle 25 – a few forecast a big Cycle 25
  - Even if it's small, it will offer great worldwide propagation with modest antennas and 100 W
  - All we can do is wait to see what happens
- Don't forget sporadic-E on 6 meters during the summer and in December
  - Not much correlation to a solar cycle
- Antennas are of a reasonable size on 15m, 12m, 10m, 6m
- Use the digital modes for their advantage over SSB and CW

Get radio-active on HF!

Worldwide foF2 for NVIS Evaluation



Worldwide MUF for DXing



K9LA Vintage Rigs

Novice and early General
NC-60, DX-35

later General
Ranger II, 2-B

most recent addition
KWM-2