More on Propagation versus Location

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The March 2021 Monthly Feature discussed propagation versus location in a very broad sense. This month's Monthly Feature digs deeper into a specific scenario.

In early March, Chad Kurszewski, WE9V, posted a message to the SMC (Society of Midwest Contesters) reflector after the March 2021 ARRL International DX Phone contest about his observation that he seems to stand in line behind many East Coast stations when it comes to working Japan. He understands why East Coast stations have the advantage over him to Europe, but he is looking for an explanation of his disappointing performance to Japan. He also stressed that he's not talking about big stacks on the East Coast beating him because he only has low power and dipoles. His antenna system is very competitive as noted in the text below and in the image to the right.

Before digging into possible explanations, here are some basic details about WE9V's location and his antenna system.

WE9V is at 42.55 North latitude / 88.05 West longitude. This puts him in southeastern Wisconsin, about midway between Chicago and Milwaukee.

His antenna system on the higher bands (20 meters, 15 meters and 10 meters) is a stacked/phased pair of KLM KT-34XAs at 50 feet and 100 feet. He also has a Cushcraft XM-240 40 meter Yagi converted to a W6NL Moxon for 40 meters above the KT-34XAs at about 110 feet.

Distances to JA

The following tabular data shows the short path distance to JA (35 North latitude / 137 East longitude) from WE9V, W1 and W2. Also included is the hop distance assuming 3 hops.

path	distance (km)	each hop in km assuming 3 hops
WE9V to JA	10,246	3415
W1 to JA	10,960	3653
W2 to JA	11,021	3674

The W1 path to JA is 714 km longer than the WE9V path to JA. The W2 path to JA is 775 km longer than the WE9V path to JA. What this does is make each hop (to reiterate, assuming 3 hops) from W1 and W2 to JA slightly longer than from WE9V to JA.

This could require a slightly lower take-off angle for W1 and W2 and it could give a smaller grazing angle on the ionosphere for W1 and W2 compared to WE9V [note 1]. Thus the MUF (maximum useable frequency) may be a bit higher for W1 and W2 to JA.

What does VOACAP say?

Let's run predictions with VOACAP for paths from WE9V, W1 and W2 to JA at 2300z in March around solar minimum. I used a minimum elevation angle of 1 degree (we'll look at terrain and obstructions later) and equal power and antenna gains for all stations. The monthly median MUFs, the required transmit/receive elevation angles and signal strength comparisons on 20 meters and 15 meters are as follows.

March, 2300z, solar minimum		20 meters			15 meters		
path	monthly median MUF in MHz	TX angle in deg	RX angle in deg	signal strength delta in dB	TX angle in deg	RX angle in deg	signal strength delta in dB
WE9V to JA	16.9	3.0	8.0	ref	5.0	5.1	ref
W1 to JA	16.2	3.0	18.0	-1.0	3.5	2.0	+15
W2 to JA	16.8	3.0	10.0	0.0	3.3	3.0	-8.0

VOACAP says the highest MUF is on the WE9V path, and the W2 path is for all intents and purposes the same. The W1 path takes last place, with the MUF being 0.7 MHz lower than the WE9V path. This says is each path "sees" slightly different parameters to determine the MUF (the two parameters being the F2 electron density and the F2 region height) along each path.

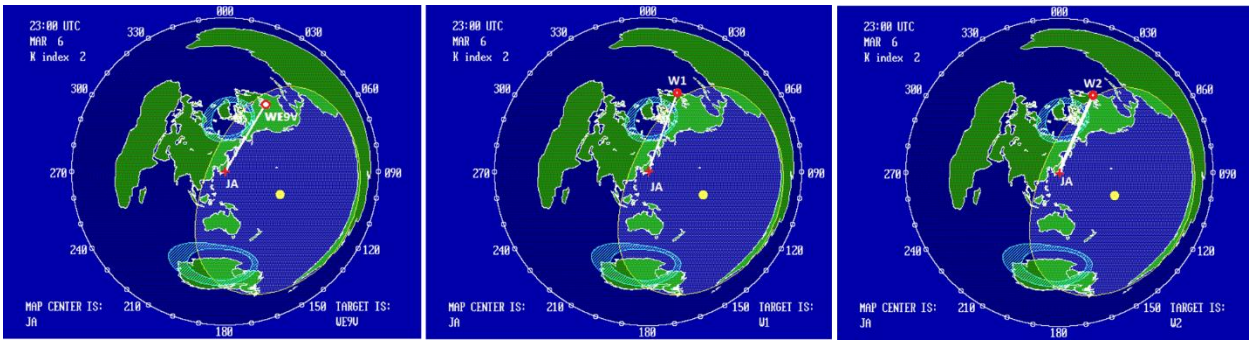
On 20 meters, the biggest difference between WE9V and W1/W2 is the predicted elevation angle of the incoming signals from JA. Thus W1/W2 may have an advantage in that higher elevation angles are needed, giving somewhat more gain in receive. You also have to wonder how sensitive the transmitted signals are to terrain and obstructions since 3^{o} is a pretty darn low angle.

On 15 meters, one might conclude that WE9V would have the advantage due to the higher elevation angles in both transmit and receive. But the signal strength results indicate W1 is first, WE9V is second and W2 is third.

One final note – these predicted results from VOACAP are monthly median results (median implies 50% probability). On any given day, the actual results could be a bit better or a bit worse. Unfortunately we do not have daily predictions yet because our current understanding of the ionosphere is statistical in nature over a month's time frame.

Auroral ovals

Being at 42.55 North latitude, the auroral oval to JA may be an issue for WE9V. The W1 and W2 (at 42.3 North latitude and 40.7 North latitude, respectively, and being farther east) paths to JA are also an issue with the auroral oval. Here are maps (from the DXAID DOS program by Peter Oldfield) for the WE9V, W1 and W2 paths to JA at a typical time (2300 UTC) for QSOs on the higher HF bands (20 meters, 15 meters and 10 meters) during the ARRL International DX PH contest at a K index of 2. This figure is in larger format on the last page of this paper.

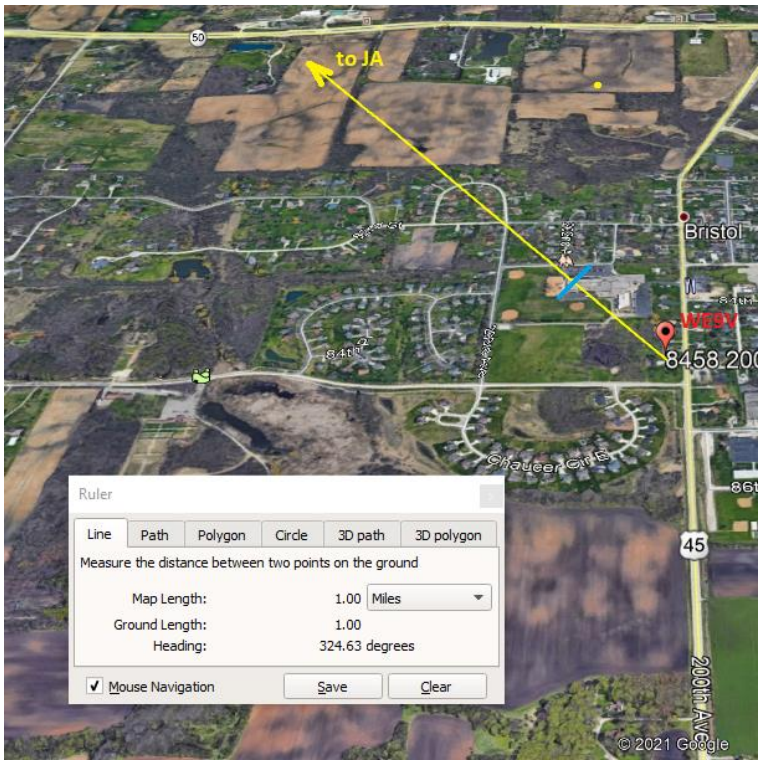


The obvious difference is that the WE9V path to JA just skirts the equatorward edge of the auroral oval, whereas the W1 and W2 paths to JA go through the auroral oval twice. Thus one might conclude that W1 and W2 have the toughest path to JA.

But there's a trough (depression) in the electron density of the F region of the ionosphere near the equatorward edge of the auroral oval at these mid-latitude locations. Although the trough is mainly a nighttime feature (from dusk to dawn), a study by Vo and Foster [note 2] indicates that severe density gradients can also occur in the daytime (which is what the paths are in per the above maps) in the trough. If the apogee of a hop encounters the F region in the trough, the MUF could be adversely affected. The trough does not appear to be a problem for W1 and W2.

Terrain issues

Here's a picture of WE9V's location from Google Earth. Also see comment #6.



Included is a mile-long yellow line that indicates the path from WE9V's QTH (in red at the middle right) to JA. The terrain out to 1 mile is very flat – using the altitude readout in Google Earth, it looks like it is flat to +/- 5 feet at most. That should not impact the antenna elevation pattern to any significant degree. See WE9V comment #7 on his terrain. This issue is the relatively close-in terrain that determines the elevation pattern of the antenna by vector summing the direct and ground reflected wave.

What about where the signal comes down, assuming 3 hops, after the first hop (first ground reflection) and after the second hop (second ground reflection)? Here's that data.

station	first ground reflection	second ground reflection
WE9V	Yukon Territory	water east of Kamchatka Penisula
W1	Northwest Territories	land in Asiatic Russia
W2	Northwest Territories	land in Asiatic Russia

If anything, one might assume that WE9V has the advantage due to the second ground reflection being on water. But the uncertainty of the ground in the Yukon Territory, in the Northwest Territories and in Asiatic Russia really muddles things up.

Obstructions

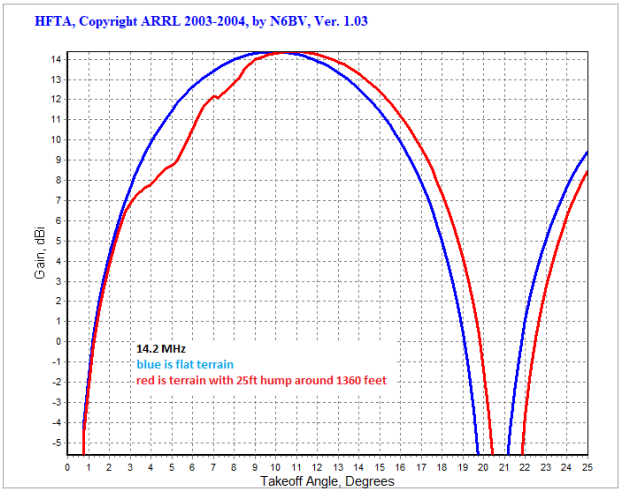
We tend to ignore obstructions that may interfere with our electromagnetic waves. For the most part, I believe that is acceptable. But if there's something metal in the way and its dimensions are on the order of a half-wavelength, you may have a problem. Remember parasitic Yagi antennas depend on this coupling.

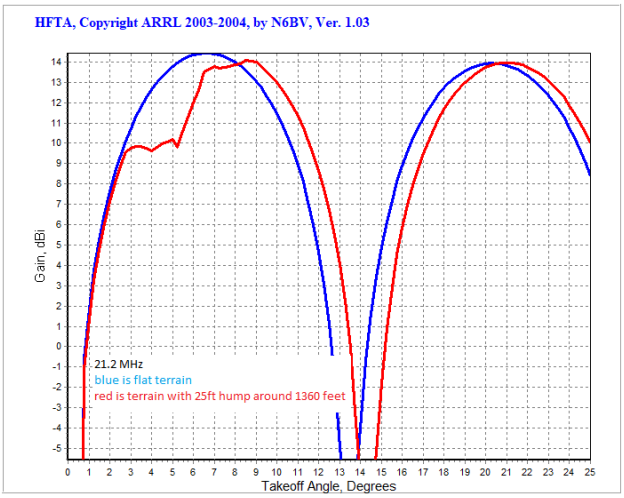
My modeling efforts suggest that obstructions can adversely affect the antenna's azimuth and elevation patterns. For example, I'm in a rural area and our neighbor is a pole vault enthusiast. Thus he erected a barn high enough (about 25 feet on the face with a slightly angled roof) and long enough (about 110 feet) to have a pole vault track for his students [note 3].

The wooden barn structure didn't worry me. But when they started putting aluminum siding on the barn, my eyebrows raised. So I made a model in NEC (which had many, many segments), and it indicated that the azimuth pattern of a vertical antenna would be distorted on 40 meters (and on 30 meters) by the pole vault barn when the distance separating the barn and the vertical is about 80 feet. I suspect that the barn looked like at very fat vertical.

Now back to WE9V's issue. Note the blue line across the yellow line in the Google Earth photo on page 3. The blue line is 1360 feet from WE9V, and it also highlight where there is a large building. What's special about 1360 feet?

Simple geometry indicates that 1360 feet away is important for low elevation angles. Using Dean Straw N6BV's HFTA (HF Terrain Analysis) software, here are plots on 20 meters and 15 meters with a 25 foot high obstruction (the assumed building height) around 1360 feet from WE9V's tower when his top KT-34XA is pointed towards JA.





What's obvious is the loss of gain (the red plots) from about 4 to 8 degrees on both bands with the 25ft hump (the "building") around 1360 feet from WE9V's tower. Note that these angles are in the vicinity of the angles in the table on page 2 that were predicted by VOACAP.

Now I have no idea if the building is brick or metal or whatever. And I don't know if any dimensions might be near a half-wavelength on either 20 meters or 15 meters. In other words, take these results with a grain of salt. Maybe someone else can run with this issue and make a definite conclusion.

I should mention that WE9V noted (comment #10) that he noticed the same issue when operating at the old KS9K contest station (Racine, WI – just south of Milwaukee) with 5/5/5/5 stacks. A cursory look with Google Earth showed residential areas to the northwest – no major buildings. So this obstruction issue may be a moot point. WE9V additionally wondered in comment #10 if this whole issue is somehow just a southeastern Wisconsin problem.

Antenna interaction

A 40 meter dipole or inverted-vee will give decent results on 15 meters as a three-half-wavelengths antenna. This is how many Novices in the 1950s and 1960s got on 15 meters. So one should wonder if a 40 meter Yagi could interact with a 15 meter Yagi – especially when they are mounted one above the other. Remember WE9V's 2-element Moxon on 40 meters is about 10 feet above the top KT-34XA.

Modeling a 2-element 40 meter Yagi ten feet above a 3-element 15 meter Yagi with 4nec2 (by Arie Voors) shows the following gain and F/B values.

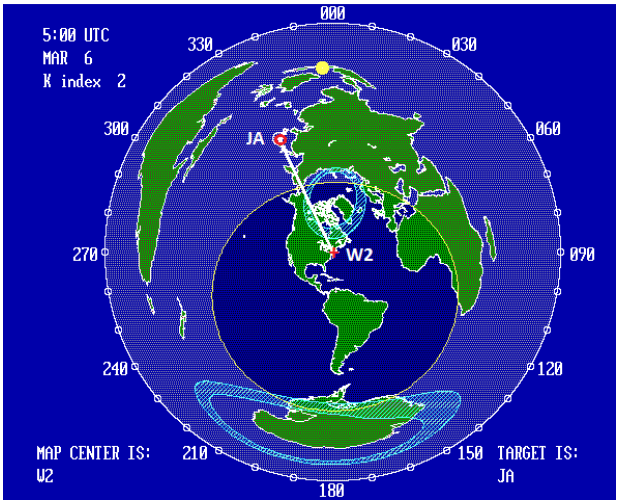
condition	gain in dBi	F/B in dB
3-el 15m Yagi at 100ft (alone)	13.3	21
2-el 40m Yagi 10ft above 3-el Yagi	12.9	20

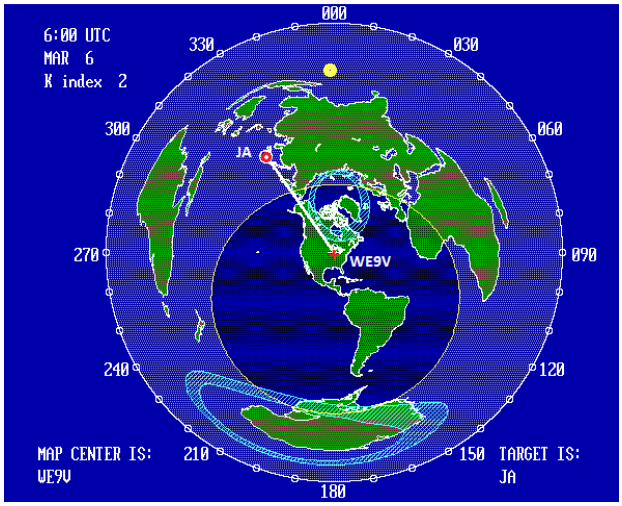
There is interaction, but it doesn't appear to be anything major that would result in WE9V's observations.

Similarity to the Midwest-to-OH/SM/LA path in the fall

One of the interesting paths here in the Midwest mainly on 15 meters and 10 meters is to the Scandinavian countries in the fall (and maybe even winter) in the late afternoon [note 4]. This was suggested by K9MA (comment #14) and mentioned by W9XT (comment #15). This path has the east end around local midnight and the west end in daylight. The east end of the path would be due to auroral-E, when the path is tangential to and under the auroral zone. The west end in daylight would need a link to auroral-E – most likely in the fall this would be an F2 hop.

Here's the scenario for W2-to-JA in March at 0500 UTC (local midnight at W2) and WE9V-to-JA at 0600 UTC (local midnight at WE9V) for this path.





It's possible that W2 could have an auroral-E opening. But WE9V may not as the path is at the equatorward edge of the auroral-E – not under it to take advantage of auroral-E.

But the link from JA to auroral-E is questionable in March at solar minimum for both paths. The F2 region has its highest ionization (highest MUFs) in the fall months, and the MUF in March is down about 15% from the fall months. This may not affect 20 meters, but it may be a problem on 15 meters (and an especially big problem on 10 meters).

Summary

We've looked at many issues, but nothing really stands out as the "AHA" moment that explains WE9V's observations. The one that may make the most sense is the mid-latitude trough in the F2 region that is equatorward of the auroral oval, but I wouldn't bet on it. Maybe WE9V's observations are a combination of several issues. Another issue that could contribute is polarization, which may be the subject of a future Monthly Feature.

So here I sit with another "no answer" issue. I've had many of these. I think we have a decent understanding of the long-term variability of the ionosphere, but we don't have a sufficient understanding of the short-term variability of the ionosphere. There's lots of stuff going on up there in the atmosphere/ionosphere. With the research that is going on right now, maybe someday we'll have a better understanding of the observations by WE9V.

Notes

1) This issue was brought up by W9IZ, and is included as comment #3 in all the comments to WE9V's post from SMC members (and additional comments from WE9V himself) on the last page of this paper.

2) H. B. Vo and J.C. Foster, *Mid-Latitude Density Gradients at the Ionospheric Trough*, Journal of Geophysical Research, December 2000.

3) Luetzelschwab, K9LA, *Our New Neighbor Is a Pole Vaulter*, Propagation column, NCJ, May/June 2007.

4) Luetzelschwab, K9LA, *Late Afternoon Openings in the Fall Months to Scandinavian Countries on 15m and 10m*, Monthly Feature, November 2020, in the Monthly Feature link at https://k9la.us.

Comments to WE9V's Post on the SMC Reflector		
1	K9GY	looked at globe and noted not much difference between WI-to-JA vs W1/W2-to-JA
2	WE9V	difference between W2/W9 to DL/JA is about 500 miles
3	W9IZ	longer distance to W1/W2 gives shallower angle of reflection on ionosphere
4	N4BAA	doesn't feel like he waits in ine in southeast Indiana
5	NN1N	mentioned his VS6DO operations in the 90s
6	N9CO	asked if there is a geographic feature in the Fresnel zone on he path to JA
7	WE9V	described his terrain
8	AB9YC	asked if this is recent or has it always been this way
9	WE9V	asked if he's the only person who observes this
10	WE9V	wondered if this is just a southeastern Wisconsin problem - remembers this at KS9K with 5x5x5x5 stack
11	WE9R	commented that contests bring out some pretty strange propagation - gave recent examples
12	W9XT	was low power on 20m and has a big hill to JA - didn't remember the East Coast beating him
13	W9RE	normally he hasn't noticed standing in line behind 1's and 2's - but it has happened before - commented on K9CT and WB9Z working many more JAs on 80 than he can
14	K9MA	wondered if this is just an instance of the Midwest-to-OH/SM/LA path shifting to JA-to-East Coast
15	W9XT	added comments on the Midwest-to-OH/SM/LA path and cited more unusual openings
16	NF9V	noted that working JAs has shifted from running JA to S&Ping JA - Asia always is tough from southeastern Wisconsin - solution is to move south, east or west