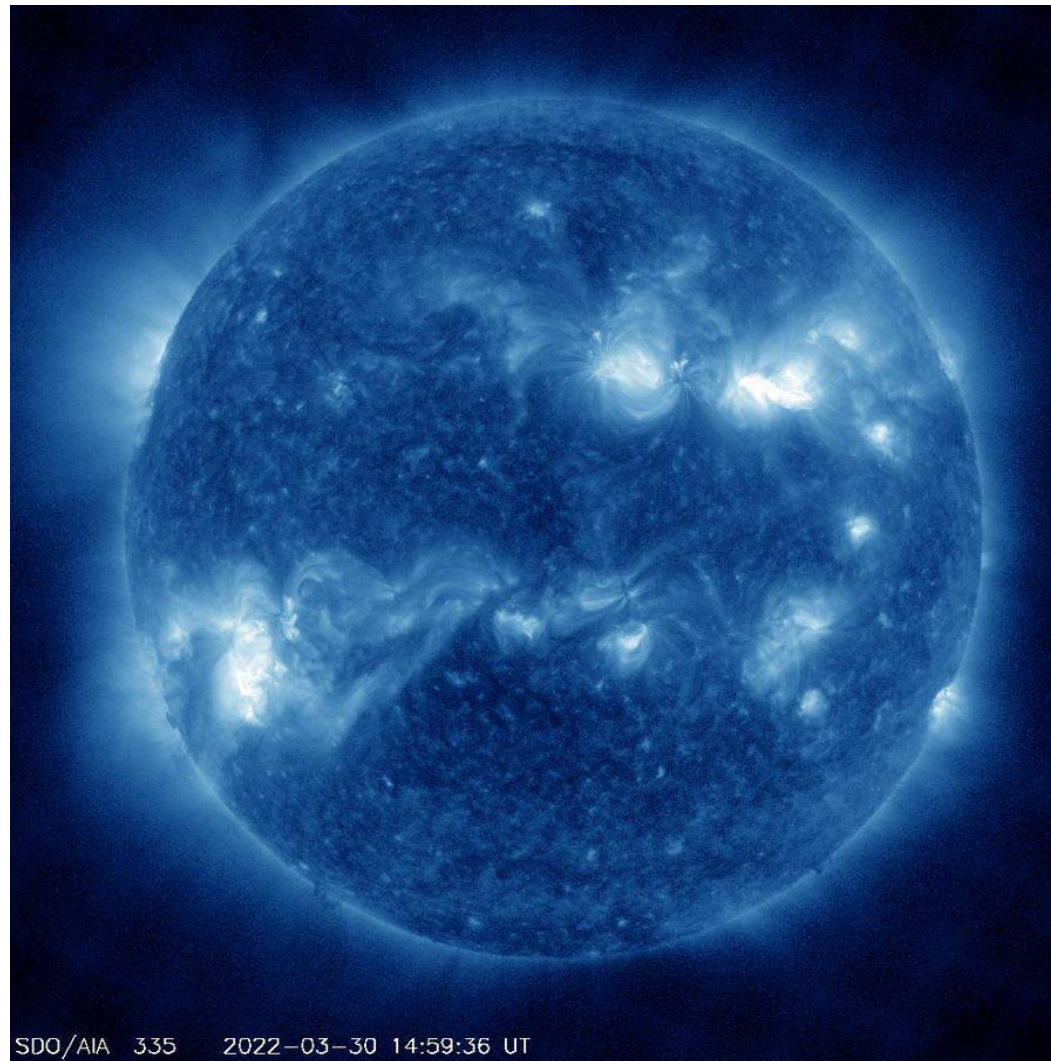


Solar Cycle 25 - Update



Jerry Spring – VE6TL

April, 2022

Special thanks to Carl Luetzelschwab, K9LA,
for granting permission to use several of his slides.

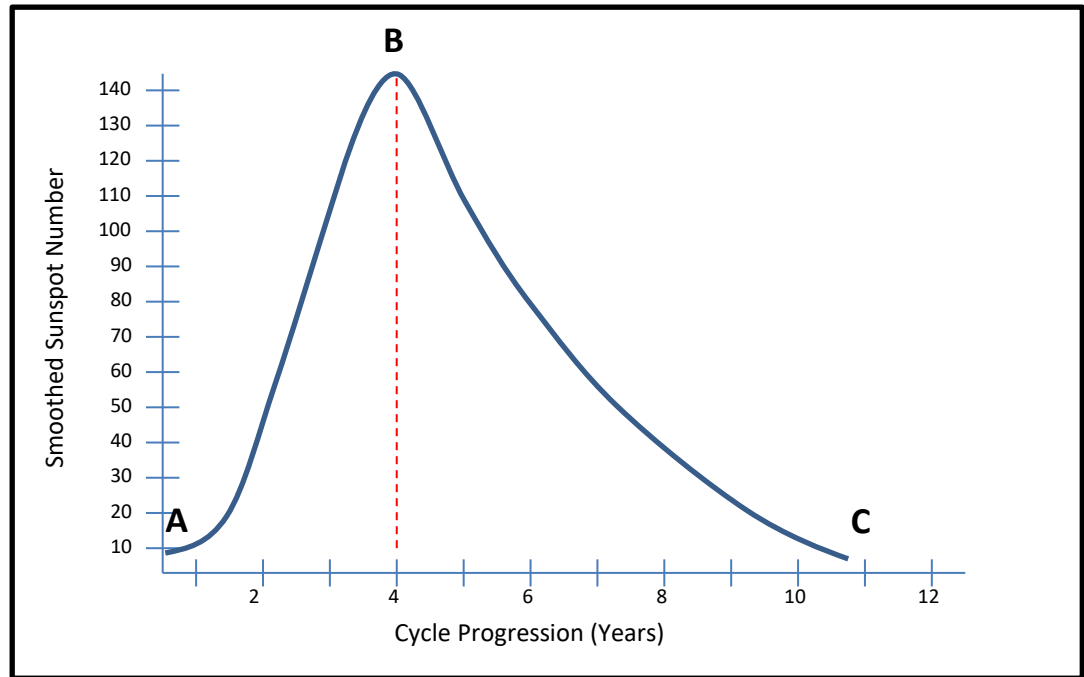


Presentation Outline

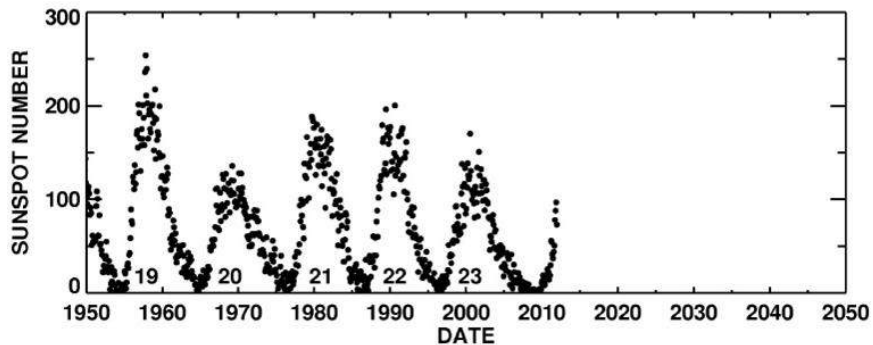
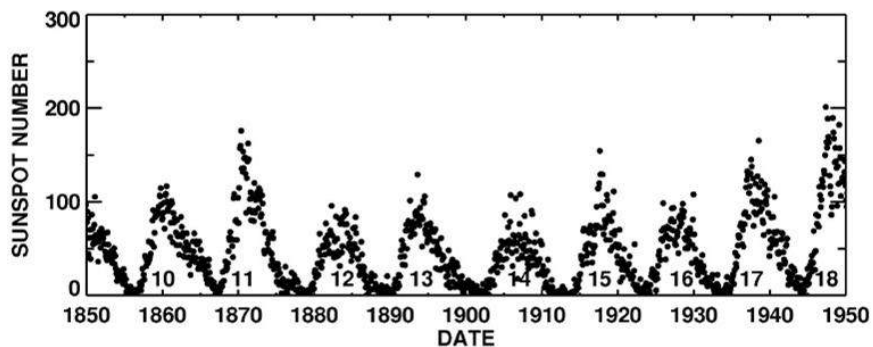
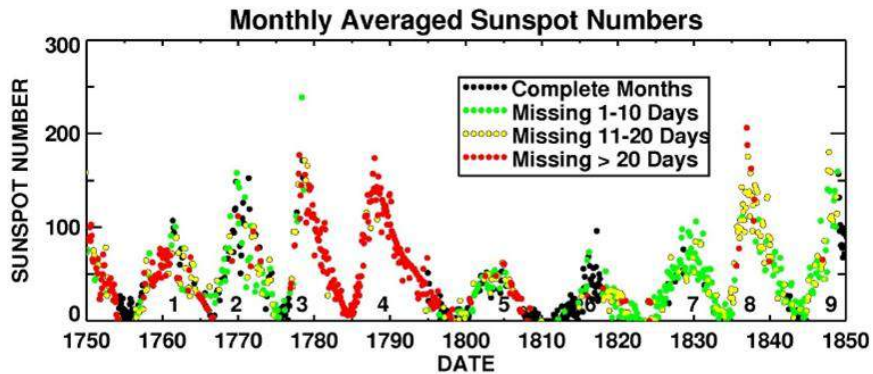
- Basic Propagation
 - Solar cycles
 - Solar radiation
 - Ionosphere
- Cycle 25 Update
 - Recorded history
 - Predictions
 - Current status
 - Optimistic model
- Space weather parameters

What is a Solar Cycle?

- Same as sunspot cycle
- Period from solar minimum (A) - very few spots, through solar maximum (B) and then back to solar minimum (C)
- Average cycle lasts 11 years
- Rise time about 4 years, descent time 7 years

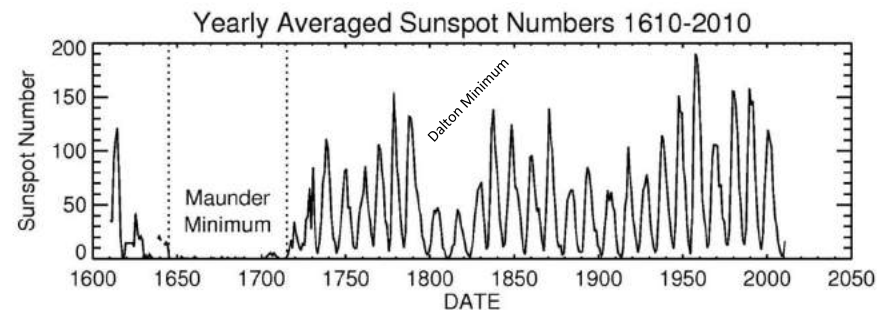


The Sunspot Cycle



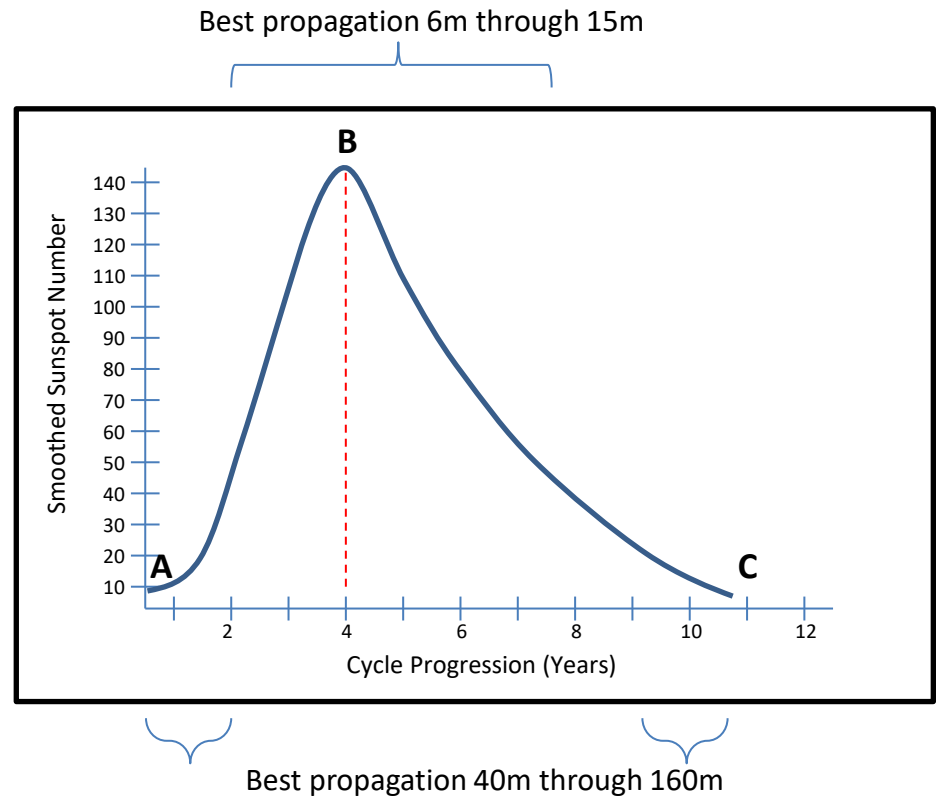
HATHAWAY/NASA/MSFC 2012/01

- Galileo (1610) made first observations of sunspots.
- Continuous daily observations began in Zurich in 1849
- Sunspot number = (10 X number groups) + (individual spots)
- Maunder Minimum – 1645-1715 with few sunspots (well documented) – “Mini Ice Age”



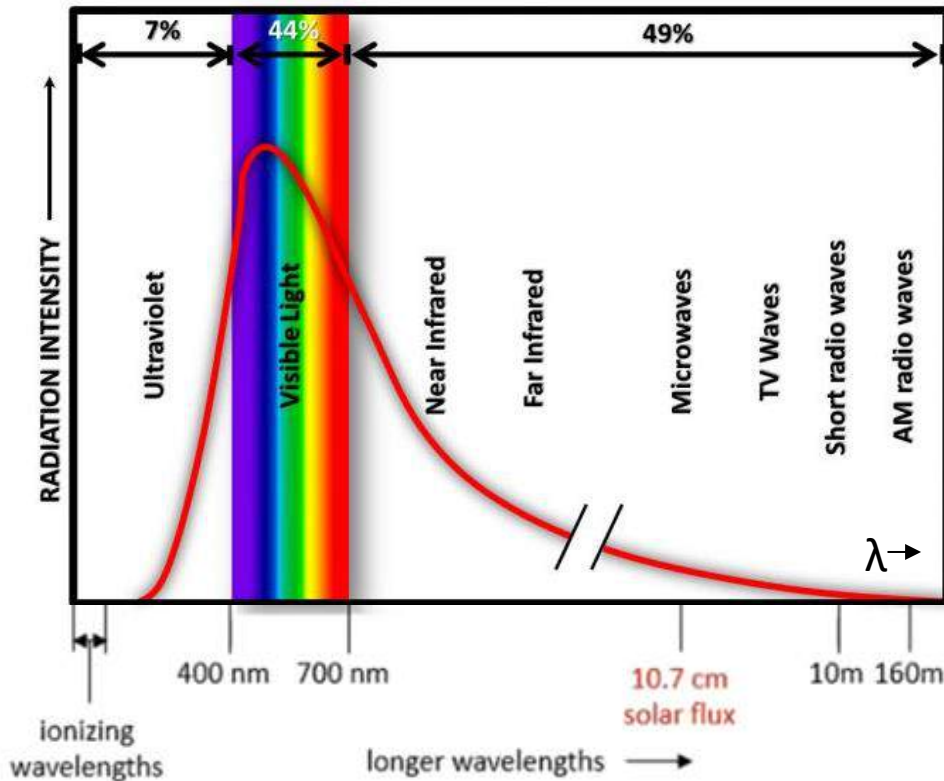
Why are Solar Cycles Important?

- In the higher HF bands (6m through 15m):
 - The area around sunspots emits EUV (Extreme **U**ltra**V**iolet) radiation, which ionizes F2 region – most important for DX
- More sunspots = more EUV ionizing radiation
 - The more EUV, the higher the MUF (**M**aximum **U**seable **F**requency)
- In the lower HF bands (40m through 160m):
 - Few sunspots = less ionospheric absorption and fewer disturbances



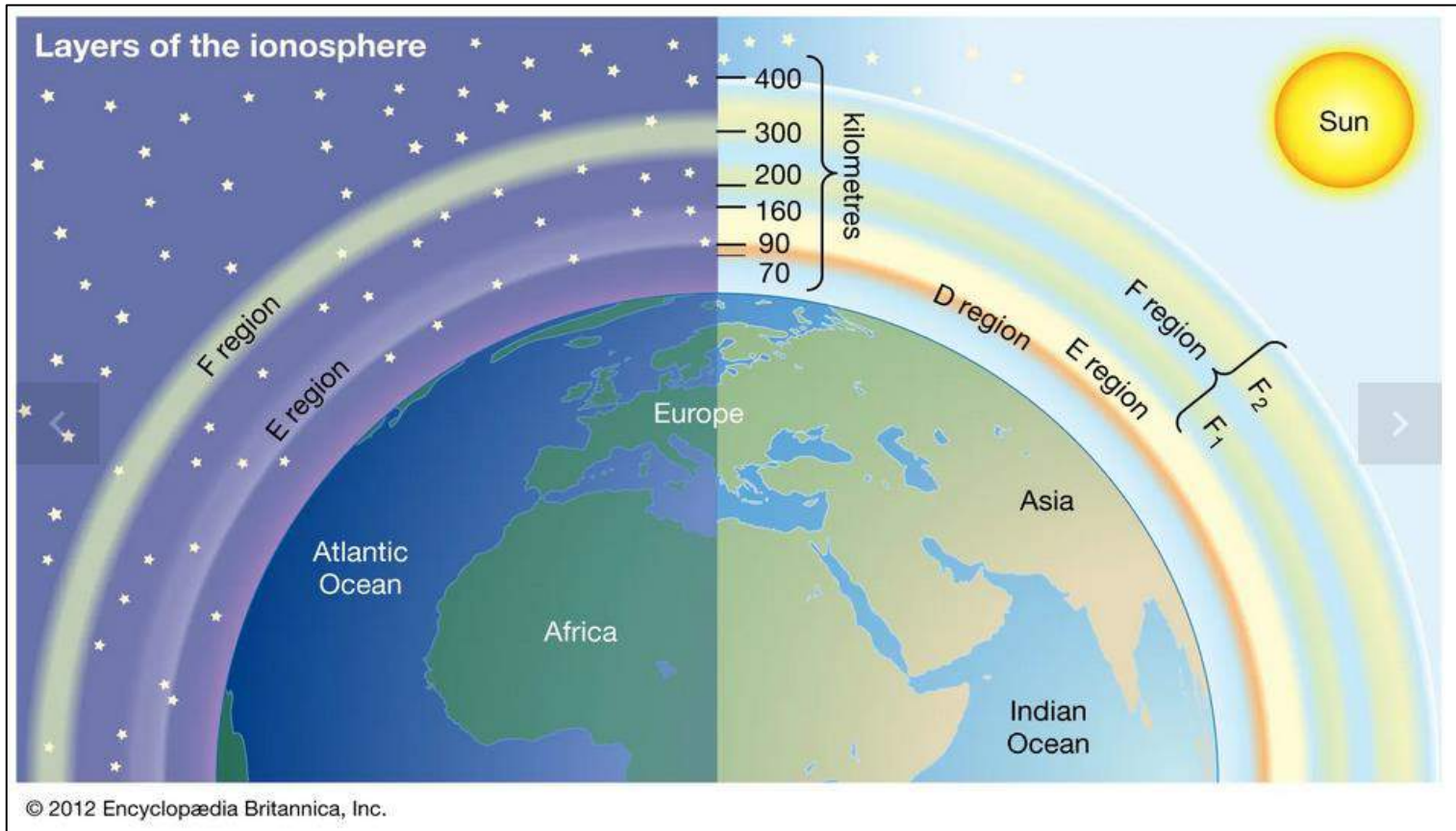
Solar Radiation

Sun's Electromagnetic Spectrum



- The sun emits EM radiation at all wavelengths
- Most intense radiation occurs at visible light (400-700nm)
- Photon energy \propto Frequency (Or shorter λ have higher E)
- EUV and X-Rays have sufficient energy to ionize atoms or molecules in the Earth's ionosphere

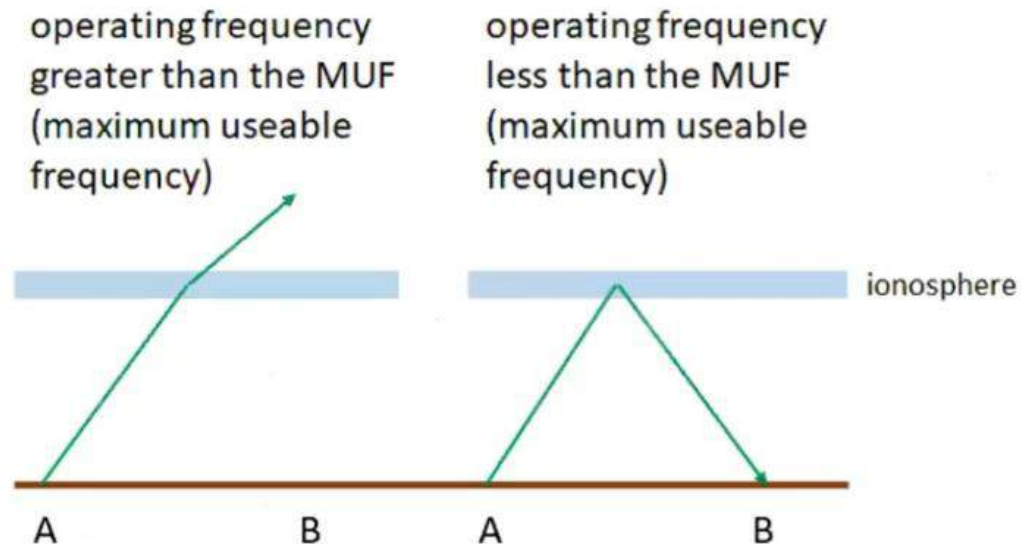
Ionospheric Regions



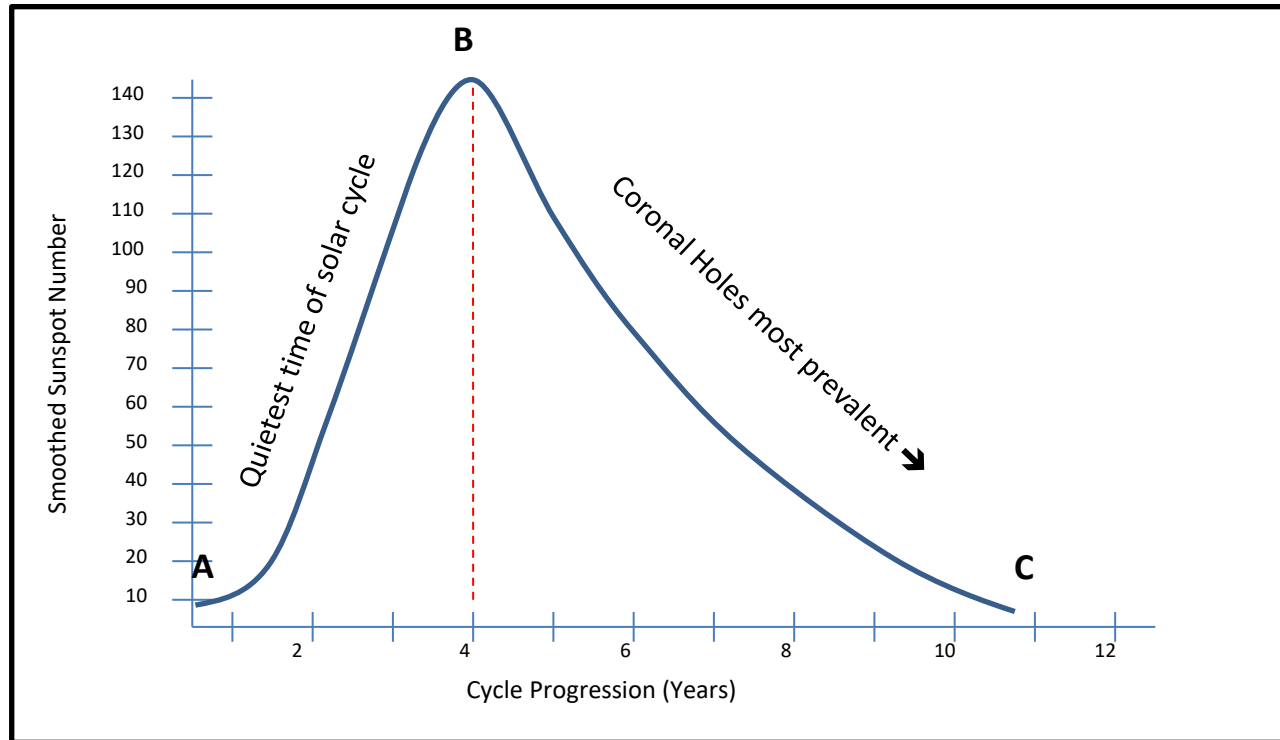
- Day – D, E, F₁, F₂
- Night – E, F
- D Region (60-90 km) – primarily absorption
- E Region (90-150 km) – shorter hops than F region, can also block signals from entering F region
- F Region (F₁ 150-200 km, F₂ 200-400 km) – Gives longest hops (highest), highest electron density and highest MUF (Max Useable Freq), best for 10m to 20m bands (main DX bands)

MUF - Maximum Useable Frequency

- The MUF is the highest frequency that propagates between A and B at a given time in a given month at a given phase of a solar cycle
- $f_{op} > MUF$ – goes thru the ionosphere
- $f_{op} < MUF$ – refracts back to earth
- Highest elevation angle that still refracts back to earth determines the skip zone distance
- NVIS decreases the skip zone distance by going to lower frequencies



Disturbances to Propagation



- CMEs and Coronal Holes can reduce F_2 region ionization
- Solar flares increase D-region absorption
- CMEs and Large solar flares most prevalent around Solar Max but can occur at any time during a solar cycle

Propagation Predictions

- No daily predictions for SFI
 - Affected by Geomagnetic field (K index)
 - Affected by tropospheric coupling from below
- We have monthly median predictions (50% probability)

3-DAY FORECAST

:Product: 3-Day Forecast
 :Issued: 2022 Mar 23 0030 UTC
 # Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center
 #
 A. NOAA Geomagnetic Activity Observation and Forecast

The greatest observed 3 hr Kp over the past 24 hours was 3 (below NOAA Scale levels).
 The greatest expected 3 hr Kp for Mar 23-Mar 25 2022 is 4 (below NOAA Scale levels).

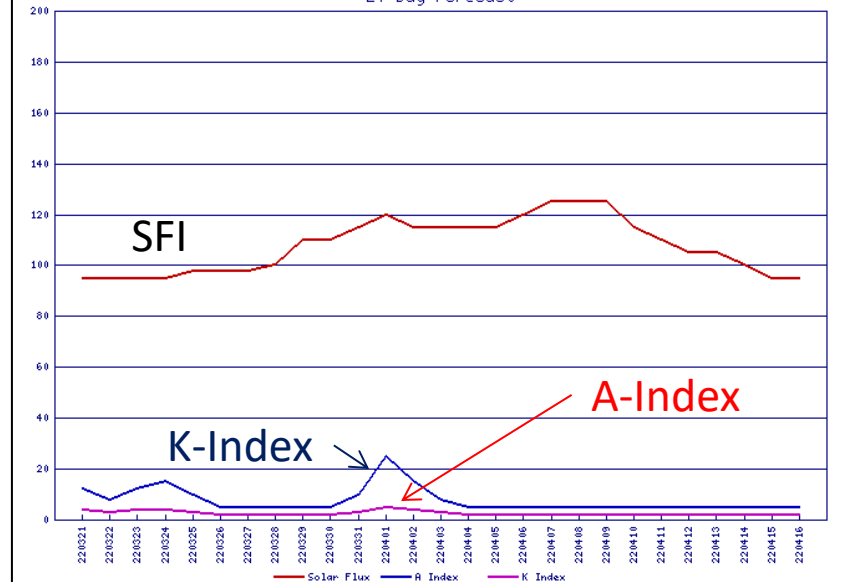
NOAA Kp index breakdown Mar 23-Mar 25 2022

	Mar 23	Mar 24	Mar 25
00-03UT	2	4	3
03-06UT	3	3	2
06-09UT	3	3	2
09-12UT	2	3	2
12-15UT	2	3	2
15-18UT	2	2	2
18-21UT	3	2	2
21-00UT	4	3	3

Kp Values – 3 hour intervals

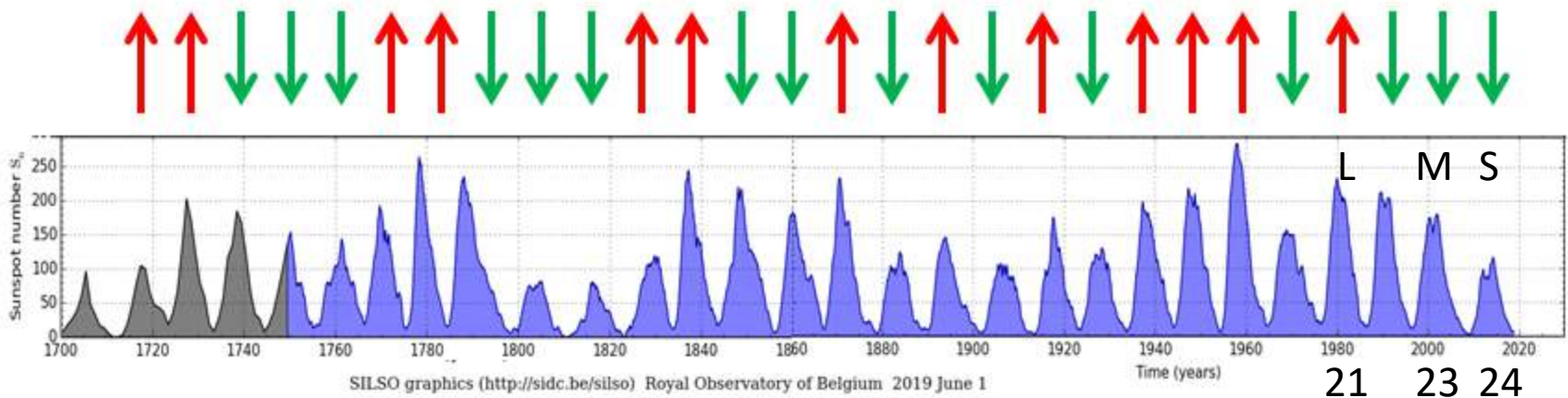
NOAA's 27 day forecast

Last update: Monday, 21-Mar-2022 14:15:03 GMT
 27 Day Forecast



Based on previous rotation of sun

Sun Spots – Ups and Downs



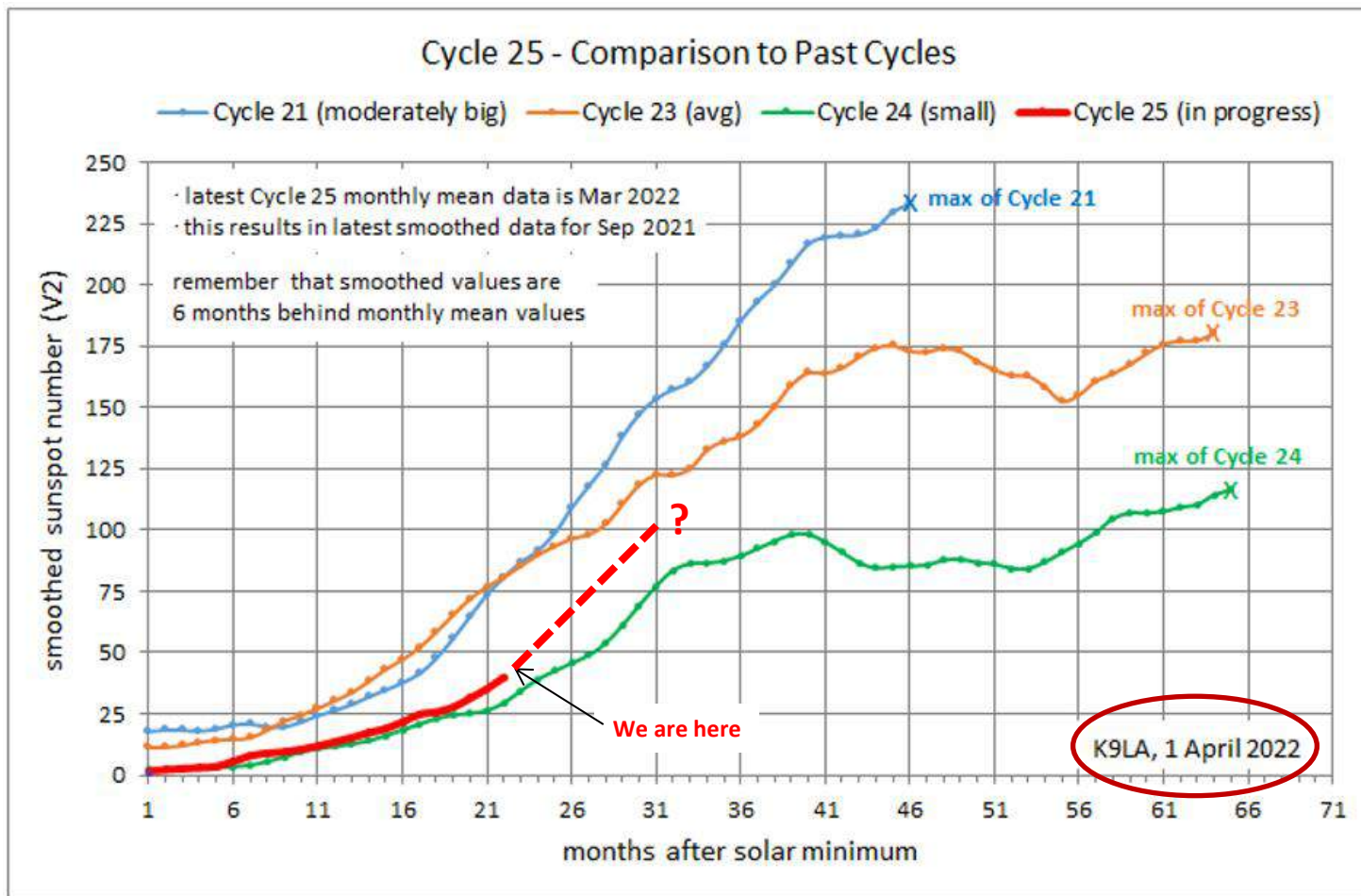
- Cycles in blue are as of when we “officially” started numbering the cycles
- We’ve experienced 3 big and 2 small cycles and may be in a third small cycle
- Average change is roughly 30% in the peak value, from one cycle to the next
- The odds of SC25 going down are very low, as we have never observed four consecutive down cycles in the previous 300+ years
- An economist would take the previous two cycles and extrapolate for this cycle
- A statistician might predict SC25 to be 30% higher than SC24

Solar Cycle 25 Update

If you've been licensed for *five years or less*, you've probably been told to wait a few more years until the HF bands (especially 10m) really get hopping....

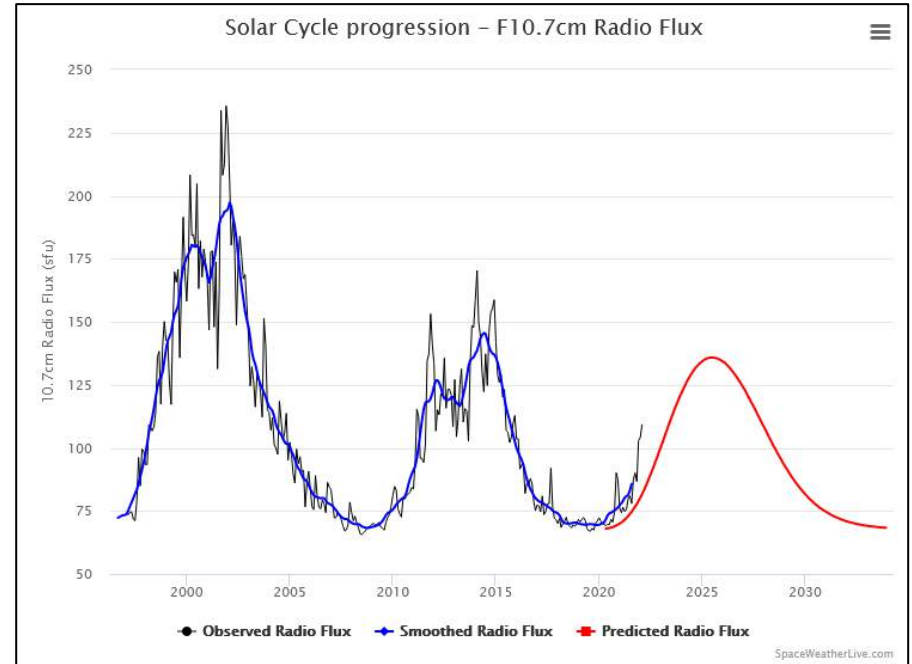
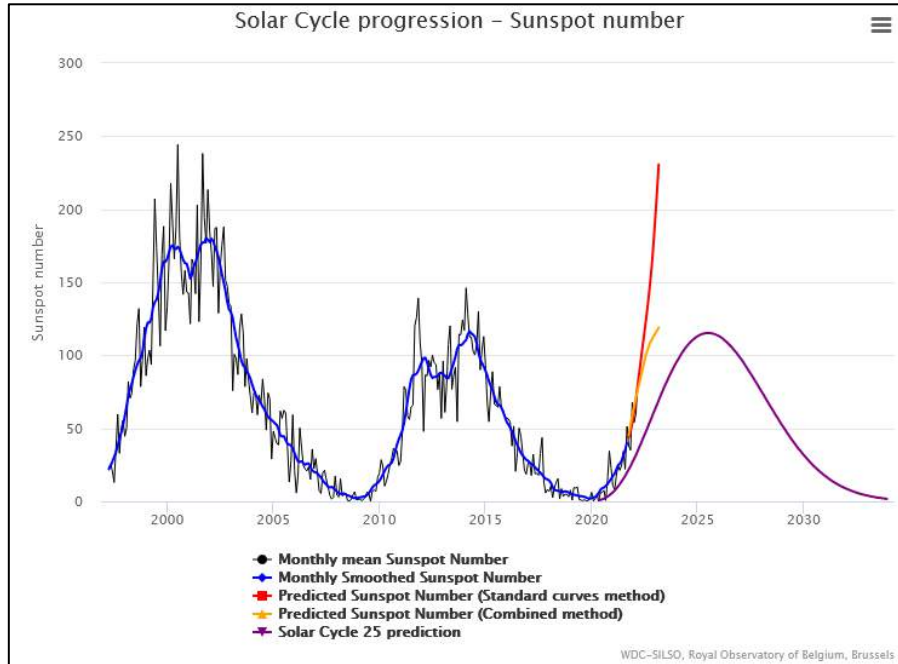
The good news... the wait is just about over!

How is Cycle 25 Doing?



- Appears to be somewhere between “medium” and “small”
- Next 6 months will be key to determining steepness of rise

Solar Cycle 25 Update – NOAA/NASA



- This prediction is among the 50 of 56 published predictions that forecast Cycle 25 to be similar to or smaller than Cycle 24 => Very Small
- Four of the 56 predictions are for an average cycle (similar to Cycle 23)
- Only two predictions of 56 support a big cycle (similar to Cycle 21)
- Actual sunspot counts have now exceeded predictions for 17 straight months

How are the bands doing?

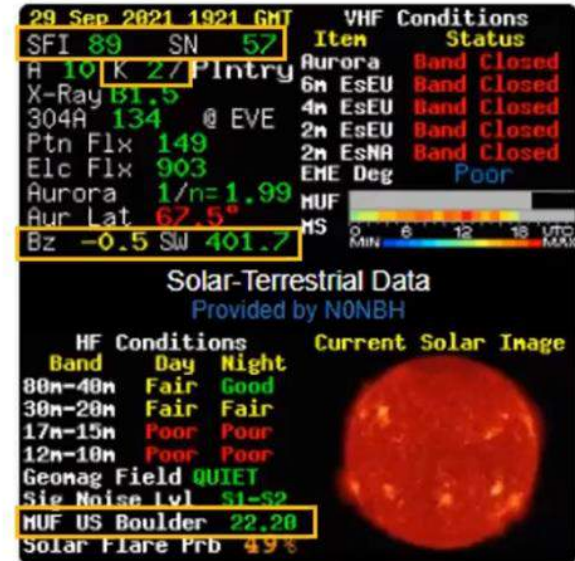
- 10m and 12m are open most days to Central and South America
 - Lots of QSB, occasional openings to EU, VK/ZL
 - Seems ahead of schedule (better sooner than predicted)
- 15m and 17m are more consistently open to many parts of the globe
 - Similar to 20m propagation
- 20m and 30m are good throughout the Cycle
- Low bands (40m through 80m) still decent at night
 - 40m has good grey-line openings to Asia and EU in the mornings
- 160m generally poor for DX

The Higher Bands Follow the Sun

- When Cycle 25 gets going in earnest
- Look to the northeast through southeast in the mornings
 - Europe, Africa, Caribbean, South America, Central America
- Look to the southeast through southwest around local noon
 - Africa, Caribbean, South America, Central America
- Look to the southwest through northwest in the afternoon and evening
 - Caribbean, South America, Central America, VK, ZL, Pacific, Japan and Southeast Asia

Parameters to Monitor

- 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
- Tell us if 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 from www.qrz.com

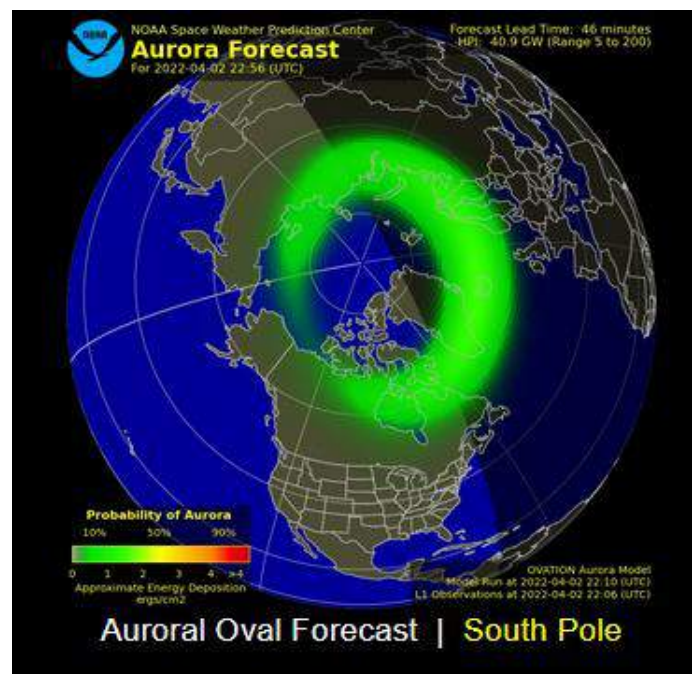
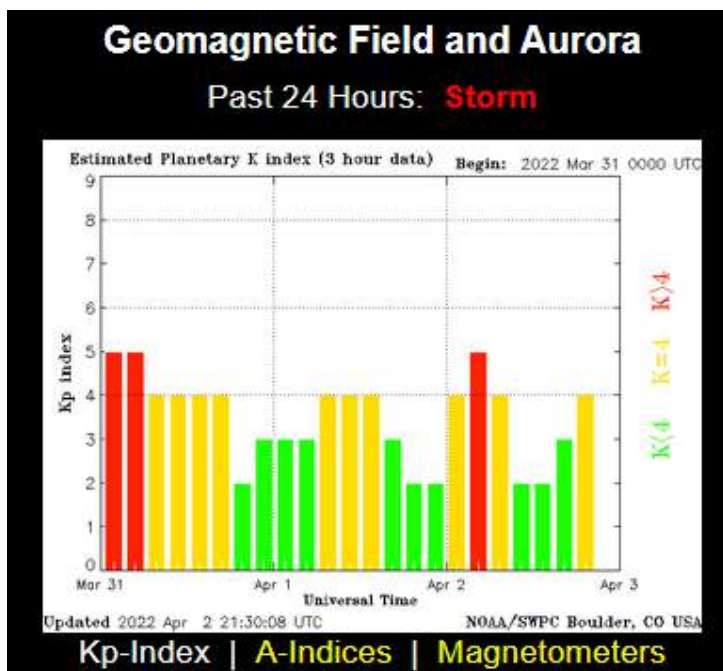
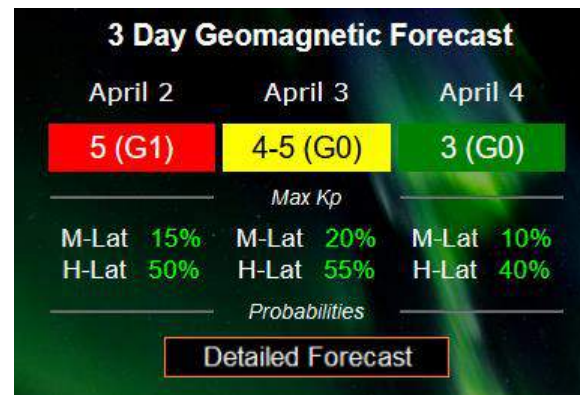
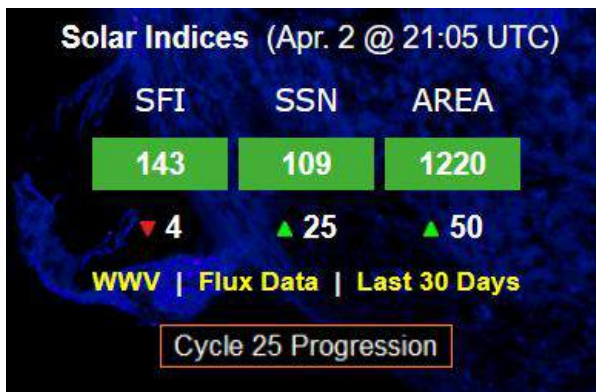
What We Generally Desire

- Caution – we're trying to make simple statements about very complicated processes
- High SFI and SN \longrightarrow
- 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

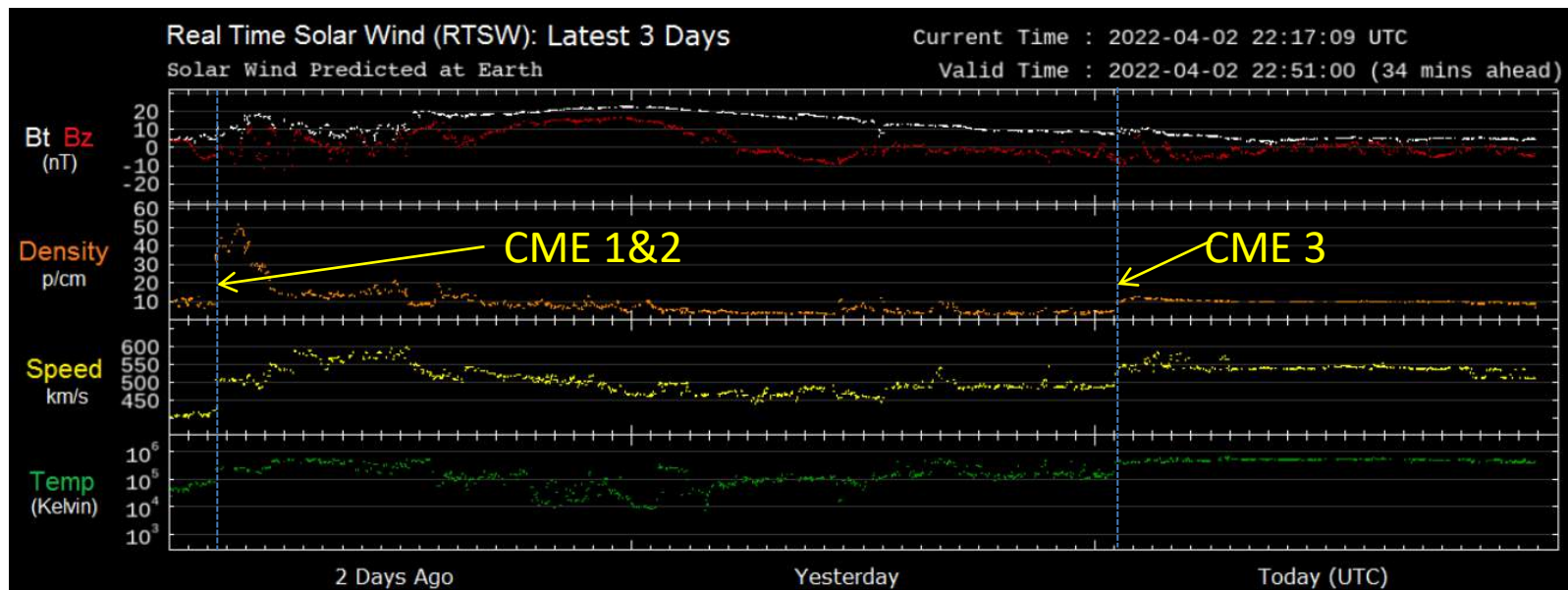
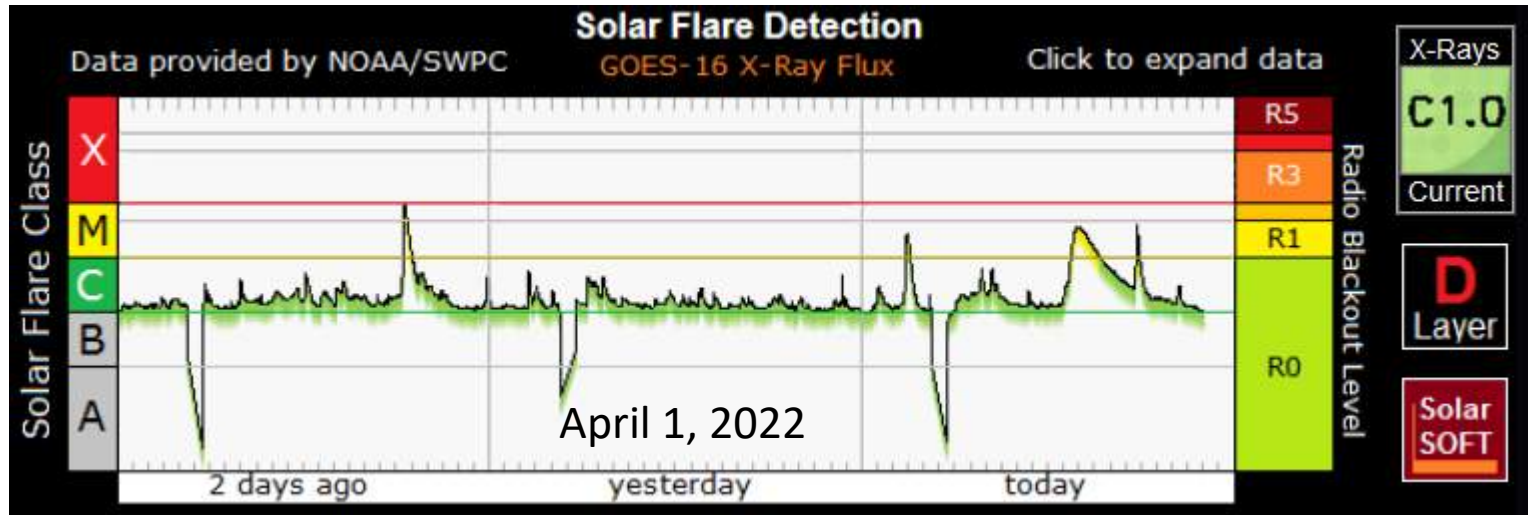
- Smoothed values are monthly means that are averaged over 12 months
- Monthly median MUF (50% probability) is for F_2 propagation in a fall/winter month in the afternoon on a mid-latitude path (there is a distribution about the median)

Current Solar Wx

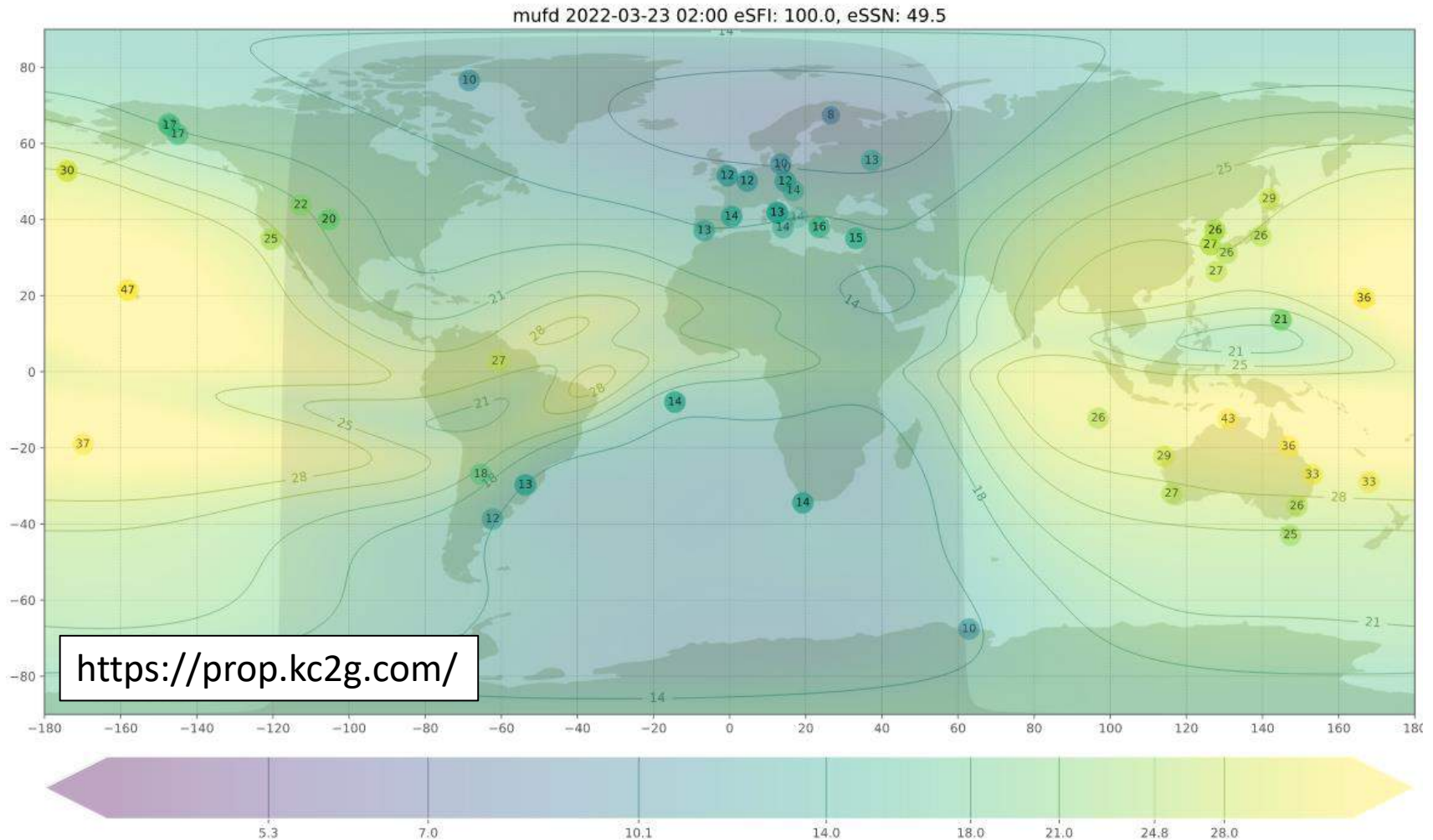


<https://www.solarham.net/>

Current Solar Wx – Cont'd

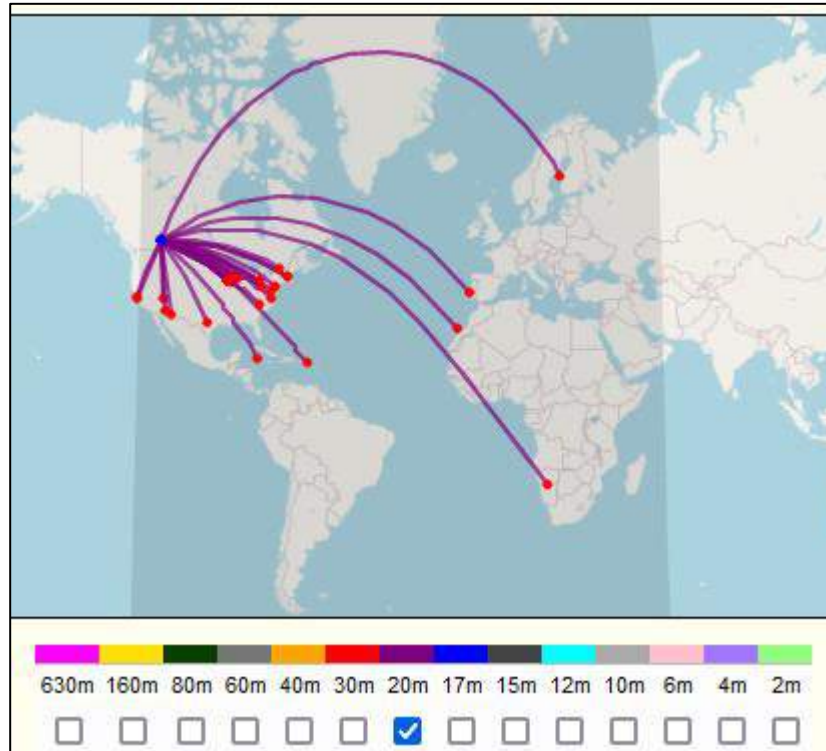


Real Time Propagation – MUF Map



- Readings from individual stations shown by coloured dots with numbers inside them
- For multi-hop paths, worst MUF value along path is what matters
- For single hop paths, useable freq < MUF because higher angles can “punch through” ionosphere

Real Time – Reverse Beacons

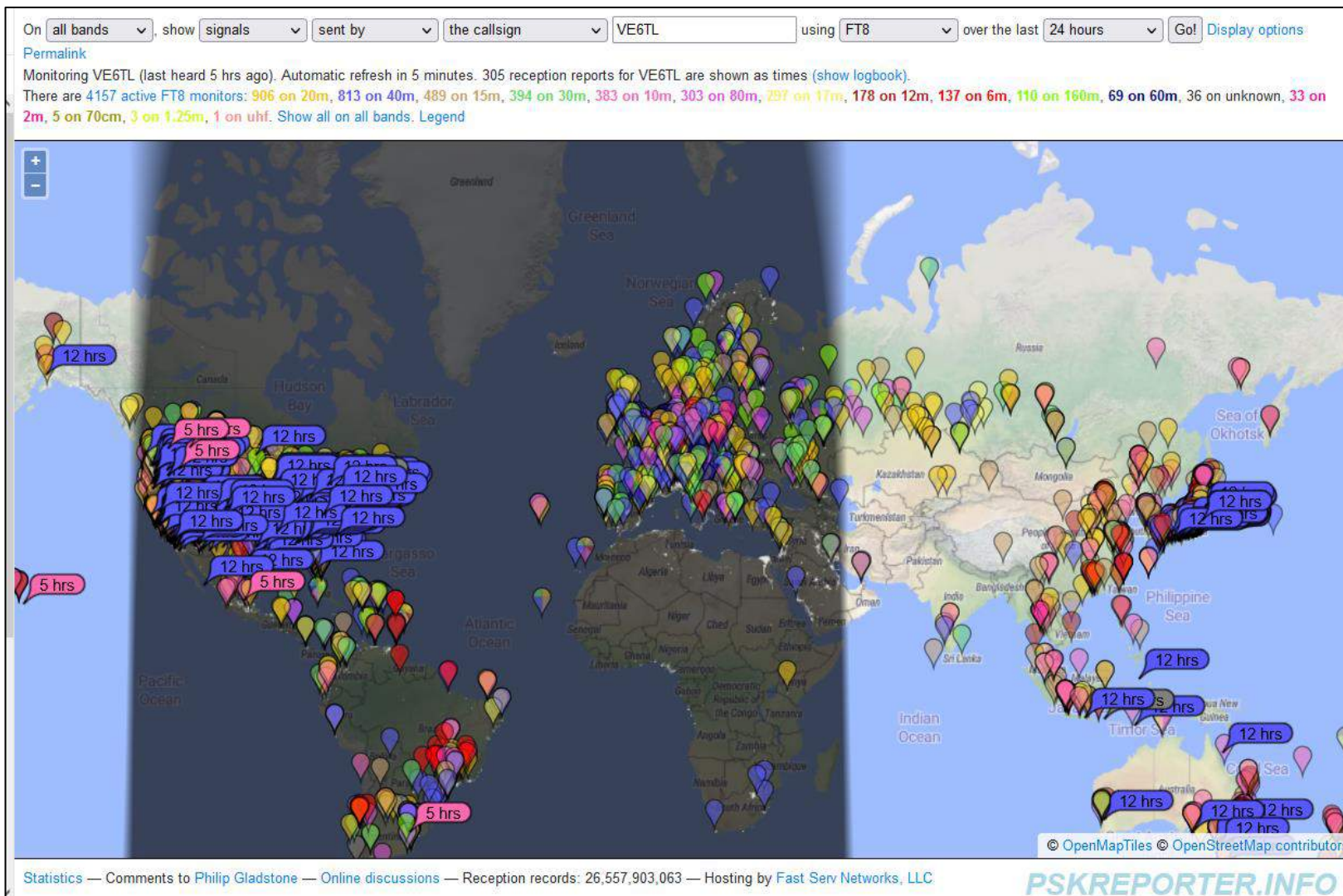


For CW, RTTY,
PSK31, PSK63

● Spotter (de)

callsign		spotter-callsign	VE6TL			
● spotter	● spotted	freq	cq/dx	snr	speed	time
V51YJ	VE6TL	14009.0	CW CQ	8 dB	24 wpm	2129z 22 Mar
KC0VKN	VE6TL	14008.9	CW CQ	3 dB	24 wpm	2129z 22 Mar
OH6BG	VE6TL	14009.0	CW CQ	28 dB	24 wpm	2128z 22 Mar
CT7ANO	VE6TL	14008.9	CW CQ	15 dB	24 wpm	2128z 22 Mar
KC0VKN	VE6TL	14008.9	CW CQ	43 dB	24 wpm	2127z 22 Mar
NA0B	VE6TL	14008.9	CW CQ	11 dB	24 wpm	2127z 22 Mar
KC0VKN	VE6TL	14023.1	CW CQ	5 dB	24 wpm	2127z 22 Mar
W3OA	VE6TL	14008.9	CW CQ	6 dB	24 wpm	2127z 22 Mar
EA8BFK	VE6TL	14008.9	CW CQ	10 dB	23 wpm	2126z 22 Mar

Real Time – PSKREPORTER – DIGITAL MODES



VE6TL – April 2022

Summary

- Cycle 25 has begun the steepest part of its ascent
- Cycle 25 appears to be consistently outperforming the NOAA/NASA Prediction
- Solar Min is best for low bands (40m - 160m)
- 17m through 30m are good throughout the solar cycle
- Solar Max best for higher bands (10m – 15m)
- Don't forget about Es on 6m during summer and December
- Try FM on 10m near Solar Max – watch out for repeaters!
- Near Solar Max, try QRP and portable operations

But Wait! There's more...

Open Access | [Published: 24 November 2020](#)

Overlapping Magnetic Activity Cycles and the Sunspot Number: Forecasting Sunspot Cycle 25 Amplitude

[Scott W. McIntosh](#) , [Sandra Chapman](#), [Robert J. Leamon](#), [Ricky Egeland](#) & [Nicholas W. Watkins](#)

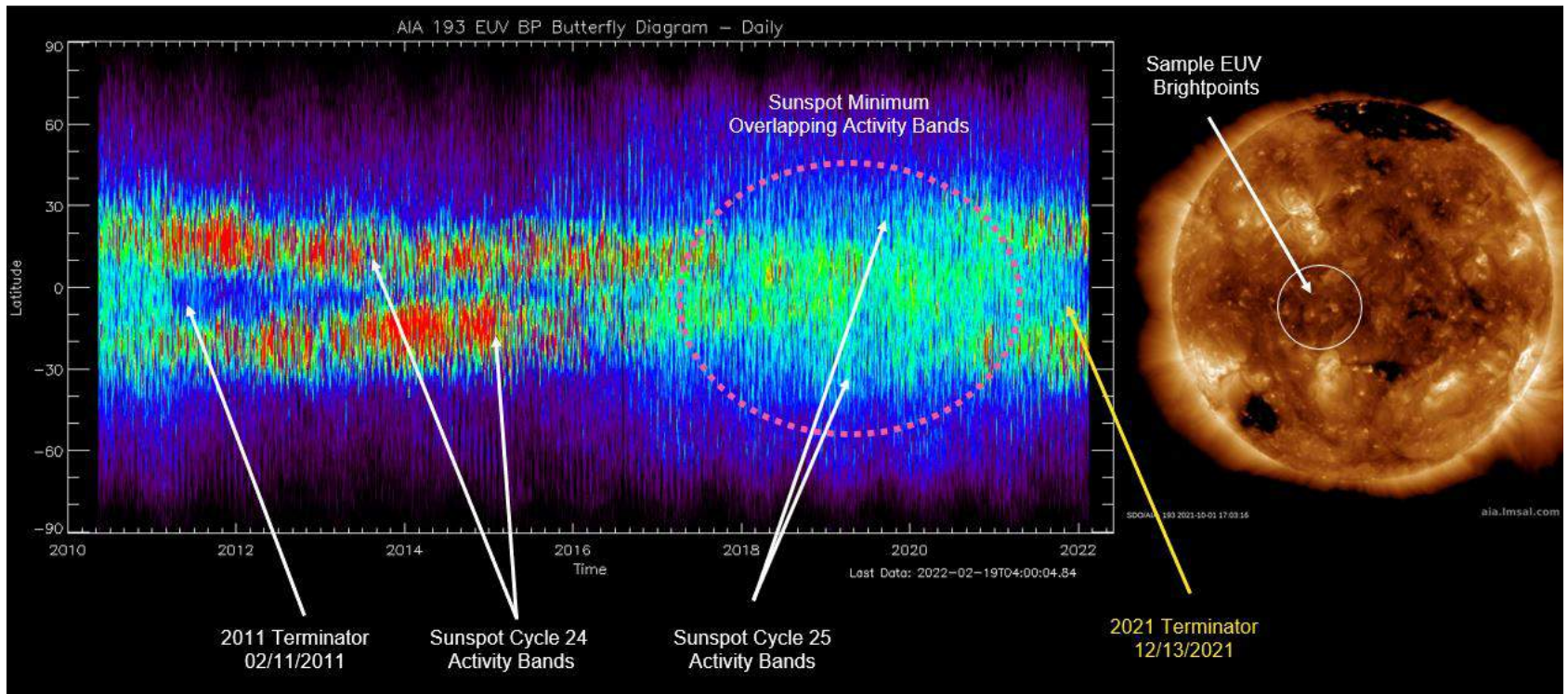
[Solar Physics](#) **295**, Article number: 163 (2020) | [Cite this article](#)

69k Accesses | **21** Citations | **492** Altmetric | [Metrics](#)

Recent observationally-motivated studies have illustrated a relationship between the Sun's 22-year (Hale) magnetic cycle and the production of the sunspot cycle landmarks and patterns, but not the amplitude of the sunspot cycle. Using (discrete) Hilbert transforms on more than 270 years of (monthly) sunspot numbers **we robustly identify the so-called “termination” events that mark the end of the previous 11-yr sunspot cycle**, the enhancement/acceleration of the present cycle, and the end of 22-yr magnetic activity cycles. Using these we extract a relationship between the temporal spacing of terminators and the magnitude of sunspot cycles. Given this relationship and our prediction of a terminator event in 2020, we deduce that sunspot **Solar Cycle 25 could have a magnitude that rivals the top few since records began**. This outcome would be in stark contrast to the community consensus estimate of sunspot Solar Cycle 25 magnitude.

Breaking news...

Solar Butterfly Diagram

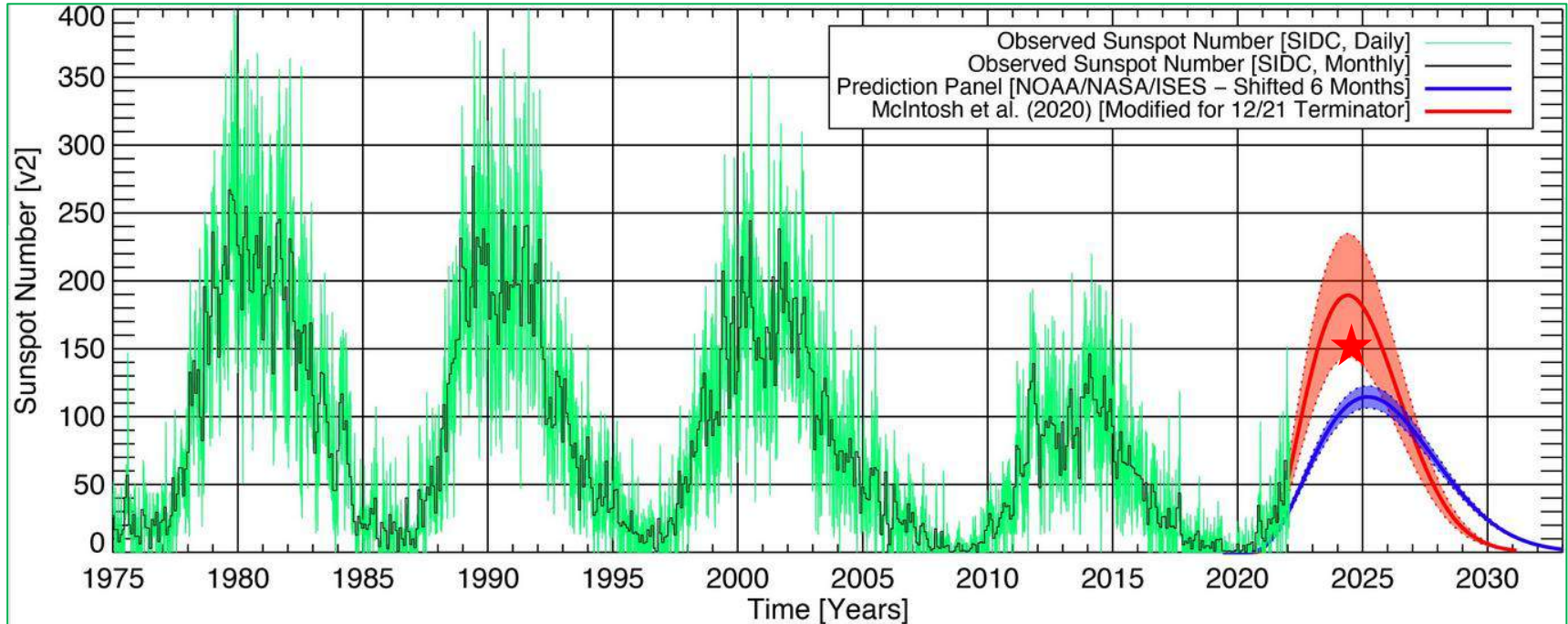


Bands of coronal bright points linked to old Solar Cycle 24 vanished in Dec. 2021, signaling a Termination Event. Solar Cycle 25 is on its own now!

Key Points

- Solar Cycles overlap as they vary in length between 10 and 15 years
- The “termination” event marks the end of the previous solar cycle
- When two cycles overlap, the magnetic fields can interact with each other (new idea)
- George Ellery Hale discovered that the magnetic polarity of sunspot pairs reverses itself from one cycle to the next (every 11 years, on average). So it is natural to conclude that opposite magnetic fields can interfere with each other and typically work to *restrain* each other
- SC25 began in Dec. 2019, but the terminator event for SC24 was not observed until Dec. 2021 – 2 years of overlap
- Without the contrary magnetic field of SC24, the new SC25 can really take off
- Based on 270 years of sunspot data, McIntosh and Leamon predict a monthly smoothed sunspot number peak for SC25 of 190 +/- 20.

McIntosh et. al. Sunspot Number Prediction SC25



★ The presenter's prediction (2018) for solar max sunspot number is 156 ± 20

Conclusions

- Based on current propagation patterns (median sunspots, smoothed SFI), we have reason to be optimistic for some great DX in the next few years
- Now that we have seen the “official” end of SC24, we can expect a steeper climb for sunspots and solar flux in SC25
- If you are not on HF, this is the time to get a rig and put up antennas



Get Active!