VK4YB to NO3M on 630m and 2200m

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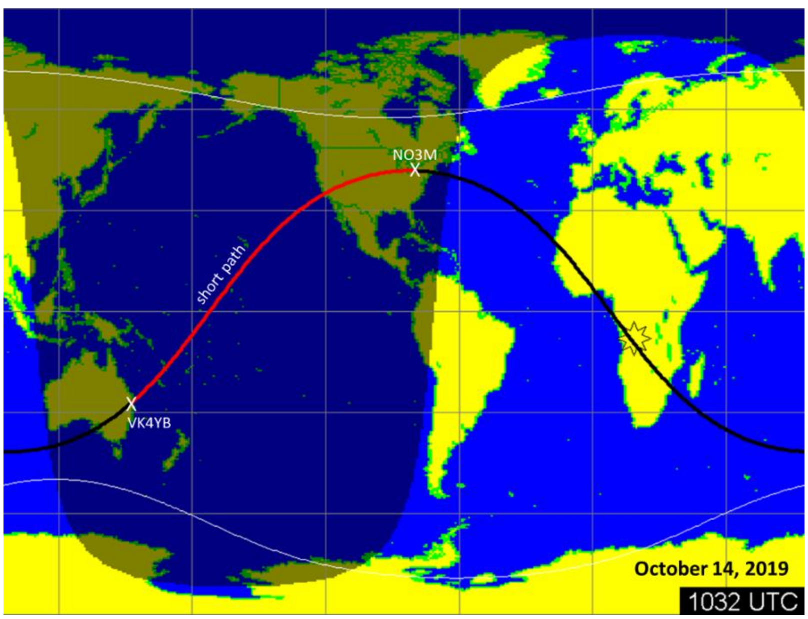
As reported at http://www.arrl.org/news/new-630-meter-distance-record-claimed, Eric NO3M and Roger VK4YB completed a 630-Meter QSO on October 14 of this year at 1032 UTC using the JT9 mode. This is a new distance record (14,979 km) on our newest MF (medium frequency 300-3000 KHz) band.

Two weeks later I received an e-mail from NO3M saying he copied VK4YB on 2200-Meters using the WSPR mode on October 28 from 1130–1148 UTC, and a follow-up e-mail a couple days later saying he again copied VK4YB on 2200m on WSPR on October 31 from 1138-1156 UTC. NO3M believes these receptions are a new distance record on our only LF (low frequency 30-300 KHz) band.

Let's take a look at this 630-Meter QSO and the 2200-Meter receptions. My first thought for both of these events was of Bob NZ5A's August 2019 QST article titled "Optimizing Propagation on 630 and 2200 Meters." NZ5A monitored non-directional beacons (NDBs) from 190-535 KHz for three years. His Figure 1 showed that the best times were around his sunrise and sunset, and Figure 2 showed the peak month was October, with the other fall and winter months about half as good. These recent VK4YB-to-NO3M events followed NZ5A's data.

<u>630-Meter QSO</u>

Here's a map of the path of the 630-Meter QSO on October 14 at 1032 UTC (W6ELProp).



Since this is 630-Meters, it is assumed that the short path (the red line) in darkness is the path that enabled this QSO (as opposed to the black line which is the long path in lots of daylight).

An important question is "what is the hop structure for this 14,979 km QSO?" Was it multi-hop? If so, that would probably involve many, many hops since 475 KHz doesn't get very high into the ionosphere – even at very low elevation angles. Ionospheric absorption would add up quickly – and the result may be prohibitive.

Perhaps ducting is involved – like on 160-Meters. There's a valley in the electron density at night just above the E region peak in which we believe 160-Meter RF ducts, and it sounds reasonable to expect that the same could happen on 630m.

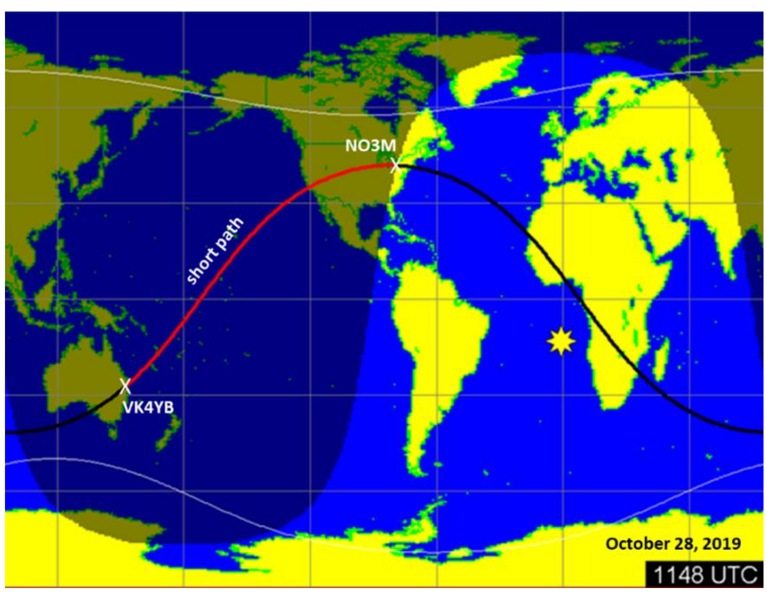
To try to sort this out, I used Propab Pro V3 (from Solar Terrestrial Dispatch) to do ray traces from VK4YB to NO3M. Unfortunately ionospheric absorption was significant on a multi-hop path, and no evidence of ducting showed up [note 1].

But there may be a problem with the model of the ionosphere in Proplab Pro. From other ray tracing work on low frequencies (specifically, VY2ZM's reception of the 100 Watt GB3SSS beacon at Poldhu in December 2006 on 1.960 MHz as discussed in my Propagation column in the December 2007 issue of WorldRadio – both VOACAP and Proplab Pro said VY2ZM should not have heard GB3SSS by a long shot), I've always believed that the ionosphere model has too many electrons per cubic meter in the lower ionosphere [note 2]. The result of modeling would be shorter hops with more ionospheric absorption, and a duct would be tough to get into due to a higher elevation angle needed to get through the nighttime E region peak.

So for now, I don't know if the path was multi-hop or involved ducting. If I had to make a guess, I'd say ducting was definitely involved to minimize ionospheric absorption, with sunrise/sunset enhancements just like on 160-Meters.

2200-Meter Receptions

Here's a map of the path of the 2200-Meter receptions on October 28 at 1148 UTC (again, thanks W6ELProp). 1148 UTC is sunrise at NO3M.



Here are the times and SNRs (signal-to-noise ratios) for the VK4YB receptions at NO3M.

date	UTC	SNR in dB	comments
28-Oct	1130	-23	receptions began 18 minutes before sunrise and ended at sunrise
	1132	-23	
	1136	-22	
	1138	-22	
	1142	-24	
	1144	-24	
	1148	-25	
31-Oct	1138	-27	receptions began 13 minutes before sunrise and ended 5 minutes after sunrise
	1140	-25	
	1142	-25	
	1150	-26	
	1154	-26	
	1156	-26	

The SNRs are remarkably constant. But that might be expected as 137 KHz only gets up to 65-70 km – the bottom of the ionosphere. Thus there is some immunity to the daily variation of the lower ionosphere and space weather (that's a good reason why the worldwide navigation system LORAN-C was down at 100 KHz). And 65-70 km is below where most absorption occurs at night (up around 90 km).

Before discussing multi-hop and ducting, we should look at ground wave propagation. With most of the path over salt water, this is an ideal scenario for ground wave on very low frequencies. Using the old DOS program GRWAVE, the loss for a 15,000 km path is several hundred dB – this is extremely prohibitive even with the WSPR SNR decode capability. So I believe groundwave is out of the picture for these receptions.

As for ducting, it's a struggle to understand how 137 KHz can get through the E region – even at night and at solar minimum [note 3]. If this path was strictly north-south (along a magnetic field line), then it would be interesting to look at magnetospheric ducting. But the path isn't north-south, so this leaves multi-hop as the possible mode.

Again, I used Proplab Pro V3 to do ray tracing on 137 KHz. Unfortunately ionospheric absorption was again significant on a multi-hop path [note 4]. But my comments about too many electrons in the model down low would be applicable here, too.

Summary

Our sophisticated propagation tools say the 630m QSO and the 2200m receptions shouldn't have happened. But they did – so either there's a new mode of propagation on these low frequencies or our models don't represent the lower ionosphere very well (which is not surprising as it's tough to measure the D region to determine its typical magnitude and variability). If I was a betting man, I'd bet on our lower ionosphere model not being correct.

Notes

1) The best scenario on 475 KHz was a very low angle ordinary-wave mode that still put the signal about 78 dB below my assumed quiet rural noise environment (in 2500 Hz) with optimistic antenna gains, the decode capability of JT9 and the use of a receive antenna to improve the SNR. The RF only got up to 70 km and it took 9 hops, with each hop being around 1660 km.

2) In the model of the ionosphere in Proplab Pro V3 (the 2007 version of the International Reference Ionosphere), the E region critical frequency foE at the NO3M end of the path at night at solar minimum is around 480 KHz (0.48 MHz). In Ionospheric Radio (Kenneth Davies, 1990, published by Peter Peregrinus Ltd), M. Leftin gives an equation for foE at midnight that works out to around 360 KHz (0.36 MHz). Thus the model may have almost twice the number of electrons per cubic meter compared to what may be closer to reality.

3) Even if foE is 360 KHz (0.36 MHz), all 137 KHz RF would be refracted back to Earth (regardless of the elevation angle). So how would 137 KHz get through the nighttime E region peak to the electron density valley above?

4) The best scenario on 137 KHz was a very low angle ordinary-wave mode that still put the signal about 46 dB below my assumed quiet rural noise environment (in 2500 Hz) with optimistic antenna gains, the decode capability of WSPR and the use of a receive antenna to improve the SNR. The RF only got up to 65 km and it took 10 hops, with each hop being around 1500 km.