A Study of Long Path Echoes – Asymmetric path

Abstract

I have planned the observations on the long path echoes using Faros software to monitor the beacon of NCDX Foundation. I have focused my attention on the beacon OA4B from Lima Peru and I recorded an anomalous behavior. also confirmed by similar studies conducted by Carl Luetzelschwab, K9LA, on another beacon, ZL6B. This seems to confirm a repeatable phenomenon independent of geographic location but caused by ionospheric anomaly.

WORK IN PROGRESS

Flavio Egano, ik3xtv

www.qsl.net/ik3xtv

doc. N.4574.16.09 date August 12, 2019

A Study of Long Path Echoes – Asymmetric path

doc. N.4574.16.09 date August 16, 2019

Abstract

I have planned the observations on the long path echoes using Faros software to monitor the beacon of NCDX Foundation. I have focused my attention on the beacon OA4B from Lima Peru and I recorded an anomalous behavior. also confirmed by similar studies conducted by Carl Luetzelschwab, K9LA, on another beacon, ZL6B. This seems to confirm a repeatable phenomenon independent of geographic location but caused by ionospheric anomaly. (Please see the Fig.4)

Anomalous Path

In this paper, we focus in that zone of instability when propagation changes from long path to short path on Delay times as we can see around 1500 UTC, in the Figure 1 left pannel. The intermediate values of delay suggest a non-great circle path, commonly referred to asymmetric path, and it would be interesting to understand what possible asymmetric path. The asymmetric path is wich the signal is misaligned by several degrees from the great circle. In this transition area, we have a multipath zone of instability, difficult to comprehend. The delay measurements of the beacon are in the right display, blue points. Note the two blue points with a delay around 60 ms, which is more of 20 ms respect to the Short path delay. This means that the signal has undergone a deviation of more than 6000 kilometers compared to the direction of the great circle for the SP. During the transition phase between the long path and the short path, something happens to the ionosphere. This event also confirms the highly unstable nature of the ionosphere. I ask myself a few questions: what happens? And what is the path of the signal in the ionosphere?
Please, consider the unstable area marked by the red rectangle in the chart. At this stage, we see that we have, almost at the same time, propagation opening Long path, short path and asymmetrical path. We must also consider that Faros Software, always discriminates the strongest signal received, this means that in this unstable area we have the ionospheric duct open for the entire earth's circumference. Note also the spread of the delays during LP time.

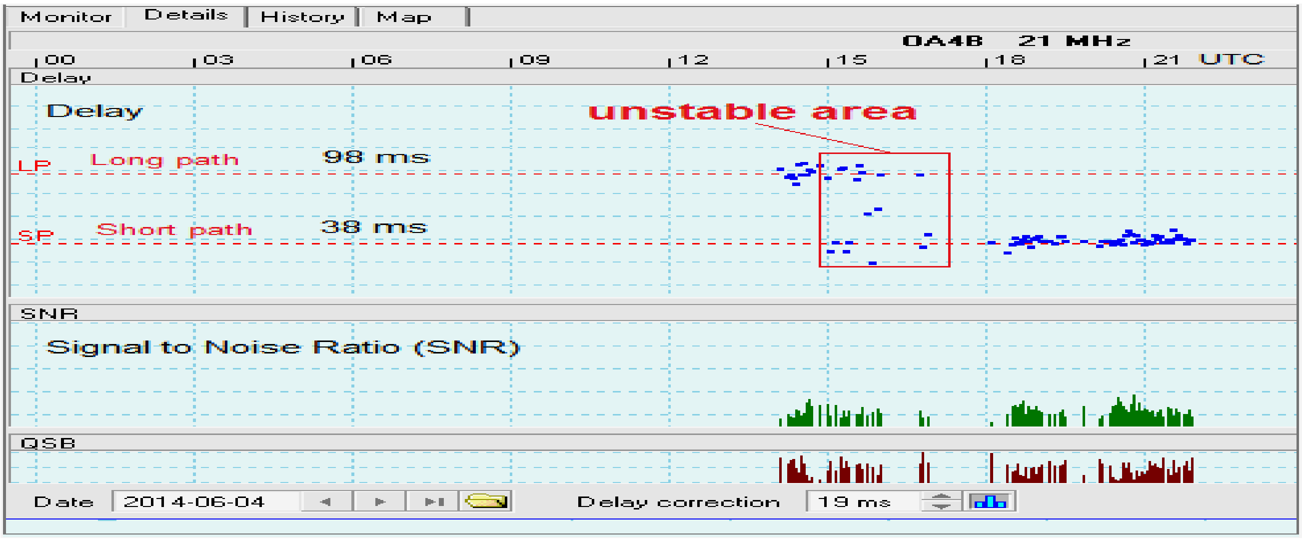
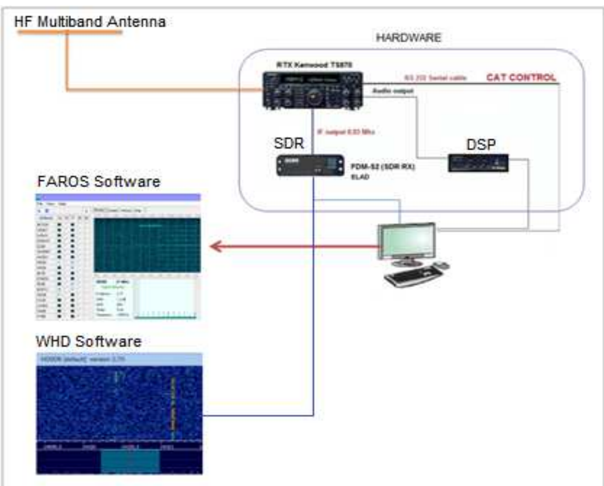


Fig.1 OA4B to IK3XTV date: 2014-06-04 FREQ. 21 MHZ – Kp=1 – Solar Flux SFU=107- ssn=61. The graph shows the zone of instability detected in the transition from LP to SP. **The right graph (the green bars) shows the amplitude of the signal, explained as signal to noise ratio. If we observe the signal amplitude Long Path, and we compare it with that of the short path, we see that the difference is minimal. This tells us that the path attenuation, does not follow the attenuation of inverse square law propagation, because we observe only a few dB of difference. There are cases in which the intensity of the signals received via the ionosphere is greater than that calculated for the free space. We have the ducting propagation phenomenon, where the signal travels within a duct with layer of high refractive index with very low attenuation. (The software is the automatic Faros beacon monitor software and the Rx Antenna was a G5RV).**



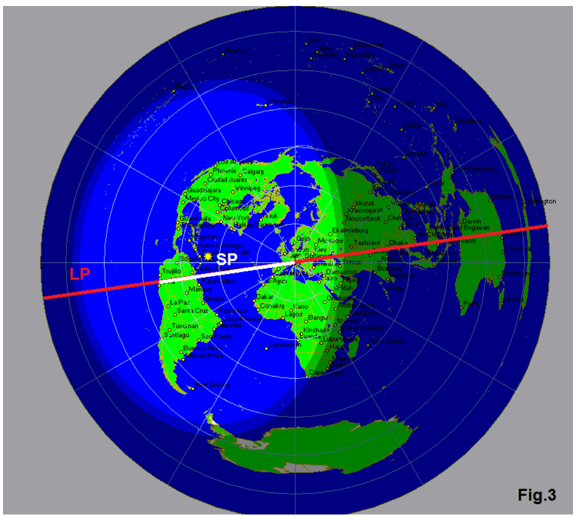


Fig.3

Fig.2 Setup of monitoring and analyzing of the beacon signal, with Kenwood TS870 with SDR Receiver as Panadapter mode, used to display the spectrum of the Beacon signal. The signal is picked up by the receiver's audio output and it is treated with Adaptive DSP to cancel noise and thereby improve the Signal to noise Ratio (SNR). Faros software has a delay correction compensates for the signal delay in the transmitter, receiver, and for the UTC clock offset that may exist due to the upload/download speed asymmetry of the internet network connection. WHD (Winrad High definition) software is used to display the spectrum of the received signal.
Fig.3 Azimuthal map that shows the Grey line position and the path of the signal during the transition period, around 16:00 UTC
The red segment is referred to the long path, and the white to the short path. Considering that LP is about 29.000 Km, the SP is 11.000 Km and the anomalous path about 17.000 Km.

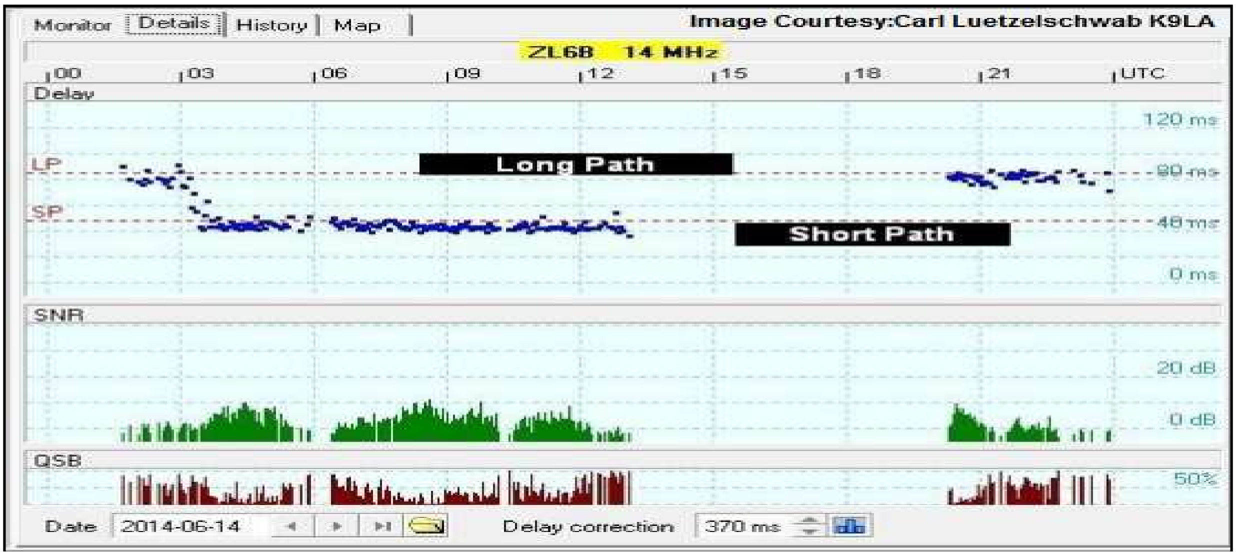


Fig.4 Another case of asymmetrical path, ZL6B to K2MO on June 14, 2014. FREQ. 14 MHZ – Kp=2 – Solar Flux SFU=153 - ssn=276
This is the result of K2MO monitoring the ZL6B beacon on 20m for the entire day on June 14, 2014. This image also shows some of the Faros software options. For this entire 24-hour period, K2MO 's 5-element monoband 20m Yagi was pointed along the long path to ZL6B.
The intermediate values of delay times when propagation changes from long path to short path around 0300 UTC, suggest a non-great circle path. C. The short path SNR is actually higher than measured as it is off the back of K2MO 's 5-element Yagi . K2MO says the front-to-back is something like 24 Db. Studies and image courtesy of Carl Luetzelschwab, K9LA.

Asymmetric path

Deviations in the direction of arrival of ionospheric propagating radio signals from the Great Circle Path is very difficult to explain. The theory suggests that deviation may occur across the equator or near the polar areas, when signals lapping on the auroral oval. but I do not think that this is the case. I try to formulate a possible explanation. Around 15 UTC, you may also notice that there is a zone of instability in which the reports came that both LP SP. We must also consider that If the software receives the signal from LP and SP simultaneously, it is programmed for discriminate the strongest signal, it would mean an open tube that throughout the full turn of the earth's circumference. The dynamic to deviation from Great-circle Path could be caused by Reflections caused by ionospheric irregularities that are accentuated in this transition phase.

One possible explanation

The mechanism to deviation from Great-circle Path Generally it is accepted that there are three mechanisms of signal propagation through the ionosphere: 1. By refraction caused by the gradient ionized ionospheric layers. 2. By reflection caused by auroral ionization. 3. By scattering of the signals by ionospheric irregularities and also by irregularities in the earth's surface. As explained more then once, the ionosphere is not a homogeneous refractor. It is a heterogeneous and continuously changing cloudy and patchy region with different ionization density areas. There is more scattering and skewing going on there than most of us ever thought or imagined. The general mechanism causing the signal waves to deviate from the great-circle path is the more or less horizontal ionization gradients with unequal thickness. Signals traveling into a layer with a higher degree of ionization will be refracted away from the gradient. Depending on the tilt of the gradient, the wave will deviate with an angle differing from the great-circle heading.
Note that both cases analyzed, they occurred in a high solar activity period and the mechanism appears to be independent of frequency (14 MHz and 21 MHz).

OA4B Beacon Information

Lima is located in the central coastal part of Perù, overlooking the Pacific Ocean, in a flat area near the Andes mountain, with very high peaks over 6000 meters a.s.l. which get worse the Antenna beaming take off to east direction and then to Europe. This position certainly has an influence on propagation path, making easier the Long Path opening to Europe. This particular geographical position, could significantly affect the propagation profile.
Beacon coordinates: OA4B Lima-Perù Lat:12 04 S Long:76 57 W.

ZL6BB Beacon Information

The beacon is located in a flat area in the open countryside.
Beacon coordinates: ZL6B Masterton-New Zealand Lat:-41.043 N Long:-175,59 W.

Experiments with FT8 - Sidescatter (Skew) Propagation

I would like to describe this anomaly that I have encountered many times. Figure 5 describes a QSO with a Swiss station received with the antenna beam to South America, 60 degrees azimuthally of offset error compared to direct pointing towards Switzerland. In the direction of South America, the 15-meter band was open. That was the direction with the MUF open. HB9TVS transmitted with his 4 elements Yagi antenna, pointed to South America, looking for FT8 15 meters qso. I have experienced many cases similar to this, even with other stations, for example German, Dutch and British stations. I have also excluded possible reflections on the mountains. I wonder if this phenomenon has a correlation with what is described in this document.

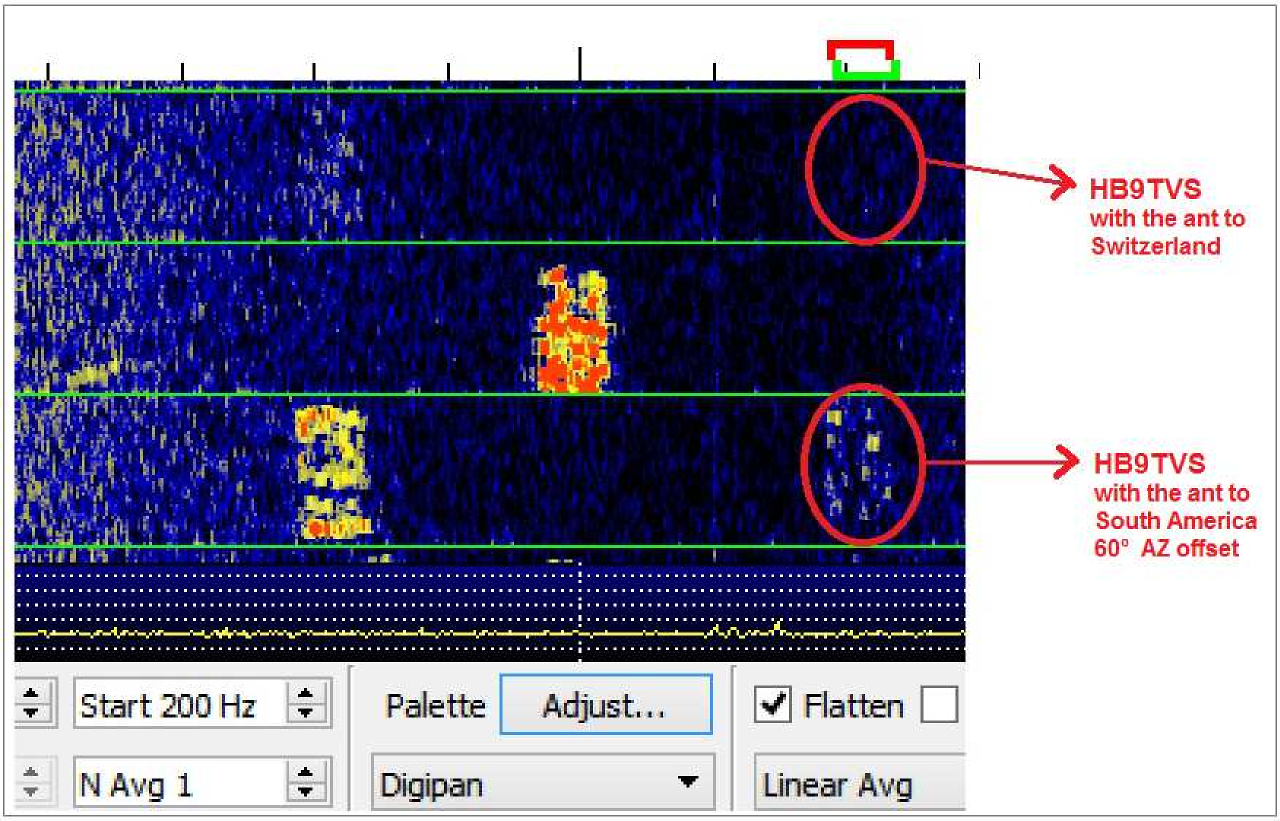


Fig.5 Screen shot of FT8 Software spectra panel, with the trace of HB9TVS during my QSO of April 25, 2018 on the frequency of 21 Mhz. The signal was receivable only by pointing the antenna to South America and not directed to Switzerland.

The big question is: where does the reflection of the signal occur? it is difficult to answer this question with absolute certainty
I think that reflection occurs, in order of probability:

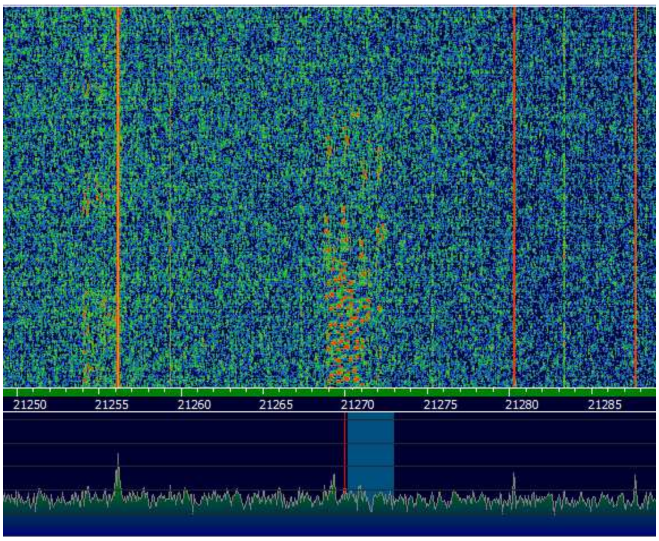
1- in the Ionosphere due to a local increase in the ionization gradient
2- Over the sea surface (good salt water conductivity)
3- on the Earth's terrain surface (low reflection capacity, only about 7% of the energy)

I've mostly assumed it's in the ionosphere because of gradients in the electron density have been in the right place, but sea scatter and ground scatter are also plausible explanations.
Knowing the location of the intersection of the two great circle paths could suggest if it was the ionosphere (significant gradients for the frequency involved), sea scatter (the wave conditions in the ocean) or ground scatter (topography variation).
There must be an equivalent mechanism to an electron density gradient to change the direction of an electromagnetic wave when it encounters the sea or land. A smooth flat sea can not change the azimuth direction, so that suggests waves at the intersection point. A smooth flat terrain can not change the direction, either, so that suggests valleys, hills or mountains at the intersection point.

Ground back- and side-scatter
Off-great-circle propagation, involving two ionospheric hops and intermediate scattering at the Earth's surface, may permit propagation at frequencies beyond the great-circle basic MUF. Such scatter signals often have fading rates greather than 1/s and are received with variable azimuth angles of arrival. Signal strengths gradually decrease to 25-40 dB less than that of the great-circle mode as the propagation paths progressively deviate from the great circle. Scattering coefficients of the Earth's surface may be quite variable, depending upon the nature of the surface and the elevation angle. The ground-scatter coefficient is a function of azimuth and azimuth difference between the downcoming and upgoing rays, the presence of land or sea, the ground roughness, elevation angles and also upon focusing due to ionospheric curvature for grazing-incidence angles. There have been conflicting observations concerning the intensities of signals scattered from the sea as compared with those from land. The intensities of back- and side-scatter signals at frequencies above the basic MUF for the great-circle path will depend on their respective path lengths, and will vary in proportion to their respective basic MUFs. The lowest path loss should normally occur for the beam of intersection of the skip distances around the transmitter and receiver because of skip-distance focusing. However, in practice the directivities of the transmitting and receiving antennas can influence the bearing of the maximum received signal strength. It has been suggested this is the dominant mechanism responsible for ABM propagation for single-hop shorter paths of up to 4 000 km length.

DH1TT Side scatter experiments

The experiment done with DH1TT is important because it seems to highlight that it is a fixed reflection on some earth surface. Land or sea. Both my signal and the DH1TT signal were not affected by any kind of fading. The DH1TT signal arrived 5/8 at my station and my signal arrived 5/2 in Germany.



DH1TT with a 21MHz 6el.50ft boom @75ft Antenna and 750 w. August 11, 2019, 17:17 UTC-
IK3XTV with a 21MHz 2el.7ft boom@50ft Antenna and 100w.
both antennas pointed to the southwest, towards Spain

Geographical position of the stations and some possible scatter areas. The first is located on the Iberian peninsula and the second on the Atlantic Ocean, in the area of the Canary Islands or or maybe in the Sahara desert.

Conclusion and Acknowledgements

An electromagnetic wave travels in a straight line (on a great circle path) unless it is refracted, reflected or scattered. So those intermediate delays between long path and short path are probably made up of two great circle paths connected with a refraction (or reflection) point.

Special thanks to Carl Luetzelschwab K9LA for permission to use his studio on Beacon ZL6B and its image, and also for several suggestions and for providing a lot of documentation.

References

ITU - REPORT ITU-R P.2011-1 PROPAGATION AT FREQUENCIES ABOVE THE BASIC MUF
VOACAP online http://www.voacap.com/prediction.html
Ionospheric Radio Propagation by U.S. Department of Commerce - National Bureau of Standard