Long Path / Short Path Switching on 15-Meters – Part 1

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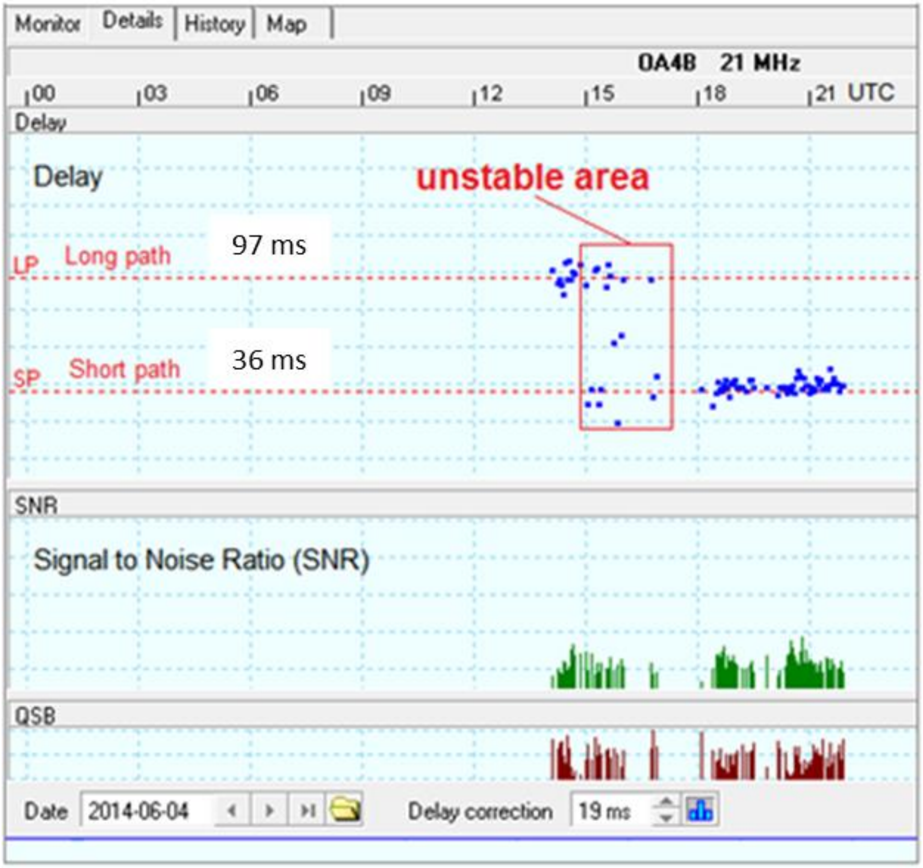
Earlier this year I received an e-mail from Flavio IK3XTV (see his www.qrz.com home page and his related article in the January/February 2017 issue of QEX). The e-mail discussed his IARU/NCDXF beacon monitoring (note 1) with Faros software (note 2), and included a screen shot of his measurements of the OA4B beacon in Peru on 21 MHz on June 4, 2014. Here is this picture. The annotation “unstable area” is IK3XTV’s comment.



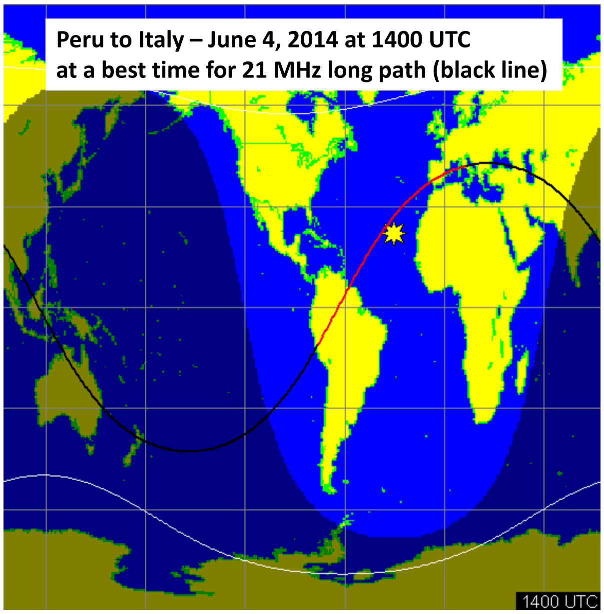
On June 4, the 15-Meter path between Peru and Italy opened up from about 1400 to almost 1700 UTC via long path (nominal 97 msec delay), with the best times from 1400 to 1500 UTC. The 15-Meter path was open from about 1500 to 2200 UTC via short path (nominal 36 msec delay), with the best times from 1830 to 1930 UTC and 2000 to 2200 UTC.

What’s even more interesting are the two receptions around 1550 UTC when the path was neither long path nor short path – it was something in between. The delay for these two receptions was about 64 msec (note 3). What was this path? Let’s start by understanding the more common long path and short path, and then we’ll move on to the 64 msec receptions.

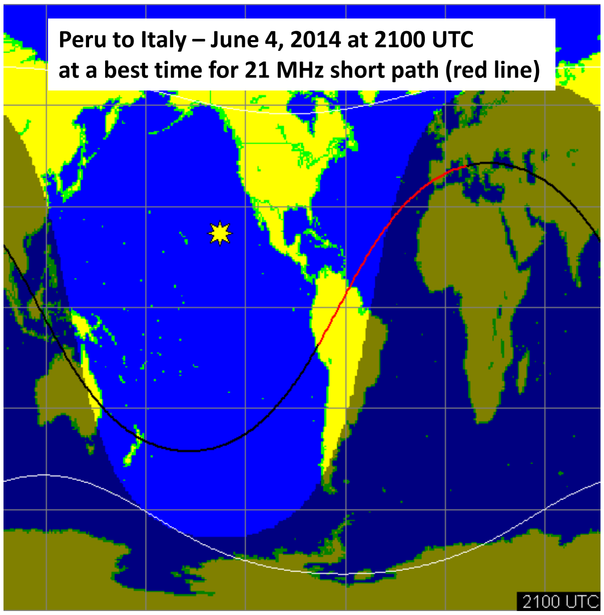
There are two parameters required for a QSO to be made. First, there needs to be enough ionization to refract signals back to Earth all along the path. In other words, the MUF (maximum useable frequency) has to be high enough to support the operating frequency (21 MHz in this case). Second, the total loss along the entire path needs to be low enough to allow the signal to be readable at your QTH. In other words, the signal must be above your noise. Just meeting one of these parameters is not enough – both need to be met.

Before investigating MUF and loss issues, it should be pointed out that June 2014 was around the second peak of Cycle 24. The second peak was significantly higher than the first peak. This translated into the most ionization of Cycle 24, which certainly helped the MUF issue.

Now let's start by taking a look at the 'big picture'. We'll do this by looking at worldwide maps at 1400 UTC (a good time when long path was available) and at 2100 UTC (a good time when short path was available). These maps will show the long path, the short path and the terminator. Although this is a high-level view, it can tell us quite a bit about what may be going on. Here are the maps (from W6ELProp).



Peru to Italy – June 4, 2014 at 1400 UTC
at a best time for 21 MHz long path (black line)



Peru to Italy – June 4, 2014 at 2100 UTC
at a best time for 21 MHz short path (red line)

<u>1400 UTC – short path or long path?</u>

From the W6ELProp map on the left, the short path (the red line) was entirely in daylight. Being around solar max and in the equatorial ionosphere, the short path should have no problem with MUF. But along with lots of ionization comes more absorption. Note the position of the overhead Sun (the yellow star) – it is pretty much right over the path (which translates to a solar zenith angle of close to 0 degrees). Although the amount of ionospheric absorption is inversely proportional to the square of the frequency and thus absorption is significantly reduced on 21 MHz compared to the lower frequencies, there's still a concern since the overhead Sun is right over the path.

How do we determine the amount of absorption on the short path? The best (but somewhat tedious) way is to do ray traces with Proplab Pro V3 (note 4). With lots of ionization, there are at least three F region modes that are available from Peru to Italy on 21 MHz via short path. At very low elevation angles (up to about 5 degrees), there's a long chordal hop across the geomagnetic equator followed by one normal F hop to get into Italy. At higher elevation angles, a normal 3 hop F mode and a normal 4 hop F mode are available (and likely even more hops at even higher angles due to the amount of ionization). But all these modes have one thing in common – roughly 26 dB of ionospheric absorption. That's unusually high for a normal 21 MHz path. Calculating the received power in the manner that I've done before (note 5), the received power is in the neighborhood of -126 dBm from the 100 Watt OA4B beacon with omni-directional antennas on both ends of the path. This is below the man-made noise environment in a 500 Hz bandwidth of even a rural QTH.

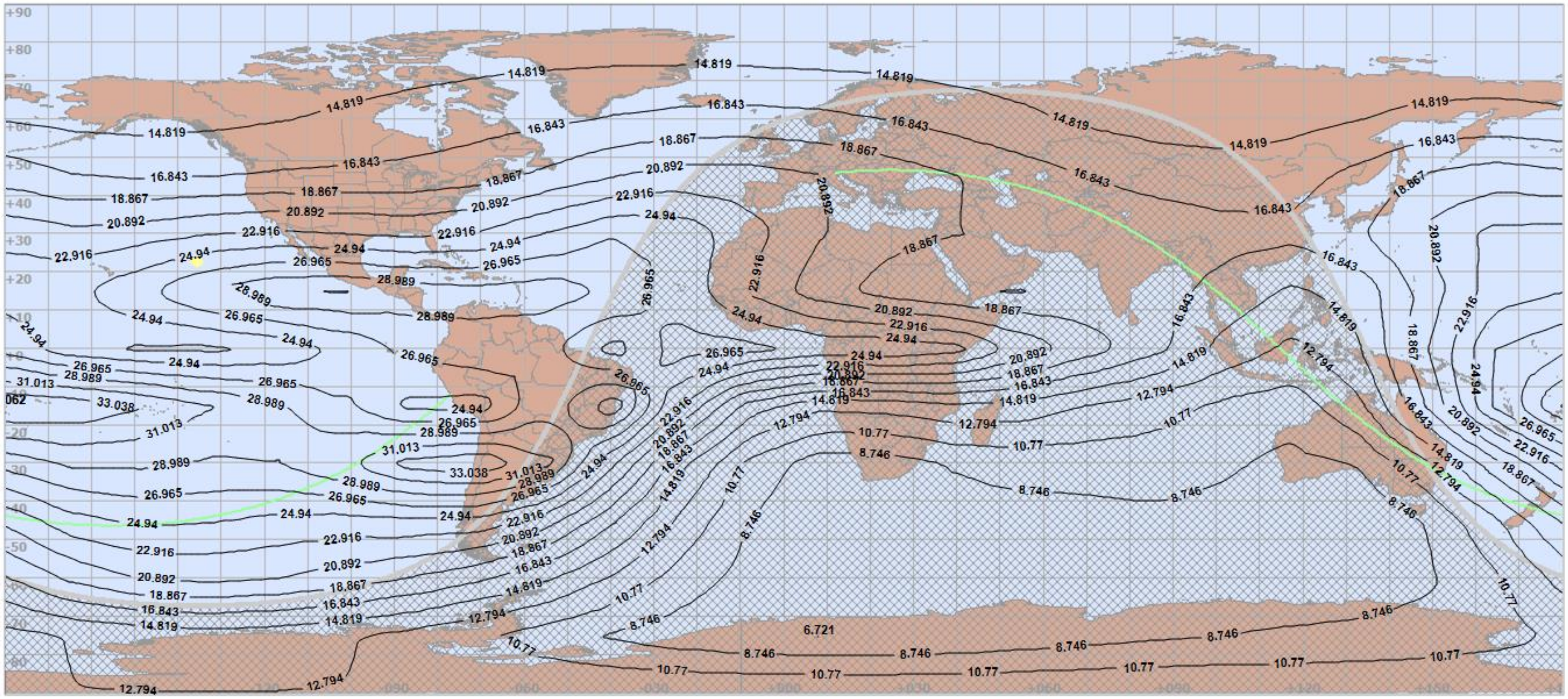
So how about the long path (the black line)? Absorption should be minimal as much of the long path is in the dark ionosphere. Additionally, the fact that sunrise is southwest of Peru and sunset is east of Italy is a clue to what may have been happening. At sunrise and sunset there are tilts in the ionosphere that could induce chordal hopping (note 6) without any transits through the absorbing region and without additional loss from ground reflections. I again used Proplab to do ray traces out of Peru to the southwest. Unfortunately Proplab does not ray trace a long path, so I had to set up a dummy location less than 20,000 km away from Peru on the long path. After an initial F hop in the daylight portion, chordal hopping was instigated. With chordal hopping, low MUFs in the dark ionosphere are not as critical as low MUFs in the dark ionosphere for normal multi-hop.

In summary for 1400 UTC, I'm very confident that short path was not available due to too much ionospheric absorption, while long path was available because of a chordal hopping mode.

2100 UTC – short path or long path?

From the W6ELProp map on the right, the short path (the red line) was mostly in daylight, but the Sun was not very close to overhead (in other words, a much higher solar zenith angle with less ionospheric absorption than at 1400 UTC). The Italy end of the short path was in darkness. But it wasn't too far past sunset, so the slow recombination process at F2 region altitudes didn't result in a quick reduction in electron density. Again using Proplab, ray tracing shows the only likely mode is 4 hops via the F region at an elevation angle of 6.5 degrees. The total ionospheric absorption is only 5.9 dB, and this results in a -109 dBm signal power in Italy – this should be readable. There is an extremely low angle (0.5 degrees) 3 hop F mode, but this appears to be out of the picture due to being way far down on the elevation pattern of the antennas.

As for the long path (the black line), there doesn't appear to be any help from ionospheric tilts as there isn't any on the Italy end (since Italy is in darkness). Thus the problem area for long path is likely to be supporting multi-hop modes on that portion of the long path between Australia and Italy – especially near Australia. The Australia end has been in darkness all night, and the MUF would be significantly lower than the daytime MUF. To check this out, the next page has the Proplab worldwide map for MUFs for a 3000 km hop via the F2 region on June 4, 2014 at 2100 UTC.



Global Ionospheric Chart for 2014/06/04 21:00:00 UTC

Monthly median map for a 3000 km hop via the F2 region at 2100 UTC centered on June 4, 2014
Green line is long path from Peru to Italy
Yellow dot is overhead Sun
Note terminator

Indeed, that part of the long path over Australia has a significantly reduced MUF. Even the rest of the path into Italy is not enough to propagate 21 MHz via multi-hop – that indicates how important tilts in the ionosphere can be for propagation thru the dark ionosphere on the higher bands.

In summary for 2100 UTC, I'm very confident that short path was available due to enough ionization and minimal absorption. The long path was not available due to not enough ionization.

Okay, that's enough for this month. Next month we'll look at paths that could give around 64 msec delays. That could get very interesting.

Notes

Note 1 – For detailed information on the IARU/NCDXF beacon system on 20-Meters, 17-Meters, 15-Meters, 12-Meters and 10-Meters, visit http://www.ncdxf.org/beacon/

Note 2 – For detailed information on the Faros automatic NCDXF beacon monitoring software by Alex VE3NEA, visit http://www.dxatlas.com/faros/

Note 3 – The delays are derived from the path length divided by the speed of light. Short path between OA4B and IK3XTV is 10,850 km. The speed of light is 300,000 km/sec, so the delay is 36.2 msec. Similarly, long path is 29,174 km divided by 300,000 km/sec = 97.2 msec. The 64 msec delay corresponds to a path length of 19,200 km.

Note 4 – Remember that Proplab (available from Solar Terrestrial Dispatch), along with all our other propagation prediction programs, uses a monthly median model of the ionosphere. The results (usually MUF and signal strength) are monthly median values – they are the median values (50% probability) over a month's time frame centered on the date chosen. We do not have daily predictions.

Note 5 – Received power in dBm = transmitted power in dBm + transmit antenna gain in dBi + receive antenna gain in dBi – free space path loss in dB – ground reflection loss in dB – ionospheric absorption in dB. The antenna gains can be negative.

Note 6 – Read https://k9la.us/20M_Ionosphere-Ionosphere_Mode.PDF, which is an article about 20-Meter chordal hopping. Note the similarities to the 21 MHz Peru-to-Italy path.