

Effect of Near-Total Solar Eclipse on Radio Propagation of High Frequency, Weak-Signal Propagation Reporter (WSPR) Transmissions

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Background: What effect do solar eclipses have on propagation of high frequency (HF) radio transmissions? Multi-band, HF, weak signal propagation reporter (WSPR) transmissions originating at semi-rural New York location (Maidenhead FN22, 42°N 74°W) during near-total (97.6% obscuration) solar eclipse on April 8, 2024 were studied.

Equipment: *Transmitter* (Zachtek WSPR Desktop Transmitter; 200mW output on 80/40/30/20/17/15/12/10M amateur radio bands); *Antenna System* (EFHW consisting of ~66', 16awg, silicon-insulated, multi-stranded, tinned copper wire, 20' over ground, oriented in horizontal east-west configuration; 49:1 toroidal impedance transformer; 25' RG58c/u coaxial cable)

Methods: WSPR transmissions cycled through 80M-10M (minus 60M) bands, transmitting for 105 seconds per band, followed by 4 minutes of rest. Twelve 18-minute multi-band transmission cycles were completed before, during, and after the eclipse, and each complete transmission cycle was considered a "time slot". Spot distances were obtained from WSPR Rocks! database. For each band, propagation distance for spots in a given time slot were compared with those of all of the other time slots (Mann-Whitney U for non-parametric, independent data, one- and two- tailed, $p < 0.05$) This was repeated for each band. When identified, significant findings suggest a particular band's aggregated propagation distances within a given time slot are different (longer or shorter) than those in that band's remaining time slots.

Results: WSPR transmissions at 10.14MHz and 14.09MHz were received at significantly longer distances at the height of the eclipse and afterwards, compared to those preceding maximum sun coverage. This signal path lengthening was not observed in other bands. Solar eclipses may affect 30M and 20M radio wave propagation, causing transmission distances to lengthen at and following maximum solar obscuration.

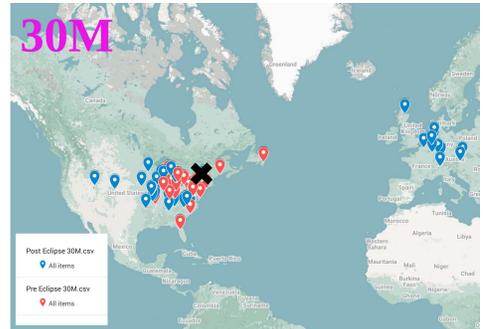


Table 5. 20 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	14	1377	740	1063	802	3053	0.145	n/a	-12
2	8	1451	982	965	802	3053	0.047	0.024 (<)	-13
3	15	957	178	931	796	1469	0.000	0.000 (<)	-11*
4 (start) ⁴	33	2319	1667	1545	802	6144	0.285	n/a	-15
5	23	1317	781	1054	802	3557	0.007	0.004 (<)	-12*
6	7	1015	156	1054	796	1243	0.037	0.019 (<)	-13
7	31	1987	1341	1184	923	6144	0.411	n/a	-14
8 (max.) ⁴	8	2787	2252	1404	931	6144	0.284	n/a	-11
9	4	1312	218	1337	1071	1503	0.704	n/a	-17
10	34	2646	1828	1490	1054	6745	0.000	0.000 (<)	-18*
11 (end) ⁴	32	2485	1987	1436	862	6110	0.016	0.008 (>)	-15
12	23	1541	1158	1079	931	6144	0.448	n/a	-13
Total	232	1954	1538	1184	796	6745	--	--	-16

Table 4. 30 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	21	784	448	656	0	1810	0.049	0.024 (<)	-15
2	20	803	370	739	446	1545	0.098	--	-18
3	22	603	276	493	78	1123	0.000	0.000 (<)	-15
4 (start) ⁴	21	810	408	769	414	1810	0.067	--	-10*
5	23	762	406	725	78	1545	0.030	0.015 (<)	-15
6	16	712	301	691	414	1545	0.020	0.010 (<)	-15
7	23	945	455	879	414	1839	0.738	--	-17
8 (max.) ⁴	20	1295	629	1066	656	3053	0.027	0.014 (<)	-18
9	28	2207	2308	1074	0	6745	0.014	0.007 (>)	-19
10	25	2469	2127	1490	725	6733	0.000	0.000 (<)	-19
11 (end) ⁴	12	890	321	872	88	1490	0.980	--	-14
12	30	2650	2385	1358	477	6745	0.000	0.000 (>)	-19
Total	261	1353	1521	864	0	6745	--	--	-16

¹Signal-to-noise ratio; asterisk (*) denotes $p < 0.05$ compared to remainder of in-band spots

²Standard deviation

³Mann-Whitney U test; (<) indicates that the distance from the KM1NDY WSPR beacon to stations receiving spots at that particular time slot were significantly less than all of the rest of the receiver stations at all of the times slots for this particular band; (>) indicates that the distance to the receiver stations at a particular time slot were significantly more than the rest of the receiver stations at all time slots for that band.

⁴Indicates start, maximum coverage, and end times of solar eclipse at transmitter location (maidenhead grid square FN22vr)

Table 1. Time Slot Assignments for Duration of Solar Eclipse

Time Slot	Eastern Daylight Time		Coordinated Universal Time (UTC)
	(-04:00 UTC)	Time (UTC)	
1	13:20 to 13:34	17:20 to 17:34	
2	13:38 to 13:52	17:38 to 17:52	
3	13:56 to 14:10	17:56 to 18:10	
4 (start) ¹	14:14 to 14:28	18:14 to 18:28	
5	14:32 to 14:46	18:32 to 18:46	
6	14:50 to 15:04	18:50 to 19:04	
7	15:08 to 15:22	19:08 to 19:22	
8 (max.) ¹	15:26 to 15:40	19:26 to 19:40	
9	15:44 to 15:58	19:44 to 19:58	
10	16:02 to 16:16	20:02 to 20:16	
11 (end) ¹	16:20 to 16:34	20:20 to 20:34	
12	16:38 to 16:52	20:38 to 20:52	

¹Indicates start, maximum coverage, and end times of solar eclipse at transmitter location (Maidenhead grid square FN22vr)

Table 2. 40 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	5	201	79	229	78	291	0.441	--	-20
2	5	252	129	232	78	472	0.950	--	-20
3	5	208	79	227	78	291	0.441	--	-20
4 (start) ⁴	5	215	121	229	78	307	0.602	--	-20
5	6	545	44	532	303	307	0.932	--	-23
6	5	268	35	289	227	307	0.231	--	-24
7	10	222	61	238	138	307	0.765	--	-24
8 (max.) ⁴	17	319	227	278	130	1123	0.121	--	-20
9	18	256	115	245	78	483	0.750	--	-16
10	16	236	106	232	78	483	0.541	--	-20
11 (end) ⁴	12	215	70	232	78	307	0.396	--	-18
12	7	227	78	227	78	307	0.788	--	-17
Total	78	349	121.6	237	78	1123	--	--	-20

Table 3. 40 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	41	208	124	262	58	492	0.372	--	-9
2	41	312	181	282	58	1123	0.330	--	-12
3	36	315	135	289	78	614	0.711	--	-12
4 (start) ⁴	45	319	152	302	58	760	0.828	--	-11
5	35	327	131	302	91	614	0.799	--	-12
6	35	311	199	262	58	1144	0.189	--	-8
7	46	524	400	388	28	1600	0.006	0.000 (F)	-11
8 (max.) ⁴	34	378	235	227	91	1144	0.475	--	-10
9	39	304	189	284	0	1144	0.183	--	-12
10	52	416	340	308	0	1775	0.467	--	-11
11 (end) ⁴	48	364	279	308	0	1144	0.412	--	-12
12	33	302	134	307	58	725	0.760	--	-9*
Total	483	356	743	307	0	1775	--	--	-11

Table 6. 17 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	15	1225	1332	1327	906	1377	0.058	n/a	-19
2	14	2666	1536	3044	1490	5762	0.804	n/a	-19
3	20	3277	1386	2442	1490	5917	0.579	n/a	-15
4 (start) ⁴	15	2718	1417	2506	1377	5762	0.166	n/a	-14*
5	24	3643	2398	3083	1490	13225	0.084	n/a	-16
6	21	2189	1544	1839	1490	3481	0.408	0.044 (F)	-19
7	17	2886	1375	3038	1377	6745	0.538	n/a	-16
8 (max.) ⁴	17	3616	1203	2446	1123	4039	0.347	n/a	-14
9	21	3385	1915	2957	1123	6261	0.765	n/a	-24*
10	7	2419	745	2483	1490	3689	0.211	n/a	-18
11 (end) ⁴	26	3067	1704	3083	1060	6745	0.244	n/a	-22*
12	25	3069	1301	3143	1060	6275	0.101	n/a	-16
Total	209	3131	1622	3053	1060	13225	--	--	-18

Table 7. 15 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	19	3718	1310	3708	1830	6906	0.236	n/a	-17*
2	16	3286	1043	3067	1545	5239	0.888	n/a	-16
3	13	3589	1244	3708	1545	6745	0.648	n/a	-18*
4 (start) ⁴	16	3226	1081	3086	1545	5114	0.692	n/a	-14*
5	9	3884	1252	3089	1545	5033	0.750	n/a	-12
6	7	3321	1100	3080	1593	4022	0.714	n/a	-14
7	4	2869	1335	2931	1593	4022	0.689	n/a	-9
8 (max.) ⁴	5	3234	137	2596	2108	3053	0.955	n/a	-17
9	6	2857	687	3012	1714	3746	0.157	n/a	-15
10	11	3426	469	3689	1700	4039	0.600	n/a	-16
11 (end) ⁴	13	3112	1037	3433	583	4039	0.700	n/a	-14
12	15	3725	1450	3708	1796	6745	0.395	n/a	-14
Total	134	3543	1112	3689	581	6745	--	--	-15

Table 8. 12 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	11	3410	1271	3053	1852	6756	0.916	n/a	-1*
2	12	4827	1757	4688	3496	6756	0.009	0.005 (>)	-19
3	9	3032	540	3053	2264	3746	0.376	n/a	-18
4 (start) ⁴	9	3452	1148	3131	1852	6006	0.702	n/a	-17
5	9	3736	1794	3053	1852	6745	0.957	n/a	-18*
6	6	2615	838	2775	1490	3743	0.654	n/a	-16
7	7	2797	926	3053	1490	3746	0.338	n/a	-19
8 (max.) ⁴	8	2071	693	3053	1490	3746	0.347	n/a	-15
9	15	3188	770	3053	1090	4039	0.642	n/a	-17
10	6	3484	365	3487	3053	3880	0.209	n/a	-18
11 (end) ⁴	6	3048	496	3053	2496	3746	0.700	n/a	-16*
12	2	3242	387	3242	3053	3431	0.298	n/a	-15
Total	100	3385	1227	3053	1490	6756	--	--	-17

Table 9. 10 METERS – WSPR Propagation Distance And Signal-To-Noise Ratio Across Duration Of Solar Eclipse

Time slot	# Spots	Distance (km)						SNR ¹ (dB)	
		mean	SD ²	median	min.	max.	$\rho(2\text{-tail})^3$	$\rho(1\text{-tail})^3$	mean
1	2	3798	341	3798	3557	4039	0.207	n/a	-19
2	6	3251	483	3131	2756	3746	0.451	n/a	-18
3	8	3414	428	3407	2834	4039	0.956	n/a	-18
4 (start) ^{4</}									