October 2023 Annular Eclipse Propagation Anomalies at HF: Preview of FST4W Observations

Part 3: Frequency spread - Indicator of change in propagation mode

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Two-hop becomes one-hop during the eclipse

Previous work [1] has shown that frequency spread, as measured in WSJT-X's FST4W protocol, is useful for discriminating between propagation modes. For surface wave propagation spread for the 120 s variant, given GPSDOs at receiver and transmitter, is 4–6 mHz. Single hop F2 layer frequency spread at 14 MHz (quiet geomagnetic conditions, mid latitudes) is <50 mHz. Two-hop propagating alone has a typical median of ~260 mHz with a median absolute deviation of 60-80 mHz. Against these values we can examine frequency spread on eclipse-affected paths.

In this example the 14 MHz transmitter at W7WKR (CN97uj, WA, 84% obscured) was a QRP Labs QDX with a 25 MHz GPSDO from N6GN. The receiver at KV6X (DM75aq, NM, annular at 16:36 UTC) was an RX888 SDR running 'KA9Q radio' [2] within the WsprDaemon reporting package [3] for multimode, multiband simultaneous spot acquisition. The path was 1808 km at 133° from transmitter to receiver.

Figure 1 (top) shows circuit reliability for 14 October at KV6X for 14.097035 MHz FST4W transmissions from W7WKR. Here, circuit reliability (CR) is the number of transmissions, sent every 2 minutes, received in 20-minute intervals expressed as a percentage. The band opened at about 15:00 UTC. It did not close completely during the eclipse: but there were short gaps.

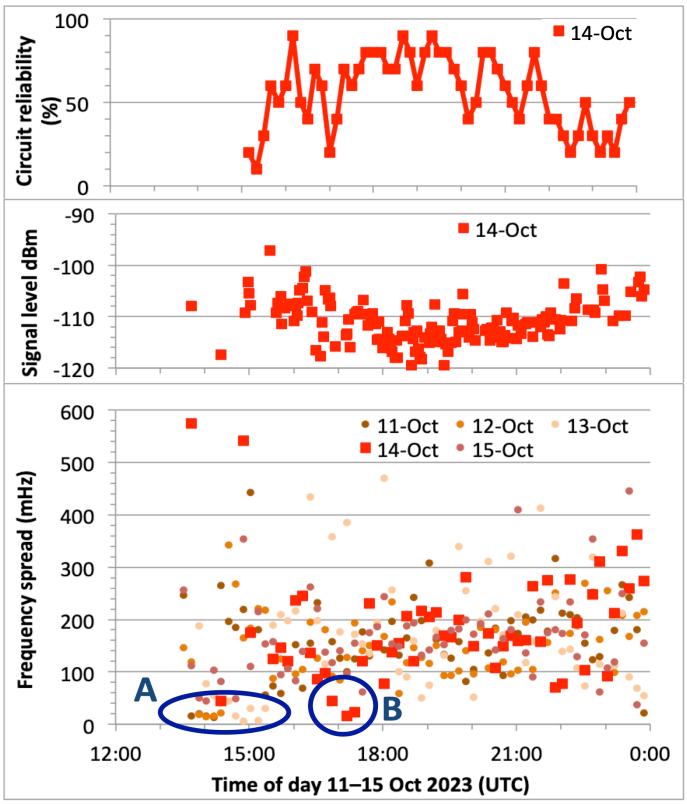

Figure 1. Top: Circuit reliability in 20-minute intervals for FST4W transmissions every 2 minutes at 14.097035 MHz from W7WKR to KV6X, a 1808 km path, for 14 October 2023. Middle: Signal level computed from SNR and noise level,showing diurnal variation due to absorption with lower signal levels near the time of the eclipse. Bottom: Frequency spread on 14 October 2023 and for four non-eclipse days. Cluster 'A' shows low values of frequency spread (<50 mHz) associated with one-hop propagation as the band opened. At other times the propagation was a mix of one- and two-hops. Cluster B, only observed during the eclipse, shows the path to have reverted to one-hop as the F2 layer critical frequency fell.

The first CR dip, to 40%, was at 16:30 UTC with a second dip to 20% at 17:00 UTC. The signal level computed from SNR and noise level, Figure 1 (middle), shows a diurnal pattern due to absorption in the lower ionosphere. Either side of 17:00 UTC the fewer spots (lower CR) had lower signal levels than previous or later spots.

Figure 1 (bottom) shows the frequency spread for each day 11–15 October identified by colour. These are 10-minute averages. Cluster 'A' shows spots with low spread, <50 mHz, each day as 14 MHz opened. This is interpreted as indicating one-hop propagation exclusively. Each day, as the F2 layer critical frequency (foF2) increased, the frequency spread changed: it increased and became more variable as both one-hop and two-hop propagation modes were supported. Their coexistence at a range of 1808 km is seen in the PyLap [4] ray-trace in Figure 2.

Cluster 'B' including an average spread minimum of 16 mHz at 17:12 UTC was, with certainty, pure one-hop propagation. The implication was that foF2 had dropped sufficiently to lengthen the skip zone for two-hop propagation from the ~1550 km in Figure 2 to over 1808 km. At least two questions remain for the spots in cluster 'B':

1. Was the one-hop path during the eclipse a single simple refraction, or was it, due to the dip in foF2 along the path, a more complex ionosphere-to-ionosphere mode such as a Pedersen or chordal hop ray?
2. Reducing the effective smoothed sunspot number (SSNe) from 125 [5] to 75 in PyLap caused the two-hop skip distance to increase to ~1875 km. Was the electron density reduction during the eclipse compatible with the empirically reduced SSNe?

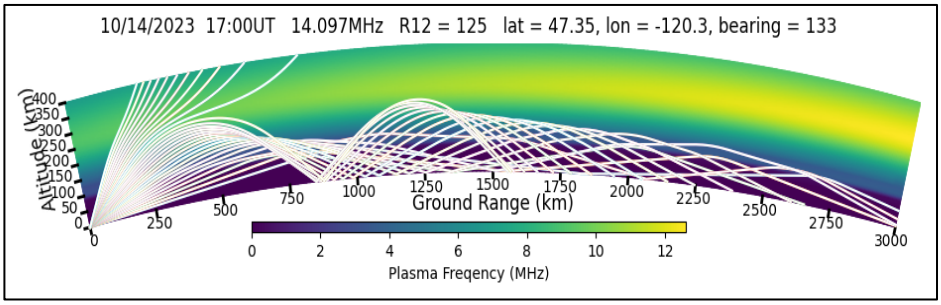

Figure 2. Ray trace for 17:00 UTC on 14 October 2023 for the path W7WKR to KV6X with SSNe of 125 [5] showing co-propagating one- and two-hop paths at 1808 km. An empirical reduction in SSNe to 75 in the model would give a two-hop skip zone of ~1875 km leaving one-hop propagating alone to KV6X.

Data availability

All data is open access. A Guide is available [3], with an Annex on access methods. Sites wspr.rocks and wspr.live also provide access and graphical outputs. Please acknowledge Rob Robinett AI6VN and individual data contributors in any output as below.

References

1. http://wsprdaemon.org/Griffiths_FST4W_2023_HamSCI.pdf
2. https://github.com/ka9q/ka9q-radio
3. http://wsprdaemon.org - see guide on the Timescale page.
4.https://github.com/HamSCI/PyLap
5. https://spawx.nwra.com/spawx/comp.html

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