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Temperate Zone Sporadic-E Model

Ken Neubeck, WB2AMU, discusses some theories on the variability of this type of propagation.

The seasonal pattern for temperate zone 6-meter sporadic E propagation consists of a major summer season, a minor winter season, and minimal activity during the spring and fall equinoxes (critical frequency >7 MHz, as shown in Figure 1). This has been determined through observations made by Amateur Radio operators, as well as statistical data collected through ionosonde stations located throughout the world. Ionosondes send a range of frequencies, and record which ones are reflected back, allowing the stations to find the critical frequency, or *fo*.

For operators in the Northern Hemisphere, the summer season begins in early May and ends toward the end of August, and the winter season is between the beginning of November into early February. During the equinox period, events are occasionally seen in September, but very few are observed during the month of March. In over 25 years of 6-meter observations, I have seen only about three openings, including one on a very unusual afternoon in mid-March 1996, where a 2-hour opening occurred that later developed into a double-hop event.

The E-Skip Mystery

While a number of mechanisms that cause sporadic E have been determined, the seasonal pattern itself (which is consistent throughout the sunspot cycle) has been a bit of a mystery. What we do know is, the metallic ions, such as iron and magnesium, that are present in the E-layer of the ionosphere have been determined to be of meteoritic origin, and the compression of thin sporadic-E layers of approximately 1 kilometer in height in the E-layer has resulted from windshear activity due to opposing direction winds that are present in the E-layer.

What probably changes throughout the season are the factors required for the metal particles to ionize in the E-layer of the ionosphere. Millions of tons of meteoritic particles enter the Earth's atmosphere every day. There is probably little variation with regard to their daily input, except for increased amounts during major meteor showers. However, meteor showers do not directly mean an increase of sporadic-E activity. There are typically no major sporadic-E openings that occur in the days after meteor shower activity, which suggests that the slower mechanism for ionization of these meteoric

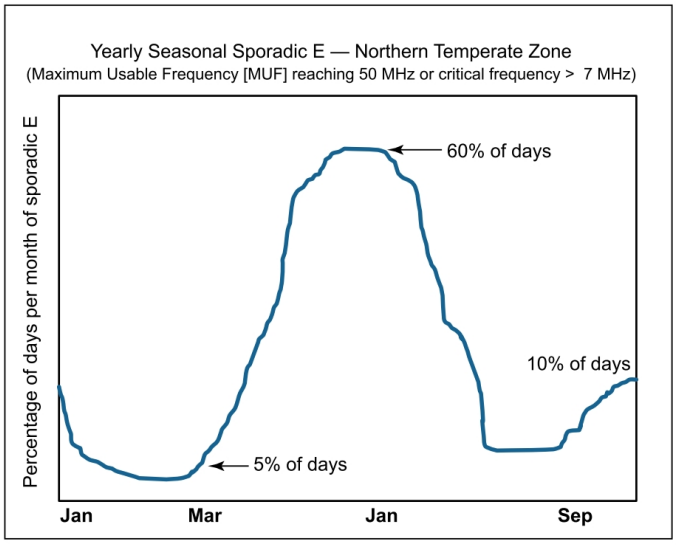

Figure 1 — Percentage of days that sporadic E occurs per month in the Northern Hemisphere.

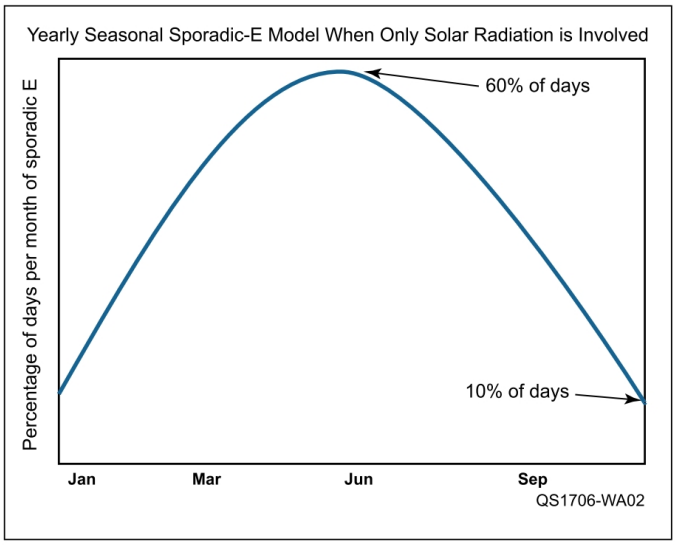

Figure 2 — Sporadic-E occurrence if only due to solar radiation ionizing the E-layer.

particles when they accumulate in the E-layer into metal ions still works in the same manner.

Obviously, solar radiation is a major factor during the summer months. But if solar radiation was the only factor for consistent sporadic-E formation, the curve of activity would be a general curve with a peak at the summer solstice and the lowest level at the winter solstice, as shown in Figure 2. However, the actual seasonal sporadic-E curve is more like what is depicted in Figure 1.

The only logical variation to the yearly model has to be in the area of magnetic field line variations or wind formation variations. However, the fact that 6-meter sporadic E appears only occasionally in September and rarely in March suggests a phenomenon that has some variability, and field lines are consistent throughout the year. Therefore, we are left to consider the variability in E-layer wind behavior.

Contacts Through a Pinpoint

Radio amateurs have observed that the actual area of the sporadic-E formation can be determined through the midpoint method (where the midpoint between stations in contact is plotted, as shown in Figure 3), and it is usually less than 100 kilometers in diameter — never widespread blanket coverage. Additionally, east-west "paths" of three and four formations are occasionally observed during the summer season (enabling contacts from the eastern US into western Europe), whereas north-south paths usually do not exceed more than two formations in line. It is uncommon for sporadic-E paths to extend past the geomagnetic equator, thus the phenomenon is restricted to the Northern Hemisphere.

Figure 3 shows a very narrow formation that I observed during the 2012 January VHF contest. In this case, the opening was of pinprick size between a small area in the northeast, and a small area in Arkansas. The sparser level of sporadic-E activity during the winter months leads to fairly precise definition of the formations that occur — but why?

I suspect that a group of ionized particles collected in one particular area to the point of being able to reflect 50 MHz radio waves. So, are we really dealing with a "collection point" or "dumping area" for metallic ions? I submit that in addition to the compression of sporadic-E formations through windshear activity, there may be variations in the east-to-west wind flow in the E-layer and opposing winds in terms of speed and force. At some point, the wind may pause or turn due to collision with opposing winds and, at these points, an accumulation of metallic ions occurs, resulting in a formation that can reflect HF and VHF radio waves.

Keep in mind that there is a modest amount of sporadic-E activity during the winter months, so while windshear activity is present, there is a significant reduction in the amount of solar radiation, compared to the summer season. However, in the winter, the E-layer winds still have mechanisms that create formations — it's just that there is less ionization of metallic particles because of the reduced amount of solar radiation.

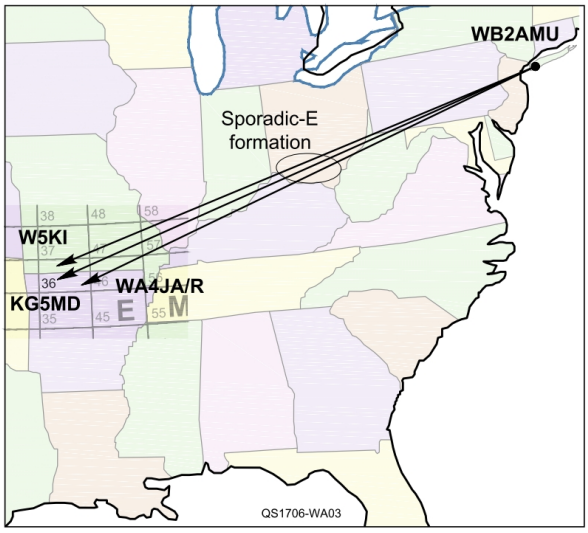

Figure 3 — Narrow focal winter sporadic-E opening.

The Collection Point

One way to explain this is to observe particle motion in a circular pool. Dirt particles that enter a circular pool that has a whirlpool-type current will eventually accumulate at the center, even though the currents are lowest in the center, as compared to the outer rings of the pool. This slower area of current could be considered a vortex, or collection area. It could be seen that a similar model could apply to sporadic E, where opposing winds reach a collision point and ionized metallic particles begin to accumulate in a "quiet area," or collection point (see Figure 4). Supporting this model is the fact that the actual sporadic-E formation is of limited size with regard to geographic area.

As for what causes occurrences of sporadic E to decline at the equinoxes, it's possible that seasonal changes in the zonal wind make conditions less optimal, possibly due to the Earth's orientation to the Sun at those times of year. Magnetic field lines may play a part. It has been observed that aurora activity seems to be a detriment to sporadic E, and that phenomenon involves altering Earth's magnetic field. Thus, without windshear and resulting collision, there are fewer opportunities for sporadic-E formations to occur. Further work is needed to prove what exact factors are required, but I do believe that E-layer wind behavior is a major part of the seasonal variation. Radio amateurs are fortunate to have a front row seat to observe the unique nuances of 6-meter sporadic E.

On the Bands

50 MHz. E_s is rare in March in North America. It has the lowest occurrence of sporadic E of any month. But a couple of rare March E_s openings took place.

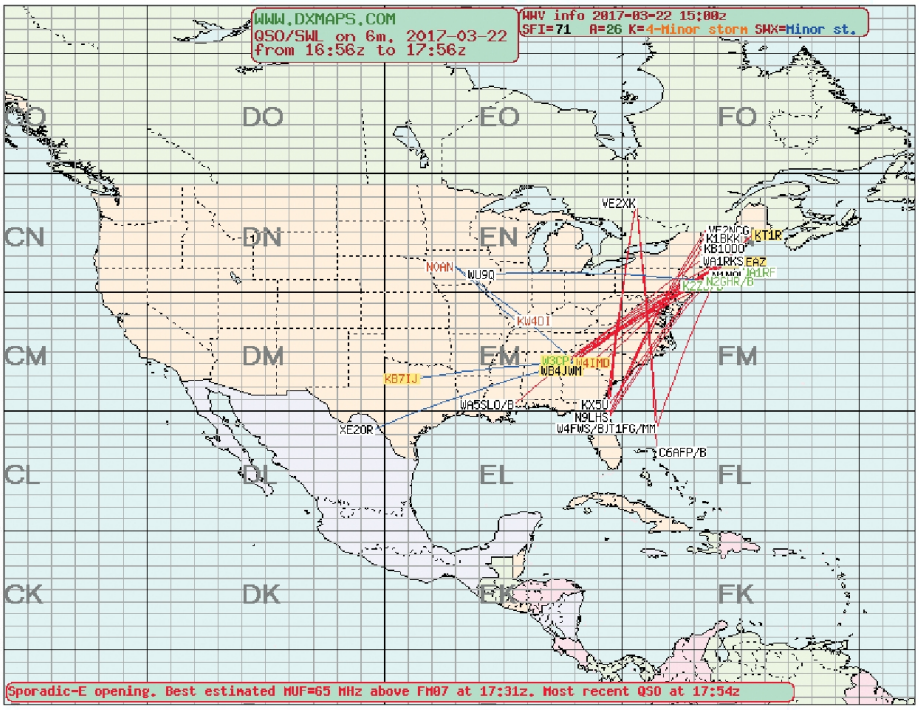

Figure 4 — Rare March 22 6-meter sporadic-E opening in North America. [**dxmaps.com**]

On 10 meters, Kurt, W6PH/VP9, had a strong E_s opening on Sunday, March 4, in the ARRL DX Phone Contest from Bermuda to the northeast states. He heard 10-meter beacons and put out a CQ on 28.401 MHz, followed by hundreds of contacts.

A brief 6-meter E_s opening took place on March 17 along the eastern seaboard between Florida and New England. WA1EAZ (FN42) heard KD4ESV (EL87) at 1651Z on 50.125 MHz. About the same time, the Ivory Coast TU7C DXpedition found a 6-meter F2 opening to Europe. Operator Patrick, F2DX, logged stations in Spain, Portugal, Belgium, and Greece, making 33 contacts. The solar flux was only 71.

A major E_s opening took place on March 22. It started around 1630Z, with stations from Florida and Georgia north to New England. The opening spread in scope. By 1750Z, Yuri, UT1FG/mm (mentioned in last month's column), appeared on 50.125 MHz from FL18. Yuri worked stations in Quebec (VE2XK), New Hampshire (WA1EAZ FN42), and west to Michigan (N8JX EN64). Terry, N8JX, notes, "Yuri UT1FG/mm (FL18) came back to VE2XK (FN07) on a CQ but was not heard here at that time. But maybe 10 minutes later was worked here. His signal was 57 and gaining in strength to 59, so that was a pleasant surprise after a dismal spring on 6." The E_s opening lasted over 4 hours. Later, a second E_s center appeared over the Gulf of Mexico. XE2JS (DL68) was spotted by W5TFW (EM41).

A strong aurora opening occurred March 27 – 28, with contacts reported along the northern tier states and Canada. Terry "heard the aurora on Monday morning with VE4 beacons, and then again Monday night with a few stations and beacons." Terry also worked aurora on March 2.

144 MHz. Regarding the south Pacific 2-meter E_s opening on November 26, 2016, from New Caledonia to Australia, Rémi, FK8CP, said peak conditions lasted only about 35 minutes. He said, "It started with VK3 at 0117Z, and ended also with VK3 0148Z." He noted a tropospheric opening on February 5 to ZL1, VK2, and VK4.

W5FH (EL29) worked UT1FG/mm (EK28) on March 1. On March 20, Sam, K5SW (EM25), logged W5FH (EL29), N5WDK (EL19), and K5LLL (EM10). The evening of March 22, N5LW (EM25), running 15 W, worked W5FH (EL29). On the morning of March 23, K5SW worked a strong tropospheric opening to south Texas and Louisiana. He worked W5FH (EL29) at 1030Z, then NT5K (EL49), KE5JXC (EL39), WB5K (DM92), and K5GUN (EM02), who was using just an omni-loop. He said W5FH heard the N0YK/b DM98 on 144.288 MHz loud at 1400Z.

222 MHz. The K5TRA/b 222.060 MHz (EM00) was S-9 for K5SW on March 20.

Here and There

Bart Jahnke, W9JJ, reports, "The ARRL Web now has the 6 meters and up Worked All States (WAS) lists posted at **www.arrl.org/50-mhz-and-up-was-lists**. Ned, AA7A, will be the custodian. Worked All States is a prestigious award for amateurs who have reached the plateau of confirming contacts with all 50 US states at VHF and above." On 50 MHz, Alaska and Hawaii are often the biggest challenge. On 144 MHz, a few stations in the center of the country have worked the lower 48 states via terrestrial modes, and from the west coast, Hawaii is workable on tropo though the microwave bands.

The Mid-Atlantic VHF Conference is scheduled for October 6 – 8, 2017. For more information, visit **lists.contesting.com/pipermail/vhfcontesting/2017-March/020378.html**.