

Elmers Corner: Getting Started with Radio Propagation

By Robert Gulley March 29, 2015

If one wants to get serious about the radio hobby there comes a time when the study of propagation (or how signals get to where they're going) is a must.

Not only will understanding some basics about propagation make listening opportunities more productive (read "fun"), but it will also allow you to take advantage of special situations where opportunities pop up only for a few minutes or a few hours at best. Catching elusive signals, or even better transmitting under special conditions is a thrill all its own.

The actual composition of the atmosphere and seasonal changes in the ionosphere are two of the biggest factors in propagation, so this is where I will start. There are many, many aspects to the study of propagation, some of which I will introduce now, with more to follow next month.

Atmospheric Layers

As you probably know already, the atmosphere is made up of several layers, determined primarily by the chemical composition and the physical characteristics of each layer and marked by varying elevations. The uppermost layer of the atmosphere is called the ionosphere, made up of a shell of electrons and electrically charged particles. This shell can either allow radio signals to pass through it into space, or it can bend some of those radio waves back toward the surface of the earth allowing communication over great distances. Radio waves which are bent back to earth usually make multiple hops between the earth and the atmosphere, depending on frequency and strength.

How much bending or refracting of a radio signal occurs depends on the frequency of the signal and on the structure of the ionosphere at any given time. Changes in density within the ionosphere (defined as layers) allow some signals to bend while others pass through into space. These layers change daily as well as seasonally. Over time scientists have learned a great deal about what to expect under a given set of conditions, in part due to experimentation and observation by radio amateurs.

While no model of propagation will guarantee signal reception on either end of the intended path, radio enthusiasts can predict with a

good deal of accuracy when one is likely to hear signals broadcast in specific portions of the radio spectrum. This ability to predict what can and cannot be heard is both a blessing and a curse. I regularly check propagation forecasts in several monthly radio publications to get an idea of what I am likely to hear at any given time. I also check online resources to see what others are experiencing. That's the upside. The downside of propagation predictions comes when one swears by them—the fact is, propagation is simply too unpredictable to say with absolute certainty something will or will not work.

Seasonal predictions are the most accurate by far, in that changes in the earth's rotation and the subsequent changes in temperature affect propagation in predictable ways. Spring and fall are good times for certain radio activities, while summer and winter are better for others. However, just because something is "out of season" doesn't mean it can't happen; it just means it's more unlikely to happen. The good news is that there are always bands which are open virtually any time of the day if one knows where to look.

The MUF, EMUF, FMUF, and LUF—Enuff Already!

Among many different propagation factors the MUF (Maximum Usable Frequency) and the LUF (Lowest Usable Frequency) are two very important numbers. These terms represent measurements of the ionosphere which determine the range of usable frequencies at any given time of the year. Roughly speaking the MUF represents a monthly prediction which says propagation/transmission at or below the maximum predicted frequency will be successful 50% of the time during a given month. (Go ahead, read that last sentence again!) Just to further complicate the issue, reliable transmission is usually estimated to be between 80-90% of the MUF on any given day.

An illustration will help clarify this: if the predicted MUF is for 21 MHz on a given day, a realistic optimum working frequency might be around 18 MHz ($21 \text{ MHz} - 15\% = 18 \text{ MHz}$). Much higher than 21 MHz and signals will not likely be heard. Some days will be better than this, other days not as good. These propagation numbers serve as guides to *likely* propagation, not absolute propagation. They are starting points to suggest which frequencies will work reasonably well for a given time of year.

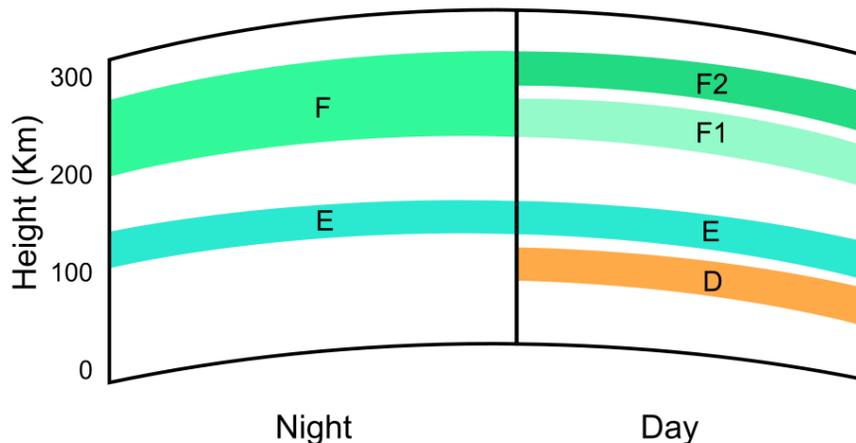
During winter months the MUF is at its highest during the day for HF frequencies, and the noise level is at its lowest since the summer storm season is over. This means stations which might normally be in the noise floor during the summer will come in fine in the winter. The

downside of this condition is the shorter daylight hours means a lower MUF overnight. Winter days are great for higher frequencies, while summer nights are better for the higher frequencies. (This is due to the ionosphere staying more active during the shorter summer nights.)

The LUF

The LUF is the lowest frequency on which one can expect to get reasonable propagation roughly 90% of the time each month. This number is perhaps even more relative than the MUF simply because what is acceptable to one person is not acceptable to another. Still, when calculating the lowest usable frequency, assume the number may actually be a bit higher than predicted.

A projection of, say 5 MHz, may translate more realistically into 6 or 7 MHz depending on local conditions. At other times the number might be a bit too conservative, and a LUF of 5 MHz actually is more accurately 4 MHz. Again, these numbers are meant to be guides, not hard-and-fast rules.



Ionosphere Layers (image from NPS)

Layers In The Ionosphere

I mentioned earlier the ionosphere is made up of several layers. These layers are generally divided as follows: the "D" layer (60 km to 90 km above the surface of the Earth); the "E" layer (90 km to 120 km above the surface of the Earth); and the "F" layer (200 km to more than 500 km above the surface of Earth, and split into the "F1" and "F2" layers during daylight hours).

Each layer has its own impact on radio waves, and both "E" and "F" layers have their own MUF (as if things were not complicated enough!). These maximum usable frequencies are known as the EMUF and the FMUF, respectively. Don't worry about following these numbers for now—keeping up with the MUF is quite enough as you begin learning the ins and outs of propagation!

How Each Layer Affects A Signal

The "D" layer is primarily active during the daylight hours, having minimal impact on signals at night. The high ionization levels during the day cause the familiar loss of distant AM signals through *absorption*. Signals are literally absorbed into the ionization field and scrambled rather than reflected. At night the signals reappear as absorption levels drop drastically. Winter is a great time for AM DX listening during the morning hours as the "D" layer often takes longer to form as the days shorten. The shorter days also mean AM DX stations appear earlier in the evening, and nighttime medium-wave DX is fantastic during the winter months because the atmosphere is much quieter.

The "E" layer primarily reflects signals below 7 MHz, but special instances of unusual activity known as *Sporadic-E* propagation allow signals in the 50 MHz and even 2-meter range to skip long distances, sometimes as much as 1400 miles on one hop. This activity can last for a few minutes or for a few hours, and even FM and broadcast TV can be affected. Summer months are the best time to catch E-Skip conditions, but fall and spring can bring interesting opportunities as well.

The All-Important "F" Layer

The "F" layer is the primary layer for HF reflection of signals, and this is the layer which allows shortwave and Amateur radio signals to travel great distances. Because the "F" layer remains throughout the day and night, DX listening is possible from around the globe. While the maximum usable frequency varies throughout the day, this layer always reflects a portion of the HF band well regardless of the season.

During the day this region splits into the "F1" layer and the "F2" layer due to a separation of ionizing particles. As night falls the "F1" layer merges back into the "F2" layer, allowing for radio propagation throughout the night. Both layers will reflect signals, but the "F1" layer is more variable overall, and most usable during summer months.

Finally, it is the "F" layer which is most susceptible to solar conditions, something I will cover next time around. While radio propagation is active in this layer year-round, high sunspot cycles help raise the MUF such that 10- and 20- meter activity is greatly enhanced. Signals in the 10-meter band are few and far between during low solar cycles, but when solar activity is high a few watts of power can be heard around the world!

Wrap Up

Well, that's all for this month! I hope I have whetted your appetite for investigating propagation, and I also hope you will join me next month for more exploration of this fascinating subject. In the meantime, I have listed some resources at the bottom of the page which I trust you will find interesting.

73, and may the gods of propagation smile kindly on us all!

Resources:

AntenneX

Radio Wave Propagation: Volumes 1-6 by M.H. De Canck, ON5AU

- <http://www.antennex.com/Sshack/prop/prop1.html>

ARRL

- <http://www.arrl.org/qst/propcharts>

Propagation Maps

- <http://propagation.hfradio.org/>
- <http://www.kg7hq.wetnet.net/node/55>
- <http://www.spacew.com/www/realtime.php>