K1FK to JA Via 160-Meter Long Path
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Over the past many years I've covered several topics tied to propagation on 160-Meters. Using the concepts discussed over these years, let's take a look at a recent extremely long distance QSO on 160-Meters that I was advised of via a personal e-mail.

The e-mail came from Dave Bowker K1FK. On January 2, 2015 at 2127 UTC, he worked JO3JIS on 160-Meter CW via long path. He began copying JO3JIS around 2120 UTC, and the opening lasted until about 2135 UTC. He runs 1.5 kW to a 75-foot top-loaded ground plane with one hundred fifty 100-foot radials, and receives on phased reversible Beverages for $150^o/330^o$ and $060^o/240^o$.

He reported that he could only copy JO3JIS on the 150^o Beverage – on the 330^o Beverage he could barely make out that a signal was present. If we assume Beverages are truthful indicators of direction (I have to admit that sometimes I doubt this assumption), then JO3JIS's signal came from the southeast – which suggests long path.

Figure 1 shows the path from K1FK to JO3JIS (thanks W6ELProp). The long path is the black line, and it goes over South America, Antarctica and Western Australia. The long path is 29,656 km on a heading of 157 degrees out of K1FK. Short path is the red line.

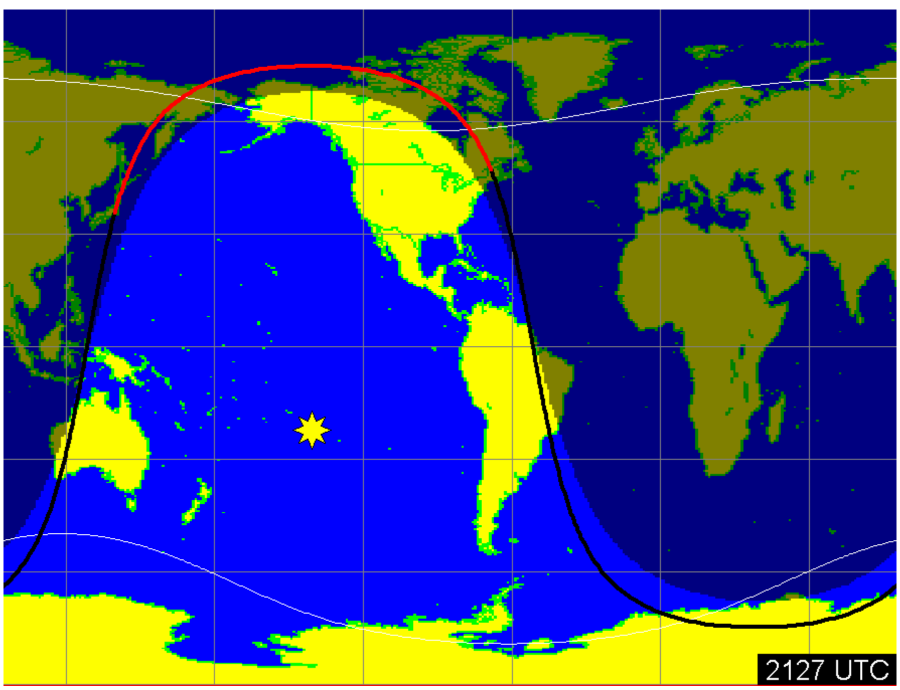

Figure 1 – K1FK to JO3JIS

Note that the long path is in daylight on the extreme southern portion of the path. Based on our understanding of the physics of the ionosphere (specifically absorption), this amount of daylight is prohibitive on 160-Meters. Indeed, both VOACAP and W6ELProp predict signal levels around -400 dBm on 3.0 MHz (I had to use 3.0 MHz since neither program is intended to be used below 3.0 MHz), which says it's even worse on 1.8 MHz. Thus the predictions are at least 270 dB below the noise floor of a typical receiver. We could claim the model of the ionosphere is off, but being off by several hundred dB is a stretch. I think our model of the ionosphere is telling us that propagation along the terminator on the low bands is not efficient as is generally believed, and that something else is going on.

I believe that "something else" is that the RF takes a short cut across the dark ionosphere [**note 1**], where absorption is minimum. This doesn't mean that the RF travels perpendicular to the terminator. It just has to get away from the terminator quickly to avoid heavy absorption. As stated earlier, the true great circle long path out of K1FK is 157 degrees. If the RF that makes it to JO3JIS with a readable signal takes a heading of 130 degrees out of K1FK, then it avoids the absorption near the terminator and stays in darkness even at the extreme southern portion of the path.

Similarly, the true great circle long path to K1FK out of JO3JIS is 199 degrees, and that heading also goes into daylight in the extreme southern portion of the path. But if RF takes a heading of 220 degrees out of JO3JIS, it also avoids heavy absorption near the terminator.

All this speculation is well and good, but now a skew point (or skew area) is needed to get the 130 degree RF out of K1FK onto the heading that comes into JO3JIS from 220 degrees. Figure 2 shows this scenario using a map from an old DOS program by Bob Brown NM7M (SK) at a K index of 3. The dotted lines are great circle paths out of K1FK in 10 degree increments.

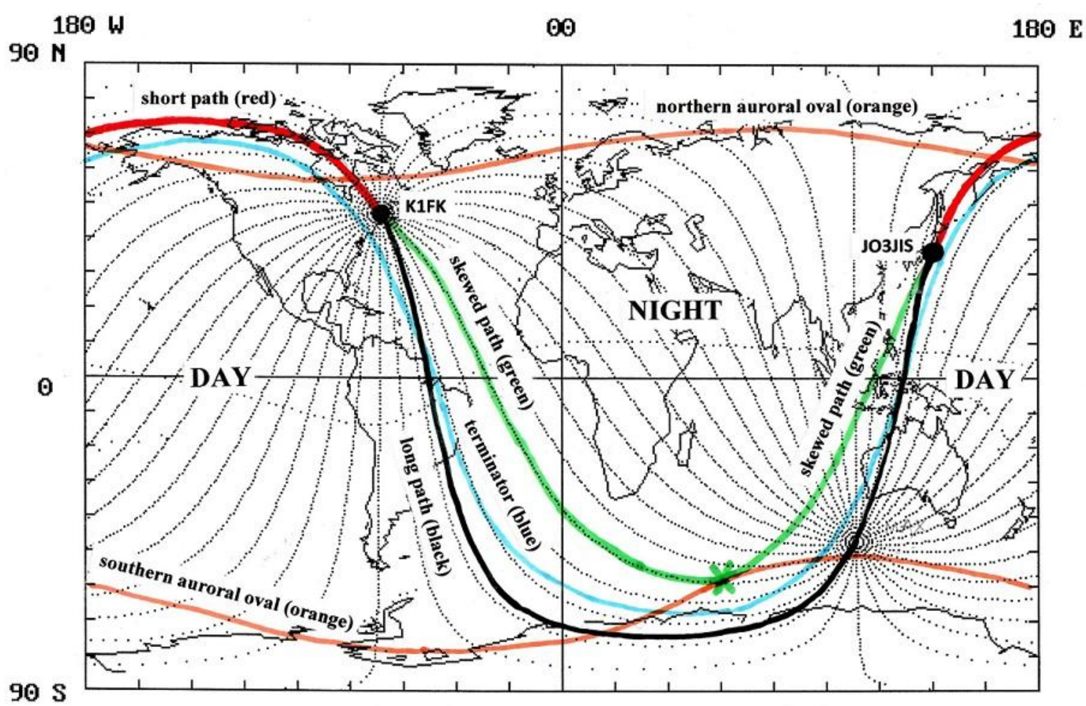

Figure 2 – The Big Picture

Figure 2 is a Mercator projection just like Figure 1, but Figure 2 is much busier. Just like in Figure 1, the true great circle long path between K1FK and JO3JIS is the black line and the true great circle short path is the red line. The terminator is the blue line, with DAY and NIGHT areas annotated. The northern and southern auroral ovals are the orange lines – they don't look like ovals because of the distortion with the Mercator projection at high latitudes.

The green lines are the two skewed paths mentioned several paragraphs earlier. As expected, they both get away from the terminator quickly and stay in the dark ionosphere. The required skew point (or skew area) is the green X below Madagascar off the eastern coast of Africa. This is where one great circle path must get skewed onto the other great circle path.

Now an electromagnetic wave travels in a straight line unless an electron density gradient reflects it, refracts it or scatters it. The equatorward edge of the auroral oval has such a gradient, and could cause 1.8 MHz RF to skew off one great circle path onto another great circle path. It's also possible that other gradients could do the same thing. For example, the equatorial region is quite dynamic, and it could provide a skew point for RF to take a more direct short cut across the dark ionosphere.

An important point assuming that the auroral zone is the gradient is that 25 or so degrees off the true great circle path will likely not be noticed by topband operators due to the relatively wide azimuth pattern of directional receiving antennas on 160-Meters. In other words, the old axiom of "southwest at sunrise" and "southeast at sunset" still applies.

Another important point with respect to my belief that absorption along the terminator is prohibitive is that I've never seen a report of a short path gray line enhancement. For example, the 3Y0X DXpedition in February 2006 had a classical gray line short path to JA around 0819 UTC. Although they worked hundreds of NA and EU stations on 160-Meters through the dark ionosphere, they only worked one JA station on 160-Meters.

Finally, one may wonder if somehow the path is the true great circle short path since Figure 1 (and Figure 2) show it to be in the dark ionosphere. Unfortunately, the short path would have to go through the auroral zone with adverse effects – not just using the auroral oval for a glancing blow as per the green lines in Figure 2.

So there you have it. I believe gray line propagation on the low bands is not efficient as is generally believed. Unfortunately this concept of low band propagation along the terminator being efficient is based solely on observations, without much ionospheric physics applied. I think the something else that is going on is a short cut across the dark ionosphere. This alternative explanation also allows observations (by many topbanders over the years) and theory (ionospheric physics) to mesh.

Note 1 – Taking a short cut across the dark ionosphere is not a new concept. Although W4ZV may have been the first to suggest this in the Amateur Radio literature in his 1991 article in Proceedings of Fine Tuning, I believe the earliest suggestion of this was in the November 1931 issue of the Proceedings of the IRE (Volume 19, Number 11). Maps at eight times throughout the day show the true great circle path from Tokyo to Monte Grande (Argentina) and the actual path determined from measurements of arrival angles.