KRSL AM 990 KHz to Finland

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The accompanying November 2016 Monthly Feature (VK9LL 160m QSOs) looks at ducting in the nighttime electron density valley on 1.8 MHz. This bonus November 2016 Monthly Feature looks at ducting at 990 KHz in the valley. The December 2016 Monthly Feature will look at ducting in the valley on other bands.

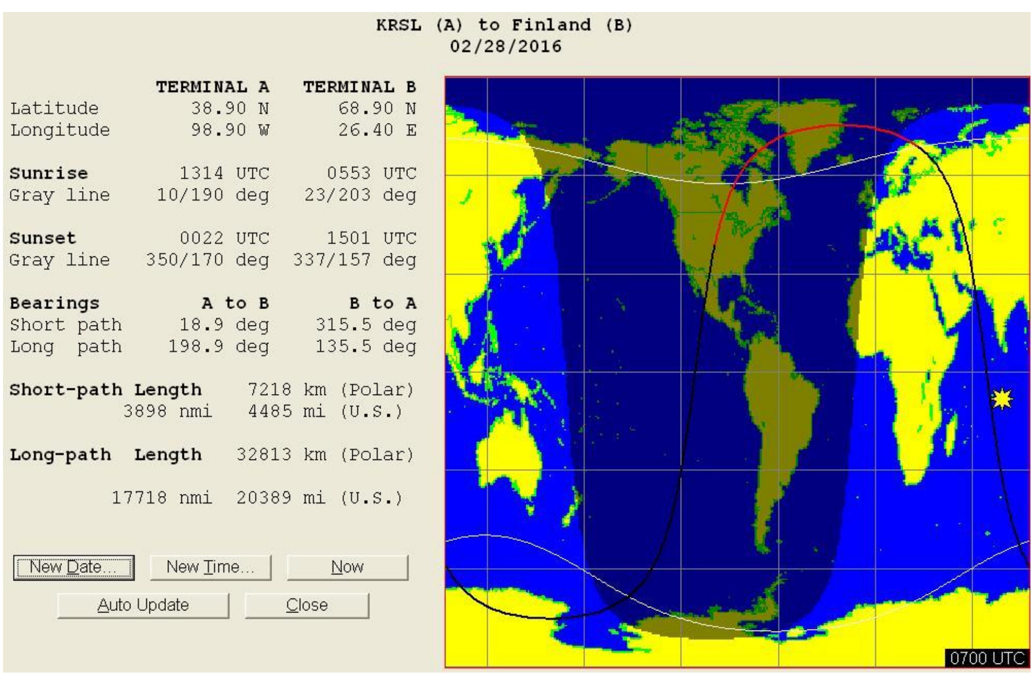
DXing on the AM broadcast band is an interesting endeavor for many SWLers (that's pretty much how I started my SWL career in the late 1950s – on the AM broadcast band with my National NC-60 receiver). Although we think of AM broadcast as a local system, there are reports of AM stations being heard extremely far away.

One example is reported in my November/December 2001 Propagation column in NCJ (National Contest Journal). It was the reception of WOWO (1190 KHz here in Ft Wayne) in Europe and even in VU (India). Back when this happened, WOWO was a 50,000 Watt clear-channel station.

A more recent example is the reception of KRSL (Russell, Kansas on 990 KHz) in northern Finland. This occurred on February 28, 2016 around 0700 UTC (1 AM local in Kansas). The SWL station sent an e-mail to KRSL telling what he heard, and KRSL confirmed his reception. For details of this, visit http://www.krsl.com/local-news/6876-krsl-am-990-heard-in-finland

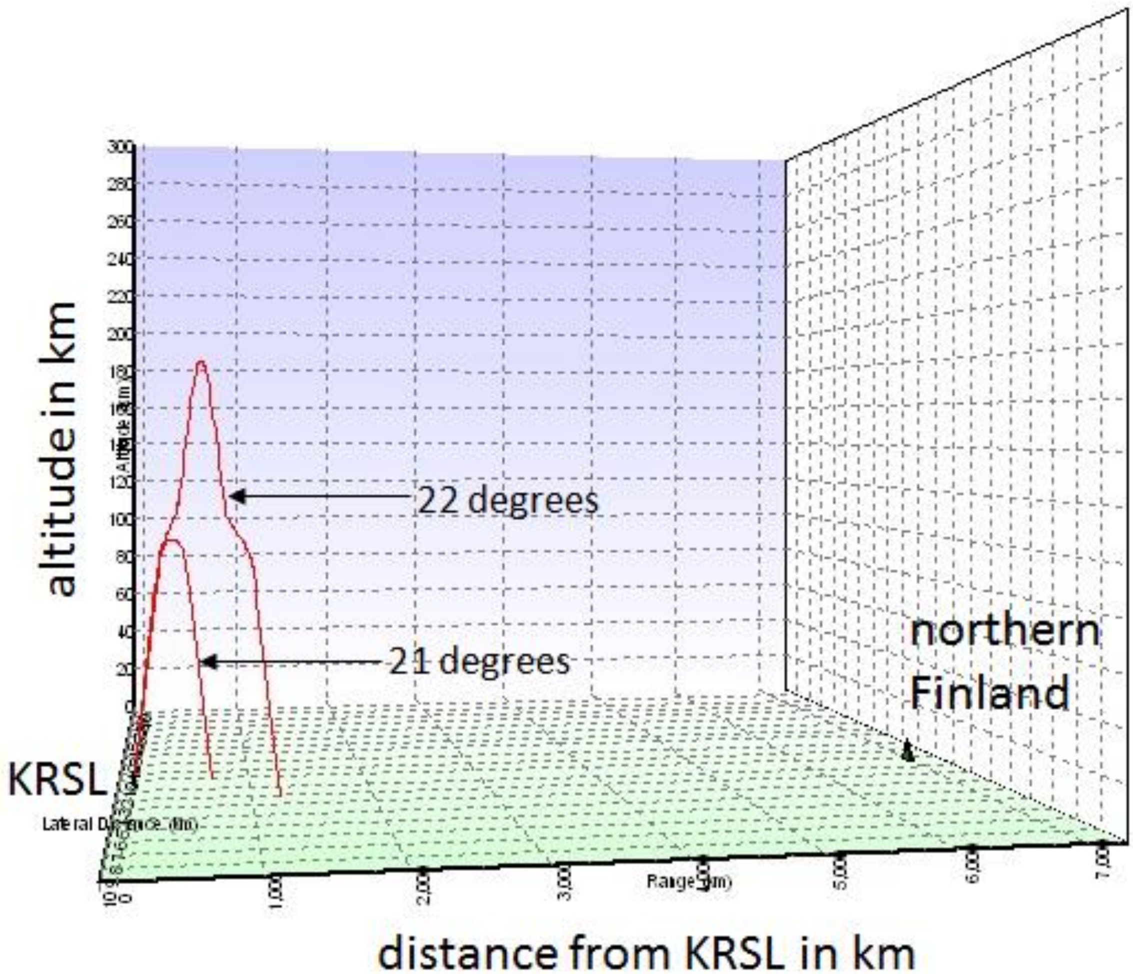
What's even more interesting about KRSL being heard in Finland is the KRSL power level. Per the FCC database, KRSL is allowed to run 30 Watts at night into a single vertical. Yes, I said 30 Watts. Wow, huh?

How did this happen? Let's take a look at the big picture. The following comes from the mapping feature in W6ELProp. It's for February 28 at 0700 UTC. The red line is the short path (7,218 km) between KRSL and northern Finland (I'm assuming this reception was short path).



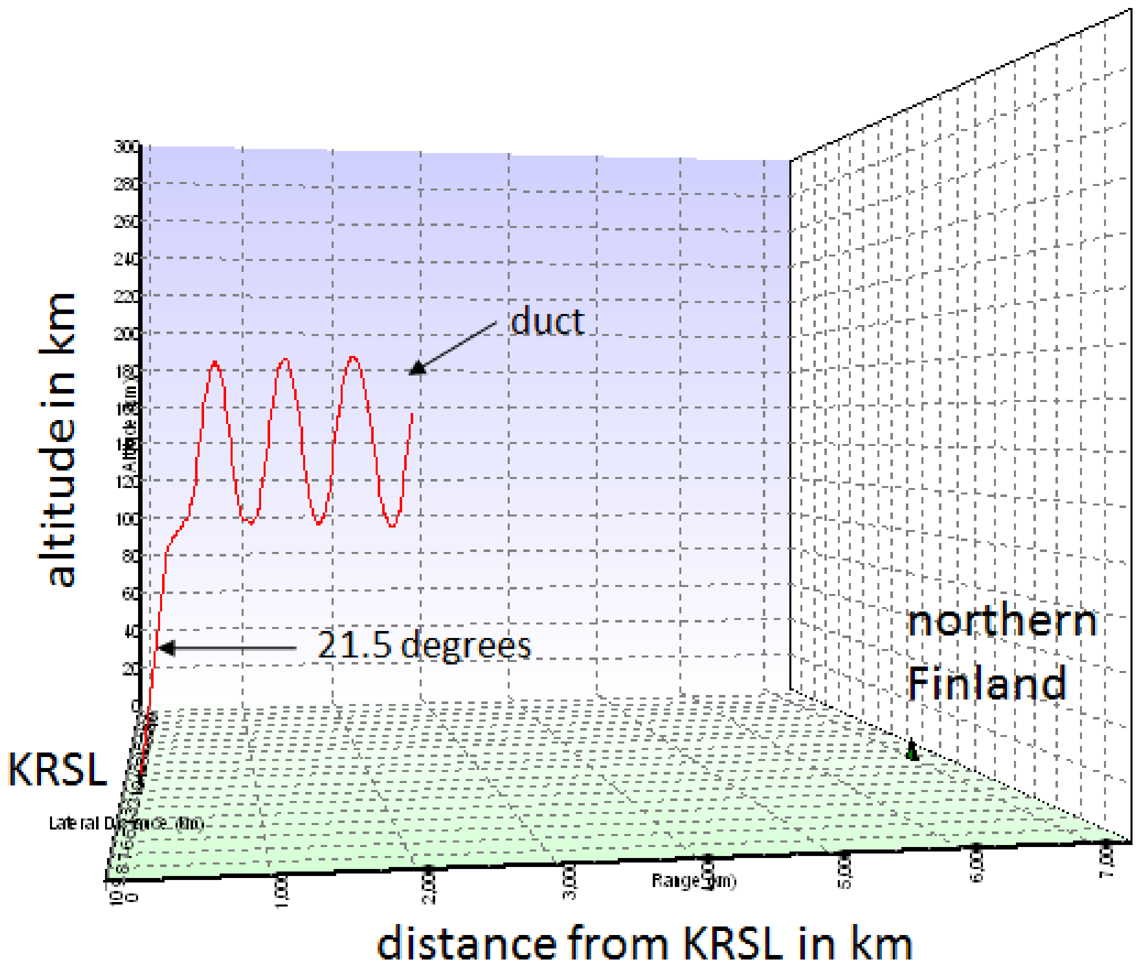
The important observation to make is that northern Finland is around sunrise [*note 1*]. This condition of sunrise on the eastern end of a path on our Amateur Radio low bands has been known to provide a significant enhancement in signal strength, and I'm assuming it's important on 990 KHz, too. The cause of a sunrise enhancement is believed to be due to the signal being dumped out of a duct [*note 2*] as a result of the tilted ionosphere at sunrise. Thus we'll look for evidence to support a duct.

Using Proplab Pro V3 (offered by Solar Terrestrial Dispatch in Canada), we can do ray traces out of Kansas to the NNE toward northern Finland on 990 KHz. After several trial runs at various elevation angles, the following figure gives us a hint of ducting.



What we see are two ray traces – one at a 21 degree elevation angle out of KRSL and one at a 22 degree elevation angle out of KRSL [*note 3*]. The 21 degree trace gives an E hop (maximum altitude of about 90 km), whereas the 22 degree trace gives an F hop (maximum altitude of about 185 km).

The “shoulders” between 80 and 100 km on the F hop are the tell-tale characteristic of a potential duct mode that may be occurring in between 21 and 22 degrees. Doing a ray trace at 21.5 degrees gives the following.



Indeed, Proplab shows a duct mode. What a duct offers is the absence of transits through the absorbing region (lower E region during the night) and the absence of ground reflections – both of which add loss to reduce the signal strength.

I let the ray trace go until it came out of the duct at around 5,000 km – well short of the distance to northern Finland. I’m not concerned with this result for two reasons. First, the model of the ionosphere in Proplab is a monthly median model, and the actual state of the ionosphere on February 28 is not captured. Second, our RF sprays radiation over a wide range of elevation angles, which means the exact elevation angle to give a duct all the way to Finland is probably in there if I bothered to do many, many incremental ray traces. The important take away is that ducting appears to be possible.

Another important issue is QRM from other American and Canadian AM broadcast stations on 990 KHz. Why weren’t they heard? Why didn’t the higher-power stations drown out KRSL? I think the answer is that KRSL was more favored with a duct than the other stations. As a side note, multi-hop was not available as the absorption and ground reflection losses were prohibitive. Another side note – the Kp index for the 06-09 time slot on February 28, 2016 was very low, giving a very stable ionosphere.

Speaking of power, would the 30 Watts of KRSL be sufficient to produce a readable signal in northern Finland assuming a duct mode? As we did in the accompanying "VK9LL 160 QSOs" monthly feature, we can estimate KRSL's signal power in Finland using the equation:

$$Pr = Pt + Gt + Gr – FSPL – abs – gnd\ refl$$

Pr is the received power in dBm, Pt is transmitted power in dBm, the two Gs are antenna gains (transmit and receive) in dBi, FSPL is the free space path loss in dB, abs is the loss in dB due to ionospheric absorption and gnd refl is the loss in dB due to ground reflections.

With Pt = 44.8 dBm, the two antenna gains = 0 dBi, FSPL = 109.6 dB, abs = 35 dB (20 dB to go through the absorbing region to get into the duct and 15 dB to go through the absorbing region to get out of the duct – these values are from ray tracing results at 990 KHz) and gnd refl = 0 dB, we end up with around -100 dBm received power in Finland.

Now we need to compare this -100 dBm received power to the noise environment in northern Finland. The man-made noise power in a remote environment like northern Finland would be around -96 dBm in 5 KHz (AM bandwidth). The atmospheric noise would be around -102 dBm in 5 KHz. Both of these values come from ITU-R P.372-12 (titled Radio Noise). We can also apply at least 7 dB of signal-to-noise ratio improvement to the worst case noise power due to the low-noise receive antenna (a 3000 foot long-wire) used by the SWL station in Finland, with the resulting noise power now around -103 dBm in 5 KHz. The signal-to-noise ratio of KRSL would be 3 dB, giving a marginal signal – which is how the KRSL reception was reported.

With reasonable estimates for critical parameters, we have a likely explanation of how KRSL was heard in northern Finland – ducting in the nighttime electron density valley.

Finally, thanks to Bill NQ6Z for alerting me to this KRSL reception report.

Notes

1 – The fact that it's a bit past sunrise in Finland is of minimal consequence as the Sun is still pretty much on the horizon down in the southern hemisphere in late February.

2 – The ducting mechanism is due to the nighttime electron density valley that is between the E region peak and the lower portion of the F region.

3 – These are traces for the ordinary wave. The traces for the extraordinary wave show no hint of ducting, and they also have significantly increased absorption.