Arrival Direction of FT5ZM in North America on 160m

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The FT5ZM DXpedition to Amsterdam Island early in 2014 provided many topband DXers with a new country (more properly called an entity in DXCC parlance). The FT5ZM team did an excellent job of handing out QSOs on all the bands. Check out the FT5ZM web site at http://www.amsterdamdx.org for the team members, information about the island, QSL procedures, etc.

Preliminaries

Understanding propagation on 160-Meters is a tough nut to crack. The region of the ionosphere that is responsible for good or bad propagation is the lower ionosphere, where we don't have a lot of data. Ionosondes (essentially swept-frequency vertical-sounding radars) don't "see" the lower ionosphere at night due to low electron densities resulting in the reflected wave being below the sensitivity of the ionosonde receiver. Thus our understanding of the lower ionosphere is through incoherent scatter radar campaigns and occasional rocket flights. Physical models of the lower atmosphere currently being developed may someday provide us with a better understanding of this region.

In my opinion, our knowledge of 160-Meter propagation can be summed up in six statements:

1. 160-Meter RF needs to be in the dark ionosphere due to ionospheric absorption in the lower ionosphere. Know how long your path to the DX station is in darkness.

2. There's always enough ionization to support 1.8 MHz – thus the MUF (maximum useable frequency) isn't an issue.

3. Signal enhancements on paths that are generally perpendicular to the terminator can occur around sunrise (especially on the eastern end of the path) and around sunset.

4. Watch for extremely long distance gray line paths. In light of #1 above, I believe the electromagnetic wave does NOT follow the terminator, but cuts across the dark ionosphere to make it look like it's following the terminator. These paths manifest themselves as "southwest at your sunrise" and "southeast at your sunset".

5. Solar minimum during the winter months appears to be best for 160-Meter propagation. But lots of DX can be worked at solar max and even during the summer – if you're active!

6. A quiet geomagnetic field is best. But watch for skewed paths at high latitudes with elevated K indices. Additionally watch for signal enhancements at high latitudes when the K index spikes up.

Zone of No Common Darkness in North America

Figure 1 is a DX Atlas map (thanks VE3NEA) that shows the terminator at sunrise at FT5ZM on February 1. FT5ZM is the red dot with the antenna in the southern Indian Ocean. Superimposed on this map is another DX Atlas map on the same date that shows the terminator at sunset at FT5ZM.

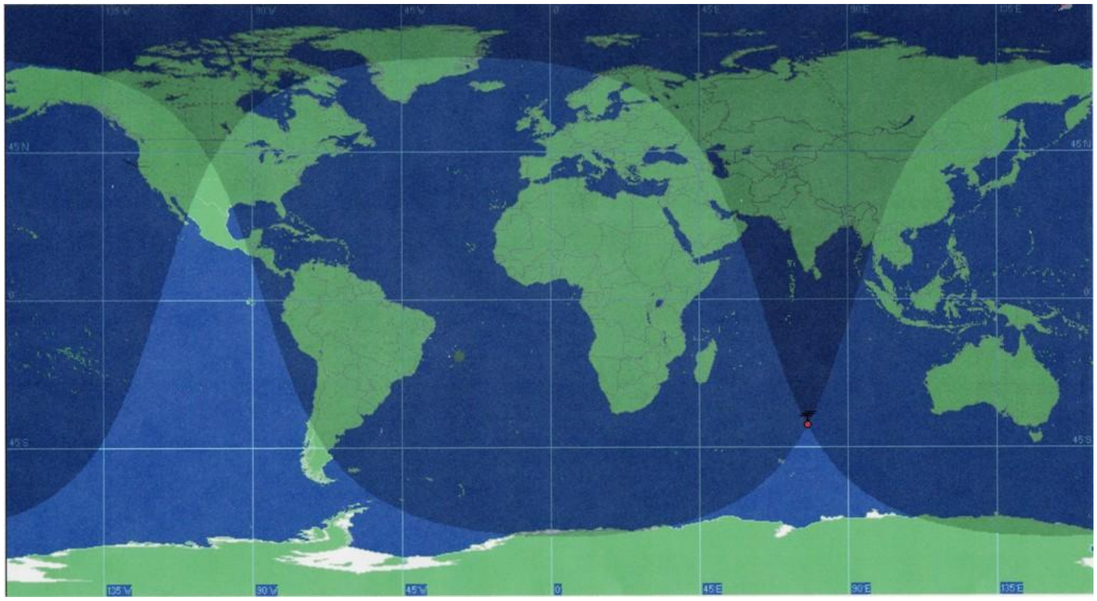

Figure 1 – Area of No Common Darkness on February 1

Note the lighter-shaded triangular-shaped area (a wedge) over the southwest of the United States and much of Mexico. This is an area where the entire path to FT5ZM was never completely in darkness during the FT5ZM DXpedition. Thus working FT5ZM on 160-Meters from this area would be extremely tough – perhaps even impossible for those in the middle of this area.

From the fall equinox to the spring equinox the apex of the daylight wedge is north of the FT5ZM antipode and the daylight wedge extends south of the antipode. From the spring equinox to the fall equinox the apex of the daylight wedge is south of the antipode and the daylight wedge extends north of the antipode. The closest the apex of the wedge gets to the antipode is halfway between the equinoxes (around mid June and mid December) – but it's still far away. Right at the equinoxes, there is a thin column of daylight all along the antipodal longitude. Also, be advised that what is important is what the ionosphere is doing where your RF encounters the ionosphere on its first hop – not what's happening overhead at your location.

This scenario is similar to the 160-Meter "black hole" seen with the VK0IR DXpedition to Heard Island in 1997. See page 171 of KK6EK's book titled *VK0IR Heard Island* (Cordell Expeditions, 1997).

Great Circle Paths

Figure 2 is a map (thanks NM7M SK) that shows great circle paths out of FT5ZM in 10^{o} degree increments. FT5ZM is in the lower right quadrant in the southern Indian Ocean.

The antipode of FT5ZM is at 38.1 degrees North latitude and 102.4 degrees West longitude. This is in Colorado. Specifically, it's about 100 miles southeast of Colorado Springs.

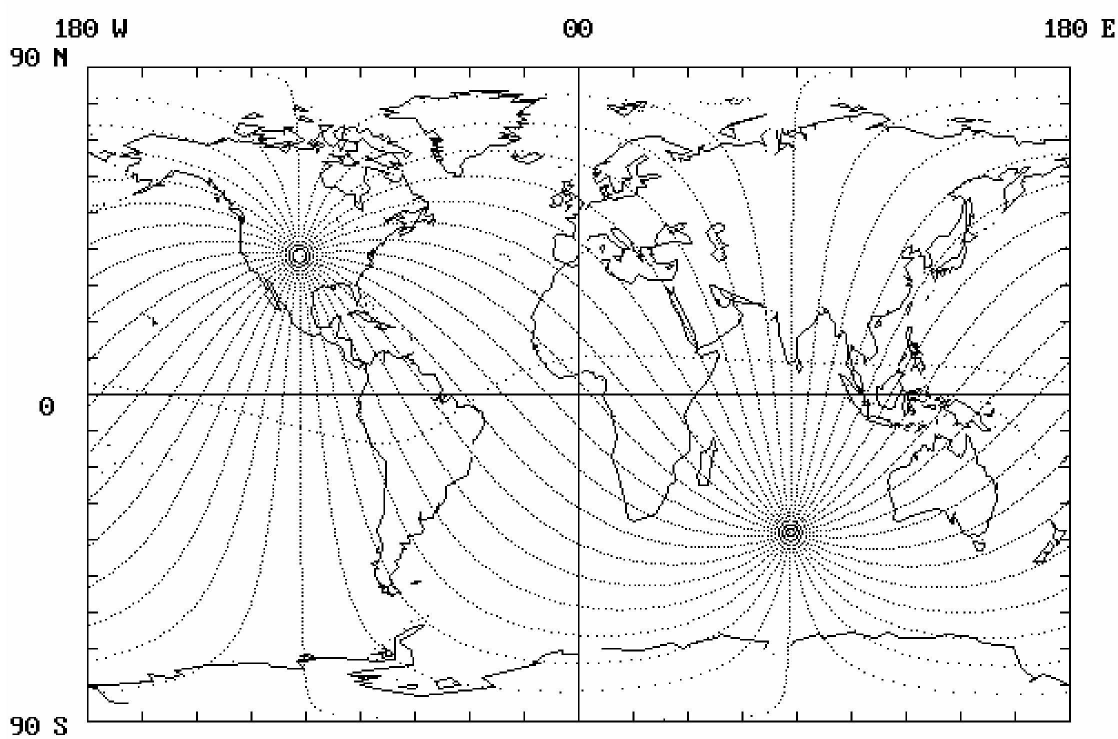

Figure 2 – Great Circle Paths from FT5ZM

This map tells us that stations located east of the antipode longitude have their short path to FT5ZM in an easterly direction, with propagation along the short path possible in the evening. Those stations located west of the antipode longitude have their short path in a westerly direction, with propagation along the short path possible in the morning.

This map, of course, also gives the approximate direction to FT5ZM. For example, a station in southern Florida would look for FT5ZM from the southeast (the direction that the great circle path heads to go into FT5ZM). A station in southern California would look for FT5ZM from the southwest. Remember that these examples are for short path.

Reported Directions from North America

On March 15 of this year, I posted a message to the topband reflector requesting direction information from those stations who worked FT5ZM on 160m and 80m. As of March 30, I have received 77 reports from 72 different people on 160-Meters. I thank all who responded.

Taking the lead of the figure on page 176 of the previously referenced *VK0IR Heard Island* book, plotted in Figure 3 are the headings from those stations who reported receiving FT5ZM. Figure 3 is an expanded view of North America showing great circle paths out of FT5ZM (and into the FT5ZM antipode).

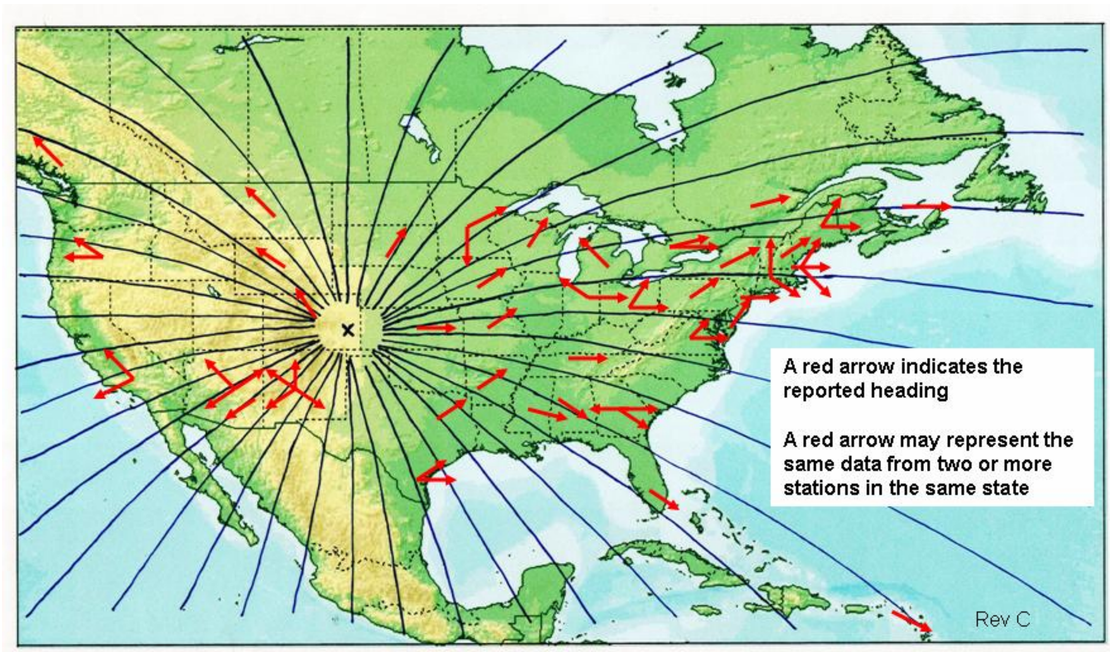

Figure 3 – Direction of Arrival Data

The red arrows indicate the reported headings to FT5ZM. There are now 49 reports of what I consider great circle path reception – that is, reception on a heading within about +/- 20 degrees of the true great circle path – which allows for some antenna beam width issues when the antenna isn't pointed exactly along the true great circle path.

That leaves 28 reports of what I consider non-great circle path reception. These were considerably off the true great circle path – some even in the opposite direction.

I was hoping there would be a lot of non-great circle paths around the FT5ZM antipode (well, at least a lot of directions going off into the dark ionosphere). New Mexico seems to be headed that way, but more data is needed. Interestingly, there are a number of reported non-great circle paths in the New England area (their path is to the east).

Finally, note that stations in Indiana and Michigan reported best reception at times from the northwest. Were signals truly coming in somehow from the northwest, or was there another issue? This leads us into the next section.

Directional Receive Antennas – How Well Can They Differentiate Headings?

I've always wondered how well our low band directional receive antennas can tell us the true azimuth arrival angle. Under certain conditions, I believe we have high confidence in what they tell us. This would be when the signal is arriving in the main lobe of the antenna(s) and is well above the noise.

But there are other conditions where I think caution should be exercised. These conditions are three-fold: pattern resolution, high elevation angles and noise.

> Pattern resolution – A 4-Square fires in four directions. Let's assume it is oriented for NE, SE, SW and NW. A signal coming in from, say, the East should be equal on the NE option and the SE option. Thus the signal may not be coming in on two paths that are separated by 90 degrees.
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> High elevation angles – It is believed that signal enhancements around sunrise and sunset are due to high elevation angle signals coming out of a duct in the nighttime electron density valley that it is above the E region peak. Thus several of the antennas may give an equal response at the high elevation angles, but one may have a lower noise level depending on how noise arrives at your QTH. The result is a false indication of direction.
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> Noise – If the signal is right at or just above the noise, it's not clear to me if selecting an antenna is maximizing the signal itself or maximizing the signal-to-noise ratio by giving up some signal strength for a direction that has much less noise. I believe this would only apply to receive systems with good pattern resolution (8-direction arrays, for example).

If any of you topband DXers have more information on these three conditions, I would love to hear your comments. I can be reached at k9la@arrl.net. Alternately, post your comments to the topband reflector.

As of March 30, I have received three responses with respect to the above request about antennas. Those commenting mentioned minor lobes of the antenna, different performance over different ground conditions, and higher elevation angles.

Summary

We now have a sizable amount of data telling how FT5ZM's signal allegedly arrived at various locations in North America on 160-Meters. With some of the data in Figure 3, I believe we need to do more work in understanding our receive antennas before we try to answer the question "why and how did the signal arrive from a non-great circle heading?"