Solar Cycle 25 Is Finally Here

An overview of what we know from Cycle 23 and 24, and some theories as to what we might see from Cycle 25.

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Set off the fireworks! Solar Cycle 25 is finally here, so now is a good time to review some basics, including what solar minimums and sunspots are, and why they're important for amateur radio. After reviewing what we know so far, we'll be able to make some predictions about what we can expect from Solar Cycle 25. Be sure to read Steve Ford's, WB8IMY, article and Bernie McClenny's, W3UR, "How's DX" column in this issue for more on Solar Cycle 25.

Observing and Measuring the Sun

Sunspots are the oldest direct record of the activity of the sun. A *solar cycle*, or sunspot cycle, starts at *solar minimum* (when there are few sunspots), goes through *solar maximum* (when there are many sunspots), and then ends up at solar minimum again.

Sunspots are the darkened regions of reduced surface temperature that are caused by the sun's magnetic fields rising up from below the sun's surface and poking through. The term "surface" is somewhat of a loose term, as the sun is not a solid.

Sunspots are a subjective parameter, because visual counting by humans is required, and there can be an unintentional bias in the counting process by the observer. This, in fact, was the main reason why the old sunspot data set was reviewed in the last decade. The new data set was created in 2015, and that is believed to be a more accurate representation of past solar activity.

In 1947, to achieve a more objective parameter of solar activity, scientists starting using radar receivers from World War II to measure the radiation from the sun at a wavelength of 10.7 centimeters (2800 MHz). Although the data doesn't extend back in time like sunspots, the 10.7-centimeter solar flux parameter is preferred over the more subjective sunspot data because the solar flux measurement is the output from a calibrated antenna/receiver system. In this process, there is no need for human interpretation.

It is difficult to determine the best correlation between sunspots and 10.7-centimeter solar flux, given that they are from two different processes in the sun. Those two parameters are indeed correlated, but unfortunately not on a daily basis, because a daily 10.7-centimeter solar flux value does not map to a unique daily sunspot number.

The next logical step was to look at monthly averages (also known as monthly means) of both parameters. This helped a lot, but still the correlation was just not good enough. The next step was to average 12 months of monthly mean data — these are called *smoothed values*. The correlation is very high doing it this way, and that's how sunspots and 10.7-centimeter solar flux values are best correlated.

Observing and Measuring the Ionosphere

Propagation on our HF bands is influenced by the *ionosphere* — the portion of our atmosphere in which solar radiation at various wavelengths ionizes neutral atmospheric constituents resulting in electrons and positive ions. The electrons are the important factor in propagation.

For our radio endeavors on the HF bands (3 – 30 MHz), we are interested in the three regions, or layers, of the ionosphere: the D region, the E region, and the F region, which is further divided into the F1 region and the F2 region (see Figure 1).

We measure the ionosphere with an instrument called an *ionosonde*, which is a swept-frequency radar looking straight up. From the resulting data, the maximum electron density in the E region, the

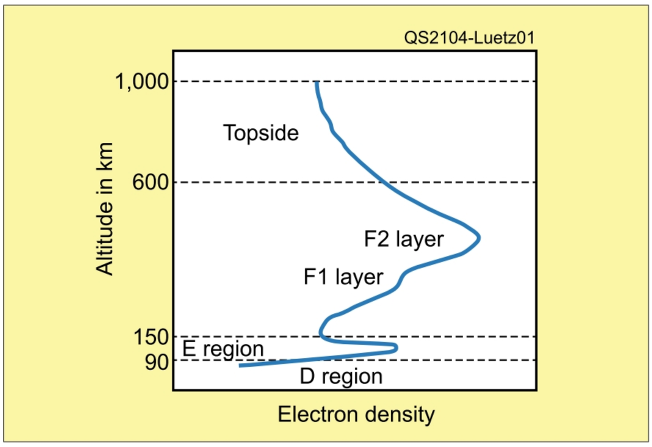

Figure 1 — A typical electron density profile as a result of the ionization process. Note that the electron density profile is a continuous function versus altitude. There aren't any thin layers as the name "layer" suggests. Also note that the E region and the F2 region have very distinct maximums, whereas the D region and the F1 region do not.

Space Weather and Assessing the Ionosphere

For a broad assessment of HF propagation and what is important for our amateur radio endeavors, we can simplify all that data to just the sunspot number and the K index.

Sunspot Number

When the sunspot number is consistently at or above 70 for a couple months, 10 meters should offer consistent worldwide openings. For 15 meters, a sunspot number at or above 50 will offer good propagation. Those sunspot numbers for 10 meters and 15 meters correspond to 10.7-centimeter solar flux values of 100 and 90, respectively.

K Index

This parameter varies from 0 to 9, and is reported every 3 hours. It is a measurement of the activity of the Earth's magnetic field. As the K index increases, the Earth's magnetic field becomes more disturbed. In general, the MUFs in the F2 region of the ionosphere become lower, possibly causing a radio amateur to lose propagation on the band they are on, and have to move down in frequency to continue the contact. For best propagation, we would like to see a K index of 3 or lower.

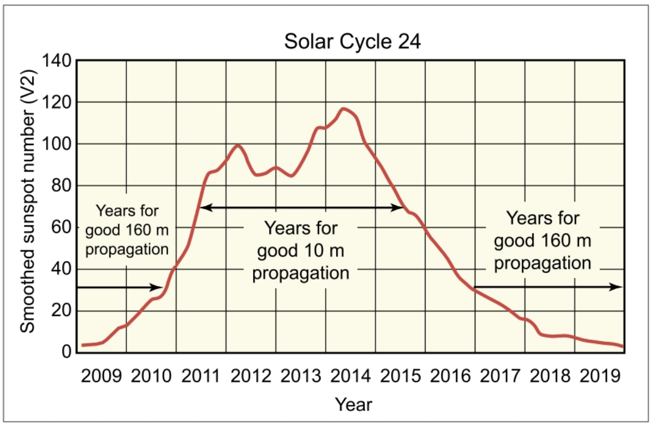

Figure 2 — During Solar Cycle 24, there were some years that were good for 160 meters and 10 meters.

maximum electron density in the F1 region, and the maximum electron density in the F2 region can be calculated.

This calculation allows us to determine the highest frequency, also known as the *maximum usable frequency* (MUF), which allows a contact over a given path at a given time. Propagation usually consists of our radio wave going up to the ionosphere and being bent, or refracted, enough to return it back to Earth. A frequency higher than the MUF is not refracted enough and goes off into space.

Correlating Propagation to the Sun and the Ionosphere

Now we're back to another correlation issue between the state of the ionosphere and what the sun is doing. Before proceeding, we should realize that 10.7-centimeter solar flux and sunspots are *proxies* for the wavelengths of radiation involved in the ionization process. We use these as stand-ins, due to the fact that before the space age, we had no way of measuring radiation at extreme ultraviolet (EUV) wavelengths (the true F2 region ionizing radiation) because its energy is used up in the ionization process and nothing gets to ground level for measurement. Now that we have satellites above the atmosphere, we can measure EUV. But our propagation predictions were developed before the space age and had to be correlated to sunspots (later, they could also be correlated to the 10.7-centimeter solar flux).

EUV is the most important ionizing wavelength for our amateur radio endeavors. The discovery that more radiation at EUV wavelengths improved propagation on the higher HF bands gave us the correlation we needed to understand why more contacts were possible on the higher frequencies as more EUV impinged on our atmosphere. At solar minimum, the ionosphere can't refract the higher HF bands (15, 12, and 10 meters) back to Earth, because there isn't enough ionization.

Around solar maximum, the ionosphere can refract the higher HF bands back to Earth. On the other hand, the lower HF bands (160, 80, 60, and 40 meters) are generally best around solar minimum, because less ionization means there is less *ionospheric absorption* — loss that reduces the signal strength (see Figure 2).

Where Cycle 25 is Headed

Figure 2 is good history, but it is not enough to determine when 160 meters and 10 meters will be good during Solar Cycle 25. It all depends on how big Cycle 25 will be. As Steve Ford mentions in his article, there are pessimistic forecasts for Cycle 25 (a small cycle), and there are optimistic forecasts (a big cycle) for Cycle 25. Unfortunately, most of the forecasts are for a small cycle. But remember these are forecasts, not concrete truths.

If Cycle 25 is similar to Cycle 24, the good years for 160 meters are roughly for another year from now and toward the end of Cycle 25. The good years for 10 meters will be roughly 2023 through 2027. A bigger Cycle 25 will shorten the 160-meter lengths and extend the 10-meter lengths.

Further Resources

Resources including websites and books are available for monitoring the status of Cycle 25 or for more information about the ionosphere and HF propagation. Recommended resources include:

- Daily 10.7-centimeter solar flux (along with other parameters) at **www.solen.info/solar**
- **www.spaceweather.com**
- **www.swpc.noaa.gov/products/solar-cycle-progression**
- **www.solarham.net**
- Propagation and information about who is working who on a given band is available at **www.dxmaps.com/spots/mapg.php?Lan=E**
- **https://pskreporter.info/pskmap.html**
- **www.wsprnet.org/drupal**
- **www.reversebeacon.net**
- For an assessment of the ionosphere itself, **http://prop.kc2g.com** shows worldwide MUFs for a 3,000-kilometer path using ionosonde data.
- Robert Brown's, NM7M (SK), *The Little Pistol's Guide to HF Propagation*, available for free at **https://k9la.us**
- Chapters on "Propagation" in *The ARRL Antenna Book* and *The ARRL Handbook*
- *The CQ Shortwave Propagation Handbook – 4th Edition* by Carl Luetzelschwab, K9LA; Theodore Cohen, N4XX; George Jacobs, W3ASK; Robert Rose, K6GKU (SK), from CQ Communications.

Be aware that the sun can hiccup, as seen by big spikes in the 10.7-centimeter solar flux and sunspot number. This can give us good propagation on the higher HF bands for a short time. This happened recently at the end of 2020. Read the "How's DX" column in this issue for more details on this. Always watch for a big spike in the 10.7-centimeter solar flux (and sunspot number), and head to the higher HF bands if it happens.

Carl Luetzelschwab, K9LA, started his radio career as a shortwave listener in the late 1950s, using a National NC-60 receiver. After discovering amateur radio, he received his Novice license in 1961. He selected K9LA as his call sign in 1977. Carl enjoys propagation, DXing, contesting, playing with antennas, and fixing/using vintage equipment. Carl is a graduate of Purdue University (where he earned his Master's degree in electrical engineering) and worked for Motorola (in Schaumburg, Illinois, and Fort Worth, Texas), and for Magnavox in Fort Wayne, Indiana (now Raytheon), as an RF design engineer. He retired in October 2013. Carl is currently the ARRL Central Division Vice Director. You can contact Carl at **k9la@arrl.net**.

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