Distance effects in 40 meters - Experiments with WSPR

In this chapter I would like to talk about some experiments carried out with WSPR. Let's see first how it works. WSPR stands for Weak Signal Propagation Reporter. It is a software mainly used in beacon mode with low power transmission, in HF and in medium waves. The transmission protocol provides for the sending of the station name, the first four characters of the locator and the transmission power expressed in dBm. The program can decode signals with S/N up to -28 dB. The stations, automatically send the receiving data to a central database called WSPRnet, which includes a map with real-time receptions. I used this technology to analyze some of the 40-meters propagation behaviors by referencing some stations.

Some tests
I have chosen two stations as a reference, located at different distances and in beacon mode, that is, active 24 hours a day. With a distance compared to my QTH of about twice as much as each other. I took as a reference the DL1FX station, located in the south west of Germany, in Hesse at 500 kilometers far away and an English station, G8VDQ, in London at 1078 kilometers. I monitored the WSPR signal for a full day of 24 hours and I made graphs where interesting things emerge. (The experiment was done with the summer Ionosphere, in early August 2013).

Data analysis
The first thing that emerges is how distance influences the behavior of the Ionosphere and a skip difference of about 500 kilometers, can lead to almost opposite propagation behaviors. The only common thing, are the large oscillations in the intensity of the received signal, but the thinner black curve, shows the trend of the signal that indicates the trend of propagation:

- **DL1FX**: The graph shows that the signal strength increases throughout the day and then disappears after sun sets and reappears again when the sun rises. So, we have a total night blackout. The beacon reappears after sunrise. There is a hysteresis at sunset and a hysteresis at dawn of opposite sign, due to the timing of ionization/recombination of the ionospheric layers. You can see also a "grey line" effect after dark.

- **G8VDQ**: In this case the beacon was received for all 24 hours. There were no overnight blackouts. In fact, the behavior was opposite to DL1FX with a signal that tended to increase during the night hours. There were no differences in the grey line, but a spike during the middle hours of the night.

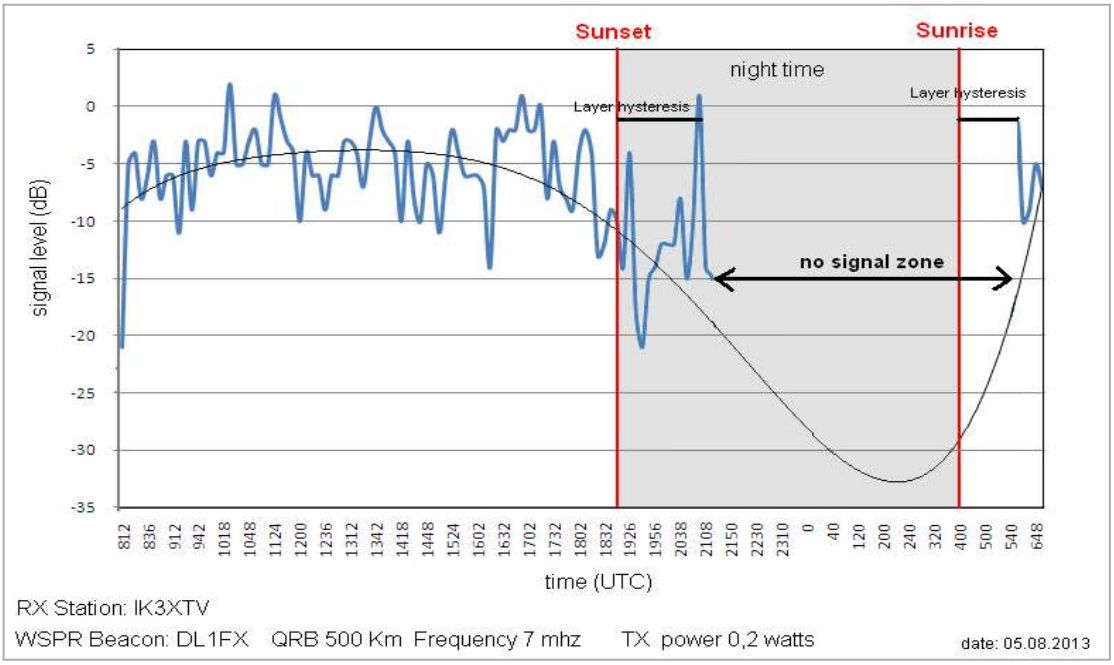


Fig. Graph of German station DL1FX that transmitted with 0,2 wats of power. With oscillation of the signal intensity up to 23db. DL1FX transmits with a G5RV antenna.

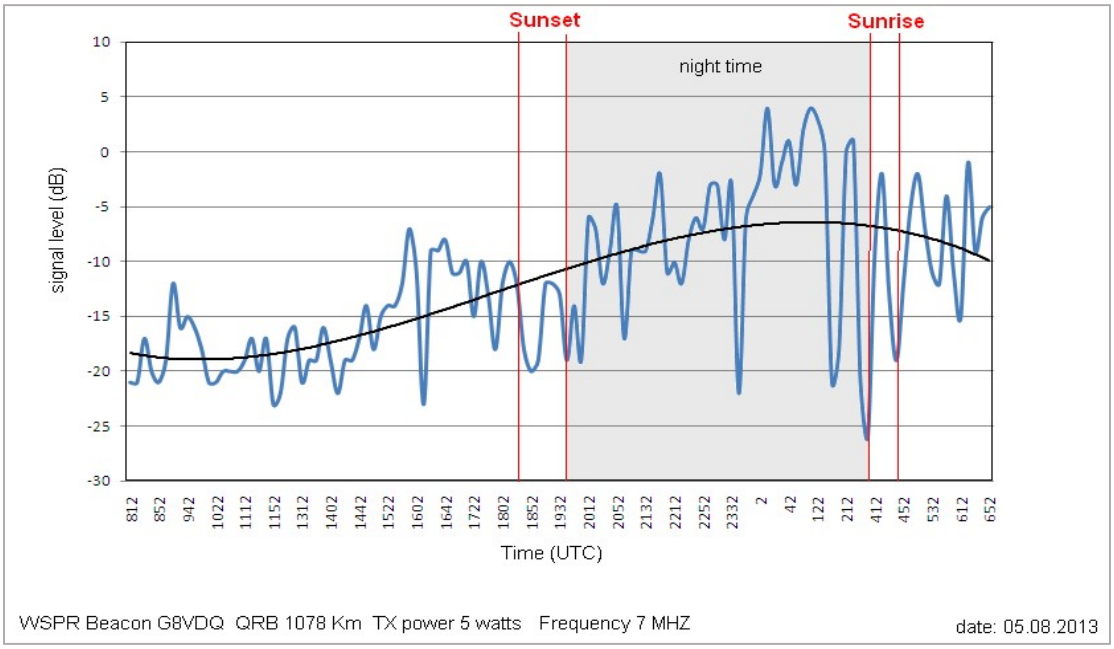


Fig. Graph of the English station G8VDQ, that transmitted with a power of 5 watts. Ionospheric oscillations cause a change in signal level up to a maximum of 30db.

WSPR experiment with DL1FX repeated years later but with winter Ionosphere
The experiment with DL1FX was repeated in winter in December, with quite similar results. I always used DL1FX as TX and this time the station IZ3EAW/B reception in WSPR beacon mode because the path is pretty much the same as the 2013 experiment. Distance is 550 kilometers.
You always see an area of hysteresis after sunset and before Sunrise and an area of silence that coincides with the night hours. The first experiment with the summer Ionosphere was done in 2013 while this winter Ionosphere experiment in 2020.

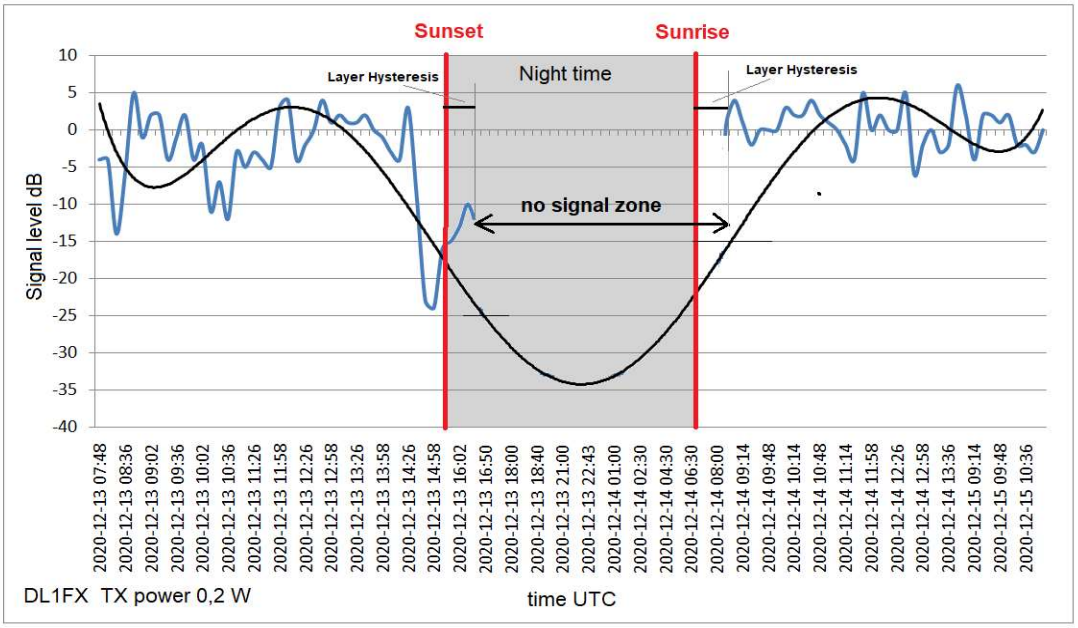


*Fig. Chart of the 2020 DL11FX reception experiment in Winter season, receive from December 13 to December 15. Signal received from IZ3EAW/B WSPR station in Beacon mode (setup:*KIWI*SDR with an antenna system of 4 interlaced loops and LZ1AQ*preamplifier*) The distance between DL1FX and IZ3EAW/B is 550Km.*

Reception experiment over more days in winter: D L1FX received from IZ3EAW/B
To better see the behavior of the winter ionosphere, I did another WSPR experiment. I needed two WSPR beacon stations and I identified the usual DL1FX and as other station, I always used IZ3EAW/B, listening data over 24 hours for 13 days. Above all, the graph shows that the DL1FX signal is received only during the hours of maximum insolation, approximately from 10 am local time until 3 pm. The DL1FX signal was only received during the day. The night path is completely closed. There are significant daily variations, both as the average signal level, and as the duration of the opening time. Propagation varies significantly, day by day. Days alternate with a higher average signal and longer openings, and days with shorter openings.

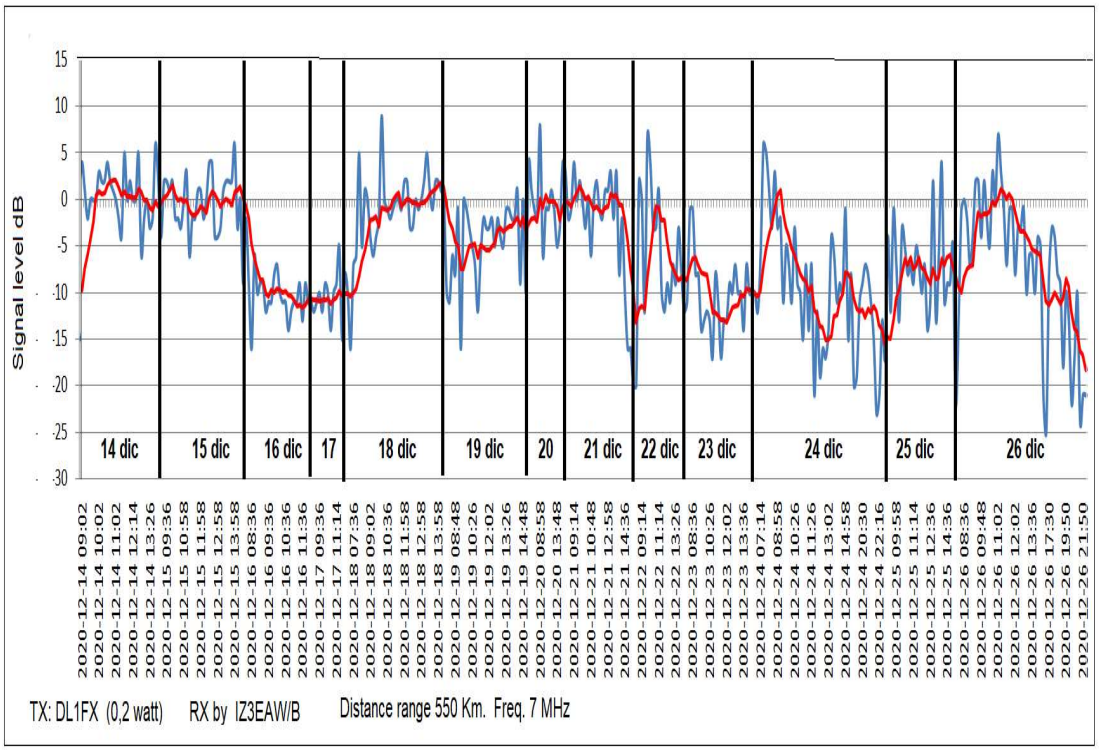


Fig. Graph of the WSPR reception experiment in DL1FX station beacon mode received by IZ3EAW/B. Distance between the two stations, 550 kilometers. Continuous reception h24 for 13 days.

Study with WSPR in 40 meters over medium distance

This is a special test, carried out in December 2020 using the transmission of DL1FX received to the Canary Islands by EA8BFK, on the 7 MHz. Time interval examined and shown in the chart covers 7 days, 24 hours a day. It is a medium distance route, about 3000 kilometers. For me, EA8 is almost a Dx for the 40 meters. The first thing that comes up is that the path opens mainly at night. The path is almost always open even in the transitional periods, that is, between the two sunrises and the two sunsets, which are obviously different between Germany and the Canary Islands. Note the great instability of the ionosphere that introduces profound variations in intensity, variations are so wide because the low power transmission of DL1FX.

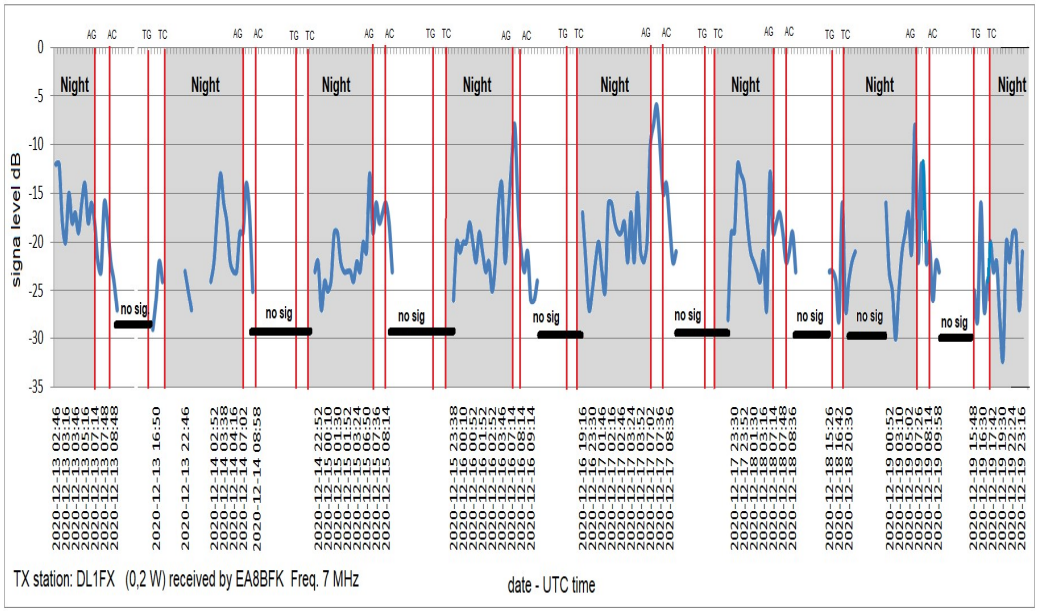
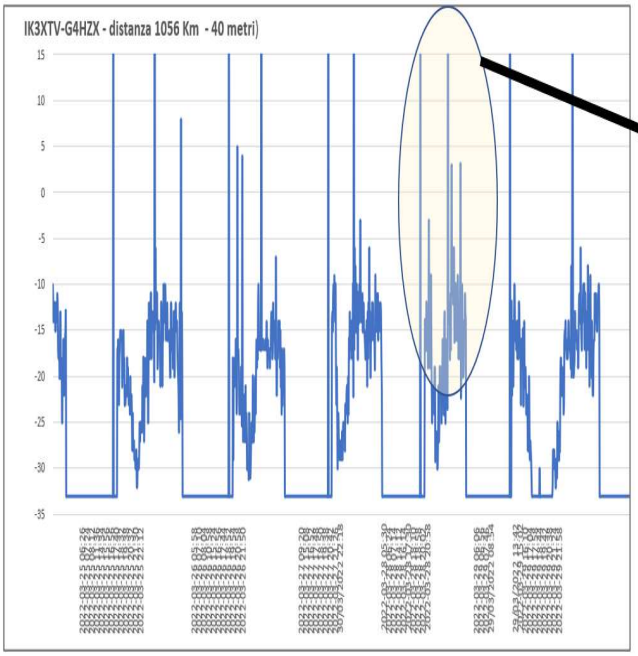


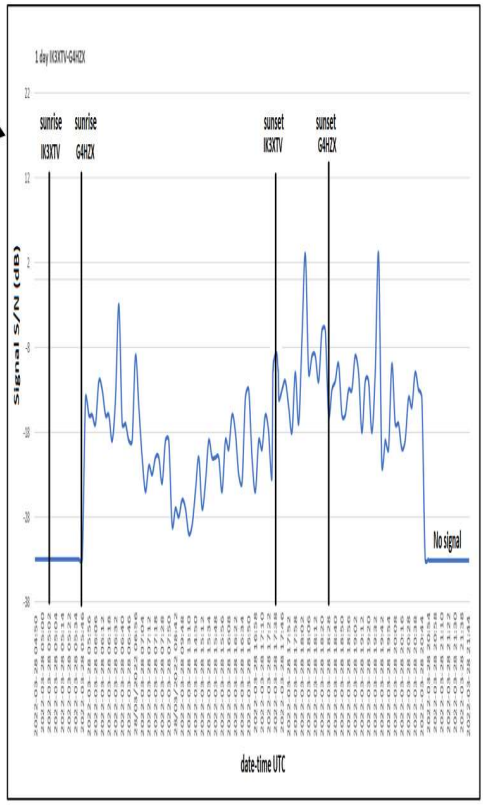
Fig. The graph shows the DL1FX signal received in the Canary Islands. The vertical red lines indicate the time of sunrise and sunset. To understand the chart, you need a small legend:
AG means Sunrise in Germany, AC sunrise Canary Islands, TG, sunset in Germany and TC sunset in the Canary Islands. The areas obscured in gray, are the night hours. The horizontal segments, with the largest black line, are the hours without any received signal.

Ionospheric focusing phenomena

Signal transmitted by IK3XTV in WSPR beacon mode, with power of 0.5 watt and Windom antenna, on the frequency of 7 MHz and received by the English station G4HZX. The signal reception curve H24 shows a prevalently diurnal propagation, which lasts after sunset for a few hours. Furthermore you can see a V-shape with a negative peak at the second part of the morning, until about noon. It is interesting to note the positive peaks, probably due to ionospheric focusing phenomena. (Experiment carried out in March 2022).



The trend of the signal shows a V-shaped trend, with the lowest peak occurring in the second part of the morning until around noon.



Zoomed image of a single day trend. Signal peaks can also be seen, probably due to ionospheric focusing phenomena.

Freq. 7 MHz distance range 1056 Km.