Rising Sunspot Numbers: It's Not All Good News

When we look at the whole picture, the D and E layers of the ionosphere may present some challenges.

John Stanley, K4ERO

The amateur radio community is getting excited about the start of Solar Cycle 25. Hams are operating on the higher frequency bands and getting some results, as well as talking about better conditions on the 20- through 10-meter bands. Higher sunspot numbers will bring the return of more signals on the higher frequency shortwave bands, however, higher solar activity also affects the lower frequency bands (and not always for the better). The worst effects occur during the day, so I'll focus on daytime paths in the mid-latitudes. The figures I've included were made for March conditions in the center of the US using data generated by the Voice of America Coverage Analysis Program (VOACAP) propagation predictions (**www.voacap.com**).

Any propagation tutorial will mention the three layers of the ionosphere: D, E, and F. As the solar activity rises, all three layers get "thicker," having more electrons per unit volume. The extra electrons in the F layer bend higher frequencies back to Earth, allowing long-distance contacts. This may seem positive, but we need to look at the whole picture, including the other two layers.

Daytime Radio Signals

The lowest region of the ionosphere is the D layer, and its effect on radio waves is not very good. When it gets thicker, the waves passing through to the E and F layers become weaker. This layer has more neutral atoms than electrons. As a wave passes through it, electrons are moved back and forth by the E field of the wave. The electrons collide with the neutral atoms and lose energy. The more electrons there are, the more lossy collisions occur, making signals weaker. The D layer mainly goes away at night, no longer weakening the low-band signals. Distant AM broadcasts and 160- and 80-meter signals get stronger.

A sunspot number (SSN) of 100 means the thicker D layer weakens the daytime signals more than when sunspots are low. Figure 1 is a plot of the total loss on a 200-mile path on 80 meters for high and low SSNs. The loss at 12 PM is 30 dB (1,000 times) more with an SSN of 100 than with an SSN of 10. If you've been operating 80 meters between 10 AM and 2 PM for the last 5 years, you'll be in for a shock when the SSN rises. You can blame the D layer for the major loss of daytime signals. Some weakening even continues into the evening, when many nets are active. The thicker D layer can weaken signals on other bands, but it's most serious on the 160-, 80-, and 60-meter bands, and still significant on 40 and 30 meters.

Effects of a Thicker E Layer

The E layer also gets thicker as sunspots rise. This causes another problem that adds to the D-layer loss. Figure 2 is a plot of signal-to-noise versus distance for 40 meters with high and low solar activity. For distances between 300 and 500 miles, the signal with an SSN of 10 (blue line) is about 10 dB stronger than the signal with an SSN of 100 (red line). This is that ugly D layer absorption again. In addition, both curves show a distance where a steep drop occurs. With an SSN of 10, this is at about 600 miles. With an SSN of 100, the steep drop-off point moves to about 460 miles. This represents a loss of nearly half the coverage area.

6 Meters Shines During Solar Cycle Peaks

Jon Jones, NØJK

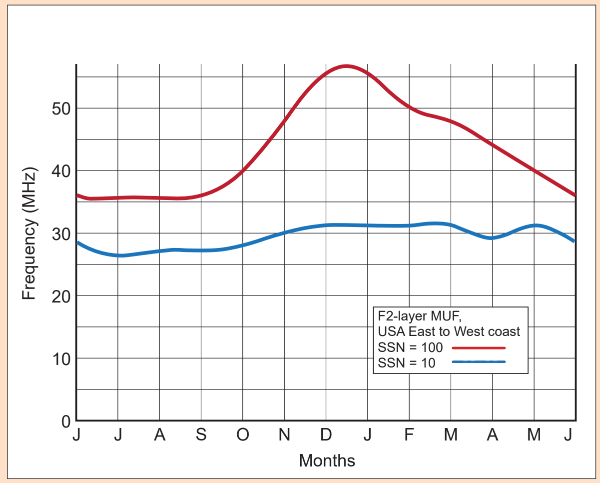
High sunspot numbers (SSNs) help VHF operators with F2 ionospheric propagation (F2 skip) on 6 meters. This type of propagation involves the refraction of radio signals off of the F2 layer of the ionosphere, which is about 200 miles (330 kilometers) above the Earth's surface. UV radiation from the sun can intensely ionize this layer, and signals can be refracted up to 2,000 – 3,000 miles (3,200 – 5,000 kilometers) from one refraction, or "hop." Multiple hops can occur under the right conditions, enabling signals to go over 12,000 miles (19,000 kilometers) with low loss. It's one of amateur radio's most exciting modes.

But there are downsides to VHF during a solar cycle peak. D-, E-, and F-layer ionospheric absorption, as well as Faraday rotation (polarization rotation of signals through ionospheric layers), increases. Solar flares can cause ionospheric radio "blackouts." The absorption decreases the already weak signals from Earth-moon-Earth (EME) communication, and Faraday rotation of radio signals can cause "lockout" with total loss of reception.

If Solar Cycle 25 is similar in magnitude to Cycle 24, some interesting propagation will occur on 6 meters, including F2 and transequatorial propagation (TEP). TEP involves refraction signals off highly ionized "bulges" located about 15 degrees north and south of the geomagnetic equator. This allows HF and VHF radio signals to cross the geomagnetic equator with low loss.

It'll be a couple of years before people can start expecting any F-layer propagation on 50 MHz. In the meantime, rare propagation is occurring now on 6 meters. Sporadic-E/TEP occurs when sporadic-E hops can link to TEP, potentially covering thousands of miles.

The high maximum usable frequency (MUF) in the F2 layer critical for 6-meter propagation occurs during the fall, winter, and early spring months in the Northern Hemisphere. Six meters will not open for F2 during the summer, even at solar cycle peak. This is called the winter anomaly. The graph shows a path from the east to west coast in the US with both lines representing the F2 layer. The red line is the MUF for an SSN of 100 and the blue line is the MUF for an SSN of 10. The generally accepted explanation for the anomaly is increased ionized oxygen relative to nitrogen in the F layer, due to seasonal circulation in the ionosphere.



The winter anomaly in the F2 layer.

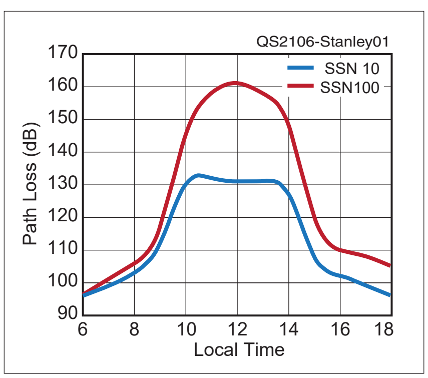


Figure 1 — Path loss versus time of day for the 75- and 80-meter bands.

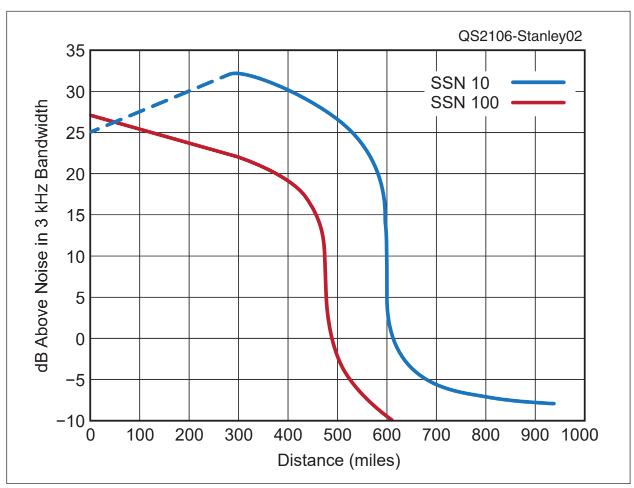


Figure 2 — Distance versus signal strength on 40 meters during the day.

For shorter paths, the curve representing SSN 10 drops (dotted line). This is because there isn't enough ionization in the F layer to give a solid return to high-angle signals. This can cause a close in a zone where signals aren't heard, even though distant signals are heard. This is called a "skip zone." With an SSN of 100, the daytime skip zone is gone on 40 meters, but overall the signals are weaker, and the maximum range is less. Nearby coverage is better, but distant stations are lost.

This sharp drop-off in signal at 460 and 600 miles is caused by the E layer, as shown in Figure 3. A 60° or 45° signal (near vertical incidence skywave) from the transmitter point (point T in the figure) goes through the D and E layers, bounces off the F layer, and comes down at points A or B. Signals sent out at 30° would arrive at point E if the E layer wasn't thick enough to reflect them. All lower-angle signals are also blocked. We can't reach point E via one hop from the F layer, and to reach point D or E, the E layer must be used. This passes through the lossy D layer via a longer, slanted path. For the distance where a critical angle at the E layer reflects rather than passes the wave, the signal strength drops drastically. Using two E or F hops would mean four trips through the D layer with double the loss.

While sporadic E can sometimes give unusual DX on 10 and 6 meters, a thicker E layer normally does more harm than good to shortwave propagation. By blocking signals from reaching the F layer, it limits the maximum distance covered. Forty-meter daytime nets may have to do some adjusting as the sunspots go from near 0 to maximum. This may mean changing the hours of operation or going to a higher band.

Choosing the Best Band for Daytime Operation

As the higher bands open up, the lower bands will get worse overall (especially in the daytime), due to higher D-layer losses and the greater blocking effect of the E layer. Anticipating these changes, operators can plan for and use the most appropriate band for a given activity. In propagation planning, FOT (frequency of optimum transmission) is used. This is the frequency predicted to be the most reliable between two points. It varies based on time of day, latitude, season, sunspot activity, and distance.

Figure 4 shows that the daytime FOT changes as the sunspots rise. It shows that with an SSN of 10, 5 MHz is optimum up to 250 miles, moving to 7 MHz for 400 miles, and 14 MHz for 1,000 miles. With an SSN of 100, 7 MHz is best up to 250 miles, 10 MHz for 470 miles, and 14 MHz at 800 miles. When the SSN goes from 10 to 100, the FOT rises by about the difference between one band and the next. Thus, by moving up one band during the high sunspot years, one should have similar coverage.

The problem with moving to the next higher band is that 60 and 30 meters have their limitations. One would ideally move from 75 to 60 meters, 60 to 40 meters, and 40 to 30 meters. However, SSB nets on 40 meters can't move to 30 meters, and there would be congestion if the 75-meter nets all tried to go to 60 meters. Moving from 75 to 40 meters is possible in some cases, and some nets have done that in the past. It's not ideal, as the frequency increase is more than what's needed to stay with similar coverage. A 40-meter CW net moving to 30 meters would work well.

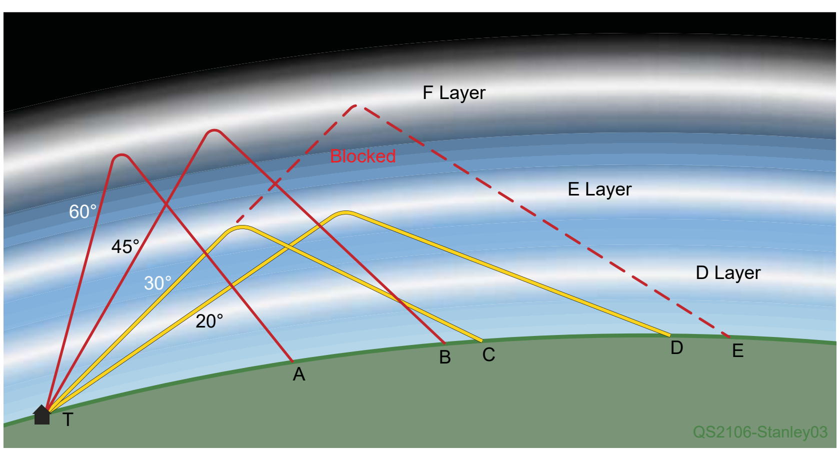


Figure 3 — The ionosphere's E layer blocks low-angle signals.

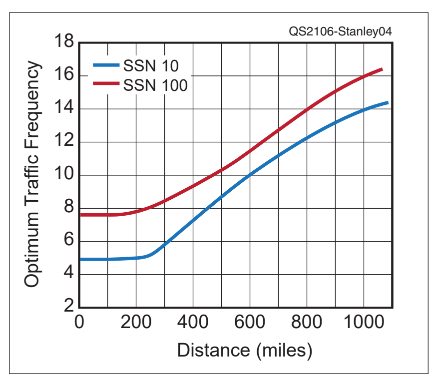


Figure 4 — Frequency of optimum transmission (FOT) versus distance, daytime, and mid-latitudes.

When going to a higher band is impractical, the next best option is to change the time of day. Operation on 160 meters will have to move toward the evening hours, because daytime propagation dies quickly with sunlight. Morning nets on 75 and 40 meters or longer-lasting contacts may have to move to earlier hours and early evening nets to later hours.

Conclusion

Whether the sunspots are high or low, we can work with propagation as opposed to waiting for it to improve. As we begin Solar Cycle 25, the lower bands will still be good at night. In the daytime and early evening, paths on the higher bands will be very exciting.

With the prediction and monitoring tools we have, we should be able to anticipate and keep track of what's going on. Doing what we can now will help us use the new conditions to our best advantage.

John Stanley, K4ERO, and Ruth Stanley, WB4LUA, did broadcast engineering for 45 years, performed ionospheric research, taught, and helped radio stations around the world find the best frequencies for their shortwave broadcasts. John and Ruth have held many call signs in some of the dozens of countries in which they've worked. As an ARRL Technical Advisor, John has contributed to many ARRL publications. Now retired in their off-grid, self-built home on Lookout Mountain in northwest Georgia, they're involved in church work, writing, and consulting. John keeps up with old friends on 75 meters and plays with digital modes on many bands. He can be reached at **jnrstanley@alum.mit.edu**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

Life Members

Elected April 5, 2021

Brady G. Alleman, N3BGA
Michael R. Antonyak, KC2AIW
Nathan G. Barnes, KN4KJS
Scott L. Bastian, AK6Q
Richard Berube, WB1SKY
Steven A. Bonica, KI5IOC
Patrick K. Booth, WW5Z
Ricky L. Brewer, NI2C
Angela M. Briggs, KL3VA
Michael W. Briggs, KL3UX
Angela R. Brown, N3ARB
Matthew D. Brown, K2EAG
Sarah E. Brown, KA3GMC
Brian Brunsch, KC2YON
Ronald L. Buskirk, KD9GDN
Chris A. Carlisle, N7IOF
David S. Carlson, KI5KMV
David M. Carney, KO1C
Michael B. Cash, W6PM
Phillip N. Cash, KG6JEL
William B. Cotter, N4LG
Albert E. Creswell, KD2RIT
Sarah Day, KN4JYI
Gregory Deemer, KFØDBB
Austin Deventer, N9AJD
Thomas Dickerson
Maurits Dijkmans, PD3MLP
Hugo L. Dominguez, KM6DQU
Karl W. Edmark, KE3KWE
Carl L. First, N6CKV
Austin Fite, N7AJ
Thomas Frerichs, AEØGQ
Thomas Frohnapfel, K5EIS
Mark T. Goldstein, N5WEI
Bill Grammer, KW4W
William W. Greaves, K9GN
Thomas P. Griffin, AA4PG
Eugene C. Gruhler, AEØLB
Thomas J. Guida, W2NZ
Pierre J. Guimond, N1EZT
Carla R. Hall, KF4YBM
Darryl L. Hambly, W2DLH
Ken Hart, K4KN
Gary D. Haynie, WØDBL
John E. Hearne, AF5EK
Joan Heinen, KBØYRX
Patrick J. Hogan, KK4NDY
Andre K. Hunt, N2JDH
Nina Hunt, KC1LWY
Patrick D. Hutton, KG5VKV
Charles A. Jackson, KN4FKF
Frandy Johnson, N1FJ
Robert J. Johnson, NQ5P
Susan M. Johnson, KD8BJW
Gary W. Lackey, N5GWL
Chris D. Long, N1CL
Colin Lord, KT4ATL
Robert T. Love, KE5FNA
Kevin J. Lynch, N1KL
Christopher Magelitz, K3BBC
Dale L. Martin, KG5U
Timothy A. Martin, WB2VVQ
Barry A. Mather, AD7CL
Jerome P. McDonald, W7FVB
Michael McGarvey
Russell J. Mckay, KC3RNM
Harry Mueller, W1HMM
Dan R. Oetting, NØBAF
Todd W. Oldenburg, KK2I
Joseph M. Pepe-Phelps, KL3JY
Christopher Porter, AA7KL
Richard Preston
Theodore C. Price, N5EYS
Bradley D. Prouse, KDØUED
Timothy S. Reed, W3HR
Chris Reich, WB2DYJ
Adam Rennison, ADØAM
David L. Rhodes, WK4T
Andrew Rizkalla, AD2BJ
David R. Robbins, K1TTT
Alan P. Rothermich, WBØQLU
Rachel M. Runion, KN6KGW
DJ Sandler, KD6JIX
Rachel L. Schmoyer, KC1OHY
Jack L. Sheldon, KN7Y
Earl F. Skelton, N3ES
Christopher Smith, K2WCS
Brian L. Stamper, W4ES
George A. Stone, WD4CYV
John C. Tobias, KD3OA
Craig D. Troop, N3GW
Barry M. Tucker, AG4GD
Jeremy M. Turner, NØAW
Fred B. Twigge, K7DTU
Suzanne C. Van Der Valk, NDØD
Asher Waldfogel, KØAU
Brent A. Washer, AJ6MQ
Richard Weber, K7EEY
Michael G. Williams, KJ7LDW