A Look at the 160-Meter QSOs of the VK9LL DXpedition of September 2013

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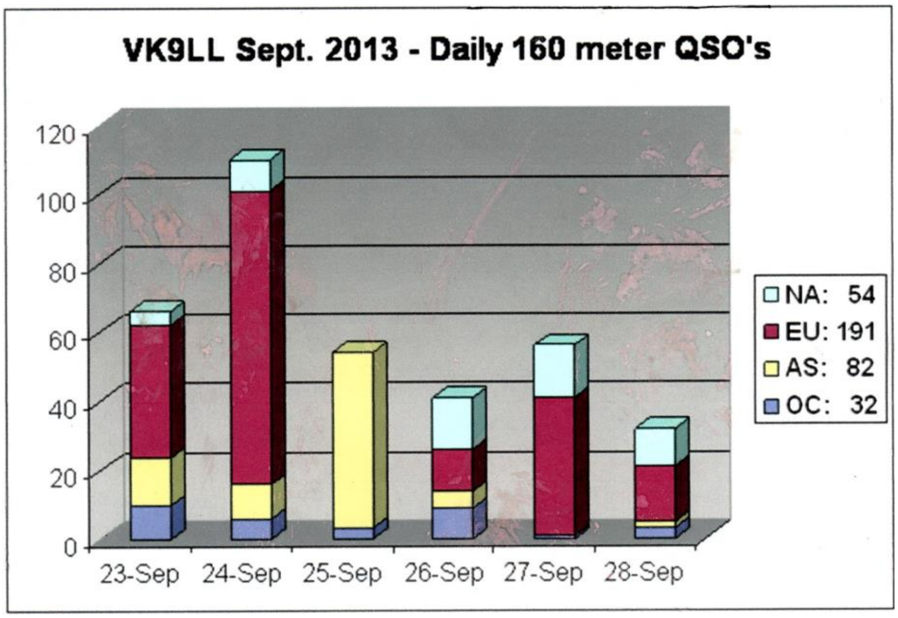
During late September 2013, Tomas VK2CCC activated VK9LL on Lord Howe Island. His focus was on 80-Meters and 160-Meters. Six days of operation on 160-Meters produced the following results.



One of the comments that Tomas made after the DXpedition was that he didn't understand why he had so many more QSOs with Europe than North America. As can be seen in the legend on the right, he made 191 European 160-Meter QSOs [*note 1*], but only 54 North American 160-Meter QSOs. That's a good comment from Tomas for three reasons:

1) Depending on the country, the path to Europe is 16,000 – 17,000 km, whereas the path to North America is 11,000 – 14,000 km. With a shorter path, North America should have dominated due to less ionospheric absorption and less ground reflection loss.

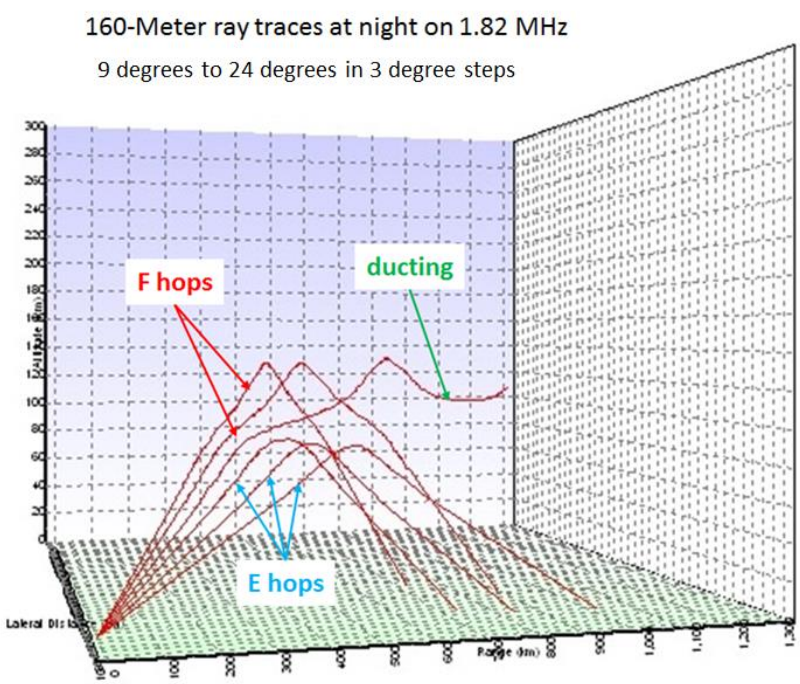
2) The path to Europe had about two hours of common darkness (this is the time the entire path between VK9LL and Europe was in darkness – which is where 160-Meter RF needs to be). The path to the West Coast of North America offered about six and a half hours of common darkness. With more hours of common darkness, North America should have dominated due to much more available time.

3) The path to Europe at the VK9LL end appears to have a terrain issue, but the path to North America has an open horizon. Digging deeper by looking at a terrain map of Lord Howe Island indicates that the hills to the northwest of VK9LL on the heading to Europe are about 2.5 km away and go up to 147 meters. Doing a little math says the hills would block RF below about 3.5 degrees. I don't see that as a problem on 160-Meters – as we'll see later. The following figure shows the paths from VK9LL to Europe and North America along with the local terrain.

Reason #1 above gives us a clue as to what may have been happening. Indeed, the farther the distance the more the loss (absorption and ground reflection) and thus less signal strength. This assumes propagation is via multi-hop – successive refractions and reflections between the ionosphere and ground. If this doesn't happen, then maybe some other mode is involved.

The other mode is ducting. For paths similar in distance to that between VK9LL and Europe, one needs to consider ducting [*note 2*] in the nighttime electron density valley that exists between the E region peak and the lower F region. In order for a signal to get into a duct, it has to have a high enough elevation angle to get through the E region, but not so high as to not be refracted back down from the lower F region – and then it needs to be refracted back up again by the E region.

Working with a ray racing program [*note 3*] on 160-Meters hints that there are three ranges of elevation angles on 160-Meters that give us three different modes. The following figure depicts this concept for a representative nighttime path on 160-Meters.



In this example, rays are traced from 9 degrees to 24 degrees in 3 degree steps. Elevation angles up to 15 degrees result in E hops. Elevation angles above 21 degrees result in F hops. Between 15 and 21 degrees we see the start of a ducted mode – successive refractions between the E region peak and the lower F region. The ducted mode results in no transits through the absorbing region to add loss and no ground reflections to add loss.

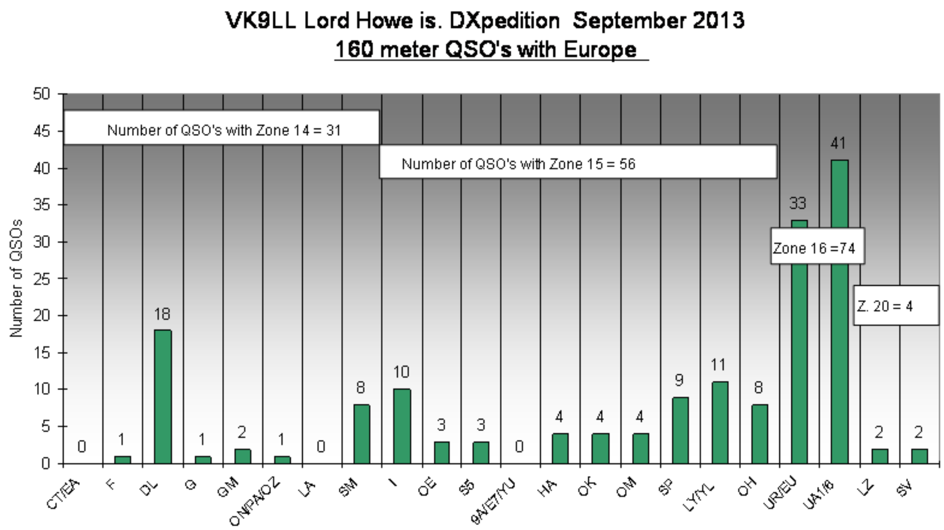
Doing ray traces from VK9LL on 160-Meters to Europe (specifically DL) in September 2013 at 1830 UTC (halfway between DL sunset and VK9LL sunrise) shows a range of angles down around 9 degrees where RF out of VK9LL enters a duct [*note 4*]. In a similar manner, doing ray traces from VK9LL to North America (specifically W6) at 1330 UTC (an hour before W6 sunrise) shows no ducting at all on the VK9LL end. Thus ducting appears to give the possibility of European QSOs, but lossy multi-hop is all that may be available to North America.

This certainly hasn't been an exhaustive analysis, but it suggests that the mechanics of ducting may not be the same for different headings out of a given location. The underlying reason is likely the electron density of the E region and the electron density of the lower F region – both of these would determine if an elevation angle could get through the E region but still be refracted back down from the lower F region and back up again by the E region.

In summary, the moral of this month's feature is there may be another player in the mysteries of 160-Meter propagation – the mechanics of ducting. In addition to being dependent on heading, ducting may be dependent on time of day, month and phase of a solar cycle. Again we see that simply using 10.7 cm solar flux and the K-index is not adequate to predict 160-Meter openings.

Notes

Note 1 – Here's the breakdown of the 160-Meter European QSOs.



Note 2 – A simple calculation shows why multi-hop is a problem. We can estimate the received signal power (Pr in dBm) with the following formula:

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

Pt is the transmit power in dBm, Gt is the transmit antenna gain in dBi, Gr is the receive antenna gain in dBi, FSPL is the free space path loss (spherical spreading of the wave) in dB, abs is the total ionospheric absorption in dB and gnd refl is the total ground reflection loss in dB.

Let's make an estimate for an 11,000 km path (the shortest path to North America from VK9LL). This will take 6 hops since the maximum hop length on 160-Meters is about 2000 km – regardless of whether it's an E hop or an F hop. With Pt = 50 (VK9LL ran 100 Watts), Gt and Gr = 0, FSPL = 119, abs = 42 (7 dB per hop for 6 hops) and gnd refl = 10 (2 dB per ground reflection for 5 ground reflections), we get Pr = -121 dBm.

That's certainly above the MDS (minimum discernible signal) of a typical receiver (which is around -135 dBm), so all is okay – right? No, it's not. Unfortunately external noise (both man-made and atmospheric) limits our receive performance on 160-Meters to around -103 dBm in a quiet rural environment (even worse in a more noisy environment). Doing some more math with Pt = 61.8 dBm (1500 Watts) suggests that 10,000 km or so is about the maximum distance for multi-hop on 160-Meters. Of course using 4-Squares on both ends would extend this a bit – but not by much.

Note 3 – For example, Proplab Pro V3 from Solar Terrestrial Dispatch does ray tracing. Remember that the ray tracing results give monthly median results since the model of the ionosphere in Proplab Pro (and in all our other propagation prediction programs) is a monthly median model. MUF, signal strength and even elevations angles are statistical over a month's time frame, with the predicted median being akin to what the ionosphere looks like "on average" over the desired month.

Note 4 – With ducting occurring at around 9 degrees to Europe, the hills to the northwest of VK9LL should pose no problem.